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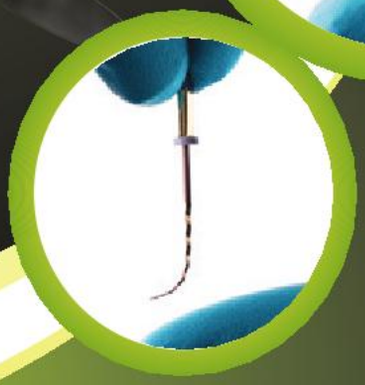

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Editorial

From The Desk of Guest Editor.....

Virtual Autism: A Modern Developmental Concern in the Digital Era

Abstract

Virtual autism refers to a set of autism like symptoms observed in young children exposed to excessive screen time during early developmental years. These children may exhibit delayed speech, poor eye contact, social withdrawal, and repetitive behaviours mimicking autism spectrum disorder (ASD) yet show significant improvement when screen exposure is reduced and replaced with interactive, real world activities. Though not officially recognized in diagnostic classifications like the DSM-5, virtual autism is gaining clinical attention due to its potential reversibility and increasing prevalence. For pediatric dentists and clinicians, understanding this condition is essential for effective behaviour management and accurate case assessment. A detailed developmental and screen use history is now a critical component of pediatric evaluations.

This editorial emphasizes the importance of limiting screen time in early childhood, promoting caregiver child interaction, and raising awareness among health professionals. Early intervention and preventive education can play a pivotal role in reversing or minimizing the effects of virtual autism.

Keywords: Virtual autism, Screen time, Child development, Pediatric dentistry, Digital exposure

The rapid rise in early childhood screen exposure has given rise to growing concern over a condition informally termed "virtual autism." This concept refers to a cluster of developmental challenges in young children including reduced speech, poor eye contact, emotional detachment, and repetitive behaviours that bear a striking resemblance to symptoms seen in autism spectrum disorder (ASD). Notably, these symptoms often show significant improvement when screen time is restricted and replaced with interactive, real world experiences.

Although not formally classified in current psychiatric manuals like the DSM-5 or ICD-11, the concept of virtual autism is gaining traction, especially in clinical and developmental circles. Observations suggest that children excessively exposed to screens during early critical developmental windows typically before the age of three may develop patterns of delayed social and language development. In some cases, these children are mistakenly thought to be on the autism spectrum.

From a clinical perspective, especially in pediatric dentistry and child focused health care, it is vital to distinguish between permanent neuro-developmental disorders and screen-induced developmental delays. A thorough case history must now include questions about the child's screen habits, interaction with caregivers, and real-world play. This approach is critical not only for diagnosis but also for tailoring behavior guidance strategies during dental visits.

As oral health professionals, we often encounter children who are withdrawn, unresponsive to verbal commands, or display heightened sensory sensitivities. While such behaviors may stem from a range of causes, prolonged digital exposure during the early years is increasingly recognized as a contributing factor. It is important to recognize that this condition may be reversible with early intervention, including limiting screen exposure, encoura-ging face to face communication, and increasing play based learning.

Public health bodies such as the World Health Organization recommend that children under two years of age should not be exposed to screens at all, and those aged 2–5 should be limited to no more than one hour per day, under supervision. These guidelines are particularly important today, as the use of digital devices becomes nearly universal even among toddlers.

Ultimately, raising awareness about virtual autism is crucial. Parents, caregivers, and healthcare professionals must work together to ensure children grow in environments rich in verbal, emotional, and social stimulation. Human interaction remains the most powerful tool for healthy brain development. In our roles as clinicians, educators, and advocates, we must help families strike a healthy balance between technology and the real world experiences essential for early development.

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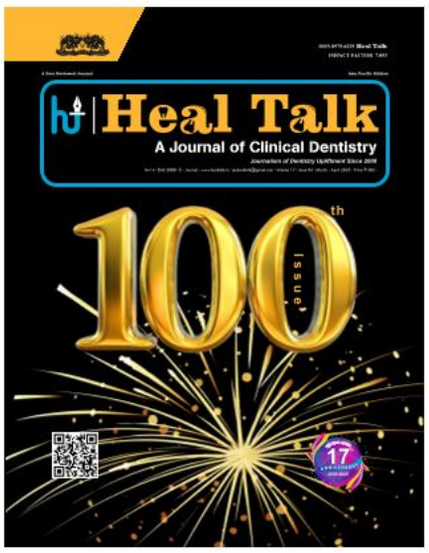

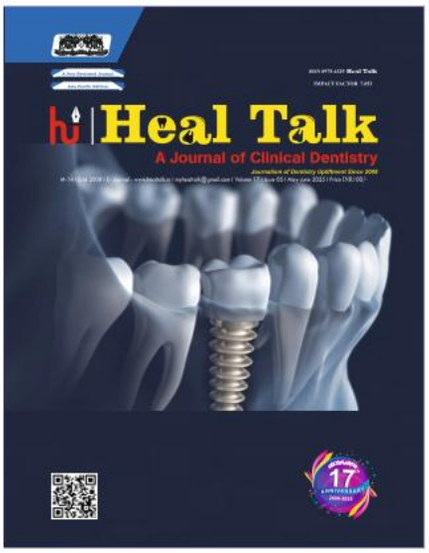

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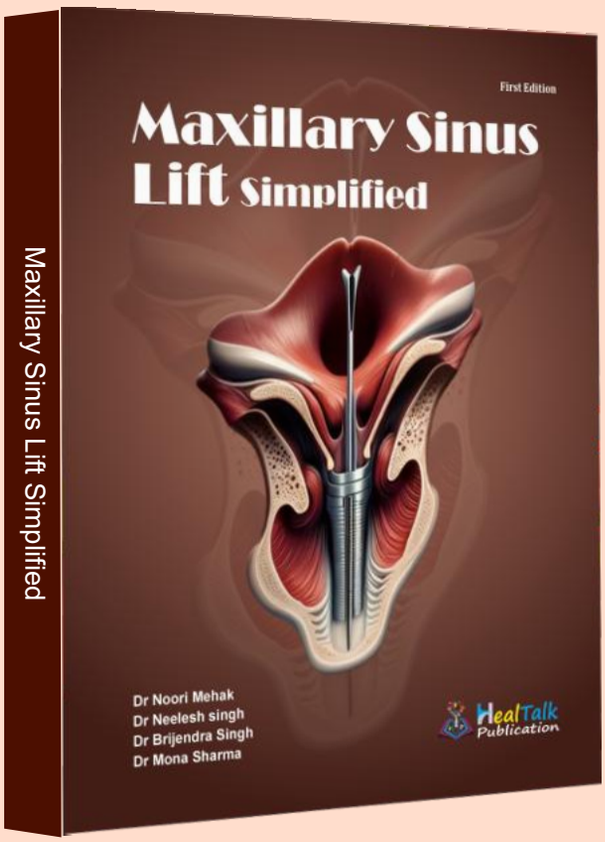

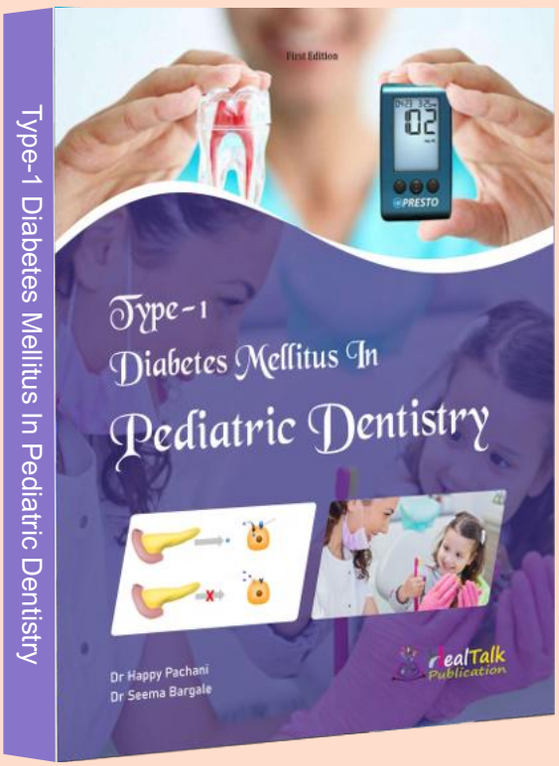

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Endo Talk

Cone Beam Computed Tomography In Endodontics (Part III)

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CBCT and Pre-surgical Assessment

Introduction

Cone beam computed tomography facilitates the clinician to view the relationship of the tooth to its surrounding anatomical structures in a three dimensional view. Cone beam computed tomography with its visual clarity can assist the surgeon in the planning of surgical procedures. The presence/absenceof a periapical lesion can change the course of action(s)in any surgical procedures.

The role of cone beam computed tomography in the surgical assessment of maxilla CBCT's guidance enables accurate measurement of the distance between the cortical plate and the palatal root apex. Even the proximity to the maxillary sinus can be evaluated. Using CBCT the size, location and extent of the periapical lesion can be determined. CBCT can meticulously recognise apical pathology as compared to periapical radiology. Clinicians faced difficulty with periapical radiographs, especially in second molar region and areas with close proximity to the maxillary sinus. CBCT could detect the expansion of the lesion into the sinus, missed canals and thickening of the sinus membrane.

The role of CBCT in the surgical assessment of mandible. It is possible to evaluate the dimension of the periapical lesions, the relationship of the mandibular roots to the inferior alveolar canal and buccal bone dimension with CBCT and periapical radiographs before attempting apical surgery. It has been found that a large number of lesions diagnosed with CBCT were undetected on periapical radiography. The dimension of the buccal bone can be as certained as well thereby stressing on the importance of CBCT assessment in the mandibular quadrant before surgery.

Concluding Remarks

CBCT is recommended for endodontic surgery. CBCT can provide a three-dimensionalview of bone topography, tooth anatomy and proximal anatomical structures. CBCT can provide an accurate idea about the quantity and shape of the bone. However, there is less certainty about the quality of the bone. Cone beam computed tomography can be used to visualise the root morphology and thereby influence the outcome of the treatment.

CBCT and Vertical Root Fractures (VRF)

Introduction

Vertical root fractures extend longitudinally from the canal space to the periodontium. They provide a pathway between the oral cavity and the bacteria leading to destruction of the periodontal space and subsequent bone loss. The clinical presentation of vertical root fractures is an isolated periodontal probing depth on either side of the tooth, multiple sinuses and a characteristic 'halo' or 'J'-shaped radiolucency However, these signs may not be associated with long standing or incipient fractures. Vertical root fractures are commonly associated with endodontically treated teeth. Some of common predisposing factors are over zealous root preparation, forces delivered during root canal obturation and intra-radicular post. The prognosis of vertical root fractures is dependent on the location of the fracture and the extent of radicular involvement. Timely and accurate diagnosis can prevent extraction of the concerned tooth. However, these fractures present as a diagnostic dilemma. Clinical features are inconclusive and conventional radiographs are limited in their diagnostic abilities due to compression of a three dimensional anatomy into a two dimensional image, geometric distortion and anatomical noise.

Conventional radiography may not be diagnostically useful in the diagnosis of vertical root fractures unless the x-ray beam coincides with the fracture line. To overcome this hurdle, it is advised that two radiographs be taken with a shift in the horizontal beam. Nevertheless, even after using the parallax method, overlapping may be inevitable preventing the visual-isation of the fracture line.

It has been found that the cone beam computed tomography can be promising in the diagnosis of vertical root fractures due to its three dimensional nature, minimal geometric distortion and reduction of anatomical noise.

Concluding Remarks

There is insufficient evidence to advocate the use of CBCT for detection of VRF. However, CBCT may be indicated where symptoms and/or signs are absent or ambiguous and VRF is suspected. In these cases, CBCT may reveal signs of peri-radicular bone loss indicating a VRF within the adjacent root. The artefacts caused in the presence of root filling and intra-radicular

post hinders diagnostic accuracy. The role of CBCT in the diagnosis of VRF needs further clarification and extended research.

CBCT and Resorption

Introduction

Root resorption is defined as the loss of dentin and cementum as a result of osteoclastic activity. The common method of classificationis based on the location of the resorption that is external or internal. The process of resorption can continue for up to 2–3 weeks and may present itself as an inconspicuous finding. The process of resorption can be stimulated by pressure or infection triggering osteoclastic resorption of the injured root resulting in extensive damage.

External Cervical Resorption

External cervical resorption (ECR) is mostly initiated by damage to the cementum (usually caused by luxation and avulsion injuries) eventually leading to colonisation of the area by osteoblasts. Furthermore, this condition can be idiopathic in nature. Other causes are trauma, orthodontic treatment and intracoronal bleaching. The diagnosis can be challenging due to the absence of the characteristic 'pink spot'. The radiographic signs are usually an ill defined radiolucency in the cervical third of the root. If the walls of the root canals run through the radiolucent defect, the lesion is external in nature.

Parallax radiography can be used to determine the type of resorption. However, the sensitivity of conventional radiographs is poor in the detection of external root resorption. Furthermore, till the time external root resorption becomes evident on the conventional radiographs, considerable hard tissue damage has already occurred. Also, it is difficult to differentiate between the type of resorption. On the contrary, CBCT can effectively diagnose the type of resorption and the area of extent of the lesion.

Internal Resorption

Internal root resorption is the process of the destruction of the intra-radicular dentin and dentinal tubules. It occurs around the middle and apical region of the canal walls due to osteoclastic activity. A 'ballooning out' appearance is characteristic of internal root resorption. The lesion is oval/round radiolucency with a smooth well defined outline.

Cone beam Computed Tomography or Conventional Radiography?

Resorption may present as a diagnostic dilemma leading to inappropriate treatment. Clinically differentiating between internal and external resorption can be difficult especially without the signs of pink spot, localised gingival inflammation and osseous defects. The first step towards the diagnosis of resorption is conventional radiography. Conventional radiography using the parallax technique can be used to confirm the location (palatal or labial) of the root resorption. The parallax technique does not provide information about the dimension and extent of the lesion. The diagnostic information revealed is incomplete due to the compression of a three dimensional anatomy into a two dimensional shadowgraph. Moreover, anatomical noise results in an underestimation of the size of the resorption.

Various studies have shown that CBCT scans diagnosed root resorption accurately. The software allows selection of a favourable orthogonal view and adjustment of the thickness between each slice, thus increasing diagnostic susceptibility. CBCT can be a useful in the assessment of root resorption shaping the treatment plan.

It can be concluded that periapical radiograph had a limited accuracy in the detection of the size, circumferential spread and location of external cervical resorptions lesions compared to CBCT.

The additional information gained from CBCT has resulted in the introduction of a 3-dimensional classification to describe external cervical resorption. The aim of this descriptive classification is to ensure an accurate diagnosis and aid communication of external cervical resorption between clinicians. It should allow objective outcome assessment as well as aid in decision making. Ultimately, treatment outcome and prognostic factors may also be assessed in relation to the three dimensional nature of external cervical resorption.

Concluding Remarks

In cases where (parallax) radiographs provide limited information, CBCT should be considered as an additional method to assess the nature of a resorptive lesion; this information improves diagnosis and management of root resorption. CBCT can be a useful tool in the assessment of root resorption thus assisting shaping the treatment plan of a patient as it has higher sensitivity as compared to conventional radiographs. However, most resorptive lesions are unpredictable and occur as incidental findings on routine radiographic assessment. The use of CBCT for routine use is difficult to justify. Limited volume, high resolution CBCT can be used in cases of suspected or established resorption where CBCT can influence the management and prognosis of the tooth.

CBCT and Dento-alveolar Trauma

Introduction

The diagnosis, treatment planning and determination of the prognosis of traumatised teeth is a challenging task. Most commonly used systems for trauma assessment are computed tomography, magnetic resonance imaging, periapical radiography and cone beam computed tomography. Trauma to the oral region comprises 5% of all dental injuries. The probability of trauma is high in children and adolescents. Incisors are the commonly affected teeth. Effective time management in diagnosis can influence the prognosis of the concerned tooth/teeth. Parallax and occlusal radiographs are recommended for the diagnosis of dental trauma. Even after multiple radiographs taken at several different angles, the fracture line may still not be diagnosed leading to inappropriate treatment and guarded prognosis of the teeth. Commonly misdiagnosed area is the maxillary anterior quadrant due to the oblique nature of the fracture in the sagittal plane.

Horizontal root fractures are classified according to their location and the extent of displacement of the coronal fragment. The prognosis of these fractures is dependent on several factors such as the age of the patient, root development, dislocation and mobility of the coronal fragment. They are common in the maxillary central region (68%), followed by lateral incisors (27%)and rarely mandibular incisors. Root fractures can be horizontal or diagonal in their direction. Detection of these fractures is possible only if the central beam passes through the fracture line. This usually happens with the fractures of the

cervical third.

Cone beam computed tomography can be an asset in the diagnosis and management of dento-alveolar trauma. It has the added advantage of minimisation of anatomical noise and geometric distortion. A single scan can assess the nature and severity of the injuries. Furthermore, the direction of the displacement can be clearly visualised.

Since CBCT is an extra oral technique, it is considered far more comfortable for a patient who has recently sustained dental trauma as compared to several periapical radiographs taken using a paralleling device.

Cone beam computed tomography can effectively detect the nature of the trauma and associated cortical bone defects. Furthermore, CBCT is accurate as compared to multiple periapicals in determination of horizontal root fractures. Rarely single tooth trauma is seen. With the aid of CBCT, multiple teeth are covered in a single scan without the disadvantages of geometric distortion.

Conclusion

It is clear that the additional information provided by CBCT may increase and/or improve diagnostic accuracy and confidence in decision-making as well as have an impact of treatment planning. More clinical studies are required to assess the long-term impact of CBCT on the outcomes of endodontic treatment.

Any effective endodontic treatment is dependent on the accuracy of imaging systems and usually requires radiographic assistance in three stages:

Stage 1- before commencing the treatment to assess tooth morphology and periapical lesion;

Stage 2- working length/master cone radiograph;

Stage 3- that is post-obturation radiograph.

For straightforward endodontic cases, exposure of the patient to CBCT it is not justifiable. CBCT imaging comes at the expense of increased radiation dose; therefore, CBCT should only be reserved for cases where there is potential benefit from a three-dimensional assessment. It is essential that patient radiation exposure is kept as low as reasonably practicable.

The benefits of a CBCT investigation must outweigh any potential risks. Therefore, each scan must be optimized to reduce patient exposure by adjusting the CBCT settings, thus allowing each examination to be personalized to the individual patient and the diagnostic needs, rather than just using manufacturer's default settings.

However, when normal periapical radiography is not in a position to demonstrate accurately the root canal morphology and the clinician is not in a position to formulate his/her treatment plan which would consequentially influence the outcome of the treatment, only then a limited volume, high-resolution CBCT should be attempted.

Prerequisites for CBCT Diagnostics

1. Justification of every radiation exposure after undertaking patient history and clinical examination including periapical radiography. They should add additional information to assist in the patient's management.
2. Risk/benefit assessment should be done for every patient.
3. CBCT should not be used for routine screening of imaging.
4. Radiation dose to the patient should be as low as reasonably practicable.
5. Accurate positioning and patient preparation should be done.
6. Appropriately trained individuals should engage in conducting a scan.
7. All exposures should be reported by a trained individual.

Please note that CBCT must not be used as a substitute to conventional radiography. However, it can be used in some circumstances where clinical and periapical radiographic assessment is inconclusive. CBCT, therefore, offers an advanced direction to improve standards of care. It is safe to state that in the hands of a responsible practitioner CBCT can do wonders to the world of endodontics, expanding diagnostic and treatment possibilities. It is, perhaps, time to welcome CBCT as a part of the endodontic armamentarium, albeit judicially!

To be continued.....

(It's a review of literature and not an original article)

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Overcoming The Sleep Demon: Orthodontist's Perspective

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Abstract

Obstructive sleep apnoea (OSA) is a prevalent sleep-related breathing disorder in growing children, characterized by recurrent episodes of upper airway obstruction during sleep. If left untreated, paediatric OSA can lead to significant health complications, including neurocognitive impairment, behavioural issues, and craniofacial developmental abnormalities. Sleep Diseases pose a significant health care burden for both individual and society at large. Orthodontists play a crucial role in identifying risk factors and consequences of sleep disorders associated with oral or masticatory system during routine patient visits.

This article explores the current treatment modalities for OSA in growing children and aduts, with a focus on orthodontic interventions. Traditional management strategies such as adenotonsillectomy and continuous positive airway pressure (CPAP) therapy remain primary treatment options; however, orthodontic approaches, including rapid maxillary expansion (RME), mandibular advancement devices (MADs), and myofunctional therapy, have gained prominence due to their potential to address underlying craniofacial anomalies contributing to OSA. Emerging evidence suggests that early orthodontic intervention can facilitate favourable skeletal growth, improve airway patency, and reduce OSA severity in paediatric patients.

Keywords: Airway management, Mandibular advancement, Myofunctional therapy, Obstructive sleep apnoea, Orthodontic treatment, Paediatric OSA, Rapid maxillary expansion.

Introduction

Obstructive Sleep Apnoea (OSA) is a sleep related breathing condition characterized by repeated instances of partial or total blockage of upper airway during sleep. Affecting approximately 1-5 % of children, often leading to cognitive, behavioural and cardiovascular complications if left untreated.

Since craniofacial structures play a significant role in airway patency, orthodontic intervention is an important part in the administration of OSA in growing children. The majority of severe cases might be better managed with early discovery, which would also decrease secondary effects, including growth limits.[1]

Given the serious health implications of OSA, early diagnosis, management and care can be provided by orthodontist.[1]Parents should make an observation on how child breathes and its impact on dental health, facial development and overall, well being. Children with severe malocclusion experience sleepiness far more frequently & correlation is noted between daytime sleepiness and craniofacial morphology.[2]

If child habitually breathes through their mouth, it could lead to serious long-term health and orthodontic problems, including crooked teeth, poor jaw development, sleep issues and even changes in facial structure. Recognizing the need of early intervention of this issue, as an orthodontist and dentofacial orthopaedist specializing in airway and health. Early intervention can make a huge difference.

Paediatric Obstructive Sleep Apnea (OSA), being a multidimensional state, through screening procedures including a medical history taking, performing physical examination, following appropriate apnea questionaries, performing clinical assess-

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ments, radiographic findings. Confirming the diagnosis, a follow-up referral to a sleep medicine expert, generally to a physician board certified in sleep medicine (PBCSM).[3]

Following diagnosis confirmation, the PBSCM should be consulted when making treatment decisions, priority to least harmful treatments. Orthodontists plan the overall treatment by advising patients on weight loss and significance of changing their sleep posture.[4] For patients who are asymptomatic or who don't seem to be at risk of driving safely ,behavioural therapy is advised .[5]Orthodontist may perform risk assessment for OSA through values of classification, recommended questionnaires, tests to assess airway.[6] Providing patients with accurate information and encouraging long-term lifestyle modification are essential initial steps in both managing obstructive sleep apnea & reducing the risks of its progression to more severe stages.[7]Early treatment include maxillary expansion & myofunctional therapy can benefit 2-3 years old children, despite limited evidence supporting their effectiveness. Screening for OSA signs & symptoms should be done by orthodontist and refer to medical practitioners, when necessary, but early intervention should not be based on unsubstantiated claims.[8]

Etiology

The majority of OSA patients has a restricted upper airway, usually caused by anomalies of craniofacial structures or fat accumulation in pharyngeal muscles and parapharyngeal fat pads. In obstructive sleep apnoea, there occurs substantial changes in intrathoracic pressure, hypoxemias and sudden arousal from sleeping. Intermittent hypoxemias, especially when accompanied by hypercapnia, this condition stimulates the sympathetic nervous system, causing short term and sustained increase in blood pressure.[9,10]

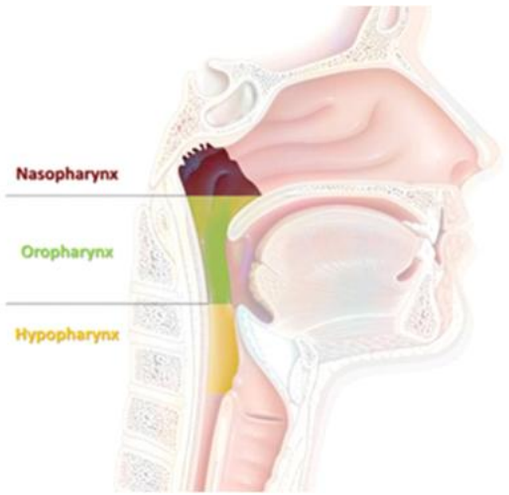

Figure 1:: Upper airway, with areas of the nasopharynx (between skull base and hard palate), oropharynx (soft palate to the upper border of the epiglottis), and hypopharynx or laryngopharynx (from the tongue base to the lower border of the cricoid cartilage)

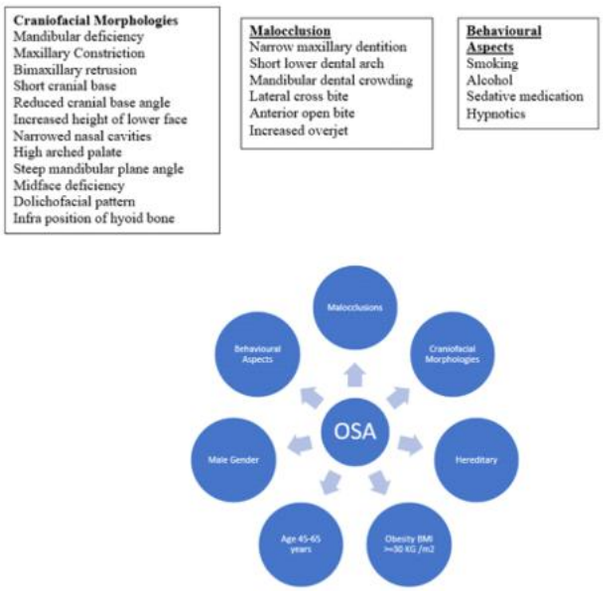

Figure 2: Risk Factors of OSA

Pathophysiology OSA in children involving various anatomical, neuromuscular & environmental factors.[11]

1. Adenoid Hypertrophy

It is most prevalent cause of paediatric OSA. Enlarged adenoids obstruct the upper airway, leading to difficulty in breathing, especially during sleep. This obstruction contributes to disrupted sleep patterns, snoring, and daytime fatigue.

2. Craniofacial Abnormalities

Several craniofacial conditions can predispose children to airway collapse, including:

Retrognathia and Micrognathia: A retruded or small lower jaw can narrow the airway, increasing resistance to airflow.

Midface Deficiency: Hypoplastic maxilla results in a smaller airway, further increasing obstruction risk.

Retro-positioning of the Mandible: Posterior displacement of the mandible reduces airway patency.

Lower Positioned and Displaced Hyoid Bone: Altered hyoid positioning is associated with compromised airway stability.

3. Obesity

Adipose tissue around neck and pharyngeal region can exacerbate airway narrowing. One established risk factor for OSA is obesity, contributing to increased upper airway collapsibility and respiratory dysfunction.[12]

4. Neuromuscular Disorders

Children with neuromuscular disorders may experience reduced muscle tone, impairing the ability to maintain airway patency. Conditions such as cerebral palsy and muscular dystrophy can increase susceptibility to OSA due to weak

pharyngeal muscles.

5. Allergic Rhinitis and Nasal Obstruction

Chronic nasal congestion leads to habitual mouth breathing, disrupting normal respiratory function. Nasal obstruction, whether due to allergies or structural issues, can result in compensatory breathing patterns that negatively affect craniofacial growth and airway stability. Rarely there may be presence of some upper airway tumours.

Impact of Mouth Breathing

Mouth breathing, particularly during sleep, is a significant contributor to paediatric OSA. While temporary mouth breathing due to conditions like a common cold is not problematic, chronic mouth breathing can lead to long-term developmental concerns.

Consequences of Chronic Mouth Breathing

Narrow Palates and Crowded Teeth: Habitual mouth breathers tend to develop smaller upper jaws, leading to malocclusion and orthodontic complications.

Increased Risk of Cavities & Gum Disease: Reduced saliva production due to mouth breathing allows bacterial growth, increasing the chance of periodontal disease and dental decay.

Poor Sleep and Concentration Issues: Sleep disordered breathing caused by mouth breathing can result in fragmented sleep, leading to fatigue, hyperactivity, and difficulty focusing. In some cases, these symptoms may mimicattention deficit hyperactivity disorder.

Facial Changes and Weak Jawline: Prolonged mouth breathing can alter facial development, leading to elongated faces, recessed chins, and improper jaw growth.

Clinical Presentation

Symptoms include loud snoring, behavioural disturbances, fragmentation of sleep, nocturnal cerebral hypoxia, excessive daytime sleepiness, intellectual impairment, memory loss, impotence in men. Changes in position of hyoid bone and adjustment of head posture is seen according to severity of condition. Those presenting with risk factors and clinical features are referred to sleep clinics. Epworth Sleepiness scale, commonly utilized tool for both clinical & research settings to evaluate daytime sleepiness,however, its sensitivity in detecting OSA remains limited. [13]

Metric	Description	Additional information	Sensitivity, %[a]	Specificity, %[a]
Questionnaire				
Berlin Questionnaire	Eleven items grouped in 3 domains: snoring/apneas, fatigue/sleepiness, and obesity/hypertension. Range, 0-3; 0 indicates the lowest risk and 2-3 indicate high risk of OSA.	Developed for assessing sleep apnea risk in the primary care setting.	77 (73-81)	44 (38-51)
STOP-Bang questionnaire	Eight items assess snoring, sleepiness, apneas, hypertension, obesity, neck girth, age, and sex. Range 0-8; 0 indicates the lowest risk of OSA.	Developed for sleep apnea screening in the preoperative setting.	90 (86-93)	36 (29-44)
Epworth Sleepiness Scale	Self-administered assessment of sleep tendency in 8 common situations. Range 0-24; 0 indicates the least sleepy and greater than 10 indicates excessive sleepiness.	Widely used for assessing sleepiness and response of sleepiness to therapy; not useful in screening for OSA.	47 (35-59)	62 (56-68)
Sleep Testing				
Polysomnography	Monitors electroencephalogram, eye movements, and chin muscle tone to assess sleep-wake state and thoracic and abdominal excursion, oronasal airflow, and pulse oximetry to identify apneas and hypopneas. Measures number of apneas plus hypopneas per hour of sleep.	Criterion standard for diagnosis of OSA; permits diagnosis of sleep disorders other than sleep apnea; cost is high relative to HSAT.		
Home sleep apnea testing (HSAT)	Multiple available devices; most include monitoring of airflow, respiratory effort, and oximetry; some use nonstandard measures, such as peripheral arterial tonometry. Measures number of apneas plus hypopneas per hour of recording.	Lower cost and greater convenience compared with polysomnography; false-negative results possible; unable to diagnose disorders other than sleep apnea.	79 (71-86)	79 (63-89)
Oximetry	Overnight recording of blood oxygen saturation. Measures number of 3% or 4% desaturation events per hour of recording.	Inexpensive and convenient; false-negative results possible; cannot distinguish OSA from central sleep apnea; can document resolution of hypoxemia with treatment of OSA.	7-100	15-100

Table 1 :Methods to identify Obstructive Sleep Apnea (OSA)

Laboratory based polysomnography is involved compre-hensive monitoring of both sleep architecture and respiratory function throughout the night.[13]

Treatment	Description	Advantages	Disadvantages and adverse effects
Behavioral interventions			
Weight loss	Weight loss via lifestyle interventions (also effective for OSA when achieved via medication or bariatric surgery)	Can have positive effects on multiple cardiovascular and metabolic diseases	Difficult to achieve for many patients; takes time to achieve; not efficacious in all patients
Exercise	Aerobic exercise	Contributes to weight loss; can have positive effects on multiple cardiovascular and metabolic diseases	May be difficult for patients with significant musculoskeletal or cardiopulmonary illness
Sleep position restriction	Avoidance of supine sleep position; positioning pillows or devices can help maintain side sleep position	No cost for self-positioning; pillows and devices are inexpensive	Applicable only to patients with positional OSA; difficult for some patients, particularly those with discomfort lying on their side
Medical devices			
Positive airway pressure (PAP)	Pressure generated by the device is delivered via a mask worn over the nose or both nose and mouth; pressure may be continuous or bilevel and may be automatic titrating or delivered at a preset pressure	Efficacious in most patients, regardless of disease severity, level of airway collapse, or body weight; improves sleepiness, quality of life, and blood pressure	Poor tolerance in approximately one-third of patients; minor adverse effects, such as mucosal dryness, nasal congestion, and skin irritation, are common
Mandibular repositioning devices (oral appliances)	Fabricated to fit the upper and lower teeth, these devices provide adjustable forward advancement of the mandible during sleep	Well tolerated by many patients who are intolerant of PAP	Lower efficacy than PAP in most patients, especially in those with severe OSA or class 2 or 3 obesity; requires adequate dental and periodontal structure; can cause temporomandibular joint discomfort and occlusal abnormalities due to tooth movement
Surgical procedures			
Uvulopalatopharyngo-plasty (UPPP) and related soft tissue procedures	Involves resection of the uvula and a portion of the soft palate; other soft tissue procedures focus on reducing volume of the lateral pharyngeal walls or base of tongue to increase pharyngeal volume	Extensively studied; results in improvement in OSA severity in many patients; adherence to therapy is ensured	Lower efficacy than PAP in most patients; effectively manages airway collapse only at the level of the velopharynx; postoperative pain is common; small risk of velopharyngeal insufficiency; relapse can occur with weight gain
Maxillomandibular advancement	LeFort I maxillary and bilateral mandibular osteotomies with forward fixation of the facial skeleton	Highly efficacious regardless of disease severity, level of airway collapse, or body weight; adherence to therapy is ensured	Complex surgical procedure involving bony structures with recovery time of 2 to 10 weeks; potential complications include malocclusion, poor cosmetic result, and facial numbness or paresthesia
Tracheostomy (rarely used)		Curative in most patients with OSA, regardless of disease severity, level of airway collapse, or body weight; adherence to therapy is ensured	Unacceptable cosmetic result; effect on speech; need for long-term tracheostomy care
Hypoglossal nerve stimulation	Surgically implanted electrode stimulates the hypoglossal nerve to enhance tongue protrusion and stabilize the upper airway during inspiration	Highly effective and well tolerated in select patients (body mass index <32 and absence of concentric collapse of the retropalatal airway on drug-induced sleep endoscopy)	Expensive compared with alternative therapies; potential complications include temporary tongue weakness and tongue soreness and discomfort from stimulation

Table 2 :Primary Treatments for Obstructive Sleep Apnea (OSA)

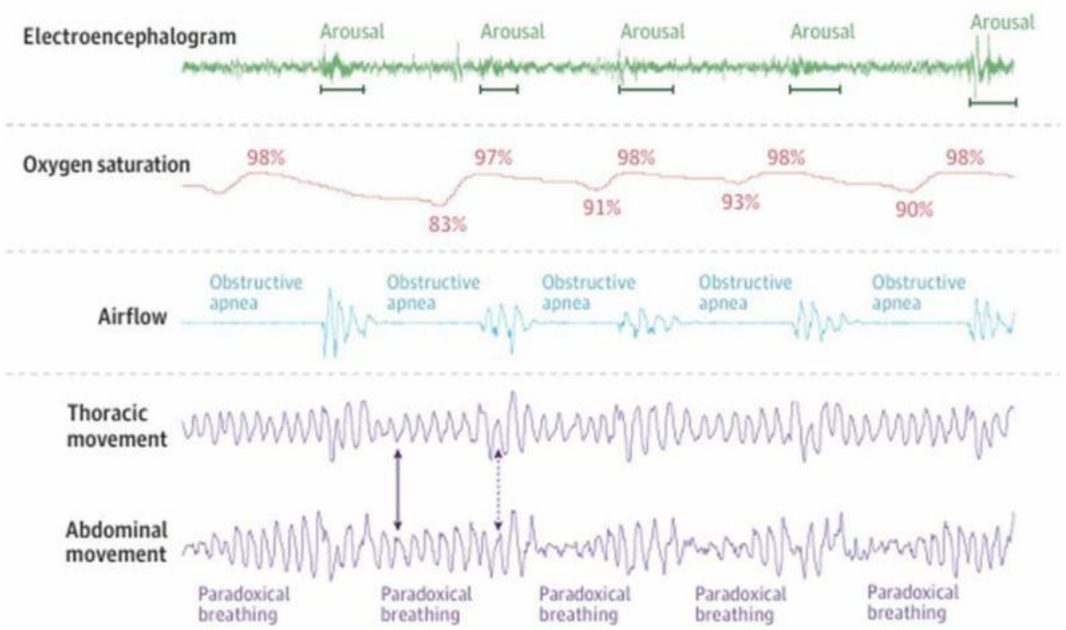

Figure 3: Polysomnogram Demonstrating Physiological Effects of Obstructive Apnea.

OSA risk	Mild	Moderate	Severe
Child	1 ≤ AHI < 5	5 ≤ AHI < 10	AHI ≥ 10
Adult	5 ≤ AHI < 15	15 ≤ AHI < 30	AHI ≥ 30

Table 3 :: Summary of values for classification of obstructive sleep apnea (OSA) in adults & children, according to the apnea-hypopnea index (AHI).

OSA Diagnosis & Risk Assessment

Determining the degree of Respiratory Obstruction including for clinical and radiographic examination.

Apnea / Hypopnea Index

OSA is twice as frequent in males as in women, and its predominance raises with age. Overweight & obesity are also linked to OSA. Because they are asymptomatic or ignorant of the issue, many people do not disclose sleep difficulties. To assess OSA risk, specific questionnaires should be used[6].With a sensitivity of 77 and 90% respectively, Berlin & Stop Bang questionnaires are highly sensitive, risk assessments should be performed. For a correct diagnosis and potential referral to an orthodontist for mandibular advancement device treatment, a patient risk has to be referred to a sleep physician. [6]

EXAM	INDICATION	ADVANTAGE	LIMITATION
Lateral cephalometric radiograph	Provides a 2D evaluation of the profile	Adenoid hypertrophy evaluation	2D representation of a 3D structure. Provides a limited use for UA assessment, as the mediolateral direction in not evaluated
Conventional tomography (CT)	3D evaluation	One of the best imaging modalities for evaluating the nasal cavity and paranasal sinus geometry	High doses of radiation
Cone Beam CT (CBCT)	3D evaluation	Good to evaluate hard tissue structures, good to visualize the airway lumen	No information on muscular tone, susceptibility to collapse or function of the airway. Cannot be used to diagnose OSA alone. There is no direct link between radiographic measures (airway size and volume) with PSG
Magnetic resonance imaging (MRI)	Accurate in measuring the soft tissue lining, fat pad and surrounding structures of the airway in 3D	Good to visualize the airway lumen. No radiation	Metals (fillings and braces) can interfere with the images
Nasoendoscopy	Gold standard for diagnosis of UA obstruction	Direct and functional view of the airway in real time. No radiation	Little opportunity for objective measurement, relies on professional opinion (low interobserver agreement)
Acoustic rhinometry (AR)	Objective method for examining the nasal cavity (evaluates the sound pulse propagation in the nasal cavity by changes in acoustic impedance)	Simple, fast, and noninvasive technique. Clinically useful with very good reliability in the anterior and middle parts of the nasal cavities. No radiation	Reduced accuracy in the posterior part of the nasal cavity
Acoustic pharyngometry	Acoustic reflection technique provides a noninvasive, dynamic assessment of the physiologic behavior, dimensions, and structure of the UA	Useful method to assess OSA. Marketed as a screening method to quickly assess potential sites of UA obstruction and to determine the appropriate treatment. No radiation	Limited accuracy, applicability, and information
Ultrasonography -Ultra sound (US)	Assessment of the UA with no use of ionizing radiation	Simple, fast, and noninvasive technique. Assessment of the UA while in function. No radiation	Evaluation relies on professional knowledge and experience

Table 4: Some tests requested to assess the airway, with a description of their advantages and limitations

Diagnosis - OSA diagnosis requires sleep assessment. Gold standard is laboratory polysomnography (Type 1),evaluated brain activity (EEG), eye movement (EOG), body position, sleep movements.

Home Sleep Apnoea testing (HSAT)

HSAT is becoming increasingly popular because of affordability &convenience. It measures airflow, respiratory effort, oxygen saturation, though it does not record brain activity or limb movements.

Cone beam computed tomography is a diagnostic imaging tool in oral and maxillofacial practice. A three dimensional (3D) view of head& neck region is provided.

Minimum cross sectional area (MCSA) can be automatically detected by software through volume measurements or activated using specific software features. It is considered a more significant indicator than volume alone in identifying airway related pathological conditions. Therefore, combining Cone Beam Computed Tomography with other diagnostic methods and collaborating with a sleep specialist or otolaryngologist ensures a more thorough evaluation for diagnosing OSA.

Ultrasound has been explored for detecting OSA risk factors for some time, and its advancements in recent years make it a promising technology. As a radiation free, cost effective, and portable imaging method, ultrasound offers as accessible and practical option for examination.

The accuracy of ultrasound in identifying individuals with severe OSA and to understand its pharyngeal characteristics was done using submental ultrasonography. It is important to do risk assessment of OSA by understanding airway collapsibility. Diagnosis include Sleep history taking, performing Epworth sleepiness scale questionnaire, doing Apnea hypopnea index (AHI), performing Polysomnography.

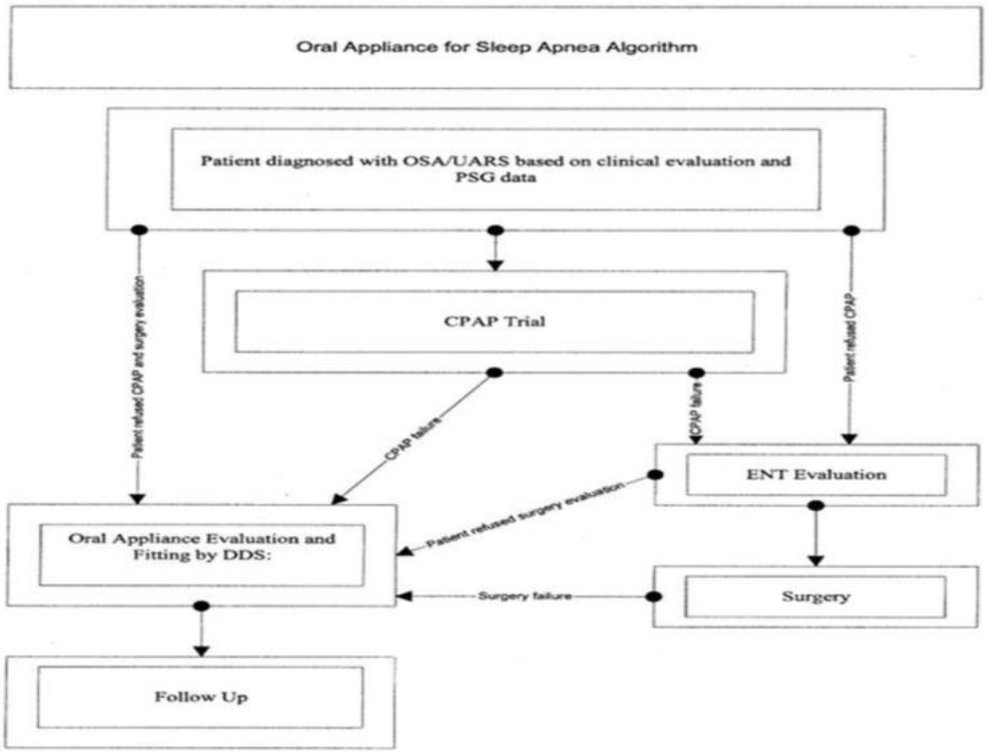

Figure 4:Treatment Alternatives

Treatment Modalities of OSA

Treatment	Description	Advantages	Disadvantages and adverse effects
Behavioral interventions			
Weight loss	Weight loss via lifestyle interventions (also effective for OSA when achieved via medication or bariatric surgery)	Can have positive effects on multiple cardiovascular and metabolic diseases	Difficult to achieve for many patients; takes time to achieve; not efficacious in all patients
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Table 2

Table 2 describes primary treatment options for maintaining or improving the airway.[11] Orthodontic procedures can influence airways & play a part in management of sleep disorders. It is necessary for orthodontist to ask appropriate questions during history taking and clinical examination and if there are sleep apnea concerns, referrals can be made for further evaluation.

It is an accepted treatment goal to maintain or improve the airway during orthodontic procedures. With a narrow maxilla, there is the possibility to use rapid expansion to widen the upper airway, if functional appliances are used for class 2 cases, there may be sign of an improved pharyngeal airway if the mandible is further forward at end of treatment. Performing Surgical orthodontic Maxillomandibular Advancement, mandibular advancement by making use of oral Appliances including Rapid Maxillary Expansion has shown positive effects in both children & adults with OSA and maxillary narrowing.[4] A patient centred perspective regarding use of PAP, American Academy of Sleep Medicine has established management.[5]

Figure 4 Simple procedures like somnoplasty and laser assisted uvulopalatoplasty are rarely performed on soft palates, but they only temporarily relieve symptoms. Surgical techniques resolve patient related issues. Conservative measures can also be advantageous at times. Sleeping for 7-8 hours each night can help reduce tiredness. Patients are advised to avoid sleeping in supine position, as this posture can compromise airway patency despite the use of CPAP therapy. Positional therapy presents challenges, particularly when monitored at home, its clinical effectiveness may vary. It is commonly used in conjunction with pharmacological treatments & adjunctive interventions such as oral appliances or surgical procedures, often yielding variable outcomes.[14] Weight loss through exercise and a healthy diet can be beneficial .[7] Orthodontists specialize in areas closely linked to airway. Various orthodontic treatment methods and their potential impact on upper airway anatomy and breathing pattern is discussed .[6]

Headgear

Maxillary protraction can be beneficial, particularly in individuals with midfacial deficiency, as it may contribute to a reduction in apnea hypopnea index (AHI). Similarly, mandibular advancement appliance can enhance upper airway patency by anteriorly repositioning tongue, soft palate.

Oral Appliance Therapy for OSA

Treatment of patients should be planned on an individual basis.[15] Adjustable oral appliances allow for ongoing titration across various settings to optimize mandibular advancement, while fixed devices can be positioned to achieve enhanced forward positioning of mandible as needed.[16] Higher response rate, overall acceptability and compliance is shown with the mandibular advancement splint. It is to be superior for OSA in the clinical setting in terms of reducing the apnoea hypopnoea index.[17]

Orthodontic Interventions in OSA Management

Orthodontists are uniquely positioned to identify craniofacial anomalies and provide targeted treatment strategies that enhance airway function. Several orthodontic interventions are:

1. Maxillary Expansion

Maxillary constriction is often associated with nasal airway obstruction and mouth breathing, both of which contribute to OSA. Rapid Palatal Expansion (RPE) is a widely used technique in paediatric patients to widen the maxilla, improve nasal airflow, and reduce airway resistance.

2. Mandibular Advancement Devices (MADs)

For both children and adults with OSA, mandibular advancement devices are effective in repositioning the lower jaw forward, thereby increasing airway space. These custom made oral devices work by maintaining an open airway. They are good alternative to CPAP in OSA patients where protrusion of mandible is required. [18] Custom made MAD have demonstrated greater effectiveness in managing snoring & mild obstructive sleep apnea compared to prefabricated, thermoplastic models .[19] Their effects causes decreased overjet, overbite changes. Occlusal bite changes are also predictable by occlusal characteristics and specific design of oral appliance, allowing for personalized follow-up protocols or consideration of alternative therapeutic options for individuals at risk .[6]

Figure 5 :Mandibular Advancement Appliance

3. Orthopedic and Functional Appliances

Orthopedic appliances such as Herbst, Twin Block, and Myo brace are used in children with retrognathia or micrognathia. These devices encourage mandibular growth and repositioning, thereby improving airway dimensions and reducing the likelihood of airway obstruction.[20]

4. Orthognathic Surgery

In cases where skeletal abnormalities are severe, orthognathic surgery may be necessary. Procedures such as maxillomandibular advancement (MMA) significantly increase pharyngeal airway space and are considered a definitive treatment option for severe OSA cases that do not respond to conventional therapies.[21,22] There is need of evidence-based research in guiding surgical interventions for upper airway obstruction & various surgical approaches & considerations in treating nasal and airway issues in children and adults.[23]

5. Myofunctional Therapy and Habit Correction

Anatomy of nasopharynx and adenoid tissue in adjacent region should be studied in lateral cephalograms.[24,25] Presence of allergic rhinitis & asthma may promote mouth breathing can disrupt normal craniofacial development and lead to altered orofacial growth pattern.[26] Effective management should encompass the diagnosis and treatment of these underlying conditions to address both the functional and structural consequences.

Appliance variety include Nocturnal Airway Patency Appliance, Breathe easy twin block , Moses appliance , Orthopnea appliance , Pierre Robin's Original Monoblock , Herbst Appliance , EMT appliance, SomnoMed MAS, Mandibular Repositioning Appliance, Fixed Splint ,Adjustable Splint , OPAP device , Soft Palate Appliance, Tongue Stabilising device, Tongue Retaining Device , Titratable Mandibular Advancement Device , Medical Dental Snorting Appliance, Thorton Adjustable Positioner ,Tongue Retaining Device , Karwetzky Activator ,Mandibular Advancement Splint.

Innovations in Digital Health

Recent advancements in smart phone technology have catalysed the development of health related mobile applications and wearable devices designed to monitor sleep patterns and respiratory events. Consumer Sleep Technologies are becoming increasingly accessible, offering cost effective, continuous home monitoring options. However, the clinical utility of such technologies remains under scrutiny. AASM emphasizes that any device used for diagnostic or therapeutic purposes must undergo rigorous validation and FDA approval. The current lack of standardization and regulatory oversight blurs the line between clinically relevant tools and wellness gadgets.

Batists et al. explored the landscape of sleep apnea-related applications available through major application stores and compared findings against peer-reviewed literature indexed in MEDLINE, Embase Web of Science, Scopus. The results highlight a wide variance in quality, functionality, clinical relevance, underscoring the urgent need for standardized validation protocols.[6]

APP OBJECTIVE AND COMMENTS	APP NAME / PLATAFORM (IF SINGLE)	RESEARCH PAPER RELATED TO THE APP	RESEARCH RESULTS
Sleep monitoring Provides users with a graph detailing the level of wakefulness and light/deep sleep	Sleep time	Bhat S, Ferraris A, Gupta D, Mozafarian M, DeBari VA, Gushway-Henry N, et al. Is there a clinical role for smartphone sleep apps? Comparison of sleep cycle detection by a smartphone application to polysomnography. J Clin Sleep Med. 2015;11.17.	The app was compared to PSG in adults and found a poor correlation between them concerning the sleep efficiency, light sleep, and deep sleep. No correlation was found between the app and PSG sleep latency with a deficiency in detecting wakefulness. Not effective to awaken individuals during light sleep.
Sleep monitoring Accelerometer-based app designed to ease awakening during light sleep periods.	Sleep cycle	Patel P, Kim JY, Brooks LJ. Accuracy of a smartphone applicationin estimating sleep in children. Sleep Breath. 2017;21:505-11.	App data were compared to sleep analysis with PSG in a clinical population of 25 children (2-14 years) with clinical suspicion of OSA. No significant correlation was found between total sleep time and sleep latency compared to PSG. The authors concluded that the app is not yet accurate enough to be used for clinical purposes.
Sleep monitoring Behavioral training response to auditory stimuli estimates sleep onset.	**Sleep on Q** (iOS)	Scott H, Lack L, Lovato N. A pilot study of a novel smart-phone application for the estimation of sleep onset. J Sleep Res. 2018;27:90-7	Authors found high correspondence between the app and PSG sleep onset. The app tended to overestimate sleep latency. The authors highlight the potential relevance of use for facilitating power naps in the home environment.
Sleep monitoring Monitors and provides feedback on auditory snore activity.	SnoreLab	Stippig A, Hübers U, Emerich M. Apps in sleep medicine. Sleep Breath. 2015;19:411-7.	Authors tested the ability to distinguish between snoring events and other background noise. Results did not correspond to the concurrent validated ApneaLink Plus screening device, which led authors to conclude that reliability and accuracy are insufficient to replace common diagnostic standards.
Adjunct CPAP monitoring Engagement tool that allows patients to track nightly sleep data and empowers patients to stay engaged and compliant with long-term therapy.	**ResMed My Air**	Woehrle H, Arzt M, Graml A, Fietze I, Young P, Teschler H, et al. Effect of a patient engagement tool on positive airway pressure adherence: analysis of a German healthcare provider database. Sleep Med. 2018;41:20-6	This tool was associated with significant compliance improvement in first-time users receiving CPAP therapy and a significant reduction in air leakage.

Table 5:Apps presenting favourable results or compatible with standard diagnostic methods

Evidence supports that weight loss, cessation of tobacco and alcohol use, avoidance of sedative medications, regular physical activity can lower frequency and intensity of apnoeic events. In some patients with severe OSA, significant weight reduction alone has led to complete remission of symptoms.

Conclusion - Early identification and intervention of OSA in children are crucial to preventing long-term health consequences. Orthodontic treatments such as RME, Mandibular Advancement Appliances and myofunctional approach remains the gold standard to ensure optimal outcomes in growing children affected by OSA.

Orthodontists, as integral members of care team, contribute both diagnostic insights and therapeutic options, particularly in patients with craniofacial abnormalities. The importance of multi-disciplinary evaluation & management for improved outcomes in conditions like Pierre-Robin syndrome, down syndrome, cerebral palsy, severe mental insufficiency. Effectiveness of treatments like tonsillectomy & adenoidectomy in children with OSA considering its impact on health, behaviour & quality of life. [27]

Future Directions

Future research is needed to refine treatment protocols, optimize orthodontic interventions and develop personalized approaches based on craniofacial and genetic risk factors.

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Digital Dentistry: An Evolution in Modern Dental Care – A Review

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Abstract

Background: The integration of advanced technologies such as intraoral scanners, CAD/CAM systems, 3D printing, and artificial intelligence (AI) has significantly transformed traditional dental practices. These innovations enhance diagnostic accuracy, procedural efficiency, and patient satisfaction across various dental specialties.

Objective : This review outlines the evolving role of digital dentistry in clinical practice, highlighting its multi-disciplinary applications, advantages, and current limitations.

Methods: A comprehensive review of contemporary literature was undertaken to explore the use of digital technologies in prosthodontics, oral and maxillofacial surgery, orthodontics, pediatric dentistry, and public health dentistry.

Results: Digital workflows have improved the precision and predictability of restorative and surgical outcomes. In prosthodontics, tools like digital smile design and intraoral scanning enhance implant planning and prosthesis fabrication. Robotic-assisted surgeries offer improved implant placement accuracy in oral surgery. In orthodontics, AI facilitates automated cephalometric analysis and treatment planning. Digital platforms also contribute to patient education and remote care through teledentistry. Despite these advancements, barriers such as high costs, the need for specialized training, and interoperability issues persist.

Conclusion: Digital dentistry represents a major advancement in modern dental care, offering enhanced clinical accuracy, efficiency, and patient engagement. Addressing the challenges of implementation is essential for broader adoption and long-term integration into routine dental practice.

Keywords: Digital dentistry, CAD/CAM, intraoral scanners, 3D printing, artificial intelligence, teledentistry, clinical efficiency, multi-disciplinary applications.

Introduction

Digital dentistry has revolutionized traditional practices with advanced technologies like intraoral scanners, CAD/CAM, 3D printing, and AI. These innovations enhance precision, efficiency, and patient comfort. Digital imaging, such as CBCT, provides highly detailed diagnostics, while CAD/CAM enables same-day restorations. Digital dentures offer improved accuracy, faster production, and eco-friendliness by reducing waste. Overall, digital dentistry streamlines procedures and enhances treatment outcomes [(1)].

Digital dentistry enhances precision and accuracy in diagnosis, treatment planning, and execution through advanced imaging and computerized systems. These technologies allow for meticulous assessments and customized treatments, leading to improved patient outcomes. Additionally, digital tools streamline workflows by reducing the time required for procedures like dental impressions and restorations, optimizing both time and resources while enhancing the overall patient experience[(2)].

Moreover, digital dentistry improves patient engagement by using visual aids and interactive treatment planning, helping patients better understand their options and actively participate in decision making. The integration of digital technologies has also expanded treatment possibilities, enabling advancements in prosthetics, dental imp-

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lants, and orthodontics. These innovations provide more personalized, efficient, and aesthetically pleasing results, transforming restorative and cosmetic dentistry[3].

Digital dentistry is utilized across multiple fields within dentistry, and this review article explores its applications in different dental specialties, along with the role of artificial intelligence in dental care.

Applications of Digital Dentistry

A. Prosthodontics

1. **Digital Smile Design:** Digital dentistry plays a crucial role in smile designing by enhancing precision, efficiency, and customization. Advanced technologies such as digital imaging, CAD/CAM, and 3D printing allow for accurate assessment and virtual simulations of smile transformations. Digital smile design (DSD) enables dentists to create personalized treatment plans, ensuring aesthetically pleasing and functional results. Patients can visualize their expected outcomes before treatment, improving communication and satisfaction. By streamlining procedures and reducing errors, digital dentistry enhances the predictability and success of smile makeovers[4].
2. Intraoral scanners (IOS) play a crucial role in digital implant impressions in prosthodontics, with accuracy influenced by both patient and operator associated factors. Patient related variables include the number and position of implants, inter-implant distance, angulation, and arch location (maxillary or mandibular). Studies indicate that an increased number of implants and greater interimplant distances may reduce accuracy, while the arch and implant position (anterior vs. posterior) also affect results. Posterior implants are more challenging to scan due to limited accessibility. The depth of implant placement and supramucosal height of the scan body have shown mixed effects on accuracy. Operator dependent factors such as IOS hardware, software, scanning patterns, lighting conditions, and operator experience also contribute. Various IOS models differ in precision, with some demonstrating superior accuracy over others. Additionally, scan body characteristics, splinting techniques, and artificial landmarks influence the accuracy of impressions, particularly in edentulous cases[5].

Bite registration accuracy is another critical aspect of digital workflows in implant prosthodontics. Factors such as defect size, location, and the scanning strategy play essential roles in determining the precision of virtual occlusal records. Studies suggest that digital bite registration is generally more accurate than traditional methods, with bilateral posterior occlusal scans recommended over single anterior scans for full-arch cases. Maxillomandibular relationship accuracy can be affected by occlusal collisions, bite force variations, and software correction algorithms. Intraoral scanning systems with static and dynamic occlusion scanning capabilities, such as Trios 3Shape and Medit Mandibular Movement, are still in their early clinical stages, with limited research on their effectiveness. Despite challenges, intraoral scanners continue to advance, offering enhanced accuracy and efficiency in digital implant impressions and bite registration, ultimately improving outcomes in prosthodontic treatments[6].

3. Digital dentistry has revolutionized the fabrication of obturator prostheses for maxillectomy patients, offering a more efficient and patient friendly alternative to conventional methods. Traditional impression techniques are often uncomfortable, technique sensitive, and prone to complications such as allergic reactions, infections, or the need for repeated impressions due to damaged models. Digital techniques, including intraoral scanning, 3D printing, and CAD/CAM technology, provide precise, lightweight, and bio-compatible obturators while minimizing patient discomfort and treatment time. Studies have shown that digital workflows enhance dimensional accuracy, improve prosthetic fit, and eliminate the need for invasive procedures, making them a viable option even for patients with restricted mouth opening or healing defects[7].
4. Digital dentistry enhances RPD fabrication by improving accuracy and efficiency. Fit accuracy is assessed using silicone-based evaluation and digital superimposition, but no standard method exists. Traditional techniques, like visual inspection, have limitations, while digital methods such as CAD/CAM, SLM, and micro-CT offer greater precision. Studies show resin milling, especially with PEEK, provides superior accuracy, though clinical validation is limited. SLM improves fit but isn't always superior to casting. Advanced surface matching using STL files shows potential but needs refinement. Further research is needed to optimize digital workflows, standardize assessments, and validate clinical outcomes[8].

B. Oral and Maxillofacial Surgery

1. **Robot assisted implant surgery:** Dental implant robots are classified into active, passive, and semi-active systems based on the level of human involvement. Active robots, like YekeBot, perform implant placement autonomously, while passive robots, such as Yomi and DentRobot, require surgeon guidance. Semi-active systems, like Remebot, combine automation with manual control. Advanced technologies, such as r-CAIS, integrate robotic assistance with task autonomy, allowing precise implant placement under surgeon supervision. Notable robots, including YekeBot, r-CAIS, Yomi, DentRobot, and Remebot, utilize robotic arms and optical tracking to enhance implant accuracy. These systems reduce human error, improve efficiency, and ensure better patient outcomes, making robotic assisted dental surgery a promising innovation in implantology[9].
2. Digital impressions offer a promising alternative for infants with cleft lip and palate (CLP), improving accuracy, efficiency, and parental experience. They eliminate airway risks associated with conventional impressions and provide better morphology capture without displacement. However,

challenges include difficulty in scanning deep cleft defects due to limited mouth opening and scanner bulkiness. Operators prefer digital impressions despite issues like infant movement and excessive salivation. Parents favor them for their non-invasive nature, though their impact on treatment related stress remains under explored. Further research is needed to optimize scanning techniques, assess scanner accuracy, and enhance overall treatment outcomes for CLP patients [10].

C. Orthodontics

1. Analysis of Lateral Cephalograms

One of the key applications of digital dentistry in orthodontics is the automated analysis of lateral cephalograms. Traditionally, orthodontists manually identify cephalometric landmarks to evaluate skeletal and dental relationships. However, artificial intelligence (AI) and machine learning algorithms have significantly improved landmark detection accuracy. Modern AI-based systems can detect cephalometric landmarks with high precision, reducing human error and enhancing treatment planning. Despite these advancements, variations in AI models and the need for standardized evaluation metrics remain challenges in achieving universal applicability in clinical practice [5].

2. Orthodontic Treatment Need and Contraindication Detection

Digital dentistry also facilitates the assessment of orthodontic treatment needs and the detection of contraindications. AI-driven software can analyze digital models and intraoral scans to assess tooth alignment and occlusal discrepancies. Additionally, AI can identify factors such as periodontal disease or dental caries, which may impact orthodontic treatment success. Automated analysis of these factors enhances diagnostic accuracy and helps clinicians develop personalized treatment plans. However, challenges such as variability in clinical decision making and data generalizability require further refinement of AI applications for widespread clinical integration [12].

C. Pedodontics

Digital technology has become a key component of modern dentistry, with artificial intelligence (AI) enabling a range of automated procedures. Among these advancements, 3D printing has seen widespread adoption across various dental disciplines, including oral and maxillofacial surgery, prosthodontics, and orthodontics. However, its utilization in pediatric dentistry remains limited and warrants further exploration. Pediatric patients often experience dental anxiety, making it essential to develop efficient and minimally invasive techniques. 3D printing offers precise, patient friendly solutions that can help streamline pediatric dental procedures while reducing chair side time [13].

D. Public Health Dentistry

1. Digital dentistry enhances patient communication and health education by using advanced imaging and planning tools to visually explain dental conditions and treatment options. This improves patient understanding, engagement, and informed decision making. Real time digital simulations help patients visualize expected outcomes, reducing anxiety and increasing compliance. Additionally, digital platforms facilitate remote consultations and personalized education, making dental care more accessible. Improved communication fosters stronger dentist patient relationships, leading to better treatment adherence and overall oral health. By integrating digital tools, dental professionals can enhance patient education, ensuring more transparent discussions and improved awareness of preventive and therapeutic dental care [1].
2. Teledentistry, enabled by digital advancements, allows dentists to remotely consult with patients, provide follow-up care, and offer guidance through video conferencing and other digital communication tools. This technology enhances accessibility, improves patient convenience, and facilitates timely dental care without requiring in person visits [14].

Advantages

Digital dentistry offers numerous advantages, significantly improving the patient experience by minimizing discomfort, reducing treatment time, and allowing personalized care. Advanced diagnostic tools like CBCT and intraoral scanners enhance early detection and treatment planning, leading to better outcomes. CAD/CAM technology enables the creation of customized restorations and prosthetics tailored to individual needs. Additionally, digital workflows streamline procedures, reducing chair time, minimizing appointments, and optimizing resources, ultimately increasing both efficiency and profitability for dental practices [15].

Limitations

Despite its benefits, digital dentistry has limitations, including high initial investment costs for equipment, software, and training. Financial constraints and the need for continuous skill development can be challenges for adoption. Integrating multiple digital systems requires careful planning to ensure smooth interoperability. Furthermore, dependence on technology makes dental practices vulnerable to software malfunctions, system failures, and compatibility issues, potentially disrupting workflows and impacting patient care. Addressing these challenges is essential to maximizing the benefits of digital dentistry while minimizing operational risks [16].

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From Gap To Glam: Single-shade Composite For Effortless Smile Makeovers - A Case Series

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Abstract

The pursuit of aesthetic excellence in restorative dentistry has led to significant advancements in composite resin technology. One of the most revolutionary developments in recent years is the introduction of single shade universal composites, such as Omnichroma. These innovative materials are engineered with smart chromatic technology that allows them to blend seamlessly with a wide range of natural tooth shades, eliminating the need for shade matching. The unique optical properties of Omnichroma, based on structural color rather than pigments, enable it to mimic the surrounding tooth structure with remarkable precision. This case series highlight the monochromatic composite for estheic rehabilitation in various anterior restorations, emphasizing its excellent shade-matching ability, ease of handling, and superior aesthetic outcomes. Each case highlights the material's versatility and its ability to harmonize with different tooth shades without the need for multiple composite shades. The results demonstrate that single shade composites offer a simplified, time efficient, and highly aesthetic solution for modern restorative procedures, reinforcing their growing role in everyday clinical practice.

Keywords: Aesthetic, Omnichroma, single shade composite, Restorative procedures.

Introduction

Aesthetic dentistry has emerged as a cornerstone of modern dental practice, driven by the increasing patient demand for natural looking, conservative, and long-lasting restorations. The anterior region, often referred to as the "aesthetic zone," plays a critical role in facial appearance, smile harmony, and overall self-confidence. Even minor imperfections such as diastemas, peg laterals, discolorations, or fractures can significantly impact a patient's aesthetic perception and social confidence [1].

Direct composite restorations have become a preferred choice in aesthetic cases due to their conservative nature, ease of repair, minimal chair time, and excellent optical properties [2].

Traditionally, these restorations required careful shade selection from a wide range of composite shades to match the natural dentition a step that could be time consuming and technique sensitive [3].

The introduction of single shade universal composites Omnichorma (Tokuyama Dental, Tokyo, Japan) has simplified this process by utilizing smart chromatic technology, which allows the composite material to blend seamlessly with the surrounding tooth structure regardless of shade variations. These materials rely on structural color rather than traditional pigments, enabling them to adapt to a wide range of natural tooth shades using a single material [4,5]. This innovation not only reduces the need for multiple shades in inventory but also minimizes clinical errors related to mismatched shades [6].

This case series presents the clinical application of a single shade composite Omnichroma (Tokuyama Dental, Tokyo, Japan) resin in managing various aesthetic challenges in the anterior region. Each case highlights the versatility, efficiency, and aesthetic outcomes achieved using this material in daily dental practice [7].

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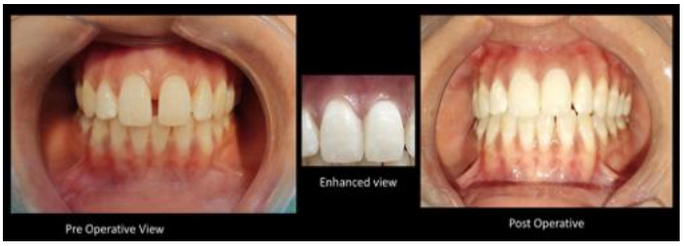
Case Report

Case 1: Midline Diastema Closure

A 22-year old female patient with the chief complaint of a noticeable gap between her upper front teeth. She expressed a desire for an aesthetic solution to close the midline diastema and improve her smile. Clinical examination revealed a 1.5 mm space between the maxillary central incisors (teeth #11 and #21), with healthy gingiva, normal occlusion, and no caries or structural defects. Radiographic evaluation showed normal periapical findings, and no underlying pathology was detected. Given the patient's young age and preference for a conservative, non invasive approach, a direct composite build-up using a single shade universal composite Omnichroma(Tokuyama Dental, Tokyo, Japan) was planned.



Case 1: Midline Diastema Closure

Case 2: Class III Lesion With Single Shade Composite

A 24-year old male patient with the chief complaint of a broken tooth and frequent food lodgment in the affected area. He stated that the tooth had fractured a few weeks ago while eating, and since then, he experienced discomfort during mastication and occasional sensitivity. Clinical examination revealed a fractured disto-proximal surface of the maxillary front region (tooth #12) with carious involvement extending into the dentin. Food debris was found impacted in the area, indicating open contact with the adjacent tooth. The tooth was tender on vertical percussion, but there were no signs of swelling or sinus tract. Radiographic evaluation showed a radiolucent lesion in the distal aspect of the tooth involving dentin but not reaching the pulp, with normal periapical tissues. The diagnosis was a Class III carious lesion with proximal fracture and open contact leading to food impaction. Treatment involved conservative cavity preparation under rubber dam isolation. After caries excavation, the cavity was restored with a single shade composite resin Omnichroma (Tokuyama Dental, Tokyo, Japan) composite resin using a sectional matrix system to restore proper proximal contact and contour.

Case 2: Class III Lesion With Single Shade Composite

Case 3: Spacing in Anterior Region

A 25-year old female patient with the chief complaint of a visible gap between her upper front teeth region. She was concerned about the appearance of her smile and expressed a desire to have the spaces closed for aesthetic improvement. Minor spacing between lateral incisors and Central incisors . The gingival health was satisfactory, and the teeth showed no signs of caries, trauma, or structural anomalies. Radiographic evaluation confirmed normal bone levels and no pathological findings. After discussing treatment options, including orthodontics and veneers, the patient opted for a conservative and immediate solution through direct composite restorations. A single shade universal composite resin Omnichroma (Tokuyama Dental, Tokyo, Japan) was selected due to its excellent blending capabilities and natural finish.

Case 3: Spacing in Anterior Region

Case 4: Ellis Class II Fracture

A 27-year old male patient with the chief complaint of a fractured front tooth and requested an aesthetic correction. The patient gave a history of trauma a few days ago, following which he noticed a visible fracture and mild sensitivity while consuming cold foods. Clinical examination revealed an Ellis Class II fracture involving the incisal edge and labial surface of the maxillary left central incisor (tooth #21), with no pulp exposure. The tooth was vital, with no discoloration or mobility, and adjacent teeth appeared normal. Radiographic evaluation confirmed the absence of periapical pathology or pulpal involvement. A single shade universal composite resin Omnichroma(Tokuyama Dental, Tokyo, Japan) was selected due to its excellent blending capabilities and natural finish.

Case 4: Ellis Class II Fracture

Clinical Procedure

Rubber dam isolation was carried out to ensure proper moisture control throughout the procedure. Tooth preparation began by placing a shallow bevel on the enamel using a diamond bur to create a smooth transition for the restoration. The prepared

surface was then etched with 37% phosphoric acid for 15 seconds, thoroughly rinsed with water, and gently air dried to achieve a frosty enamel appearance. A universal adhesive (Palfique Universal bond (Tokuyama, Japan) was applied uniformly to the etched surface and light cured according to manufacturer instructions to ensure optimal bond strength. For the composite build up, a mylar strip was positioned to help establish the proximal contour and prevent overhangs. A single shade composite resin was placed incrementally, with each layer sculpted to approximate natural tooth anatomy and light cured for 20 seconds. Finishing was accomplished using diamond finishing burs to shape the restoration accurately, followed by progressive polishing with discs(Shofu INC, Japan) and for proximal contouring proximal strip(Shofu INC, Japan) was used to enhance the surface smoothness. A final high gloss polish done with platina Hi- Gloss (Prevest denpro, India) was achieved using silicone based polishers, resulting in a seamless, natural looking restoration.

A. Omnochroma (Tokuyama Dental, Tokyo, Japan), B. Universal adhesive (Palfique Universal bond (Tokuyama, Japan)

Discussion

The demand for aesthetic restorations has grown substantially in recent years, with patients increasingly seeking treatments that are both visually appealing and minimally invasive. Direct composite resins have been the material of choice for such restorations, especially in the anterior region, owing to their conservative approach, cost effectiveness, and reparability [8].

However, the traditional multi-shade composite systems often require detailed shade matching, layering techniques, and artistic skill to mimic the natural dentition accurately. This complexity can introduce inconsistencies in shade matching and increase clinical chair time [9].

Single shade composites, based on smart chromatic or structural color technology, have significantly simplified this process. These materials do not rely on pigment based matching; instead, they interact with the surrounding tooth structure and ambient light to generate the appropriate shade through a phenomenon known as structural color [10,11]. As a result, they exhibit remarkable chameleon like properties, enabling them to blend seamlessly with various enamel shades across a wide range of patients [11].

In this case series, single shade composite resin was used to manage four different anterior aesthetic challenges: diastema closure, Class IV fracture, and general anterior space management. In all cases, the material adapted well to the surrounding dentition without the need for complex layering or multiple shades. The ease of use allowed for efficient workflow and reduced appointment time, while the aesthetic results met both clinician and patient expectations.

Clinical outcomes demonstrated the versatility of single shade composites in terms of shade adaptability, anatomical sculptability, and polishability [12]. Additionally, the material showed good marginal integrity and surface smoothness, which are essential for long-term color stability and resistance to plaque accumulation [13]. These advantages make single shade composites an excellent choice for practitioners aiming to deliver high quality aesthetic restorations with simplified protocols.

However, certain limitations must be acknowledged. These materials may have reduced effectiveness in masking underlying dark dentin or in cases of severe tooth discoloration, where opaque or multi-shade systems may still be required [11]. Furthermore, proper case selection, finishing, and polishing are critical for achieving optimal optical blending and longevity of the restoration.

Conclusion

Single shade composites offer a promising alternative to traditional multi-shade systems by combining ease of application with excellent aesthetic outcomes. Their ability to adapt to various tooth shades simplifies the restorative process and enhances clinical efficiency. With proper technique and case selection, single-shade composites can serve as a reliable tool in modern aesthetic dentistry.

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Assessment of Color Changes on Composite Resins, GIC and Tooth Under the Influence of CHX, CHX with ADS, Octinidine and Oil Pulling Mouth Rinses: An In Vitro Study

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Abstract

Background - Restorative dentistry has seen remarkable progress due to advancements in dental materials. The field is benefiting from the development of materials that offer improved aesthetics, durability, and bio-compatibility. Innovations such as resin based composites, ceramic materials, and bio-active substances are not only enhancing the functionality of restorations but also contributing to minimally invasive procedures and longer lasting results.

Aim - The aim of this study was to evaluate and compare the effect of various mouth rinses on Composite resin, GIC and natural teeth using UV Spectrophotometer: An in vitro study.

Material and Method - A total of 36 composite specimens comprising nanohybrid composite disks of size 10-mm diameter and 0.5-mm thickness were prepared on a customized model for standardization using the composite filling instrument. The specimens were cured with light curing unit for 20 s and polished with a composite polishing kit and a total of 36 GIC specimens comprising zirconomer disks of size 10-mm diameter and 0.5-mm thickness were prepared on a customized model for standardization using the GDC filling instrument. A total of 36 extracted human premolar teeth for periodontal and orthodontic purposes were selected for the study. Four mouthrinses comprising CHX and CHX with ADS, orahex pro and oil pulling were used. Baseline color values of natural tooth, composite resins and GIC were recorded using an ultraviolet spectrophotometer. After baseline spectrophotometric measurements, all the samples were subjected to the mouth rinses. The post immersion color values of the samples were then recorded, respectively, using the same spectrophotometer.

Statical Analysis :- The statistical analysis was done using One way ANOVA and paired t-test.

Results :- Reflectance values showed a statistically significant difference between CHX, CHX with ADS, Orahex pro and Oil pulling among Composite resin, GIC, natural teeth.

Conclusion:- Within the limitations of the current study, CHX with ADS and Orahex pro may aid in avoiding stains, thereby making it more acceptable for patients.

Introduction

Restorative dentistry has seen remarkable progress due to advancements in dental materials. The field is benefiting from the development of materials that offer improved aesthetics, durability, and bio-compatibility. Innovations such as resin based composites, ceramic materials, and bioactive substances are not only enhancing the functionality of restorations but also contributing to minimally invasive procedures and longer lasting results[1].

Over the years, patient demand for natural looking restorations has driven the increased use of resin composites in restorative dentistry[2].

Composite resin has become a cornerstone in restorative dentistry for both anterior and posterior teeth due to several reasons like enhanced physical properties, adhesive properties, versatility and minimally invasive property. Composite resins are highly valued for their ability to replicate the natural color and shade of teeth, making them the material of choice for esthetically pleasing dental restorations. This capability is attributed to several key factors like shade matching system, translucency, opalescence, customizable aesthetics and stain resistance. This aesthetic versatility has revolutionized the

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approach to restorative dentistry, allowing for functional repairs that are virtually indistinguishable from natural teeth[3].

Nanohybrid composites have become a preferred choice in restorative dentistry consisting of milled glass fillers that acts as dispersed phase which provides better mechanical strength and surface finish as compared to hybrid composites[3].

Zirconia reinforced glass ionomer cement (Zr-GIC) restorations have demonstrated significantly higher strength compared to conventional and silver reinforced GICs, particularly when used in stress bearing areas. This improvement is attributed to Zirconia's exceptional mechanical properties, which enhance the overall durability and fracture resistance of the cement.

Additionally, Zirconia reinforced GICs maintain better esthetics compared to silver reinforced counterparts, making them a preferred choice for visible restorations that require both strength and visual appeal. Unlike other additives, Zirconia does not dissolve with prolonged soaking time, ensuring the integrity and longevity of the material.

Despite Zirconia based GIC'S growing popularity, tooth-colored restorations are prone to discoloration, particularly from the consumption of colored beverages or the use of mouth washes[12].

Among the available mouthwashes, chlorhexidine gluconate a cationic chlorophenyl bisbiguanide with excellent bacterio-static properties has proven highly effective in reducing dental plaque. Over the years, various formulations of chlorhexidine, including gels, chips, sprays, and mouthwashes, have been developed, with mouthwashes being the most commonly used. In many studies, chlorhexidine serves as a positive control to assess the efficacy of other products, as it is considered the gold standard. However, side effects such as undesirable tooth dis-coloration, an unpleasant taste, dryness, and a burning sensation in the mouth often discourage patients from using this mouthwash[15].

To address the tooth-staining drawback of chlorhexidine (CHX), a CHX formulation with an anti-discoloration system (ADS) was introduced to the market. This innovative mouthrinse combines CHX with ADS to effectively prevent plaque formation while minimizing tooth staining. A key component of this formulation is Plasdone K-29/32, a water-soluble, high molecular weight homopolymer of vinylpyrrolidone, specifically designed as an anti-discoloration agent to reduce staining[1].

OctinidineDihydrochloride (OCT) is a bispyridine derivative, chemically defined as N,N- [1,10-decanediyldi-1(4H)-pyridinyl-4-pylidene] bis(1-octanamine) Dihydrochloride. This novel bipyridine antimicrobial compound has been developed as a potential antimicrobial and antiplaque agent for use in mouthwash formulations. Existing data suggest that a 0.1% OCT mouthrinse may offer significant clinical benefits in reducing plaque accumulation and gingivitis. Several studies have reported that OCT in mouth rinse form effectively inhibits dental plaque and caries in both rats and humans. Additionally, OCT has demonstrated superior prolonged bacterial anti-adhesive activity compared to chlorhexidine[17].

Oil pulling is a traditional Ayurvedic practice originating in ancient India, aimed at maintaining oral health. It is believed to treat over thirty systemic diseases while also offering numerous oral health benefits, including improved gingival health with reduced inflammation and bleeding, relief from symptoms of dry mouth, throat, and chapped lips, whiter teeth, reduced halitosis, enhanced oral hygiene, and the strengthening of muscles and jaws in the oral cavity[18].

Since the color stability of composite and GIC still remains a long term clinical problem, this study was carried out to assess the color changes in teeth, composite resins and GIC under the influence of CHX with and without ADS, Octinidine and oil pulling mouth rinses using a spectrophotometer.

Material and Methods

A total no. of 36 nanoceramic composite samples was prepared. It was comprised 36 each Neospectra ST (Dentsply Sirona) disks of size 10mm and 1mm thickness. Samples were prepared on customized model for standardization using composite filling instruments (GDC). The thickness was confirmed by vernier caliper. The samples were cured with light curing unit (Ivoclar Vivadent) for 20 seconds and polished with composite polishing kit (Shofu).

A total no. 36 GIC samples were prepared. It was comprised 36 Zirconomer (Shofu) disks of size 10mm and 0.5mm thickness. Samples were prepared on customized model for standardization using filling instruments (GDC). The thickness was confirmed by vernier caliper.

36 freshly extracted mandibular premolars teeth for periodontal and orthodontic purposes was collected. Collected teeth were stored, sterilized and handled according to the occupational safety and health administration and the centre of disease control and prevention guidelines[1].OSHA enforces regulations to protect workers from physical hazards, such as falls, machinery accidents, chemical exposure, and other workplace dangers.

The samples which were prepared were immersed in distilled water in separate containers and incubated it at 37^0C for 24 hours. After 24 hours baseline color values of each sample were recorded at 400nm and 700nm by using UV Spectrophotometer.

After baseline color measurement the sample were exposed to respective mouthrinses. Chlorhexidine (Hexidine), Chlorhe-xidine with ADS (Dr. Reddy's), ORAHEX PRO (ABOTT), Pulling oil (DABUR) was used in this study.

Samples were divided into 3 groups for this study. Group 1 (n=36) Nanoceramic composite disks, Group 2 (n=36) Zirconia based GIC, Group 3 (n=36) Natural tooth. Further, each group was divided into 4 sub groups, namely A, B, C and D containing 9 samples each.

Samples under subgroup A from each group were subjected into chlorhexidine, samples under subgroup B from each group were subjected into chlorhexidine with ADS, samples under

subgroup C from each group were subjected into ORAHEX PRO and samples under subgroup D from each group were subjected into pulling oil mouth rinse. Samples from each group were immersed in mouth rinses respectively for 1 minute twice daily till 21 days.

Between the exposure to the mouth rinse, sample were stored in artificial saliva at 37^{0}C. Storage media were changed after every exposure of the sample to the mouth rinse.

Post immersion color values of the sample were recorded respectively by using same UV Spectrophotometer at 400nm and 700nm.

Result

Mean reflectance in Group 1: Subgroup 1 ≈ Subgroup 2 ≈ Subgroup 3 ≈ Subgroup 4

In Group 1, the mean reflectance value using 400 nm wavelength after completing the procedure (i.e., after 21 days) for Subgroup 1 was 1.77±0.11, for Subgroup 2 was 2.57±0.23, for Subgroup 3 was 2.15±0.10, and for Subgroup 4 was 1.31±0.11. There was a significant difference in the reflectance value between the groups, with F value 119.49 and p value 0.001.

In Group 1, the mean reflectance value using 700 nm wavelength after completing the procedure (i.e., after 21 days) for Subgroup 1 was 1.74±0.12, for Subgroup 2 was 2.45±0.16, for Subgroup 3 was 2.32±0.13, and for Subgroup 4 was 1.45±0.10. There was a significant difference in the reflectance value between the groups with an F value of 95.90 and a p value of 0.001.

Mean reflectance in Group 2: Subgroup 1 ≈ Subgroup 2 ≈ Subgroup 3 ≈ Subgroup 4

In Group 2, the mean reflectance value using a 400 nm wavelength after completing the procedure (i.e., after 21 days) for Subgroup 1 was 1.15±0.25, for Subgroup 2 was 1.34±0.25, for Subgroup 3 was 1.30±0.12, and for Subgroup 4 was 0.84±0.27. There was a significant difference in the reflectance values between the groups, with F value 7.17 and p value 0.001.

In Group 2, the mean reflectance value at 700 nm after completing the procedure (i.e., after 21 days) for Subgroup 1 was 0.90±0.24, Subgroup 2 was 1.58±0.07, Subgroup 3 was 1.22±0.13 and Subgroup 4 was 0.67±0.35. There was a significant difference in the reflectance value between the groups with an F value of 27.28 and a p value of 0.001.

Mean reflectance in Group 3: Subgroup 1 ≈ Subgroup 2 ≈ Subgroup 3 ≈ Subgroup 4

In Group 3, the mean reflectance value using 400 nm wavelength after completing the procedure (i.e., after 21 days) for Subgroup 1 was 1.73±0.14, for Subgroup 2 was 2.62±0.34, for Subgroup 3 was 2.35±0.13, and for Subgroup 4 was 1.21±0.14. There was a significant difference in the reflectance value between the groups, with an F value of 81.19 and a p value of 0.001.

In Group 3, the mean reflectance value using 700 nm wavelength after completing the procedure (i.e. after 21 days) for Subgroup 1 was 1.75±0.11, for Subgroup 2 was 2.45±0.30, for Subgroup 3 was 2.27±0.18 and for subgroup 4 was 1.25±0.08. There was a significant difference in reflectance values between the groups with an F value of 71.64and a p value of 0.001.

Mean reflectance of sub groups in all groups was: Subgroup 4 <Subgroup 1<Subgroup 3 <Subgroup 2.

Discussion

Esthetics and appearance play a crucial role in modern dentistry. With the growing emphasis on smile enhancement, patients seek treatments that not only restore function but also improve their overall appearance. An ideal restorative material should closely mimic the natural characteristics of teeth in terms of shade, translucency, and surface texture while maintaining color stability over time. Materials such as composite resins, ceramics, and Zirconia have been widely used in modern dentistry due to their excellent esthetic and functional properties[6].

Evaluating whether a restorative material truly mimics natural teeth is a complex task because multiple optical properties like reflectance, translucency, and transparency interact to create a lifelike appearance[19].

Mouthwashes are medicated solutions formulated for gargling and rinsing to maintain oral hygiene and provide therapeutic benefits[8]. Mouth rinses are commonly used formulations for oral cleansing, especially before dental surgical procedures, as they help reduce microbial load in the oral cavity[20]. However they are known to cause discoloration of teeth and restorations.

In this study we have evaluated the color changes on restorations and natural teeth after exposure to the mouthwashes. Color changes in materials can be evaluated using various instruments, such as spectrophotometers and colorimeters, which provide precise and objective measurements of color stability[21].In this study, a spectrophotometer was used as it is considered more accurate for measuring color changes[1].

Group I

Composite resins have gained widespread popularity in restorative dentistry due to their superior esthetics, cost-effectiveness, and minimally invasive application. Their ability to closely mimic natural tooth structure makes them a preferred material for both anterior and posterior restorations[7].

The clinical performance of dental resin composites has seen remarkable improvements, largely due to the incorporation of nano-fillers. These advancements have enhanced strength, wear resistance, translucency, and overall longevity, making modern composites more reliable and esthetically pleasing. The incorporation of well dispersed inorganic particles into the resin matrix plays a crucial role in enhancing the mechanical, esthetic, and functional properties of composite resins. These fillers improve the overall performance of polymer based restorations by increasing strength, wear resistance, and polishability while reducing polymerization shrinkage. The fillers in dental resins significantly influence their radiopacity, mechanical properties, wear resistance, and elastic modulus, making them a critical component in composite formulations. The type, size, shape, and

distribution of fillers determine how well a composite performs in clinical applications[22]. Previous studies have identified multiple chemical, physical, and environmental factors contributing to color changes in resin composites over time. These factors affect the resin matrix, filler properties, and overall composite stability, leading to discoloration[23].

Staining and discoloration are among the most common reasons for replacing tooth colored restorative materials, particularly composite resins. Discoloration can be classified into intrinsic and extrinsic causes, both of which affect the longevity and esthetic quality of restorations. Intrinsic discoloration can occur due to aging of material itself, like alteration of the resin matrix and changes in the interface of matrix and fillers. Extrinsic discoloration may occur due to adsorption or absorption of colorants from exogenous sources such as coffee, tea, nicotine, beverages, and mouthrinses[9].

Staining susceptibility of resin composites is closely related to water sorption and hydrophilicity of the matrix resin. The ability of a composite to absorb water also makes it prone to absorbing stain inducing substances like tea, coffee, red wine, and dyes (e.g., Methylene blue). The glass filler particles will not absorb water in the bulk of the material, but, they can absorb water onto the surface. Extra water sorption may decrease the life of the resin composites by expanding and plasticizing the resin component, hydrolyzing the silane and leading to microcrack formation. As a consequence of the high water sorption and solubility of restorative resins, studies have shown that composite restorations may have decreased mechanical properties and reduced longetivity.

The composition of the resin matrix plays a crucial role in determining the water sorption, solubility, hydrophilicity, and microstructure of composite resins, all of which directly impact their long-term color stability. Composites primarily composed of bisphenolAglycidyl methacrylate (Bis-GMA) oligomers tend to exhibit greater hydrophilicity and water sorption compared to those predominantly containing urethane dimethacrylate (UDMA). The incorporation of a small amount of triethylene glycol dimethacrylate (TEGDMA) into a Bis-GMA based resin matrix can significantly enhance the composite's water sorption. This effect arises from the central repeating ethoxy group in TEGDMA, which has a strong affinity for water molecules through hydrogen bonding with oxygen, thereby increasing the surface hydrophilicity of the composite material. Composite resins with elevated water sorption and hydrophilicity are more prone to discoloration, as water absorbed colorants may penetrate the resin matrix. Additionally, the inorganic fillers in composite materials are believed to influence color stability, as their size, type, distribution, and interaction with the resin matrix can affect the adsorption and absorption of colorants.

The adhesion of external colorants to the surface and their penetration into the resin matrix can lead to color changes, ultimately affecting the esthetic quality of the restoration. Surface roughening caused by wear and chemical degradation can affect gloss levels, making the composite more prone to extrinsic staining. In composite resins, insufficient curing and residual unconverted camphorquinone are key factors contributing to discoloration. Nanohybrid composites typically contain milled glass fillers (40 to 50 nm) as the dispersed phase, offering enhanced mechanical strength and a superior surface finish compared to hybrid composites[3].

Resin composites with smaller filler particles, such as nano-hybrid and Nanofilled composites, are generally believed to offer a superior surface finish and gloss, which may contribute to improved color stability over time[26].

Group II

Glass Ionomer Cements (GICs), developed by Wilson and Kent, and are now widely used in clinical dentistry[27].

Glass Ionomer Cement (GIC) is a versatile dental material composed of fluoroaluminosilicateglass powder and polyacrylic acid, commonly used in various dental procedures due to its adhesion to tooth structure, fluoride release, and bio-compatibility[28].

Over the past decade, glass ionomer powder has been reinforced with various nanoparticles, including amorphous materials like hydroxyapatite and metal nanoparticles, to enhance its mechanical properties, bioactivity, and antibacterial effects. A high-strength restorative material, reinforced with Zirconia fillers and known as Zirconomer (white amalgam), has recently emerged as an alternative to glass ionomer cement in dentistry. Zirconia (ZrO_2) is a white crystalline oxide of zirconium[29].

The composition of Zirconomer includes zirconium oxide, glass powder, tartaric acid, polyacrylic acid, and de ionized wateras its liquid component (Silva et al., 2009). The primary component of Zirconia-reinforced GIC is nano-sized Zirconia filler particles, comprising 96.5% to 98.5% of the material. These filler particles are designed to enhance translucency, allowing for a closer resemblance to the natural tooth color[30].

The low pH of certain active preventive agents in mouthwashes can affect restorative resinmaterials by reducing hardness, increasing wear, and compromising color stability over time[8].

Sub-group A

Chlorhexidine was first developed in the 1940s by Imperial Chemical Industries in England. Later, in 1954, Davis et al. conducted a study on polyguanides and discovered that certain bisbiguanides exhibited a broad antimicrobial spectrum[31].

Chlorhexidine is a biguanide compound commonly prescribed by dentists for its strong bactericidal properties and effective anti-plaque action. It works by blocking free acid groups such as sulfates, carboxyl's, and phosphates, preventing bacterial adhesion and co-aggregation. Additionally, chlorhexidine interacts with negatively charged bacterial cell walls, disrupting their adhesion mechanisms. However, this compound is also associated with color instability due to its chromogenic potential, leading to brown staining on teeth, the tongue, and silicate or resin composite restorations. Various staining mechanisms have been

identified, including the degradation of chlorhexidine into parachloraniline, non-enzymatic browning reactions, protein Denaturation with metal sulfide formation, and the precipitation of anionic dietary chromogen by cationic antiseptics[2].

Chlorhexidine is widely regarded as the gold standard agent for chemical plaque control due to its proven clinical efficacy. It exhibits broad spectrum antibacterial activity while maintaining very low toxicity. Additionally, chlorhexidine has a strong affinity for epithelial tissues and mucous membranes, enhancing its effectiveness in oral hygiene applications. The use of chlorhexidine is associated with certain side effects that may impact patient compliance, with the most prominent being its tendency to cause staining[32].

Sub-group B

To combat this disadvantage of chlorhexidine mouthwash, at the beginning of the 2000s in Italy, a patented system called ADS (anti discoloring system) was developed. The ADS system can disrupt the two primary reactions responsible for stain formation: the Maillard reaction and the protein Denaturation process. It aids in reducing the risk of side effects associated with the long-term use of alcohol-based mouthwashes, thereby enhancing patient compliance[33].

CHX with ADS contains the patented ingredient Plasdone K-29/32, a water-soluble, high molecular weight homopolymer of vinylpyrrolidone. It is specifically designed as an anti-discoloration agent, added to CHX to minimize staining. Plasdone K-29/32 functions by binding to stain-causing chemicals, enhancing their solubility, and facilitating stain removal. It is a non oxidative agent, as it is neither peroxide based nor a peroxide generator, and it is also nonabrasive[1].

Recent efforts to reduce these undesirable side effects have led to the addition of sodium metabisulfite and ascorbic acid to chlorhexidine. This combination, known as the Anti-Discoloration System (ADS), significantly minimizes adverse effects while maintaining the mouthwash's antiseptic efficacy[34].

Sub-group C

More recently, OctinidineDihydrochloride, a bispyridinamine, has gained attention as a promising alternative for use in oral antiseptics, offering properties comparable to those of chlorhexidine[35].

OctinidineDihydrochloride (OCT) is a novel antimicrobial cationic surfactant compound developed in the 1980s at the Sterling Winthrop Research Institute in Rensselaer, NY (Al-Doori et al., 2007;Slee & O'Connor, 1983)[36].

OctinidineDihydrochloride (OCT), a bispyridinamine, is a novel antiseptic agent developed in the 1980s. Since 1995, it has been licensed for use as an antiseptic in 20 European countries. Its molecular structure features two active cationic centers separated by a long aliphatic hydrocarbon chain, preventing interaction between them. This unique structure ensures toxicological safety, as it prevents the release of 4-chloraniline[37].

Studies have shown that OctinidineDihydrochloride (OCT) exhibits greater effectiveness than chlorhexidine in providing prolonged bacterial anti-adhesive activity[17].

Sub-group D

Oil pulling traces its origins back to ancient Hindu texts and scriptures. While alternative healing methods like oil pulling warrant further scientific exploration, limited studies have evaluated its oral health benefits. However, existing reports suggest that oil pulling can significantly enhance oral hygiene[38].

Dabur Red Pulling Oil Ayurvedic Mouthwash offers the benefits of Kavala Gandusha Therapy, an ancient Ayurvedic oral detox regimen. This oil-based mouth rinse involves swishing oil in the mouth, helping to protect against diseases of the mouth, teeth, and gums while providing numerous wellness benefits. It effectively kills 99.9% of germs and is enriched with natural oils like Coconut and Sesame, along with Ayurvedic herbs such as Tulsi, Clove, Cinnamon, and Thyme Mint. Developed by Dabur as a proprietary Ayurvedic formulation, it helps prevent gingivitis, plaque, bad breath, bleeding gums, swelling, and infections.

Conclusion

Within the limitations of this study, it can be concluded that composite resin, GIC, and natural tooth structures exhibit significant discoloration, when exposed to Chlorhexidine (Subgroup A) and oil pulling (Subgroup D) mouth rinses for a period of 21 days. To minimize staining associated with these rinses, it would be advisable to prescribe CHX with ADS (Subgroup B) and Orahex Pro (Subgroup C), enhancing patient acceptance and compliance as the sub-groups have not shown discoloration after exposure.

A final aspect of our study that limits its clinical relevance is the fact that in vivo conditions may be challenging due to inherent differences between laboratory settings and real-life oral environments.

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Effect of Autoclave Sterilization on the Cyclic Fatigue Resistance of Dentsply Protaper Next, Mani Jizai, and Twisted Nickel Titanium Endodontic Rotary Files: An In Vitro Study

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Abstract

Introduction: Using nickel titanium (NiTi) rotational endodontic files increased the predictability of chemomechanical cleaning and shaping; however, instrument separation is a possibility and has been mentioned as a complication in the endodontic literature. Cyclic fatigue occurs as a result of repeated bending of the instruments in curved canals that lead to deformation and stress within the instruments, which end up with fracture due to complete tension compression cycles. Sterilization of NiTi files must be ensured before clinical use, with the exception of those that are presterilized. In this study we are comparing the cyclic fatigue resistance of Dentsply Protaper Next rotary files, Mani Jizai NiTi rotary files, and Sybron Endo Twisted rotary files, in a single curved simulated canal before and after autoclave sterilization.

Aim: This study aims to measure and compare the cyclic fatigue resistance of Dentsply Protaper Next rotary files, Mani Jizai rotary files, and Sybron Endo Twisted rotary files in a simulated canal before and after autoclave sterilization.

Materials and Method: 66 NiTi rotary files of the same size, i.e., having a tip diameter of 0.25 mm and constant taper 0.06 were used in this study. The files were distributed into 3 groups, each group having 22 files. Then each group was subdivided into two, sterilized and non-sterilized, subgroups having 11 files each. The files were selected on the basis of their metallurgical properties. The files were distributed as Group A: Dentsply Protaper Next; Group B: Mani Jizai; and Group C: Sybron Endo Twisted rotary files. The files were tested using a stainless steel plate. The number of cycles to fracture was calculated.

Results: It was observed that increased resistance to cyclic fatigue was seen among non-sterilized files as compared to the sterilized files. Mani Jizai files showed significantly higher fracture resistance than the other files used i.e. Dentsply Protaper Next and Sybron Endo Twisted files.

Conclusion: The study provides valuable insights into the selection of NiTi files, their metallurgical properties, and importance of sterilization. As the effect of clinical use was not evaluated in this study, further clinical investigations should be performed.

Introduction

The use of nickel titanium (NiTi) rotary endodontic files improved the predictability of mechanical cleaning and shaping; inspite of this, instrument separation is a possibility and has been mentioned as a complication in the endodontic literature.[1]

These instruments offer remarkable advancements, such as improved flexibility, increased resistance to torsional stress, and an overall enhancement in performance.[2]

Despite the exceptional properties of NiTi instruments, they still can be separated due to cyclic or flexural fatigue. Cyclic fatigue occurs due to repeated bending of the instruments in curved canals that lead to deformation and stress within the instruments, which ultimately results in fracture due to complete tension compression cycles.[3]

Many factors influence cyclic fatigue: the curvature of the canal, instrument dimensions, their design, and manufacturing process.[4]

The distinctive characteristics of NiTi alloy such as super elasticity and shape memory are greatly influenced by the

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manufacturing procedure of the file.[5]

When files are used repeatedly under clinical conditions, it requires autoclave sterilization after every use. Prearranged collections of chosen files are not permitted for use during the same appointment. Consequently, the unused rotary files are also subjected to multiple autoclave cycles.[6]

Numerous advancements in contemporary manufacturing methods, such as thermal and surface treatments, have been achieved. A particularly innovative NiTi alloy known as M-wire, which was introduced in 2007 by Dentsply, Tulsa, Oklahoma, USA, was created utilizing these advanced manufacturing techniques. Its enhancement in flexibility and cyclic fatigue resistance is due to the unique nanocrystalline martensitic microstructure of the treated alloy.[7]Dentsply protaper next rotary files comes under M-wire technology.

Twisted File (TF) represents a category of NiTi rotary files created by Sybron Endo (Orange, California). Introduced in 2008, this file was produced using an innovative manufacturing process that incorporates three novel techniques: heat treatment (R-phase), the twisting of the metal wire, and specialized surface conditioning.[8]

NiTi rotary instruments made from a NiTi controlled memory wire or CM wire (DS Dental, Johnson City, TN) was introduced.[9] It was introduced in 2010. A novel file system named Jizai (Mani Inc., Tochigi, Japan) has been introduced, offering attributes such as enhanced strength and flexibility that minimizes canal transportation. It is designed to instrument straight and slightly curved canals.[10]

In this study we are comparing the cyclic fatigue resistance of Dentsply Protaper Next rotary files, Mani Jizai NiTi rotary files, and Sybron Endo Twisted rotary files, in a single curved simulated canal before and after autoclave sterilization.

Materials and Method

66 nickel titanium rotary files of the same size having tip diameter 0.25 mm and constant taper of 0.06 were used in this study. The files were distributed into 3 groups (22 for each group), Group A: Dentsply Protaper Next; Group B: Mani Jizai; and Group C: Sybron Endo Twisted rotary files. Then each group was subdivided into 2, sterilized and non sterilized, subgroups (11 for each group). For the sterilized instruments, three cycles of sterilization was used. Autoclave (GDP Enclave B-Class, Dibya Industries, India) was used for the sterilization. Each cycle lasted 35 minutes at a temperature of 134^0C. A specially designed artificial canal was used for testing cyclic fatigue. It had an angle of curvature of $60^0$with a radius of 5 mm. It had a curvature center at 5 mm from the canal end, and the length of the curve of 5.25 mm. A stainless steel plate was utilized to shape the artificial canal. It had a working length of 18 mm and an inner diameter of 1.5 mm. A stereomicroscope was used to examine the instruments for any signs of deformation that would lead to their exclusion. The speed and torque of the endomotor (Dentsply X-SMART) was used following the manufacturer's instructions. In order to keep the endomotor in its position, it was secured to a surveyor during the procedure. The files were rotated until separation was observed. A fracture was discovered, and the time taken from the beginning of file rotation to the point of separation was noted in minutes. By multiplying the recorded duration by the motor's speed, we could determine the cycle count at which each instrument ultimately fractured. The length of each broken fragment from the files was assessed using a vernier caliper.

Fig: Stainless Steel Plate with Artificial Canal

Fig: Endomotor secured to a Surveyor during Procedure

Results

Increased resistance to cyclic fatigue was seen among non-sterilized files as compared to the sterilized files. Mani Jizai files showed significantly higher fracture resistance than the other files, i.e. Dentsply Protaper Next and Sybron Endo Twisted files.

Discussion

The introduction of rotary instruments composed of nickel-titanium (Ni-Ti) alloy was a turning point in modern endodontics.[11] Buehler created the nickel-titanium (NiTi) intermetallic alloy at the beginning of the 1960s. Nitinol, an abbreviation referring to its composition (Ni stands for nickel, Ti for titanium, and Nol for the Naval Ordinance Laboratory where it was invented), is another name for the NiTi alloy. In 1988, Walia produced size 15 hand files using nitinol orthodontic wire, publishing the first study on the flexibility, resistance, and cutting capacity of new files in NiTi in the field of endodontics. The endodontic market thereafter saw the commercial proposal of various instrument types in the 1990s.

The NiTi alloy has 3 distinct, temperature dependent, microstructural phases: Austenite, Martensite, and R-phase.[12]

Austenite is a high temperature phase. This phase exhibits superelastic mechanical characteristics and demonstrates minimal plastic deformation.[13] In this phase, the metal exhibits

increased rigidity. The conventional NiTi alloy predominantly exists in the austenite phase at room temperature. Instruments made from austenitic materials exhibit restricted flexibility and exhibit a low tolerance to fatigue.[12]

Manufacturers employ a particular thermomechanical process to create soft and ductile instruments that can be easily deformed, leading to the production of a NiTi alloy predominantly featuring a stable martensite phase. These modifications enhance the physical properties of the rotating NiTi files, resulting in increased efficiency in dentin cutting and improved fracture resistance.[12]

R-phase is produced through a 2 stage grinding process followed by twisting. It serves as an intermediate phase between austenite and martensite.

The innovative M-wire technology is employed to manufacture instruments that exhibit exceptional elasticity. This method involves subjecting the NiTi wire to multiple heat treatments throughout the manufacturing process. Dentsply Protaper Next rotary files are obtained through M-wire technology.[14] Protaper Next represents an innovative collection of rotary instruments characterized by their variable tapers and an off-centered rectangular cross-section.[15]

New NiTi instruments, developed through specialized thermomechanical processes, can change to a martensite phase when used clinically, by being able to control the memory of the file. This characteristic, referred to as "Control Memory," enhances their flexibility and increases their resistance to fracture.[16]Mani Jizai instruments feature a distinctive asymmetrical cross-sectional design, resulting in an offset mass of rotation.[17]

An additional development in the production process of NiTi alloy is the R-Phase technology.[18] Sybron Endo Twisted Files are produced using this technology. The manufacturing process involves two rounds of grinding, which are subsequently followed by a twisting procedure.[19]

In the current investigation, the sterilized instruments exhibited a diminished cyclic fatigue resistance compared to their non-sterilized counterparts. This finding suggests that the autoclaving process leads to a notable decrease in cyclic fatigue resistance, likely due to the elevated temperature and pressure involved, which may alter the metallurgical properties and subsequently impact the integrity and flexibility of the file. Additionally, the autoclaving cycles enhanced the depth of surface irregularities on the file, which serve as sites for stress concentration and the initiation of cracks. This would make the instruments more susceptible to fatigue crack propagation, resulting in reduced cutting efficiency and diminished resistance to wear.[1]

In the present study, Mani Jizai displayed a greater number of cycles to fracture among the sterilized and the non-sterilized files. When comparison was done between the Dentsply Protaper Next and the Twisted Files, it was seen that Protaper Next displayed a greater number of cycles to fracture among the sterilized and non-sterilized files.

Within the limitations of this in-vitro study, autoclave sterilization of newer endodontic instruments decreases resistance to cyclic fatigue. Autoclave sterilization significantly decreases the resistance to cyclic fatigue of Mani Jizai, Dentsply Protaper Next, and Twisted files. Cyclic fatigue resistance was higher in Mani Jizai files, as compared to the other files.

Conclusion

Mani Jizai files has a significantly higher cyclic fatigue resistance compared with the Dentsply Protaper Next and Sybron Endo Twisted files. Dentsply Protaper Next is significantly more resistant to fatigue compared with Twisted Files. The cyclic fatigue resistance of non-sterilized files was significantly higher than that of sterilized files.

As this is an in-vitro study, the results cannot be extrapolated to the clinical scenario. In clinical contexts, cyclic as well as torsional stresses act on the files which are affected by numerous clinical factors which cannot be replicated in an in-vitro study. Also, instruments undergo sterilization procedures after use, whereas in the study, the files have been used before sterilization also.

A final aspect of our study that limits its clinical relevance is the fact that the tested files rotated in contact with stainless steel plate which is different from dentin.

As the effect of clinical use was not evaluated in this study, further clinical investigations should be performed to better understand the combined effects of canal instrumentation and autoclaving.

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Comparative Assessment of Role of Modified Triple Antibiotic Paste, Calcium Hydroxide And Curcumin In Pain Reduction During Endodontic Treatment: An In Vivo: Visual Analog Scale Study

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Abstract

Background: The most frequent cause of pain is the existence of bacteria brought on by improper canal disinfection. Therefore, the primary goal of endodontic therapy is to eradicate these microorganisms as completely as possible. Intracanal medications have been recommended as between appointment dressings to eradicate any leftover microorganisms following root canal therapy and lessen tissue inflammation at the periapical level.

Aim- The aim of this study was to evaluate and compare the efficacy of Modified Triple Antibiotic Paste, Calcium Hydroxide & Curcumin as an intracanal medicaments in post operative pain reduction using Visual Analog Scale (VAS).

Material and Method: Sixty four maxillary central incisiors, lateral incisiors or canines with a chief complaint of pain and planned for root canal treatment were randomly selected and were further divided into four groups. Group I (n-16) control group, Group II (n-16) receiving calcium hydroxide, Group III (n-16) receiving triple antibiotic paste and Group IV (n-16) receiving curcumin as an intracanal medicament. Pain was measured using visual analogue scale (VAS). The scores were recorded preoperatively, at 24 hours, till 7th day. The result was tabulated and statistically analysed.

Results: At baseline, the mean score pain for all four groups were in the same range. There was no statistically significant difference between the preoperative mean pain score values. Group III showed the highest pain reduction followed by Group IV, Group II and Group I respectively.

Conclusion: Within the limitation of this study it can be concluded that Modified Triple antibiotic paste showed effective pain control as an intra-canal medicament.

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Introduction

Endodontics is the branch of dentistry that deals with the etiology, prevention, diagnosis and treatment of diseases and injuries affecting the dental pulp and periapical tissues.[1]

The main objective of endodontic treatment is complete cleaning and shaping of canals followed by three dimensional seal with no discomfort to patients. For both patients and clinicians, endodontic origin pain has been a major concern.[2]

Numerous strategies, such as different mechanical instrumentation techniques, irrigation techniques and intracanal medications, have been implemented to decrease the number of bacteria from the root canal system.[3,4,5]

Calcium hydroxide is considered to be the first choice of root canal dressing material. Antimicrobial activity, tissue dissolving capacity, and hard tissue development are few of its biological characteristics.[6]

Enterococcus faecalis is the predominant bacterium in resistant endodontic infections; the addition of calcium hydroxide finds this difficult to overcome.

Triple antibiotic paste (TAP) is the preferred intracanal medication in these situations.TAP, which includes minocycline, metronidazole, and ciprofloxacin, was initially utilized and launched by Hoshino. Clindamycin has been used in place of minocycline because it discolors teeth. These days, this modified triple antibiotic paste (M-TAP) is widely used.[7]

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Since there has been an increase in theincidence of antibiotic overuse & cytotoxic reaction there is growing increase in the use of herbal products.[8-9]

Curcuma longa (CL), a perennial herb and member of the Zingiberaceae (ginger) family, The primary component derived from turmeric roots, curcumin, has anti-inflammatory, anti-bacterial, antioxidant, and anticancer properties. Several authors have used CL as an intracanal medication, pulpotomy medication, or root canal irrigant with encouraging outcomes.[10]

This study evaluate and compare the efficacy of three intracanal medicaments i.e., M-TAP, Calcium hydroxide and curcumin in pain reduction during endodontic treatment in symptomatic irreversible pulpitis using Visual Analog Scale.

Material and Method

In this study total 64 maxillary central incisiors, lateral incisiors or canines were randomly selected from the patients undergoing non surgical root canal treatment in the Department of Conservative Dentistry and Endodontics, at Maharana Pratap College of Dentistry and Research Centre, Gwalior. Written informed consent was taken from each patients who participated in this study.

Inclusion Criteria

- Patient should be more than 18 year of age.
- Patient diagnosed teeth with acute or chronic apical periodontitis with irreversible pulpitis.
- Single rooted teeth i.e. maxillary central incisors, lateral incisors or canines.

Exclusion Criteria

- Patient with periodontally compromised teeth
- Patient teeth with open apex
- Patient teeth with granuloma
- Patient teeth with cyst
- Patient presenting with swelling and abscess in teeth.
- Patient tooth with incomplete root formation
- Patients who are taking analgesic, antibiotic or anti-inflammatory drugs during the 7 days prior to the treatment

Teeth that had acute pain on percussion and palpation but had minimal apical changes on the radiograph, such as periodontal ligament widening or minimal bone resorption in the apical area, were classified as having symptomatic apical periodontitis and were included in the study.

Pre-operative pain score recording using VAS

Thereafter, the patients were given the information about VAS and asked to record their preoperative pain score on VAS. Preoperative pain was recorded, with each patient given pain scale chart (VAS) in order to record his/her pain level before any intervention. The pain was recorded on a scale of 0-10.Pain intensity categorized as-

- No Pain (0)
- Mild Pain (1-3)
- Moderate Pain (4-6)
- Severe Pain (7-10)

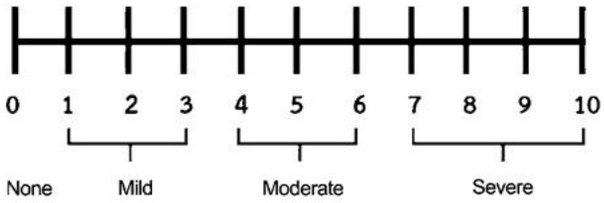

Figure 1: VAS (Visual Analog Scale)

The access cavity was prepared using a high speed endo access bur (Dentsply Maillefer, Tulsa, Oklahoma, USA). The glide path was prepared with stainless steel hand K-files, #06, #08, and #10 (MANI, Tochigi. Japan). Working length was determined by K file (MANI, Tochigi. Japan) using an electronic apex locator (Root ZX mini, J Morita, Tokyo, Japan) at the "0.5" mark then was confirmed with radiovisiography (RVG), to be 0.5–1 mm, shorter than radiographic apex. The root canal preparation was carried out to #20 (0.02 taper) with a hand K-file.The apical portion of the canal was enlarged using K-file to size 3 file larger than the initial apical file and the rest of the canal were prepared using step back technique.

During instrumentation, copious irrigation with 3% NaOCl (Neelkanth Ortho Dent Private Limited, Jodhpur, India) was carried out and the canals were flooded with 17% EDTA (Prime Dental Products Private Limited, Maharashtra, India) for 3 min. post root canal preparation, to remove the inorganic component of the smear layer. 5 mL saline solution was used between NaOCl and EDTA for a more efficient action of the chemical on the tissue.

Following instrumentation & irrigation canals was dried using sterile paper point and Intracanal medicaments was placed into the canal using Lentulospiral (Mani, Inc., Utsunomiya, Tochigi, Japan) and the patients were divided into four groups that are as follows:

- GROUP I (n=16): No intracanal medicament was placed. A dry cotton pellet was be placed (negative control group) and the access opening was sealed with Temporary filling material.
- GROUP II (n=16): The whole length of the Lentulo spiral was coated with the calcium hydroxide paste (Neocal Orikam) and inserted up to 1 mm from working length using low speed handpiece. The procedure was repeated until the paste extruded from the canal orifice indicating adequate fill.

  GROUP III (n=16): M-TAP was prepared by removing the coating of tablets and weighing on a digital machine (ATOM

Selves Enterprises) and crushing the equal amount of Ciprofloxacin (Ciplox 500mg, Cipla, India), Metronidazole (Flagyl 400mg, Abbott, India) & Clindamycin (Dalacin C 300mg, Pfizer Limited) tablets separately using mortar and pestle. M-TAP was mixed in the ratio 1:1:1. A total of 100mg of this modified triple antibiotic mixture will be dispensed and mixed with a drop of propylene glycol and polyethylene glycol (Purenso Global) to get a thick paste like consistency. This paste was inserted into the canal using lentulospiral .

- GROUP IV (n=16): Curcumin gel (Curenext gel Abbott, India) was inserted into the root canal using lentulospiral.

In all medicament groups excess medicaments coronal to the cementoenamel junction were removed with a moist cotton pellet, followed by placement of a sterile dry cotton pellet in the pulp chamber. Subsequently, the cavity was sealed with Temporary filling material. (OraFil-G Prevest Den Pro, Jammu, India) The teeth were ground out of occlusion to prevent pain from occlusal forces and the cycle was repeated as stated above.

Post-operative pain score recording

All study participants were given pain evaluation sheets and instructed to record their pain scores at designated time points i.e. post operatively at 24 h, and then every day till the seventh day. In addition, the operator made a telephonic call to every patient and recorded their post-operative pain scores at designated observation time points. Patients were recalled after 7 days along with the evaluation sheets. At this time, pain scores obtained from the patient and values telephonically recorded by the operator were compared. No oral medication was prescribed to the patient postoperatively unless the pain was severe which required intervention and the patient to be eliminated from the study.

Figure 2: Pre-operative Radiograph

figure 3: Acccess Opening

Figure 4: Working Length Determination

figure 5: Working Length Confirmed Radiographycally

Figure 6: Placement of Intracanal Medicament Using Lentulospiral

Results

The data obtained were subjected to statistical analysis using Statistical Package for the Social Sciences (SPSS Version 26; Chicago Inc., IL, USA). Data comparison was done by applying specific statistical tests to find out the statistical significance of the comparisons.

The pair wise comparison of VAS scores on the 7th day showed statistically significant differences between some groups ($p< 0.05$), indicating that pain relief varied slightly depending on the intra-canal medicament used.

- Group III (M-TAP) and Group IV (curcumin gel) both had complete pain relief, as indicated by the non-significant difference between them ($p = 1.000$, NS), confirming that both medicaments were equally effective in eliminating pain by the 7th day.
- Group I (no medicament) showed significantly higher residual pain compared to all other groups, with mean

differences of 0.56 when compared to Group III (p = 0.000) and Group IV (p = 0.000), reinforcing its inferior pain management.

- Group II (calcium hydroxide) had lower pain levels than Group I, but the difference was only moderately significant (p = 0.031), suggesting a slower but eventual reduction in pain. However, it was not significantly different from M-TAP or curcumin gel (p = 0.492), indicating that by the 7th day, its effect was comparable to the more effective medicaments.

By the 7th day, M-TAP and curcumin gel had completely eliminated pain, confirming their superior efficacy in post-endodontic pain management. Calcium hydroxide also showed effective pain reduction, although its effect was slightly delayed. The control group (no medicament) exhibited the slowest pain resolution, reinforcing the necessity of an intra-canal medicament for effective pain management. These findings further highlight M-TAP and curcumin gel as the most effective intra-canal medicaments for long-term pain relief.

Parameter	Group I (n=16)	Group II (n=16)	Group III (n=16)	Group IV (n=16)	p-value
Age (Mean ± SD)	35.00 ± 9.80	32.12 ± 6.60	32.37 ± 10.07	30.50 ± 7.39	0.527 (NS)
Gender (Male/Female)	8/8	9/7	9/7	8/8	0.969 (NS)
Pre-Operative VAS Score (Mean ± SD)	9.06 ± 1.57	9.06 ± 1.43	9.12 ± 1.45	9.00 ± 1.59	0.997 (NS)

Table 1: Demographic and Baseline Characteristics

Time Interval	Group I (Mean ± SD)	Group II (Mean ± SD)	Group III (Mean ± SD)	Group IV (Mean ± SD)	p-value
24 Hours	8.31 ± 1.19	8.06 ± 1.12	5.87 ± 0.88	7.68 ± 1.25	0.000*
2nd Day	7.00 ± 1.09	6.93 ± 1.06	3.31 ± 0.47	6.00 ± 0.51	0.000*
3rd Day	6.25 ± 0.77	5.50 ± 0.51	1.06 ± 0.85	5.00 ± 0.51	0.000*
4th Day	5.12 ± 0.61	4.12 ± 0.80	0.00 ± 0.00	2.81 ± 0.40	0.000*
5th Day	3.68 ± 0.70	2.62 ± 0.50	0.00 ± 0.00	1.25 ± 0.57	0.000*
6th Day	1.12 ± 0.71	0.50 ± 0.73	0.00 ± 0.00	0.00 ± 0.00	0.000*
7th Day	0.56 ± 0.62	0.18 ± 0.40	0.00 ± 0.00	0.00 ± 0.00	0.000*

Table 2: Comparative Evaluation of VAS Scores Over Time

Discussion

The most painful dental procedure is usually thought to be a root canal treatment. It is challenging to discover whether a single or a combination of factors cause pain in a clinical trial. The host bacteria relationship, microbial interactions, or the presence of clearly pathogenic bacteria prior to treatment may exacerbate a residual infection if a root canal was not debrided correctly.[11]

A medicament an antimicrobial agent is inserted into the root canal in an effort to eradicate any remaining microbes and prevent reinfection. Thus, they can be used to control inflammatory root resorption, eradicate apical exudates, kill bacteria, lessen inflammation, and avoid contamination in between sessions.

VAS ratings were divided into four categories: 0 for no pain, 1–3 for mild pain, 4-6 for moderate pain, and 7–10 for severe pain. This was done to help the patient comprehend the pain scale more precisely and quantitatively.[12]

A study by Prasad et al.[13]evaluated the effectiveness of calcium hydroxide (CH) and triple antibiotic paste (TAP) as an intracanal medicament in pain reduction. This study signifies that patients undergoing endodontic therapy with TAP carry high significant (twice) results in pain reduction with each visits.

According to Swati Pai et al[14]Calcium hydroxide and triple antibiotic paste are effective for managing inter-appointment flare ups in diabetic patients. When it comes to preventing diabetes flare ups, triple antibiotic paste works better than calcium hydroxide.

A study by Mittal R et al[15] compared and evaluated the antibacterial efficacy of calcium hydroxide (CH) paste, triple antibiotic paste (TAP), and double antibiotic paste (DAP) and concluded that TAP and DAP have similar antimicrobial efficacy though better than CH.

Chandwani et al[16] has conducted research to assess and contrast the antibacterial effectiveness of triple antibiotic paste (TAP) with bromelain and calcium hydroxide (CaOH)2 against Enterococcus faecalis bacteria. Bromelain's antibacterial efficacy against E. faecalis was found to be comparable to TAP and more effective than $Ca(OH)_2$ paste

Khan AM et al[17]evaluated the effects of triple antibiotic paste, calcium hydroxide, and chlorhexidine on pain following root canal therapy. Post-operatively, patients were asked to rate their pain on the Wong Baker FACES pain rating scale at 4, 48, 72, and 96 hours. When used as an intracanal medicine on necrotic teeth with apical periodontitis symptoms, triple antibiotic paste demonstrated efficient pain management.

The concern of the TAP is that it may cause bacterial resistance. To overcome this, disadvantage of TAP, Curcumin was introduced.

In vitro studies have compared CL with CH and found its antibacterial efficacy against E. faecalis to be either superior to CH or equivalent to it.[18-19] Prabhakar et al. stated that it is effective in inhibition of E. faecalis. In addition, it has no adverse effect on root dentin microhardness compared to CH.

Upadhyay K[20] et al demonstrated that Turmeric extract has substantial its antibacterial efficacy against all important root canal pathogens.

A study conducted by Eskandarinezhad M et al[21] showed that antibacterial effects of calcium hydroxide, curcumin as an intra-canal medicament on 6-week old Enterococcus faecalis biofilm in which curcumin had the most significant effect, followed by calcium hydroxide.

Within the limitations of this study, it is recommended to use the M-TAP intracanal medicaments in symptomatic apical periodontitis, which could lead to efficient pain relief post-operatively.

Very few studies have been conducted on Curcumin. The antibacterial effect of Curcumin as an intracanal medicament is still unknown. Further clinical trials with large sample sizes, using different vehicles, including multi-rooted teeth, different preoperative diagnoses and evaluation of antibacterial effectiveness are recommended to draw definitive clinical conclusions.

Further in vivo and immunological studies are needed to identify the exact mechanism by which the M-TAP resulted in decreasing postoperative pain and to determine the cytotoxic effect of M-TAP.

Conclusion

M-TAP paste as an intracanal medicament was more effective in pain reduction followed by Curcumin and calcium hydroxide during multi-visit root canal treatment. As this study has a limited observational period, further studies are to be conducted with extended observational periods.

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Zirconia Crowns: Aesthetic Masterpiece of the Restorative World

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Abstract

Background : A healthy smile is vital for proper speech, effective chewing, and plays a key role in enhancing a child's self esteem. Traditionally, crowns have been utilized in cases of extensive caries, following endodontic treatment, or to address decalcification and developmental anomalies. In recent years, zirconia crowns have become a popular choice due to their superior aesthetics, bio-compatibility, and durability.

Case Presentation : A 15-year old female patient reported with the chief complaint of difficulty in chewing in her lower left back tooth region since 10 days. Tooth #36 was endodontically treated one month back and it was restored with fabrication of zirconia crown w.r.t 36.

Conclusion: Zirconia crowns offer strong retention and an appearance that appeals to both children and their parents, though they cost more than other crown types typically used in pediatric dentistry.

Categories: Pediatric dentistry, Prosthodontic rehabilitation

Keywords : Children, zirconia crowns, esthetics

Introduction

Esthetic dentistry represents the blend of both the artistic and scientific aspects of dental care. It encompasses all branches of dentistry. Among the most ancient and widespread dental conditions affecting both children and adults is dental caries. Various behavioral, psychological, and social factors significantly influence its development. Recently, zirconia crowns known for their esthetic appeal have emerged as a promising restorative option in pediatric dentistry, offering an alternative to traditional materials and crowns [1].

Zirconia crowns are a recommended choice for restoring severely damaged teeth, offering excellent esthetic results. These include extensive carious lesions that weaken the tooth structure, large or multiple proximal cavities, tooth reconstruction following pulp therapy, and hypoplastic teeth. Clinically, zirconia crowns are considered effective, with parents generally expressing greater satisfaction compared to other full coverage options. Additionally, zirconia crowns provide excellent biocompatibility, high strength, minimal wear on opposing primary and permanent teeth, reduced risk of gingival irritation in primary teeth, and enhanced durability. However, they cannot be crimped, so the tooth must be carefully shaped to ensure proper crown adaptation [2].

Case Presentation

A 15-year old female patient reported to the department of Pediatric and Preventive Dentistry with the chief complaint of difficulty in chewing in her lower left back tooth region since 10 days [Figure1]. Past dental history underwent root canal treatment w.r.t 36 and past medical history was non-contributory. Radiographic examination revealed endodontically treated tooth w.r.t 36 [Figure 2].Treatment plan was made after considering the mechanical requirements of posterior restorations for withstanding masticatory forces, as well as the esthetic preferences of the patient, monolithic zirconia

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(here after referred to as zirconia) for the restoration of lower left posterior tooth was advised. In the first appointment, the procedure was explained to the parent and the patient.

In the second appointment, local anesthesia was administered prior to the tooth preparation. Preparation steps for the zirconia crown:

Step 1: Marginal design - The margins received 1 mm shoulder preparation, which allowed more precise preparation of zirconia.

Step 2: Preparation of axial walls the preparation had a 6-8° taper starting from the margin to one-third of the occlusal surface. All angles, margins, and sharp edges was rounded.

Step 3: Occlusal surface reduction -The central groove of the occlusal surface was reduced by 1.5-2 mm. This space allowed for creation of the correct anatomy of the occlusal surface [Figure 3].

Impression making and laboratory steps: After tooth preparation, a putty-wash impression was made from the mandibular arch using polyvinyl siloxane impression material. An alginate impression was also made from the maxillary arch, and bite registration wax was used to record the jaw relations. The impressions were sent to a laboratory. The tooth color was determined under natural light with a shade guide (VITA classical A2). Occlusal view of Zirconia crown w.r.t 36 on cast [Figure 4]. Zirconia crown in left side view w.r.t 36 on cast [Figure 5].

Cementation was carried out using Calibra universal self adhesive resin cement (DentsplySirona). The tooth was rinsed and dried. The cement was applied to the internal crown surface, and the crown was seated on the tooth. After 2-3 seconds, the buccal and lingual margins were light cured, and excess cement was removed. The entire crown was then light cured for 20-30 seconds [Figure 6],occlusion was rechecked after cementation [Figure 7-8]. Radiograph of zirconia crown w.r.t 36 [Figure 9].

The patient was recalled after 3 months for follow-up [Figure 10]. The follow-up appointments comprised of reinforcement of oral hygiene instructions, as well as occlusal examination as necessary.

Figure 1: shows pre- operative photograph w.r.t 36

Figure 2: shows pre- operative radiograph w.r.t 36

Figure 3: shows zirconia crown preparation w.r.t 36

Figure 4: shows occlusal view of zirconia crown w.r.t 36 on cast.

Figure 5: shows photograph of zirconia crown in left side view w.r.t 36 on cast

Figure 6: shows occlusal view of zirconia crown w.r.t 36

Figure 7: shows photograph of occlusal w.r.t 46

Figure 8: shows photograph of occlusal zirconia crown w.r.t 36

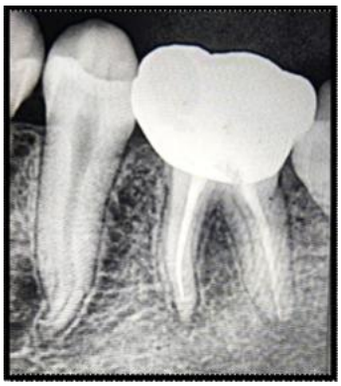

Figure 9: shows radiograph of zirconia crown w.r.t 36

Figure 10: shows photographafter 3 months of follow up of zirconia crown w.r.t 36.

Discussion

The clinical application of zirconia, a high strength ceramic material, is widespread. Its mechanical strength is superior to that of porcelain baked materials and lithium disilicate containing ceramics used in conventional full ceramic restorations. Additionally, high translucency zirconia, while slightly reduced in strength compared to conventional zirconia, allows for excellent esthetic restorations. Zirconia crowns are often fabricated using optical impressions taken with intraoral scanners [3].

Zirconia known as ceramic steel has proven its efficiency in adult dentistry. But to date, a minimal number of studies have been done in using zirconia as a restorative material (partial/ full coronal) for children. Zirconia, which is a polymorph occurs in three different forms namely monoclinic, tetragonal and cubic. The phase transforming property of zirconia facilitates the prevention of crack propagation thus aiding its durability and longevity [4].

Zirconia materials used in dentistry are anatomically contoured, metal free, completely bio-inert, and highly resistant to decay. The most commonly used form is zirconium dioxide (ZrO), also known commercially as Zirconia. This crystalline solid ranges in color from clear to white and is valued for its exceptional fracture toughness and chemical resistance, particularly in its cubic form. In dental applications, three main types of zirconia are typically utilized: yttria-stabilized tetragonal zirconia polycrystal (Y-TZP), magnesia partially stabilized zirconia, and zirconia toughened alumina. Among these, Y-TZP, a form of tetragonal zirconia polycrystal stabilized with yttrium, is widely used in pediatric dentistry due to its superior mechanical properties and biocompatibility [1].

Zirconia possesses mechanical properties comparable to those of stainless steel, with a tensile strength ranging from 900 to 1200 MPa and a compressive strength of approximately 2000

MPa. It is a polycrystalline ceramic devoid of glassy phases and exists in three crystalline forms depending on temperature: monoclinic (stable below 1107°C), tetragonal (above 1107°C), and cubic (above 2370°C). Under high stress, pure zirconia tends to crack due to volumetric expansion; however, the addition of small amounts of yttria stabilizes the structure, significantly enhancing its compressive strength, fracture resistance, corrosion resistance, durability, and biocompatibility. Zirconia also has a density of 6.05 g/cm³ and a hardness of 1200 HV, making it a robust and reliable material for various dental applications [1].

Zirconia restorations are indicated in cases where teeth exhibit significant crown destruction, particularly when more than two walls are compromised, or in instances of crown fractures. They are also recommended for endodontically treated teeth, which are at higher risk of crown fracture and require reliable sealing. Additionally, zirconia is suitable for managing enamel and dentin developmental defects, such as amelogenesis imperfecta, dentinogenesis imperfecta, hypoplasia, and hypomineralization. Furthermore, zirconia restorations are often chosen to meet high aesthetic demands due to their natural appearance and translucency [1].

Zirconia crowns are not recommended in cases where tooth structure is severely compromised and cannot be restored, or where there is physiological or pathological root resorption affecting more than two-thirds of the root. They are also contraindicated in patients with excessive bruxism, anterior crossbites, or severe dental crowding. Despite these limitations, zirconia crowns offer several advantages, including high strength and durability, the ability to withstand significant wear, and a translucent appearance that closely resembles natural teeth. They require minimal tooth reduction, and their size, shape, and color can be customized. Additionally, they are biocompatible and generally well accepted by patients. However, zirconia crowns have some drawbacks they cannot be crimped like stainless steel crowns, and gingival inflammation or bleeding during placement may interfere with proper cementation. Moreover, they tend to be more expensive than other types of crowns [1].

Mundhe et al. evaluated the effects of natural enamel, zirconia, and metal ceramic crowns on the wear of the natural enamel of the opposing teeth 1 year after prosthetic restoration. They found that zirconia caused less wear compared to metal ceramic crowns, but more wear compared to natural enamel [5].

Lohbauer et al.[6] reported that monolithic zirconia crowns (LAVA Plus) resulted in acceptable wear of the opposing natural enamel or ceramic surfaces after 2 years.[6] However, some reports also suggest that the wear of the opposing natural enamel due to a well polished monolithic zirconia surface is less than that occurring between enamel surfaces [7,8].

In the present case report, the zirconia crown was first selected to restore the tooth since the parents required an esthetic restoration for the endodontically treated tooth w.r.t 36.

Conclusions

Posterior monolithic zirconia crowns demonstrate strong clinical performance in the medium term and represent a promising alternative to traditional metal ceramic crowns, particularly in cases where a tooth colored restoration with minimal tooth reduction is desired. Monolithic zirconia crowns are unlikely to negatively impact periodontal health, indicating good compatibility with surrounding tissues. These crowns are generally associated with high levels of patient satisfaction due to their aesthetics and performance. Nonetheless, it is important for clinicians to carefully adjust occlusal contacts, as improper adaptation may lead to changes or wear on the opposing dentition.

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3D Printing In Orthodontics- A Review

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Abstract

The integration of 3D printing technology into orthodontics has revolutionized treatment planning and appliance fabrication processes. This paper reviews the current applications, benefits, and limitations of 3D printing in orthodontic practice. From the production of custom aligners and indirect bonding trays to the creation of precise orthodontic models and surgical guides, 3D printing enhances treatment accuracy, efficiency, and patient comfort. Various printing technologies such as stereolithography (SLA), fused deposition modeling (FDM), and selective laser sintering (SLS) are discussed in terms of their relevance and suitability for specific orthodontic applications. Furthermore, this review highlights ongoing research, material advancements, and the potential future role of fully digital orthodontic workflows. Despite certain challenges related to cost, regulatory standards, and material bio-compatibility, 3D printing continues to drive significant innovation in the field, pointing toward a more customized and patient centric approach in orthodontic care.

Key words - Aligners, Orthodontic retainers, 3D printing

Introduction

Many people see 3D printing as a game changing innovation that will alter the production process. In addition to its many uses in the aerospace, defense, artistic and creative industries, 3D printing is now gaining attention in the dental field. Thanks to developments in 3D imaging and modeling techniques like intraoral scanning and cone beam computed tomography, as well as the relatively lengthy history of CAD-CAM technologies in dentistry, this technology will gain prominence in the field of dentistry. Drill guides for dental implants, physical models for prosthodontics, orthodontics, and surgery are all made possible through 3D printing. Dental, craniomaxillofacial, and orthopaedic implants are also manufactured using this technology. Additionally, copings and frameworks for implant and dental restorations are also fabricated using 3D printing.[1]

Orthodontics has benefited greatly from 3D printing's rising popularity, particularly in the areas of treatment planning, digital impression creation, arch wire and bracket customization, rapid orthodontics, and clear aligner therapy.[1]

History of 3D printing

As far as anybody can tell, 3-D Systems' Charles (Chuck) Hull created the first functional 3D printer in 1984. After establishing 3-D Systems in 1986, Charles Hull created the first commercially available 3-D printing equipment, the Stereo lithography Apparatus.[2] His use of this stereo lithographic method was successful in achieving patency. In 1993, MIT was granted a patent for "3-D Printing techniques." 2D printers employ a technique that is comparable to this. One regenerative medicine firm that has made bioprinting a priority is Organovo Inc., which in 2010 made public details of the first totally bioprinted blood vessels.[2]

Advantages and Disadvantages of 3D printing - The benefits of 3D printed restorations will undoubtedly outweigh those of traditional or computer aided design and manufacturing restorations. They open the door to the prospect of simple and fast manufacture of high quality repairs. Several

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investigations have shown that these restorations are of high quality, but the price is still a big concern. The removal of support materials is a necessary step in stereolithography and digital light processing, and these processes are limited to light curable liquid polymers. In addition to being unsightly, resin has the potential to irritate the skin and even induce inflammation when inhaled or touched. In addition to being an expensive technology, they have a short shelf life, a vat life and cannot be heated to sterilize. The long processing time and high cost of selective laser melting are its major drawbacks.

Steps in 3D Printing- Electronic health records (EHRs) for patients include the highly accurate open file formats and may be saved, accessed, and maintained remotely via a protected digital hub in the cloud. It is possible to scan raw pictures with most digital intraoral scanners and then safely send them to a cloud storage site to be processed and improved for diagnostic reasons[1] (Fig.-1 and 2).

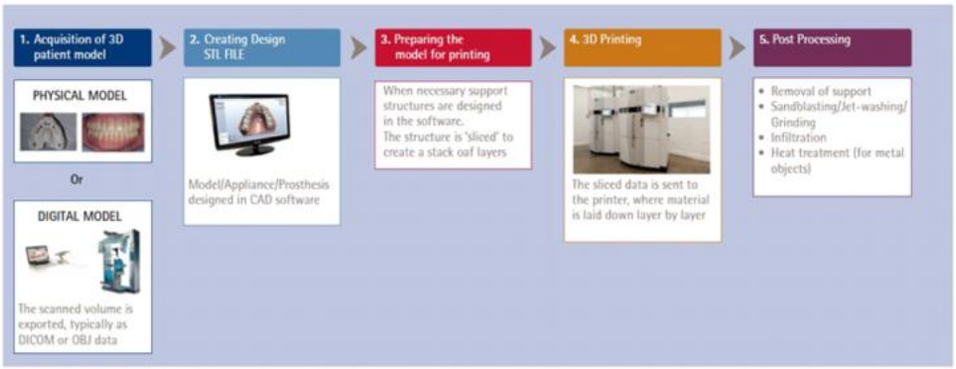

Figure 1: Steps in 3D printing

Figure 2: 3D printing process

Customizing appliances in Orthodontics - As a basic goal of orthodontic treatment, moving or realigning a patient's teeth within the mouth so they work together optimally and form smooth arch forms in opposite and complementary positions is the main goal of orthodontic treatment. To accomplish this, a typical orthodontic treatment involves placing brackets on the teeth of the patient in such a way that the slots for the arch wire will line up when the teeth are in their proper positions. Then, an elastic arch wire is inserted into these slots, and the teeth are gently but steadily pushed toward their corrected positions as the archwire straightens. In a perfect world, the teeth would be moved to their intended corrected locations without the orthodontist having to bend wires since the appliance is correctly positioned and meant to be used in this way. Use of computer aided design and fabrication of individualized orthodontic equipment. Data collection of the patient's dental anatomy shapes, data processing to create an appliance according to the orthodontist's treatment plan, precise and economical manufacture of the custom orthodontic appliance, and efficient and accurate placement of the appliance on the teeth are all important parts of automated appliance design and manufacturing systems. The three-dimensional data is especially useful for designing jigs(Fig.-3) that contour to the tooth surfaces, allowing for a one of a kind appliance placements. As a result, the orthodontic field is in dire need of an automated system for the design and production of bespoke appliances that is both practical and dependable, as well as a means of treating patients with these appliances.

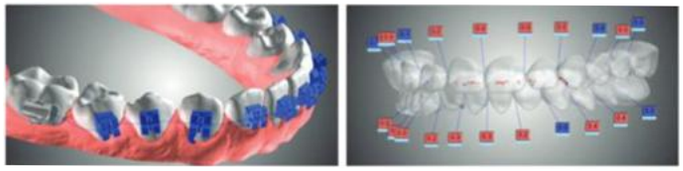

Figure 3: Customized Jigs made for placement of brackets

Individualized Attachments For Impacted Tooth Traction based on 3D Simulation and Printing Technology- Following data obtained by scanning binarization, contour extraction, vectorization, and 3D picture reconstruction, the 3D digital image of the jaws and teeth (Fig.-4) was created. The orthodontist and surgeon collaborated on a treatment plan and diagnostic for impacted teeth using the three dimensional picture.[3]

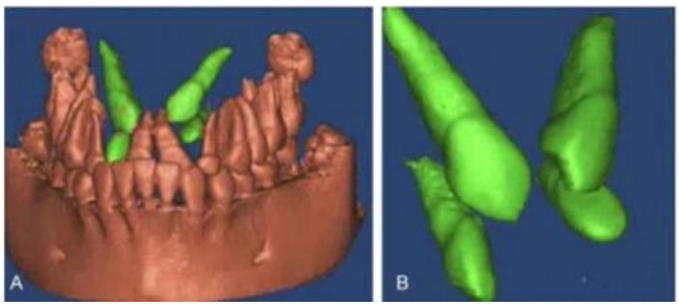

Figure 4: 3D digital image of jaws (A) and impacted teeth (B) by 3D reconstruction

Following discussions with the orthodontist and surgeon, the surgical exposure zone is established for the purpose of designing the unique attachment base. Developing a guiding rod: The precise setting, planned traction route, and affected tooth depth in alveolar bone dictated the orientation and length of the guiding rod that extends from the attachment base. Positioned above the guiding rod, the horizontal traction tube was designed. In relation to the impacted teeth, its long axis ran vertically. The recommended pre-adjusted orthodontic brackets had a diameter of 0.22 inch × 0.28 inch (0.56 mm × 0.70 mm), which was the same as the inner duct diameter (Fig.-5).

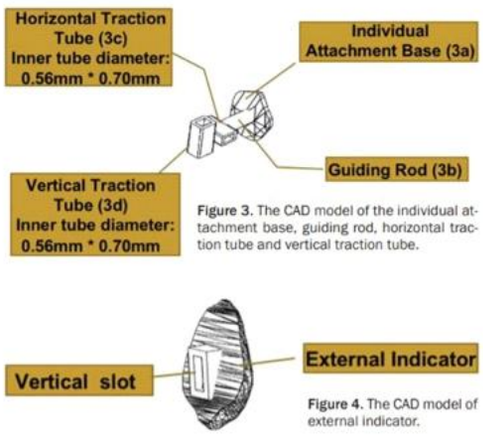

Figure - 5: The design of horizontal and vertical traction tube

An identical replica of the impacted tooth's labial surface is used to create the resin encased tooth's surface. The process of making each resin model and casting each metal model involves:

The quick manufacturing machine creates the individual resin attachment model by importing the STL file (Fig.- 6). The metal attachment, which includes the individual base, guiding rod, horizontal traction tube, vertical traction tube, and external indicator, is cast for clinical use after a series of procedures comprising embedding and casting precision technology (Fig.-7).[3]

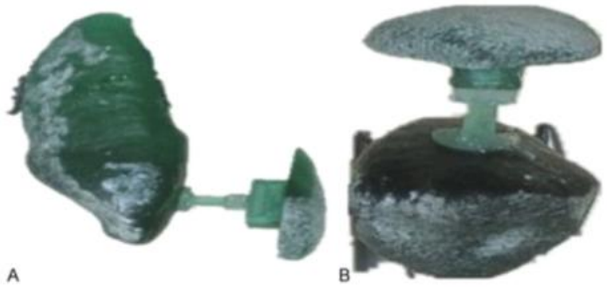

Figure 6: The lateral view(A) and frontal view(B) of the individual resin attachment model

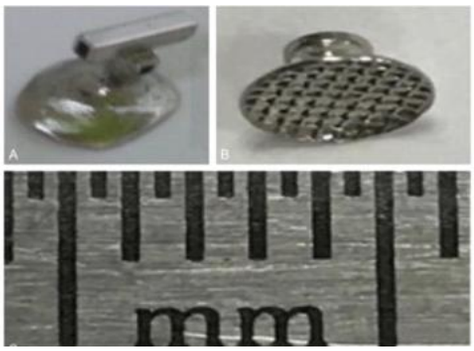

Figure 7: The casted individual(A) and traditional (B) metal attachment sets for embedded tooth traction and the scale display of this ruler(1 millimeter of each scale) (C)

Objectives of 3D printing in Orthodontics

One of the main goals of 3D printing is to provide a platform for the design and production of practical, dependable, and efficient bespoke appliances. This might include a way to create personalized orthodontic equipment and treat patients with them.

Our primary goal is to enhance automation in the orthodontic appliance design and manufacturing processes, with a focus on personalized orthodontic appliances.

Another goal is to provide individualized orthodontic appliance design and production that involves a well coordinated transfer of authority and decision making among the orthodontist, the appliance manufacturer, and the customized computer system.

A secondary goal is to ensure that the orthodontist and appliance manufacturer work together as efficiently as possible

throughout the process of creating custom appliances, taking into account the size and other specifics of each practitioner's practice. This will allow the orthodontist to have complete control over the final arch form and the treatment itself, which will improve treatment accuracy, make better use of the orthodontist's time, and eliminate chances of error. Another goal is to make orthodontics better by helping practitioners treat patients more effectively, more precisely determine where their teeth should be placed, and, most importantly, make it so that the appliance works as intended and the patient's final crown or bridge fits snugly into place. Another goal is to make it easier to influence the design, production, and usage of orthodontic appliances as well as the movement of patient teeth in orthodontic therapy in three dimensions.

Orthodontic retainers using 3D printing- Retention is essential for preventing tooth recurrence. There are a variety of retention methods, each with its own set of pros and cons.

In the case of detachable retention, aspects impacting compliance, such as comfort, speech, and cleanliness, are particularly crucial to take into account since retention is most effective when it lasts a life time.[4]

Priorities in Initial Design : Sustainability Improved undercut detection and usage Less bulkiness and no huge clasps Greater comfort Wear ability when eating Minimal to no inter-occlusal metal use of a flexible but non-deformable alloy.

Procedure- The dental stone is poured using the PVS impressions that have been obtained. The Dental Wings TM model scanner is used to digitize the models and generate an STL file. A proprietary open format program (DWOSTM) is used to open the STL file and create a virtual retainer. In order to determine the best route for inserting the future appliance, the program makes use of a virtual surveyor (DWOSTM).[4]

Fig.-8 shows the final retainer design that was created using the program. To contact the right undercut regions and prevent occlusal interferences, great care is used. After the virtual design (Fig.-9) is finished, it is delivered to a 3D printer (Phenix Fusion Printer) and processed in chromium cobalt alloy using laser sintering. The software used for this procedure is Dental Wings Compiling Software(DWOSTM). Laser sintering eliminates the need for extra thick metal to endure casting and the possibility of errors that come with it. By streamlining the printing process, we can produce smaller and cleaner appliances with less processing time. A superior fit with little distortion was achieved using laser interred frameworks by assembling many 20-um layers of powder.[4]

Retainer Delivery and Assessment: Retainers for the upper and lower jaws were sent out. Participants are requested to wear the retainer for a minimum of one hour, communicate while it is in their ears, and practice taking it out and putting it back in.

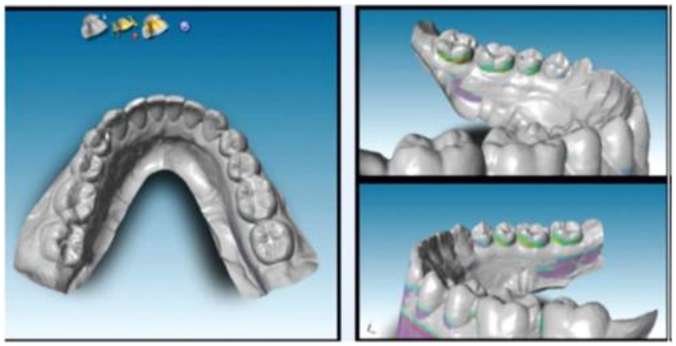

Figure 8: Digitization of stone model by virtual surveyor used to detect blocked dental wings and maximum undercut areas.

Figure 9: Retainer using 3D printing

Advantages of CAD CAM Retainers

Pleasant, sturdy, and aesthetically pleasing are the CAD/CAM retainers. Compared to fixed retainers, they are easier to clean. Depending on the severity of the undercut, these retainers may be adjusted to fit. Appliances should be easier to install and remove from the design.[5]

3D Printing In Accelerated Orthodontics

Orthodontic therapy aims to make patients' lives better by improving their smile and their ability to chew and speak clearly. While treating adult or teenage patients might be difficult, many patients prefer shorter therapy. When combined, orthodontic treatment and surgical alveolar corticotomies may shift teeth quickly while shortening the therapy period.[6] Cutting into the cortical bone for surgical purposes is called a corticotomy. Claiming to remove orthodontic tooth movement resistance from thick cortical bone, this procedure may supposedly drastically shorten treatment time. In orthodontics, corticotomy is the safe and effective way to speed up tooth movement, even if there are other methods reported in the literature.

Surgical Template Manufacturing- The dental arches are first impressioned, going as deep into the vestibular fornix as feasible. Step one involves making an imprint tray. Step two involves making a second impression. Finally, a cast is poured. Finally, a 3D scanner is used to digitally acquire the model (Fig.-10). The STereo- Lithography (STL) files are used to save both the cast and template scanning images.[6]A 3D model of the teeth and jaws is created from an image and stored as an STL file (Fig.-11). A 3D printer designed for medical equipment was used to manufacture the surgical guide's 3D STL model (Fig.-12).[6]

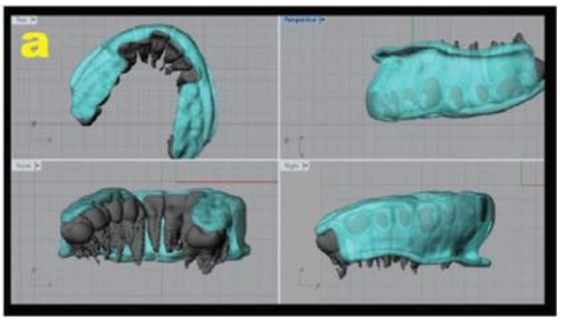

Figure 10: Impression with a 3D scanner

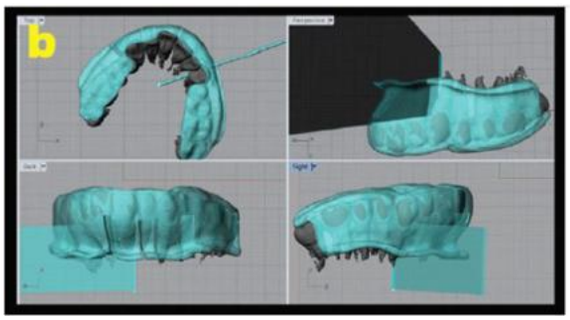

Figure 11: The STL files of a template

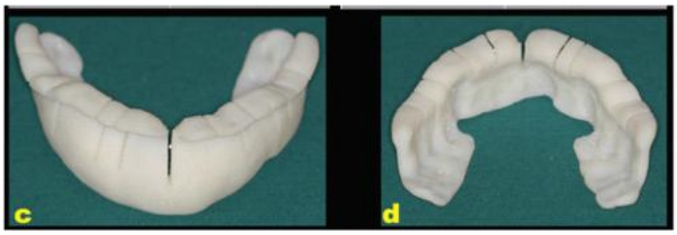

Figure 12: Acquired 3D bone model

Surgical phase - A piezosurgical instrument is used to produce the vertical slices during the corticotomy (Fig.-13). Next, the vertical incisions will be sutured using Vicryl 3.0 thread to finish the process.[6]

This new flapless technique uses 3D printed CAD-CAM surgical guides in conjunction with piezosurgical cortical micro-incisions; it causes much less damage to periodontal tissues and does not need either hard or soft tissue grafting, and it does not obstruct the marginal periodontium.

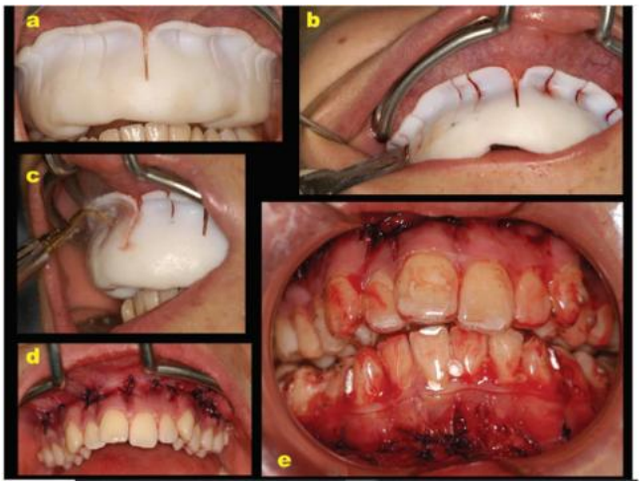

Figure 13: A: The Positioning of 3d-printed Surgical Template To Perform Flapless Corticotomy In The UpperArch. The Initial Surgical Guide Stability Check. B: The Gingival Vertical Incisions Using A Blade Number 15. C: The Cortico-tomy Vertical Cuts Performed Using A piezosurgical Device. D: The Suturing Of The Vertical Incisions. E: The Positioning of Clear Aligners Immediately After Surgery.

3D Printing in Orthodontic Aligners

Traditional orthodontic therapy involves the orthodontist or their assistant attaching orthodontic appliances, such brackets, to the patient's teeth and inserting an arch wire into a bracket's corresponding slot. The arch wire is used to exert pressures that push the teeth into their proper orthodontic placements. The arch wire is held in place inside each bracket slot by traditional ligatures, which may be tiny elastomeric o-rings or fine metal wires. Instead of using a ligature, which may be a pain to apply to each bracket individually, self ligating orthodontic brackets use a sliding clasp orlatch to secure the arch wire into the bracket slot. Stainless steel is the typical material for traditional orthodontic brackets. Which is tough, won't absorb liquid, can be welded, and is simple to shape and machine. Metal orthodontic brackets are aesthetically unpleasing and might cause patients to feel self conscious throughout treatment.

Some older orthodontic brackets solve the aesthetic problem of metal brackets by using a nonmetallic material that is see through or translucent as the bracket body. For example, a polymer that is either see through or transparent, or a ceramic that can take on the tone and color of the natural tooth.

Other, less obvious equipment may be used in place of orthodontic brackets. The most popular kind are the removable "aligners" that patients may swap out as needed. In order to shift one or more teeth from their natural position to a more aesthetically acceptable one, the dentist or orthodontist may recommend a set of aligners that the patient wears over their teethwithout actually attaching them. Because an aligner can only shift the teeth so far, patients usually need a succession of them to get the full benefit of treatment. Therefore, when used in a series, each aligner may be tailored to complete a specific step of the

treatment procedure or to shift one or more teeth along a specific segment of the total treatment distance.

Method of forming Clear Aligners

A physical and computer aided molding method is used to create the Invisalign aligners. Step one of the process involves utilizing an appropriate imprint material to create a mold of the patent's teeth. Polyvinylsiloxane (PVS) is one example. A computer generates a three dimensional digital positive model of the patient's teeth and gingival from the scanned imprint using CT. The next step in the process of designing a custom appliance for a patient's teeth involves creating a new three dimensional model of the patient's dentition in the desired configuration.

The next step is to import the tooth forms from the 3D plaster model into the CAD program.

The next step is to use the computer aided design system to electronically separate the teeth and then reset them to the proper configuration. The next step is to print out a real replica of the patient's teeth based on the digital model of their dentition that was created in the appropriate arrangement. At last, the actual model of the teeth's structure is covered with a transparent material, such polyurethane, that will later be the aligner. After that, you'll need to physically cut the molded aligner so it doesn't have any sharp edges or parts that might rub against your gums. Furthermore, the straightener Tumbling is a common method for smoothing surfaces and edges. Attachments help the aligners stick to the teeth incertain instances. The attachments are put using a thermoformed template aligner over a mold that matches the patient's original tooth locations in the Invisalign procedure. To make the template aligner more flexible and less retentive than traditional aligners, thin material may be used. For every attachment,a pocket or well is made in the template aligner.

After the patient's arch is properly positioned, the template is filled with attachment compound and inserted into these wells. After that, we cure each attachment according to the directions given by the manufacturer. After the template's attachments have dried, you may take it out and use a carbide or stone finishing bur to remove any flashing.

Moving towards precision Orthodontics

An evolving approach to illness treatment and prevention, precision medicine (formerly personalized medicine) takes into consideration individual heterogeneity in genes, environment, and lifestyle, according to the Precision Medicine Initiative Cohort Program at the NIH. Because it relies on physical devices and pressures to control the movement of teeth and to aid craniofacial orthopaedics, orthodontics places a major focus on technology, in contrast to many dental and medical disciplines. Therefore, it is essential for precision orthodontics to include individualized appliances and force delivery to tissues, going beyond the traditional concept of precision medicine based on individuals' unique biology and lifestyle (Fig.-14).

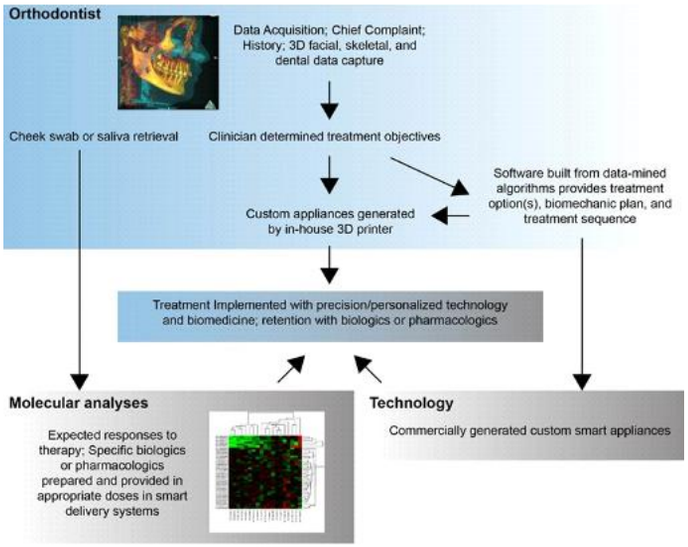

Figure 14: A Proposed Vision For The Integration of Technology and Biomedicine towards Precision Orthodontics

Conclusion

In orthodontics, the use of high resolution resin printing is already a viable option, and related technologies are being considered for use in restorative dentistry, printing models and patterns for the lost wax process, which is gaining significance due to the advent of intraoral scanning systems. Anatomical models created using a variety of 3D printing processes are increasingly indispensable in maxillofacial and implant surgery for the planning of intricate procedures.

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Orthodontic Considerations For Tooth Agenesis : A Narrative Review

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Abstract

Tooth agenesis is one of the most prevalent dental developmental anomalies, commonly affecting the upper front teeth and both upper and lower premolars. Its causes are complex and include a mix of genetic, environmental, and epigenetic influences. This condition may be associated with syndromes such as ectodermal dysplasia or may occur in non-syndromic familial patterns. The absence of teeth can significantly impact bite alignment, appearance, chewing efficiency, and emotional well being.

Managing tooth agenesis orthodontically demands a team based approach that integrates accurate diagnosis, strategic treatment planning, and coordination with restorative and prosthodontic specialists. Clinical choices are guided by factors such as the number and position of missing teeth, the patient's age, growth stage, and the health of surrounding teeth. Treatment may involve either closing the spaces through orthodontic tooth movement or opening spaces to accommodate future prosthetic solutions like implants, bridges, or dentures. For younger patients who are still growing, temporary space maintainers may be used until they are ready for permanent treatment. A collaborative, interdisciplinary strategy is key to achieving optimal function and aesthetics. Detecting the condition early and initiating timely care is vital to reduce complications and ensure proper dental and facial development.

Keywords: Genetics, Orthodontic space management, Tooth agenesis

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Introduction

Tooth agenesis is described as developmental absence of one or more teeth, occurring either in the primary or permanent dentition. It occurs after disruptions in the formation of tooth buds, which are critical to normal dental development. The condition poses significant clinical challenges, particularly when permanent teeth are congenitally missing. A central decision in managing these cases is either to close the space orthodontically or to restore it using prosthetic options, dental implants, or, in certain cases, auto-transplantation.[1]

Tooth agenesis is classified by the number of missing teeth: hypodontia involves the absence of one to five teeth (excluding third molars); oligodontia refers to the absence of six or more teeth; and anodontia, a rare condition, is the complete absence of all teeth. While anodontia and syndromic oligodontia are often linked to systemic conditions like ectodermal dysplasia or Down syndrome, oligodontia can also appear as a non-syndromic, isolated anomaly.[2]

Epidemiological data indicate a higher prevalence of dental agenesis in European and Australian populations compared to North American Caucasians, with females generally more affected than males. Females are nearly 1.37 times more likely to be affected by this condition, highlighting a potential gender based genetic component.[3]

Effective management requires early diagnosis, careful assessment of skeletal and dental development, and individualized treatment planning. A multidisciplinary approach involving orthodontists, prosthodontists, and other specialists is required to achieve both functional and aesthetic outcomes for patients with tooth agenesis.[3]

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According to Butler's Field Theory:

- Maxillary Lateral Incisors: It is one of the most prevalent form.
- Mandibular Incisors: Particularly the mandibular right lateral incisor.
- Permanent Molars: Agenesis of third molars is also commonly observed. [4]

Tooth agenesis can be categorised as:

1. Selective Tooth Agenesis: Involves specific teeth like lateral incisors.
2. Syndromic Tooth Agenesis: Associated with genetic disorders like ectodermal dysplasia, cleft lip and palate, or Van der Woude syndrome.
3. Non syndromic Tooth Agenesis: Occurs independently of other physical abnormalities.
4. Sporadic Tooth Agenesis: Occurs randomly without a familial pattern.[5]

Etiology

Environmental

Several factors are related to the etiology of tooth agenesis. Evolutionary changes in human dentition have contributed to a reduction in dental arch length, possibly leading to congenital absence of certain teeth as part of an adaptive mechanism. During tooth development, localized infections or inflammatory processes may disrupt endocrine activity, which in turn could be linked to ectodermal dysplasia a condition often associated with severe tooth agenesis. Environmental factors also play a role; for instance, exposure to teratogenic substances such as thalidomide, as well as chemotherapy or radiotherapy. While general maternal health during pregnancy does not appear to have a direct correlation with the development of hypodontia, specific infections like rubella have been identified as potential contributors to tooth agenesis in the fetus. Although tobacco and alcohol use have been proposed as possible risk factors, current evidence does not establish a definitive link between these exposures and the occurrence of hypodontia.[6]

Genetics

1. Although more than 300 genes have been implicated in odontogenesis in murine models, the precise molecular mechanisms governing human tooth development remain only partially understood. Genetic studies have identified several genes that contribute to tooth formation and, when mutated, may lead to tooth agenesis. Among these, mutations in MSX1, PAX9, AXIN2, TGFA, IRF6, WNT10A, and FGFR1 have been associated with disrupted dental development. However, only three genes MSX1, PAX9, and AXIN2 have been conclusively linked to familial, non-syndromic, autosomal dominant forms of tooth agenesis.[7]
2. The transcription factors MSX1 (Muscle Segment Homeobox 1) and PAX9 (Paired Box 9) are essential for early stages of facial and dental formation. Genetic mutations in these genes are frequently linked to inherited cases of tooth agenesis, particularly affecting several back teeth like molars and premolars. On the other hand, mutations in AXIN2, a gene involved in the Wnt signaling pathway, are associated with a broader and less region-specific pattern of missing teeth. This often includes the absence of several permanent teeth, though the upper central incisors are generally present. The differing patterns of tooth loss associated with specific gene mutations suggest that analyzing which teeth are missing can help identify the underlying genetic cause.[8]
3. People born with missing teeth often display changes in the size and shape of their remaining teeth for example, lateral incisors may appear peg shaped or smaller than normal. (Fig 2) These features are typically seen as partial expressions of the same genetic factors responsible for tooth agenesis. A peg shaped maxillary lateral incisor, for instance, might reflect a milder form of the same genetic mutation that could otherwise result in the complete absence of the tooth. The frequent association of missing teeth with peg shaped laterals reinforces the idea that both may arise from the same genetic variation, potentially due to differences in gene expression or penetrance.[9]
4. Tooth agenesis often occurs alongside other dental abnormalities, indicating a more widespread developmental disturbance rather than an isolated issue. Commonly associated conditions include taurodontism (enlarged pulp chambers), shortened tooth roots, ectopic eruption, microdontia, unusual tooth shapes, and enamel hypoplasia. This combination of anomalies supports the view that tooth agenesis may be part of a broader pattern of developmental instability. In cases of oligodontia (where many teeth are missing), taurodontism and reduced root length are particularly prevalent. These features may stem from underlying ectodermal defects or systemic disruptions during tooth development.[10]

Ectopic eruption of permanent teeth is most common dental anomaly occurring along with hypodontia. This may occur due to the absence of adjacent teeth that typically provide eruption guidance, leading to misdirected or displaced tooth positioning. Without these neighbouring teeth, the developing permanent teeth may deviate from their normal eruption paths. These associations further support the idea that hypodontia is part of a broader spectrum of developmental disturbances affecting both tooth formation and eruption patterns.[11]

Figure 1: Child with missing upper lateral incisor and multiple teeth in lower arch

Figure 2: Mother with missing upper lateral incisor and peg shaped opposite lateral incisor

Tooth Agenesis and Family History

Tooth agenesis is known to have a strong hereditary basis, often following familial patterns of inheritance. (Fig1)When a child presents with congenitally missing teeth, it is not uncommon to find that one or both parents have experienced similar dental anomalies, although the number and specific teeth affected may differ among relatives due to variable expressivity and incomplete penetrance. In certain instances, tooth agenesis may be a feature of a broader genetic syndrome that is transmitted through generations. Therefore, a thorough evaluation of family dental history plays a vital role in the early identification and management of the condition. For families with a known history of tooth agenesis or syndromic conditions involving dental anomalies, genetic counseling can provide valuable insight, particularly in the context of family planning and assessing the risk of recurrence in future offspring.[11]

Diagnosis

Clinical Examination

1. First sign of agenesis can be made by a radiograph in which no evidence of presence of tooth is seen.
2. The failure of lateral incisor or premolar on side to erupt compared to its counterpart
3. Absence of permanent teeth causes the primary tooth infra-occlusion.
4. As many as two thirds of individuals missing premolars exhibit infra-occlusion of the related primary molars.[12]

Definitive Diagnosis

Radiographic examination is the key diagnostic factor in determining the agenesis of tooth.

Management of Tooth Agenesis

Patients with congenitally missing teeth are treated orthodontically. Managing these spaces created is critical not only for aesthetic concerns but also for ensuring proper long-term function. Orthodontists must carefully evaluate whether to close or maintain/open spaces, based on what will best benefit the patient's overall dental health and appearance. Extraction of retained deciduous teeth may be indicated to facilitate the natural migration of adjacent teeth where permanent teeth are absent.

Decision for extracting a retained primary tooth largely depends on its prognosis.[13] If the tooth is healthy and stable, it may be retained to preserve space and alveolar bone for future restorative treatments. Conversely, extraction is advisable when the tooth is severely decayed or has a poor prognosis, with subsequent orthodontic intervention to manage the space.[14]

Several key factors determine whether orthodontic treatment should aim to close or maintain space in cases of tooth agenesis. These include the presence of gaps or rotated teeth near the missing tooth site, which often need to be corrected before considering prosthetic solutions. The quantity and quality of alveolar bone in the affected area also play a critical role, as they influence both the potential for tooth movement and the suitability for dental implants. Another crucial factor is the vertical position of any retained primary molar in relation to the occlusal plane, which can impact the overall treatment plan. Ultimately, the decision-making process involves a thorough evaluation of the patient's bite alignment, facial structure, growth potential, degree of dental crowding, smile aesthetics, and tooth shape to determine the most appropriate orthodontic strategy.[15]

Space Opening Orthodontically

Patients with Angle's Class I malocclusion are generally ideal candidates for space opening. Cases presenting with upright maxillary incisors requiring proclination or those with anterior cross bites are also suited for space opening. Conversely, patients exhibiting bimaxillary protrusion or a convex soft tissue profile are typically poor candidates for this approach, making space closure a more appropriate option.

When managing congenitally missing maxillary lateral incisors, treatment planning often incorporates the principles of the Golden Proportion. This principle states that the perceived mesiodistal width of an anterior tooth should follow a ratio of approximately 1:0.618 relative to its adjacent tooth. Specifically, the lateral incisor's width should be about 61.8% that of the central incisor. This guideline is most applicable in cases of unilateral lateral incisor agenesis but may be challenging when the contralateral lateral incisor is peg-shaped, hypoplastic, or worn.[16]

Bolton analysis provides critical insight into tooth size relationships, with an ideal anterior tooth width ratio of 0.78 (sum of mandibular anterior widths to maxillary anterior widths). Additionally, a diagnostic wax-up can be valuable in predicting the optimal space required for prosthetic replacement.

In the mandibular arch, deciduous molars are often preserved to maintain alveolar bone and prevent arch length discrepancies. Slenderization (interproximal reduction) may be performed to manage space and alignment, while hemisection of a deciduous molar can be considered in select cases.

Following orthodontic space management, prosthodontic rehabilitation proceeds, with the timing of restorations largely dependent on the patient's skeletal maturity to ensure optimal outcomes

The treatment approach for tooth agenesis varies depending on the number of missing teeth and their functional and aesthetic impact. Common management strategies include:

- **Dental Implants and Bridges:** For patients missing a limited number of teeth, fixed prosthetic options such as dental implants or bridges are often preferred to restore both function and appearance.
- **Orthodontic Treatment:** Particularly important in younger patients, orthodontics helps align existing teeth and creates or maintains adequate space for future prosthetic replacements.
- **Dentures:** In cases of extensive tooth loss, removable partial or complete dentures may be necessary to restore oral function and aesthetics.
- **Multidisciplinary Care:** When tooth agenesis is part of a broader genetic syndrome, comprehensive care involving multiple specialists including geneticists, orthodontists, prosthodontists, and paediatric dentists is essential for holistic management.
- **Oral Health Maintenance:** Regardless of treatment modality, meticulous oral hygiene practices are vital to prevent secondary dental problems and ensure the longevity of restorations.[16]
- **Regular Dental Follow-up:** Ongoing dental evaluations are crucial to monitor oral health, assess growth and development, and promptly address any complications associated with tooth agenesis.

Figure 3: Missing both the upper lateral incisors. Replacement of the missing teeth by orthodontically opening the spaces

Orthodontic Space Closure

In cases of congenitally missing lateral incisors, the adjacent canines often erupt more mesially, naturally occupying the lateral incisor position. This spontaneous tooth migration eliminates the need for future prosthetic replacements, as the canine moves within the alveolar bone, helping to preserve both the bone volume and soft tissue architecture. Importantly, the gingival and periodontal tissues remain largely unaltered, supporting long-term periodontal health.[17]

However, orthodontic space closure with canine substitution has some limitations. The canine typically has a greater mesiodistal width than a lateral incisor, necessitating reshaping to achieve an esthetically acceptable form. In contrast, the premolars, which may substitute for canines, are generally wider both incisogingivally and mesiodistally, requiring more extensive recontouring and often the addition of a palatal cusp build up to mimic canine function and anatomy. Additionally, the gingival margin levels differ between canines and lateral incisors; therefore, the canine must be extruded slightly, while the premolar is typically intruded to harmonize the gingival contour and achieve a balanced smile line.[18]

Figure 4: Missing both the upper canines. Orthodontically closing the spaces by mesialising the premolars.

Conclusion

Tooth agenesis is a developmental dental condition characterized by the absence of one or more teeth, with severity ranging from a single missing tooth to complete tooth loss. This anomaly can have a considerable impact on oral function, appearance, and overall dental well being. While hereditary factors are the most common cause, environmental elements and syndromic conditions can also play significant roles in its onset. Successful management involves a thorough understanding of the condition, routine dental evaluations, and coordinated care among dental professionals, including orthodontists and prosthodontists. Treatment strategies should be tailored to each individual, often combining orthodontic correction, prosthetic restoration, and, when needed, genetic consultation. Educating patients and their families is crucial to support informed choices and encourage active involvement in the treatment process. Although tooth agenesis presents certain clinical challenges, well timed, personalized care can help individuals maintain good oral health and quality of life. Moreover, ongoing progress in dental technologies and regenerative medicine offers promising future solutions for improving treatment outcomes.

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Comprehensive Orthodontic Protocol in Cleft Lip and Palate Rehabilitation

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Abstract

Cleft lip and palate rank among the most prevalent congenital conditions worldwide, with variations observed across different races, ethnicities, and regions. Issues related to cleft lip and/or palate tend to exacerbate as individuals age. While it presents as a distinct condition, its existence can adversely affect aesthetics and functionality, impacting growth, dental health, speech, hearing, and overall appearance, leading to social and psychological challenges for both the child and their parents. The origins of cleft lip and palate are multi-factorial, including genetic factors, exposure to teratogenic substances, and nutritional deficiencies, and it can manifest as either syndromic or non-syndromic clefts. The management of cleft lip and palate involves a team of various specialists, each bringing unique perspectives to a specific case, which ultimately contributes to achieving successful treatment outcomes. While the timing and methods for each intervention are still subject to debate, the orthodontist has a vital role in pre-surgical maxillary orthopaedics, which includes aligning the maxillary segments and teeth in preparation for subsequent alveolar bone grafting and achieving optimal dental relationships. Additionally, they prepare the dentition for potential prosthetic rehabilitation or orthognathic surgery if needed. Thus, to ensure an effective treatment outcome and to refine individual techniques or variations of the treatment protocol, it is essential to have a highly skilled team of specialists from various disciplines, ideally working on a multi-centre basis.

Keywords : Cleft lip; Cleft palate; Dental care; Orthodontics

Introduction

One of the most prevalent congenital abnormalities in the craniofacial region is cleft lip and palate[1]. Approximately 700 infants worldwide are born with cleft lip and/or cleft palate per day, meaning that a newborn with one of these clefts is born every two minutes [2]. Geographical location, ethnicity, gender, and socioeconomic level all affect the occurrence of cleft lip and palate, with Asians having the highest frequency, Africans the lowest, and Caucasians having an intermediate rate [3].

Although the mix of genetic and environmental variables is undeniable, the exact cause of clefts is still unknown. Epidemiology takes into account environmental influences, the prevalence of drugs, alcohol, and smoking, in addition to hereditary factors as well as the mother's consumption of folic acid. It has been noted that each race in a particular nation has a different case frequency. Although the deformity is usually unilateral, it can also be bilateral[4–6].

CLP is a congenital abnormality that develops during pregnancy. Palatal shelves typically converge and merge during the fifth to twelfth week of pregnancy. Clefts may appear as a result of developmental abnormalities caused by disruptions in mesenchymal and endodermal cell proliferation during embryogenesis [7]. Cleft palate and cleft lip with or without cleft palate are included in the division of clefts [8]. In addition to being restricted to the uvula, cleft palate may affect the development of soft tissues [7]. About 15% of all cleft cases have solitary cleft lip, while 40% of individuals have isolated cleft palate[9].

Because of its ability to work in tandem with other patient treatment requirements, the job of an orthodontist has expanded over time. In the early stages of cleft patient care,

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the orthodontist can help with pre-operative maxillary orthopaedics; in the intermediate stages, they can align the maxillary segments and dentition and prepare for secondary alveolar bone grafting; and in the final stages, they can help obtain the ideal dental relationship and prepare the dentition for orthognathic surgery or prosthetic rehabilitation. Soft tissues, skeletal abnormalities, and/or dental anomalies may be linked to the orthodontic malocclusion in a patient with cleft lip and palate. In order to achieve full ortho-dontic success, the orthodontist must prioritize treatment goals for each intervention and make important decisions for orthodontic intervention at the right moment.

Interdisciplinary Team

Figure 1:Diagrammatic representation of the interdisciplinary team for CLCP patients [10]

An orthodontist, an oral and maxillofacial surgeon, and a cleft surgeon make up the majority of the core team. A prosthodontist, a speech and ENT expert, and a plastic surgeon are among the other essential team members.[10]

Treatment Protocols in Cleft Patients

Since they are the main members of the interdisciplinary team that support the surgeon during the entire reconstructive care process, orthodontists play a crucial role in managing clefts. The orthodontist helps the cleft surgeon with preoperative maxillary and nasal orthopedics throughout infancy. The orthodontist's only responsibility during the deciduous dentition stage is to address crossbite, if required. In order to prepare for secondary alveolar bone grafting, the maxillary segments and dentition must align during the transitional dentition period. The orthodontist's job is to achieve good dental and occlusal interactions during the permanent dentition and late adolescence. They also have to get the dentition ready for orthognathic surgery and prosthetic rehabilitation, if necessary.[11]

This is summarized in the table given below

Stage	Treatment
Infancy	Presurgical nasal and maxillary orthopedics • Feeding devices • Pre-surgical orthopedics • Nasoalveolar moulding • Primary Lip Surgery • Cleft Palate Surgery • Velopharyngeal Dysfunction & its treatment
Deciduous Dentition	Crossbite Correction (if necessary)
Transitional Dentition	Maxillary Expansion Intrusion of Premaxilla Maxillary Protraction Alveolar bone grafting
Permanent Dentition	Comprehensive Orthodontic Treatment Distraction Osteogenesis Orthognathic Surgery

Infancy

The maxillary arch is invariably deformed in infants with cleft lip and palate. The pre-maxillary segment is typically shifted anteriorly and the posterior segments are folded lingually in patients with bilateral cleft lip and palate. People with unilateral cleft lip and palate typically have less severe deformities.[12]

Feeding Devices

Because they are unable to achieve a satisfactory seal of the oral cavity, children born with cleft lip and palate frequently exhibit eating issues. Choking and nasal regurgitation are frequent issues that arise from the palate's incapacity to distinguish between the nasal and oral chambers. For the feeding plate, Agarwal A et al.[13] employed ethylene vinyl acetate and floss in a patient who had a unilateral cleft lip and palate. Using ethylene vinyl acetate instead of acrylic had the advantage of producing a softer, smoother surface without the need for retentive wire.

A floss was used because it prevents swallowing and helps in early retrieval of the appliance. Once the appliance was placed in the oral cavity, the child could be easily fed.

Presurgical Orthopedics

Early in the 1950s, Mc Neil proposed the idea of presurgical orthopedics. Neonatal orthopaedics, according to Mc Neil, may change the maxilla's postnatal growth by promoting the development of soft tissues that cover the hard palate. The initial idea was to form a butt joint between the cleft's alveolar segments. Presurgical orthopedics helps with speech development, normalizes tongue position, and creates a good working plate. Pre-

surgical orthopaedics is also anticipated to improve the patient's psychological well being and nose and cleft maxilla symmetry.

Nasoalveolar Moulding

A method for simultaneously correcting the nose, lip, and alveoli was disclosed by Gralson et al. [14]. This is completed in the initial weeks following delivery. A tiny piece of tape is applied across the baby's face, and a specially designed molding plate that resembles an orthodontic retainer is affixed. The apparatus consists of a stiff wire connecting an acrylic bulb (nasal stent) to the maxillary plate. The nasal dome is raised by the bulb, which also shapes the soft tissue of the cleft area and the nostrils. Active molding and passive growth guidance are used to mold alveoli. The interdisciplinary cleft team typically evaluates NAM 1-2 weeks after delivery, and it must be activated and changed weekly. This is beneficial to approximate the cleft segments and reduce the cleft gap.

Advantages of NAM

By reducing the cleft side alar curvature and lengthening the columella, this therapy helps the patient. It also improves the surgical aesthetics by making the prolabium more visible through the premaxilla's retractions.

NAM Protocol

Visit	Procedure
First visit (Birth - 2 weeks)	Parent Counselling Feeding instructions Lip taping only
Second visit	Impressions for NAM plate Lip taping
Third visit	Delivery of NAM plate Lip taping
Subsequent visit (every 2 weeks)	NAM plate adjustment Lip taping

Primary Lip Surgery

Repairing a cleft lip is often done about 10 weeks of age. This enables a thorough medical assessment of the patient in order to identify any congenital abnormalities that may be affecting other organ systems. The rule of ten states that lip repair should be postponed until the infant is at least 10 weeks old, weighs 10 pounds, and has a hemoglobin level of at least 10 dL/mg. The major goal of primary surgery is to achieve a functional lip that can produce a healthy lip seal while also improving the appearance of the lip, prolabium, and columella.

There are two common techniques for primary lip closure:

1. Millard's rotation flap
2. Randall Tennison's triangular flap procedure

Cleft Palate Surgery

Repairing a cleft palate typically takes place between the ages of 9 and 18 month. Closing oronasal communication, which involves the hard and soft palate, and anatomic repair of the musculature which is necessary for appropriate speech are the two primary objectives of cleft palate surgery during infancy. Numerous methods for palate repair have been documented.

The commonly used techniques include:

1. Bardach two flap palatoplasty
2. von Lange back palatoplasty

Pushback procedures are not preferred since they do not improve speech, limit growth, and increase palatal scarring.

Velopharyngeal Dysfunction

Unwanted communication between the nasal and mouth canals leads to velopharyngeal dysfunction. Giving the child an oronasal structure that promotes proper speech and resonance is the main goal of palate restoration. To keep the nasal and oral cavities apart, the palate must be closed.

All oral sounds must be produced with the velopharyngeal valve closed completely and firmly for normal speaking. Velopharyngeal insufficiency (VPI), which is defined as inadequate closure of the velopharyngeal valve due to an irregularity of the anatomy, is the biggest issue for children with cleft palate.

Treatment of Velopharyngeal Dysfunction involves a secondary surgical procedure or the use of a pharyngeal obturator.

Deciduous Dentition

The eruption of primary teeth near an alveolar deficiency may be delayed in children with an alveolar cleft defect. It is possible for the primary lateral incisor to be congenitally absent or deformed. In addition, the primary dentition grows similarly to children without clefts. The dentition frequently reflects the underlying skeletal difference, even though the distribution of the young child's adipose tissue and soft tissue draping conceals the midface's developing skeletal insufficiency in children with clefts. There may be bilateral or unilateral anterior and/or posterior cross bites. The crossbite may be linked to a functional shift, such as a slip from centric relation to centric occlusion. In certain instances, the issue may be resolved by equilibration, which eliminates occlusal interference.

Orthodontic tooth movement could be required in other situations. It was thought that, even if it is conceivable, orthodontic therapy in the primary teeth is not recommended [15]. Detachable appliances may not be able to be used at this point due to limited patient participation, and the possibility of lengthy treatment makes this strategy inappropriate.

Mixed Dentition

Maxillary Expansion

About 21% of children have some kind of transverse skeletal discrepancy involving the dental arches, according to a research by Silva et al. (2007). Therefore, enlargement is necessary in the majority of cleft instances.[16] Patients with cleft lip and palate are frequently treated with the following expansion devices:

- Alternate Rapid Maxillary Expansion and Constriction (Eric Liou, 2005): Fan shaped expander that aids in the growth of a

hypoplastic maxilla

- NiTi palatal expander (Arndt WV, 1993): Uses super elastic and shape memory of nickel titanium wires
- Hyrax Expander (Biederman, 1968): Comfortable, hygienic, and prevents lesions to the oral mucosa
- Quad Helix (Ricketts, 1978): A slow expander that offers asymmetrical expansion in both the anterior and transverse directions

Intrusion of Premaxilla

One of the most prevalent abnormalities in patients with bilateral cleft lip and palate in primary and mixed dentition is a large and downward displaced premaxilla. Numerous studies have shown that the premaxilla's prominence gradually diminishes and disappears during the growing phase. As a result, several experts advise against treating pre-maxillary abnormalities until adulthood. But if these abnormalities are not corrected until adulthood, it could make alveolar bone grafting more difficult and have a psychological effect on the young patients. For the orthopedic intrusion of the premaxilla, Liou et al.[17] created an intraoral tooth borne distraction device that applies a strong, sporadic force. The extension arm and screw pivot around the hinge when the screw is twisted clockwise, and the hinged bolt moves upward and somewhat rearward generating intrusive force.

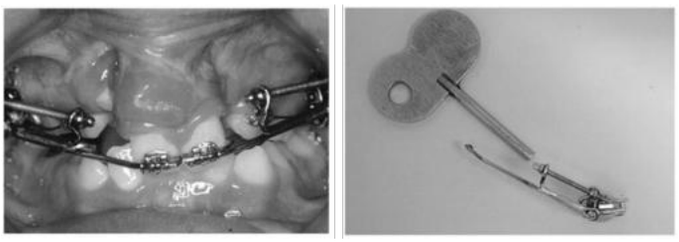

Figure 3: Intraoral distraction device for intrusion of premaxilla - Liou et al [17]

Maxillary Protraction

Patients with cleft lip and palate frequently have maxillary hypoplasia. In moderate situations of Class III malocclusion, facemask therapy or protraction headgear (PHG) can be used non-surgically to encourage sutural growth at the circum-maxillary sutures in developing patients.

Facemask therapy's primary drawbacks are clockwise mandibular rotation, non-compliance, and dentoalveolar compensation.[18] A labiolingual arch, quad helix, and fast maxillary expansion are examples of intraoral devices that have been employed to transfer the orthopedic force from the protraction facemask to the maxilla.[10] By transferring orthopedic force directly to circum-maxillary sutures, a novel approach known as Bone Anchored Maxillary Protraction[19] removes the necessity for an extraoral facemask and permits the use of intermaxillary traction 24 hours per day.

Alveolar Bone Grafting (ABG)

More than a century ago, in 1914, Drachter reported the first successful alveolar bone graft. Its goal is to give the cleft in the alveolus region a bone bridge. When ABG is successful, the maxillary arch is stabilized, there is enough bone for periodontal health and tooth support, the piriform rim architecture is normalized, nasal aesthetics are improved, and speech parameters are improved. An ineffective ABG, on the other hand, may result in tooth loss, ongoing nasal regurgitation, nasal air emission, and jeopardize subsequent orthodontic and orthognathic therapy.[20] Since extra surgery is necessary to harvest bone at a relatively young age, primary and early secondary bone grafting is no longer practiced.

The maxilla may have more growth abnormalities as a result of these procedures. Boyne and Sands introduced secondary bone grafting in 1972. Grafted cancellous bone from the iliac crest is used to bridge the cleft segment; after an average of three months, the bone becomes unidentifiable in radiographic images.

Permanent Dentition

Comprehensive Orthodontic Treatment

Usually, between the ages of 10 and 15, patients will come in for extensive orthodontic treatment. The procedure is delayed until the permanent teeth have emerged and all of the primary teeth have exfoliated. Treatment for patients with cleft lip and palate, however, may begin earlier; that is, two to three years after secondary bone grafting, when the permanent canines have erupted.

Based on the maxilla's negative overjet and deficit, the case is evaluated for orthodontic therapy or, alternatively, orthodontic treatment in conjunction with orthognathic surgery.[21] Fixed appliances are used to complete the orthodontic therapy. This aids in proper arch alignment and the treatment of dental malpositions. Every effort should be made to preserve the lateral incisor if it is located in a cleft location. If the lateral incisor is absent, the gap can be preserved for prosthetic rehabilitation or it can be closed with orthodontic therapy.

Orthognathic Surgery

In order to achieve good aesthetics and stable dental occlusion, patients with significant maxillomandibular basal jaw discrepancies and unfavorable growth patterns need orthodontics and orthognathic surgical treatment. Typically, a Le Fort I osteotomy is performed to advance the mandible, either alone or in conjunction with BSSO (Bilateral Sagittal Split Osteotomy) for the reduction of mandibular length.

Soft tissue infection, bone necrosis, tooth loss, and delayed recovery make cleft orthognathic surgery extremely challenging. Scarring from prior surgery and vascularity impairment are the main causes of these problems. Due to the forward motion of the soft palate and the advancement of the maxilla, patients with palatal clefts are at risk of developing deteriorating velopharyngeal insufficiency (increased hypernasality of the voice). As a

result, the speech pathologist must always perform a pre-operative evaluation. For these people, distraction osteogenesis is a good alternative.[22]

Distraction Osteogenesis

Distraction Osteogenesis is the process of separating the two sides of a bone to create new bone after an osteotomy or corticotomy. Distraction osteogenesis, which was first discovered for orthopaedic surgery, is now recommended as a successful treatment method for a number of craniofacial abnormalities. It makes it possible for the surrounding soft tissue envelope to expand concurrently with the progressive bone production, improving the reconstruction's long-term stability and lowering the chance of recurrence.[23]

Distraction osteogenesis can be carried out with the help of an external or internal distractor. The steps involved include:[23]

1. Osteotomy and placement of the distraction device
2. Latency period (Callus organisation)
3. Distraction (time when gradual traction is applied and distraction regenerate is formed). Gradual distraction is carried out at 0.5-1mm per day
4. Consolidation (allows maturation and corticalization of the regenerate after traction forces are discontinued)

Conclusion

Treatment for a child with cleft lip and palate starts the moment of birth. Many dentists find treating patients with clefts to be difficult, time consuming, and expensive. For the patient to receive high quality care and benefit, a thorough evaluation of the youngster is required.

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Marketing Strategies and Ethical Dilemmas in Dentistry: A Cross Sectional Study Among Private Dental Practitioners in Delhi NCR

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Abstract

Introduction: Dentistry, being one of the healing professions, bears a responsibility to uphold ethical standards that reflect the profession's commitment to society. One such ethical concern is the practice of advertising dental services. While the Dental Council of India (DCI) enforces strict guidelines against advertising in dentistry, evolving professional landscapes and the influence of digital media have prompted a shift in practitioners' attitudes. However, empirical data on dentists' perspectives, especially in the Indian context, is limited.

Aim: This study aimed to determine the attitudes and practices regarding marketing strategies among private dental practitioners in Delhi NCR.

Materials and Methods: A cross sectional survey was conducted involving 220 randomly selected private dental practitioners in the Delhi NCR region. A pre-tested, self structured questionnaire consisting of 23 closed ended questions was self administered. The questionnaire captured demographic details, opinions on advertising, use of marketing strategies, and social media engagement. Data was analyzed using SPSS version 20, applying descriptive statistics and Chi-square tests to examine associations.

Results: Among the participants, 41.8% were BDS qualified and 55.9% were MDS-qualified. A significant proportion (64.1%) supported advertising of dental services. Years of experience were significantly associated with the adoption of advertising strategies (p=0.000) and the use of social media as a marketing tool (p=0.003). Older practitioners were more likely to agree with and comply with the government's restrictions on advertising (p=0.000).

Conclusion: The study indicates a notable shift in dentists' attitudes toward marketing in Delhi NCR, with many no longer viewing advertising as unethical. This reflects a broader tension between traditional professional norms and the modern commercial realities of private dental practice in metropolitan regions.

Key Word: Dentist, Marketing, Ethics, Law, DCI.

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Introduction

Dentistry, like other health professions, is grounded in a foundation of ethics, trust, and professionalism.[1] The dentist patient relationship is inherently based on the expectation that dental practitioners prioritize the well being of their patients over commercial interests. In India, advertising by medical and dental professionals has traditionally been viewed as ethically inappropriate, primarily due to concerns that it may compromise the dignity and trustworthiness of the profession.[2]

The Dental Council of India (DCI), through its professional conduct regulations, prohibits direct or indirect forms of advertising that could be perceived as self-promotion or a means to solicit patients. These regulations aim to preserve the professional integrity of dentistry and to ensure fair competition and responsible patient care.[3]

However, the healthcare landscape in India has witnessed a rapid transformation. Nowhere is this shift more visible than in Delhi NCR, one of the most urbanized and economically dynamic regions of the country. With increased competition, the growth of corporate dental chains, patient

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consumerism, and widespread internet usage, many private practitioners in Delhi NCR feel compelled to adopt marketing strategies to stay relevant and competitive.[4]

The ethical dilemma arises when the traditional regulatory framework does not align with the practical demands of modern dental practice.[5] Despite the widespread use of promotional techniques, there has been limited research on how dentists in India perceive and navigate the issue of marketing.[6] This study seeks to explore these perspectives in the context of the Delhi NCR, where both opportunities and ethical challenges are magnified by urban dynamics.

Aim

To determine the attitudes and practices of marketing strategies, including the use of social media, among private dental practitioners in Delhi NCR, and to evaluate whether these practices align with existing ethical and regulatory guidelines issued by the Dental Council of India.

Materials and Methods

Study Design and Setting

A cross sectional questionnaire-based survey was conducted among private dental practitioners operating in the Delhi NCR region, covering the cities of Delhi, Noida, Gurgaon, Ghaziabad, and Faridabad. These areas represent a diverse blend of solo dental clinics, multi-specialty practices, and corporate dental setups.

Sample Size and Sampling Technique

A total of 220 private dentists were selected using simple random sampling. This ensured representation across varied levels of experience, qualifications, and practice environments in the region.

Survey Instrument

The questionnaire was self administered, pre-tested, and structured, consisting of 23 closed ended questions grouped into three primary sections:

1. Demographic Details – Age, gender, academic qualification (BDS/MDS), years of clinical experience, and practice location.
2. Attitudes Toward Advertising – Beliefs about the ethicality, necessity, and impact of marketing in dentistry.
3. Marketing Practices – Use of promotional tools such as digital ads, brochures, clinic branding, patient referral systems, and social media platforms.

Ethical Considerations

The study was approved by the Institutional Review Board (IRB) of the respective academic institution. Informed consent was obtained from all participants, with assurances of anonymity and data confidentiality.

Data Analysis

Collected data were analyzed using SPSS version 20. Descriptive statistics (percentages, frequencies) were used to present demographic and response distributions. The Chi-square test was used to assess associations between demographic variables and attitudes/practices. A p-value of less than 0.05 was considered statistically significant.

Results

Demographic Distribution

Among the 220 respondents:

- 41.8% were BDS graduates, and 55.9% were MDS specialists.
- Age and experience levels varied, with practitioners ranging from recent graduates to those with over 20 years of practice.

Attitudes Toward Advertising

- 64.1% of dentists supported the idea of advertising their services, citing competition and patient outreach as major reasons.
- Only 25% believed that advertising makes dentistry seem more like a commercial trade.
- Many viewed ethical advertising as a means to educate the public, improve clinic visibility, and build patient trust in an informed way.

Marketing Practices in Delhi NCR

Dentists in Delhi NCR reported using various marketing techniques, including:

- Clinic brochures, signage, and branded material
- Website development and search engine optimization (SEO)
- Referral discounts and promotional packages
- Social media platforms (Instagram, Facebook, WhatsApp, YouTube) for case showcasing, patient reviews, and service awareness

Key Statistical Associations

- Years of experience was significantly associated with the likelihood of using advertising strategies ($p = 0.000$).
- Newer practitioners (<10 years experience) were more inclined to use digital marketing and social media ($p = 0.003$).
- Older practitioners (>15 years experience) were more likely to comply with the DCI ban and expressed concerns about over commercialization ($p = 0.000$).

Discussion

The results of this study highlight a significant transformation in the perception and adoption of marketing practices among dental professionals in Delhi NCR. While DCI guidelines remain conservative in nature, the professional environment in Delhi NCR a hub of private healthcare demands visibility and patient engagement.[7]Several important observations emerge : Market Competition Drives Marketing In a saturated environment with numerous dental clinics, patients often base their decisions on online presence, reviews, and perceived professionalism through branding.[8] Digital Influence is Growing With smartphone

penetration and social media usage high among urban patients, digital platforms have become essential tools for outreach. [9] Generational Shift in Ethical Perception Younger dentists tend to view marketing as a strategic necessity, while more senior practitioners retain concerns about preserving ethical norms.[10] Despite the growing normalization of marketing in dental practice, the study raises concerns about the gap between regulatory compliance and actual practice. With 64.1% in favor of advertising and only 25% seeing it as ethically questionable, it is evident that DCI regulations may be outdated in the face of modern practice realities.

Conclusion

The study conducted among private dental practitioners in Delhi NCR indicates a clear shift in professional attitudes toward marketing and advertising. While Indian dental law discourages commercial promotion, in practice, many dentists particularly those newer to the field are adopting marketing strategies, including extensive use of digital and social media platforms.

There is a need to reconcile ethical expectations with evolving realities. A reformed regulatory framework that allows ethical, truthful, and educational marketing can provide clarity to practitioners while protecting patient interests and maintaining professional dignity.

Recommendations

1. **Reform DCI Guidelines:** Introduce clearer distinctions between ethical education based advertising and unethical commercial promotion.
2. **Educate Dentists on Marketing Ethics:** Integrate digital professionalism and communication ethics into undergraduate and postgraduate dental curricula.
3. **Encourage Transparent Practice:** Promote honest patient communication and evidence based promotional content to ensure public trust.
4. **Develop a Professional Code for Digital Conduct:** Dental councils and associations can issue best practices for social media use and digital branding.
5. **Engage Patients in Dialogue:** Increase public awareness about selecting dentists based on credentials and quality, not just marketing appearance.

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Current Concepts and Trends In Forensic Odontology - A Review

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Abstract

Forensic Odontology is a relatively new science that utilizes the dentist's knowledge to serve the judicial system. It has established itself as an important indispensable science in medicolegal matters and in particular in identification of the dead. Worldwide, dentists qualified in forensic science are giving expert opinion in cases related to human identification, bitemark analysis, craniofacial trauma and malpractice. Dental professionals have a major role to play in keeping accurate dental records and providing all necessary information so that legal authorities may recognize malpractice, negligence, fraud or abuse, and identify unknown humans. This article presents a literature review referring to the understanding the various methods along with their applications employed in forensic odontology.

Keywords: Forensic Odontology, Tongue prints, Dental Identification, Bite marks, Cheiloscopy, Rugoscopy

Introduction

Forensic odontology has been defined by the Fédération Dentaire Internationale (FDI) as 'that branch of dentistry which, in the interest of justice, deals with the proper handling and examination of dental evidence, and with the proper evaluation and presentation of dental findings'. It primarily deals with identification, based on recognition of unique features present in an individual's dental structures. Forensic dentistry plays a major role in identification in man made or natural disasters events which result in multiple fatalities that may not be identifiable through conventional methods such as visual recognition or even fingerprints.[1]

As dental surgeon has to actively involved in various objectives of forensic dentistry like age and sex determination, personal identification of unknown deceased person, analyzing bite marks as evidence, participating in mass disaster, studying lip prints, giving evidence in child abuse and in civil and criminal litigation, his role in personal identification and criminal investigation is very much important, as his evidence would be very much useful in law and justice.

Dentist's role in criminal investigation includes collection of information from bite marks, lip prints and teeth found in the crime sites like, quarrel, robbery, murder and rape.[2]

Methods used for Identification [3]

1. Visual Information
2. Personal or medical information:

a. General information: Height, weight, build, age, presence or absence of hair, its colour and style, eye colour, facial hair, facial characteristics

b. Specific information: Scars, tattoos, birth-marks, operations, amputations, breast implants, old injuries, medical conditions, body piercings

c. Radiological information: Anatomical abnormalities, foreign bodies (prosthesis)

3. Clothing: Items last seen wearing, patterns of fabrics, labels, alterations/ repairs
4. Personal effects and documentation: Contents of pockets and bags, jewellery may be recognizable or have specific inscriptions/engravings.
5. Dentistry

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6. Fingerprints: May be on record, but it is often necessary to take them from personal items in the home or workplace for comparison purposes
7. Feet: Foot prints are kept on record by some armed forces. Records from a chiropodist/podiatrist may hold useful information
8. DNA profiling

Dental Record and Identification

Dental identification assumes a primary role in the identification of remains when postmortem changes, traumatic tissue injury or lack of a fingerprint record invalidate the use of visual or fingerprint methods.[4]

Collection of dental postmortem examination information [3]

The following will be noted:

1. Dental arch shape, alignment, occlusion
2. Number and position of teeth present and missing
3. Size, shape, position and material of any restorations, presence and position of decayed surfaces
4. Denture and other appliance design and material
5. Individual tooth characteristics, for example tooth wear, fractures, anomalies of size, shape and colour
6. Hard tissue and soft tissue (if present) status, abnormalities or pathologies
7. Any other findings of interest, or clues to age, race, diet, occupation etc.

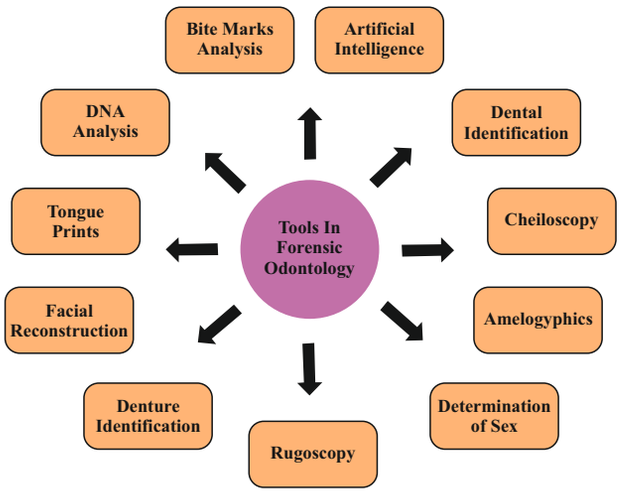

Figure 1: Tools In Forensic Odontology

Bite Mark Analysis

In forensic sciences, odontology evidence is the third most accurate technique of fingerprint and DNA analysis identification.[5] According to a study by Pretty and Turnbull, the bite mark analysis is based on the factor that human dentition is unique and its uniqueness is rendered during biting that aids in the identification.[6] Bite marks can deform because of the flexibility and elasticity of the skin. The amount of pressure exerted while biting, along with the body posture and the angle of the maxilla and mandible during the bite, can all determine the appearance of a bite mark .[7]

Literature reveals different methods for bite mark analysis like manual, radiographic, and computed assisted techniques. According to the studies of Van der Velden et al.,[8] and Osman et al.,[9] indirect methods for bite mark analysis using computed-assisted techniques were more accurate.

The American Board of Forensic Odontology (ABFO) guidelines state that the evidence should be gathered from both the victim and the suspect and a proper basis for evidence collection should be instituted. Any variations from these recommendations and guidelines should be questioned.[10]

Dental Profiling

Dental Profiling is a specialized technique within the field of forensic odontology that involves the analysis & interpretation of dental characteristics to establish individual identities. It plays a crucial role in victim identification, criminal investigations & medicolegal cases. Here's a detailed overview of dental profiling;

Dental Characteristics : - Teeth are highly resistant to decomposition & can withstand extreme environmental conditions, making them valuable sources of identification evidence. Dental characteristics, such as - tooth morphology, restorations, anomalies, & pathologies are unique to each individual & can be used for identification purposes.

Dental Records Comparison : - Dental profiling often involves comparing ante-mortem (before death) dental records with post-mortem (after death) findings. Ante-mortem records may include dental charts, radiographs, treatment notes, & photographs provided by dentists or, obtained from dental clinics. Post-mortem records are collected during the forensic dental examination of the deceased individual. The comparison of ante-mortem & post-mortem records helps establish a positive identification or, exclude potential matches.

Radiographic Analysis : - Dental radiographs, such as bite-wing, periapical, & panoramic radiographs provide detailed information about tooth morphology, restorations & bony structures. Comparison of ante-mortem & post-mortem radiographs is a reliable method for identification, as radiographic features are unique & remain stable over time. Advanced imaging techniques, such as Cone beam computed tomography (CBCT), offer 3D visualization & enhance the accuracy of radiographic analysis.

Dental Restorations & Anomalies : - Dental restorations including fillings, crowns, bridges & implants can provide valuable identification evidence. The type, location, & material of restorations are recorded in dental charts & can be compared with post-mortem findings. Dental anomalies, such as missing teeth, supernumerary teeth, rotated or, tilted teeth & developmental defects can also aid in identification.

Dental Age Estimation : - Dental profiling techniques can estimate the age of an individual based on the development & eruption of teeth, as well as age related changes in dental

structures. Dental age estimation is particularly useful in cases involving unidentified juvenile remains or, in determining the legal age of an individual. Various methods, such as the Demirjian method, Radiographic method of Kvaal, Gustafson's methods are employed for dental age estimation.[11]

Cheiloscopy

Cheiloscopy is a forensic procedure that uses human lip traces for identification.[5] It is commonly used to compare the results of an autopsy and a patient's postmortem examinations.[2] Unlike other methods, lip prints are unique and do not change during the lifetime of a person. They provide forensic investigators with sufficient information to perform their investigations.[12]

The lip print pattern is determined by the mouth being open or closed. The lip has well defined grooves when the mouth is in a closed position, whereas the grooves in the open mouth posture are ill defined and difficult to understand. Changes in lip prints can also be caused by missing anterior teeth leading to support loss in that area. Lip print recording can be hampered by debris or moisture on the surface of the lip, a dense lipstick layer, or over stretching of cellophane tape.[13]

Rugoscopy

In mammals, the presence, number, and arrangement of palatal rugae vary by species.[14] They are asymmetrical in humans, which is a unique trait of humans.[15,16] Palatal rugae can be utilized as a complement in edentulous mouths where postmortem identification of dental status is not possible. Many academics are concerned about the prospect of palatal rugae pattern alterations with aging and other external stimuli. Orthodontic tooth movement, neighboring tooth extractions, surgery of cleft palate, periodontal surgical procedures, and forced eruption of impacted canines are a few of the issues that need to be addressed.[17]

Tongue Prints

Tongue prints are as unique as finger print.[18] Even identical twins cannot have same tongue print. The color, shape, and surface of tongue are characteristic of each and every individual and emerging as a potential biometric tool in the field of forensic dentistry [19]. The tongue biometric template is feasible with three views such as right lateral view, left lateral view, and profile view. The efficient template for shape of the tongue can be obtained by extraction of tongue algorithm of collecting points. The normalized histogram with Scale Invariant Feature Transform is utilized for texture analysis. By combining both the extraction techniques templates, the matching can be done.[20] These databases can be collected and stowed by dentist during routine dental procedure which can serve as forensic tool in future.

Determination of Sex

Sex determination is a crucial subset of forensic odontology that aids in an unknown person's identification following natural calamities, as well as chemical and nuclear bombing situations. There are four ways to do it:[21]

1. Dimension and morphology of the craniofacial complex: The mastoid, supraorbital ridge, skull size and architecture, zygomatic extensions, nasal aperture, and mandible gonial angle, as well as the pattern established by these traits, are all taken into consideration.
2. Sex difference in dimension of tooth: The most reliable approach for sex determination is to measure the mesiodistal and buccolingual dimensions. In males, both dimensions are larger than in females.
3. Tooth morphology: The male canine has a more prominent distal accessory ridge than the female. In females, the mandibular first molar has fewer cusps. These characteristics may be due to an evolutionary reduction in the size of the female lower jaw.
4. DNA analysis for sex determination: According to Das and his colleagues' investigation, sex determination might be acquired up to four weeks after death by examining the X and Y-chromosomes.

Facial Reconstruction

Forensic facial reconstruction is a quick, non invasive, and effective approach for identifying people from skeletal remains. This forensic tool combines scientific approaches with artistic abilities.[22] There are two sorts of reconstruction techniques: two-dimensional (2D) and three dimensional (3D).[23]

In the case of 2D face reconstruction, the method focuses to re-create the face from the skull using estimates of soft tissue depth based on the antemortem photographs.[24] In the case of 3D manual reconstruction, a recreation of the face is performed by using clay, plastic, or wax directly on the skull of the victim which is to be identified. This method employs tissue depth markers of particular lengths to specify various depths of soft tissue.[25]

DNA Analysis

It is a novel tool employed in forensic investigations due to its ability to overcome the effects of traumatism, heat, and autolytic processes. In addition, it allows investigators to perform DNA typing with minimal resources. [26] DNA is found in various parts of the teeth, such as the pulp tissue, the cement, and the alveolar bone. In forensic cases, DNA can be extracted using a variety of methods.[27]Genomic DNA and mitochondrial (mt) DNA are used in forensic investigations.

Digital Research

Accurate and comprehensive dental records are crucial in forensic odontology, particularly in identifying individuals. These records should include the patient's medical history, clinical examination, dental records, therapy, and follow-up information. Any errors in charting can invalidate the record. Dental records may also contain radiographs, study casts, impressions, and clinical pictures. In many European countries, registering dental data is mandatory, and erasing a patient's record requires state legislation permission. Digital imaging technologies, like Dental Cross, can also positively identify individuals. Teeth are often identified using two techniques: comparing previous dental records with PM dental characteristics or creating

a PM dental profile to guide the search for AM materials. Dental identification is critical, as teeth are more resistant to deterioration than other bodily tissues. [28]

Saliva Analysis

Saliva analysis providing valuable information for identification and investigation purposes. Saliva contains DNA, enzymes, hormones, and other biomarkers that can be analyzed to identify individuals, detect diseases, and determine the presence of drugs or toxins. In forensic odontology, saliva analysis can be used to analyze saliva stains on bite marks, clothing, or other objects found at crime scenes. This can help investigators link suspects to crime scenes, identify victims, and reconstruct events. Additionally, saliva analysis can also be used to detect saliva on dental evidence, such as dentures or orthodontic appliances, aiding in the identification of human remains. [28]

Ameloglyphics

Ameloglyphics is the study of enamel patterns. Since the enamel rod pattern varies by gender and is unique to each person, it can help with human identification. It also helps in age estimation ,bite mark analysis ,victim and suspect linkage. It is useful when DNA or fingerprints are unavailable. It can be applied to both living individuals and deceased bodies. Enamel rod patterns can be visualized using acid etching, scanning electron microscopy (SEM), or polarized light microscopy. It requires high magnification tools for clear pattern visualization.

After examining the enamel pattern of the left maxillary canine and first premolar in 30 male and 30 female volunteers using the cellulose acetate peel technique, Manjunath et al. came to the conclusion that the branched wavy sub pattern was the most prevalent kind by visual inspection.[29]

AI Current Trend

AI and machine learning are now used to analyse rugae patterns digitally, improving accuracy and reducing human error. High resolution 3D laser scanners and CBCT allow detailed visualization and comparison of palatal rugae. 3D printing of palatal rugae models helps forensic experts reconstruct oral structures from remains. AI assisted rugae pattern classification are also recently evolved.

Recently use of 3D scanning technology allows for more detailed lip print analysis, especially in cases where prints are distorted on different surfaces. AI and machine learning algorithms are being used to enhance the classification and comparison of lip prints, reducing human error and improving accuracy. Next generation sequencing (NGS) has made it possible to analyze damaged and mixed DNA material with previously unheard of precision. By revealing information about tissue origin and environmental exposure, methods like forensic epigenetics and microbiome analysis have given DNA based evidence additional dimensions. Algorithms assess pulp to tooth ratio and tooth mineralization for accurate age prediction. The enamel of teeth contains sex specific proteins, such as AMELY and AMELX peptides, which remain intact even in ancient or degraded remains. Studies suggest that differences in protein expression in dentin and cementum can help in sex identification. [29]

Conclusion

Forensic odontology is a looming branch that holds a promising scope in forensic discipline. How much ever less the available remnant is, the forensic dentistry will try to resolve it. Forensic dentistry is constantly trying to update the available forensic tool and simultaneously developing novel tools for identification. Sometimes it plays adjunct role in identification procedure whereas sometimes plays main role in identification procedure. With the constantly developing novel tools and with the further research in the field of forensic odontology it is evident that soon this discipline will cherish an unconquerable position in the world of forensic science. Dentists should update their knowledge in this field since their contribution is undeniable for making the base of this discipline even stronger.[18]

Future Proposal

Dental records are majorly contributing in solving forensic mysteries including personal identification. Unique IDs such as Aadhar cards are already linked with individuals bank accounts, driving license, PAN cards, registration certificates of the vehicles. We recommend that dental records such as Orthopantomogram (OPG) providing a holistic information about the individual dentition should be linked to individuals Aadhar cards.

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Fracture of Mandible : A Review of Literature

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Abstract

Fracture of mandible accounts for 25% out of all maxillofacial fractures. Most common cause is vehicular accidents, assaults, falls and then sports activities. The body fractures are mainly classified into 2 types i.e., favourable and unfavourable fractures on the basis of fracture line and the effect of muscle pull. Evaluation can be done via OPG Xray, CT scan, etc. There are two methods to treat mandibular fracture i.e., surgical management (open reduction) and non surgical management (closed reduction).Most common complications of mandibular body fractures are osteomyelitis or infection.

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Introduction

Out of all maxillofacial fractures, the 25% are fracture of mandible.[1] Mandible body fractures accounts for almost 11%-36%, with personal violence as the principal factor among the different types mandible fracture.[2]

Etiology

The etiology of mandible body fractures are violence/assault, falls, sports activities and vehicular accidents.[2][1] Most common cause is vehicular accidents that is 43%, followed by assault that is 34%,then falls (7%) and sports accidents that is 4%.

Epidemiology

According the various studies in all the mandibular fractures, the mandible body fracture is 29% (11-36% range) ,followed by condyle and angle. Condylar and body fractures are most prevalent maxillofacial fractures in children.[3] Body fractures are more common in males than females.[1]

Pathophysiology

Fracture of mandible body generally occurs between the distal aspect of canine and a hypothetical line that communicate to the region of anterior attachment of the masseter muscle. They are classified based on the position of teeth relative to the fracture, anatomic location, favourableness and the direction of fracture line.[4][5]

Based on the direction of fracture line and the effect of muscle distraction on the fracture fragments, the body fractures are classified into two types ; favourable and unfavourable fractures. The body fragments are drawn together by muscle distraction in favourable fracture but the body fragments becomes displaced by the muscle forces is unfavourable fractures.

There are various muscles which exerted forces that furnish unfavourable fractures are medial pterygoid muscle, masseter and temporalis. The muscles deflect the proximal bony segments in the supermedial direction. Moreover, mylohyoid and anterior belly of diagastrics may also plays a role in displacing the segment in the posterior and inferior direction.

History and Physical Examination

History

Patient's thorough history include any collagen vascular disorder, neoplasia affecting the bone, pre-existing systemic bone disease, arthritis and temperomandibular joint dysfunction must merit consideration. Any additional fractures preserve and the

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nature of the injury is the assessable traumatic force. Vehicular accidents tends to have a larger magnitude forces which results in multiple, compound, comminuted mandibular fractures compared to assaults that results in a single , simple, non displaced fractures.

Physical Examination

Intraorally, on physical examination a change in occlusion may be apparent. Anaesthesia, paresthesia or dysesthesia of the lower lip may be present. Sensation of lower lip changes generally in displaced body fractures that are distal to mandibular foramen (along with the distribution of the inferior alveolar nerve) and they are not generally seen in non displaced mandibular fractures.[6][7]

In general, the common sign of body fractures are step defects in the occlusion, laceration in the gingiva , and/or ecchymosis in the floor of the mouth. Mobility in the fractures should be noted by the examiner by the use of both hands on the occlusal surface of the teeth and finger on the inferior border of the mandible. Then slowly carefully, pressure should be between the two hands.[6][7]

Extraorally, there may be change in facial contour due to skin abrasion and loss of external mandibular form. Flattened appearance of the lateral aspect of the face often results due to body fracture. Loss of the mandibular body present on palpitation. An unfavourable fractures should be suspected. Anterior face may get displaced in the forward direction which results in the elongation. In these cases, the anterior mandible displaced in the downward direction. Other finding include hematoma, ecchymosis and laceration.

Evaluation

Evaluation of the body fractures is done via radiographs using plain radiography (occlusal, lateral -oblique, panoramic, periapical and posterioanterior views) and CT Scan. Caldwell posterioanterior view shows the presence of the medial or lateral displacement of body fractures. The lateral oblique view helps to diagnose posterior body fractures. Panoramic radiographic is the most informative among all the radiographs. Entire mandible can be viewed in a single plain along with several advantages such as cost effectiveness, simplicity of technique and low radiation exposure compared with CT or CBCT (Cone Beam Computed Tomography) . In severely traumatised patient it is challenging to take a panoramic radiograph because it usually requires the patient to be upright postion. Also, it becomes difficult to appreciate buccolingual bone displacement as it is a 2-D image.

CBCT can be useful as it is highly sensitive in identifying fractures when convention 2-D radiographs cannot give accurate picture of the fracture. Also, it decreases the chances of interpretation error and provides better image quality.[7][8]

Treatment/Management

There are 2 methods to treat mandibular fracture i.e., surgical management and non -surgical conservative management. The treatment of fractures using non-surgical or surgical means depending on the type , consequences and severity of fracture. In non surgical management (also known as closed reduction), MMF (maxillomandibular fixation) serves to stabilise the fracture.[9]

It offers various advantages such as it is a less invasive procedure, low sensitivity to the professional experience and low cost as it does not requires any surgical treatment and hospitalisation. However MMF should not occur in a patient with seizure disorder, intellectual disability, pregnancy, multiple system injuries, psychosis , severe pulmonary dysfunction and non-complaint patient. Indication for closed reduction includes:

1. Edentulous fractures.
2. Presence of adequate occlusion.
3. Non displaced favourable fractures.
4. Grossly comminuted fractures.
5. Fractures in children with developing dentition.
6. Presence of healthy dentition with sufficient teeth to obtain a stable occlusion.
7. Good facial esthetics and adequate open mouth.

In this procedure use 24 gauge wire for the placement of Ivy Loops between 2 stable teeth followed by a smaller gauge to provide MMF between the loops (Ivy loops) frequently used arch bars are bars with 24 and 26 gauge wires. Arch bar by tension bonding mechanism provides additional stability which results in a second line of resistance. While placing arch bars , at least includes all the teeth in the affected quadrant of the mandible. It is not necessary to enclose whole dental arch . Arch bars have low cost, are easy to place , reduce the distraction of the bones at the healing site and restore normal occlusion. However, they provide only semirigid fixation and requires a second procedure for their removal. By using circum mandibular wires dentures can be wired to the jaw in the case of an edentulous mandible. Due to wires in the mandibular vestibule postoperative discomfort present. Also , there is a risk of damage to structures on the floor of mouth and there is a risk of submental scar formation.[10]

MMF screws are an alternative option to fix the dentures. These are self tapping screws, that placed in the sound bone in the vestibular regions anteriorly and posteriorly. They provide a bone anchor where wires or elastics can be placed for MMF while establishing the occlusion of patients.[11][12] By placing arch bars in the denture and intermaxillary fixation can be achieved. In such cases another options are Gunnning Splints.[13]

In surgical management i.e., internal rigid fixation (IRF) and open reduction, the fracture site easily visualise by surgeon and control the reduction. There is the quick recovery of the occlusion, maintainance of periodontal tissue, reconstruction of anatomic osseous morphology to its pre-surgery form , and due to good nutrition and verbal communication return to early function.[14] However, there is a risk of increased morbidity in it. A tooth in line of fracture may need to extract before any surgical treatment. Extraction is indicated when the tooth has compromised periodontium resulting in mobility or has fracture roots, or has an extensive peri apical infection or it is impossible or

difficult to reduce the fracture due to the presence of the tooth. However, that tooth may helps in guiding the reduction of fracture before extracting. After applying for the plate across the fracture, the occlusion is checked and the reduction is confirmed. The screws and plates are then removed, extraction of tooth is done and the plate reapplied by replacing the screws in the initial holes.

Surgical management can be take place using and extraoral or intraoral approach, the choice depends mainly on the type of body fracture and on the site. Preferably treatment for simple and fracture in the entire segment with no or slight dislocation by use of intraoral approach.[15] The intraoral approach provides great access to the fracture site and it allows observing of the occlusion to reduce fracture and application of rigid fixation. Approximately 5 to 7 mm inicision is placed in the vestibular region below the mucogingival junction to facilitate closure. The location also helps in the prevention of wound dehiscence. Care is necessary to avoid injuring the mental nerve during an intraoral approach.

On the other hand, the clinician can treat fracture in the posterior segment with a high degree of dislocation and comminuted fracture with an extraoral approach as placing stronger and longer plates is difficult by intraoral approach. Fracture that lie between the mandibular body inferior and lingual aspects extraoral surgical approach may be use. To avoid injury in the marginal mandibular nerve care should be done.[16][17]

Indication for Open Reduction

1. Fracture of an edentulous mandible (involving a severe displacement of fracture fragments) to re establish mandible continuity.
2. Displaced unfavourable body fracture.

Postoperatively, analgesics should be given to the patient with open reduction, to cover gram positive organisms antibiotic therapy should be given. Nutritional needs reevaluation should also follows. Inter maxillary fixation (IMF) is maintained for 4 to 6 weeks in most of the adult mandibular fracture cases. 2 weeks may sufficient for patients with a minimal displaced fracture in the tooth bearing area. A radiograph should be done to ensure the union of the fracture after the removal of wires.

Differential Diagnosis

Thorough evaluation and monitoring of the patient's general physical condition are necessary before treating mandibular body fracture. Force which cause mandibular body fracture may also injures other organs system. There may occur pneumothorax, pneumomediastinum, concurrent postraumatic thrombosis occlusion of the internal carotid artery posterior basilar skull fracture, spleen laceration and bilateral cervical subcutaneous emphysema after trauma. Therefore, patients should not treated unless there issues are addressed by surgical reduction of mandibular body fractures.

Prognosis

Favourable results in terms of bony union can be achieved by both open and closed reduction of mandibular body fractures. As the fractured teeth may become infected and jeopardise the treatment of dental injuries should be done concurrently with the fracture . Hence, they require removal. Mandibular canines should be preserved as it help to determine the occlusion , if possible. Edentulous body fractures the management and prognosis are often challenging due to multiple comorbidities and advanced age.

Complications

Most common complication is osteomyelitis or infection (resulting in malunion or non-union). Contributing factors are:[18]

1. Alcohol abuse and Chronic disease.
2. Oral Sepsis.
3. Fracture of the plate.
4. Poor patient compliance.
5. Displacement of fracture.
6. The prolonged time prior to treatment.
7. Teeth in the fracture line.

Other complications are delayed union of the fractured mandible. The airway may get impaired if the mandible body fraction is bilateral along with the parasymphyseal, or condylar fractures. This impairment resulting in the obstruction of the oropharynx by the tongue because of the muscular action that pulls the distal mandibular segment backward. There may also nerve damage such as neurotmesis, in which function may take around 18 months to return or neuropraxia , in which function takes around 4-6 weeks to return.

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Histopathological Grading of Leukoplkia: A Review

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Abstract

Leukoplakia, a which is a common oral potential malignant lesion, often preceding into the development of oral carcinoma. Clinically, it typically appears as whitish patches on the oral mucosa. Despite advancements in diagnostic tools, histopathological grading remains the gold standard for evaluating such lesions, primarily by identifying characteristics of epithelial dysplasia a pre-malignant alteration marked by specific cellular & architectural changes.

However, grading leukoplakia histologically presents significant challenges for oral & diagnostic pathologists, including inter- & intra-observer variability & ambiguity in selecting the extremely relevant diagnostic criteria. To enhance consistency & accuracy, it is essential that pathologists adopt standardized grading protocols & clearly defined criteria when interpreting dysplasia in leukoplakia. This article provides a concise overview of the various histopathological grading systems currently used for assessing leukoplakia.

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Introduction

Oral cancer ranks eighth in men & fourteenth in women worldwide among all cancer types, in accord with the International Classification of Diseases classification system, World Health Organisation & the International Agency for Research on Cancer.[1] Information gets collected by the Indian Council of Medical Research, oral cancer is the utmost prevalent disease among males, especially those aged between 30-69 years, whereas breast cancer is the most common found malignancies within women. It has been estimated that 20% of all malignancies in the nation are oral cancers, with an incidence of 20 cases per 100,000 people.[2]

In India, mouth cancer is still a major public health concern due to its high frequency. Timely intervention, higher cure rates, & a decrease in morbidity & death all depend on early identification.3 Lymphatic metastasis is quite prevalent in the H&N (head & neck) region due to the physical closeness of the lymph nodes. Interestingly, the 5 year rate of survival might drop to levels as low as 9% if metastases arise.[4]

Oral leukoplakia is the most often recognised among a variety of potentially malignant illnesses that precede the majority of OSCC cases. Oral epithelial dysplasia, in which abnormal alterations are limited to the epithelium, is a characteristic of several illnesses.[5] The lesion is deemed malignant after the connective tissue underneath is invaded by these changed cells. Leukoplakia is thought to have an aggressive growth rate of about 1%.[6]

Leukoplakia histopathological grading is essential for diagnosis & treatment, but it is still difficult due to the observer variability & the absence of the standardised grading criteria. A summary of the various histological grading schemes used to evaluate leukoplakia has been mentioned in this article.

Criteria For Dysplasia

Dysplasia is the word used when cytological a typia, or changes in the size & form of the keratinocytes, coexist with architectural disruption. The following is a list of diagnostic standards for the oral epithelial dysplasia.[7]

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Tissue Modifications

The layering of epithelium is irregular.

Loss of basal cell polarity

Increased basal cell size

Rete ridges in the form of drops

A higher quantity of mitotic figures

Mitoses that are abnormally superficial

Single cell premature keratinisation (dyskeratosis)

Pearls of keratin inside rete-ridges

Cytological Changes

Irregular nuclear size fluctuation

Irregular nuclear pleomorphism/ modifications in the nuclear shape

Unusual cell size alteration

Aberrant cellular pleomorphism

Elevated ratio of nuclear to cytoplasm

Nuclear size enlargement

Development of unusual mitotic figures

Larger size & numerous nucleoli

Larger amounts of colour

These characteristics can be roughly classified as alterations to the epithelium's architecture (strata) & those that show up as cellular a typia.

Histopathological Grading of Leukoplakia

Different grading methods are used to grade the extent of such cellular & tissue alterations. Ljubljana, 2005 WHO, & Kujan et al.'s 2-tier categorisation (Binary System) are the most widely used & recognised categorisation schemes. 8. The cytological & architectural differences seen in Haematoxylin & Eosin (H & E) stains beneath light microscopy serve as the primary foundation for these categorisation schemes.

LCP classification & staging (1994)[9]

At an international meeting in Uppsala, Sweden, in 1994, this was suggested. L. provisional: An initial diagnosis of oral leukoplakia is determined whenever a lesion from clinical examination cannot be positively diagnosed as any other unique white looking condition of the mouth cavity.

L. conclusive: The identification and, if feasible, removal of potential etiological variables, as well as histological evaluation in the event of persistent lesions, lead to an accurate identification of oral leukoplakia.

L prov The size is shown by the first symbol (L):

Type	Size of the OL
One	Less than 2 cm
Two	Less than 2-4 cm
Three	More than 4 cm
X	Non specified

Second symbol (C) indicates clinical characteristics where:

Type	Clinical aspect
One	One Homogenous
Two	Non- homogenous
X	Non-specified

3rd symbol symbolizes the (P) pathological characteristics as follows:

Type	Microscopic features
One	One No presence of dysplasia
Two	A little degree of dysplasia is seen.
Three	Mild to moderate dysplasia
Four	There is a significant degree of dysplasia.
X	Non - specified

Classification of stages

Stages	Grouping of the stages
One	One Any of the L C1 P1 P2
Two	Any of the L C2 P1 P2
Three	Either L/ or any of the C P3 P4

The remarks are as follows:

1. In cases of uncertainty regarding the appropriate L, C, or P category classification, the lower category should be assigned to ensure conservative & consistent categorization.
2. The lesion with the greatest L classification should be chosen for categorisation if there are several leukoplakic lesions present at the same time. Parentheses should be used to indicate the existence of several lesions, such as L2 (many).
3. The lesion exhibiting the largest clinical score amongst the various forms of oral leukoplakia should be taken into consideration for categorisation when several clinical types coexist.
4. When many biopsies are taken, either from distinct leukoplakias or from one leukoplakic lesion, the maximum pathology score seen in all of the biopsies should be noted.
5. The International Classification of Diseases for Dentistry & Stomatology should be followed when documenting & reporting the oral subsite in question.

The following is the LSCP classification and stage scheme for oral leukoplakia:

LSCP Classifications	Staging system
First symbol	L- extension of lesion Lo - no evidence of lesions present L1 - lesion less than 2 cm L2 - lesion of 2 - 4 cm L3 - lesion less than equal to 4 cm Lx= non-specified
Second symbol	S - site of lesion S1 - all oral sites, besides floor of mouth & tongue S2 - floor of tongue Sx - non-specified
Third symbol	C - clinical aspect C1 - homogenous Cz - non-homogeneous Cx – non-specified
Forth symbol	P – histo-pathological characteristics of biopsy, if taken P1 - No presence of dysplasia Pz - A little degree of dysplasia is seen. P~ - Mild to moderate dysplasia P4 - There is a significant degree of dysplasia P~ - non-specified

Only leukoplakias with prior histological inspection are eligible for staging.

Oral Leukoplakia Staging System

Stages of oral leukoplakia	Criteria
Stage One	Either of the L, S1, C1, P1 / P2
Stage Two	Either of the L, S1, C2, P1/ P2 OR Either of the L, S2, C1, P1/ P2
Stage Three	Either of the L, S2, C2, P1 /P2
Stage Four	Either of L, S, C, P3/ P4

Legends
- L= lesion size category
- S= site risk category
- C= clinical appearance
- P= pathological grading

General Rules for Applying the LSCP System

1. Uncertainty in Category Assignment: If there is uncertainty about assigning a specific L (Lesion size), S (Site risk), C (Clinical appearance), or P (Pathology) category, choose the lower (less severe) category. This choice will influence the overall staging outcome.
2. Several Concurrent Leukoplakias: When there are several leukoplakia lesions at the same time, group them according to the lesion that has the highest L and/or S score. Put numerous lesions in parenthesis, such as L2 (m), to indicate their presence.
3. Many Clinical Presentations: For categorisation purposes, choose the most significant clinical score amongst the many clinical forms of leukoplakia that are seen.
4. Several Biopsies: Use the highest pathology grade among the readily accessible biopsies for staging when several biopsies are obtained from either one leukoplakia or from distinct leukoplakias.
5. Site Documentation: For proper reporting, the particular oral subsite in question needs to be recorded in accordance with the ICD-DA.

The Oral Leukoplakia Staging System and Modified Classification:[10]

Modified Oral Leukoplakia Classification System

L – Lesion Size

L1: Total size of leukoplakia less than 2 cm

L2: Total size of leukoplakia between 2–4 cm

L3: Total size of leukoplakia more than 4 cm

Lx: Size of the leukoplakia non- specified

P – Pathological Grading

P0: No dysplasia of the epithelium (including no or possibly mild dysplasia)

P1: Differential epithelium dysplasia, which includes mild to moderate to moderate - potentially severe dysplasia

Px: The pathology report does not specify the dysplasia state.

OPEL staging system

Stage	Classification
One	L1P0
Two	L2P0
Three	L3P0 or L1/L2P1
Four	L3P1

OLEP (Oral Leukoplakia Evaluation & Prognosis) Staging System – General Rules

1. Category Uncertainty: If there is any slightest of the doubt about correct L (size) or P (pathology) category, assign the lower (less severe) category. This conservative approach influences the final stage grouping.
2. Multiple Biopsies: When multiple biopsies are available whether from one leukoplakia or from multiple lesions use the highest pathological score observed to determine the staging.
3. Anatomic Location Reporting: For documentation purposes, always specify the oral subsite based on the ICD-DA-Anatomical Sites.

Ljubljana Grading System for Epithelial Hyperplasia

(Originally for the larynx, adapted for oral epithelial lesions)

1. Simple Hyperplasia

Features indicate : Benign thickening of the epithelium due to an increase in the prickle

cell layer.

2. Abnormal Hyperplasia

Features indicate : Benign proliferation of basal & parabasal layers, up to 1.5× normal epithelial thickness.

Nuclear Changes: Slight enlargement, but chromatin distribution remains uniform.

Stratification: Fully retained.

Dyskeratosis: Seen in more than 5 percent of the epithelial cells.

3. Atypical Hyperplasia

Features indicate : The cells show early malignant transformation signs but not enough to classify as carcinoma.

Nuclear Changes: Enlarged, irregular nuclear contours, increased nuclear cytoplasmic ratio.

Mitosis: Increased mitotic figures, found in lower 2/3 of the epithelium.

Stratification: Still preserved but may be irregular.

Civatte Bodies: Perhaps they might be present (apoptotic keratinocytes).

4. Carcinoma - In Situ

Features indicate: Full thickness epithelial atypia without invasion.

Stratification: Largely lost, though a thin superficial layer may remain.

Cytology: Marked cellular atypia, frequent abnormal mitoses throughout all layers including the upper third.

Diagnostic Significance: Considered pre-invasive cancer.

The Ljubljana classification was originally designed for laryngeal epithelial lesions but has since been considered for application to oral epithelial dysplasia due to its detailed stratification of pre-cancerous changes.

Strengths of the Ljubljana Classification

1. Detailed Stratification

It clearly separates atypical hyperplasia from carcinoma in situ (CIS), recognizing that these entities differ both morphologically & in malignant potential.

This allows clinicians to tailor treatment strategies according to the specific stage of epithelial alteration.

2. Progression Mapping

It aligns well with the multistep model of carcinogenesis, acknowledging that different grades carry distinct risks for progression to OSCC.

Brothwell DJ et al (2003)[12]

A progressive gradation of epithelial abnormalities according to histological severity is provided by this method, which uses a 5-point ordinal scale to classify epithelial dysplasia:

Grading criteria

Grade	Description
One	No dysplasia
Two	Mild dysplasia: Nuclear hyperchromatism & pleomorphism limited to basal & parabasal layers.
Three	Moderate dysplasia: Atypia extends into prickle cell layer, with bulbous rete pegs.
Four	Severe dysplasia: Atypical changes through entire epithelium, including bulbous rete pegs.
Five	Carcinoma in situ (CIS): Marked atypia across full epithelial thickness, with early signs suggestive of superficial invasion (but no definitive connective tissue invasion).

Advantages

1. High Observer Agreement

The authors demonstrated excellent intra- & inter-observer reproducibility, which addresses a major limitation in most dysplasia grading systems (e.g., WHO).

2. Clear Morphological Criteria

Well defined characteristics like bulbous rete pegs, layer specific atypia, & early invasion cues help standardize grading & reduce ambiguity.

3. Enhanced Diagnostic Confidence

The clarity between CIS (Grade 4) & Severe dysplasia (Grade 3) aids pathologists in making decisions on clinical management, particularly in borderline cases.

Considerations

Institution specific: Though effective, this system is not universally adopted & may not align with WHO or other commonly used frameworks.

Clinical Correlation Needed: As with all histopathological grading, clinical data (lesion size, site, duration, patient risk factors) should supplement diagnosis.

The Brothwell grading scale provides a robust, reproducible, & precise tool for grading oral epithelial dysplasia. Its layer wise categorization & emphasis on reproducibility make it especially useful for institutions focused on research consistency & high diagnostic fidelity.

WHO System (2005)[13]

Grade	Histological Features	Key Notes
Hyperplasia	Cell proliferation in spinous or basal/parabasal layers Regular architecture & stratification No cytological atypia	- Often represents reactive or benign processes - Also called acanthosis or basal cell hyperplasia
Mild Dysplasia	Nuclear abnormalities (e.g., hyperchromatism, pleomorphism) in basal third Maturation & stratification are retained No abnormal mitoses	Considered low grade dysplasia
Moderate Dysplasia	Nuclear atypia extends to basal two-thirds Mitoses in basal & intermediate layers Maturation persists in upper third	- Borderline between low & high grade changes
Severe Dysplasia	Marked atypia involves > two-thirds of epithelium Abnormal mitoses may occur in upper layers Maturation still seen in most superficial cells	Requires close clinical follow-up - Precursor to carcinoma in situ
Carcinoma in Situ (CIS)	Full thickness atypia No stromal invasion Primitive undifferentiated cells from basal to surface	Last step before invasive carcinoma - Must be treated aggressively even without invasion

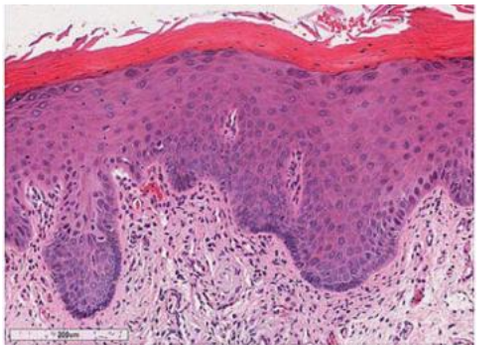

Figure 1: Hyperplasia

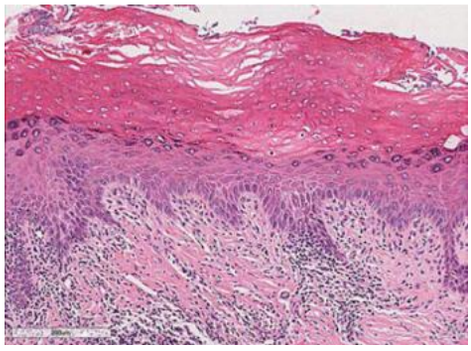

Figure 2: Mild Dysplasia

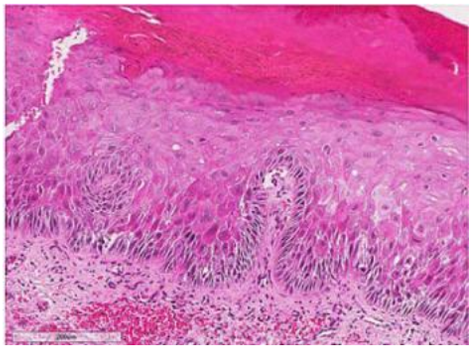

Figure 3: Moderate Dysplasia

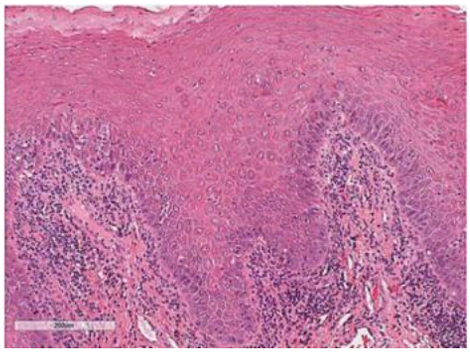

Figure 4: Severe Dysplasia

Binary System (2005)[8]

This method was suggested by Omar Kujan et al. & considered the lesions under:

High-probability lesions (perhaps susceptible to malignant transformation): It was based on the finding of at least four architectural changes & five cytological abnormalities (WHO criteria 2005). Low risk lesions, or those that are not likely to develop into cancer: It was associated with the identification of less than four architectural alterations or fewer than 5 cytological abnormalities, as per WHO guidelines from 2005.

Malignant Transformation

Around the world, there are variations in the incidence of malignant change in oral leukoplakia, most likely due to ethnic & environmental factors such dietary & dental practices. Compared to males (3.9 per 1000 annually), women had higher rates of malignant transformation (6 per 1000 annually). Ages 55 & older

had the greatest overall malignant transformation rate for both sexes (10.2 per 1000 annually).[14] The probability of malignant transformation was greater for leukoplakia linked to chewing practices (8.3 per 1000 annually) than for those linked to a combination of smoking & chewing (3.8 per 1000 annually). Smoking related leukoplakia by itself did not develop into cancer.[15]

Conclusion

Leukoplakia categorisation is still a controversial topic. Leukoplakia grading is also subjective & differs from observer to observer. Furthermore, because there is no consensus, several systems are now in use.

Future molecular biology research & standard techniques for assessing large genomic aberrations will surely improve ways to help with the diagnosis & prognosis of oral leukoplakia; however, a more precise method of forecasting the course of cancer is needed. There is little question that future genetics & molecular biology research will increase the potential for identifying pre-cancerous & cancerous diseases. The gold standard for predicting the malignant evolution of precancerous lesions is still the histological assessment of the degree of dysplastic alterations in oral leukoplakia.

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The Unseen Root: Re-Treatment of a Biradicular Mandibular Second Premolar

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Abstract

Mandibular second premolars are typically considered single rooted and single canaled teeth, but anatomical variations can present significant endodontic challenges, especially in re-treatment cases. This case report presents the conservative re-treatment of tooth 45 in a 65 year old female with persistent post operative pain. Radiographic evaluation revealed a missed root and canal, along with associated periapical pathology. Upon re-treatment, two distinct roots with one canal each were identified. The case highlights the importance of recognizing rare anatomical variations and using a biologically guided approach to ensure successful outcomes.

Keywords: Two rooted premolar, Re-treatment, Mandibular Second Premolar, Missed Canal, Bioceramic sealer

Introduction

Anatomical variations in root canal morphology are critical determinants of endodontic success, particularly in retreatment cases. Variations in root and canal configurations depend on several factors, including ethnicity, age, and gender of the population studied. Among all teeth, mandibular second premolars are considered some of the most challenging to treat endodontically due to their highly variable root anatomy.[1]

Mandibular second premolars are usually single rooted and have a single canal in more than 95% of cases. However, rare variations, including the presence of two roots with one canal each, have been reported with low incidence rates ranging from 0.3% to 1.9%.[2,3,4] Missed anatomy, particularly untreated canals or roots, remains a common cause of failure in previously treated teeth.[5] This case report highlights the successful non-surgical re-treatment of a two-rooted mandibular second premolar (tooth 45), previously mismanaged due to unrecognized anatomical variation.

Case Report

A 65 year old female patient named Varisha reported to the Department of Conservative Dentistry and Endodontics, Shree Bankey Bihari Dental College, Ghaziabad, with a chief complaint of dull, continuous pain in the lower right back region of the jaw for the past one week.

The pain was aggravated by mastication and relieved only upon taking medication. The patient gave a dental history of root canal treatment in the mandibular right second premolar (tooth 45) approximately two weeks prior.

A preoperative intraoral periapical radiograph (Figure 1) revealed a previously treated tooth with a single obturated canal. However, a second root and canal had been missed, and periapical radiolucency was evident, indicating apical pathology. Upon re-entry and thorough assessment, two separate roots were identified, each containing a single canal.

Figure 1: Pre operative radiograph

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Treatment Procedure

Local anaesthesia was administered, and tooth 45 was isolated using a rubber dam. The previous restoration was removed, and the access cavity was refined, revealing a previously missed distal root canal. Hedström (H) files were used to remove the existing gutta-percha manually.

Both mesial and distal canals were negotiated using a #10 K-file, and working length was determined with an apex locator and confirmed radiographically (Figure 2).

Figure 2: Working Length Radiograph showing separate mesial and distal canals in tooth 45.

Cleaning and shaping were performed using Dentsply ProTaper Gold rotary instruments. Both canals were prepared up to F1 (20/.07 taper). Irrigation was carried out with copious amount of 2.5% Sodium Hypochlorite(UPS Hygienes Pvt. Ltd., Mumbai, Maharashtra, India), 17% EDTA (DeSmear, Ahmedabad, Gujarat, India). Final rinse was done with sterile saline.

The canals were dried using paper points, and a creamy paste of calcium hydroxide was placed in both canals using a Lentulo spiral. The access cavity was temporarily sealed with Cavit-G, and the patient was recalled after 7 days.

Second Appointment: At the 7-day follow up, the patient was asymptomatic. The temporary restoration was removed, and canals were irrigated with normal saline and NaOCl to remove the intracanal medicament. Master cones were selected and verified radiographically (Figure 3).

Figure 3: Master Cone Radiograph

Obturation was completed using the single cone technique with gutta-percha and bioceramic sealer. A post-operative radiograph was taken to confirm the quality of the obturation (Figure 4).

Figure 4:Post-Obturation Radiograph

Discussion

Successful endodontic therapy relies on the complete debridement, disinfection, and three-dimensional obturation of the root canal system. One of the most common causes of endodontic failure is the presence of missed anatomy, particularly additional roots or canals.[5] The mandibular second premolar is generally considered to have a single root and canal, making rare configurations such as two roots with separate canals a diagnostic challenge.

Cleghorn et al. reported that two rooted mandibular second premolars occur in approximately 0.3% to 1.9% of cases, making this a rare but clinically significant variation.[3]These variations are often overlooked due to the limitations of conventional radiography and insufficient inspection during access preparation. Studies by Zillich and Dowson[2], and Kartal and Yanikoglu[6], as well as CBCT based reviews by Patel et al.[7], further support the existence and complexity of such variants.

Morphological diversity in lower premolars continues to receive growing clinical interest due to their wide range of anatomical presentations.[8] Compared to mandibular first premolars, second premolars are less frequently documented in the literature. This scarcity of data can contribute to diagnostic uncertainty. For example, Arayasantiparb et al. found multiple roots in 5.73% of first premolars but observed no additional roots in second premolars within a Thai population.[9] Similarly, Dosunmu et al. reported the prevalence of two rooted mandibular second premolars as low as 0.4%.[10]

In the present case, a previously untreated distal root and canal led to persistent symptoms and periapical pathology.Re-treatment was successfully performed using Dentsply ProTaper Gold rotary instrumentation, calcium hydroxide as an intracanal medicament, and a bioceramic sealer with the single cone obturation technique, each of which is supported by clinical literature for its effectiveness in disinfecting and sealing complex canal systems.[11,12] The role of calcium hydroxide in eliminating microbial contamination and promoting periapical healing is well documented.[13]

This case emphasizes the importance of thorough radiographic interpretation, use of magnification, and modified access preparation in identifying uncommon anatomical configurations. Early recognition of such variations is essential to avoid

endodontic failure and ensure favorable treatment outcomes.

Conclusion

This case highlights the importance of careful evaluation and recognition of root canal anatomy in retreatment cases, particularly in mandibular second premolars, which may occasionally present with two roots and two canals. Missed anatomy remains a common cause of endodontic failure, and its identification is critical for successful outcomes. Conservative non-surgical retreatment, supported by effective cleaning, shaping, and obturation techniques, can resolve persistent periapical pathology and restore function without surgical intervention.

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Artificial Intelligence In Orthodontics : Review Article

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Abstract

This comprehensive review explores the applications and limitations of Artificial Intelligence (AI) in orthodontics, covering diagnosis, treatment planning, and prognosis prediction. AI has transformed orthodontic care by enhancing treatment efficiency, accuracy, and patient outcomes. The review discusses various AI subfields, including machine learning, neural networks, and deep learning, and their applications in cephalometric analysis, occlusal trait diagnosis, facial analysis, and upper airway assessment. AI driven solutions have shown promise in managing impacted teeth, cleft lip and palate management, custom orthodontic appliances, and aligner therapy. While AI holds immense potential for improving orthodontic care, limitations such as data scarcity, biased models, and ethical considerations need to be addressed. This review aims to provide insights into the current state of AI in orthodontics and its future directions, highlighting the need for further research to refine AI models and ensure widespread adoption in clinical practice.

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Introduction

Orthodontics is one of the nine dental specialties primarily focused on diagnosing malocclusion and working to prevent and correct it. It deals mainly with the craniofacial skeleton, with particular emphasis on modifying the dentoalveolar structures. Accurate diagnosis and treatment planning are crucial for successful orthodontic treatment. Diagnosis in orthodontics relies on a patient's dental and medical history, clinical examination, study models, and radiographs with OPG and cephalometric radiographs being the most valuable tools [1].

Over the past few decades, dentistry has undergone significant advancements, particularly with the introduction of technologies that mimic human brain function [2]. New technologies and procedures, such as intraoral scanners, digital models, and measurements, along with increasing use of CBCT [3], have slowly expanded, enhancing overall patient care, treatment plan management, and prevention, particularly in the early stages [4,5].

Artificial intelligence (AI) has played a vital role in these advancements, providing automated tools to assist in diagnosis and treatment planning [2]. AI is a subfield of computer science that refers to the ability to imitate cognitive function of human intelligence [6]. AI-based systems have become essential in helping orthodontists deliver standardized patient care and improve treatment outcomes [7]. These technologies support clinical decision making, enhancing precision and efficiency [8].

Various AI subfields are widely applied in biological and medical diagnostics, including machine learning (ML), artificial neural networks (ANNs), convolutional neural networks (CNNs), and deep learning (DL)[9]. These neural networks are mathematical computing models designed to replicate brain function. By training with clinical datasets, they can be used for various diagnostic and treatment related tasks in dentistry and medicine [10]. This review discusses the applications and current limitations of AI and aims to explore the scope and effectiveness of AI-based models

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in orthodontic diagnosis, treatment planning, and prognosis prediction [10].

Key Concepts of Artificial Intelligence

Machine Learning and Neural Networks

Machine learning can be categorized into two main types:

Supervised Learning: Uses labeled training data and human feedback to teach algorithms the relationship between inputs and outputs, enabling precise predictions about new data [11].

Unsupervised Learning: Trains models on unlabeled datasets, allowing them to operate independently and identify patterns without prior knowledge of output data [11].

Reinforcement Learning: Reinforcement learning is a type of machine learning where an algorithm is developed to maximize a specific reward by learning from its past experiences. This approach is commonly used in situations where a system learns and adapts through interactions with its environment, refining its decisions through trial and error [12]

Neural Networks: Are the algorithms inspired by human brain's structure and functioning and uses artificial neurons to process the data. - Consist of node layers, including input, output, and hidden layers.- Use weights and thresholds to determine node activation and data transmission.

Neural networks learn and improve their accuracy through training data, becoming powerful tools in computer science. Similar to biological neurons, artificial neurons receive input from other neurons, process the information, and produce an output, enabling rapid data categorization and clustering. Through training, neural networks can become increasingly accurate and effective in performing complex tasks.

A neural network consists of three primary layers:

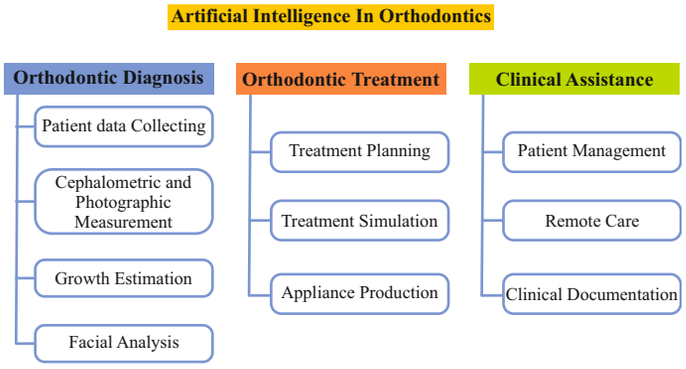
Input Layer: Receives data and forwards it to subsequent layers.

Hidden Layer: Enables complex performance through multiple concurrent calculations.

Output Layer: Stores the solution or output of the problem.

Deep Learning: A subfield of machine learning that utilizes a neural network with multiple computational layers to interpret data and automatically identify patterns, enhancing feature recognition.

Types of Artificial Intelligence And Its Applications In Orthodontics



1. Diagnostic Artificial Intelligence

AI algorithms can analyze orthodontic images, such as intraoral photos and radiographs, to automatically identify dental structures, landmarks, and abnormalities enabling the orthodontists to quickly assess parameters like tooth angulations, root positions, and facial proportions . Few examples of AI-powered software that streamline diagnosis and treatment planning are :

1. **Dolphin Imaging:** AI-powered image analysis for cephalometric analysis, tooth segmentation, and measurement.
2. **Ortho Insight 3D:** 3D image analysis for comprehensive assessment and virtual treatment planning.
3. **Orchestrate 3D:** AI-driven treatment planning and outcome prediction.
4. **Onyx Ceph:** AI-based cephalometric analysis, automatic landmark detection, and treatment simulation.
5. **EasyRx:** Cloud based platform for AI-powered case analysis, treatment planning, and communication.

AI In Cephalometric Analysis

Cephalometric analysis is crucial for orthodontic diagnosis and treatment planning. AI has transformed this field by enabling automated landmark detection, improving efficiency, accuracy, and reproducibility. Key advancements include:

Automated landmarking: AI-powered algorithms like CNNs (e.g., YOLOv3) and deep learning models have achieved high accuracy, with mean errors ranging from 1.038 to 1.36 mm [13, 14, 15, 16,17,18,19].

3D cephalometric analysis: AI has made progress in 3D landmark detection, with CNN based models achieving mean errors of 1.0-2.73 mm [20,21,22,23].

Deep reinforcement learning: This algorithm has shown promise in 3D localization of landmarks, achieving mean detection errors of 1.96 mm [24].

While AI has improved cephalometric analysis, limitations remain, such as down-sampling quantization errors and the need for preprocessing or postprocessing. Future research will likely focus on addressing these limitations and expanding AI applications in cephalometric analysis.

Diagnosis of Occlusal Traits Using CNNs and ANNs

Deep learning models, such as Convolutional Neural Networks (CNNs) and Artificial Neural Networks (ANNs), have been applied to diagnose various occlusal traits. Studies have utilized different imaging modalities, including:

Panoramic Radiography: CNNs achieved 93% accuracy in classifying canine impaction and 90% accuracy in segmenting third molars .

A deep learning-based algorithm for automatic tooth segmentation in digital dental models achieved a 97.26% success rate, accurate measurements, and high efficiency, making it a promising tool for orthodontic diagnosis and treatment planning.

Intraoral clinical images: CNNs detected malocclusion with 99% accuracy, while ANNs predicted mesiodistal tooth

dimensions with high correlation (r = 0.91).

In another study done by Bardideh et al, AI outperformed orthodontists in detecting various classes of malocclusion, particularly in predicting angle classification. However, it fell short in accurately measuring overjet and overbite compared to expert orthodontists.

Profile photos: CNNs predicted skeletal Class III malocclusion with 76% accuracy and 83.39% accuracy.

Lateral cephalometry: CNNs classified mandibular growth with 85% accuracy and diagnosed sagittal and vertical skeletal malocclusions with 80% and >90% accuracy, respectively.

Budiman et al. used an ANN based software for predicting the dental arch form (oval, square or tapered) on two dimensionally scanned dental casts and achieved an accuracy of 76.3 %.

These studies demonstrate the potential of deep learning models in automating occlusal trait diagnosis, with varying degrees of accuracy depending on the specific application and imaging modality [25].

Facial Analysis for Orthognathic Surgery

Artificial Intelligence (AI) optimizes maxillofacial imagery by enhancing data acquisition, processing, and pre-analysis. AI-powered intra-oral scanners enable efficient data capture, while machine learning techniques facilitate 3D reconstructions and diagnostic tool superimposition. [26,27]

This helps identify and calculate upper airway dimensions, particularly useful in treating obstructive sleep apnea.[28] AI also automates cephalometric analysis, freeing cognitive resources for practitioners [29]. Moreover, AI enables objective tridimensional perception of dento-facial characteristics, making it a highly effective tool for diagnosis. Research indicates that at least 100-200 craniometric points are required for accurate 3D facial biometric analysis using Cone Beam imaging [30].

Upper Airway Assessment Using Deep Learning

Deep learning models, specifically CNNs, have been applied to evaluate the upper airway. Studies have utilized different imaging modalities, including:- Lateral cephalograms: A deep CNN model assessed upper airway obstruction with an F1 score of 0.88 [31].- CBCT images: CNN models achieved high accuracy in segmenting pharyngeal airway space (DSC of 97%) [32] and detecting adenoid hypertrophy (F1 score of 0.90) using Hierarchical Masks U-Net [33].

These studies demonstrate the potential of deep learning models in automating upper airway assessment, with promising results in detecting obstruction and segmenting airway spaces

2. Predictive AI

Predictive modeling is a mathematical process in orthodontics that uses machine learning to analyze data and predict treatment outcomes. AI can analyze large data sets of orthodontic study models and photographs to identify patterns and predict treatment outcomes. This can aid orthodontists to: Optimize treatment plans, estimate treatment duration and evaluate treatment stability

Studies have shown promising results:

Jahnavi Prasad et al: 84% average accuracy in predicting orthodontic diagnosis and treatment plans.

BanuKiliç et al: 76% accuracy in diagnosing Class-III malocclusion using machine learning.

Growth assessment using AI

1. Automated CNN based age estimation on panoramic radiographs using the Demirjian method achieved 92-96% accuracy, outperforming manual classification by 3%, and produced results in 0.3 seconds.[25]
2. AI was applied for cervical vertebrae maturation (CVM) staging on lateral cephalometric images, with studies showing varying accuracy rates [25]:

a. Average of 58.3% agreement was observed between the ANN models and the human observers .

b. For CVM staging best results were achieved using ANN algorithm with accuracy of (0.926), LR Model (0.968) for concavity detection and DT model (0.949) for vertebral body shape .

c. Out of 4 deep learning models , CNN model with a layer of tunable directional filter achieved the highest accuracy of 84.63% in six stage classification.

d. According to the average rank of all the algorithms , ANN was found tom be the most accurate algorithm (CVS1 - 93% , CVS2 - 89.7 % , CVS3 - 68.8% , CVS4 – 55.6% , CVS5 – 78%).

e. A convolutional neural network (CNN) model, particularly ResNet152, achieved an accuracy of 67.06% and a weighted κ of 0.826, showing potential as a reliable and efficient auxiliary diagnostic tool for cervical vertebral maturation (CVM) analysis in orthodontics.

f. The proposed iCVM convolutional neural network achieved superior performance in automatic Cervical Vertebral Maturation assessment, demonstrating high consistency with clinical criteria, though exact accuracy metrics aren't specified in the conclusion.

g. The AI algorithm achieved an accuracy of 80.2% in determining cervical vertebra maturation stages, with high accuracy for pre-pubertal (78% sensitivity) and post-pubertal stages (98% sensitivity), showing potential to aid in faster diagnosis and treatment planning.

h. Six deep learning models, led by Inception-ResNet-v2, achieved over 90% accuracy in cervical vertebral maturation classification, promising to enhance dental diagnosis and treatment planning.

i. AI achieved a CVM staging accuracy of 71%, with high agreement with human examiners.

3. Artificial neural networks (ANN) in two studies were found to be stable and effective for automated CVM detection compared to other algorithms like random forest and decision tree [25].
4. Convolutional neural networks (CNNs) were used to automate CVM staging, achieving accuracy rates ranging from 61.62% to 90%, with one study producing results in under 0.1 seconds [25].
5. A custom designed CNN with tunable directional filters demonstrated 75% higher accuracy than commonly used pre-trained network models without directional filters [25].

In summary, ANNs received much attention and recognition in the early years, but in recent years, CNNs are gradually becoming more prominent in image related tasks and are expected to achieve more encouraging results in the future.

Prediction of orthognathic surgery using artificial intelligence

Dynamic virtual set-ups, such as ClinCheck, Insignia, and Orthoanalyser, are some of the Deep learning models which facilitates facial recognition and analysis, enabling orthodontists to better comprehend facial structures and anticipate the outcomes of orthodontic treatments [34]. Adults with significant dentofacial deformities often require orthognathic surgery in conjunction with orthodontic treatment to correct jaw alignment. The lack of standardized criteria for surgical intervention can pose challenges for inexperienced orthodontists, especially when deciding between surgery and alternative treatments [35].

Lateral cephalograms are commonly used in clinics to evaluate sagittal skeletal discrepancies. Studies have reported accuracy rates exceeding 90% when using lateral cephalograms with CNNs or ANNs [35].

Shin et al. used a comprehensive dataset including lateral and PA cephalograms to assess both sagittal and lateral jaw relationships, achieving 95.4% accuracy in predicting surgical need [35].

Facial aesthetics also play a crucial role in determining the need for surgical intervention. Knoops et al. employed SVMs to predict surgical necessity with 95.4% accuracy using 3D facial scans [35].

In contrast, Jeong et al. reported 89% accuracy when training a CNN model on frontal and right facial images. Choi et al. used a multifaceted approach, incorporating cephalometric data, dental features, and profile characteristics, achieving an accuracy range of 88-97%. However, the study's exclusion of Class I surgical cases may limit the model's applicability to broader populations. Lee et al. investigated random forestRF and logistic regression LR models for predicting surgical necessity in Class III patients, reporting 90% accuracy for RF and 78% for LR [35].

Further development is required to cover a wider variety of cases, particularly borderline cases [35].

3. **Operative AI:** AI can enhance orthodontic treatment efficiency and effectiveness by providing practice guidance, remote care, and clinical documentation support.

1. **Practice Guidance:** AI powered decision support systems can aid in treating complex malocclusions like deep overbites, providing detailed treatment protocols with high success rates (94.40%).

3D Image Segmentation: Deep learning algorithms like 3D U-Net and its variants can accurately segment 3D images, enabling automated measurements and predictions, such as ideal sites for palatal mini screws.

Tooth Root Position Monitoring: AI can help predict tooth root positions using deep learning based tooth segmentation in CBCT scans, reducing radiation exposure and improving treatment assessment [36].

The data suggests that Artificial Intelligence (AI) has been increasingly applied in orthodontic treatment planning, with promising results. The studies reviewed demonstrate the potential of AI in predicting various treatment outcomes, including:

Decision making for teeth extraction

Extraction decisions in orthodontics currently lack a standardized formula, relying heavily on orthodontists' experience, which can lead to incorrect decisions and issues like unfavourable profiles and improper occlusion. AI can help reduce incorrect extraction decisions, with artificial neural networks (ANNs) being the most utilized method for predicting extraction diagnosis and patterns. Studies have shown that ANNs can achieve high accuracy rates, ranging from 84% to 94%, in determining extraction diagnosis and patterns. Different machine learning algorithms, such as random forest (RF) and support vector machine (SVM), have their own strengths and weaknesses, and may be more suitable for specific tasks. While ANNs have demonstrated significant advantages in extraction decision making, other algorithms like RF and SVM may also be effective, but require further research. Recently, four convolutional neural networks (CNNs) algorithms have been used with intraoral photographs to predict tooth extraction, "VGG19" achieved high accuracy rates (up to 0.922)in maxilla and (0.898) in mandible.

Overall, AI has shown promise in extraction decision making, but further research is needed to compare results across studies and determine the most effective algorithms for different input data types [36].

AI in Orthodontic Force System Design

Orthodontic treatments involving extractions require careful consideration of individual canine retraction, incisor retraction, and en masse retraction. Precise and calibrated orthodontic loops are used to apply controlled forces for optimal clinical and histological outcomes during space closure [37].

AI modeling using neural networks and genetic algorithms can simulate force systems generated by orthodontic appliances, offering advantages in accuracy. A significant benefit of AI modeling is its ability to replicate the actual behavior of orthodontic appliances, particularly spring systems.

Force System Projections Using AI

Parameters like force, moment, and moment to force ratio affect retraction loop force systems. Kazem et al. created an artificial neural network (ANN) to predict T-retraction spring force systems using experimental assessments. Their experiment investigated the influence of activation distance and cross-sectional area on T-retraction spring force systems. ANN modeling was used to evaluate prediction performance, with network inputs and targets undergoing preprocessing to enhance training effectiveness [37].

Management of Impacted Teeth: Challenges and AI-Driven Solutions

Impacted canines are a common dental issue affecting approximately 2% of the population, with maxillary canine impaction being more prevalent in females [38, 39]. Early diagnosis and treatment are crucial to prevent complications. AI technologies, such as CNNs, have shown promising results in:

Detecting impacted canines with high accuracy [40,41] by analysing panoramic radiographs and CBCT using angular and linear measurements [42]. AI can simulate tooth movement, assess effective paths for eruption or alignment, and provide data driven insights for optimal treatment approaches. Also, it can track treatment progress and suggest adjustments to ensure successful outcomes.

Studies have demonstrated the effectiveness of AI in impacted canine diagnosis and treatment planning, including:

CNN based classification: AI models, such as DetectNet and Inception V3, have achieved high accuracy in detecting impacted canines and classifying impaction types [40,43].

Predictive Modeling: AI can identify relevant predictors of maxillary canine impaction, enabling early intervention and improved treatment outcomes [40,41].

Artificial Intelligence In Cleft Lip And Palate Management

AI and machine learning are transforming the field of cleft lip and palate management. Some key applications include:

Predictive modeling: AI can analyze large datasets to identify patterns and develop predictive models for cleft development, allowing for early intervention and prevention [44].

Prenatal diagnosis: AI-powered diagnostic techniques have shown high accuracy in detecting clefts during the prenatal period, enabling expectant parents to prepare for potential treatment needs [45,46,47].

Treatment planning: AI can assist in treatment planning and analysis of post treatment results, providing valuable insights for orthodontists and surgeons [48].

Computer assisted surgical planning: 3D planning and simulations can improve the outcome of orthognathic surgeries, allowing for more accurate and personalized treatment plans [49].

Custom Orthodontic and Surgical Appliances

CAD/CAM technology has revolutionized orthognathic surgery by enhancing treatment planning and transfer methods. Virtual Surgical Planning (VSP) is a powerful tool for complex cases, such as facial asymmetries, allowing for precise planning and simulation [50]. This technology also enables seamless remote collaboration between practitioners through dematerialized medical data. Furthermore, CAD/CAM has improved the accuracy of surgical planning transfer with options like CAD/CAM surgical splints, patient specific osteosynthesis titanium miniplates, and surgical navigation [51]. These advancements have significantly improved the precision and effectiveness of orthognathic surgery.

Aligners and AI

The integration of AI and aligner technologies has revolutionized orthodontics, enhancing treatment planning, customization, patient experience, and outcomes. AI excels in planning tooth movement by determining the optimal path from pre-treatment to end positions, as specified by orthodontists. This benefits practitioners who struggle with traditional bracket only orthodontics due to limited manual dexterity or training. AI analyzes patient data to formulate precise treatment plans and designs customized aligners tailored to each patient's unique dental anatomy, using software such as ClinCheck and Insignia. AI powered simulations and visualizations educate patients about treatment, fostering engagement and compliance. Technologies like SureSmile and OraScan facilitate real time progress tracking, analyzing actual tooth movement and enabling orthodontists to adapt treatment plans. This synergy has redefined the orthodontic landscape, complementing clinical expertise and holding immense promise for continued advancement in orthodontic care [52,53].

List of assessed commercially available clear aligner systems and their corresponding treatment planning software solutions [54]:

Clear Aligner System	Software	Company	Origin	Type
MTM Clear Aligner	Decentralign	DentsplySirona	Bensheim, Germany	In-office/Lab-made
Reveal CA	Studio Pro 4.0	Henry Schein Orthodontics	California, USA	In-office/lab-made
3Shape Clear Aligner	3Shape Clear Aligner Studio	3Shape	Copenhagen, Denmark	In-office
----	ArchForm	ArchForm Inc.	California, USA	In-office
Blue Sky Plan	BlueSkyPlan Ortho Module	BlueSkyBio	Illinois, USA	In-office
CS Model+	CS Model+	Dexis	Virginia, USA	In-office
Deltaface	Deltaface Aligner	Coruo	Limoges, France	In-office
Dicaon 4D	Dicaon 4D	DENTIS	California, USA	In-office
Diorco	DentOne	Diorco	Gyeonggi-do, Republic of Korea	In-office
Irok	OrthoRx	Irok	California, USA	In-office
Maestro	Maestro3D	AGE Solutions	Virginia, USA	In-office
Moon Aligner	Moon Aligner System	BioTech Innovations, Inc	California, USA	In-office
Nemotec	NemoCast	Nemotec	Madrid, Spain	In-office
OnyxCeph	OnyxCeph	Image Instruments GmbH	Gottingen, Germany	In-office
Orchestrate®	O3D	Orchestrate Orthodontics Technologies	California, USA	In-office
OrthoInsight3D	OrthoInsight3D	MotionView Software	Tennessee, USA	In-office
Orth'up	Orth'up	C4W	Montpellier, France	In-office
SLX Clear Aligners	StudioPro 4.0	Ortho Organizers	California, USA	In-office
Smilers	Smilers® Expert	Biotech Dental Smilers®	All. de Craponne, France	In-office
SoftSmile	Vision	SoftSmile Inc.	New York, USA	In-office
SureSmile® Aligners	SureSmile Simulator	DentsplySirona	Bensheim, Germany	In-office
ULab	uDesign® 7	uLab Systems, Inc.	California, USA	In-office

2. Remote Care

AI-enhanced remote monitoring software can: Track treatment progress, provide timely feedback, reduce chairside time, improve patient compliance.

Examples include Dental Monitoring (DM), which can detect various metrics, such as ill-fitting clear aligners and bracket breakages. Dental Monitoring™ (DM) is a smartphone based application that enables patients to capture and share images or videos of their teeth, allowing orthodontists to remotely monitor treatment progress. With the widespread use of smartphones, such tele-orthodontic tools have become increasingly popular. This technology is especially beneficial in regions with limited access to orthodontic care, or for individuals with busy schedules or who travel frequently [55].DM GoLive™: Offers real time weekly guidance ("GO" or "NO-GO") on aligner progression, based on AI analysis. Alerts the orthodontist about tracking issues or poor hygiene, but does not provide detailed 3D matching. [55].

The IvoSmile Orthodontics app allows orthodontists to provide patients with a quick, no obligation visual preview of their potential treatment outcome during consultations. Using AI and augmented reality, the app creates a realistic simulation of the patient's future smile on their smart phone within minutes.

The process involves scanning the patient's teeth with a 3Shape TRIOS scanner (Gen 3 or higher), after which the TRIOS Treatment Simulator generates a virtual tooth alignment. This setup is transferred to the IvoSmile app via the 3Shape Communicate portal. The app then overlays the projected outcome onto the patient's live image using AR, allowing them to see real time changes while talking, smiling, or moving.

3. Clinical Documentation

Artificial intelligence (AI) can significantly enhance clinical practice efficiency by classifying and categorizing clinical images, such as photos and radiographs, used for diagnosis and treatment monitoring (Ryu et al., [56]; Li et al., [57]). For instance, convolutional neural networks (CNNs) have been successfully applied to automatically classify facial and intraoral photographs with high accuracy rates, ranging from 98% (Ryu et al., [56]) to 99.4% (Li et al., [57]). Li et al.'s DeepID model, in particular, demonstrated not only high accuracy but also improved computational speed in categorizing a wide range of orthodontic images, including facial photos, intraoral images, panoramic films, and lateral cephalograms [57].

Limitations and Future

Recent advancements in artificial intelligence (AI) have significantly impacted orthodontics, particularly in clinical practice, treatment planning, and diagnosis. This comprehensive review provides a detailed overview of the latest AI developments within the field. While these advancements hold promise for improving orthodontic care, several challenges hinder their widespread adoption. The reliability of current research is compromised by the limited and non-representative training data availability. Although certain AI models demonstrate high accuracy, their ability to perform well on uncommon deformities is questionable due to inadequate representation in the training dataset. Approaches like data augmentation, semi-supervised learning, and few shot learning are intended to mitigate data scarcity, but their efficacy is constrained [58].

To minimize the requirement for a large amount of training data, transfer learning uses pre-trained models in similar domains; however, these models may not be as generalized when applied to other domains.

Data augmentation can increase sample size but cannot improve biological variability. Semi-supervised learning still requires a large amount of unannotated data and high-quality annotations even with limited annotated data. Few-shot learning faces challenges due to the absence of standardized assessment frameworks and specialized data. Ethical and privacy considerations make data sharing difficult, resulting in biased AI models trained on data with limited [58].

Conclusion

Artificial Intelligence (AI) has revolutionized orthodontics by enhancing diagnosis, treatment planning, and prognosis prediction. AI's applications in cephalometric analysis, occlusal trait diagnosis, facial analysis, and upper airway assessment have shown promising results. Predictive modeling, growth assessment, and orthognathic surgery prediction are other areas where AI has demonstrated potential. AI-driven solutions have also improved treatment efficiency and effectiveness in managing impacted teeth, cleft lip and palate management, custom orthodontic appliances, and aligner therapy. While AI holds immense potential for improving orthodontic care, limitations such as data scarcity, biased models, and ethical considerations need to be addressed. Further research is necessary to refine AI models, ensure widespread adoption in clinical practice, and fully realize AI's transformative impact on orthodontics.

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Navigating Aberrant Root Canal Anatomy: A Case Series on Complex Variations

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Abstract

An in-depth understanding of root canal anatomy and its variations is essential for achieving endodontic success. This case series highlights the endodontic management of teeth exhibiting complex anatomical variations: a mandibular molar with confluent middle mesial canal, a mandibular molar with radix entomolaris and a mandibular premolar showing Vertucci Type V configuration. The cases were diagnosed and managed using enhanced visualization through a dental operating microscope. Thorough exploration of the pulp chamber floor, ultrasonic troughing and meticulous cleaning and shaping techniques enabled successful location, negotiation and obturation of these aberrant canals. Postoperative follow ups showed favorable outcomes in all cases. This series underscores the importance of clinical vigilance, appropriate use of technology and anatomical knowledge in managing a typical canal configurations to ensure long-term treatment success.

Keywords: Anatomical Variaton, Middle Mesial Canal, Radix Entomolaris, Vertucci Type V, Gulabivala Type I, Sert and Bayirli Type XVIII

Introduction

The prerequisite of any endodontic therapy is to have familiarity with the root canal anatomy of the tooth. Proper and accurate interpretation of radiographs taken at different angulations, especially using the paralleling technique, is crucial for diagnosing the number of roots and root canals in a tooth. Identifying all the portals of exit, debridement of the entire root canal system and sealing all the exits with three dimensional filling materials make endodontic treatment successful.[1]

Clinically, mandibular molars exhibit a wide range of anatomical variations, including the presence of additional roots such as a distolingual (radix entomolaris) or mesiobuccal root (radix paramolaris), C-shaped canal configurations and complex root canal systems with three canals in either the mesial or distal roots. These may include a middle mesial canal (MMC) or a middle distal canal (MDC), both of which can follow various morphological patterns.[2]

The incidence of having an extra canal in the mesial root is 1-15%.[3] Pomeranz et al., in 1981, classified the middle mesial canal into three types, namely: A fin, A confluent, and an independent type.[4]

Carabelli was the first one to mention the presence of an additional root in mandibular first molar and called it as radix entomolaris (RE).[5]Literature suggests the presence of RE in less than 5% population in white Caucasian, African, Eurasian and Indians whereas it is present with a frequency of 5–30 % in races with Mongoloid traits such as the Chinese, Eskimos, and Native Americans.[6]

Pulp space is complex, root canals may divide and rejoin. Depending upon the configuration, root canal may exit apically through one or more than one apical foramen. Some mandibular first premolars show Vertucci type V canal configuration accounted for only 1.5% to 6.66%.[7]

Several classifications have been proposed to describe root canal configurations for communication. Some of which we will discuss in this case report will be Vertucci FJ (1984), Gulabivala K et al. (2001) and Sert and Bayirli (2004). [8]

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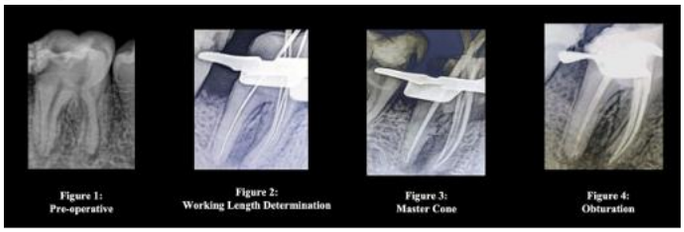
This case series highlights the clinical management of three mandibular teeth with complex anatomical variations.

Case Report

Case 1: Management of Middle Mesial Canal in mandibular first molar with root canal configuration classified under Gulabivala K et al Type I (3-1) and Sert and Bayirli Type XVIII (3-1)

A 26 year old male patient reported to Department of Conservative Dentistry and Endodontics, with the chief complaint of pain in his lower right back tooth region since a week. The pain was intermittent, exacerbated by the intake of hot food and beverages and persisted for 2-3 hours. Clinical examination revealed deep proximal caries in the right mandibular first molar, with otherwise satisfactory oral hygiene. Pulp sensibility testing revealed an exaggerated and lingering response to the heat test, indicative of symptomatic irreversible pulpitis.

A preoperative radiograph showed a radiolucency involving enamel and dentin, approaching the pulp. Periapical radiolucency was observed in intraoral periapical radiograph, indicating periapical lesion in relation to mesial root.



Case 1: Middle Mesial Canal

Treatment Procedure

Inferior alveolar nerve block (IANB) was administered using 2% lignocaine hydrogen chloride (HCl) with 1:2 lacs units of adrenaline (Lignox, Indoco Remedies Ltd, Mumbai, Maharastra, India). The access cavity was prepared by endodontic access bur size 2 (Dentsply-Sirona, Charlotte, North Carolina, United States) under rubber dam isolation. The access cavity was refined using Endo-Z bur (Dentsply-Sirona), exploration of the pulp chamber was done using an endodontic explorer and the canals were negotiated using a size 10 K file (Mani, Inc., Japan). Three canals were initially located, two mesial and one distal.

Ultrasonic tips (Start-X, Dentsply-Sirona) were used to explore the MMC orifice and the canal was negotiated using a size 10 K file. The working length was determined using Apex locator (Root ZX mini, J. Morita Inc, USA).

Finally, a total of four distinct orifices were identified and verified using magnifying loupes (iMag™ ,Vision Forward LLP, Mumbai, India): Mesially three (MB, middle mesial, ML) and distally one. The Middle mesial canal orifice was found near to mesiobuccal canal orifice and all three mesial canals converged apically to exit as a single canal.

The shaping and cleaning were carried out by ProTaper Universal NiTi rotary instrument (Dentsply-Sirona) in a crown-down manner till F2(25/8%) and distal with F3(30/9%).

Copious Irrigation was carried out using 3% sodium hypochlorite solution (Prime Dental Products Private Limited, Thane, Maharastra, India), Endoprep-RC (Anabond Stedman Pharma Research Pvt Ltd, Chennai, Tamil Nadu, India) and saline. Canals were dried using paper points and obturation was done using single cone technique with bioceramic sealer (MTA fillapex, Angelus, Brazil). The mesiobuccal canal was obturated first followed by mesiolingual and then middle mesial canal up to the point of convergence.

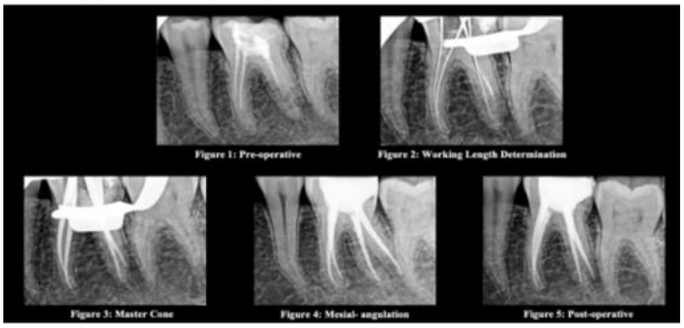
Post-obturation radiograph revealed three distinct mesial canal orifices, merged in the apical third and exited as one. The access cavity was restored using a composite restoration (3M™ ESPE Filtek™ Bulk Fill, 3M, St. Paul, Minnesota, United States).

Case 2: Re-Treatment of Radix Entomolaris in mandibular first molar

A 32-year old male patient reported to the Department of Conservative Dentistry and Endodontics with the chief complaint of persistent dull pain in the lower left back tooth region for the past 10 days. The discomfort was continuous in nature, with occasional episodes of sharp pain aggravated during mastication and intake of hot beverages.

The patient gave a history of prior root canal treatment in the same tooth approximately 6 months back, which had provided temporary relief. However, over the last few days, the pain had intensified. On clinical examination, tooth presented with restoration and tenderness on vertical percussion. Oral hygiene was fair.

A preoperative intraoral periapical radiograph revealed previous root canal treatment with inadequate obturation and presence of an additional root distally. Another radiograph was taken at mesial and distal angulation to confirm the same. A distinct periapical radiolucency was observed in the distolingual root, suggestive of apical periodontitis.



Case 2: Radix Entomolaris

Treatment Procedure

Access cavity preparation was done under local anesthesia with an endo access bur (Dentsply, Switzerland). Subsequent isolation of the area with a rubber dam, the occlusal filling was removed. A total of four canal orifices were identified and verified using magnifying loupes (iMag™ ,Vision Forward LLP, Mumbai, India). The removal of gutta-percha was accomplished

through the utilisation of retreatment rotary files (ProTaper Universal Retreatment Files, Dentsply Sirona).

The determination of working length was conducted using an apex locator (Root ZX mini, J. Morita Inc, USA) and afterwards verified through radiographic examination using a 10 K hand file (Mani, Inc., Japan). The canals were prepared using ProTaper Universal NiTi rotary instrument (Dentsply-Sirona) in a crown-down manner till F2(25/8%). The canals were irrigated using a solution consisting of 2.5% sodium hypochlorite (NaOCl), 17% Ethylenediaminetetraacetic acid (EDTA), 2% Chlorhexidine (CHX) and saline solution. The application of intracanal medicine, specifically calcium hydroxide (CH) paste was applied using Lentulo spiral (Dentsply Maillefer) size 25. Access cavity was closed with a cotton pellet and a temporary cement Cavit (3M ESPE). Patient was scheduled for next visit after 1 week.

After 1 week, the tooth was asymptomatic and the temporary filling was intact. Following the rubber dam isolation, the temporary cement and cotton pellet were extracted from the access cavity. The use of 2.5% NaOCl in combination with ultrasound activation was done effectively to eliminate the CH paste present in the root canal. The experimental procedure concluded with a final rinse utilizing a solution of 17% EDTA for a duration of 1 minute.

Canal was dried with a paper point and obturated using Gutta percha with single cone technique and bioceramic sealer (MTA fillapex, Angelus, Brazil). Patient was recalled after one week for complete coverage restoration.

Case 3: Management of mandibular first premolar with Vertucci Type V (1-2) root canal configuration.

A 24 year old female patient presented to the Department of Conservative Dentistry and Endodontics with the chief complaint of intermittent pain in the lower left posterior region for the past week. The pain was dull, occasionally sharp and aggravated on chewing and cold beverages. On intraoral examination, a deep occlusal carious lesion with tenderness on percussion was observed. Pulp sensibility testing revealed exaggerated and lingering response to cold, suggestive of symptomatic irreversible pulpitis.

Thorough radiographic examination revealed existence of single root with one canal in coronal region dividing into two separate canals in middle third region, suggesting a Vertucci type V root canal configuration. Radiolucency was observed involving enamel, dentin and extending to the pulp chamber, without periapical involvement.

Case 3: Vertucci Type V (1-2) configuration

Treatment Procedure

Access cavity preparation was done under local anesthesia with an endo access bur (Dentsply, Switzerland). First a #10K file inserted in buccal canal, the next #10K file was pre-curved and inserted in a distolingual direction to traverse the canal bifurcation into the second canal.

Working length was taken using an electronic apex locator (Root ZX mini, J. Morita Inc, USA) and an IOPA radiograph was also taken to confirm the presence of a single coronal canal bifurcating into two separate canals. Biomechanical preparation was done with protaper rotary instrument upto # 25/04 file. Irrigation procedure was carried out with 5.25% NaOCl, 17% EDTA and saline solution. Canals were dried using sterile paper points and gutta-percha master cones corresponding to the size of master apical file were inserted to the full working length. Obturation was done using single cone technique with buccal canal first followed by lingual canal using AH plus sealer (Dentsply Sirona). The tooth was restored with composite resin (Ceram.X Spectra™ ST HV (Dentsply Sirona, Konstanz, Germany).

Discussion

Clinical triad of diagnosis, adequate chemo-mechanical preparation and three dimensional obturation determine the success of root canal therapy. Endodontic re-treatment requires addressing a series of challenges that may be morphological or iatrogenic, such as under extended access cavity, filling materials or foreign objects.[9]

Critical evaluations of multiple angulated radiographs help the operator better plan the endodontic treatment. A study done by Chavda et al. showed that magnification predominantly helped in identifying the thin MMC, along with ultrasonics. MMC are very tiny and may be present deep into the isthmus.[10]

In our report, Case 1 had an confluent type MMC. Based on the Pomeranz et al.'s classification, a confluent canal implies that it originates separately but merges with either the mesiobuccal or mesiolingual canal before exiting the root, appears as an additional orifice but does not exit independently, which is found to be rare.[11] Toubes et al. stated that the MMC orifice was closer to MB (46%), followed by ML (31%), and found separately between MB and ML (23%).[12]

In Case 2 of this report, Type 1 radix entomolaris was seen. The radix can be classified based on the root/canal curvature, proposed by Ribeiro et al.[13]: Type 1, straight root/root canal; Type 2, initially curved entrance followed by straight root/root canals; and Type 3, curvature at coronal third followed by buccally oriented curvature starting from middle to apical third.

The exact etiology of radix entomolaris is still not known but according to some authors it may be due to disturbance during odontogenesis or may be due to the high degree of genetic penetrance.[14]

In Case 3, preoperative radiographs showed a distinct narrowing in the middle third of the canal, prompting further

investigation, which eventually confirmed the presence of a Vertucci Type V configuration. Miyoshi et al. concluded that variation in canal anatomy may be suspected when the middle third of the root appears equal to or greater in diameter than the coronal third on a preoperative radiograph.[15] Similarly, Yoshioka et al. indicated that a sudden narrowing or abrupt loss of canal continuity on a parallel radiograph is often suggestive of multiple canals.[16]

The clinical success of endodontic therapy hinges on recognizing and treating anatomical variations that may otherwise be overlooked. This case series reinforces the need for careful radiographic interpretation, use of magnification and thorough exploration of the pulp chamber floor. Identifying uncommon variations such as middle mesial canals, radix entomolaris, and bifurcating premolar canals ensures complete debridement and obturation, preventing failures and enhancing long-term prognosis.

Conclusion

The complexity of the root canal system often presents a challenge to clinicians. Undetected anatomical variations can compromise the prognosis of endodontic treatment. This case series demonstrates how careful identification and management of complexities such as middle mesial canals, radix entomolaris, and Vertucci Type V configurations, can lead to improved outcomes. Clinical vigilance, combined with advanced techniques and a thorough understanding of root canal anatomy, remains essential for endodontic success.

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Biomimetic Materials in Conservative Dentistry and Endodontics: A Narrative Review

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Abstract

Biomimetic dentistry represents a transformative approach in conservative and endodontic therapy, wherein materials and techniques are designed to emulate the biological structure and function of natural dental tissues. This review aims to explore the current scope, mechanisms, and clinical applications of biomimetic materials in the restoration of enamel, dentin, and pulpal tissues. Key materials such as calcium silicate cements, resin-based systems, and bioactive glasses are assessed for their ability to promote remineralization, enhance sealing ability, and induce tissue regeneration.

Biomimetic principles are particularly evident in pulp capping and regenerative endodontics, where materials like mineral trioxide aggregate (MTA), biodentine, and enamel matrix derivatives are instrumental. These materials influence stem cell differentiation, mineral deposition, and interface adaptation, thereby mimicking the dentin-pulp complex. Moreover, advancements in nanotechnology and ion-releasing restorative materials have led to promising outcomes in maintaining tooth vitality, improving bond strength, and reducing microleakage.

Despite considerable progress, limitations exist, including technique sensitivity, cost, and variable clinical evidence. This article underscores the critical need for long-term studies and standardized protocols to integrate biomimetic dentistry fully into mainstream clinical practice.

Keywords : Biomimetic dentistry, Endodontics, Remineralization, Pulp capping, Bioactive materials, Dentin bonding, Calcium silicates

Introduction

Biomimetic materials are engineered to replicate the structure, function, and biological behavior of natural tissues. The term "biomimetics" derives from the Greek roots bios (life) and mimesis (imitation), and its application in dentistry focuses on restoring structural integrity and function of teeth using biologically inspired materials. In the context of conservative dentistry and endodontics, biomimetic strategies aim to minimize tooth structure removal, enhance adhesion, promote pulp vitality, and regenerate lost dental tissues using materials that closely resemble dentin and enamel in composition and behavior.

Over the past two decades, the transition from mechanical retention to adhesive bonding has revolutionized restorative dentistry, making biomimetics central to clinical protocols. The goal is to achieve restoration longevity while preserving the tooth's native architecture, biomechanics, and biological responsive-ness.

Biomimetic Paradigms in Dental Practice

Biomimetic dentistry is governed by four core principles:

1. Maximized Bond Strength-Strong adhesion mimics natural tooth resilience.

2. Long-term Marginal Seal-Prevents microbial ingress and supports pulp vitality.

3. Increased Pulp Vitality-Enhances resistance to fractures and secondary caries.

4. Reduced Residual Stress-Maintains structural stability under occlusal forces.

These paradigms influence both material selection and clinical protocol in restorative and endodontic procedures.

Classification of Biomimetic Materials

Biomimetic materials can be broadly categorized based on their regenerative potential and interaction with biological tissues:

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1. Osteoproductive Materials: Facilitate direct colonization by osteogenic stem cells (e.g., Bio-glass).
2. Osteoconductive Materials: Provide a scaffold for bone growth (e.g., Hydroxyapatite).
3. Restorative Biomimetic Agents: Mimic enamel or dentin in elastic modulus and surface hardness (e.g., GIC, nano-composites, bioceramics).
4. Regenerative Biomaterials: Stimulate tissue healing or cellular responses (e.g., MTA, PRF, BMPs, ACP).

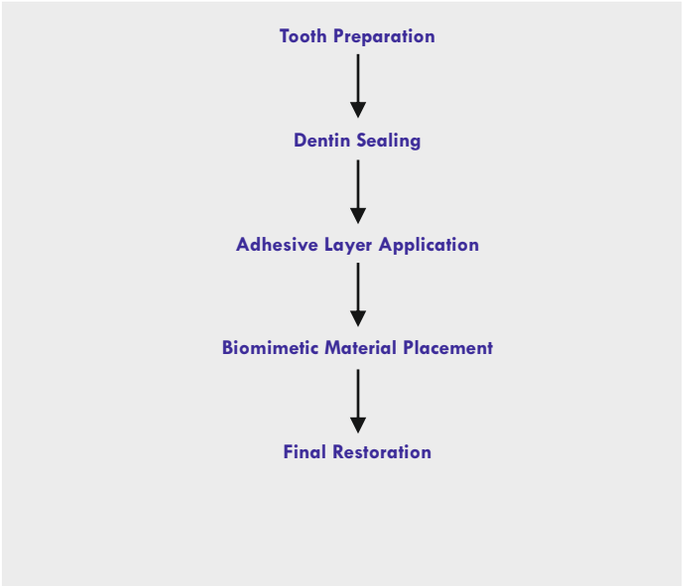
Properties of Ideal Biomimetic Materials

Elastic Modulus (EM): Should match natural dentin/enamel to distribute stress evenly.
Surface Hardness (SH): High resistance to wear.
Biocompatibility: Non-toxic, non-irritating, and conducive to pulp tissue.
Bioactivity: Promote hydroxyapatite formation and remineralization.
Adhesion: Chemical and micromechanical bonding to tooth structure.

Diagnostic Properties of Selected Biomimetic Materials

Material	EM (GPa)	SH (GPa)	Bioactivity	Remineralization	Use in Endo
Glass Ionomer Cement	6–10	0.5–1.5	Moderate	Yes	Yes
MTA	15–30	1.2–1.5	High	Yes	Yes
Calcium Hydroxide	N/A	Low	Moderate	Moderate	Yes
ACP	Variable	Low	High	Excellent	Yes

Mechanisms of Action in Biomimetic Endodontics



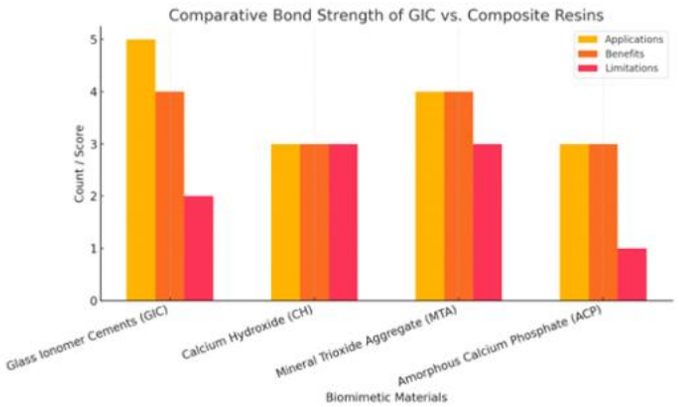
Flowchart: Biomimetic Restorative Workflow in Endodontics

A. Bottom-Up Remineralization: A key strategy in dentin regeneration. Uses nano-precursor particles (e.g., ACP) to infiltrate and rebuild demineralized collagen matrices.
B. Bioinductive Mechanisms: Materials like MTA and PRF release ions that stimulate odontoblasts and support the formation of tertiary dentin and hard tissue bridges.

Key Biomimetic Materials in Endodontics

1. Glass Ionomer Cements (GIC)

Benefits: Fluoride release, adhesion to moist dentin, thermal compatibility, minimal pulp irritation.
Applications: Liners, bases, core build-ups, ART, and permanent restorations.
Limitations: Low flexural strength, brittle nature

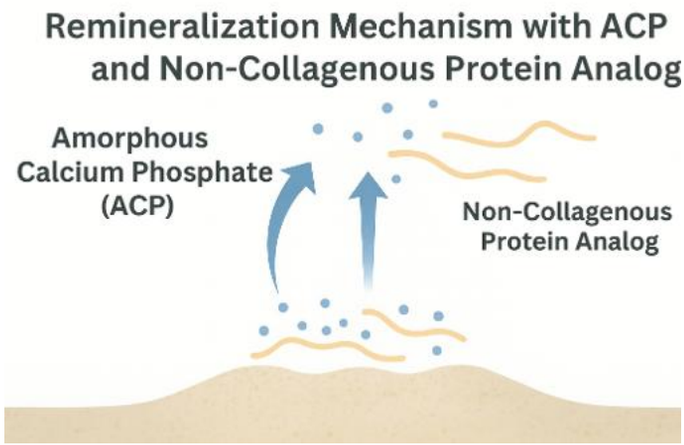


2. Calcium Hydroxide (CH)

Mechanism: High pH promotes fibroblast stimulation, neutralizes acids, and induces mineralized tissue.
Uses: Pulp capping, apexogenesis, weeping canals.
Limitations: Poor long-term adhesion, solubility, dissolution under acid etching.

3. Mineral Trioxide Aggregate (MTA)

Composition: Tricalcium silicate, bismuth oxide, and other calcium aluminates.
Applications: Root-end fillings, perforation repair, apexification, pulpotomy.
Properties: Biocompatible, radiopaque, promotes cementogenesis and dentinogenesis.
Drawbacks: Long setting time, tooth discoloration, cost.



4. Amorphous Calcium Phosphate (ACP)

Role: Acts as a precursor to hydroxyapatite.
Applications: Varnishes, chewing gum, GIC additives.
Biological Role: Enhances remineralization and osseointegration; precursor to enamel and dentin mineral.

Recent Advances and Future Directions

Nanotechnology: Integration of nanofillers (e.g., Nano-HA,

nano-bioactive glass) into composites or GIC to improve strength and bioactivity.

Biopolymers: Chitosan, polydopamine, and peptide-based scaffolds for enhanced regenerative outcomes.

Antibacterial Modification: Incorporation of agents like chlorhexidine, propolis, and graphene oxide to enhance antimicrobial efficacy without cytotoxicity.

Smart Materials: Materials that respond to environmental pH or enzymatic activity to release ions or change behavior.

Clinical Applications and Performance

Material	Application	Advantages
MTA	Pulp capping, apexification	High biocompatibility, hard tissue formation
Biodentine	Dentin replacement	Bioactivity, fast setting
Resin-modified GIC	Cervical restorations	Fluoride release, easy handling
ACP-composites	Remineralizing restorations	Sustained ion release

Advantages of Biomimetic Materials

Mimicry of natural tooth properties.
Promotion of biological healing and regeneration.
Improved bond interface stability.
Reduced polymerization stress and secondary caries.

Challenges and Limitations

Technique sensitivity in placement and curing.
Higher cost of novel biomaterials.
Limited long-term RCTs.
Outcome standardization issues.

Future Directions

Smart biomaterials responsive to pH or bacteria.
Nanotechnology and 3D-printed scaffolds.
Injectable dentin substitutes.
Trials focusing on clinical longevity and biomarker expression.

Clinical and Scientific Insights

The introduction of biomimetic materials into restorative and endodontic dentistry has not only changed the clinical practice but also created a new frontier for scientific inquiry. These materials are designed with the intent to imitate the structural and functional components of natural dental tissues such as enamel, dentin, and pulp. Their efficacy lies in the ability to interact with the biological environment by releasing ions, guiding tissue regeneration, and resisting degradation over time.

Clinically, the success of such materials depends on a combination of factors including their composition, bioactivity, mechanical performance, and ease of manipulation. MTA and Biodentine are prime examples that have shown superior outcomes in pulp capping and vital pulp therapies due to their biocompatibility and dentinogenic properties. Bioactive glasses and calcium phosphate cements offer unique benefits such as apatite formation, which supports mineralization at the restoration-dentin interface.

From a restorative standpoint, the goal is not only structural replacement but also biological support. This includes stabilizing the hybrid layer, preventing collagen degradation, and promoting ion exchange to reinforce dentin. The challenge lies in tailoring these properties for different clinical scenarios-whether deep carious lesions, exposed pulp, or necrotic immature teeth requiring regenerative therapy.

Emerging technologies such as nanostructured bioactive fillers, smart polymers, and injectable hydrogels are currently being evaluated for their ability to mimic the dynamic behavior of dental tissues. Injectable calcium silicate systems, for example, offer easier handling while maintaining mineral induction potential.

Conclusion

Biomimetic materials represent a significant advancement in conservative and endodontic dentistry. By combining biologically inspired design with material science, these agents offer improved healing, restoration longevity, and patient outcomes. While challenges persist, especially in clinical standardization, biomimetic dentistry is rapidly evolving into a core component of patient-centered care.

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Vital Pulp Therapy and Apical Barrier Formation: An Insight into Apexogenesis and Apexification

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Abstract

Background: Immature permanent teeth present unique clinical challenges when pulp vitality is lost or compromised. The thin dentinal walls, wide-open apex, and incomplete root development complicate endodontic treatment. Two biologically distinct approaches-apexification and apexogenesis-form the cornerstone of management. Apexification aims to induce apical closure in non-vital teeth, while apexogenesis seeks to preserve pulp vitality and promote continued root maturation.

Aim: To provide a comprehensive review of apexification and apexogenesis, detailing the biological principles, clinical protocols, materials, prognosis, and recent advances, including regenerative endodontics.

Methods: Literature was reviewed from PubMed, Scopus, and ScienceDirect databases (1960-2025) using keywords "apexification," "apexogenesis," "immature permanent teeth," "regenerative endodontics," and "MTA." Studies included clinical trials, systematic reviews, meta-analyses, and key case reports.

Results: Multi-visit calcium hydroxide apexification, though historically successful, has been largely replaced by single-visit mineral trioxide aggregate (MTA) and bioceramic apical plugs. Apexogenesis remains the gold standard for vital immature teeth, yielding thicker dentinal walls and reduced fracture risk. Regenerative protocols, guided by the American Association of Endodontists (AAE), offer promising pulp–dentin complex regeneration in necrotic immature teeth.

Conclusion: Case selection is the critical determinant of success. Contemporary materials and biologically driven protocols have improved outcomes, reduced treatment times, and expanded the therapeutic possibilities for immature permanent teeth.

Keywords: Apexification, Apexogenesis, Immature permanent teeth, Regenerative endodontics, Mineral trioxide aggregate, Bioceramic materials.

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Introduction

Tooth development is a continuous process that extends for up to three years after eruption. In immature permanent teeth, Hertwig's epithelial root sheath (HERS) orchestrates root elongation and apical closure. Disruption due to trauma, caries, or developmental anomalies can halt root maturation, leading to open apices and thin radicular dentin.

Epidemiological studies show that traumatic dental injuries affect 25–30% of school-aged children, with maxillary central incisors being the most commonly involved . When pulp vitality is compromised before apical closure, endodontic therapy is complicated by the lack of an apical stop for condensation, poor sealing ability, and increased risk of fracture.

Historically, calcium hydroxide apexification was the treatment of choice for non-vital immature teeth . However, long treatment times and structural weakening prompted the shift toward bioactive materials such as MTA. Conversely, apexogenesis aims to preserve the vital pulp tissue to allow natural root development, and remains the first-line choice for vital immature teeth.

In recent years, regenerative endodontic procedures (REPs) have emerged, aiming not only for root-end closure but also for the regeneration of functional pulp tissue.

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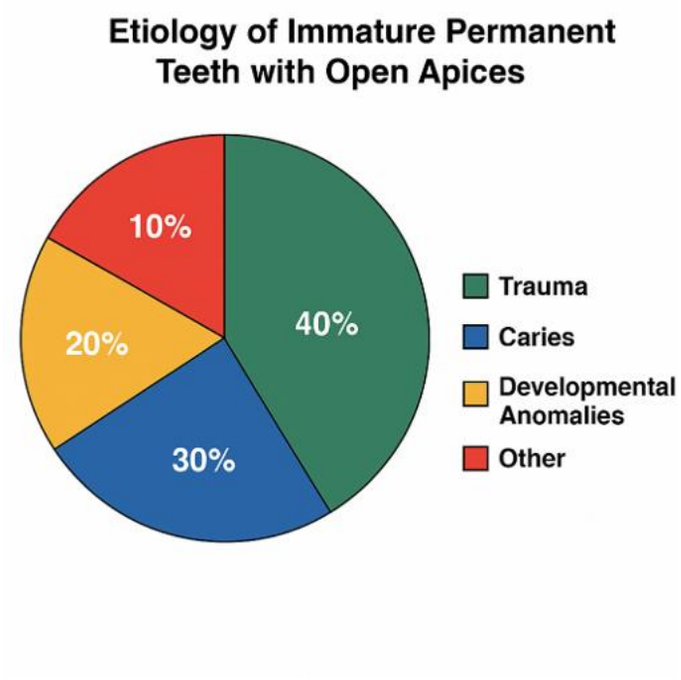


Figure: Etiology of immature permanent teeth with open apices, showing trauma as the leading cause (40%), followed by caries (30%), developmental anomalies (20%), and other factors (10%)

Figure X: Radiographic view of an immature permanent tooth with open apex

Biological Basis

Role of Hertwig's Epithelial Root Sheath (HERS)

- HERS guides root lengthening, curvature, and apical constriction.
- Damage or early loss of HERS halts dentin deposition at the apex, leaving an open canal.

Apical Papilla

- Contains stem cells (SCAP) essential for root development.
- Preservation of apical papilla is crucial in regenerative therapies.

Apexification

Definition

Apexification is a method to induce calcific barrier formation at the apex of a non-vital immature tooth, enabling obturation.

Indications

- Necrotic pulp in immature teeth with open apices.
- Apical resorption in immature teeth without potential for root elongation.

Historical Calcium Hydroxide Protocol

- Introduced by Kaiser (1964).
- **Mechanism:** High pH stimulates alkaline phosphatase activity, inducing calcified tissue formation.
- **Application:** Placement of $Ca(OH)_2$ paste for 6–24 months, with periodic replacement.

Limitations:

- Prolonged treatment duration
- Increased risk of root fracture due to reduced dentin modulus.

Contemporary MTA/Bioceramic Protocol

- **Single-Visit Apexification**

  Cleaning and shaping with minimal mechanical instrumentation.

  Irrigation: 1.5–3% NaOCl followed by 17% EDTA.

  Placement of 3–5 mm MTA plug at the apex.

  Backfill with thermoplasticized gutta-percha or resin sealer.

- **Advantages:** High success rate, biocompatibility, excellent sealing.
- **Alternative Materials:** Biodentine, EndoSequence Root Repair Material (ERRM).

Property	Calcium Hydroxide [$Ca(OH)_2$]	Mineral Trioxide Aggregate (MTA)
Mechanism of Action	High pH stimulates alkaline phosphatase activity and hard tissue barrier formation over several months	Bioactive material induces cementogenesis and hard tissue barrier formation rapidly
Setting Time	Does not set; requires replacement every 3–6 months	Initial set: 3–4 hours (fast-set variants: <20 min)
Treatment Duration	6–24 months with multiple visits	Single visit or 1–2 visits
Sealing Ability	Moderate; prone to microleakage if coronal seal is compromised	Excellent sealing due to expansion and low solubility
Biocompatibility	High; antibacterial due to high alkalinity	High; induces less inflammation and promotes tissue regeneration
Effect on Dentin	Long-term use weakens dentin, increasing fracture risk	Maintains dentin strength; no significant weakening
Radiopacity	Moderate	High
Handling	Easy to place; requires frequent recall	More technique-sensitive; requires proper isolation during placement
Cost	Low	High
Prognosis	Good if patient complies with multiple recalls; risk of fracture in long-term use	High success rate; reduced follow-up time and better patient compliance

Table 1: Comparative Properties of $Ca(OH)_2$ vs. MTA in Apexification.

Apexogenesis

Definition

Vital pulp therapy in an immature permanent tooth to promote continued root growth and apical closure.

Indications

- Immature teeth with vital pulp.

- Traumatic or carious exposures without irreversible pulpitis.

Techniques

- **CvekPulpotomy:** Removal of 1–2 mm of inflamed pulp beneath the exposure site.
- **Full Coronal Pulpotomy:** Complete removal of coronal pulp, preservation of radicular pulp.

Procedure

1. Rubber dam isolation
2. Caries/trauma removal
3. Hemostasis with sterile saline or dilute NaOCl
4. Placement of MTA/Biodentine over pulp tissue
5. Definitive coronal restoration (composite, glass ionomer)

Advantages:

- Continued root lengthening and dentin thickening.
- Reduced risk of fracture compared to apexification.
- Diagram showing apexification vs. apexogenesis outcomes.

Diagram showing apexification vs. apexogenesis outcomes

Recent Advances-Regenerative Endodontics

Principles

Biological regeneration of pulp–dentin complex using stem cells, scaffolds, and growth factors.

Protocol (AAE Guidelines)

1. Minimal instrumentation to preserve stem cells in apical papilla.
2. Canal disinfection with low-concentration NaOCl and EDTA.
3. Placement of intracanal medicament (Triple Antibiotic Paste or $Ca(OH)_2$).
4. Induction of apical bleeding to provide a scaffold.
5. Sealing with MTA/Biodentine and permanent restoration.

Adjunctive Materials

- Platelet-rich plasma (PRP) and platelet-rich fibrin (PRF) for enhanced healing.
- Collagen matrices as scaffolds.

Advantages: Potential for true pulp vitality and natural immune defense restoration.

Prognostic Factors

Factor	Favourable for Apexogenesis	Favourable for Apexification
Pulp vitality	Positive	Negative
Root development stage	Early to mid	Mid to late
Patient compliance	Moderate	Low (due to single-visit option)
Coronal seal quality	Critical	Critical

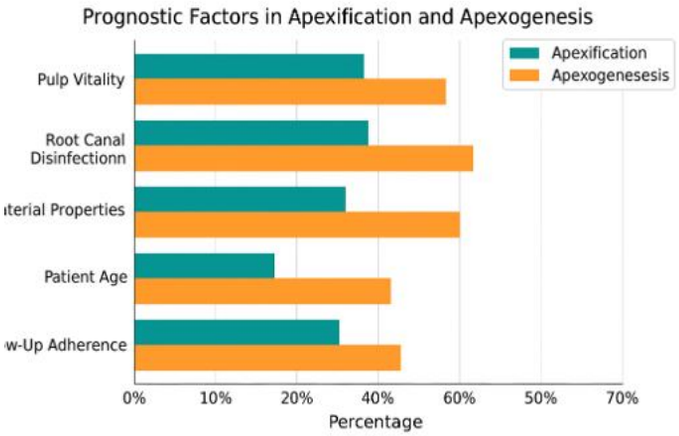
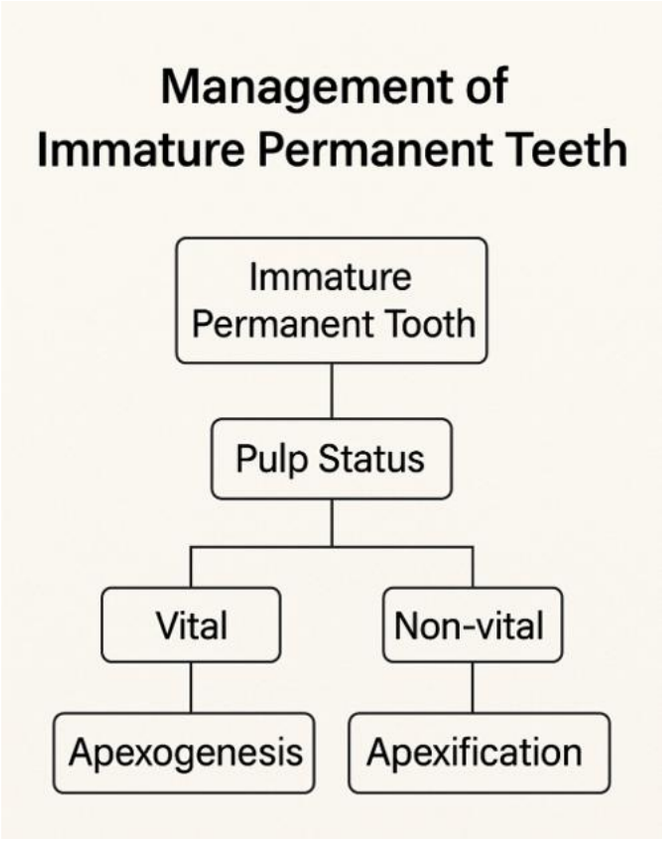


Figure: Comparative prognostic factors in apexification and apexogenesis, showing relative importance of pulp vitality, root canal disinfection, material properties, patient age, and follow-up adherence.

Clinical Decision-Making Flow



Flowchart – Management of Immature Permanent Teeth.

Complications and Management in Apexification and Apexogenesis

Despite advances in biomaterials and treatment protocols, both apexification and apexogenesis carry potential risks that may compromise long-term prognosis. Understanding these complications, their etiology, and preventive strategies is essential for clinicians managing immature permanent teeth.

1. Complications in Apexification

a) Root Fracture

Cause: Prolonged calcium hydroxide dressing can lead to dehydration of dentin and decreased flexural strength.

Evidence: Andreasen et al. reported a significant increase in cervical fractures in teeth dressed with $Ca(OH)_2$ for more than six months.

Management:

Prefer single-visit MTA apexification or short-term $Ca(OH)_2$ use.

Reinforce cervical region with bonded composite resin after obturation.

b) Persistent PeriapicalPathosis

Cause: Inadequate disinfection, persistent bacterial biofilm, or microleakage.

Management:

Re-treatment with improved disinfection protocols.

Use of adjunctive irrigants (chlorhexidine) and passive ultrasonic activation.

c) MTA Displacement or Washout

Cause: Premature obturation or inadequate setting time in presence of moisture contamination.

Management: Ensure proper isolation, allow sufficient setting (minimum 3–4 hours or use fast-set MTA), confirm placement radiographically.

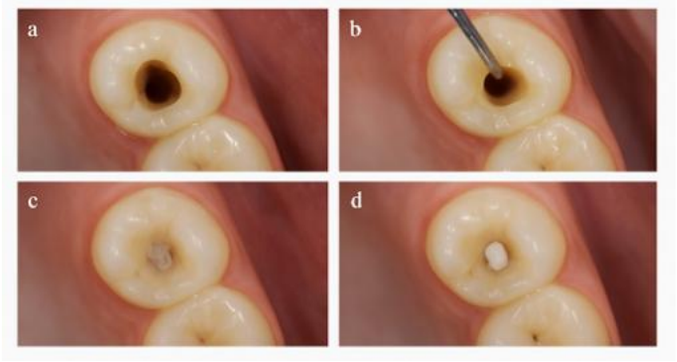


Figure : Clinical steps in apexification procedure using mineral trioxide aggregate-(a) access cavity preparation, (b) canal cleaning, (c) placement of MTA apical plug, and (d) final obturation.

2. Complications in Apexogenesis

a) Pulp Necrosis

Cause: Misdiagnosis of pulp status or failure to achieve asepsis during procedure.

Management: If pulp necrosis occurs, convert to apexification or regenerative protocol depending on remaining root development.

b) Internal Resorption

Cause: Chronic inflammation within pulp tissue stimulating odontoclast activity.

Management: Early radiographic detection; immediate pulpectomy and apexification if resorption is progressive.

c) Failure of Root Development

Cause: Disruption of Hertwig's epithelial root sheath from trauma or infection.

Management: Consider regenerative endodontics to stimulate new tissue formation.

3. General Factors Affecting Outcomes

Patient Compliance:

Apexogenesis requires regular follow-up until apex closure is confirmed radiographically. Missed appointments may delay detection of failure.

Coronal Seal Integrity:

Coronal leakage remains a primary cause of failure in both procedures. Use of bonded permanent restorations soon after treatment is critical.

Operator Skill:

Misplacement of MTA, over-instrumentation, or inadequate hemostasis can compromise healing. Strict adherence to protocols is essential.

4. Prevention Strategies

Use rubber dam isolation in all cases to minimize contamination.

Select materials with proven bioactivity and sealing ability (MTA, Biodentine).

Limit $Ca(OH)_2$ dressing duration to less than three months to avoid dentin weakening.

Schedule periodic recalls (every 3-6 months) with periapical radiographs to assess healing and root development.

Educate patients and guardians about the importance of follow-up care, especially in pediatric and adolescent patients.

5. Prognosis Considerations

Overall, apexogenesis has a higher success rate and better long-term prognosis than apexification, owing to continued root thickening and increased fracture resistance. Apexification with MTA offers rapid and predictable apical closure but does not reinforce dentinal walls; therefore, strategic restorative reinforcement is advised.

With the integration of regenerative endodontics into treatment planning, many complications associated with traditional techniques may be minimized in the future. However, these newer approaches require stringent case selection and meticulous procedural execution to ensure predictable outcomes.

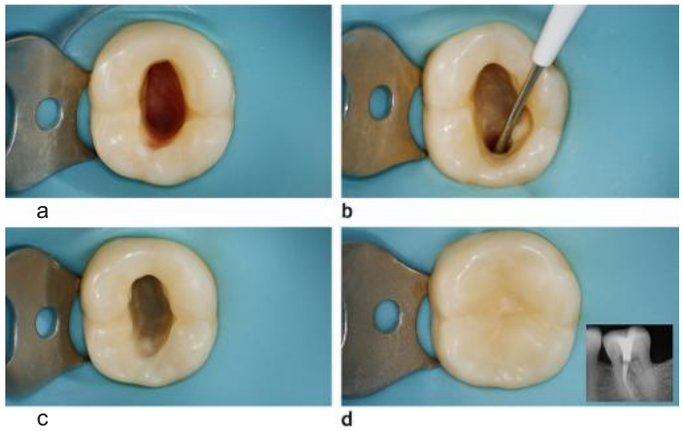


Figure X: Partial pulpotomy in apexogenesis using MTA-(a) initial pulp exposure, (b) hemostasis, (c) placement of bioactive material, (d) final restoration with postoperative radiograph.

Conclusion

Apexification, apexogenesis, and regenerative endodontics form the triad of modern approaches to immature permanent teeth. While apexogenesis should be prioritized for vital teeth, single-visit MTA apexification offers predictable outcomes for necrotic cases. Regenerative procedures hold promise for restoring vitality and function, but require careful case selection and strict adherence to biological principles.

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Role of HPV in Oral Squamous Cell Carcinoma: A Review

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Abstract

Human papillomavirus (HPV) is increasingly recognized as a contributing factor in oral squamous cell carcinoma (OSCC). Although HPV has a well-established role in oropharyngeal cancers, its association with OSCC is less clear, with global prevalence rates around 6%. This review explores the epidemiology, risk factors, clinical implications, and preventive strategies, highlighting the necessity for clear diagnostic and preventive approaches tailored specifically to OSCC.

Keywords : HPV, oral squamous cell carcinoma, epidemiology, prevention, risk factors.

Introduction

Human papillomavirus (HPV) infects most sexually active individuals at some point in their lives[1]. While widely known for its association with cervical cancers, HPV is also implicated in oral cancers. This article critically examines HPV's role in OSCC, contrasting it with HPV-positive oro-pharyngeal squamous cell carcinoma (OPSCC).

Understanding HPV and Head & Neck Cancer

HPV Types and Infection Pathways

Over 200 HPV types exist, with HPV-16 and HPV-18 categorized as high-risk strains closely linked to cancer development [2]. HPV transmits primarily via skin-to-skin and mucosal contact, notably through sexual activities. Persistent infections can lead to oncogenic protein expression (E6, E7), disrupting tumor suppressors p53 and RB pathways[2].

HPV Association with OPSCC

HPV is strongly associated with OPSCC, with approximately 70% positivity in these cancers, leading to generally better prognoses compared to HPV-negative cases[3].

HPV & OSCC: Epidemiology and Prevalence

Global and Regional Prevalence

A recent meta-analysis reported HPV prevalence in OSCC at approximately 6%, with variability from 0% to 37% across regions, often higher in tongue carcinomas[4].

Interpreting Evidence

The comparatively low prevalence of HPV in OSCC suggests it plays a limited etiological role, influencing current guidelines against routine HPV testing for OSCC[5].

Risk Factors for OSCC

Traditional vs. Emerging Risks

Primary risk factors for OSCC remain tobacco, alcohol, and betel quid use, with HPV being a relatively minor factor, especially in high tobacco-use regions[6,7].

Comparative Risk Analysis (OPSCC vs. OSCC)

Factor	OPSCC	OSCC
HPV Prevalence	~70%	~6%
Prognosis (HPV-positive)	Improved survival	Not clearly improved
Recommended HPV testing	Yes	No
Main Risk Factors	HPV, sexual behavior	Tobacco, alcohol, betel quid

Clinical Implications

Screening and Diagnosis

Routine HPV testing is recommended for OPSCC but not OSCC; thus, clinical examinations and biopsies are essential for OSCC diagnosis5.

Prevention Strategies

- HPV Vaccination: Vaccines targeting HPV-16 and HPV-18 significantly prevent HPV-related cancers. WHO recommends vaccination for ages 9–14[8].
- Reduction of Tobacco, Alcohol, and Betel Use: Lifestyle modifications remain critical for prevention, and

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dental professionals play essential roles in patient education and early detection[6].

Education and Awareness

Educating patients about HPV vaccination, safe practices, and regular oral screenings is vital.

Graphical Insights

Figure 1 shows a bar chart comparing HPV prevalence in Oral Squamous Cell Carcinoma (OSCC) vs. Oropharyngeal Squamous Cell Carcinoma (OPSCC), highlighting the significantly higher prevalence in OPSCC.

Figure 2 illustrates a pie chart representing the primary risk factors for OSCC, emphasizing that tobacco use remains the dominant factor, with HPV contributing a smaller portion.

Figure 3 illustrates hypothetical global regional variability in HPV prevalence in OSCC, providing a simplified view of geographic differences.

Figure 4 presents a flowchart illustrating the transmission of HPV and its pathway to developing Oral Squamous Cell Carcinoma (OSCC).

Future Directions and Research Needs

- Detailed investigations into HPV's specific roles in oral cavity sub-sites.
- Research interactions between HPV and other carcinogens.
- Evaluate HPV vaccine long-term effectiveness in OSCC prevention.
- Develop OSCC-specific screening protocols.

Conclusion

HPV's role in OSCC is modest but significant. Primary preventive measures should prioritize lifestyle changes and HPV vaccination, accompanied by enhanced education and awareness.

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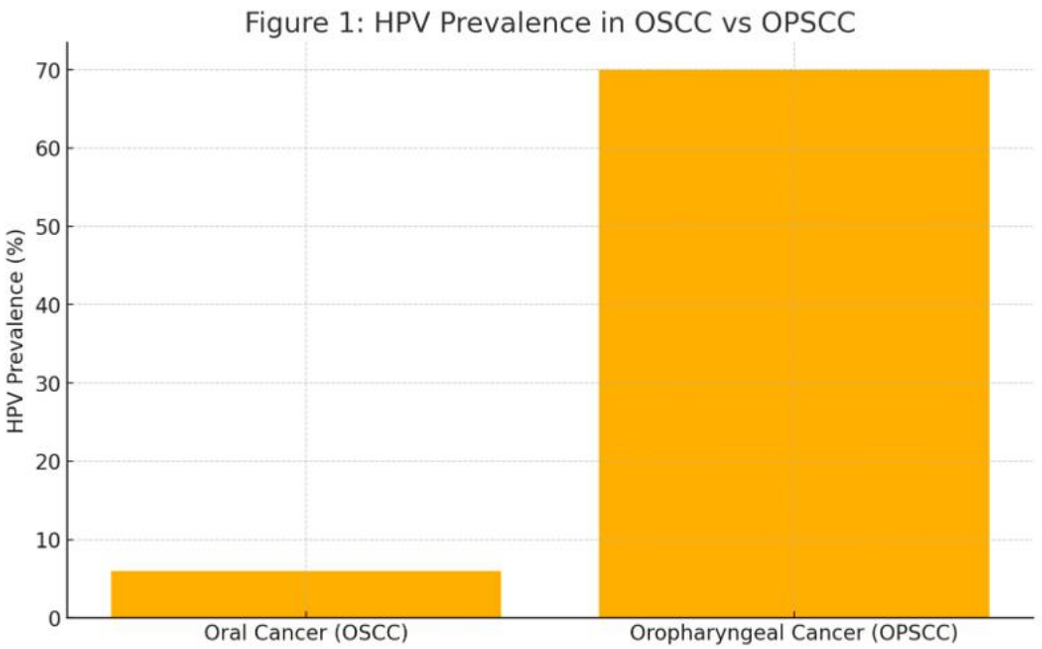

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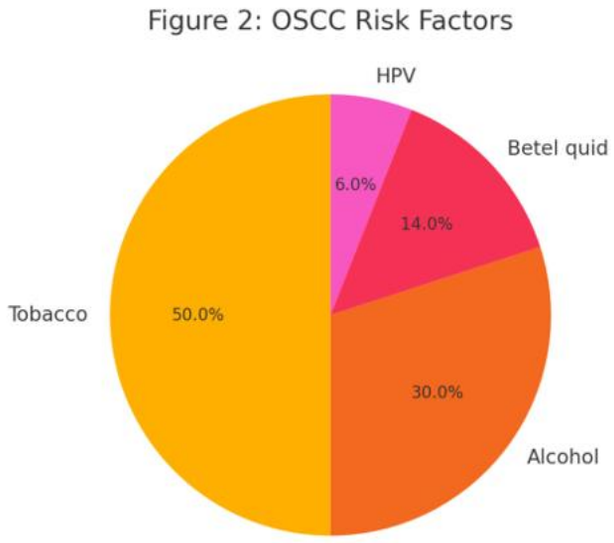

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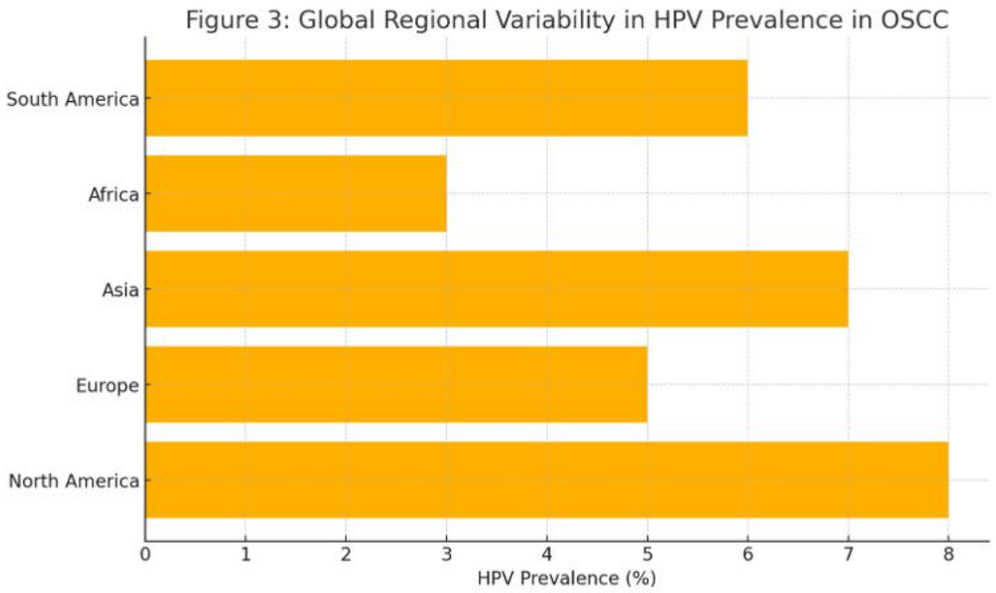

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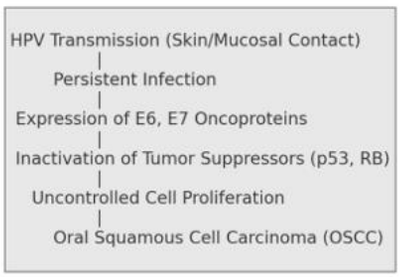
Figure 4: HPV Transmission and Cancer Development Pathway



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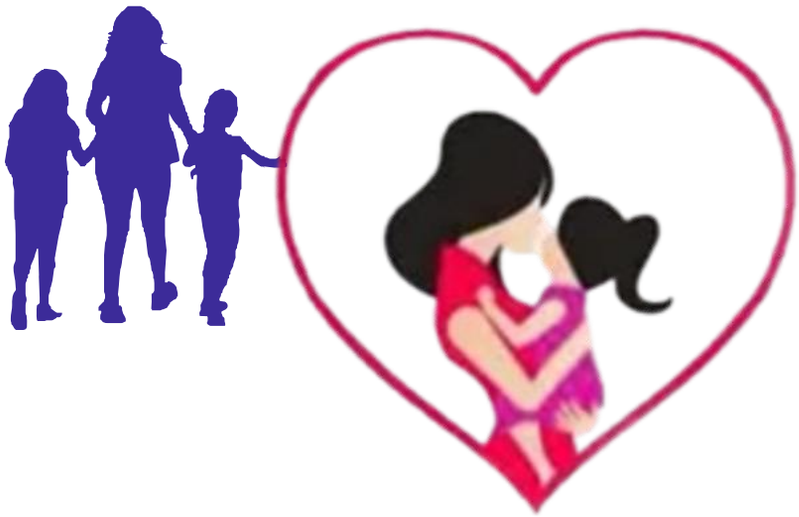

Save The Girl Child

"Girls are Diamonds. Shape them for the Betterment of the Generation" - Afzal A. Zaidi

The Strength and Resilience of Women: A Journey of Progress and Challenges

Women possess immense mental strength and resilience, nurturing a spirit of giving throughout their lives. As the foundation of families, societies, and the world at large, they play an indispensable role in shaping the future. Girls who experience struggles early in life, much like the protagonist in TV serial Udaan of 1989, channel their hardships into strength, driving change and challenging societal norms. As natural multitaskers, women balance personal and professional responsibilities with remarkable efficiency. Their strength is self sustained, standing firm even in the absence of public support.

Many Indian girls have displayed extraordinary grit and strength to achieve remarkable success despite facing immense challenges. Malavath Poorna, born into a tribal family in Telangana, scale Mount Everest at just 13. Despite limited resources and societal constraints, she trained rigorously, proving that determination knows no boundaries. Likewise, Mary Kom, hailing from a small village in Manipur, rise as a six-time world boxing champion. She proved that perseverance and dedication can break any barrier. Another trailblazer, Kiran Bedi, became India's first female IPS officer. She introduced several prison reforms and earned national recognition for her fearless leadership and commitment to justice. These women serve as powerful inspirations, demonstrating the power of determination, courage, and resilience, inspiring generations to break barriers and chase their dreams.

Historically, girls in India faced several challenges due to deep rooted patriarchy and gender discrimination. Education was often denied, with early marriage prioritized over schooling. Child marriages and early motherhood limited their opportunities, while restrictive social norms curbed their mobility and independent choices. Economic dependence kept women out of the workforce, and even those who worked faced wage disparities and job discrimination. Social customs like dowry, purdah, and honor based restrictions further suppressed their freedom. Weak legal protections left women vulnerable to violence and exploitation. Despite these hardships, reforms such as article 16(1) in matters related to employment and article 39(d) equal pay for equal work as well as changing mindsets have gradually improved opportunities for women6.

Politically, women have faced political marginalization, with limited representation in governance and policy making. However, initiatives like reservation for women in Panchayati Raj institutions and the Women's Reservation Bill 2023 aim to increase their participation. Despite these advancements, patriarchal attitudes, safety concerns, and leadership barriers remain significant challenges. Women leaders like Indira Gandhi, Sushma Swaraj, and Droupadi Murmu have paved the way, but greater representation is needed to drive gender inclusive policies.

Economically, women's economic participation has increased, yet wage disparity, job segregation, and financial dependence persist. Many women work in informal sectors with low wages and no social security. Entrepreneurship is rising among women, supported by government schemes like Mudra Yojana and Stand Up India. However, workplace discrimination, career breaks due to maternity, and limited leadership roles remain concerns. Enhancing financial literacy, access to credit, and corporate inclusivity can bridge these economic gaps.

Socially, Gender norms continue to shape women's lives, affecting education, marriage, and career choices. Although female literacy rates have risen from 65 to 77% (NFHS 2011, 2019-2021), early marriage, safety concerns, and gender based violence still pose threats. Women are expected to balance family responsibilities with professional ambitions, often without adequate societal support. Changing attitudes through awareness campaigns like Beti Bachao, Beti Padhao and promoting male allyship can help challenge traditional mindset and create a more equitable society.

Technologically, Digital literacy, online education, and remote work have opened new avenues for career growth. However, cyber harassment, data privacy risks, and the digital gender gap pose significant threats to women's safety. Encouraging STEM education for girls and implementing strong cyber laws can ensure technology serves as a force for empowerment rather than exploitation.

Legally, Several laws protect women's rights, including the Protection of Women from Domestic Violence Act (2005), the POSH Act for workplace harassment, and laws against dowry and child marriage. However, implementation remains weak, and many women are unaware of their legal rights. Strengthening fast-track courts, gender-sensitive policing, and legal literacy programs can bridge the gap between law and justice. The recent push for equal inheritance rights and marital rape recognition reflects a positive shift toward stronger legal safeguards.

Environmentally, women are disproportionately affected by environmental issues such as climate change, water scarcity, and deforestation, particularly in rural areas where they bear the responsibility of fetching water and firewood. Eco-feminism highlights the role of women in sustainable development and conservation. Programs promoting clean energy, organic farming, and women led environmental initiatives can enhance both gender equality and environmental sustainability.

To conclude, women have come a long way, overcoming deep seated societal challenges to carve a space for themselves in various domains. While progress is evident, continued efforts in education, legal reforms, economic empowerment, and social transformation are necessary to achieve true gender equality. By addressing these challenges holistically, we can create a world where every woman and girl has the freedom to dream, achieve, and thrive.

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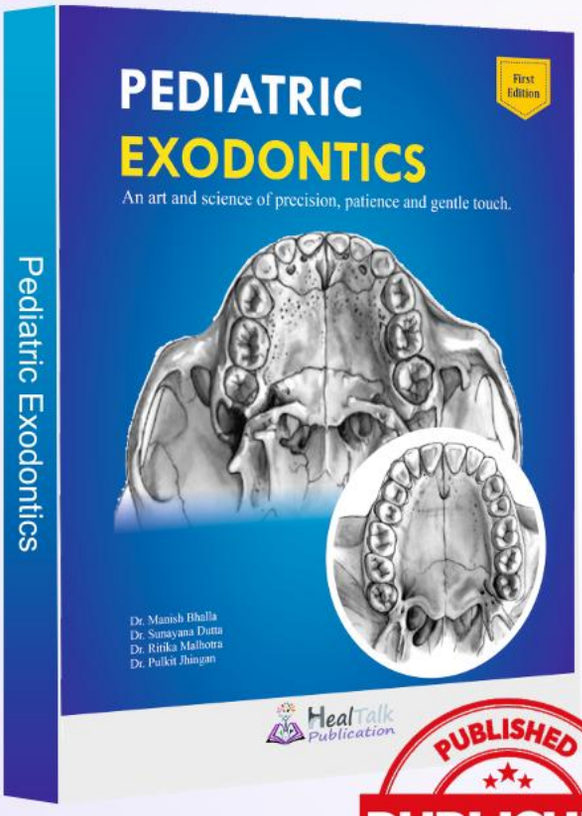

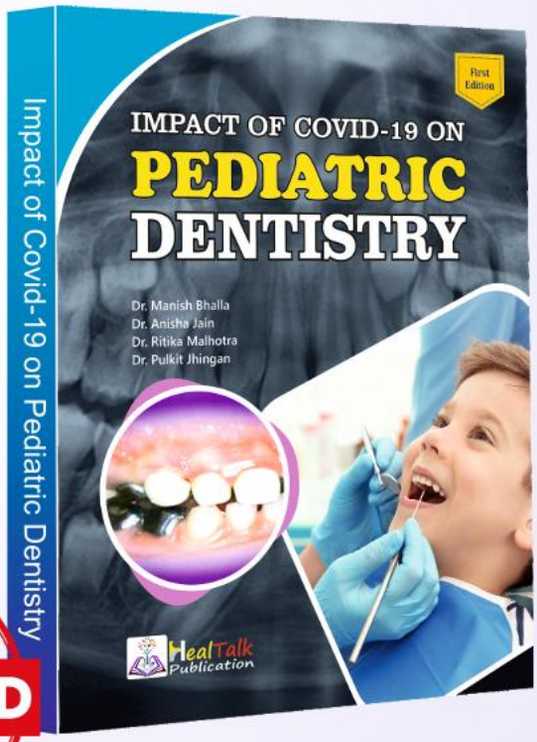

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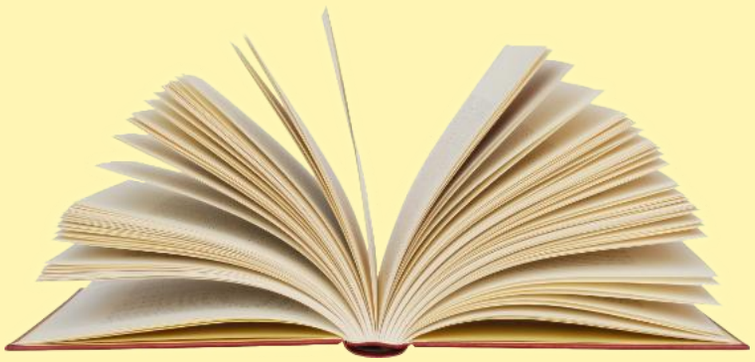

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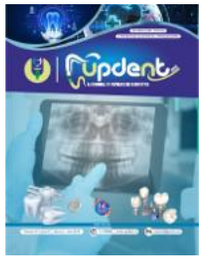

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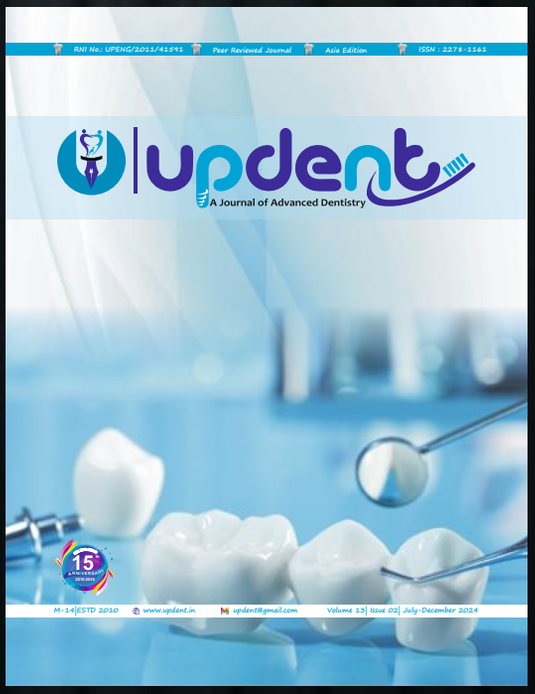

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