Research paper
ISSN: 2321-1520

Stainless Steel Crowns In Pediatric Dentistry:

The Bottom Line

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Received Date : 08-08-2020

Published Date :03-09-2020

Abstract

Maintenance of the primary dentition in a non pathologicand healthy condition is important for the overall well being of the child. No other factor plays a more significant role in pediatric dentistry than restoring deciduous dentition till its exfoliation time. Premature loss of deciduous tooth might lead to wide range of implications. The literature on caries risk factors in young children indicates that children at high risk exhibiting anterior tooth decay and/or molar caries may benefit by treatment with stainless steel crowns to protect the remaining at-risk tooth surfaces. Studies evaluating restoration longevity, including the durability and lifespan of sscs and class ii amalgams demonstrate the superiority of sscs for both parameters. Children with extensive decay, large lesions or multiple surface lesions in primary molars should be treated with stainless steel crowns. Because of the protection from future decay provided by their feature of full coverage and their increased durability and

longevity, strong consideration should be given to the use of sscs in children who require general anesthesia. Finally, a strong argument for the use of the ssc restoration is its cost effectiveness based on its durability and longevity.

Keywords: preformed metal crowns, stainless steel crowns, kids crowns, pediatric preformed stainless steel crowns, pediatric dentistry, crowns in pediatric patients.

Introduction

Dental caries has been a highly prevalent disease in the world, representing the most common infectious disease in the pediatric population. It is the common dental disease that affects all population regardless of age, gender and race[1]. Pediatric population represent higher risk group known as early childhood caries before they are 6 years old.

Guidelines of american academy of pediatric dentistry, 2011 recommends full coverage of teeth with multisarface carious lesion with stainless steel crowns, so as u. K. National clinical guidelines for paediatric dentistry.[2, 3]

Stainless steel crowns were introduced by ingle and developed by humphrey in 1950[4]. Stainless steel crown reinforces the tooth structure against the trajectory of the force during mastication and restores the vertical relationship.

Since the introduction of stainless steel crowns, technique to place it has been evolved by rapp (1966) and castaldi (1966)[4].

Indications for stainless steel crowns include developmental defects, following pulpectomy and pulpotomy, after clinical failure of other restoration, as abutment for space maintainer and as an interim restoration for permanent tooth[7]. For multisurface carious lesions, stainless steel crowns are superior to amalgam restorations[5].

Early childhood caries also involves primary anterior teeth especially maxillary anterior teeth. They can be restored with stainless steel crowns. Unfortunately, they offer poor aesthetics and some parents report they would rather have incisors extracted if sscs are the only restorative option. Because crowns play crucial role in restoring a child's carious anterior teeth, aesthetic alternatives of sscs have been developed. These include (1) open-faced crowns; (2) preveneered sscs.[6]

Thus, stainless steel crowns are the most important part of pediatric dentists' armamentarium which gives extremely durable, relatively inexpensive treatment modality that offers the advantage of full coronal coverage.

History

Year	Event(s)
1950	♠ Humphery introduced stainless steel crowns.[8]
1950's	♠ The first preformed crowns (rocky mountain) marketed having straight sides and were considerably longer than the average tooth.
1960's	♠ Significantly improved crown (unitek) was designed to require fewer alterations in clinical placement and was manufactured to match more closely the dimensions of posterior primary teeth, the crown was only slightly longer than the average tooth, and the margins were festooned to correspond to the cervical aspect of the tooth. ♠ The buccal and lingual walls of the crown were slightly contoured at the occlusal third to correspond to the anatomy of the tooth. ♠ The stainless steel crown was not strain–hardened before placement; this was accomplished during adaptation to the tooth. Considerable trimming, contouring, crimping and finishing were required in the placement of this crown. ♠ After that nickel chromium crowns were manufactured (3m) to correspond more closely to actual anatomic crown height and therefore, seldom require trimming. They are festooned, contoured in the middle third and crimped at the cervical margin.
1990's	♠ Attempts were made to give stainless steel crowns an aesthetic advantage, results of which produced preveneered stainless steel crowns. ♠ They are veneered with resin material to give aesthetic appearance.[9]

Metallurgy

Stainless steels are low-carbon alloy steels. Chromium contributes to the formation of a very thin surface film, probably oxide that protects against corrosive attack. There are three general classes of stainless steel:

i) Heat hardenable 400 series martensitic types,
ii) Non-heat hardenable 400 series ferritic types,
iii) Austenitic types of chromium-nickel-manganese 200 series and chromium-nickel 300 series.

1. Austenitic type stainless steel crowns:
   - The crowns are referred to as 18-8 since they contain about 18% chromium and 8% nickel (nash, 1981)[10].
   - High ductility, low yield strength, and high ultimate strength.
   - They are readily welded and can be work hardened to high levels.
   - They provide the best corrosion resistance, particularly when they have been annealed to dissolve chromium carbides and then rapidly quenched to retain the carbon in solution.
2. Ion crowns:
   - They are primarily nickel-chromium crowns.
   - Higher hardness renders the lon crown more difficult to contour and adapt to the prepared tooth.
   - Vickers micro hardness test reading: 325-350(nash 1981)[10].
   - Vickers micro hardness test reading for stainless steel: 250 to 306 (nash 1981)[10].

Composition

1. Stainless steel crowns:
   - They were often referred to as “chrome steel crowns”.
   - (18-8) austenitic type of alloy is used.
   - e.g. Rocky mountain and unitek.
   - Composition:
     - 17-19% chromium
     - 10-13% nickel
     - 6-7% iron
     - 4% minor elements (carbon, manganese & silicone)
   - These crowns exhibit the following properties[26]:
     - Heating does not increase their strength.
     - They work-harden; strength increases from manipulation with pliers.

- Their high chromium content reduces corrosion.
- Soldering with flux reduces their corrosion resistance.

2. Nickel-base crowns:

- They are iconel 600 types of alloy (nash 1981).[10]
- They have good formability and ductility necessary for clinical adaptation of crowns and wear resistance to resist opposing occlusal forces.
- The metallurgical characteristics of ni-chrome crown allows the crowns to be fully shaped and strain hardened without a defect during manufacture[11].
- So, due to difference in the material used in manufacturing of the crowns they are sometimes also called as "preformed metal crowns"
- Composition: 72 % nickel
  - 14% chromium
  - 6-10% iron
  - 0.04% carbon
  - 0.35% manganese
  - 0.2% silicon

Classification

- Preformed metal crowns can be classified according to[65]:
  - According to trimming
    - Untrimmed crowns (e.g. Rocky mountain): these crowns are not trimmed, not contoured, require lot of adaptation & thus are time consuming.
    - Pretrimmed crowns (e.g. Unitek stainless steel crowns and denvo crowns): these crowns have straight, non-contoured sides but are festooned to follow a line parallel to the gingival crest. They still require contouring and some trimming.
    - Precontoured crowns (e.g. Ion crowns and unitek stainless steel crowns): these crowns are festooned and are also precontoured though a minimal amount of festooning and trimming may be necessary.
    - Note: 3m crowns are both pretrimmed and precontoured.

- According to composition
  - Stainless steel crowns
  - Nickel chromium crowns
- According to position
  - Crowns for posterior teeth
  - Crowns for anterior teeth
- According to company
  - Rocky mountains
  - Prime pedo
  - 3m
  - Inconel
  - Nusmile
- According to occlusal anatomy
  - Ion: compact occlusal anatomy
  - Unitek: best occlusal anatomy
  - Rocky mountains: occlusally small
  - Ormco: smallest & least occlusally carved

Did you know?

- Preformed steel crowns are available in kit form in six sizes for each primary tooth and first permanent molars. Sizes 4 and 5 are most often used. A size 7 is available for large teeth. The user needs to reorder only those sizes frequently used.[12]

Crown shape	No. Of sizes	Md width range(in mm)
Upper 1st primary molars	2,3,4,5,6,7	7.2 to 9.2
Upper 2nd primary molars	2,3,4,5,6,7	9.2 to 11.2
Lower 1st primary molars	2,3,4,5,6,7	7.3 to 9.3
Lower 2nd primary molars	2,3,4,5,6,7	9.4 to 11.4

- Ktr crowns are the only crown till date in the market which are laser etched with "dual-system" universal & palmer numbering systems. On the other hand, nusmile crowns though laser etched, are marked with only palmer numbering system. Laser etching makes the markings on the crowns fully autoclave proof & thereby nullifying the chances of the ink to come off during autoclave sterilization preventing any possible errors.[63,64]
- Ideal characteristics of crowns[13]
    - The crown should represent the natural tooth
    - The dimension of crown i. E. Mesiodistal width should be in proportion
    - The crown should restore the function and aesthetics of the tooth and help in maintaining the arch length
    - Should be biocompatible with adjacent structures
    - Should be economical
- Objectives for using stainless steel crowns[14]
    - To achieve biologically compatible competent for masticatory function and clinically acceptable restoration.
    - To maintain the form and function and where possible vitality of tooth should be preserved.
- Goals for stainless steel crown preparation[15]
    - To eliminate all carious tooth structure in a vital tooth and preserve the pulp.
    - To re-establish proper occlusal contacts.
    - To re-establish normal mesiodistal coronal dimension for maintenance of arch length and spatial relationships.
    - To be free of periodontal disease as a result of emergence profile, embrasure form, proximal contacts or marginal integrity.
    - To create a durable restoration with a service life greater than the duration of the deciduous tooth.
    - To require a minimum of treatment time and cost.
    - To prepare the tooth causing no or minimal trauma to soft tissues

Advantages

- The close proximity of the pulp to the outer mesial surface of the first primary molars makes it difficult to obtain adequate retention for an amalgam restoration[16].

- The broad contact area between primary molars can lead to flared proximal box preparations in class ii situations, weakening the tooth and reducing support for an amalgam restoration.
- Superior to multisurface amalgam restorations with respect to both life span and replacement rate.
- Most advantageous system of restoration because of its retention and resistance.
- The preformed metal crown is a preferred treatment for multisurface caries on primary molars. Unlike amalgam, which requires retention features to be incorporated into the cavity design, the preformed crown obtains its retention from the flexibility of the thin, precontoured crown margins. This allows it to spring into and be obtained by the undercut area apical to the cej in a primary molar.[10,22]
- Factors influencing longevity of restorations are:
  - Operator's error,
  - Patient neglect or abuse of the restoration and
  - The nature of the oral environment in which the restoration was placed.

Author(s)	Year	Observation(s)
Braff[20]	1975	♠ Reviewed 74 patients comparing success rate of class-ii amalgam restoration with stainless steel crowns. Of the primary teeth restored with the amalgam, 88.7% required replacement treatment. By comparison, only 30.03% of the stainless steel crowns required remedial care. ♠ He concluded that economy of time and cost favour stainless steel crowns.
Dawson et al[21]	1981	♠ Concluded that nearly 70% of the multisurface amalgam restorations in their study, needed replacement with stainless steel crown.
Messer and levering[17]	1988	♠ The success of crowns placed on primary molars increases with the age of the child at initial placement.

		♠ That is in children, younger than 4 years are predicted to show a success rate which is approximately twice than that of class ii amalgams, for each year, up to 10 years of service and crowns relative risk of a failure than those placed over vital coronal pulps.
J. Einwag and p. Dunninger [18]	1996	♠ Examined two alternative methods of restoring primary teeth that had multisurface lesions, in a clinical longitudinal study. In a paired comparison stainless steel crown proved far superior to multisurface amalgam restorations.
Randall et al[19]	2000	♠ Demonstrated evidence of a more favourable outcome for preformed metal crowns than for amalgam restorations in primary molars requiring multisurface restorations. ♠ They are acceptable to both patient and dentist. ♠ They are also more cost effective because of comparatively simple procedure involved in restoring even severely affected primary molars.

Indications

- Aapd recommendation for stainless steel crowns [2]:
    - Children at high risk exhibiting anterior tooth caries and/or molar caries may be treated with sscs to protect the remaining at-risk tooth surfaces.
    - Children with extensive decay, large lesions, or multiple-surface lesions in primary molars should be treated with sscs.
    - Strong consideration should be given to the use of sscs in children who require general anaesthesia.

Indication	Explanation(s)
Extensive decay in primary tooth with caries on 3 or more surface or where caries	♠ The proximity of the pulp on mesial side make placement of an acceptable amalgam restoration difficult. Primary incisors with class v lesion i.e.

extends beyond the anatomic line angles.	The primary anterior teeth that are extensively decayed from the nursing bottle syndrome.[22,23]
Following the pulp therapy	♠ In both the primary and permanent teeth as pulp therapy leaves the treated tooth brittle because of fluid loss, it is likely to fracture.
As a preventive restoration	♠ If the patient has high susceptibility to caries manifestation, either by numerous gross carious lesions or by rampant caries and in a handicapped child whose lack of oral hygiene may encourage further decay. ♠ For instance, developing class v lesion is a sign of poor oral hygiene and cariogenic diet. When this occurs in the preschool children, who also has class ii lesion in the same tooth, the stainless steel crown is indicated particularly in the first primary molar.[22,23]
For teeth with hypoplastic defect	♠ They may be more susceptible to caries, because retention of the plaque occurs in hypoplastic defects. On the placement of stainless steel crowns in hypoplastic teeth, treatment may involve the crowning of the teeth in all 4 quadrants (often all posterior teeth). ♠ Thus there is danger of altering the vertical dimensions by impinging on the freeway space. So the crowns should be fitted quadrant wise.
Extensive abrasions	♠ Abrasions have already resulted in a loss of vertical dimension. In such a case a slight (less than 2mm) opening of the bite is acceptable. If the bite is opened more than 2mm, it will result in tenderness of the treated tooth and possible in an adverse pulp response.
Teeth deformed by developmental defects or anomalies	♠ Enamel dysplasia or dentinogenesis imperfecta
As an abutment, for a space	♠ Restoration of first primary molar when it is to be the

maintainer or prosthetic appliance	abutment for the distal extension appliance; for the placement of a stainless steel crown and loop maintainer immediately following the extraction of first primary molar.[24]
Temporary restoration of fractured tooth	
Severe cases of bruxism	♠ Teeth may be so abraded that stainless steel crowns are required to restore the inter-arch vertical dimension and prevent traumatic pulpal exposure. In the mixed dentition phase, the stainless steel crown adapted to the primary molars will assist in preventing wear of the first permanent molars
To replace prematurely lost anterior teeth	♠ Double stainless steel crowns on abutment teeth can be used for replacing the lost maxillary anterior teeth.
Child patients who are unlikely to attend regular visits	♠ Unlikely to be reliable preventive patients (pinkerton)[22]
For correcting individual anterior tooth cross bite	♠ Cementation of a preformed stainless steel crown form in a reversed position. ♠ Cementation of the crown with its lingual metallic surface facing labially creates an elongated inclined plane which, when struck by the incisal edge of the mandibular incisor deflects the maxillary tooth facially and the opposing tooth lingually. ♠ Reversed stainless steel crown crossbite correction can also be used successfully in the primary dentition.[25]

Contraindication

Even though preformed crowns have been advocated for use in other circumstances, they are not the preferred restoration for:

- Primary posterior teeth, in which conservative amalgam, restorations can be placed.
- Teeth to be exfoliated within a brief period of 6 to 12 months. The cost effectiveness of any restoration should be considered in treatment planning

in many instances, a temporary restoration can be placed in molars approaching exfoliation.

- In a patient with a known nickel allergy or sensitivity.[3]
- Inability to fit one: this includes the amount of remaining tooth structure and patient co operation (duggal).[22]
- Abutment for space maintainer: according to nash 1981[10], the preformed crowns should be considered as a means of restoring a primary tooth, not as a method of fabricating a space management appliance.

Clinical procedure

1. Preoperative evaluation
    - Dental age of the patient:
        - This is recorded by the root development of the underlying tooth when a primary tooth can be expected to exfoliate within 2 years of restoration, amalgam restoration can be done. However, failure of extensive amalgam restoration in the primary teeth can be frustrating. This can be overcome by an initial placement of stainless steel crown.
    - Cooperation of the patient*:*
        - If the patient is uncooperative, whether it is due to age (i.e.,< 3 years) or due to negative behaviour, if the child is stubborn and does not want to cooperate, first a positive behaviour has to be installed. If child is unable to cooperate, then chair side general anaesthesia may have to be considered. It is difficult to check the correct occlusion so it is always better to keep stainless steel crown at the level or slightly below the level of the adjacent tooth, so that the child does not have disturbed occlusion due to premature contact.
    - Medically compromised/disabled children:
        - Children specially suffering from heart problems should have prophylactic antibiotic cover to safeguard against any sub gingival injury during tooth preparation.
2. Armamentarium
    - Burs and stones[26]:
        - No. 169l or no. 69l f.g.
        - No. 6 or no.8 r.a.

- No. 330 f.g.
- Tapered diamond f.g.
- Green stone or heatless stone.
- Wire wheel

- Pliers and instruments:
  - No. 114 johnson contouring pliers.
  - No. 800-417 crown pliers
  - No. 112 ball and socket pliers
  - Sharp scalers or instruments.
  - Crown and bridge scissors.
  - No. 110 howe pliers.
  - No. 137 gordon pliers.
  - Glass slab / paper pad.
  - Spatula / agate's spatula.
  - Rough or whitening polish wheels.
  - Dental floss.
  - Rubber dam armamentarium.
  - Crimping pliers.

3. Selection of crown
   - The correct size crown may be selected prior to the tooth preparation by the m-d dimensions of the tooth to be restored and a boley gauge can be used for this purpose.
   - If the crown is not selected before the tooth reduction, after the tooth reduction it can be selected as trial and error procedure, which approximates the m-d widths of the crown. The smallest crown that completely covers the preparation should be chosen.
   - To produce steel crown margins of similar shapes, examine the contours of buccal and lingual gingiva.

- Buccal and lingual marginal gingiva of the second primary mandibular molar resembles smiles, with greatest occlusogingival height of the clinical tooth crown about midway on the buccal and lingual surfaces.
- Buccal marginal gingiva of the most mandibular first molar (primary) and many maxillary first molars is similar to a stretched out smile having greatest occluso-gingival height located at the mesiobuccal area. The contour of lingual marginal gingiva of all the primary molars resemble smile. The occluso-gingival height is located about midway in buccolingual direction.
- Moore and pink recommended a bite-wing radiograph at the crown try-in stage to check for any margin overextension in the interproximal area. Radiographs should only be taken where clinically indicated, however, and exposure of the patient to ionizing radiation for assessment of a pmc margin may be considered inappropriate.[22]
- Three main considerations in selecting the proper stainless steel crowns are:
  - Adequate mesiodistal diameter,
  - Light resistance to seating and
  - Proper occlusal height i. E. Correspondence to marginal ridge of adjacent tooth and lack of high points.

4. Tooth preparation

- A number of procedures must be performed before starting the tooth preparation. To eliminate the discomfort caused by cutting the tooth and possible trauma to the soft tissues during the trial fitting of stainless steel crown, there must be adequate anaesthesia of the tooth and the adjacent soft tissues.
- Evaluate the preoperative occlusion:
  - Take upper and lower dental arch impressions with alginate.
  - Pour the cast with the dental stone.
  - Note the dental midline and the cusp fosse relationship bilaterally.
- Anaesthesia:
  - In the lower arch, use an inferior alveolar nerve block, supplemented by an infiltration of the long buccal nerve.
  - In the maxilla, an infiltration on the buccal and occasionally on the palatal side of the tooth are required if pulp therapy is planned. It is not

necessary to place the anesthetic solution on the palatal side over the apex of the tooth. It can be placed in the loose soft tissues adjacent to the tooth from the buccal side after anesthetic solution has begun to produce anaesthesia.[27]

- Isolation:
  - Use of rubber dam for isolation is mandatory. When it is not possible to use rubber dam, as in case of terminal teeth in arch, cotton rolls, which are held in position by cotton roll retainer or a gauze oral screen should be used to prevent the possible aspiration of a crown.
  - Use a rubber dam in preparing a tooth for a stainless steel crown for the following reasons:
    - To protect surrounding tissue.
    - To improve visibility and efficiency.
    - To better manage behaviour.
    - To prevent ingestion of the stainless steel crown during preparation.
  - One can alter the rubber dam by cutting the interproximal rubber to avoid cutting the dam with rotating instruments. Wedges can also be used to protect the dam and tissue. An alternate method is to punch a large hole and slip it over the most posterior tooth to the tooth receiving the stainless steel crown. Then stretch the dam forward to the canine area.(28)
  - Remove the decay with large round bur in a slow speed handpiece. After caries removal and pulp therapy, if necessary, the previously carious area can be built up with a quick setting reinforced znoe cement and / or $znpo_4$ cement.

- Reduction of tooth
  - The aims of the tooth reduction are:
    - To provide sufficient space for the steel crown.
    - To remove the caries.
    - To have sufficient tooth for retention of the crown.
  - Occlusal reduction:

- Humphrey (1950)[4] recommended that the cusps be reduced, if necessary, and that the four sides of the tooth be reduced but as much tooth structure as possible be left for retention.
- Rapp (1966)[4] advises that the occlusion of the tooth be reduced so the height of the preparation is approximately 4mm from the gingival margin.
- Mink and bennett (1968)[4] on the other hand, suggested a uniform occlusal reduction of 1 to 1.5mm using a 1mm bur to make grooves in the occlusal surface to guide the reduction. Troutman (1976) recommends that the occlusal surface be reduced at least 1mm.
- Kennedy (1976)[29] that it be reduced 1.5 to 2mm. Similar variations exist in the timing of the reduction of the occlusal surface relative to the interproximal reduction.
- The most common problem encountered in attempting to learn tooth preparation for steel crowns is inadequate reduction. By keeping this in mind, it would seem that the recommendation of kennedy (1976) to reduce the occlusal surface 1.5 to 2mm is not excessive and should definitely be considered. Whether to use a large round bur, a tapered fissure bur, a diamond wheel, or a flame-shaped diamond stone to accomplish this reduction is irrelevant and should simply be determined by the preference of the operator.
- Preferably a 69l or 169l bur should be used to reduce the occlusal surface by 1.5 to 2 mm, following the cuspal outline and maintaining the original contour of the cusps reduction of occlusal surface can be judged by comparison with the marginal ridges of the adjacent teeth.
- Though various views have been expressed regarding the occlusal reduction it is found that about 1.5 -2 mm of reduction have to be done to obtain occlusal clearance. However, as much of tooth structure as possible must be left for retention.
- Gingival bleeding will occur if the proximal reduction is done at the initial step, making the diagnosis of very small pulp exposure, difficult. Thus, the best plan is to reduce the occlusal as the initial step, removing any caries as part of that step. Next perform the

necessary pulp therapy, and then proceed with proximal surface reduction.

- Proximal reduction:
  - It has been observed that many of the difficulties countered in placing a stainless steel crown are the result of attempting to fit a round or oval crown form over a rectangular tooth preparation.
  - Irregularities, projections, or sharp angle on the circumference of the prepared tooth will prevent the crown form from being properly seated, will cause time-consuming repeated adjustments, and will prevent the crown from properly fitting the tooth preparation.
  - The primary principle of the technique for fitting steel crowns is to make the tooth preparation fit the crown form rather than attempt to make the crown fit the tooth preparation.
  - By examining the crown form, prior to preparation of the tooth, one will see that the crowns of all manufactures are somewhat oval and rhomboid. This conforms to the rhomboid shape of the primary tooth.
  - In accomplishing the interproximal reduction therefore, be careful to maintain that form in the preparation.
  - By beginning on the lingual and following the contour of the proximal surface of the tooth, one can more easily accomplish an even and uniform reduction of the surface, thereby maintaining this rhomboid shape.
  - Making a slice also helps to eliminate the interproximal ledge, which seems to be the most frustrating problem in the restoration of a tooth with a steel crown.
  - Beginning the slice at the marginal ridge with the no. 69 l or 169 l bur not only will result in the frequent formation of a ledge but also will rapidly dull and wear out the tip of the bur.
- Buccal and lingual reduction:
  - The third step in the preparation concerns the reduction of the buccal and lingual surfaces. This area seems to be the most controversial. The questions is whether to (1) reduce the entire bulge, at least a significant portion of it or (2) permit the buccal and

lingual cervical bulges to remain and reduce only the occlusal third of the preparation.

- Adaptation and retention*:*
    - The flattened proximal surfaces combined with rounded line angles should be somewhat oval rhomboidal in preparation. This greatly aids in rapid crown adaptation because of the shape of the steel crown forms.
    - It has been stated by rapp that the retention of the stainless steel crown restoration originates from contact between the tooth and the margins of the crown. Mink and bennett state that it is necessary to reduce the buccal and lingual surfaces of the crown except on the buccal surface of the mandibular primary first molar or where an abnormal bulge of enamel may be present. The rationale for maintaining this bulging tooth structure is that it will contribute to the retention of the crown. .
    - Savid *et al* (1979)[30] compared five different types of preparations for retention capabilities:
        - That recommended by mink and bennett, in which only the occlusal third of both buccal and lingual surfaces is reduced,
        - That incorporating class ii preparations, in which the buccal and lingual walls of the boxes converge toward the occlusal,
        - That which reduces the buccal and lingual supragingivally to the crest,
        - That which removes the supragingival bulge, extending 0.5 mm below the gingival crest, as recommended by troutman, with all undercuts on the buccal and lingual surfaces removed, and
        - That which removes all supragingival tooth structure, permitting only part of the anatomic crown to remain (i.e. The tooth structure around which the crown would normally be adapted).
    - Crowns were adapted to these various types of preparation, and then proceeded to test the forces required to remove the crown from the preparation before and after cementation. Very little difference was shown between preparations to cementation. It was also observed that the noncemented preparations demonstrated only limited mechanical retention but that following cementation the retentive values of all

preparations improved greatly and cementation completely overshadowed the mechanical retention demonstrated in the noncemented group. The conclusion was that mechanical retention does not significantly contribute to separation resistance of the steel crown.

- Croll suggested cutting vertical grooves around the prepared tooth crown's periphery increased the surface area and perhaps enhanced crown retention by providing resistance against any rotational forces during mastication. However, the efficacy of this preparation versus a conventional preparation has not been demonstrated.[31]
- According to mathewson et al (1974)[9] retention related more to the cement than to mechanical adaptation and at variance with those of rapp, savide et el[30] concluded that in the preparation of a vital tooth, it has been determined that preparations maintaining the greatest amount of buccal and lingual tooth structure are the most retentive before cementation; however, cement increases the retentive capacity of all types of preparations and, it would behoove one to concentrate on making the steel crown restoration more physiologically acceptable to the oral cavity, particularly in the area of the gingiva. Removal of the buccal and lingual bulges will greatly facilitate the achievement of this goal.
- Croll and riesenberger stated that, in their view, the majority of pmcs, including the prebelled variety, do need adjustment to obtain optimal adaptation to the primary molar tooth.[22]
- A novel approach to restoring primary molars with pmcs has been put forward by evans et al. The crowns are cemented without prior caries removal or tooth preparation, and no local analgesia is necessary. In a pilot study of this technique, known as the hall technique, patients were recruited and 45 crowns successfully fitted. The technique was considered acceptable to the dentists, patients, and parents involved. In addition, a retrospective evaluation of record cards of patients who had received crowns placed using the hall technique documented 978 crowns in 259 patients for an average duration of 2.7 years. There was a 76% probability that a crown would survive for 1000 days, and a 65% probability for survival to 2000 days.[22] whilst this technique has not been directly compared to outcomes of sscs

placed following removal of caries, sealing in of dentine caries by placement of sscs without the use of local anaesthetic (hall technique) has been shown to be acceptable to patients and, at 23 months shows more favourable outcomes for pulpal health and restoration longevity than conventional plastic restorations placed by general dental practitioners.[3]

- One has to concentrate on making the stainless steel crown more physiologically acceptable to the gingiva; also that cement increases the retentive capacity of all types of preparations reducing supragingival bulge with reduction extending 0.5 mm below the gingival crest helps to obtain an acceptable gingival response.
- Two procedures are thought to be critical for obtaining good retention (rector et al 1985)[32]: precise trimming of the crown with respect to the gingival undercut & adapting and crimping the crown along its entire gingival margin.

- Evaluation criteria for tooth preparation:
  - The occlusal clearance should be 1.5 to 2mm.
  - Proximal slices converge toward the occlusal and lingual, following the normal proximal contour (mathewson). [26]
  - An explorer can be passed between the prepared tooth and the proximal tooth at the gingival margin of preparation.
  - The buccal and lingual surface are reduced at least 0.5 mm which the reduction ending in a feather edge 0.5 to 1mm into the gingival sulcus.
  - The buccal and lingual surfaces converge slightly towards the occlusal.
  - All the line angles in the preparation are rounded and smoothened.
  - The occlusal third of buccal and lingual surfaces are gently rounded.

5. Final adaptation of the crown
   - Crown must snap into place, should not be able to be removed with finger pressure.
   - The crown should fit so tightly that there is no rocking on the tooth.
   - Moderate occlusal displacement forces at the margin should not displace the crown.
   - The properly seated crown will correspond to the marginal height of the adjacent tooth and is not rotated on the tooth.

- Crown is in proper occlusion and should not interface with the eruption of teeth.
- There should be no high points when checked with an articulating paper.
- The crown margin extends about 1mm gingiva to gingival crest.
- No opening exists between the crown and the tooth at the cervical margins.
- Crown margins closely adapted to the tooth and should not cause gingival irritation.
- Restoration enables the patient to maintain oral hygiene.
- The crown seats without cutting or blanching the gingiva.

6. Finishing
    - It is safe to say that retention problems do not cause failure of the steel restoration; most failures result from poor and inadequate preparation, improper gingival adaptation, and the inability to properly visualize and determine the relationship of the crown margin to the margin of the preparation.
    - Brooke and king added the sensible reminder to carry out all crown trimming procedures away from the patient's face, and to ensure that the patient has adequate eye protection[22]
7. Polishing
    - While polishing the crown, margins should be blunt since knife edge finish produces sharp ends which act as areas of plaque retention. A broad stone wheel should run slowly, in light brushing strokes, across the margins, towards the center of the crown. This will draw the metal closer to the tooth without reducing the crown height and thus improves the adaptation of the crown.
    - A wire brush can be used to polish the margins to a high shine. To give a fine luster to crown, rough whiting or a fine polishing material can be used. Final polishing being done with a rubber wheel, followed by a mop and jeweller's rouge. Sem evaluation of polishing procedures for pmcs has demonstrated that the use of rouge for the final polishing step results in the most evenly smooth surface.[22]
    - The polished surface of a stainless steel crown may be an important factor influencing the amount of plaque accumulation. Polishing stainless steel crowns with various combinations of abrasive wheels has been recommended the scanning electron microscope (sem) has revealed that stainless steel crown margins

- Polished with an abrasive wheel are rougher than the unpolished margin of the original crown.[33]

8. Crown fit
    - Before cementation, a bite wing is taken to verify proximal marginal integrity. If the crown is too long, there is still an opportunity to reduce the length. If it is too short, then add an orthodontic band or adaptation of another crown is indicated.
    - Spedding (1984)[34,62] observed that most stainless crowns seemed acceptable when observed clinically. Unfortunately, radiographs of the same crown revealed many to be overextended, with ragged margins. To amend these discrepancies, he proposed two principles based on the morphology of primary teeth and gingival contour.
        - Principle 1:
            - The principle is based on the crown length.
            - The length of a ssc should allow the crown to fit just into the gingival sulcus, engaging the natural undercuts.
            - The crown length should extend just slightly apical to the tooth's height of contour. For primary teeth the buccal, lingual and proximal heights of contour happen to be just above the gingival crest.
            - As a ssc is trimmed in length such that its gingival margins come closer to the greatest diameters (heights of contour) of the tooth crown, the spaces between the margins of the crown and tooth surfaces are reduced.
            - Thus, when the margins of the metal crown nearly approximate the greatest diameter of the tooth, the spaces are small enough so that the metal can be adapted closely to the tooth. In other words, crowns that extend well beyond a tooth's height of contour are very difficult to adapt closely to the tooth surface.
        - Principle 2:
            - The principle is based on the shape of the crown's gingival margins.
            - The shape or contour of the gingival margins differs from the first to second primary molars, as well as from buccal to lingual to proximal.
            - The margins of the trimmed crown should approximate the shape of the gingival crest around the tooth.

- The outline of buccal and lingual gingiva around second primary molar resembles “smiles.”
- First primary molar:
  - Buccal outline: resembles “stretched out s”. This is because of the mesiobuccal cervical buldge, the gingival margin dips down as it is traced from distal to mesial.
  - Lingual outline: resembles “smiles.”
- The proximal contours of all primary teeth “frown” because the shortest occlusocervical heights are about midpoint buccolingually.
- By keeping these shapes in mind when trimming the sscs the close adaptation to the tooth will be made much easier.

9. Cementation

- Stainless steel crown should be cemented only on clean, dry tooth.
  - Isolation of teeth with cotton rolls is recommended.
  - Apply vaseline to contact areas.
  - Rinse and dry the crown inside and outside and prepare to cement it. $Znpo_4$, polycarboxylate, or gic are preferred.
  - If $znpo_4$ is used, 2 coats of cavity varnish should be applied on vital tooth before cementation and cement should be of consistency so that it stings about 1½ inches from mixing pad with the spatula cement is filled in approximately $2/3^{rd}$ of crown, with all inner surface covered.
  - Seat the crown completely on dried tooth surface preparation. Final placement should follow an established path of insertion of the crown. Cement should be expressed around all margins. To ensure complete seating of the crown, handle of mirror or band pusher may be used.
  - Before the cement sets, ask the patient to close into centric occlusion by applying pressure through a cotton roll and confirm that the occlusion has not been altered.
  - $Znpo_4$ cement can be easily removed with an explorer or scaler. After the polycarboxylate cement is partially set, it will reach a rubbery consistency. Excess cement should be removed at this stage with explorer tip.
  - Rinse the oral cavity and before dismissing the patient, reexamine the occlusion and the soft tissue.

- Studies

Author(s)	Year	Observation(s)
Mathewson and savide[30]	1979	♠ Refuted the prevailing opinion on the retention of steel crowns appears to be that the cervical adaptation of the crown to the tooth is the most important aspect.
Mathewson[9]	2012	♠ Studied the effect of five dental cements on the retentive properties of stainless steel crown, zinc oxide-eugenol, red copper phosphate, zinc phosphate, zinc silicophosphate and polycarboxylate. He concluded highest retentive strength using copper phosphate cement followed by zinc phosphate and polycarboxinate.
Noffsinger dp, jedrychowski jr and caputo aa[35]	1983	♠ Tested retentive properties of three dental cements using stainless steel crowns fitted to extracted third molar teeth. No significant difference was found between the overall mean retentive forces of the polycarboxylate cement and the two glass ionomer cements. Mechanical retention of the crowns was not a factor in the overall retentive value.
Berg jh, pettey de and hutchins mo[36]	1988	♠ The microleakage through margins of stainless steel crowns cemented with polycarboxylate, zinc phosphate, or glass ionomer cement was evaluated by measuring the amount of leakage through the crown margins. There was no cement specific difference in marginal leakage. The amount of leakage for each cement

		stabilized three days after crown placement and remained constant throughout the experimental period. It was concluded that the newer glass ionomer cement provides comparable protection to that of the other two traditional cements used with stainless steel crowns.
Rohilla m[37]	2013	♠ Recommended glass ionomer cement followed by poly carboxylate and other fluoride releasing cements to use as a cementing agent because of their carioprotective potential.
Veerabadhran et al[31]	2013	♠ The presence of groove did not influence the retentive strength of stainless steel crowns. Rmgic's offered better retentive strength of crowns than gic. Stainless steel crowns which were cemented without sandblasting showed higher mean retentive strength than with sandblasting of crowns and this difference was statistically significant. There is no statistically significant difference in the retentive strength of stainless steel crowns in maxillary and mandibular primary second molar.

- Type of cements
  a. Zinc oxide –eugenol
     - Zinc oxide-eugenol cements have long been recognized for their blandness to the pulp; they are the standard to which all newly developed cements are compared for pulp compatibility.
     - The set cement is a composite of unreacted zinc oxide particles and eugenol surrounded by and held together with the reaction product zinc eugenolate.
     - The shortcoming of this cement is comparatively low strength; and is very soluble in oral fluids (phillips).[39]

- The strength of these unmodified cements has been considerably improved by the addition of synthetic resins or quartz to the powder and ethoxybenzoic acid to the liquid. Although the compressive strength is increased (from 2000 to 15000 psi) solubility as measured by water immersion increases as much as fourfold.

b. Copper, zinc and silicophosphate cement
   - Copper, zinc and silicophosphate cements all have the common denominator of water-diluted and buffered orthophosphoric acid as their liquid; therefore all can be expected to produce certain degrees of pulp irritation due to their low ph.
   - The powder for copper phosphate cement is cuprous (red) or cupric (black) oxide, for zinc phosphate is zinc and magnesium oxide, and for silicophosphate essentially aluminosilicate glass.
   - The initial ph is lowest for the copper cements and highest for zinc phosphate. At 28 days the same relative ph order exists, with copper about 6, silicophosphate about 6.7 and zinc phosphate about 7.

c. zinc phosphate cement
   - Mixing zinc oxide with phosphoric acid forms zinc phosphate cement. It is used mainly for luting or mechanically locking a restoration by filling in voids and defects. It is used primarily with stainless steel bands for space maintainers. Zinc phosphate cements are easily handled and manipulated and have many years of clinical use.
   - If the manufacturer's instructions are followed, low film thickness and high compressive strengths can be obtained (. To achieve maximum strength, low solubility, proper film thickness, and less free acid in the final mix of cement, use a high powder/liquid ratio, by refrigerating cement mixing slabs have a longer working time, a shorter setting time in the mouth, and increased retention of orthodontic bands could be achieved from the mixed zinc phosphate cement (shepard) .
   - Disadvantages of zinc phosphate
     - Its low ph, which can cause pulp irritation. When first mixed, zinc phosphate cement has a very low ph that can remain below 7.0 for as long as 48 hours found that the zinc phosphate cements to be soluble in distilled water and organic acids.

- Include lack of antibacterial properties
- Solubility in oral fluids, and lack of adhesion.
- The phosphate cements usually require two coats of application of varnish prior to cementation on a vital tooth.

d. Silicophosphate
   - Due to fluoride release, silicophosphate reduces caries activity. The powder is essentially zinc oxide, and the liquid largely polyacrylic acid. Silicophosphate shows the highest 7-days compressive strength (about 25,000 psi), copper, and zinc phosphate each about 22,000 psi.

e. Polycarboxylate cements
   - Developed to provide a chemical bond between tooth structure and cement. By virtue of its chemical structure the polyacrylic acid chemically binds or chelates with certain cations. Thus tooth calcium or phosphorous chemically unites with the setting cement.
   - It consists of a mixture of zinc oxide powder with a polyacrylic acid liquid. It was observed as a direct bonding between the stainless steel, carboxylate cement, and enamel .
   - Polycarboxylate cements have minimal irritation effect on the pulp, the same as zinc oxide-eugenol. Polycarboxylate cements, when compared with zinc phosphate and improved zinc oxide eugenol cement, have a high level strength. However, the strength is not related to increased physical properties such as tensile strength, compressive strength, or film thickness.
   - The main advantage of polycarboxylate cement is the low irritant factor to oral tissue. There is adhesion to tooth substance and stainless steel alloys. The disadvantages are the requirements for precise proportioning and optimum manipulation, plus the need for a clean, uncontaminated tooth surface.[34]
   - Zinc (from zinc oxide) causes entrancement binding whereas certain restorative metals bind to the outer surface; this binding seems to occur between carboxylate cements and stainless steel this is the reason why these cements are highly recommended for use with steel crowns. Although the initial ph of polycarboxylate cements is quite low (about 1.7), their overall reaction on the pulp is comparable to that of zinc oxide-eugenol, they therefore cause minimal irritation. The reason for this,

tolerance is thought to be related to the molecular size of the acid molecule and/or to protein complexing. One way or another, diffusion through the tubules to the pulp is limited.[39] the primary objection to the carboxylate has been they're too rapid setting, which limits the number of units that can be cemented from one mix. The compressive strength of zinc polycarboxylate is less than that of the zinc phosphate; however, tensile tests (both diametric and simulated by removing cements castings) show only small differences[39]. The solubility of these cements is low and does not seem to be an important consideration. However, crown loosening does occur with over tapered preparations and is thought to be due to creep or flow of the cement.

- Two other categories of cements, acrylic and composite resins, have been used. Problems encountered have been proportioning and manipulation difficulties, to create a film thickness, difficulty in removing excess, and (especially) postoperative sensitivity. Their strength is adequate to excellent and their solubility is low, but these advantages are far outweighed by their disadvantages.

f. Glass ionomer

- Glass ionomer cements are quite new and very promising. Their powder is aluminosilicate glass and their liquid a mixture of polyacrylic, itaconic, and tartaric acid. Just as silicophosphate is a hybrid of silicate and zinc phosphate, the glass ionomers are hybrid of silicate and polycarboxylate. These cements have comparable strengths with zinc phosphate, release fluoride as do the silicophosphate, chelate or bond to tooth structure as the polycarboxylate, and are as pulpally compatible as the polycarboxylates. They could prove to be the best cement available for steel crown cementation.
- Silicate and polyacrylate systems are combined to form the glass ionomer cements. The powder is fine ground calcium, aluminium, and fluorosilicate glass combined with a solution of 50% polyacrylic itaconic acid. The powder/liquid ration is 1.3:1, which is most important. Glass ionomer cements seemed to be soluble in saliva with slow setting time. These cements have the potential to adhere to tooth structure but these surfaces must be immaculate. These cements leach fluoride with

subsequent uptake by adjacent enamel. Postoperative sensitivity in permanent teeth has been reported. The advantage of gic is similar to polycarboxylate cements. The disadvantages include moisture sensitivity; occasionally pulp irritation, initial low set and questionable adhesive properties[39], their radiolucency and the present lack of long term clinical efficacy.

- When multiple posterior crowns are to be seated, they should be adapted and cemented simultaneously to allow for adjustments in the interproximal spaces and establish proper contact areas. To get these adjustments, adapt and seat the crown on the most distal tooth first and proceed mesially.

g. Panavia 21

- Panavia 21 in a self etching advance resin cement that bonds directly to metal and silinated surface with no need for a bonding agent. The anaerobic setting mechanism of panavia 21 provides custom working time and trouble free clean up. It is available in three different radiopaque shades and translucencies. It is indicated for the cementation of metal crowns, bridges and inlays/onlays. It is anti-bacterial, eliminates the need to use additional disinfectants.[38]
- According to memarpour et al (2011) none of the luting cements investigated in the present study could seal crown margins completely. Resin-modified glass ionomer cement significantly reduced microleakage compared with polycarboxylate, zinc phosphate, and conventional gics tested with stainless steel crowns and primary molars. The combination of a dentin bonding agent prior to the resin-modified gic decreased microleakage more than resin-modified gic alone under in vitro conditions.

Response of gingival tissues to stainless steel crown restoration

Author(s)	Year	Observation(s)
Cohen and goldman[4]	1973	♠ Reported that in healthy child the gingival sulcus may be deeper than adult dentition and range of 0.5 to 2.5 is not unusual.
Myers[40]	1975	♠ Published a clinical study on the response of

		gingival tissues to steel crown restoration, concluding that the lower incidence of gingivitis around crown without defects in the margins may be due to the fact that these crowns are less likely to allow plaque to accumulate.
Warhaug[10]	1981	♠ Suggested that gingival inflammation is due to bacterial plaque accumulation rather than to mechanical defects produced by a poorly fitted crown. ♠ This being the case, it may not necessarily be the fit of the crown on the margin of the crown encroaching on the gingival that causes the gingival problem but the fact that the stainless steel crown surface enhances plaque accumulation, thereby accounting for the association between gingivitis and defective stainless steel crown. ♠ Whatever the cause, the effect is nevertheless the same; when the crown is improperly adapted or improperly polished in the gingival area, the result will be a higher percent of gingivitis around steel crowns restorations.
Henderson [40]	1975	♠ Reported this and concurred that inflammation of the gingival may be due to irritation from the surface of the material, overhanging margins, rough surfaces, retained bacterial plaque, or a combination of these. ♠ He found that soft tissue will adjust just as nicely to a rough and unpolished surface as to a highly polished one but that bacterial plaque adheres and it retained by a rough surfaces is probably due to bacterial plaque accumulation rather than to mechanical irritation.
Checchio et	2002	♠ Measured crevicular fluid flow around 50 primary

al[22]		molar crowned teeth and 50 contralateral controls. ♠ They reported a similar rate of crevicular flow for all individuals with good oral hygiene regardless of the quality of fit of the crown. ♠ Patients with poor oral hygiene demonstrated an increased level of flow¨
Einwag[22]	2002	♠ Evaluated 118 pmcs on primary teeth and 70 pmcs on permanent first molars compared with uncrowned adjacent teeth as controls over 3 years. ♠ He reported an insignificant, clinically acceptable irritation of the gingivae associated with primary pmcs. ♠ Permanent molar teeth with pmcs, however, demonstrated a noticeable increase in sulcular depth once the patient reached 15 years of age.
Fuks et al[41]	1981	♠ Concluded that no matter how accurately the preformed stainless steel crown form is adapted to the preparation or how well it is polished some inflammation is always observed around the gingival margin. ♠ This is quite likely due to the difference in contour between the original tooth structure and the crown. ♠ Reduction of the cervical bulge will do a great deal to minimize this problem.gingival health of succedeaneus tooth is not affected with gingivitis of crowned primary tooth

Special considerations for stainless steel crown

1. quadrant dentistry:
    - When the quadrant dentistry is practiced, stainless steel crowns are to be placed on adjacent teeth.
    - Few points, which are to be considered (nash 1981)[10]:
        - Prepare the occlusal reduction of one tooth completely before beginning the occlusal reduction of the other tooth because there is tendency to under reduce both, when reduction on both the teeth is done simultaneously.
        - When two adjacent crowns have to be placed reduce the adjacent proximal surface of the teeth being restored more. The greater reduction will ease the placement of the crowns and interproximal approximation.
        - Both crown should be trimmed, contoured, and prepared for cementation simultaneously to allow for adjustments in the interproximal spaces and establish proper contact areas.
    - To get these adjustments, adapt and seat the crown on the most distal tooth first and proceed mesially.
2. crowns in areas of space loss[53]
    - When there is an extensive and long standing caries, the primary teeth shift into the interproximal contact areas. As a result, the crown required to fit over the buccolingual dimensions will be too wide than mesiodistal to be placed and the crown selected to fit over mesiodistal space will be too small in circumference.
        - Select larger crown, which will fit over the tooth's greatest convexity.
        - Reduce the mesiodistal width by grasping the marginal ridges of the crown with howe utility pliers and squeezing the crown.
        - Recontour the proximal, buccal, and lingual walls of the crown with the no. 137 or no. 114 pliers.
        - Do the additional reduction of buccal and lingual surface of tooth and select a smaller crown, if this crown is difficult to place.
    - Another "trick of the trade" is that an upper first primary molar from the opposite side will fit a first primary molar of the opposite side. Automatically, there is similarity, the advantages being that the upper first primary molar crown is narrower mesiodistally.
3. preparing a stainless steel crown adjacent to class ii amalgam

- Place the rubber dam.
- Crown reduction is completed and crown is adapted.
- Next on the adjacent tooth, a matrix band and wedges are placed amalgam is inserted and carved.
- With the matrix band in place, the crown is removed safely without fracturing the amalgam.
- Then remove the matrix band and the final carving of amalgam is done, as there is good visibility and access to the proximal box area.
- Now complete the crown adaptation and cement the crown.
- The advantage of this approach is that, because the crown and class ii amalgams are prepared and resorted concurrently, better restorations may result and it helps to overcome the nuisance of placing rubber dams

4. crown for anterior crossbite[25]

- One well-known method for correcting individual anterior tooth crossbite is cementation of a preformed stainless steel crown form in a reversed position. Cementation of the crown with its lingual metallic surface facing labially creates an elongated inclined plane which, when struck by the incisal edge of the mandibular incisor deflects the maxillary tooth facialy and the opposing tooth lingually.
- Reversed stainless steel crown crossbite correction can also be used successfully in the primary dentition.'- this treatment has even been used for a 10-month-old who had only four erupted primary incisors, two of which were in crossbite relationship.

5. Crowns for patient with bruxism[54]

- A child at risk of grinding through a stainless steel crown may be identified by history of bruxism as reported by the parents, and by careful observation of wear patterns in the mouth.
- Study models are also quite helpful in revealing areas of abnormal enamel abrasion from bruxism.
- Although difficult to diagnose, hypertrophy of the masseter muscles may also suggest a chronic tooth grinding habit.

- When it is expected that a patient may wear through a crown, the following technique is advocated:
    - Perform the recommended procedures for stainless steel crown preparation. Select a non-precrimped preformed crown which would normally be suitable for proper restoration of the tooth.
    - Prior to crown adaptation select a crown of the next smallest size. Using a high speed carbide bur, cut the occlusal table from the smaller crown. The periphery of the metal should be smoothed with a rotary wheel. Since unitek brand crowns are machined so that any one size fits perfectly within the next larger size, the cut occlusal surface adapts well to the internal aspect of the selected crown.
    - After roughening the inside surface of the larger crown and the occlusal surface of the smaller crown segment with a diamond stone, place pieces of silver solder inside the larger crown and soldering flux on the smaller segment. Place the cut occlusal segment over the solder within the crown. A high heat, fine-flame torch is then used to melt the solder, attaching the two stainless steel surfaces. Excess solder expressed around the internal margins suggests even solder flow. A metal instrument or graphite pencil point may be used to gently push the stainless steel surfaces together while the solder is flowing to eliminate void spaces.
    - The internal aspect of the crown is then roughened with an abrasive stone or diamond bur, and excess solder is removed.
    - Crown finishing then proceeds as usual. Cross sections of the unprepared crown can be compared to the crown as supplied by the manufacturer. It is apparent that surface thickness is greatly increased. The only modification in tooth preparation which may be necessitated by this technique is that occlusal reduction may need to be somewhat increased. Careful attention in rounding of occluso-axial line angles also aids in proper crown seating. Increased occlusal surface thickness has not proven to be problematic in adapting or cementing the crown.[54]

6. Orthodontic band adaptation on primary molar stainless steel crown

- Beemer *et al* (1993)[54] suggested a technique for orthodontic band adaptation on primary molar stainless steel crowns. The rationale for use of design of

the fixed unilateral space maintainers is well established in the practice of pediatric dentistry when a primary molar is prematurely lost. A space maintainer prevents migration of adjacent teeth, thus holding space in the dental arch for the succedaneous teeth to erupt. Fixed unilateral space maintainers may be of two types according to the current clinical guidelines of the american academy of pediatric dentistry: band and loop and crown and loop.[55]

- The crown and loop inherently has the advantage of superior retention, but takes two appointments to fabricate and is difficult to adjust intraorally if deformed or rotated. If broken or replacement is required, the crown must be removed and a new crown and loop appliance fabricated. Placing a band and loop on a primary molar stainless steel crown is a simpler and less time-consuming procedure. Only one crown need be placed at the initial appointment and administration of local anesthetic is not usually required for the band cementation appointment. If the need arises, the band and loop can be removed, adjustments made or a new appliance fabricated, and recemented without removal of the abutment stainless steel crown.
- Christensen and fields (1988) advice that the crown and loop is not a recommended technique.
- Fields (1993) states that it is no longer considered advisable to use the crown-and-loop appliance because it precludes simple appliance removal and replacement. He recommends that teeth with stainless steel crown should be banded like natural teeth.
- Mcdonald states that a primary first molar stainless steel crown provides a desirable retentive contour for placing a stainless steel band.[23]

7. Mink and hill (1971)[42] reported several ways of modification of stainless steel crown when the crowns are either too large or too short.
   - Undersized tooth or the oversized crown
     - This commonly occurs when, due to a long-standing interproximal caries, space loss has occurred. To reduce the crown circumference, a v cut is made up of the buccal surface to the occlusal surface. The cut edges are reapproximated to overlap one another making the crown circumference

smaller. The crown is tried on the tooth and amount of overlapping necessary is marked on the crown. The overlapped edges are then spot-welded. The crown is polished with a rubber wheel and fine abrasives.

- Oversized tooth or the undersized crown:
  - Separate the edges as needed and weld a piece of 0.004inch orthodontic band material across the cut surface. After contouring, apply the solder to fill any microscopic deficiency in seal, polish the soldered crown.
- Deep sub gingival caries:
  - One approach is to complete the indirect pulp treatment and then restore the cavity preparation with silver amalgam.
  - The proximal areas are sliced as in a routine crown preparation, stainless steel crown is adapted with amalgam substitutes for tooth structure at the interproximal finish line of the subgingival caries occurs interproximally, the unfestooned rocky mountain crown will be deep enough to cover the preparation. Another method is to solder an extension on interproximal areas of the crown.
- Open contact
  - If the closed contact area (except for the primate spaces) is not established, it will result in food packing, increased plaque retention and subsequently gingivitis.
  - This problem can be solved by selection of a larger crown or exaggerated interproximal contour can be obtained with a 112 (ball and socket) plier to establish a close contact. Interproximal contour can also be build by addition of a solder.

8. Aesthetic stainless steel crown

- The stainless steel crowns can be modified in anterior teeth by a open faced stainless steel crown with the labial surface trimmed away to leave a crown perimeter, which is then restored with a resin veneering.
- Dental esthetics has become a significant focus of attention for dentists and patients in the recent years. Innovative dental materials, bonding procedures and veneers have propelled the dental profession towards the esthetic excellence. Cosmetically acceptable restoration of grossly decayed primary teeth in young

children is an ongoing dilemma for dentists. Cooperation of the young child can be poor and the procedures are often time consuming.

- Removing the labial portion of crown and placing resin composite in that area may improve esthetics. Veneering over the labial / buccal surface of the stainless steel crown with composite resin is another option to improve the esthetics. Chair side veneering of composite resin to anterior stainless steel crown is also done.
- Children too are becoming much aware of their appearance because they live very much in an era of peer evaluation. The esthetic implications of dental treatment would be of a major concern to the parents and young patients in 21st century. The esthetic revolution is here. Adhesive dentistry has developed at an accelerated rate in the recent years; continuous processes since the introduction of acid etch technique for decades ago. With the advent of the etched cast0 restorations, research has been devoted to resin to metal bond, using different techniques. Bonding a white resin to stainless steel crown offers the potential of wider acceptance of this restoration and an entire new standard in pediatric dentistry.
- Hartmann (1983)[8] described veneering of anterior stainless steel crown according to following technique.
    - Tooth preparation:
        - Anesthetizing the tooth begins the operative procedure. After profound anesthesia is established, the mesial distal and facial surfaces are reduced with a no. 699 bur, in a high-speed handpiece, maintaining the walls parallel to the long axis of the tooth. The reduction is extended 0.5mm into the gingival sulcus, in order to remove enough of the bulbous portion of the tooth to insure a well-fitted stainless steel crown. The incisal edge is then reduced 1.5mm. Finally, any remaining caries is removed with a no. 4 round bur in a slow-speed handpiece, and any pulp treatment indicated is performed.
    - Adaptation of the crowns:
        - A stainless steel crown is selected and fitted in the customary fashion. The gingival margin on the facial surfaces is extended as deep as the sulcus will allow. After final crimping and polishing, the crown is cemented with carboxylate cement. Any excess cement is removed after setting.

- Window preparation:
  - A window is now placed in the facial surface of the crown. A no. 330 or no. 245 bur used to cut the rough window. The window is refined incisally with a no. 35 diamond disk in a slow-speed handpiece. The incisal portion of the window is reduced in order to allow a 0.5mm undercut, while keeping the margin as straight as possible. The esthetics of the finished crown is improved with a straight incisal surface, which is parallel to the incisal surfaces of the adjoining teeth.
  - The window is opened mesiodistally with a no.330 or no.245 bur so that very little stainless steel is showing. Little retention is expected to be gained proximally.
  - The same bur is used to shape the gingival margin of the window to the level of the gingival crest.
  - A no. 699 bur is then used to prepare a retention channel 1mm in depth, gingivally. With this accomplished, all remaining cement is removed from the incisal undercut and proximally to within 1mm of the margins of the window. The depth of the window should be sufficient so that no tooth structure or remaining cement will be seen through the finished resin.
- Insertion of composite:
  - After cleaning and drying the prepared window, the composite resin is inserted with a syringe. The injection begins by filling the gingival channel and continues up a proximal surface. The incisal undercut is then filled, followed by the other proximal surface. This method will insure that the entire retention area has been filled with composite. Filling the central portion of the window completes the resin injection.
  - A premier cervical matrix form no. 722 g is then used because it contours well to the margins of the window and establishes a good facial contour. The matrix is slipped 1mm beneath the tissue with a cotton forceps and then gently passed toward the crown with finger pressure until all margins are contacted. It is then held in place until the composite is set.

- Polishing and finishing
  - After the composite is polymerized, the matrix is removed and the excess composite is trimmed from the margins. No other polishing or finishing should be necessary.

- Studies

Author(s)	Year	Observation(s)
Waggoner	1995	♠ Non veneered stainless steel crown have more durability and retention than veneered crowns but lacks in aesthetics.
Carrel and tanzilli[43]	1989	♠ Evaluated new composite resin that is bonded to stainless steel crowns. Within one year, only a third of the composite cases were totally intact. Shade stability decreased over a short period of time. Patient brushing habits profoundly affected veneer surface removal.
Hatten et al[44]	2013	♠ Composites that bonded to stainless steel crowns with the scotchbond universal bonding agent show significantly greater shearbond strengths and fewer adhesive failures when compared to traditional single bottle systems.
Roberts[47]	1990	♠ Reported two cases with successful use of the open-faced stainless steel crown for primary molars.
Widenfeld kr, draughn ra and welford jb[45]	1994	♠ Described and evaluated an aesthetic technique for veneering anterior stainless steel crowns with composite resin. ♠ The aesthetic surfaces of the crowns were sand blasted with 50μm aluminium oxide particles for 2-4 seconds, followed by the application of adhesive resin cement (panavia) to the sandblasted surfaces in a thin layer. ♠ A thin coat of opaque light cured pit and fissure

		sealant (delton) was applied by rolling the panavia bonded surfaces in a drop of sealant and was cured for 20 seconds, followed by the application of light cured composite resin to the sealant surface and was cured for 40 seconds. ♠ A study on 10 specimens was conducted in which beads of composite resins were bonded to the sandblasted stainless steel crown in the same manner. ♠ The bond strengths of the beads to the crowns were measured by applying shear stresses at a crosshead speed of 1mm per minute. The bonding failed at the panavia cement and the metal interface. ♠ The results included mean shear bond strength of 24.4±2.0mpa. To conclude, this technique yielded excellent aesthetics and a very high bond strength of the veneered stainless steel crowns.
Waggoner w.f. and cohen h.[46]	1995	♠ Conducted an in vitro study to determine the amount of shear force required to fracture or dislodge the veneer facings of four commercially available veneered primary incisor stainless steel crowns. ♠ The four types of crowns tested were cheng crowns, kinder crowns, nusmile primary crowns and whiter-biter crowns. ♠ Analysis of variance and multiple comparison tests demonstrated that the whiter-biter crowns required significantly more force for failure than the other three groups. ♠ The veneers of the whiter-biter crowns and the cheng crowns are attached primarily to the metal using a meshwork spot welded to the stainless steel crown surface. ♠ The attachment of the veneers to the stainless steel

		crowns of the nusmile and kinder crowns differs from the cheng and whiter-biter crowns. No metal mesh work was utilized to hold the veneers instead the veneers were bonded directly to the stainless steel crowns following some pre-treatment. ♠ The whiter-biter crowns utilized a different thermoplastic veneer material which is melted on to the mesh where it is mechanically retained. All the other three veneer crowns utilized composite resins for their facing material. In the samples of whiter-biter crowns tested all the failures seen were failure of the spot welding, the veneers stayed embedded in the mesh work and did not break. The cheng crowns showed a mixed adhesive/cohesive failure. Often the veneers would crack circumferentially to the underlying meshwork, but the mesh would stay attached to the crown.
Croll and helpin[48]	1996	♠ Described the technique for preformed resin veneer stainless steel crowns for restoration of primary incisors. ♠ A study cast was poured in dental stone. Prospective crown preparation was simulated on the stone cast prior to the scheduled restorative appointment. A crown form that fit the proposed preparation and had suitable mesiodisal and labio-lingual dimension was selected. Preformed resin veneered stainless steel crowns were cut to proper length with straight angle diamond wheel and crimped in the regions where there was no bonded resin and the crowns were adapted successfully on the incisors.
Maclean et al[6]	2007	♠ Nusmile crowns are a clinically successful restoration for anterior primary teeth. Despite some negative

		clinical changes, 91% of nusmile crowns retain a good to excellent overall appearance after 6 months. There is an increased incidence of attrition with increased time and with bulky crowns.
Shah et al[49]	2004	♠ Kinder krowns performed well over an average of 1 ½ years, with 100% of the crowns being retained despite the inability to modify or crimp the facial cervical margin. ♠ Resin facings were completely lost in 13% of the crowns, with most of these restorations remaining white due to the presence of the resin opaque. ♠ Facing failure was significantly associated with an increased overjet. Parental satisfaction with the appearance, colour, shape, and size of the kinder krowns restorations was very high.
Leith et al[50]	2011	♠ Studied parentral satisfaction and clinical out come of recently available preveenred molar stainless steel crowns. ♠ They concluded both posterior nusmile and kinder crowns can be successfully used with no significant differences in their clinical performance after 12 months. While a minority of crowns displayed facing loss, they remained aesthetic in the patients smile. ♠ Parental satisfaction with these crowns was found to be excellent; however it is recommended that parents be informed of the possibility of veneer failure.
Selene et al[1]	2013	♠ Concluded ultraviolet irradiation of pediatric stainless steel crowns was found to significantly increase the shear bond strength of composite resin. Uv irradiation of sscs could provide suitable adhesion of composite resins to withstand forces of occlusion.

Complications

1. Interproximal ledge
    - A ledge will be produced instead of a shoulder free interproximal slice, if the angulation of the tapered fissure bur is incorrect. Failure to remove this ledge will result in difficulty in seating the crown.
    - When the adjacent tooth is partially erupted, and the contact is poorly established, the interproximal slice is difficult to prepare. To clean the contact area, extensive subgingival tooth reduction is required which may result in formation of a ledge or damaging the erupting tooth. In such a case, it may be advisable to delay crowning until contact areas are properly established.
2. Crown tilt
    - Complete lingual or buccal wall may be destructed by caries or improper use of cutting instruments. This may result in finished crown tilting towards the deficient side. Placement of restoration prior to crowning provides a support to prevent crown tilt, the alloy as core. The clinical significance of crown tilting is minimal unless it occurs on young permanent molars, where supra-eruption of the opponent tooth may occur.
3. Poor margins
    - When the crown is poorly adapted, its marginal integrity is reduced. Recurrent caries may occur around open margins. Chances of plaque retention and subsequently gingivitis increases with marginal discrepancy. The tolerant potential of young periodontal ligament tissues is very high to an extreme amount of cement pushed into lingual sulcus during the cementation procedure. The foreign body was incorporated without any signs of gingivitis and discomfort to the patient. Widely accepted indication for these crowns has been in cases where poor oral hygiene predisposes the patient to recurrent caries. , a patient with poor oral hygiene exhibits a high plaque and debris index, accompanied by an increase in marginal gingivitis.
    - To minimize gingival problems, it is as important to stress oral hygiene in a patient with preformed stainless steel crown as in a patient with a high caries rate. Only three considerations should determine whether a crown should be carried subgingivally, esthetics, extent of existing caries, and the need of length for mechanical retention. Since primary teeth are short occluso-cervically, the

cervical border of the stainless steel crown must often be carried subgingivally to acquire sufficient mechanical retention[4].

- Henderson reported that inflammation of the gingivae might be due to irritation from the material per se, overhanging margins, rough surfaces, retained bacterial plaque, or a combination of these factors.[40] he found that soft tissue adjusts just as nicely to a rough and unpolished surface as to a highly polished one, but that bacterial plaque adheres and is retained by a rough surface. He concluded, therefore, that gingival inflammation adjacent to restorations is due to bacterial plaque rather than to mechanical irritation.
- Goto et al[40,] found that, in children, ages 2-9 years, gingivitis was associated with 23.6% of all crowns with good marginal adaptation and the most (33%) associated with those crowns exhibiting poorly adapted margins.
- Myers (1975)[40] also noted a significant correlation between crown defects and the clinical evidence of gingivitis in children, ages 4-12 years.
- Henderson[4], after examining children ages 4-13 years, concluded that no matter how accurately the preformed stainless steel crown was trimmed, adapted, and polished some inflammation was always observed because of the differences in form and contour between the tooth and crown.
- Similar research by webber (1974) did not show an adverse relationship between stainless steel crowns and gingival health. Webber stated that the preformed stainless steel crown can be used successfully to restore primary molar teeth without adversely affecting the health of the gingiva or the status of the patients oral hygiene.
- Machen *et al.*[22] found that in children, age 3-10 years, no significant differences existed between the gingival tissues surrounding teeth restored with stainless steel crown and the tissues surrounding uncrowned antimeres.
- The results of the study by durr *et al* (1982)[57] indicated that the majority of stainless steel crowns placed by undergraduate dental students were clinically functional and acceptable. However, most of the crowns had one or more observable defects, ninety-five crowns in forty-four patients were judged non-ideal. Errors in crown crimping were the most common, with defects in crown length, contour, position, polish, contact, and cementation following in order of decreasing frequency. Only six crowns in six patients were judged ideal

- In the retrospective study by fuks *et al* (1983)[41] the gingival health around the permanent successors of crowned primary molars was not different from that of the rest of the mouth. This would suggest that even if gingivitis was present around the crown of primary teeth it was resolved with the exfoliation and subsequent eruption of the permanent teeth. This conclusion should not be misinterpreted as a justification for ill-fitting and poorly contoured preformed crowns.
- Alshaibah, et al (2011)[58] reported that *streptococcus mutans* adhesion to preveneered crowns was significantly higher than ssc. Full mouth rehabilitation led to a significant decrease in the *s. Mutans* count. An increase in *s. Mutans* counts is associated with an increase in both ohis and gi.

4. Nickel allergy
    - Feasby et al, reported an increased nickel-positive patch test result in children 8 to 12 years of age who had received old formulation nickel-chromium crowns. A second group of children with conventional stainless steel crowns showed no statistically significant difference in patch test responses compared to a third control group with no history of nickel-containing dental appliance use.[22]
    - Nickel hypersensitivity is more prevalent in females than males and is considered to be associated with pierced ears or metal buttons in clothing. Studies reported that orthodontic treatment with nickel-containing stainless steel appliances, if carried out before ear piercing, appeared to reduce the prevalence of nickel hypersensitivity. Higher concentrations of contact allergen may be required to elicit a response from the oral mucosa compared with skin, but the type and duration of oral exposure needed to initiate this potential is not known. It is difficult to evaluate nickel release into the oral cavity, and it is considered that salivary proteins may have a protective effect by acting as corrosion inhibitors on the surface of the alloy. Adjustment of a crown by cutting or crimping the margin will leave a roughened surface. To minimize any likelihood of corrosion, it is important that these areas are then smoothed and polished to a high gloss. In a similar way to orthodontic appliances, soldered or welded crowns are likely to be more susceptible to corrosion.

5. Impaction of adjacent erupting permanent tooth
    - When an overextended distal margin on a second primary molar ssc engages the mesial marginal ridge of the permanent molar in its eruptive course. One case was reported in which a poorly adapted ssc on a permanent molar engaged and impacted the adjacent second premolar and second molar, resulting in serious malocclusion and caries .[59]
6. Ingestion of crown
    - To prevent such mishaps, the rubber dam should remain in place until cementation. It prevents accidental swallowing or aspiration of a crown. Sometimes sudden movement may result in ingestion of the crown, if the rubber dam is not used. In this regard, floss attachment by means of impression compound on the occlusal of the crown is the preferred practice by some clinicians.
    - Symptoms of crown aspiration includes coughing sneezing,chocking and acute dyspnea[60]
    - Gauze throught shield and rubberdam placement are suitable way to prevent aspiration of crown.
    - Because of its frequently sudden and critical nature, acute obstruction of the airway must be recognized and managed as quickly as possible. For this reason an immediate diagnosis of complete or partial airway obstruction must be made and treatment initiated as quickly as possible.
    - During dental treatment the potential is great that objects may fall into the posterior portion of the oral cavity and subsequently into the pharynx. All dental office personnel must become familiar with proper management of acute upper-airway obstruction.
    - In most cases the object causing the acute airway obstruction is lodged firmly in the airway where it can neither be seen nor felt through the mouth without the use of special equipment, such as a laryngoscope or a pair of magill forceps, items that are not normally available. The doctor therefore must be able to recognize the problem instantly and act rapidly to dislodge the object.
    - Several manual, noninvasive procedures are available for use in acute airway on obstruction. The techniques are as follows:
        - Assess unresponsiveness

- P-position victim in supine position with feet elevated
- Call for help (office emergency team)
- A-open airway (head tilt-chin tilt technique)
- B-assess breathing (look listen feel)
- Attempt to ventilate
- If unsuccessful reposition head and attempt to ventilate
- It still unsuccessful activate emergency medical services system
- Manage airway obstruction
- Check pulse
- Perform external chest compression if necessary

- Obstructed airway in children: perform the following steps when basic procedures have proved ineffective:
  - Helmtech manoeover
    - Kneel at child's feet if child is on the floor, or stand at child's feet if child is on a table.
    - Place the heel of one hand against the child's abdomen in the midline, slightly above the navel and well below the tip of the sigmoid process.
    - Place the second hand directly on top of the first hand.
    - Press into the abdomen with 6 to 10 thrusts.
  - Foreign body check
    - Keep the child's face up.
    - Use the tongue-jaw lift to open the mouth.
    - Look into the mouth and with the finger sweep or the magill intubation forceps, remove the foreign body, if it is visible.
  - Attempt to ventilate
    - Open the airway, using the head tilt-chin lift technique.
    - Attempt to ventilate.
    - If unsuccessful, repeat the preceding steps until successful.
    - Consider a surgical airway (for children older than 3 years).
    - If the crown is in bronchi or lung, medical consultation will probably result in attempt to remove it by bronchoscopy. The presence of cough reflex in the conscious child will reduce the chances of inhalation and ingestion of the crown is more likely. Ingestion is of less consequence, as the crown will usually pass uneventfully through the alimentary tract

within 5-10 days. But it should be diagnosed by absence of the crown on a chest radiograph.[60]

Sterilization and disinfection

- During the fitting of these preformed crowns to the reduced tooth, the selected preformed crown might not always fit the prepared tooth properly, and the dentist will need to try differently sized crowns in order to gain the desired fit. During test fitting, unwanted crowns become contaminated with blood and saliva and also may carry many microorganisms which can cause infection if the crown is used in another patient. Therefore, the direct and indirect contact surfaces of such crowns need to be sterilized and/or disinfected before their re-use in another patient.
- Wickersham *et al* subjected commercially available preveneered stainless steel crowns (sscs) to various sterilization and disinfection methods, such as steam autoclaving at various high temperatures and pressures and chemical sterilization (chemiclave sterilization) using formaldehyde vapour and a 2% gluteraldehyde solution. They reported that there were no changes on the vestibular surfaces of the crowns following these sterilization and disinfection methods.[61]
- Wickersham *et al*, found that the use of gluteraldehyde results in a color change in the aesthetic constituents of the crowns and a marked decrease in the resistance to fracture.
- Chemical disinfection of sscs with gluteraldehyde had other disadvantages:
  - The time needed for effective disinfection is long;
  - It is expensive;
  - The solution progressively loses its disinfectant activity over a 14 day period;
  - It causes corrosion of some metals; and
  - It is a skin and mucosal irritant.
- Yilmaz y (2008)[61] concluded that sterilization and disinfection results in crazing, contour alterations and vestibular surface changes of preveneered sscs when examined by sem. However, no fracturing was noted. Chemical disinfection in an ultrasonic bath is the preferred method of sterilization of preveneered sscs because it less damaging to their vestibular surfaces.

Cost effectiveness

- Eriksson et al,
  - Reported a 7-year follow-up of pmcs and amalgam controls.
  - They found that around 1 tooth in 5 in the pmc group needed further treatment, compared with approximately 2 out of 3 teeth restored with amalgam.
  - They calculated that the total cost of treatment for the amalgam restored teeth was 35% higher than for the pmc group.[22]
- Levering and messer
  - Examined costs associated with first and subsequent placements of amalgam and pmc restorations followed to exfoliation, or the end of the study.
  - Dentists spend approximately 50%--60% of their time replacing restorations, which creates added costs for the practitioner and involves extra time and costs for the patient and parent/caregiver to revisit the dental office.
  - Use of a well-fitting pmc, where appropriate, could be expected to last the lifetime of the primary tooth[12].

Conclusion

- Following conclusions could be drawn regarding the use of stainless steel crown for primary as well as young permanent teeth:
  - It is an invaluable and indispensable part of pedodontists armamentarium.
  - Clinician must be aware of different anatomic and metallurgic characteristics of the specific crown forms. Over the period of 5 decades of its invention still stainless steel crowns are underappreciated; due to lack of adaptation of precise techniques[62]
  - Appropriate adjustments must be made in the preparation of tooth and the crown form must be manipulated accordingly.
  - The judicious combination of one of the various tooth preparation techniques and proper manipulation of metal crown would lead to a wonderful restoration with high durability.
  - Due consideration should be given for the selection of proper luting agent.
- The well planned treatment and ability of the clinician to manage effectively, the complications and emergencies arising in the clinic, always goes hand in hand for successful outcome of the treatment and betterment of the patient.

Reference

1. Selene j, dulce m, garcía-contrera r, rogelio j, luis j, norma l. Effects of ultraviolet irradiation on the bond strength of a composite resin adhered to stainless steel crowns. Peditric dentistry 2013;35:23-7.
2. Aapd guideline on pediatric restorative dentistry. Reference manual 2014;35:6.
3. Kindelan sa, day p, nichol r, willmott n, fayle sa. Uk national clinical guidelines in paediatric dentistry stainless steel preformed crowns for primary molars: international journal of paediatric dentistry 2008;18(suppl. 1):20-8.
4. Henderson h.z. evaluation of preformed stainless steel crowns. J. Dent. Child. 1973;40:353-64.
5. Memarpour m, mesbahi m, rezvani g, rahimi m. Microleakage of adhesive and nonadhesive luting cements for stainless steel crowns. Pediatric dentistry 2011;33:501-5.
6. Maclean jk, cariann e, waggoner wf, marcia m, casamassimo p. Clinical outcomes for primary anterior teeth treated with preveneered stainless steel crowns. Pediatric dentistry 2007;29:377-83.
7. Thikkurissy s, mctigue d, matracia s, casamassimo p. Pulpotomy to stainless steel crown ratio in children with early childhood caries: a cross-sectional analysis. Pediatric dentistry 2011;33:496-502.
8. Hartman cr. The open face stainless steel crown: an esthetic technique. J. Dent. Child 1983;31-3.
9. Christensen g. Pediatric crowns are growing up. Clinicians report 2012;5(11).
10. Nash da. The nickel-chromium crown for restoring posterior primary teeth. J. Am. Dent. Assoc.1981;102:44-9.
11. Zinelis s, lambrinaki t, kavvadia k, papagiannoulis l. Morphological and compositional alterations of in vivo aged prefabricated pediatric metal crowns (pmcs). Dental materials 2008;24:216-20.
12. Sajjanshetty s, patil ps, hugar d, rajkumar k. Pediatric preformed metal crowns - an update. Journal of dental & allied sciences 2013;2(1):29-32.
13. Damle. Textbook of pedodontics.
14. Full ca, walker jd, pinkham jr. Stainless steel crowns for deciduous molars. Jada 1974;89:361-4.
15. Readman p. Preformed metal crowns. Synopses 1999;20.

16. Holan g, fuks ab, keltz n. Success rate of formocresol pulpotomy in primary molars restored with stainless steel crown vs amalgam. Pediatric dentistry 2002;24(3).

17. Messer lb, levering nj. The durabilities of primary molar restorations. Ii observations and predictions of success of ssc. Pediatr. Dent. 1988;10(2):81-85.

18. Dunninger ej. Stainless and crown versus multispace amalgam restoration an 8 year longitudinal clinical study. Quint. Int.1966;27(5):321-8.

19. Randall rc. Efficacy of preformed metal crowns versus amalgam restorations in primary molars: a systematic reviews. Jada 2000;131:337-440.

20. Braff mh. A comparison between ssc and multisurface amalgams in primary molars. J. Dent. Child.1975;42(6):478-8.

21. Dawson lr, simon jf jr, taylor pp. Use of amalgam and ss restoration for primary molars. Asdc j. Dent. Child 1981;48(6):420-2.

22. Randall rc. Preformed metal crowns for primary and permanent molar teeth: review of the literature. Pediatr dent. 2002;24:489-500.

23. Mcdonald. Dentistry for child and adolescent 5thedition 1996.

24. Myers dr. A direct technique for the placement of stainless steel crown and loop space maintains. J. Dent. Child.1975;37-9.

25. Croll tp. Correction of anterior tooth crossbite with bonded resin-composite slopes.quintessence lnt. 1996;27:7-11.

26. Richard j. Mathewson. Fundamental of pediatric dentistry 3rd ed. Quintessence publishing co. 1995.

27. Malamad se. Medical emergencies in the dental office 5th edition 2001.

28. Sturdevant's art and science of operative dentistry 5th ed.

29. Kennedy db. The stainless steel crown. Pediatr. Oper. Dent. 1976.

30. Savide nl, caputo aa, luke ls. The effect of tooth preparation on the retention of stainless steel crowns. J. Dent. Child 1979;46:25-33.

31. Veerabadhran mm, reddy v, nayak ua, rao ap, sundaram m. The effect of retentive groove, sandblasting and cement type on the retentive strength of stainless steel crowns in primary second molars - an in vitro comparative study. Journal of indian society of pedodontics and preventive dentistry 2012;30:19-28.

32. Rector ja, mitchell rj, spedding rh. The influence of tooth preparation and crown manipulation on

the mechanical retention of stainless steel crowns. J. Dent. Child.1985;422-7.

33. Myers dr, schuster gs, bell ra, barenie jt, mitchell r. The effect of polishing technics on surfacesmoothness and plaque accumulation on stainless steel crowns. The american academy of paedodontics 1980;2l.

34. Spedding rh. Two principles for improving the adaptation of stainless steel crowns to primary molars. Dent. Clin. North am.1984;28:157-63.

35. Noffsinger dp, jedrychowski jr, caputo aa. Effects of polycarboxylate and glass ionomer cements on stainless steel crown retention. Pediatric dent.1983;5(1):68-71.

36. Berg jh, pettey de, hutchins mo. Microleakage of three luting agents used with stainless steel crowns. Pediatr. Dent.1988;10(3):195-8.

37. Rohilla m, pandit ik, srivastava n. Why the carioprotective potential of luting cements crucial? J indian soc pedod & prevent dent 2009;27:219-24.

38. Phillips rw, swartz ml, rhoads bf. An evaluation of carboxylate adhesive cement. J. Am. Dent. Assoc;81.

39. Anusavice phillip's science of dental materials 11th ed.

40. Myers dr. A clinical study of the response of the gingival tissue surrounding stainless steel crowns. J. Dent. Child. 1975;42:33-9.

41. Fuks ab, zadok s, chosack a. Gingival health of premolar successors to crown primary molars. Pediatr. Dent. 1983;5(1):51-2.

42. Mink jr, hill cj. Modification of stainless steel crown for primary teeth. J. Dent. Child. 1971;38:197-203.

43. Carrel r, tanzill r. A veneering resin for stainless steel crowns. J. Pedodontics 1989;14(1).

44. Hattan ma, pani sc, alomari m. Composite bonding to stainless steel crowns using a new universal bonding and single-bottle systems. International journal of dentistry 2013.

45. Widenfeld kr, draughn ra, sheryl ge. Chairside veneering of composite resin to anterior stainless steel crowns: another look. J. Dent. Child. 1995;270-3.

46. Waggoner wf, cohen h. Failure strength of four veneered primary stainless steel crown. Pediatric dent. 1995;17(1):36-40.

47. Baker lh, moon p, mornio ap. Retention of esthetic veneers on primary stainless steel crowns. J. Dent. Child. 1996;185-189.

48. Croll tp, helpin ml. Preformed resin-veneered stainless steel crown for restoration of primary incisors. Quintessence int. 1996;27(5):309-13.

49. Shah pv, lee jy, wright jt. Clinical success and parental satisfaction with anterior preveneered primary stainless steel crowns pediatr dent. 2004;26:391-5.

50. Leith r, o'connell ac. A clinical study evaluating success of two commercially available preveneered primary molar stainless steel crowns. Pediatric dentistry 2011;33:300-8.

51. Croll tp, castaldi cr. The preformed stainless steel crown for restoration of permanent posterior teeth in special cases. Jaca 1978;97.

52. Allen kr. Restoration of extensively carious primary molar. Aust. Dent. J. 1971;16(8).

53. Mcevoy. Approximating stainless steel crown in space loss quadrants. J. Dent. Child. 1977;44:104-12.

54. Croll tp. Increasing occlusal surface thickness of stainless steel crowns: a clinical technique. Pediatric dentistry 1980;2(4):297-300.

55. Beemer rl, ferracane jl, howard he. Orthodontic band retention on primary molar stainless steel crowns. Pediatr. Dent. 1993;15(6).

56. Guidelines for management of the developing dentition in pediatric dentistry. American academy of pediatric dentistry - reference manual 1992;46-9.

57. Durr dp, ashrafi mh, duncan wk. A study of plaque accumulation and gingival health surrounding stainless steel crowns. J. Dent. Child. 1982;343-6.

58. Alshaibah b, ahmed esf, abdo edna, reda ra. Comparative study on the microbial adhesion to preveneered and stainless steel crowns. Indian journal of dentistry 2011.

59. Croll tp, epstein dw, castaldi cr. Marginal adaptation of stainless steel crowns. Pediatric dentistry 2003;25(3).

60. Adewumi a, kays dw. Stainless steel crown aspiration during sedation in pediatric dentistry, pediatric dentistry 2008;30:59-63.

61. Yilmaz y, giler c. Evaluation of different sterilization and disinfection methods on commercially made preformed crowns. J indian soc pedod prevent dent 2008;162-8.

62. Pinkam. Pediatric dentistry - infancy through adolescence 3rd ed 1999.

63. Ktr crown manual.

64. Nusmile crown manual.

65. Nikhil marwah. Textbook of pediatric dentistry. 4th edition.