Paulo Kano

Challenging Nature

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Wax-Up Techniques in Aesthetics and Functional Occlusion

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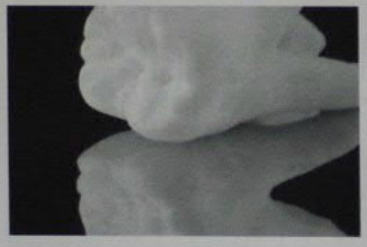

1 Chapter

NOMENCLATURE

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Posterior Teeth

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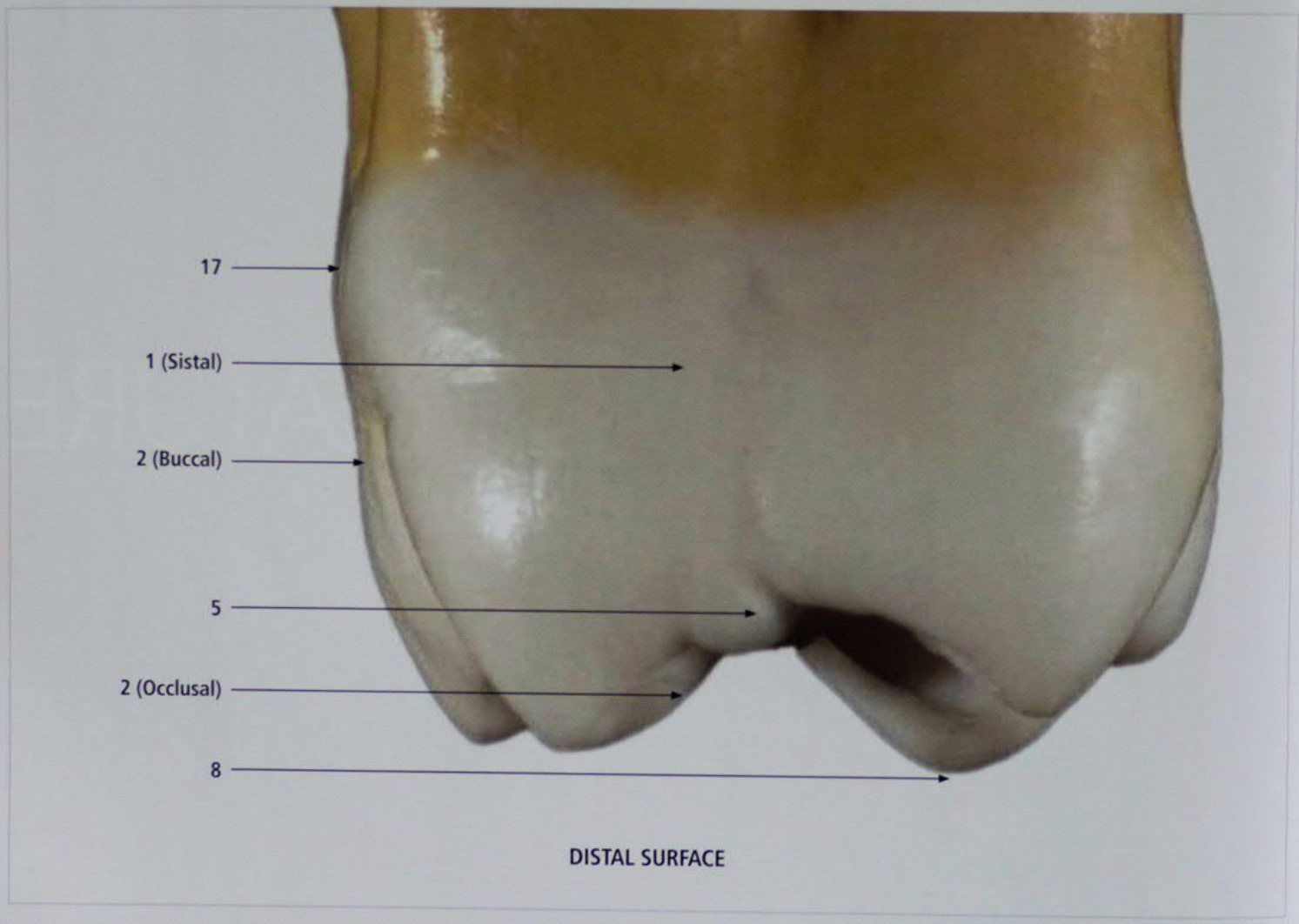
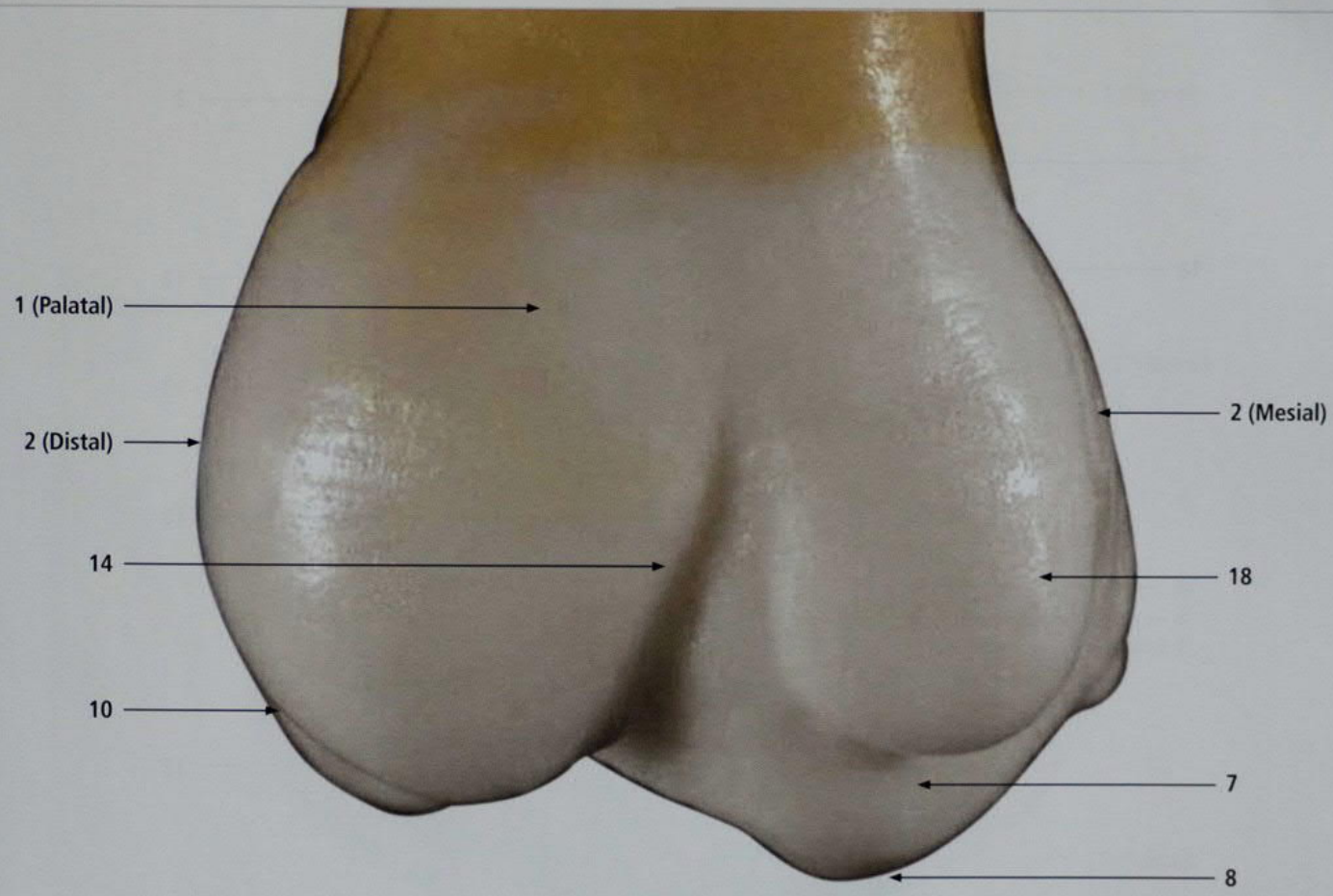
The nomenclature represents the terms used to describe tooth characteristics. It is fundamental for learning, as well as to differentiate and characterize the anatomical details further reproduced in each exercise in order to standardize the practitioner's methodology.



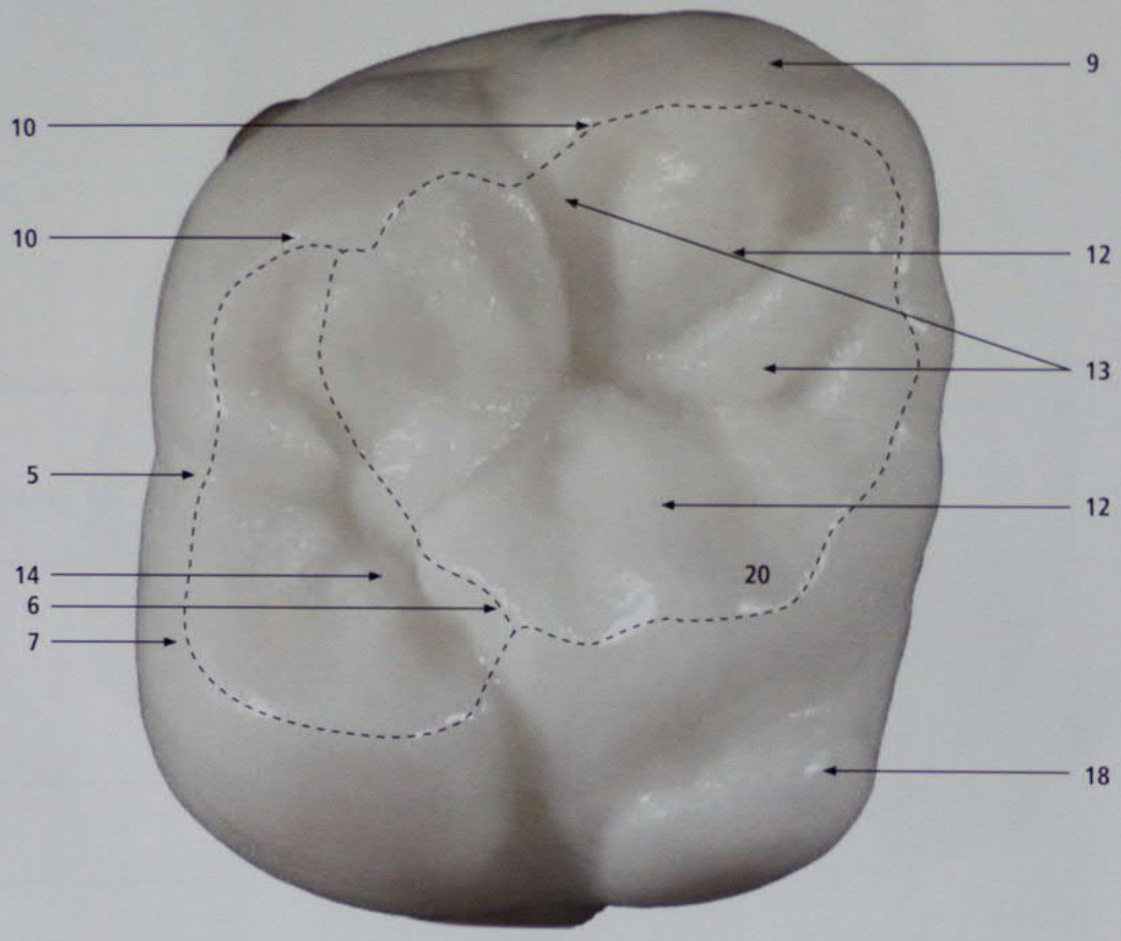
Nomenclature

Posterior Teeth

1. Surface
2. Transition line angle
3. Angle
4. Mesial marginal ridge
5. Distal marginal ridge
6. Oblique ridge or enamel bridge
7. Cusp
8. Cusp tip
9. Incline
10. Longitudinal slope
11. Transverse slope
12. Central lobe
13. Lateral lobe
14. Groove
15. Fossa
16. Central fossa
17. Bulge
18. Tubercle
19. Occlusal perimeter
20. Occlusal table



PALATAL SURFACE



OCCLUSAL SURFACE

Nomenclature

Posterior Teeth

1. Surface
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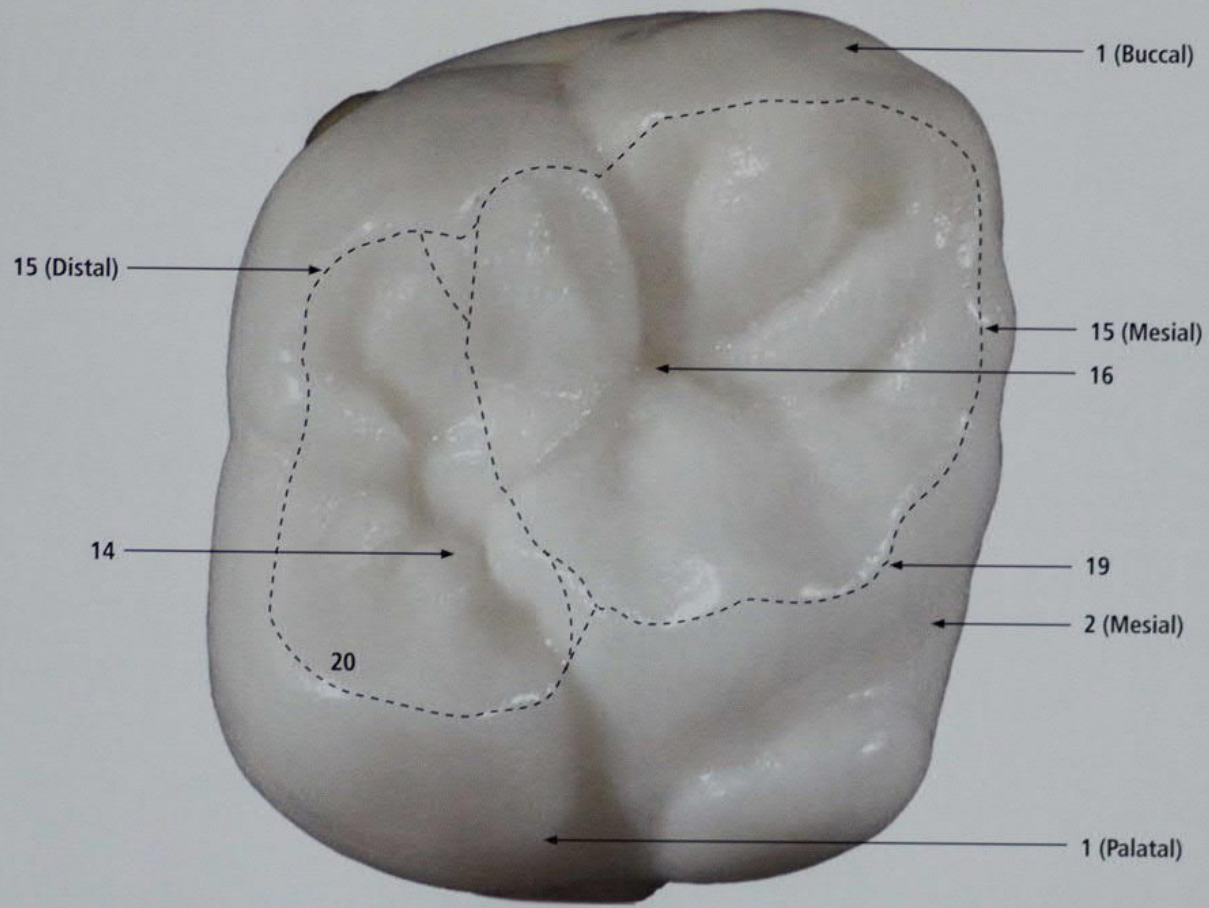


OCCLUSAL SURFACE

Surfaces

Tooth surfaces, labeled according to their spatial location (buccal/labial, lingual/palatal, mesial, distal, or occlusal).

Transition line angles

Boundaries of each tooth surface.

Angles

In dental anatomy, an angle is formed at the junction of two or more surfaces. There are dihedral and trihedral angles, formed by the junctions of two and three surfaces, respectively.

Ridges

Reinforcement structures joining two cusps at the periphery or through the occlusal surface. In the proximal region, they are called marginal ridges (mesial or distal); when they join cusps in an oblique direction through the occlusal surface, in a buccolingual/palatal direction, crossing the primary developmental groove, they are called oblique ridges or enamel bridges. These structures can be found in the maxillary first premolar and molar teeth.

Cusps

Elevation on the tooth's occlusal surface that presents four surfaces, with a sharp tip, called the vertex. Cusps are named according to location on the occlusal surface.

Inclines

Characteristic of a cusp's surface. Thus, all cusps are formed by four inclines that determine a pyramidal shape.

Slopes

Dihedral angles that, depending on their location, are called longitudinal or transverse slopes. Longitudinal slopes are formed at the junction of a buccal/labial or lingual/palatal surface with occlusal surfaces, arranged in a mesiodistal direction. Transverse slopes are found in the occlusal surfaces and are formed at the junction of two inclines of the same cusp.

Lobes

Rounded protuberances found on the buccal surfaces and cusps of posterior teeth. According to their location, they can be called buccal or occlusal lobes; according to their dimensions, they can be classified as central or lateral lobes. One of the major characteristics of the occlusal surface is the presence of lobes with different sizes and forms. Each cusp has three lobes: one central and two lateral lobes. The central lobe is more prominent, facing the central fossa, where the contact point occurs. The lateral lobes are small, lower than the marginal ridge. Because they are below the marginal ridge and the central lobe, they are not carved during wax-up because they do not contact the opposing teeth.

Grooves

Represent a straight, linear depression, classified according to their location and direction as occlusal, buccal/labial, lingual/palatal,and/or mesial/distal.

Fossae

Concavities found in the occlusal surfaces, surrounded by slopes and/or ridges. They are classified according to their surface location as central, mesial, or distal fossa. Their innermost aspect is called the central pit.

Bulges

Rounded saliences found on the buccal/labial or palatal/lingual surface.

Tubercles

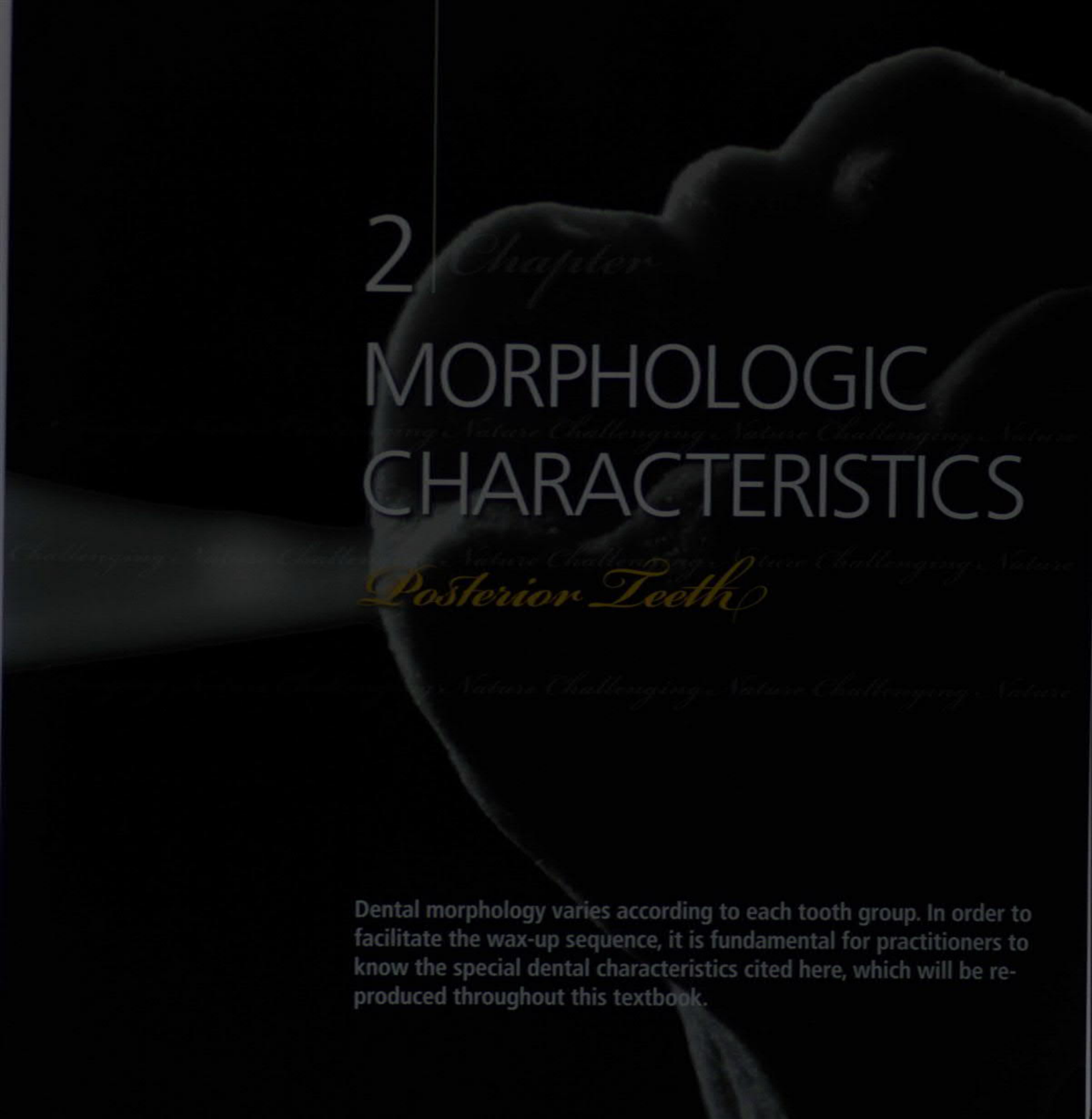
Rounded protuberances found at the palatal surfaces of some teeth, formed due to greater enamel thickness. A tubercle is often found on maxillary first molars, known as the Carabelli tubercle.

Occlusal perimeter

Imaginary line formed by the junction of longitudinal slopes and marginal ridges, delimiting the occlusal surface.

Occlusal table

Occlusal surface delimited by the occlusal perimeter.



2 MORPHOLOGIC CHARACTERISTICS

Posterior Teeth

Dental morphology varies according to each tooth group. In order to facilitate the wax-up sequence, it is fundamental for practitioners to know the special dental characteristics cited here, which will be re-produced throughout this textbook.

Buccal Surface

Palatal Surface

Mesial Surface

Distal Surface

Maxillary First Premolar

The largest tooth in the premolar group.

Buccal surface

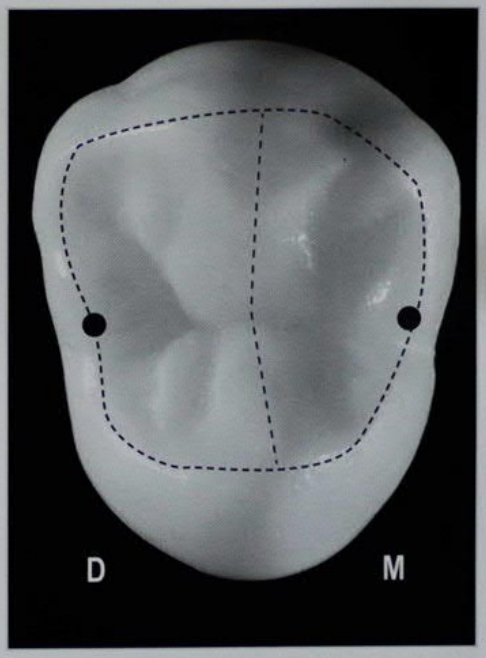
The buccal surface has an ovoid format, with a sharp cusp slightly displaced mesially. On the proximal surfaces, the transition between the middle and occlusal thirds presents no line angle formation. The mesial aspect is more pronounced; its cervical third is concave, whereas in the middle and occlusal thirds convexities are present. The distal aspect is less pronounced and convex along its extension. There is a prominent cervical bulge in this aspect. The buccal central lobe is evident, being separated from the lateral lobes by two developmental grooves. The mesial groove is more pronounced, providing palatal inclination of this segment, an anatomical landmark representing a distinguishing feature in the maxillary first premolars. Often, the distal developmental groove is not found.

Palatal surface

This surface has an ovoid format; the cusp tip is inclined mesially relative to the coronal midline. It is possible to visualize the buccal cusp profile because of the reduced dimensions of the palatal surface; no lobes or grooves are found along this surface. The mesial marginal ridge is more coronal than the distal marginal ridge; however, this situation is not observed when the tooth follows its distal inclination in the dental arch.

Proximal surfaces

In a proximal view, it is possible to see that the palatal profile is lower than the buccal profile, with a uniform convexity from cervical to cusp tip region. The cervical line is concave toward the root aspect, and the occlusal surface has two cusps of different sizes, the buccal being more prominent. On the mesial surface, its marginal ridge is more elevated than the distal ridge, being crossed by a marginal groove on its middle aspect, which forms a fissure. The distal surface has a greater bucco-palatal dimension, with a flat marginal ridge, also crossed by a marginal groove.



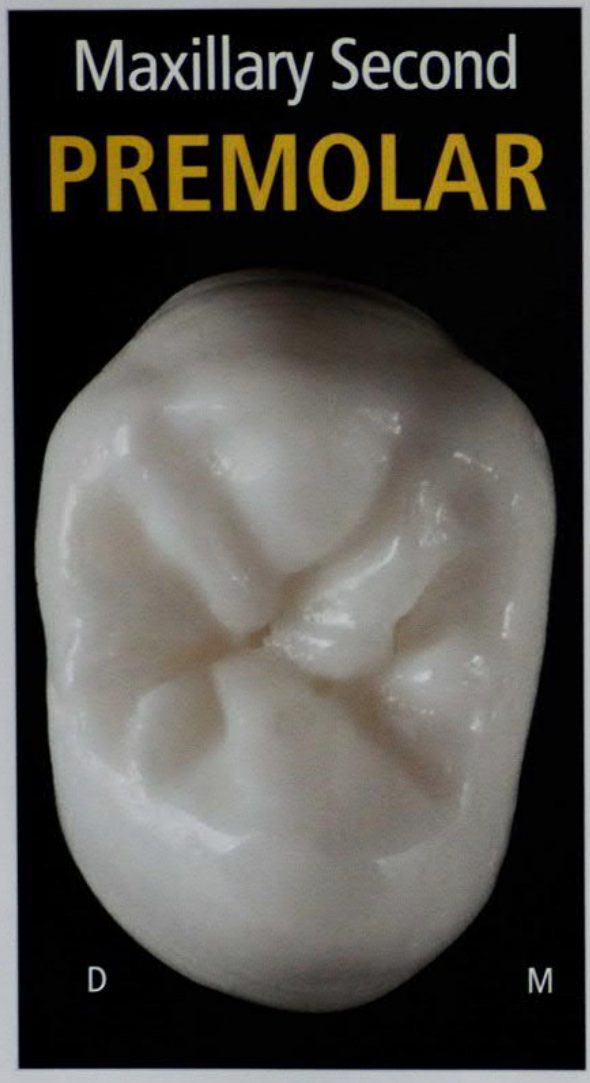
Occlusal surface

The occlusal surface is ovoid, permitting visualization of two cusps (buccal and palatal), half of the buccal surface, one-third of the palatal surface, and part of the proximal surfaces. The mesial and distal aspects present a slight convergence palatally. The occlusal table is formed by lobes, a principal developmental groove, and two fossae. In both cusps, the central lobe is more evident than the lateral lobes. It is even common to have a single central lobe in the buccal cusp. At the marginal ridges, the lobes are triangular and more reduced. The buccal cusp is bigger because of its palatal extension, and determines an eccentric developmental groove with a straight mesiodistal direction. The central groove, formed by the mesiodistal groove, penetrates the cusps and marginal ridges and establishes significant characteristics (eg, the grooves on the mesial marginal ridge). The longitudinal slopes of cusps and the marginal ridges delineate the mesial and distal fossae. A symmetric, double D–shaped perimeter is observed here. This hallmark characteristic is outlined in the figure by the brightness of the occlusal perimeter.

Centric Occlusal Contacts

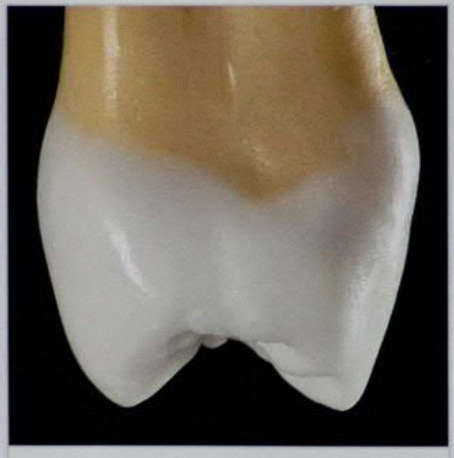
In the maxillary first premolar, occlusal contacts are found between:

- The mesial marginal ridge and the cusp tip or distal longitudinal slope of the buccal cusp of the mandibular first premolar. This is called a horizontal or H-type contact between the marginal ridge and the cusp tip or the longitudinal slope.
- The distal marginal ridge and the mesial longitudinal slope of the buccal cusp of the mandibular second premolar (H-type contact).



Buccal Surface

Palatal Surface



Mesial Surface

Distal Surface

Maxillary Second Premolar

Buccal surface

The buccal surface has an ovoid shape, with the cusp tip aligned with the crown's midline. The proximal aspects have the same characteristics as the maxillary first premolars. Along its surface, the cervical bulge is narrower and less prominent than that of the maxillary first premolar. The buccal central lobe is separated from the lateral lobes by developmental grooves that run up to the longitudinal slopes, creating sinusoidal paths on them. The mesial and lateral lobes are more evident than those of the maxillary first premolars.

Palatal surface

The palatal surface has an ovoid format, with the cusp tip slightly inclined toward the mesial, presenting anatomical details similar to those of the maxillary first premolars. It is characteristic that the palatal surface has the same height as the buccal surface.

Proximal surfaces

The proximal surfaces present characteristics similar to those found in the maxillary first premolars. The buccal and palatal cusps are on the same level.

Occlusal surface

he occlusal surface has a trapezoidal format, on which two cusps (buccal and palatal), one third of the buccal surface, and part of the proximal surfaces can be visualized. The mesial and distal aspects have little or no palatal convergence. The occlusal table is formed by lobes, a developmental groove more evident than the one in the maxillary first premolar, and two fossae. In both cusps, the central lobe is oriented toward the distal fossa. A distinguishing characteristic is the presence of prominent lateral lobes in the buccal cusp. At the marginal ridges, the lobes are triangular, being longer than the one in the maxillary first premolar. The cusps have similar dimensions, determining the centric positioning of the central mesiodistal groove, with a sinusoidal, irregular path. A D-shaped appearance is also found in the mesial and distal fossae.

Centric Occlusal Contacts

In the maxillary second premolar, occlusal contacts are found between:

- The mesial marginal ridge and the distal longitudinal slope of the buccal cusp of the mandibular second premolar (H-type contact).
- The distal marginal ridge and the mesial longitudinal slope of the mesiobuccal cusp of the mandibular first molar (H-type contact).

In addition, variations in occlusal contacts are found between:

- The central lobe of the palatal cusp and the central lobe of the buccal cusp of the mandibular second premolar, near the pit of its central fossa. This is a B-type contact found between lobes.
- The mesial incline of the palatal cusp and the oblique segment of the central lobe of the mesiolingual cusp of the mandibular second premolar. This is a C-type contact, between the upper incline and the lower central lobe.
- The distal incline of the palatal cusp and the central lobe of the distolingual cusp of the mandibular second premolar (C-type contact).

Buccal Surface

Palatal Surface

Mesial Surface

Distal Surface

Maxillary First Molar

The largest of the permanent maxillary molars, with the least morphologic variation.

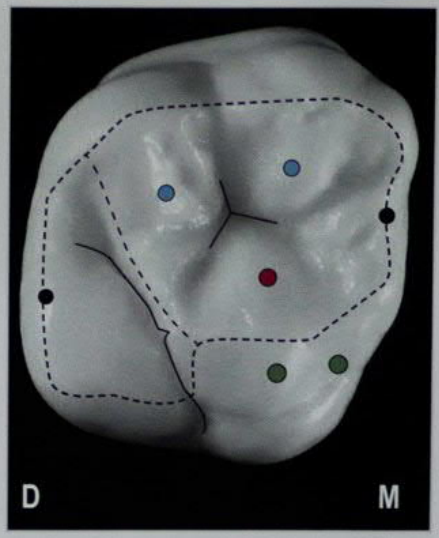
Buccal surface

The buccal surface has a trapezoidal shape, where most part of the distal surface is visualized, a strong characteristic in this tooth. The mesial aspect is flat at the cervical third and convex in the middle and occlusal thirds. The distal aspect is smaller and convex all along its extension. The cervical line encompasses two segments separated by a sharp elevation at the middle root aspect of the buccal surface. The presence of two buccal cusps forms a W-shaped contour in the occlusal surface, the mesiobuccal cusp being bigger and inclined more palatally. The mesiopalatal cusp tip is visible. The buccal surface presents a cervical bulge and two prominent central lobes. A horizontal groove is found between the bulge and the lobes. In turn, the central lobes are separated by the occlusobuccal groove that ends at the midpoint of the buccal surface, with a slight distal inclination, making the mesial lobe wider than the distal lobe. A small triangular depression is formed at the intersection of the horizontal and the occlusobuccal grooves in the middle third.

Palatal surface

The palatal surface has a mesiodistal dimension that is larger and more convex than that of the buccal surface. The cervical line here is flat, while in the occlusal aspect two cusps have a W-shaped configuration.

The mesiopalatal cusp is more rhomboidal and slightly higher than the distopalatal cusp, which is lower and narrower, having a rounded design. A palatal groove running from the occlusal surface separates the two cusps, ending at the middle third of this surface. The Carabelli tubercle is a fundamental characteristic of the mesial aspect; it varies in frequency and size from patient to patient.



Proximal surfaces

These are irregular and trapezoidal, the longest aspects being in the buccolingual direction. The buccal and palatal profiles converge to the occlusal aspect. On both surfaces, the marginal ridges are almost completely flat and are crossed by a marginal groove. On the mesial surface, it can be seen that the mesiopalatal cusp is higher than the mesiobuccal cusp. On the distal surface, the distobuccal cusp is more prominent than the distopalatal cusp. The distal marginal ridge is narrower in a buccopalatal direction and less prominent than the mesial ridge, which is usually crossed by a distal marginal groove displaced to the buccal aspect, generating a larger palatal segment. Only a small portion of each mesial cusp is visible on the distal aspect.

Occlusal surface

In this tooth, the buccolingual dimensions are greater than the mesiodistal dimensions. The occlusal surface has a rhomboidal shape, in which it is possible to identify four cusps, one-third of the buccal surface, half of the palatal surface (with the Carabelli tubercle), and parts of the proximal surfaces. By volume, the mesiopalatal cusp is the largest of all, followed by the mesiobuccal, distobuccal, and distopalatal cusps. The occlusal table has an irregular parallelogram form, encompassing four lobes, the enamel bridge, a developmental groove, and two fossae. All of the cusps have three well-defined lobes. The mesial marginal ridge presents an often segmented long, triangular lobe. On the other hand, the distal ridge has a single short, straight lobe. The enamel bridge is higher than the developmental groove and runs from the distobuccal to the mesiopalatal cusp, sometimes being interrupted. The central groove is formed by the mesiodistal and occlusobuccal grooves (dividing the buccal cusps), as well as the occlusodistopalatal groove. Two fossae (mesial and distal) can be found at this surface. The perimeter of the mesial fossa is determined by the longitudinal slopes of the buccal cusps, the enamel bridge, the mesiopalatal cusp tip, and the mesial marginal ridge, creating a triangular, heart-shaped configuration. Part of the central groove found in the mesial fossa is similar to a three-pointed star. The distal fossa is delimited by the distal marginal ridge, the distobuccal cusp tip, the enamel bridge, and the distopalatal cusp tip, having a right triangle configuration. The distopalatal groove found at this fossa is parallel to the enamel bridge and assumes the form of a right curly bracket (}), ending at the palatal aspect.

Centric Occlusal Contacts

In the maxillary first molar, occlusal contacts are found between:

- The mesial marginal ridge and the distal longitudinal ridge of the mesiobuccal cusp of the mandibular first molar (H-type contact).
- The distal marginal ridge and the mesial longitudinal ridge of the mesiobuccal cusp of the mandibular second molar (H-type contact).
- The central lobe of the mesiobuccal cusp and the mesial incline of the midbuccal cusp of the mandibular first molar. This is an A-type contact, which occurs between the lower incline and the upper central lobe.
- The central lobe of the distobuccal cusp and the distal incline of the midbuccal cusp of the mandibular first molar (A-type contact).
- The central lobe of the mesiopalatal cusp of the maxillary first molar and the central lobe of the midbuccal cusp of the mandibular first molar (B-type contact).
- The mesial incline of the mesiopalatal cusp of the maxillary first molar and the oblique segment of the central lobe of the mesiolingual cusp in the mandibular first molar (C-type contact).
- The distal incline of the mesiopalatal cusp of the maxillary first molar and the central lobe of the distolingual cusp of the mandibular first molar (C-type contact).

Buccal Surface

Palatal Surface

Mesial Surface

Distal Surface

Maxillary Second Molar

Buccal surface

The buccal surface has a trapezoidal shape similar to that of the maxillary first molar, but with reduced dimensions and less pronounced grooves. The distal surface is not visible; only the profile of the mesiolingual cusp is evident. Due to the displacement of the buccal groove toward the distal, the mesiobuccal cusp is bigger, whereas the distobuccal cusp is less voluminous and shorter.

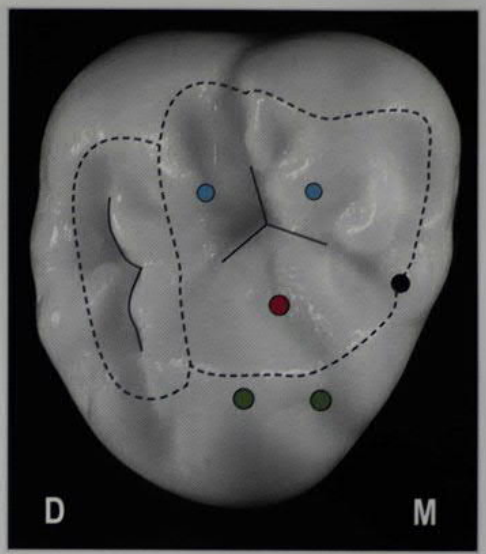
Palatal surface

The palatal surface is similar to that of the maxillary first molar, with smaller dimensions than those of the buccal surface. There is usually a single palatal cusp or perhaps a very small second cusp. The Carabelli tubercle is rarely observed. The profile of the buccal cusp is visible.

Proximal surfaces

The proximal surface are similar to those of the maxillary first molar; however, the distal aspect is narrower toward the mesial, rendering the mesiopalatal cusp much more evident.

Occlusal surface

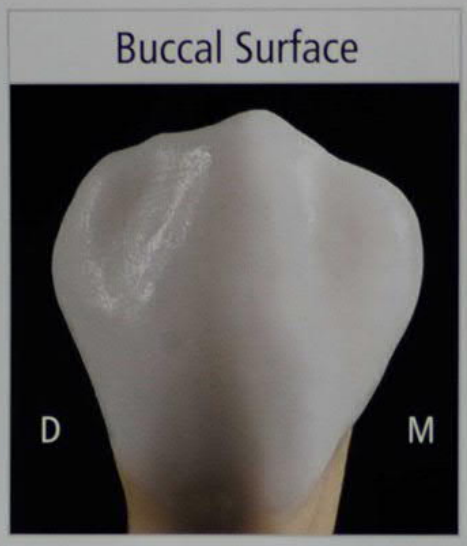


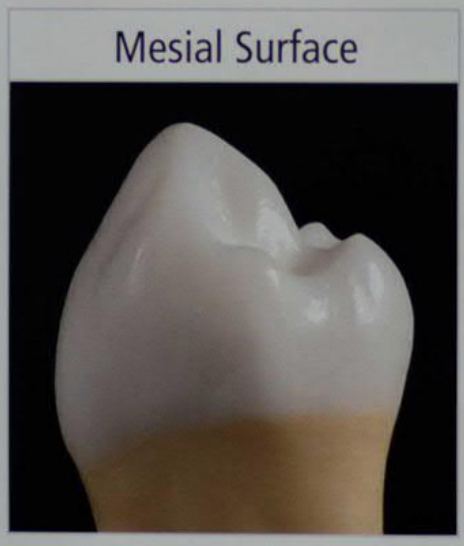
The occlusal surface has a trapezoidal shape, with four cusps, one-third of the buccal surface, half of the palatal surface, and part of the proximal surfaces visible. Frequently, the distopalatal cusp is very small or absent in this tooth group. This cusp diminishes in height from the second to the third molar. The occlusal table comprises four lobes, the enamel bridge, a principal groove, and two fossae (in the case of four cusps) or one fossa (in the case of three cusps). Also, the enamel bridge is reduced. The central groove is formed by the mesiodistal, occlusobuccal, and occlusodistopalatal grooves, with a three-pointed star found at the mesial fossa, with the irregular right curly bracket at the distal fossa. The perimeter of the mesial fossa is heart-shaped, and that of the distal fossa is similar to a scalene triangle.

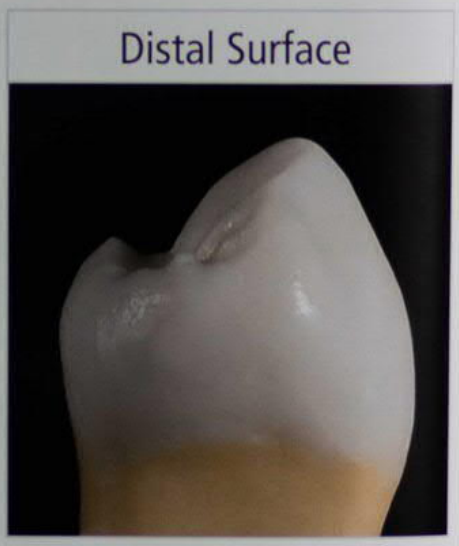
Centric Occlusal Contacts

In the maxillary second molar, occlusal contacts are found between:

- The mesial marginal ridge and the longitudinal distal slope of the mesiobuccal cusp of the mandibular second molar (H-type contact)
- The central lobe of the mesiobuccal cusp and the mesial incline of the distobuccal cusp of the mandibular second molar (A-type contact)
- The central lobe of the distobuccal cusp and the distal incline of the distobuccal cusp of the mandibular second molar (A-type contact)
- The central lobe of the mesiopalatal cusp and the central lobe of the distobuccal cusp of the mandibular second molar (B-type contact)
- The mesial incline of the mesiopalatal cusp and the oblique segment of the central lobe of the mesiolingual cusp of the mandibular second molar (C-type contact)
- The distal incline of the mesiopalatal cusp and the central lobe of the distolingual cusp of the mandibular second molar (C-type contact)







Mandibular First Premolar

One of the teeth with the greatest number of morphologic variations.

Buccal surface

The buccal surface has an ovoid shape. The proximal line angles are slightly convex and diverge occlusally. The cervical bulge is prominent along the entire buccal surface, with smooth central and lateral lobes, defined by shallow developmental grooves.

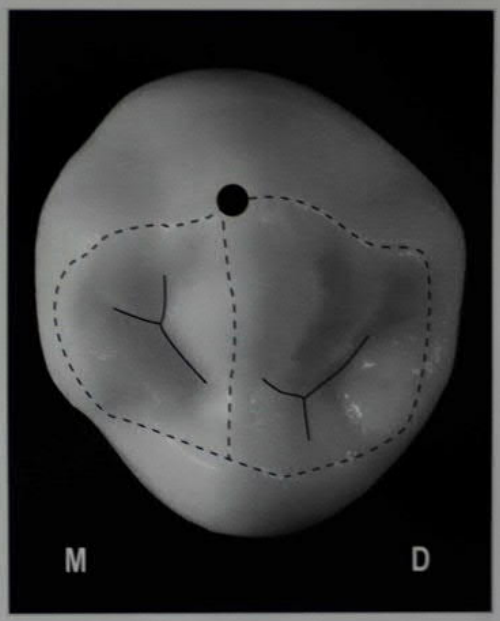
Lingual surface

The lingual surface is lower than the buccal surface, being uniformly convex, without lobes or grooves. The buccal profile and virtually almost all of the occlusal surfaces can be seen from this aspect. The mesiolingual cusp tip can be either equal with or slightly mesial to the buccal cusp tip.

Proximal Surfaces

The buccal profile is convex in the cervical and middle thirds and strongly inclined lingually in the occlusal third, with the cusp tip positioned near the central coronal region. The lingual profile is relatively flat, with a distinct convexity at the occlusal third. The buccal cusp is more evi-

dent than the lingual cusps. The occlusal aspect is toward the lingual. On the mesial aspect, the marginal ridge is inclined 45 degrees cervically. On the distal aspect, the distal marginal ridge is more prominent than the mesial and does not have a profound cervical inclination. The distal surface is wider in the buccolingual than in the mesial surface, with a larger contact area.



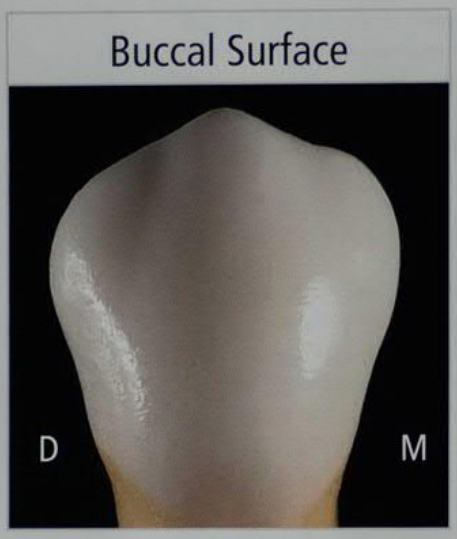
Occlusal surface

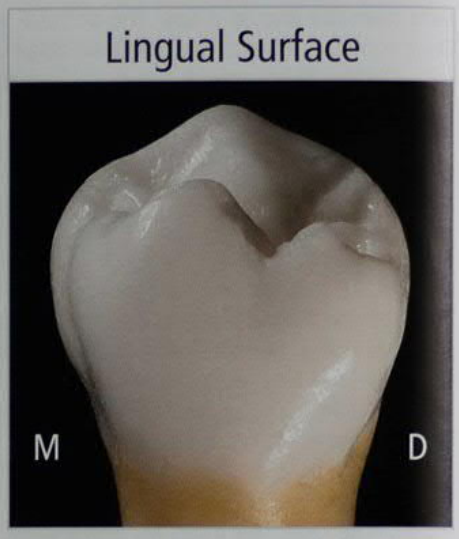
The occlusal surface has an ovoid shape, where two to three cusps, much of the buccal surface, one-third of the lingual surface, and part of the proximal surfaces can be found. The proximal aspects converge lingually. The distal aspect is more convex, and both may be penetrated by a marginal groove. The occlusal table has a trapezoidal shape, with the base facing the distal aspect, so that it appears to narrow from mesial to distal. It comprises lobes, the enamel bridge, a central groove, and two fossae. The buccal cusp is the widest of all, presenting a single lobe. The lobes are less evident on the marginal ridges. The central groove is formed by the occlusomesiobuccal, occlusomesiolingual, occlusolingual, and occlusodistal grooves. The mesiodistal groove is crossed by the enamel bridge that runs along the occlusal surface, joining together the buccal and mesiolingual cusps. The enamel bridge may or may not be interrupted. It is possible to see two fossae, one mesial and the deeper one distal. When the slopes that surround the fossae are defined, two asymmetric letter D shapes become visible. The segment of the principal groove found at the mesial fossa has a configuration similar to the letter Y.

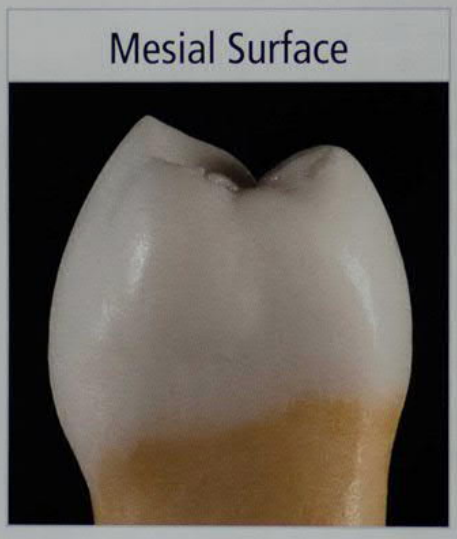
Centric Occlusal Contacts

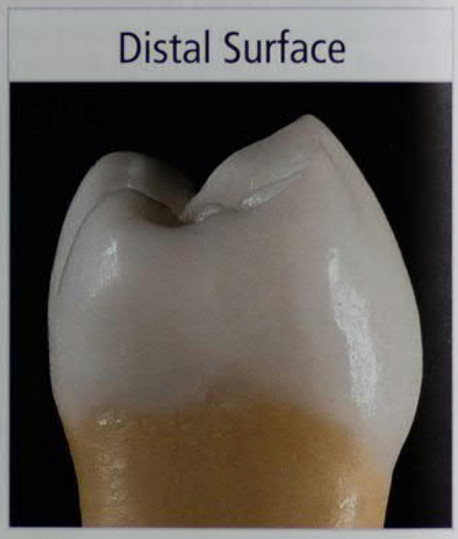
In the mandibular first premolar, occlusal contacts are found between:

- The distal longitudinal slope/tip of the buccal cusp and the mesial marginal ridge of the maxillary first premolar (H-type contact)









Mandibular Second Premolar

Buccal surface

The buccal surface is similar to that found on the mandibular first premolar. However, the cervical bulge is smaller, and the grooves are more evident.

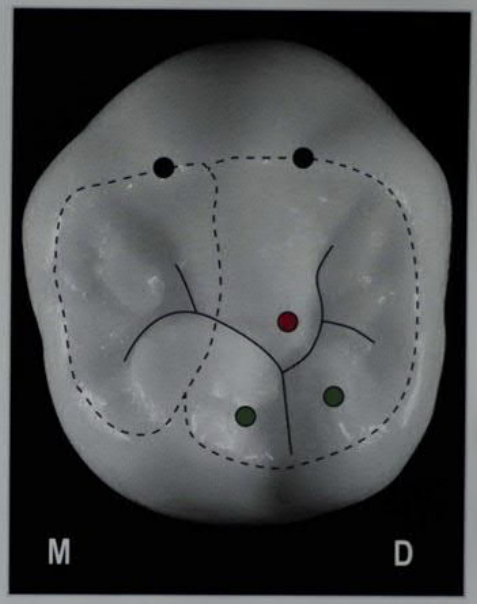
Lingual surface

The lingual surface is more convex and shorter; however, the mesiodistal dimension is as wide as that of the buccal surface. From this viewpoint, the profile of the buccal cusp is visible. Along this surface, a bulge is found in the middle third. The number of cusps has a great influence on the tooth's morphology. When two cusps are present, there is a slight groove dividing the lingual surface, the distolingual cusp being a little bit lower than the mesiolingual cusp.

Proximal surfaces

From the proximal aspect, the buccal profile is inclined lingually, and the lingual profile is straighter, with a slight inclination toward the buccal only in its occlusal third. On the occlusal aspect, the palatal segment is slightly inclined cervically. The marginal ridges are flat and irregular. On the mesial aspect, the mesiolingual cusp can be found at the same level as the buccal cusp. Finally, three cusps can be visualized from the distal surface; the distolingual cusp is the lowest of these.

Occlusal surface



Here, the anatomical characteristics depend on the number of cusps present. The occlusal surface has a quadrilateral shape; however, when there are only two cusps, this surface assumes a rounded configuration. Most often this tooth has three cusps: buccal, mesiolingual, and distolingual, in decreasing order of volume. That said, it is possible to see a large part of the buccal surface, one-third of the lingual surface, and part of the proximal surfaces (especially the mesial aspect). The mesial and distal aspects are straight and parallel to each other. The rectangular occlusal table is formed by lobes, a principal groove, an enamel bridge, and two fossae. The buccal cusp is the largest of all, having a well-defined central lobe pointed toward the depth of the distal fossa. The mesiolingual cusp has a protuberant central lobe, encompassing the whole cusp. The distolingual cusp, due to its lesser size, has small lobes. On the marginal ridges, the lobes are less evident. The enamel bridge joins the buccal and mesiolingual cusps. The central groove is displaced lingually because of the width of the buccal cusp. This groove is formed by the mesiodistal, occlusolingual (separating the lingual cusps), occlusodistobuccal, occlusomesiobuccal, occlusomesiolingual, and occlusodistal grooves. The mesiodistal groove assumes an M-shaped configuration. The conjunction of the occlusolingual, occlusodistobuccal, and occlusomesiobuccal grooves has a Y shape or is caliciform. The perimeter of the mesial fossa is D-shaped, whereas the distal fossa resembles a crescent moon.

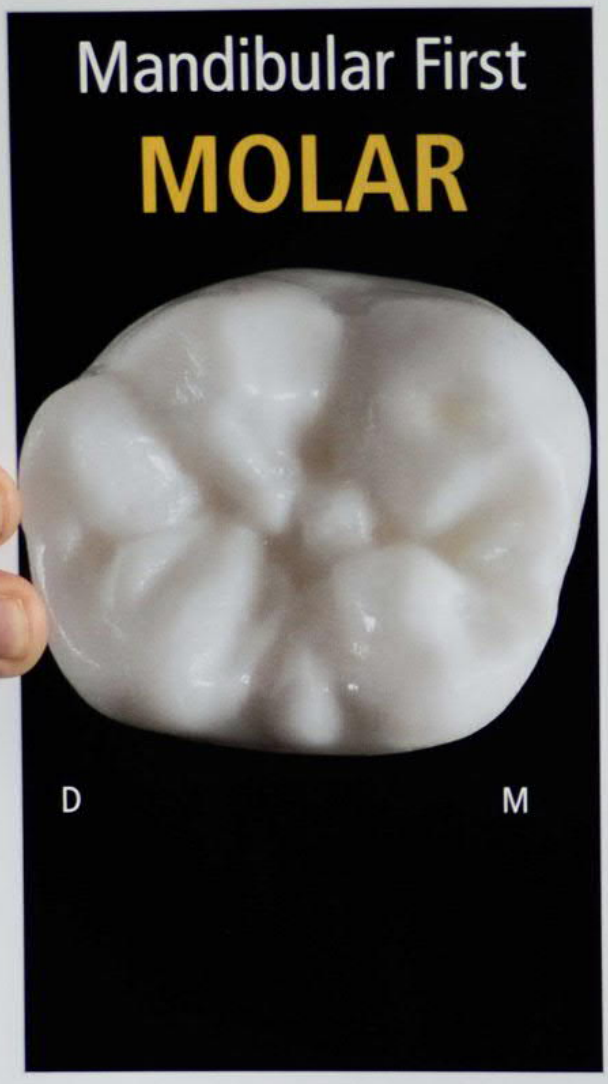
Centric Occlusal Contacts

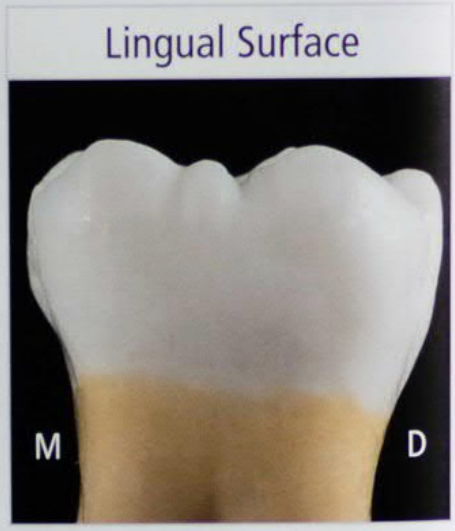
In the mandibular second premolar, occlusal contacts are found between:

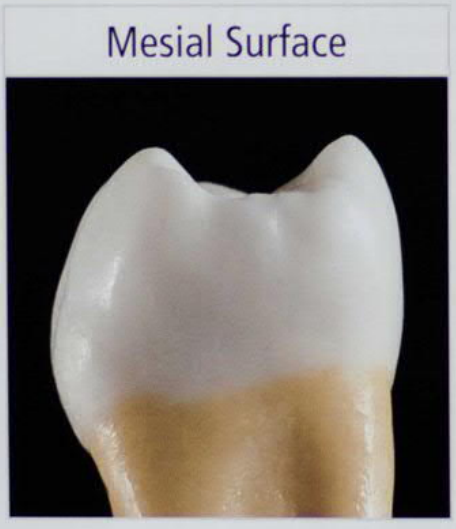
- The mesial longitudinal slope of the buccal cusp and the distal marginal ridge of the maxillary first premolar (H-type contact)
- The distal longitudinal slope of the buccal cusp and the mesial marginal ridge of the maxillary second premolar (H-type contact)

In addition, variant contacts are found in the following situations:

- The central lobe of the buccal cusp versus the central lobe of the palatal cusp of the maxillary second premolar (B-type contact)
- The oblique segment of the central lobe of the mesiolingual cusp versus the mesial incline of the palatal cusp of the maxillary second premolar (C-type contact)
- The central lobe of the distolingual cusp versus the distal incline of the palatal cusp of the maxillary second premolar (C-type contact)







Mandibular First Molar

The tooth with the greatest mesiodistal dimension.

Buccal surface

The buccal surface has an irregular trapezoidal form. On the mesial aspect, the cervical third is concave and the middle and occlusal thirds are convex, whereas the distal aspect is convex in all dimensions. Both proximal surfaces converge to the cervical region. The cervical line facing the roots has a convex configuration. On the occlusal aspect, a lower case *m* can be seen due to the presence of three cusps. The mesio- and midbuccal cusps have similar heights and are separated by the mesiobuccal groove. The distal cusp is separated from the midbuccal cusp by a smooth distobuccal groove. At the intersection of the horizontal and mesiobuccal grooves, a delta is formed, corresponding to an irregular depression.

Lingual surface

The lingual surface has an irregular trapezoidal form, with smaller dimensions than the buccal surface. It is possible to visualize two cusps, which form an upper case letter *M* at the occlusal aspect. The mesiolingual cusp is larger than the distolingual cusp. Its surface is divided by a lingual groove. A bulge can be found along the middle third of this surface.

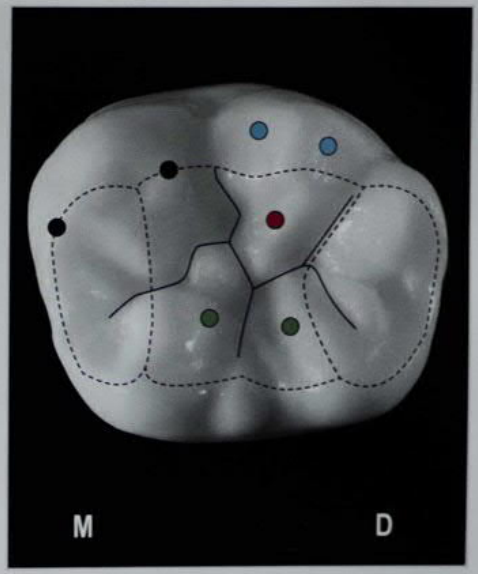
Proximal surfaces

The proximal surfaces have a trapezoid form. The buccal profile is strongly inclined lingually. The lingual profile is relatively flat on the cervical third and completely convex up to the cusp tips. On the mesial aspect, the mesiobuccal and mesiolingual cusps have different heights because of the presence of a central lobe. The mesial ridge is prominent and marked by the mesial marginal groove. On the distal surface, which is narrower than the mesial, three cusps can be found: distobuccal, distolingual, and midbuccal. The distobuccal cusp is lingually positioned with regard to the midbuccal cusp. The distal marginal ridge is lower than the mesial ridge and has a fissure formed by the distal marginal groove.

Occlusal surface

The occlusal surface has a pentagonal shape, it being possible to visualize five cusps, two-thirds of the buccal surface, the occlusal third of the lingual surface, and part of the proximal surfaces. Cusp size is established in the following descending order: mesiolingual, mesiobuccal, distolingual, midbuccal, and distobuccal. The buccal aspect is larger than the lingual aspect. The mesial aspect is wider than the distal aspect. The occlusal table, with its pentagonal shape, comprises the lobes, a central groove, and three fossae. A particular characteristic of mandibular teeth is that the central lobes of the mesial cusps are segmented, with transverse and oblique portions. In most cases the distobuccal cusp, due to its smaller dimensions, presents a single lobe. Only in the mesial marginal ridge is a lobe found.

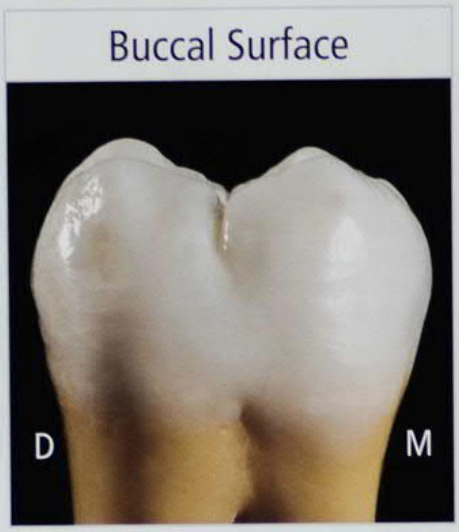
The central groove is formed by the following grooves: the mesiodistal groove, which has a sinusoidal shape and divides the buccal cusps from the lingual cusps; the occlusobuccal groove, which separates the mesiobuccal and midbuccal cusps; the occlusodistobuccal groove, which separates the midbuccal and distobuccal cusps; the occlusolingual groove, which separates the lingual cusps, and the occlusomesiolingual and occlusodistolingual grooves. An M-shaped junction is formed by the mesiodistal, occlusolingual, occlusodistolingual, and occlusomesiolingual grooves. Parts of the mesiodistal, occlusobuccal, and occlusodistobuccal grooves form a Y-shaped configuration. There are three fossae: mesial, central, and distal. The perimeter of the mesial fossa is delimited by an imaginary line connecting the mesial marginal ridge and the mesiobuccal and mesiolingual cusp tips. On the other hand, the perimeter of the distal fossa is formed by the union of the distal marginal ridge and the distobuccal and distolingual cusp tips. Both the mesial and the distal fossa have a leaf configuration. The central fossa resembles a spool, being delineated by the mesiobuccal, midbuccal, distolingual, distobuccal, and mesiolingual cusp tips.

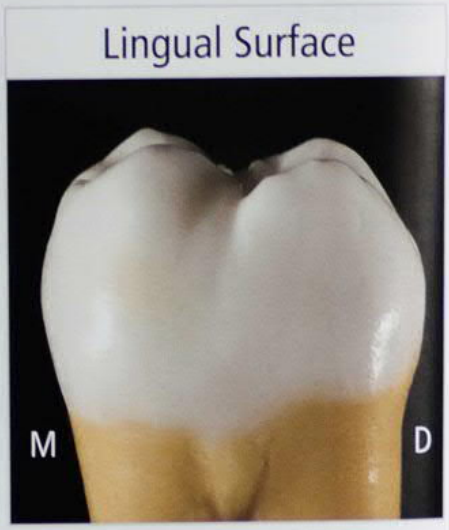


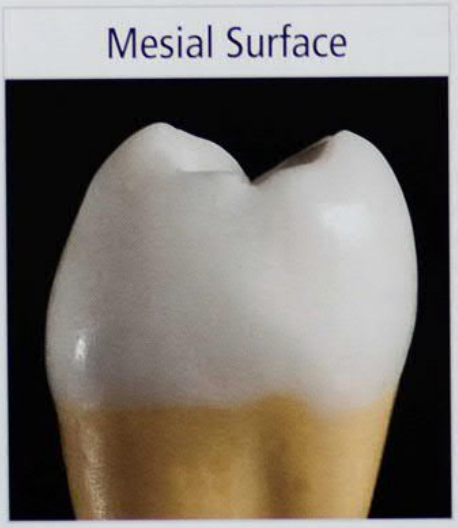
Centric Occlusal Contacts

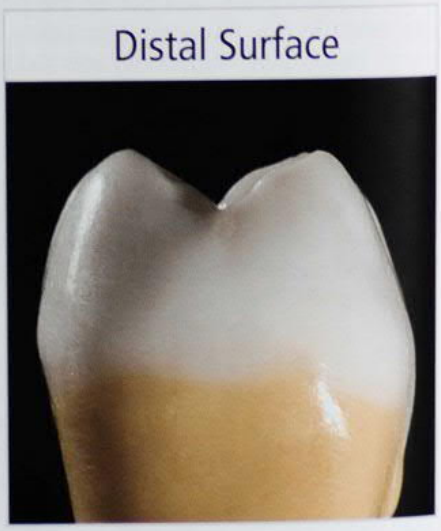
In the mandibular first molar, occlusal contacts are found between:

- The mesial longitudinal slope of the mesiobuccal cusp and the distal marginal ridge of the maxillary second premolar (H-type contact)
- The distal longitudinal slope of the mesiobuccal cusp and the mesial marginal ridge of the maxillary first molar (H-type contact)
- The mesial incline of the midbuccal cusp and the central lobe of the mesiobuccal cusp of the maxillary first molar (A-type contact)
- The distal incline of the midbuccal cusp and the central lobe of the distobuccal cusp of the maxillary first molar (A-type contact)
- The central lobe of the midbuccal cusp and the central lobe of the mesiopalatal cusp of the maxillary first molar (B-type contact)
- The oblique segment of the central lobe of the mesiolingual cusp and the mesial incline of the mesiopalatal cusp of the maxillary first molar (C-type contact)
- The central lobe of the distolingual cusp and the distal incline of the mesiopalatal cusp of the maxillary first molar (C-type contact).









Mandibular Second Molar

Buccal surface

This surface is somewhat bigger than the lingual surface. It has a trapezoidal shape, with convex proximal line angles, the distal curvature being shorter and more evident. The cervical line is convex toward the root. The mesio- and distobuccal cusps can be seen, separated by a buccal groove, displaced distally, which results in a larger mesial segment. The occlusal aspect has the form of the letter *M*. Along its surface, characteristics similar to those found in the mandibular first molar can be seen, but without a central fossa.

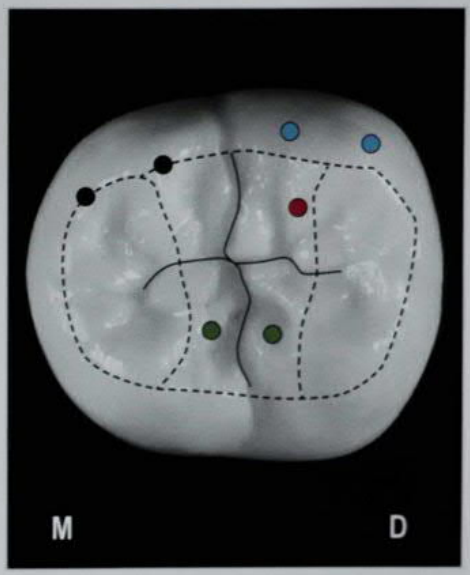
Lingual Surface

This surface is similar to the buccal surface, but with smaller dimensions and larger convexities. It has two cusps, divided by a lingual groove that is less clear than that in the mandibular first molar. The distolingual cusp is fairly convex. The profile of the buccal cusps can be visualized.

Proximal surfaces

These are similar to those found in the mandibular first molar; however, on the mesial surface, the mesiobuccal and mesiolingual cusps are the same height. On the distal surface, it is possible to visualize the profile of the mesial cusps.

Occlusal surface

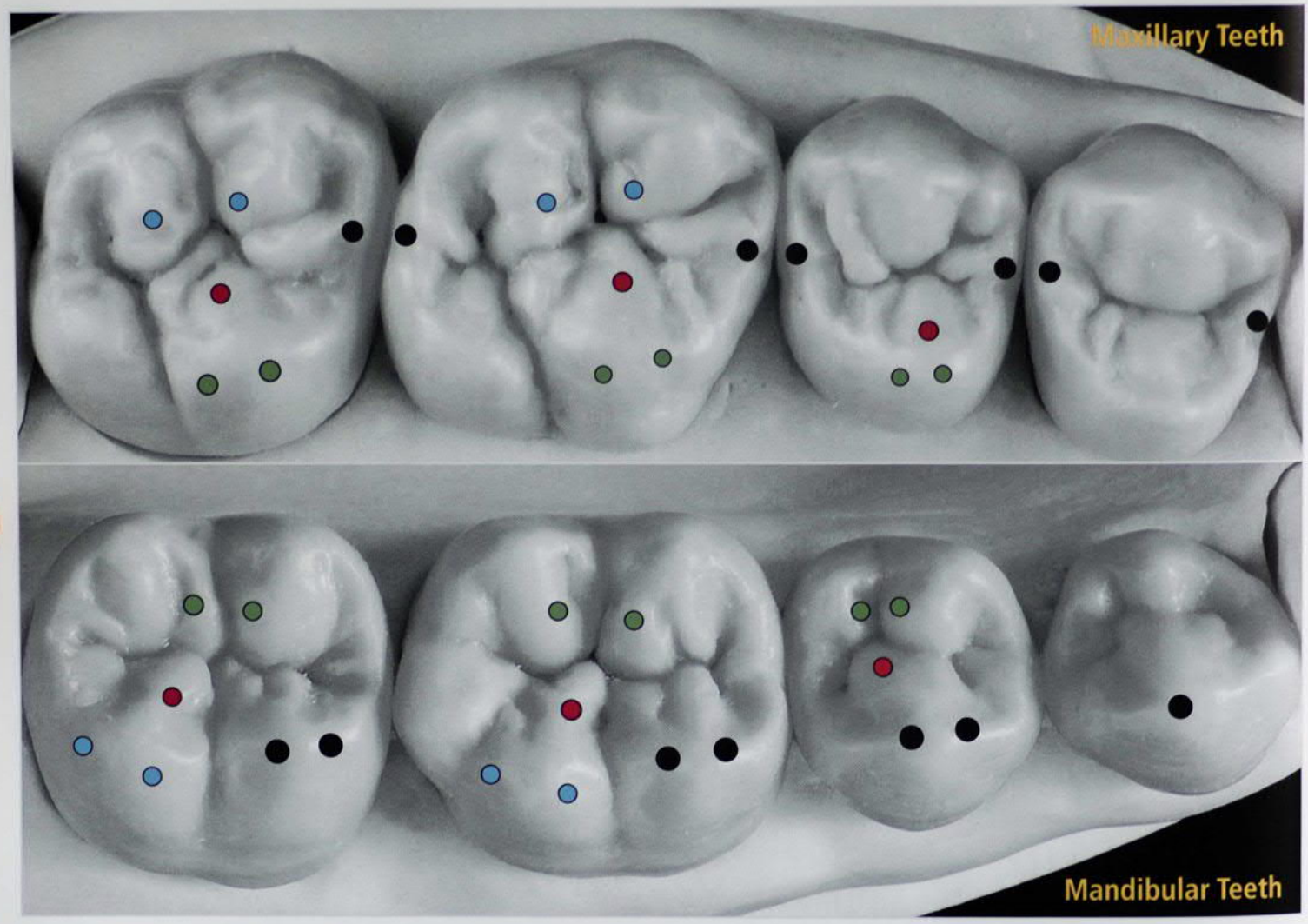


This surface has a rounded rectangular format; it is possible to visualize four cusps, two-thirds of the buccal surface, one-third of the lingual surface, and part of the proximal surfaces. In decreasing order of size, the cusps are the mesiolingual, mesiobuccal, distobuccal, and distolingual. The rectangular occlusal table is formed by lobes, a central groove, and three fossae. The lobes found on the mesial and distal marginal ridges are less evident. The developmental groove is composed by the mesiodistal, occlusobuccal, and occlusolingual grooves, which cross each other almost at the center of the occlusal surface, giving the groove a discontinuous crisscross appearance. As in the mandibular first molar, three fossae (mesial, central, and distal) are found. The perimeter of the mesial fossa is delimited by an imaginary line joining the mesial marginal ridge and the mesiolingual and mesiobuccal cusp tips. In contrast, the perimeter of the distal fossa is formed by the distal marginal ridge and the distobuccal and distolingual cusp tips. A leaf configuration is found on the mesial and distal fossae. The central fossa, which has a spool shape, is delimited by the mesiobuccal, distobuccal, and distolingual cusp tips.

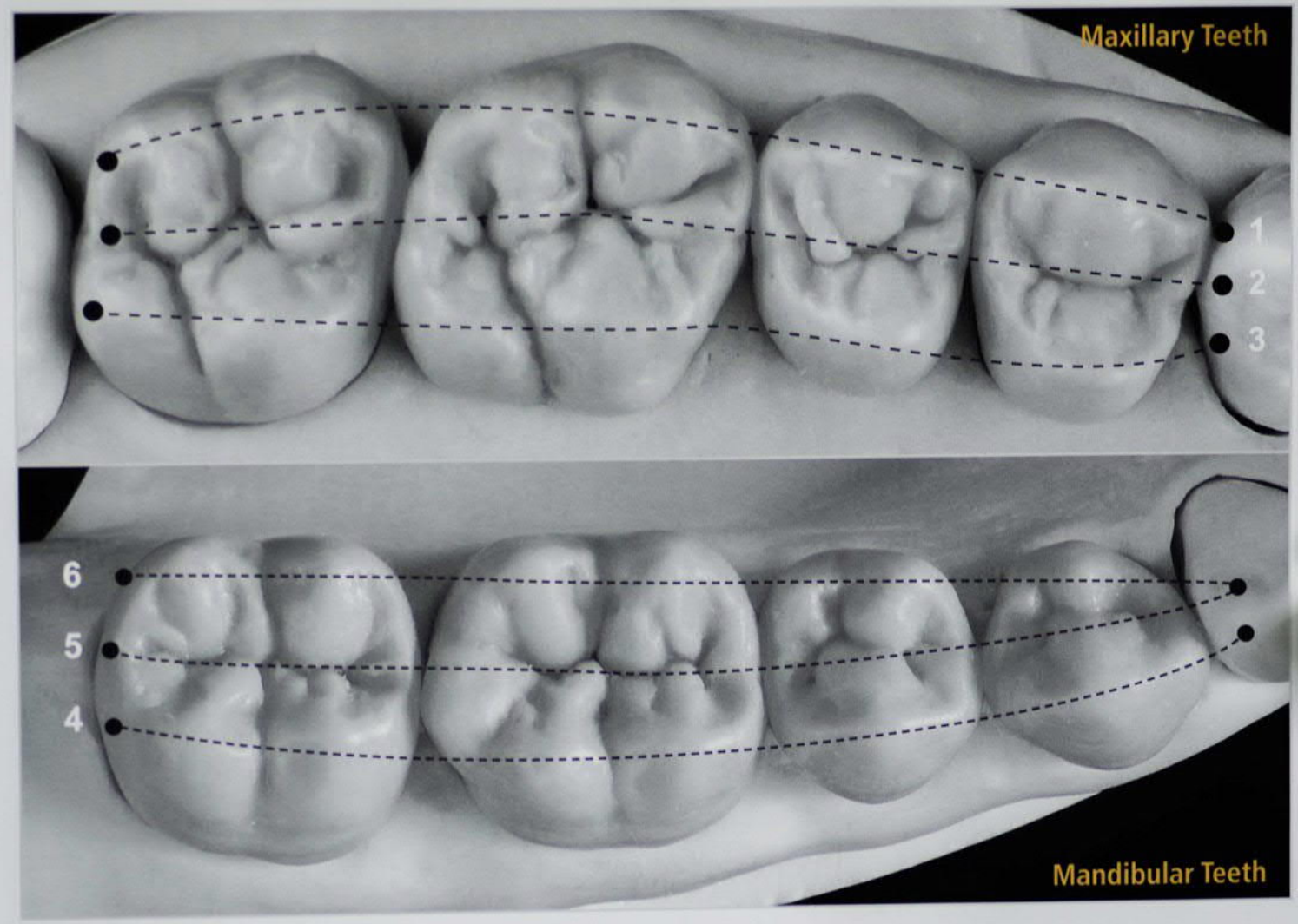
Centric Occlusal Contacts

In the mandibular second molar, occlusal contacts are found between:

- The mesial longitudinal slope of the mesiobuccal cusp and the distal marginal ridge of the maxillary first molar (H-type contact)
- The distal longitudinal slope of the mesiobuccal cusp and the mesial marginal ridge of the maxillary second molar (H-type contact)
- The mesial incline of the distobuccal cusp and the central lobe of the mesiobuccal cusp of the maxillary second molar (A-type contact)
- The distal incline of the distobuccal cusp and the central lobe of the distobuccal cusp of the maxillary second molar (A-type contact)
- The central lobe of the distobuccal cusp and the central lobe of the mesiopalatal cusp of the maxillary second molar (B-type contact)
- The oblique segment of the central lobe of the mesiolingual cusp and the mesial incline of the mesiopalatal cusp of the maxillary second molar (C-type contact)
- The central lobe of the distolingual cusp and the distal incline of the mesiopalatal cusp of the maxillary second molar (C-type contact)



Centric Occlusal Contacts



Dental Reference Lines of the Posterior Teeth

In addition to the individual characteristics of teeth, it is necessary to understand the dental reference lines before performing the wax-up process. These will help to determine the height, length, and width of the cusps.

1. **Maxillary occlusobuccal line.**
   Anteroposterior line passing through the buccal longitudinal slopes of the maxillary posterior teeth.
2. **Maxillary central fossa line.**
   Anteroposterior line passing through the central fossae of the maxillary posterior teeth.
3. **Maxillary occlusopalatal line.**
   Anteroposterior line passing through the palatal longitudinal slopes of the maxillary posterior teeth.
4. **Mandibular occlusobuccal line.**
   Anteroposterior line passing through the buccal longitudinal slopes of the mandibular posterior teeth.

5. **Mandibular central fossa line.**
   Anteroposterior line passing through the central fossae of the mandibular posterior teeth.
6. **Mandibular occlusolingual line.**
   Anteroposterior line passing through the palatal longitudinal slopes of the mandibular posterior teeth.
7. **Smile line.**
   An imaginary line that touches the incisal margins of the maxillary anterior teeth and the cusp tips of the posterior teeth describing an arch. It is important because the height of the buccal cusps of the maxillary posterior teeth is determined by it. Only the dental surgeon has access to this important reference line and must communicate it to the laboratory technician, since the smile line is related to the lip and commissural lines. The positioning of the smile line is performed by the dentist, not the technician.
8. **Mandibular incisor line.**
   Imaginary line passing through the incisal margins of the mandibular anterior teeth.

Lines 1 to 6 are parallel to each other.
Lines 1 to 7 are reference lines to determine the height of the buccal cusps of the maxillary posterior teeth.
Lines 3 and 6 determine cuspal inclination on the occlusal table. Line 3 determines the inclination of the buccal cusps of the mandibular teeth, and line 6 determines the inclination of the palatal cusps of the maxillary teeth.
In a frontal view, lines 2 and 6 determine the height, direction, and inclination of the palatal cusps.

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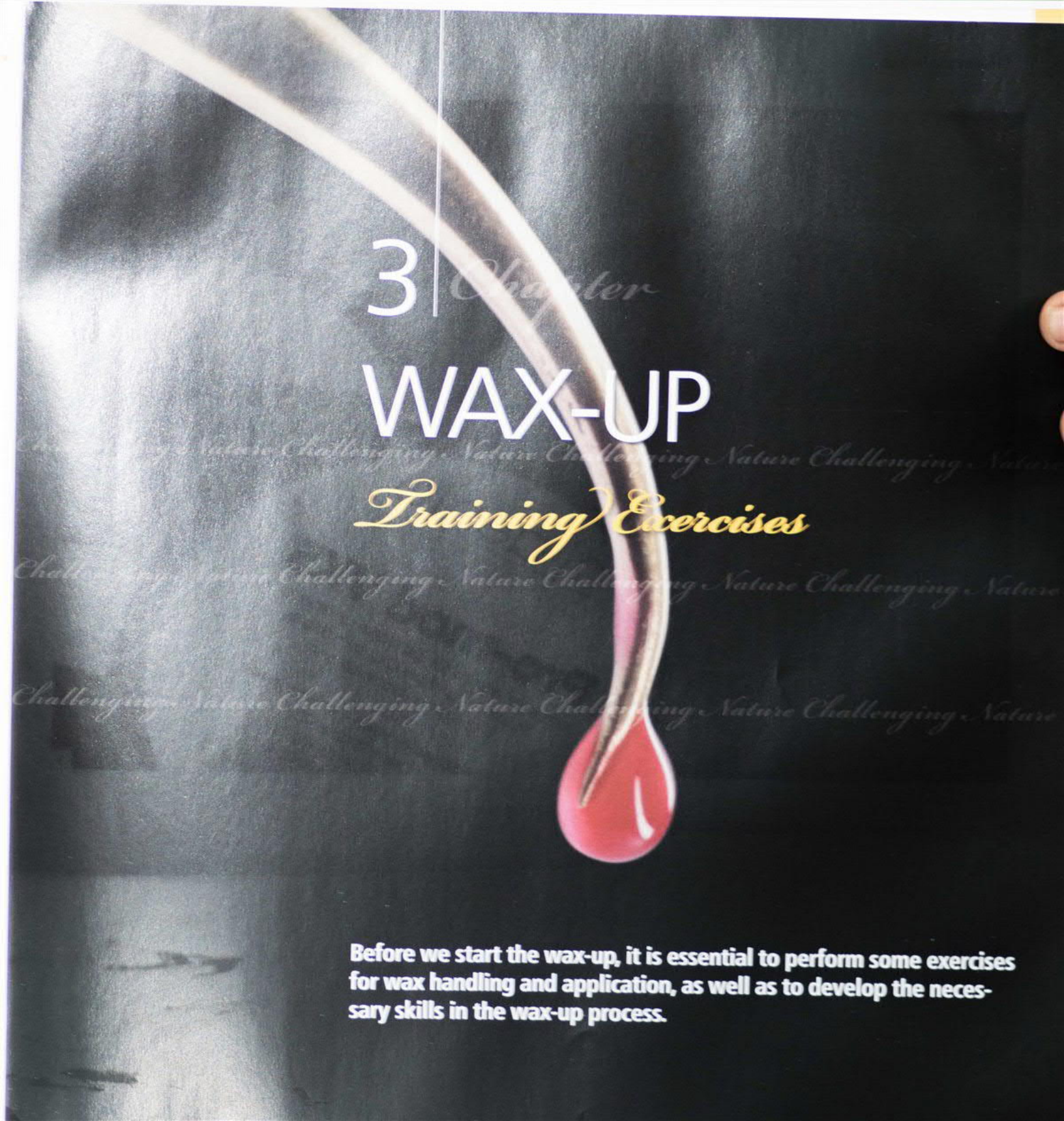
Jordan RE, Abrams L, Kraus BS. Kraus' Dental Anatomy and Occlusion, ed 2. St Louis: Mosby, 1992.
Picosse M. Anatomia dentária, ed 4. São Paulo: Sarvier, 1983.



3 Chapter

WAX-UP

Training Excercises

Before we start the wax-up, it is essential to perform some exercises for wax handling and application, as well as to develop the necessary skills in the wax-up process.

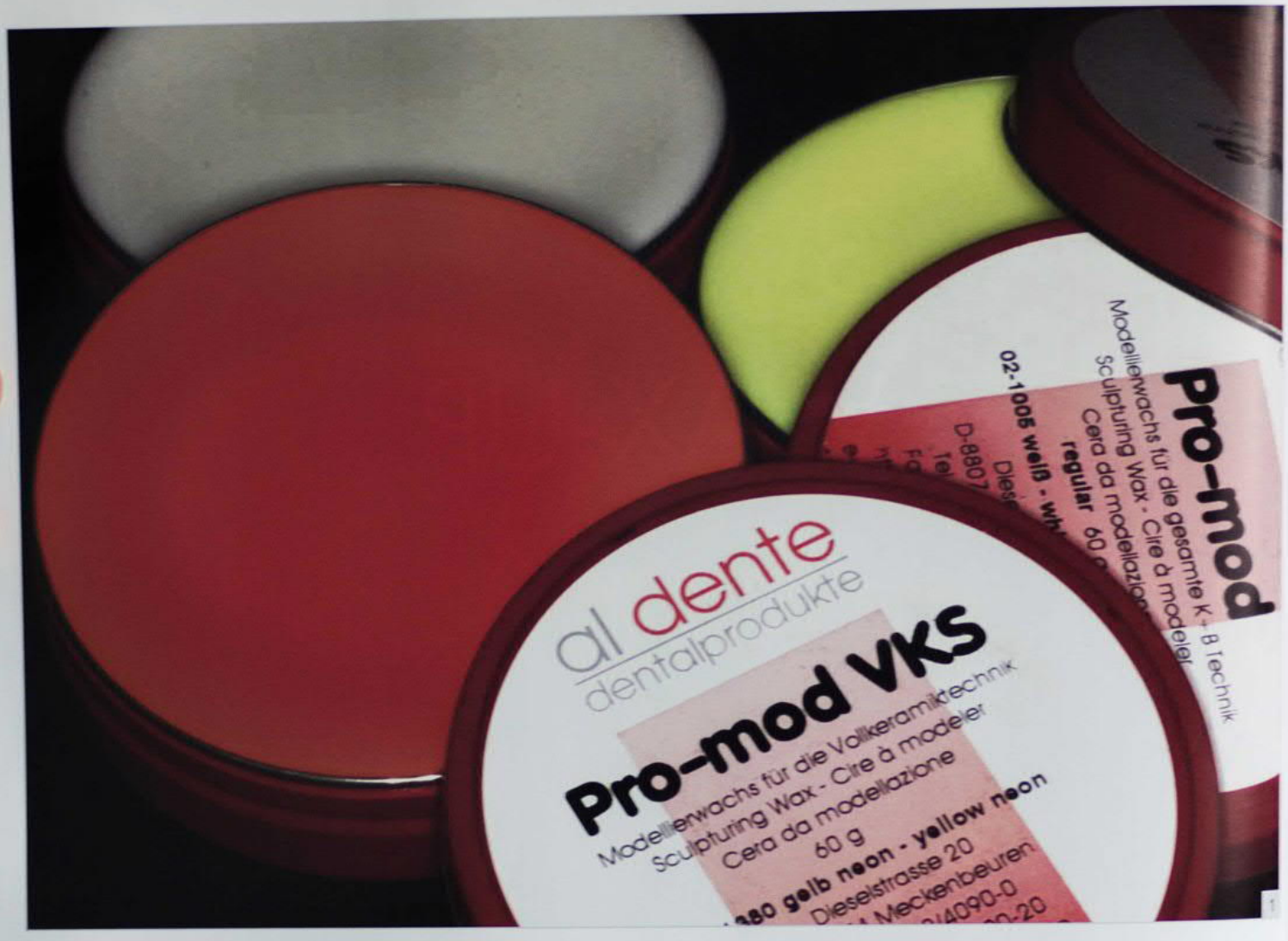


Fig 3-1 Sculpting wax (Pro-Mod VKS, Al Dente Dentalprodukte).

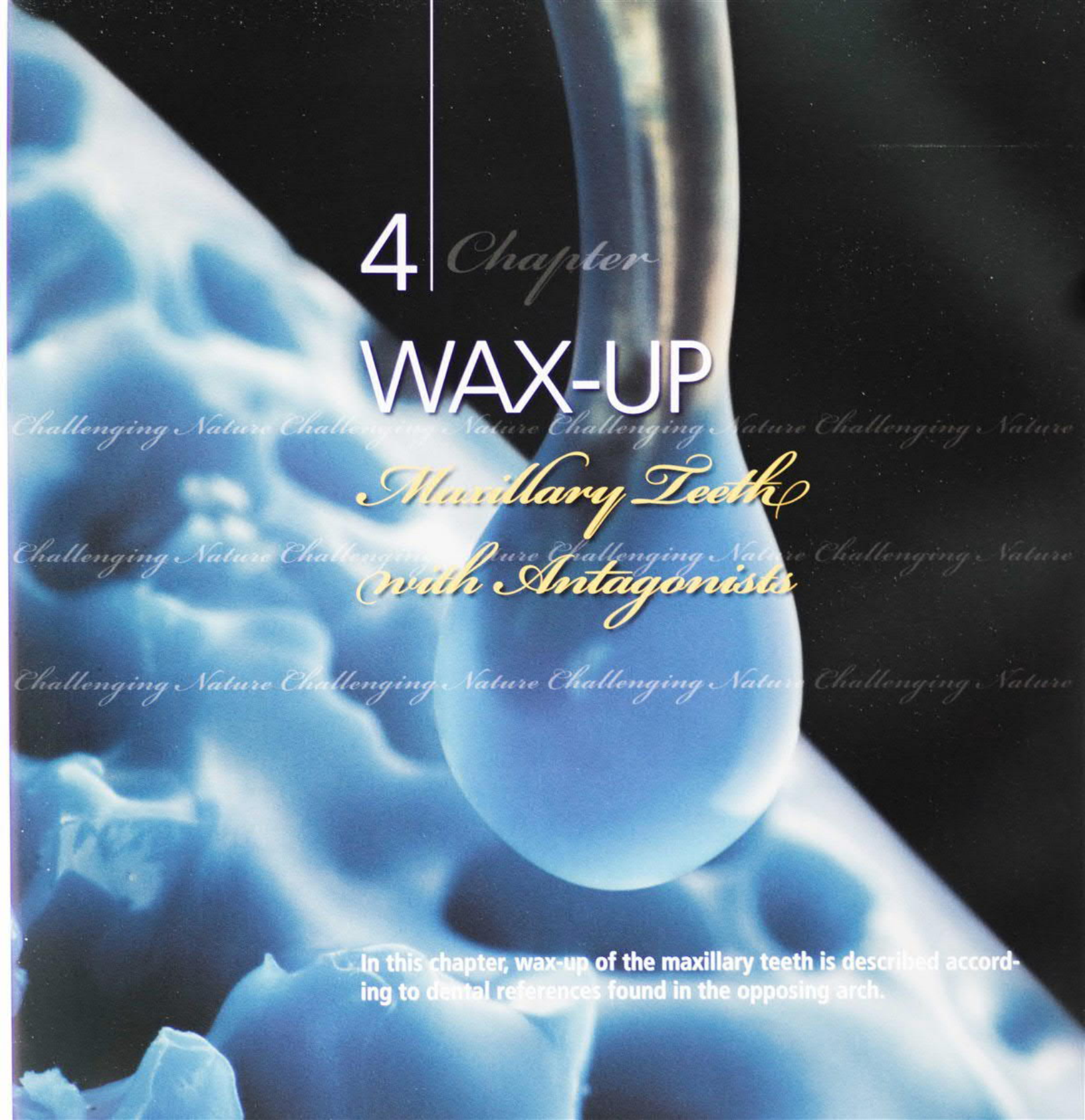
Fig 3-2 Armamentarium (carving instruments and adding instruments) used in the wax-up process.

Fig 3-3 Device used for wax application. This apparatus has three types of adding instruments to help in the sculpting process. The viscosity of the melted wax is controlled by a thermostat.

Fig 3-4 Molten wax for the sculpting process. The temperature can be set to provide the ideal viscosity. The wax must not be too fluid; otherwise, it will flow off the instrument. In that case, the temperature must be reduced.

Fig 3-5 Ideal consistency of melted wax for sculpting.

Figs 3-6a to 3-6d The sculpting exercises are fundamental to familiarize oneself with wax handling and use of the instruments and should be done under a paper sheet. Training exercises include several shapes, such as drops *(a)*, lines *(b)*, almond shapes *(c)*, and the letter J *(d)*. It is important to repeat each one at least 10 times, keeping the same size, to develop skill and precision.



4 Chapter

WAX-UP

Maxillary Teeth with Antagonists

In this chapter, wax-up of the maxillary teeth is described according to dental references found in the opposing arch.

Fig 4-1 Stone casts are mounted in a semiadjustable articulator to accurately reproduce the anatomical characteristics. First, the maxillary cast can be arbitrarily positioned with the aid of the Camper plane. Next, the mandibular stone cast should be articulated in centric occlusion with its antagonist. Values for the Bennett angle and condylar guidance should be set at 15 and 30 degrees, respectively. Note that in the maxillary cast, the posterior teeth have been prepared to receive the wax-up.

Fig 4-2 Lateral view of the articulated casts, ready for wax-up of the posterior teeth.

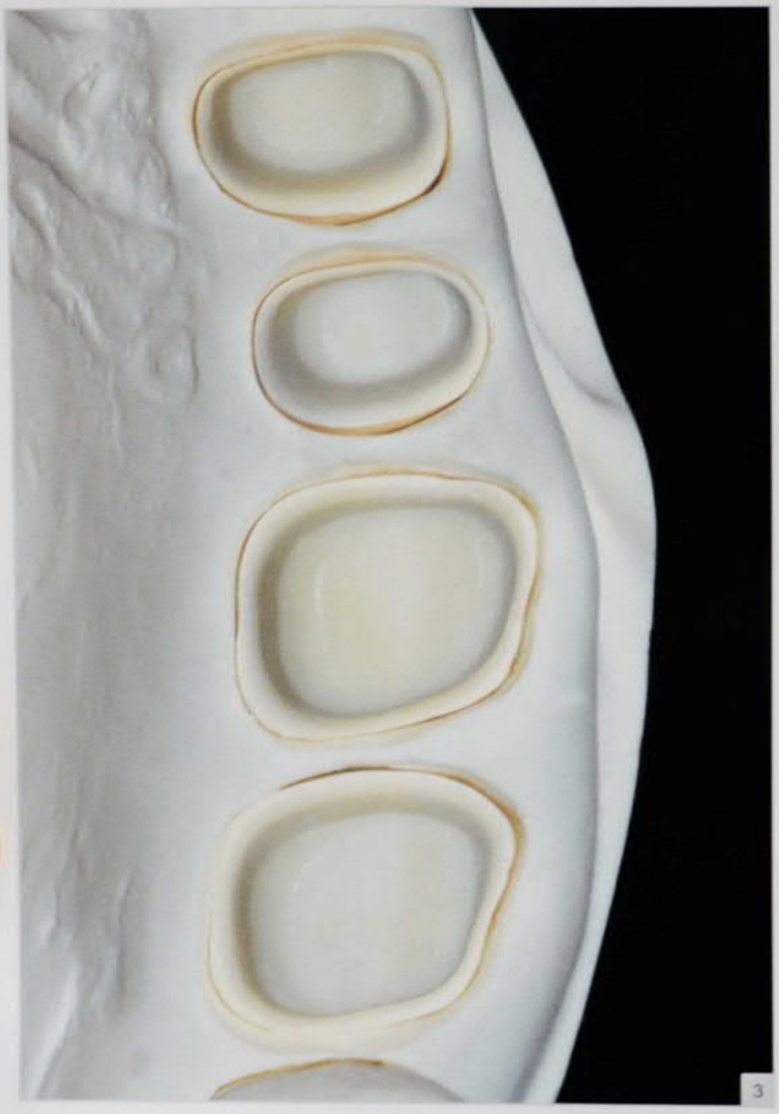


Fig 4-3 Occlusal view of the maxillary teeth prepared for wax-up.

Fig 4-4 Stone die representing the maxillary left first molar. Making dies of the teeth to be waxed up facilitates handling and finishing in the sculpting process.

Fig 4-5 Die lubricant should be applied to the coronal portion to facilitate wax pattern removal.

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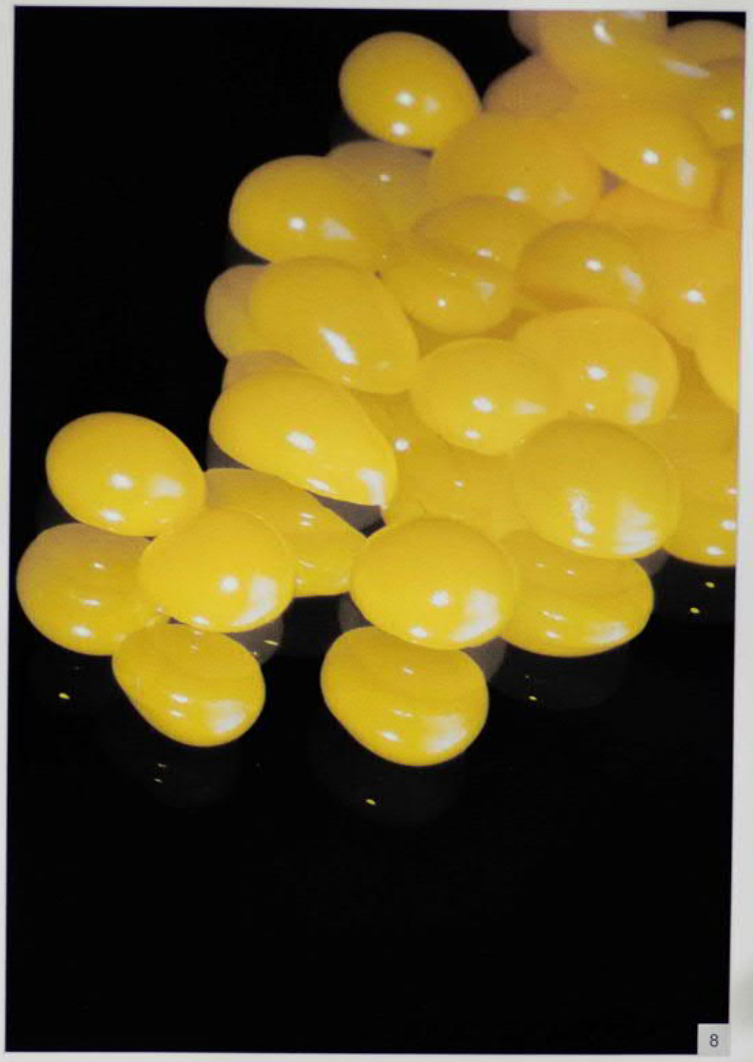

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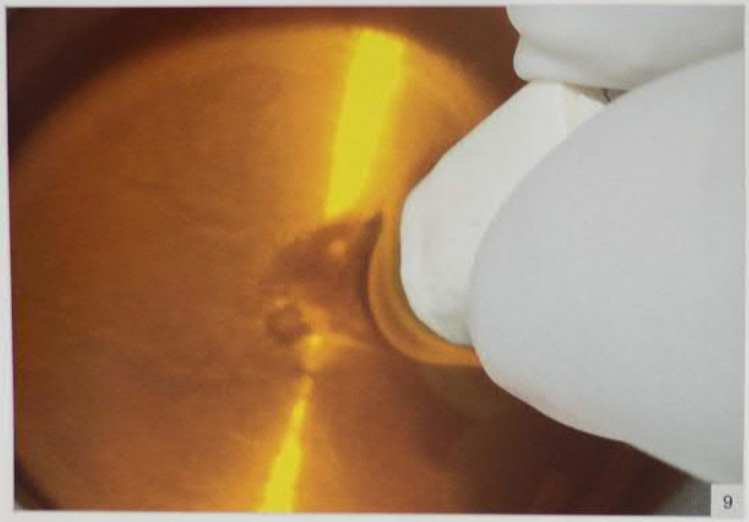
Fig 4-6 Wax-dipping pot (Hotty, Renfert)—an interesting device in the sculpting process.

Fig 4-7 The lubricated die is dipped into the melted wax to obtain a wax coping.

Fig 4-8 Yellow dipping wax (Duro Dip, al dente Dentalprodukte GmbH, Germany) to be melted in the electric dipping pot.



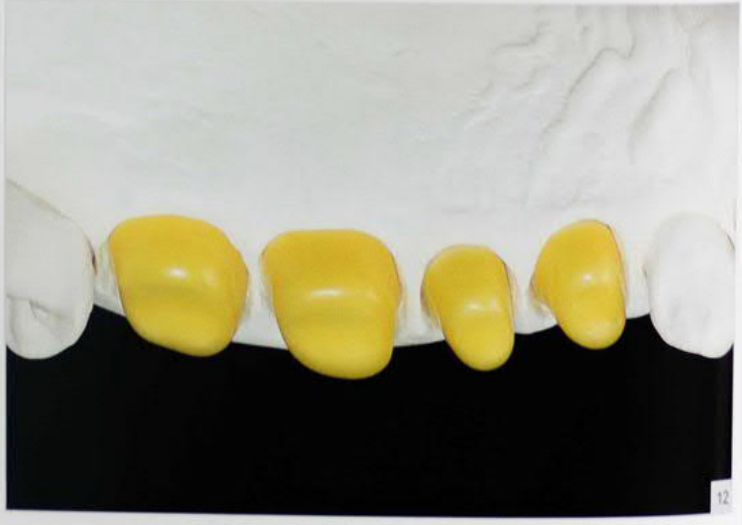


Fig 4-9 The coronal portion of the die should be covered with a uniform, smooth layer of wax. Copings can be obtained by dipping their coronal part of the dies into the melted wax, at temperatures between 89°C and 91°C, according to manufacturer recommendations. The die should be immersed quickly but removed slowly to achieve the proper thickness of 0.5 mm, which maintains adequate interocclusal space between the articulated casts.

Fig 4-10 Any excess wax at the coronal portion of the dies should be trimmed with a carving instrument to improve adaptation. Due to the plastic consistency of the wax, there is no risk of deformation, so the wax can be easily removed from the dies.

Fig 4-11 Occlusal view of the dies of the maxillary teeth with their wax copings.

Fig 4-12 Palatal view of the dies of the maxillary teeth with their wax copings.

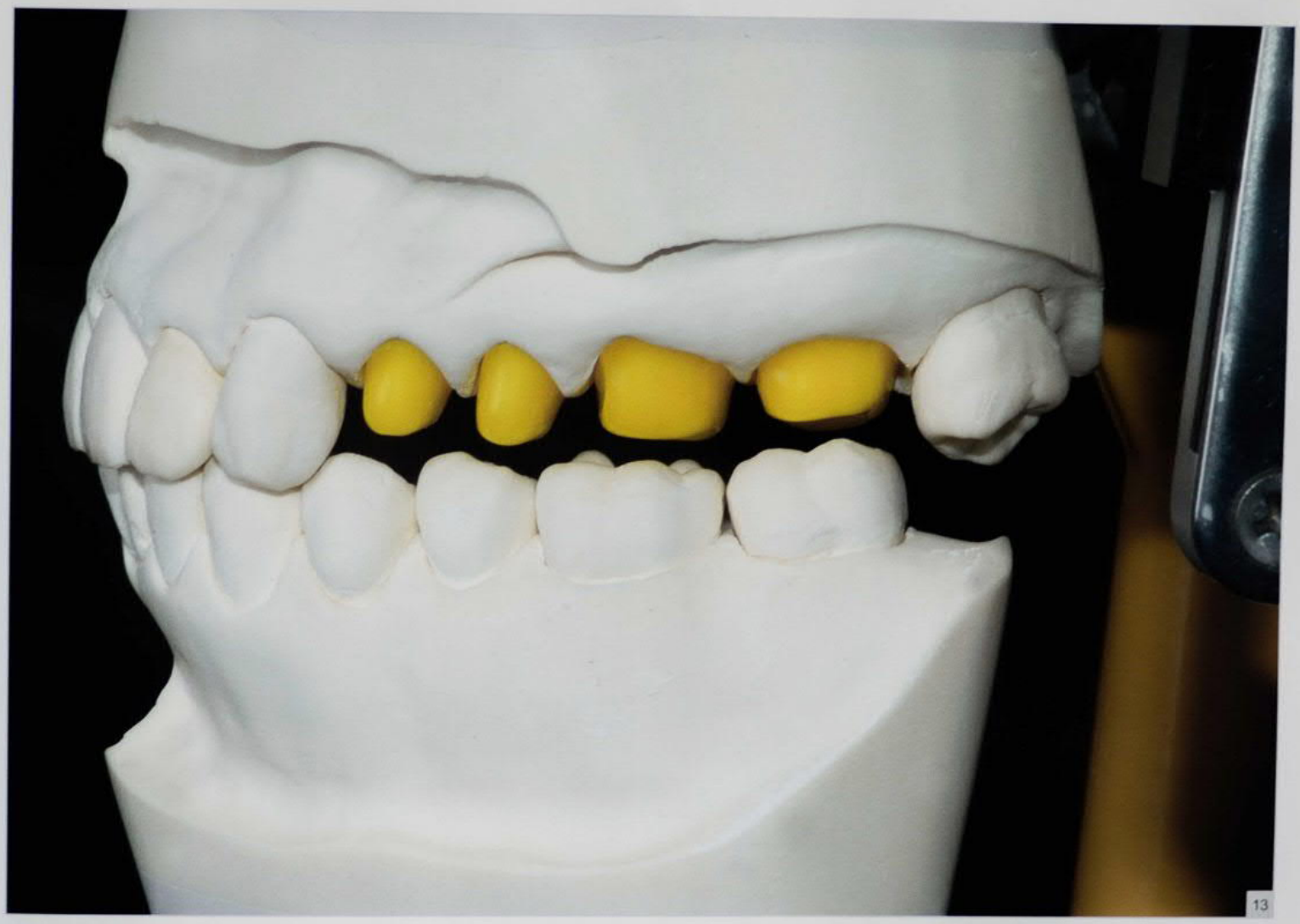


Fig 4-13 The articulated casts with wax copings. It is important to verify tooth position in order to avoid errors during the wax-up process.

Buccal Surface

Fig 4-14 The wax-up process should start at the buccal surface, due to the references provided by the opposing surfaces and the esthetic smile line determined by the anterior teeth. In this figure, the wax is applied with a warmed instrument in the region of the buccal cusp of the maxillary first premolar. Observe that the maxillary cast must be inverted for proper wax application.

Fig 4-15 The first step in the sculpting of the buccal surface is to construct a wax guiding cone determined by the following parameters: the mesiodistal direction, the buccopalatal position, and the height of the cusp tip. The mesiodistal direction of the buccal wax cones depends on which tooth is being sculpted; in the maxillary first premolar, the wax cone should be located between the mandibular first and second premolars, slightly inclined toward the mesial. However, the buccopalatal position and the height of the wax cones have the same orientation for all maxillary teeth; in the buccopalatal direction, the tip of the cone should be shifted 1 mm toward the palatal. The height of the cone depends on the anatomical characteristics of each tooth, on the established maxillomandibular relationships, on the mandibular movements, and on the individual esthetics of each patient, this last being the most important factor. According to esthetic principles, the height of the wax cone should follow the anterior teeth, in accordance with the smile line. When there is group function, this reference is associated

Buccal Surface

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with lateral translation, such that the mandibular cusps come into contact with the maxillary cones, determining their height.

Fig 4-16 Next, the longitudinal slopes must be applied to establish the width of the occlusal third of the buccal surface. The mesial slope runs from the cone tip to the buccal cusp tip of the mandibular first premolar, and the distal slope should extend from the cone tip to the buccal cusp tip of the mandibular second premolar.

Fig 4-17 A small amount of wax is added to fill the contours of the buccal surface, which in this stage should have an ovoid shape, without angles on the mesial and distal aspects and with a protuberant bulge, similar to that found in the canine. The central lobe should be prominent and separated from the small lateral lobes by the developmental grooves. The mesial groove is more accentuated, making this segment more inclined toward the palatal and highlighting the mesial lobe. Remember: adjacent buccal surfaces should never touch each other in order to leave enough room for the wax-up of the marginal ridges.

Fig 4-18 From a frontal view, the occlusocervical inclination of the buccal surface can be analyzed. In the maxillary first premolar, it should be similar to that of the canine, when these teeth are compared side by side. When the wax-up of the buccal surface is finished, there should be a distance of 3.0 to 3.8 mm from the cusp tip to the buccal surface of the mandibular teeth, which corresponds to half the length of the occlusal surface, varying with the height of the opposing tooth. This parameter should be reproduced in all maxillary teeth. In addition, mandibular movements should be performed in the articulator to ensure that no contacts are seen due to the clearance provided by the canine-protected articulation.

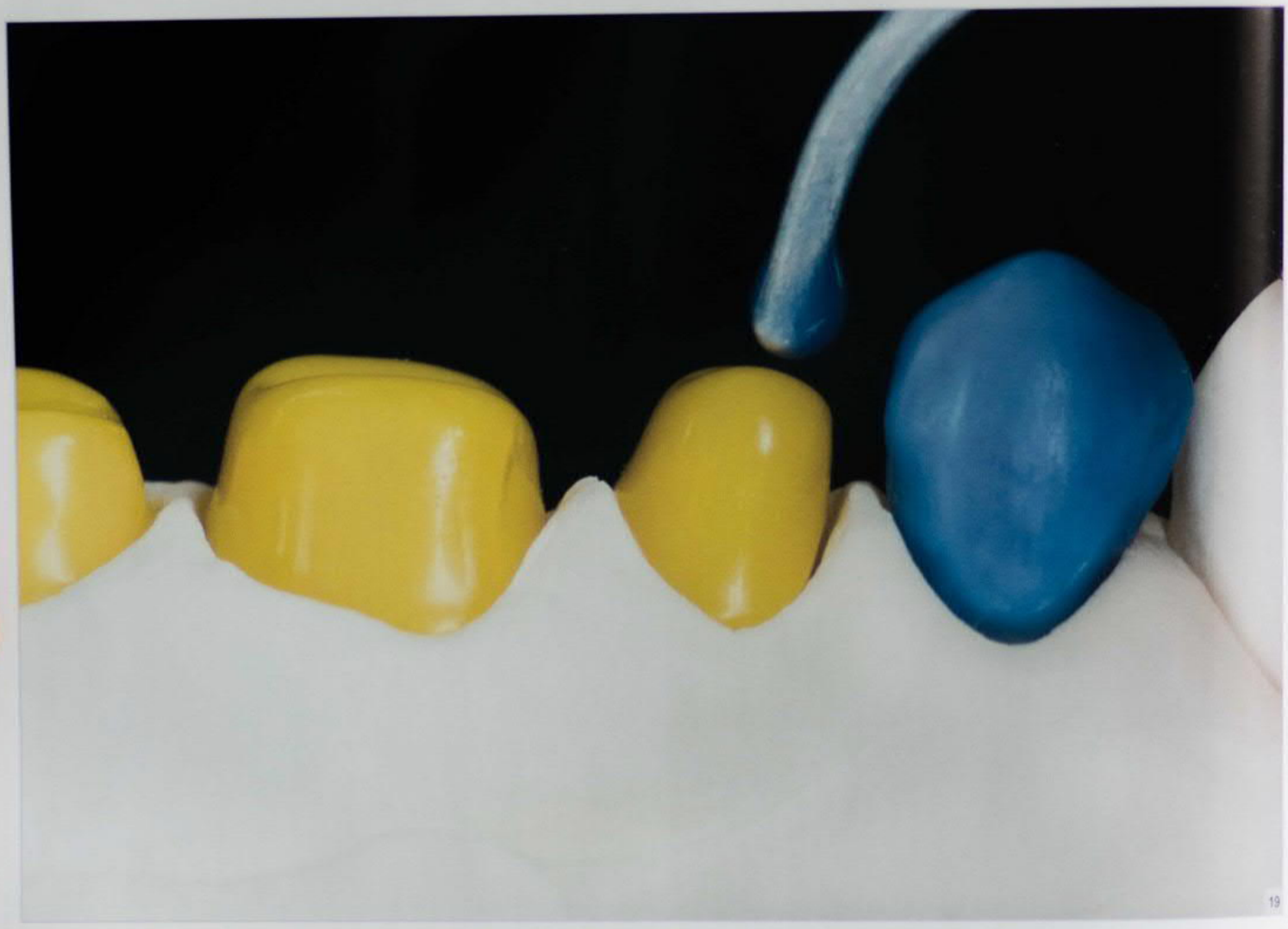


Fig 4-19 Molten wax is applied to the region of the buccal cusp of the maxillary second premolar in order to position the wax cone.

Fig 4-20 The buccal cone should be positioned between the mandibular second premolar and first molar, slightly inclined toward the mesial and shifted about 1 mm toward the palatal. The cone height should be determined by the anterior teeth, in accordance with the smile line.

Fig 4-21 The mesial longitudinal slope should extend from the cone tip to near the buccal cusp tip of the mandibular second premolar, and the distal longitudinal slope should extend from the cone tip to near the mesiobuccal cusp tip of the mandibular first molar.

Fig 4-22 The buccal surface of the maxillary second premolar is finished with an ovoid shape. Two developmental grooves (mesial and distal) should be reproduced up to the slopes, creating a sinusoidal configuration. These grooves give rise to three lobes, mesial, central, and distal, which are more evident than those in the maxillary first premolar. Another distinctive characteristic is a cervical bulge that is narrower than that of the first premolar.

Fig 4-23 Frontal view of the buccal surface. The occlusocervical inclination of the second premolar is similar to that of the first premolar.

Fig 4-24 The wax cone of the mesiobuccal cusp of the maxillary first molar is slightly inclined toward the mesial, and the cusp tip is pointed toward the mesiobuccal groove of the mandibular first molar. The cone height follows the smile line; however, it should be slightly apical in relation to the maxillary second premolar because of the distal inclination of this tooth in the arch.

Fig 4-25 Next, the distobuccal cone is constructed; its tip should project toward the distobuccal groove of the mandibular first molar, and its height should be greater than that of the mesiobuccal cone in accordance with the esthetic smile line. In the maxillary first molar, the cones follow the same buccopalatal position described for the premolars; the cervical portion of this tooth tends toward the buccal aspect due to the widening of the maxillary arch.

Fig 4-26 The longitudinal slopes must be done individually on each cusp. On the mesiobuccal cusp, the mesial slope runs from the cone to the region of the mesiobuccal cusp tip of the mandibular first molar and the distal slope from the cone to the neighborhood of the midbuccal cusp tip of the mandibular first molar. On the distobuccal cusp, the mesial ridge extends from the cone to the neighborhood of the midbuccal cusp tip of the mandibular first molar and the distal slope to the mesial outline of the buccal surface of the mandibular second molar.

Fig 4-27 The finished buccal surface presents a trapezoidal shape. In the molars, the mesial and distal segments must be done separately. The mesial segment should be bigger and more steeply inclined, with a protuberance on the central lobe similar to that on the maxillary second premolar and a distal lobe slightly toward the palatal, creating the optical illusion that the distobuccal cusp points toward the buccal. The details on the distal segment are more subtle. The segments are separated by the occlusobuccal groove, pointing toward the midbuccal cusp tip of the mandibular first molar. Other features should be reproduced according to morphologic description in chapter 2.

Fig 4-28 Frontal view of the buccal surface. Note that the cervico-occlusal inclination of the mesial segment of the first molar is similar to that of the second premolar when the teeth are compared side by side.

Fig 4-29 The mesiobuccal cone of the maxillary second molar has been formed. The cone tip points toward the buccal groove of the mandibular second molar, slightly inclined mesially; its height must follow the esthetic smile line. The bucco-palatal position is determined the same way as that of the other teeth.

Fig 4-30 Distobuccal cone with its tip directed toward the region between the distobuccal cusp tip and the distal aspect of the buccal surface of the mandibular second molar. The height of this cone is lower than that of the mesial cone.

Fig 4-31 On the mesiobuccal cusp, the mesial longitudinal slope extends from the cone to the region of the mesial aspect of the buccal surface of the mandibular second molar, and the distal slope extends from the cone to the distobuccal cusp tip of the mandibular second molar. On the distobuccal cusp, the mesial slope runs from the cone to the distobuccal cusp tip of the mandibular second molar, and the distal slope from the cone to the distal outline of the buccal surface of the mandibular second molar.

Fig 4-32 The finished buccal surface has a trapezoidal shape with features similar to those of the first molar, although with reduced dimensions and less accentuated grooves.

Fig 4-33 Frontal view of the buccal surface profile. Note that the cervico-occlusal inclination of the second molar is similar to that of the mesial segment in the first molar in a side-by-side analysis.

Fig 4-34 View of completed buccal surfaces. Observe the anatomical characteristics and the anteroposterior curvature. The occlusal outlines of the premolars have a V shape, whereas the occlusal outlines of the molars form a W configuration. Other important details of the buccal surfaces should be reproduced according to the morphologic description in chapter 2.

Fig 4-35 Palatal view showing the relationship between the buccal surfaces and the antagonist teeth. As discussed earlier, a distance of 3.0 to 3.8 mm must be verified from the buccal cusp tip to the buccal surface of the mandibular teeth, which corresponds to half the distance of the occlusal table, according to the size of the opposing teeth. The cusp tips must not make contact either in centric occlusion or during mandibular excursions.

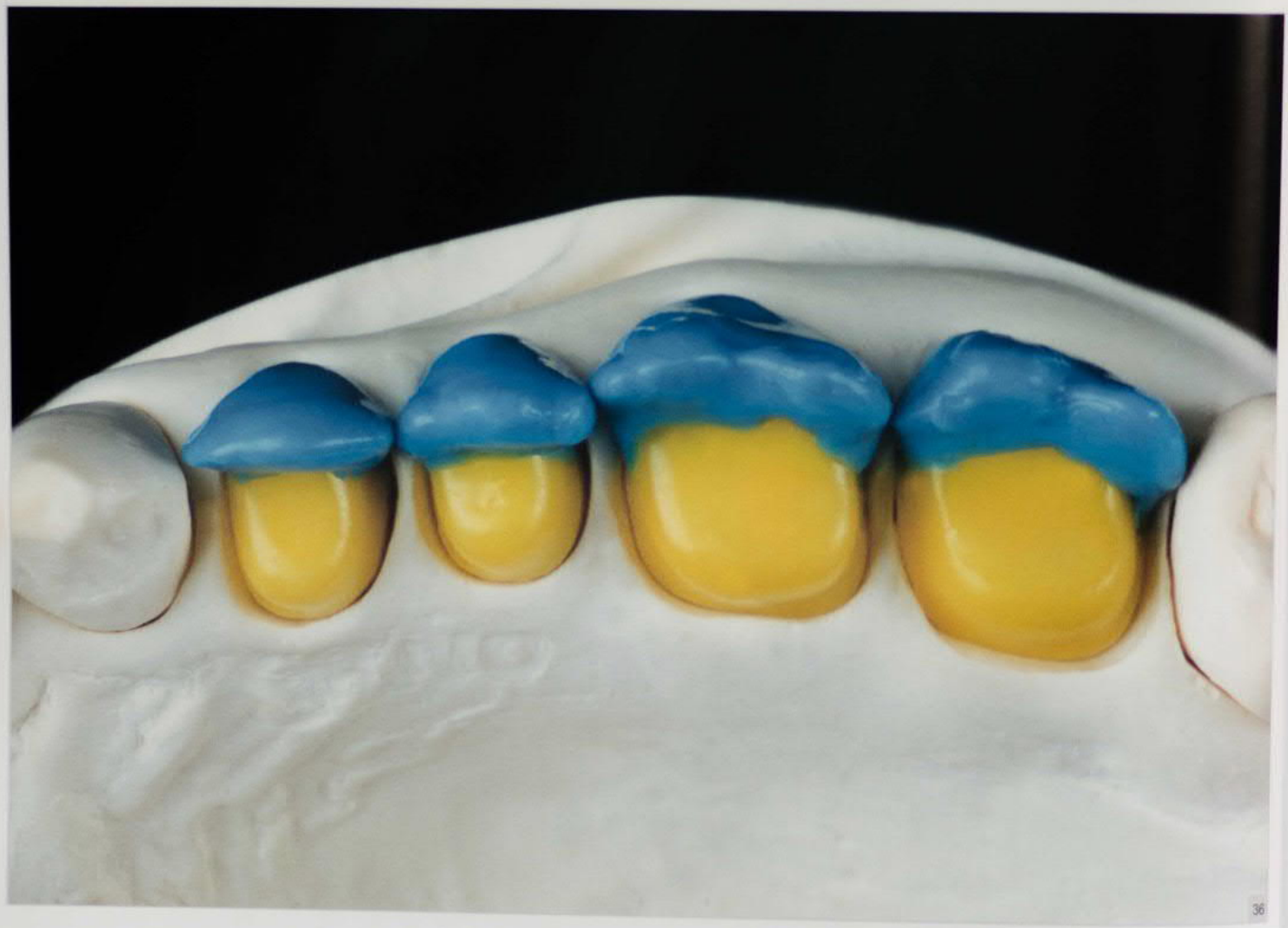


Fig 4-36 Occlusal view of the buccal surfaces. Observe that the longitudinal slopes determine the occlusobuccal reference line of the maxillary posterior teeth. In addition, the distal longitudinal slopes of the distobuccal cusps should be slightly inclined toward the palatal.

Palatal Surface

Fig 4-37 Now the palatal surfaces are constructed, using the antagonist teeth and the mandibular movements as references. The palatal cone is fabricated on the maxillary first premolar.

Fig 4-38 The tip of this cone is pointed toward the central fossa of the mandibular first premolar, although it remains 1.5 mm away from it, which determines its height. All mandibular movements must be performed to avoid contact.

Fig 4-39 The finished palatal surface has an ovoid shape with dimensions narrower than those of the buccal surface and a uniform convexity in the cervicocoronal direction. The cusp tip is strongly inclined toward the mesial to avoid interference during mandibular excursions. There are no lobes or grooves along the palatal surface. Note that a space must be maintained between the maxillary canine and the first premolar.

Fig 4-40 Occlusal relationship with the antagonist teeth. The cervico-occlusal inclination is determined by the positioning of the cusp tip toward the distal fossa pit of the mandibular first premolar, as explained previously.

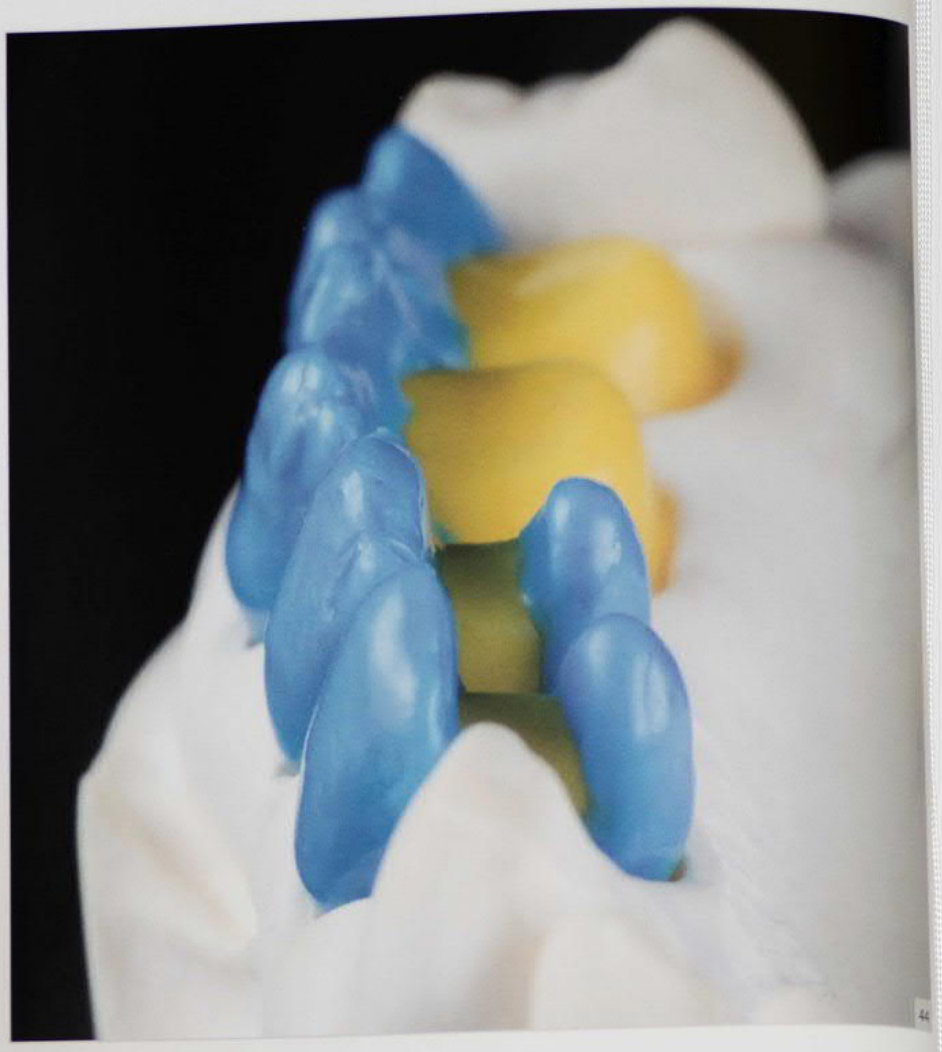


Fig 4-41 The palatal cone of the maxillary second premolar. The cone tip must point toward the distal fossa pit of the mandibular second premolar, without contacting it. The palatal surface must be at same level as the buccal surface.

Fig 4-42 The finished palatal surface has an ovoid shape inclined toward the mesial to avoid interference during mandibular excursions.

Fig 4-43 View of the occlusal relationship between the palatal surface of the maxillary second premolar and the antagonist teeth. During centric occlusion, contacts can be found between the mesial and distal inclines of the palatal surface of the maxillary second premolar and the central lobes of the lingual cusps of the mandibular second premolar. Such contacts are optional and the surfaces involved may be reduced.

Fig 4-44 Profile of the finished palatal cusps in the maxillary second premolars. The distance between the buccal and palatal cusp tips of the first and second premolars is the same. The imaginary lines running along the buccal and palatal cusp tips are parallel.

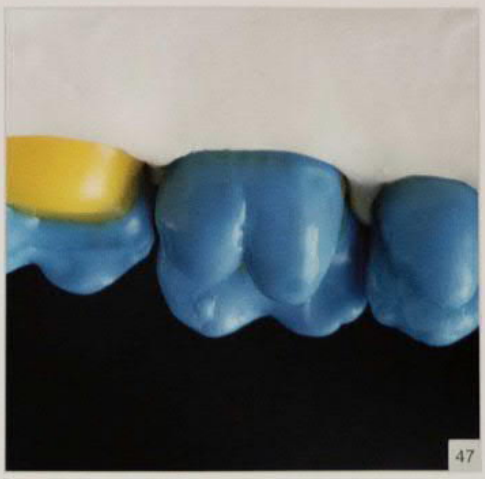


Fig 4-45 Formation of the mesiopalatal cone in the maxillary first molar.

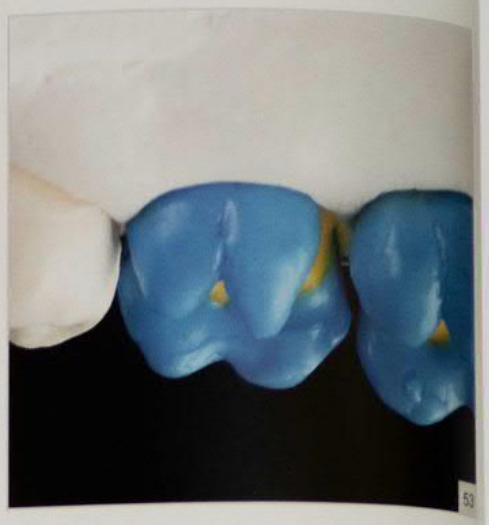
Fig 4-46 The tip of this cone should point toward the central fossa pit of the mandibular first molar. There should be no contact in centric occlusion or during mandibular excursions.

Fig 4-47 The distopalatal cone is constructed.

Fig 4-48 The tip of this cone should point toward the intersection between the distal marginal ridge and the occlusodistolingual groove of the mandibular first molar.

Fig 4-49 The finished palatal surface of the maxillary first molar. The characteristic palatal groove divides the mesial and distal segments and ends gradually at the middle third of this surface. This groove has a slight distal curvature as it reaches the occlusal outline, making the distal segment look smaller.

Fig 4-50 Occlusal relationship between the palatal surface and its antagonist. On the mesial segment, the mesial and distal longitudinal slopes extend from the mesiopalatal cone tip to the region of the mesiolingual cusp tip of the mandibular first molar and to the region of the distolingual cusp tip of the mandibular first molar, respectively. On the distal segment, the mesial and distal slopes extend from the distopalatal cone tip to the region of the distolingual cusp tip of the mandibular first molar and to the mesial outline of the mandibular second molar, respectively.



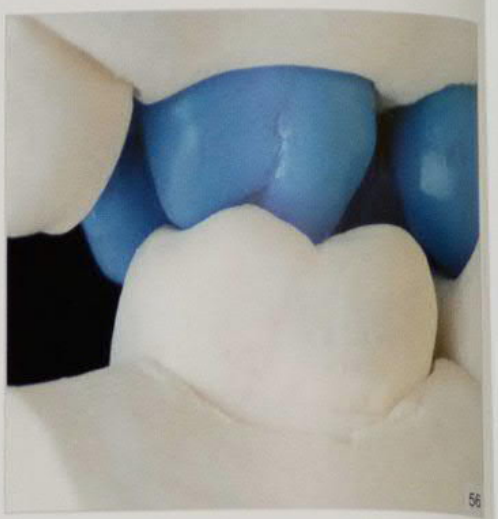


Fig 4-51 Formation of the mesiopalatal cone of the maxillary second molar.

Fig 4-52 Positioning of the distopalatal cone. The mesiopalatal cone tip should be directed toward the central fossa of the mandibular second molar, and the distopalatal cone tip should be directed toward the intersection between the distal marginal ridge and the occlusodistolingual groove of the mandibular second molar. There should be no contacts here during mandibular movements. The buccolingual distance between the palatal cone and the antagonist cusp tips is half the buccolingual dimension of the occlusal table, ranging from 3 to 3.8 mm. However, the distopalatal cone must be 0.5 mm closer to the buccal aspect than the mesiopalatal cone.

Fig 4-53 Completed mesial segment of the palatal surface.

Fig 4-54 The length of the mesial segment is determined by the positioning of the longitudinal slopes. From the cone, the mesial slope must extend from the cone to the region of the mesiolingual cusp tip of the mandibular second molar, the distal slope from the tip of the cone to the region of the distolingual cusp tip of the same tooth.

Fig 4-55 Completion of the distal segment finishes the palatal surface. Observe that the mesial and distal segments are separated by a palatal groove.

Fig 4-56 The size of the distal segment is determined by the positioning of the longitudinal slopes. The mesial slope extends from the cone to the region of the distolingual cusp tip of the mandibular second molar, and the distal slope extends from the cone to the distal outline of the mandibular second molar. There should be no occlusal contacts here during mandibular movements. The palatal aspect of the second molar is similar to that of the first molar, although with reduced dimensions.

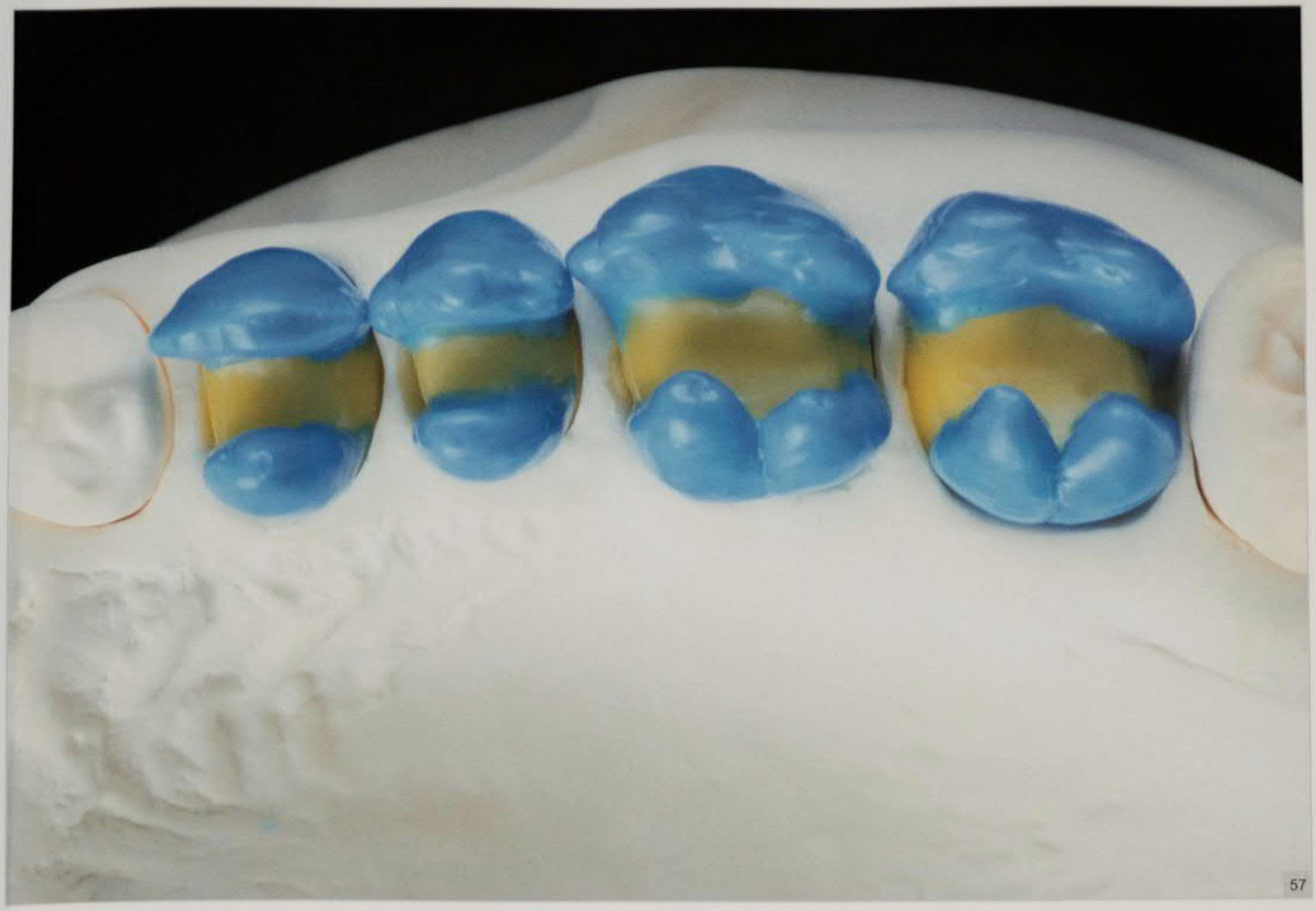
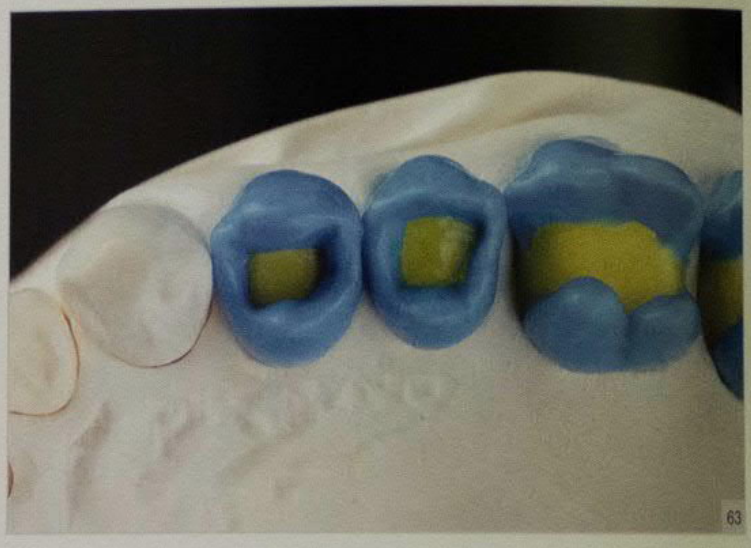


Fig 4-57 Occlusal aspect of the palatal surfaces. The occlusal outline of the premolars presents a V-shaped configuration. A W shape may be visualized in the molars. Adequate space must be maintained between the palatal surfaces for further positioning of the marginal ridges. Other important details should be reproduced according to the morphologic descriptions in chapter 2.

Fig 4-58 Occlusal view of the buccal and palatal surfaces of the maxillary premolars and molars. Observe that the slopes are aligned and a parallelism exists between the anteroposterior occlusobuccal and occlusopalatal reference lines. In addition, there are differences between the tooth sizes.

Figs 4-59a and 4-59b Next, a carving instrument is used to reshape the established contours while maintaining the anteroposterior reference line and esthetic smile line. The longitudinal slopes of the buccal surfaces must be well defined.



Marginal Ridges

Fig 4-60 Development of the marginal ridges. The wax-up of the mesial marginal ridge of the maxillary first premolar is performed; the proximal contact area occurs at the incisal third of the canines. The mesial ridge remains lower than the distal ridge and is interrupted by a marginal groove. Its height is determined by contact with the buccal cusp tip or the distal longitudinal slope of the mandibular first premolar. Both contact patterns are correct, the contacts being slightly displaced toward the buccal.

Fig 4-61 Distal marginal ridge of the maxillary first premolar. This ridge is more rounded because of the mesial placement of the palatal cusp tip. Its height is determined by its contact with the mesial longitudinal slope of the buccal cusp of the mandibular second premolar. It can also be crossed by a marginal groove.

Fig 4-62 Fabrication of the mesial marginal ridge of the maxillary second premolar. Its height is determined by its contact with the distal longitudinal slope of the buccal cusp of the mandibular second premolar. The proximal contact area with the first premolar is displaced buccally because of the reduced dimensions of the palatal aspect.

Fig 4-63 Distal marginal ridge of the maxillary second premolar. Its height is determined by its contact with the mesial longitudinal slope of the mesiobuccal cusp of the mandibular first molar.

Fig 4-64 Fabrication of the mesial marginal ridge of the maxillary first molar. Its proximal contact area with the second premolar remains toward the buccal aspect because of the reduced dimensions of the palatal aspect. Its height is determined by its contact with the distal longitudinal slope of the mesiobuccal cusp of the mandibular first molar.

Fig 4-65 The distal marginal ridge of the maxillary first molar, less accentuated than the mesial marginal ridge. The contact occurs between this ridge and the mesial longitudinal slope of the mesiobuccal cusp of the mandibular second molar. Both marginal ridges are almost flat and interrupted by a marginal groove.

Fig 4-66 Construction of the mesial marginal ridge of the maxillary second molar. Its height is determined by the contact occurring at the distal longitudinal slope of the mesiobuccal cusp of the mandibular second molar.

Fig 4-67 Construction of the distal marginal ridge of the maxillary second molar. There is no occlusal contact with the antagonist, unless the third molar is present. In this case, the contact occurs between this ridge and the mesial longitudinal slope of the mesiobuccal cusp of the mandibular third molar.

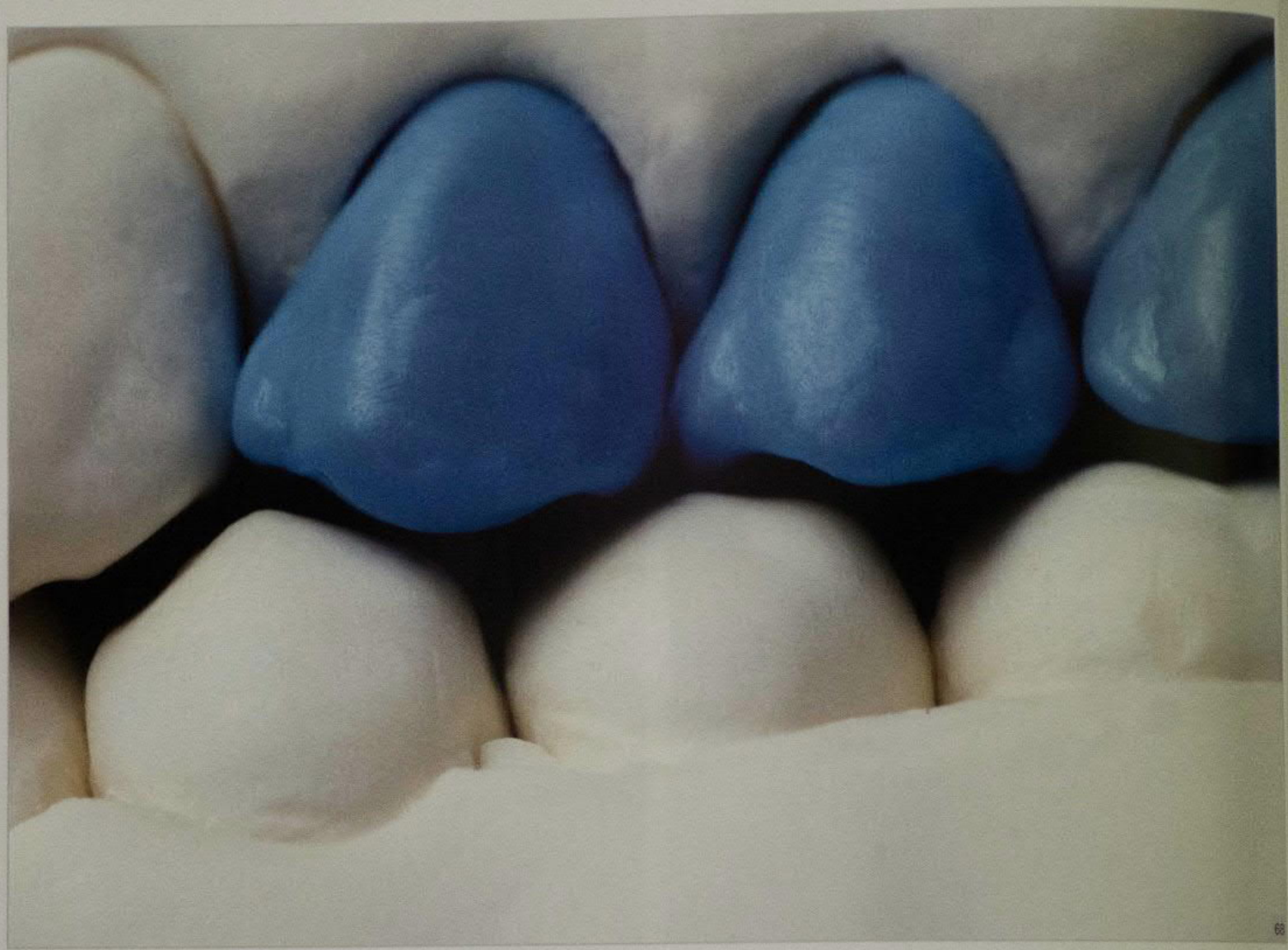


Fig 4-68 Contact relationships between the marginal ridges of the maxillary premolars and their antagonists:

- The mesial marginal ridge of the maxillary first premolar and the tip or the distal longitudinal slope of the buccal cusp of the mandibular first premolar
- The distal marginal ridge of the maxillary first premolar and the mesial longitudinal slope of the buccal cusp of the mandibular second premolar
- The mesial marginal ridge of the maxillary second premolar and the distal longitudinal slope of the buccal cusp of the mandibular second premolar
- The distal marginal ridge of the maxillary second premolar and the mesial longitudinal slope of the mesiobuccal cusp of the mandibular first molar

Fig 4-69 The contact relationships between the marginal ridges of the maxillary molars and their antagonists:

- The mesial marginal ridge of the maxillary first molar and the distal longitudinal slope of the mesiobuccal cusp of the mandibular first molar
- The distal marginal ridge of the maxillary first molar and the mesial longitudinal slope of the mesiobuccal cusp of the mandibular second molar
- The mesial marginal ridge of the maxillary second molar and the tip or distal longitudinal slope of the mesiobuccal cusp of the mandibular second molar
- The distal marginal ridge of the maxillary second molar and the mesial longitudinal slope of the mesiobuccal cusp of the mandibular third molar

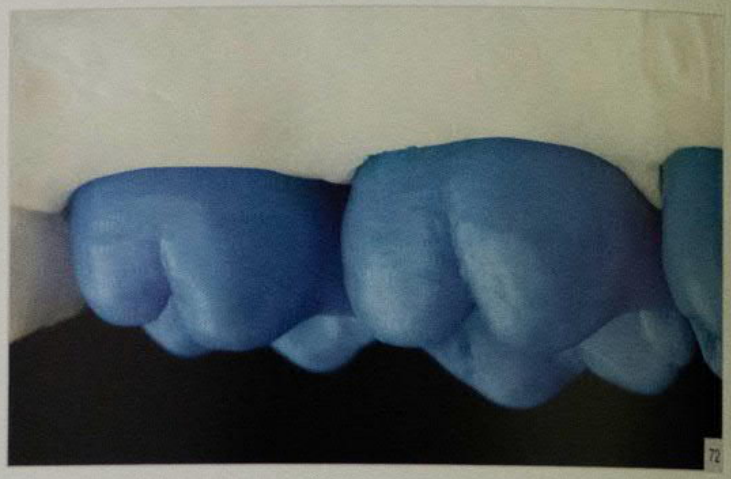
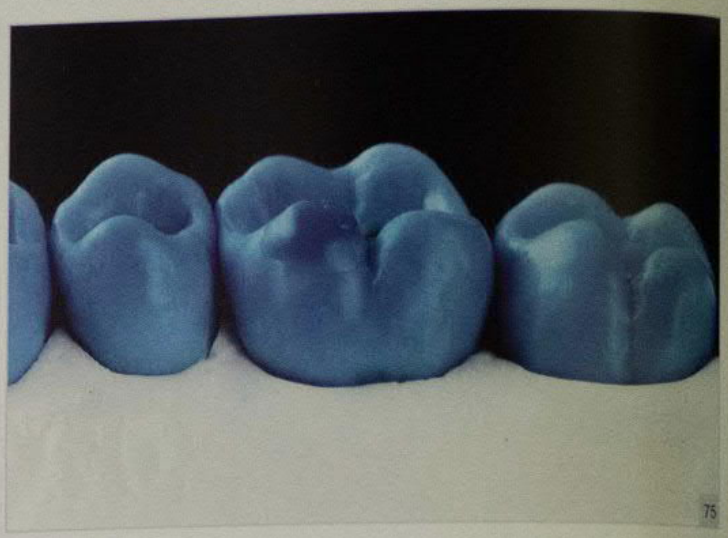


Fig 4-70 Buccal aspect after the fabrication of the marginal ridges. Note that the diastemata are closed and the proximal contacts are established. The next step is to refine the wax-up with carving instruments to highlight the sinusoidal contours, lobes, bulges, and most important, surface texturing with creation of perikymata and horizontal developmental grooves, providing a variety of anatomical details (see chapter 2).

Fig 4-71 The palatal aspect of the maxillary premolars after wax-up refinement.

Fig 4-72 The palatal aspect of the maxillary molars after wax-up refinement.

Fig 4-73 The profile of the premolars and molars after wax-up finishing.



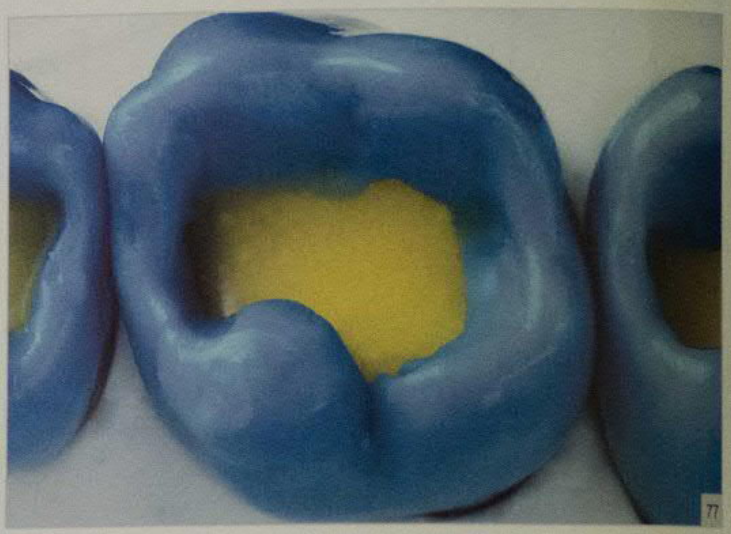


Fig 4-74 Next, the occlusal contacts between the palatal surfaces of the maxillary teeth and their antagonists should be defined. For this, the wax must be heated with an instrument at the contact region, for example, the mesiopalatal cusp of the maxillary first molar.

Fig 4-75 After the wax is softened, the maxillary and mandibular stone casts are articulated.

Fig 4-76 The maxillary model must be placed in occlusion with its antagonist in a precise and firm manner for contact registration. On the mesiopalatal cusp of the maxillary first molar, the mesial incline must make contact with the central lobe of the mesiolingual cusp of the mandibular first molar, whereas the distal incline must make contact with the central lobe of the distolingual cusp of the mandibular first molar.

Fig 4-77 Observe the contacts at the mesial and distal inclines of the mesiopalatal cusp of the maxillary first molar, known as the inner inclines.

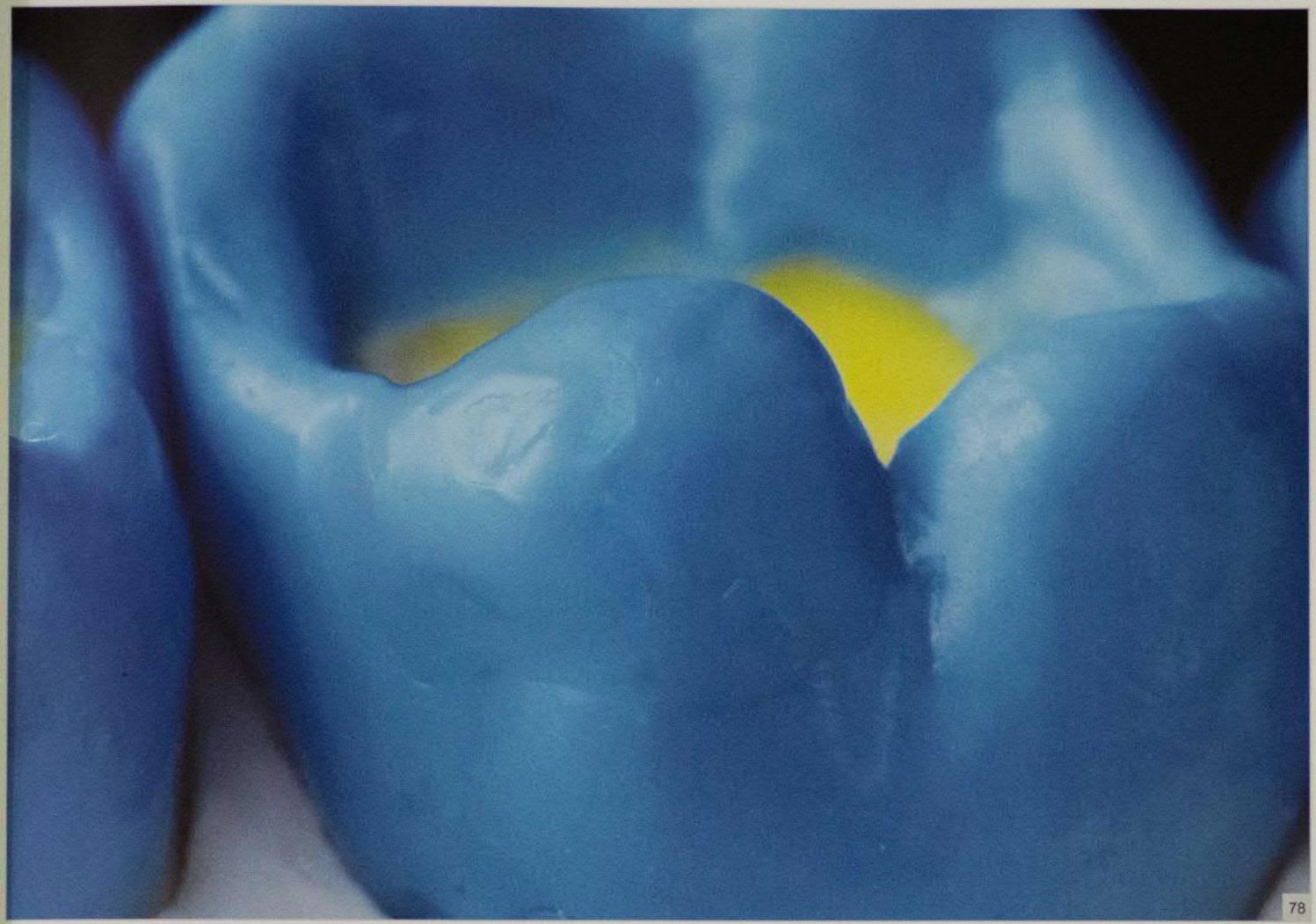
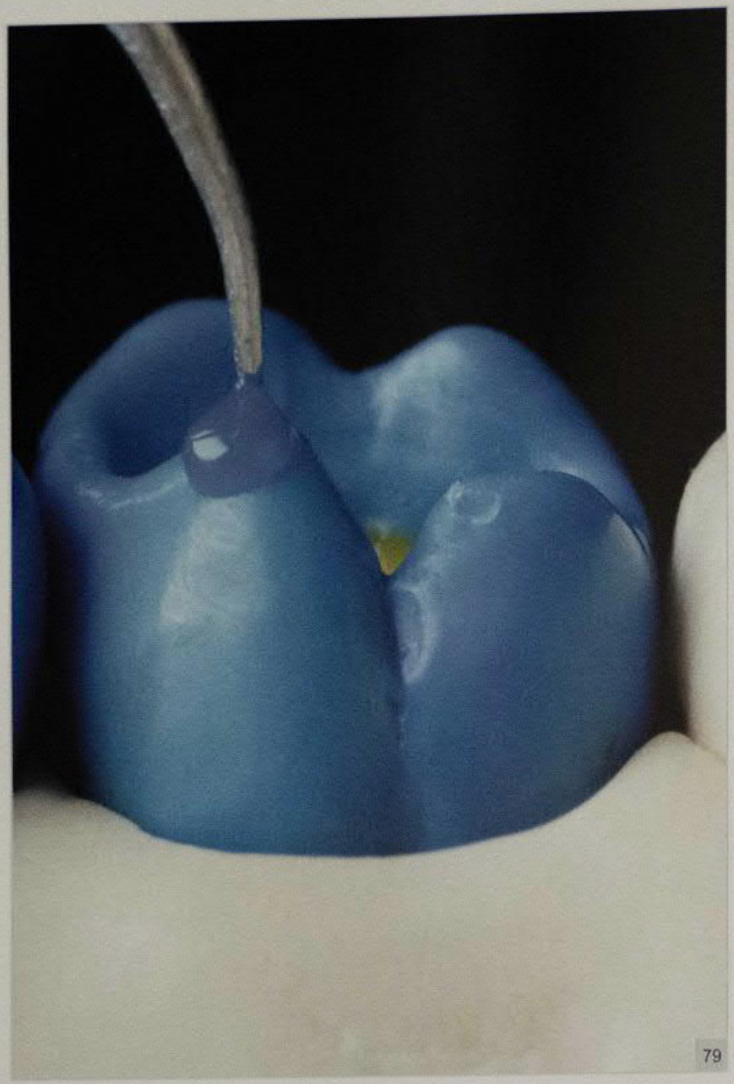


Fig 4-78 Close-up of the contact at the mesiopalatal cusp of the maxillary first molar.



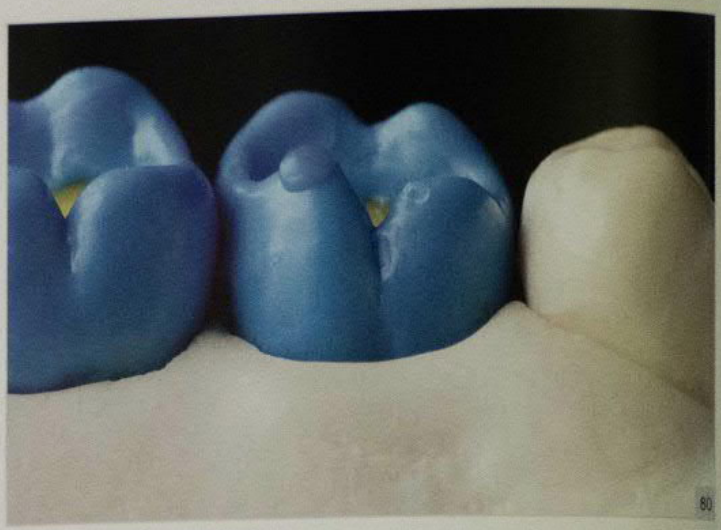


Fig 4-79 Procedures for obtaining contact must be carried out in the maxillary second premolars and molars. These guarantee well-localized functional contacts. On the maxillary second premolar, the contact should occur between the mesial incline of the palatal cusp and the central lobe of the mesiolingual cusp of the mandibular second molar, near the distal fossa pit. Here, one can see the contact refinements on the mesiopalatal cusp of the maxillary second molar, which must be done by wax softening in this region.

Fig 4-80 After softening the wax, it is important to allow the wax surface to become a bit dull, and the stone casts are then articulated.

Fig 4-81 Observe the contacts on the mesial and distal inclines of the mesiopalatal cusp of the maxillary second molar. The mesial incline makes contact with the central lobe of the mesiolingual cusp of the mandibular second molar, whereas the distal incline makes contact with the central lobe of the distolingual surface of the mandibular second molar.

Fig 4-82 Close-up of the contact obtained in the mesiopalatal cusp of the maxillary second molar.

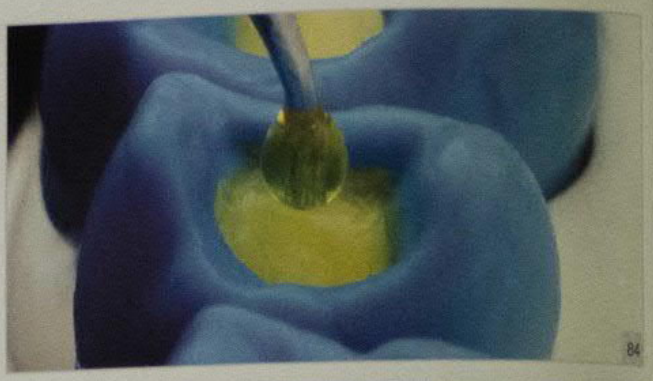


Fig 4-83 Before the occlusal surface is constructed, wax must be applied at the cavity floor to establish the fossa pit and groove depths. A useful hint here is to base the depth of the fossa pit on that of adjacent teeth.

Fig 4-84 Close-up view. The wax is placed on the floor of the maxillary second premolar. Extreme caution is necessary here to avoid compromising the surfaces that are already finished.

Fig 4-85 The occlusal aspect of the posterior teeth after establishing of the cavity floor.

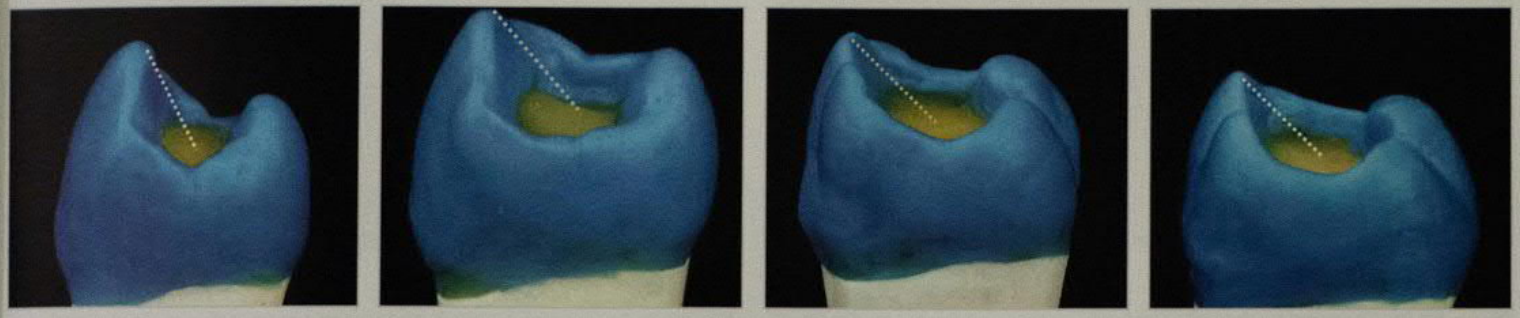
Fig 4-86 It is important to define the longitudinal slopes with a carving instrument in such a way that the occlusal perimeter becomes clearly defined. At this stage, the distances between the buccal and palatal longitudinal slopes of the premolars and molars must be similar, between 6 and 7.6 mm.

OCCLUSAL SURFACE

Groove depth
The distance from the cusp tip to the fossa pit

Table 4-1 Before starting the wax-up of the occlusal surfaces, the cavity floor of the premolars and molars must be constructed by the addition of melted wax in order to standardize the level of fossa and groove depths. Groove depth is measured from the buccal cusp tip to the cavity floor as shown.

Maxillary First Premolar	Maxillary Second Premolar	Maxillary First Molar	Maxillary Second Molar
3.5 mm	3 mm	3 mm	3 mm



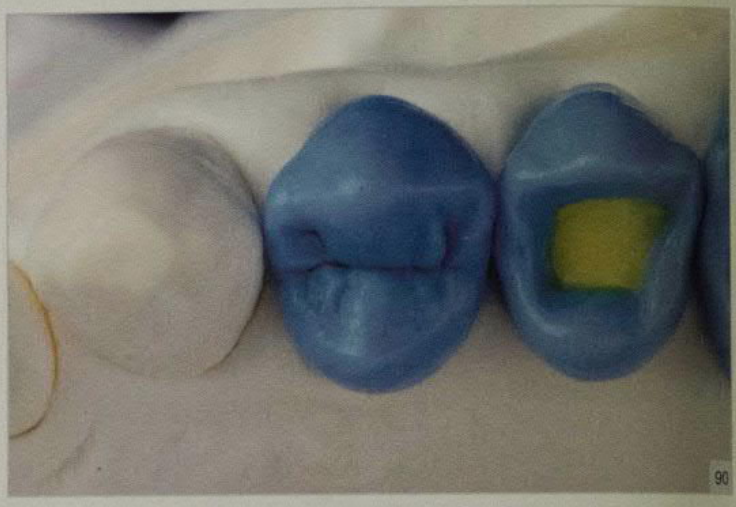


Fig 4-87 The next step is to develop the occlusal surface. Here, the central lobe of the buccal cusp of the maxillary first premolar is added. It is long in the mesiodistal direction and shifted toward the palatal, making the buccal cusp larger than the palatal cusp. Its convexity is similar to that of the palatal surface of the canines, extending beyond the marginal ridges; however, it must not compromise canine-protected articulation. The base is flat, which determines the straight configuration of the developmental groove.

Fig 4-88 The mesial lobe of the buccal cusp and the lobe of the mesial marginal ridge. The mesial lobe (in the region of the mesial angle of the buccal cusp) must be small and directed toward the center of the crown, not extending to the developmental groove. The lobe of the mesial marginal ridge should be small and triangular. After it is constructed, one can see an extension of the developmental groove running toward the buccal aspect.

Fig 4-89 The distal lobe of the buccal cusp and the central lobe of the palatal cusp. On the buccal cusp, the distal lobe is smaller, with an elongated shape, and pointed toward the developmental groove. On the palatal cusp, the central lobe also presents a straight base, which is turned toward the developmental groove. As this lobe is smaller than the central lobe of the buccal cusp, the grooves presented here are less evident.

Fig 4-90 The occlusal surface is finished after the mesial and distal lobes have been applied on the palatal cusp. These lobes are small and run to the developmental groove. A small, triangular lobe should be positioned at the distal marginal ridge. After wax-up of the cusps, an eccentric, straight developmental groove should be formed, 1 mm apical to the marginal ridges, along with the mesial and distal fossae. The perimeter of these fossae represents two mirror-image D letters. Also, the developmental groove and the lobes of the marginal ridges joined together should have a cotton swab shape. Since all the occlusal contacts were established on the marginal ridges, adjustments must be made to prevent interference during excursive movements.

Fig 4-91 The central lobe of the buccal cusp of the maxillary second premolar. Note that it has a triangular shape, with a round apex slightly toward the distal but still pointing toward the developmental groove, determining a centralized, irregular developmental groove in the mesiodistal direction. Its height is slightly greater than that of the marginal ridges.

Fig 4-92 The mesial and distal lobes at the angles of the buccal cusp. These are more accentuated and defined than those in the maxillary first premolar, being pointed toward the distal fossa pit and extending as far as the developmental groove.

Fig 4-93 The distal lobe of the palatal cusp. This lobe is long and well visualized, pointing transversely toward the distal fossa pit and extending to the developmental groove. It remains lower than the buccal lateral lobes. Next, the long, triangular lobes of the marginal ridges are applied.

Fig 4-94 The central lobe of the palatal cusp, which should be pointed toward the developmental groove and slightly distally. It can contact the central lobe of the buccal cusp of the mandibular second premolar. The mesial lobe is triangular, extending to the developmental groove in the mesial fossa. The grooves formed by these lobes are shallower than the one on the buccal cusp. Also, the mesial and distal fossae have a symmetric letter D shape.

Fig 4-95 The mesiobuccal cusp of the maxillary first molar. The central lobe is triangular, with the apex pointing to the central fossa pit, and its height is slightly above the mesial marginal ridge. This lobe makes contact with the mesial incline of the midbuccal cusp of the mandibular first molar. The lateral lobes have reduced dimensions and do not make centric contact with the antagonist. The mesial lobe should be pointed toward the region of the developmental groove and the distal lobe toward the region of the occlusobuccal groove, contributing to its formation. The lobe of the mesial marginal ridge is a fundamental feature of the maxillary first molar. It has a long, triangular shape pointed toward the central fossa pit, contributing to the formation of the developmental groove.

Fig 4-96 Development of the distobuccal cusp. This cusp has two surfaces, one pointed toward the central and the other toward the distal fossa, separated by the enamel bridge. On the one hand, the former presents a fairly small central lobe, and at its most prominent contour there is a contact with the distal incline of the midbuccal cusp of the mandibular first molar. Because of this contact, wear facets can be found in this region. The lateral lobes do not make contact with the antagonist. The mesial lobe is long and parallel to the occlusobuccal groove. The distal lobe is triangular, running from the distal to the developmental groove on the central fossa, contributing to the occlusobuccal groove. On the other hand, the latter has a central lobe pointing to the occlusodistopalatal groove; it has only one triangular lateral lobe with reduced dimensions. This surface receives the occlusodistal groove. The crest of the enamel bridge is a well-defined structure of the maxillary first molar, running transversely from the distobuccal cusp tip to the developmental groove. The enamel bridge and the distobuccal groove of the mandibular first molar run in the same direction.

Fig 4-97 Next, the mesiopalatal cusp, the largest cusp of the maxillary first molar, is positioned. The central lobe is well developed; it points transversely toward the central fossa pit, in the direction of the occlusobuccal groove, making contact with the central lobe of the midbuccal cusp of the mandibular first molar. On the other hand, the mesial lobe is small and pointed transversely toward the developmental groove, while the distal lobe reaches the central lobe of the distobuccal cusp, forming the enamel bridge. After the mesiopalatal cusp has been applied, it is possible to visualize the mesial fossa perimeter, delineated by the longitudinal slopes of the buccal cusps, the enamel bridge, the mesiopalatal cusp tip, and the mesial marginal ridge, creating a triangular, heart-shaped configuration. The segment of the developmental groove found at the mesial fossa is similar to the Mercedes-Benz symbol.

Fig 4-98 The occlusal surface of the maxillary first molar after the distopalatal cusp has been developed. This is the smallest cusp on this tooth, with a small central lobe pointing obliquely toward the mesial aspect, ending at the distal fossa pit. The lateral lobes are also small. On the distal marginal ridge, a short and narrow triangular lobe must be applied, aimed toward the distal fossa pit. At the palatal aspect of this lobe there is a distal marginal groove. The wax-up of these lobes determines the occlusodistal groove, whose shape is similar to a curly bracket, running parallel to the enamel bridge and ending at the palatal aspect of the palatal groove. At this stage the distal fossa is formed, its outline delineated by the distal marginal ridge, distobuccal cusp tip, enamel bridge, and distopalatal cusp tip, with an irregular right triangle shape. Where the perimeters of these two fossae meet, one can visualize a large, irregular number 9. Observe the myriad anatomical details on the occlusal surface as well as the rhomboidal outline that arises from the buccolingual dimension being larger than the mesiodistal dimension.


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Fig 4-99 The maxillary second molar has anatomical characteristics similar to those of the first molar but with smaller dimensions. Here, the development of the mesiobuccal cusp is shown. The central lobe is triangular, having an oblique course until it reaches the central fossa, presenting a convexity that determines contact with the mesial incline of the distobuccal cusp of the mandibular second molar. The incline of the antagonist tooth, where the contact develops, must be refined so as to obtain a mesial inclined path, similar to a wear facet. The mesial and distal lobes are small and distinct, pointing to the center of the crown. On the mesial marginal ridge, a lobe directed to the central fossa pit must be applied, contributing to the establishment of the developmental groove.

Fig 4-100 The distobuccal cusp has been developed. The central lobe is pointed obliquely toward the mesial aspect, ending at the central fossa. Like that of the first molar, this lobe is divided by the enamel bridge. Because of its convexity, it makes contact with the distal incline of the distobuccal cusp of the mandibular second molar. Observe that the enamel bridge is not very evident. The mesial lobe is long and parallel to the occlusobuccal groove, running to the occlusal outline of this groove. The distal lobe should come from the distal to the region of the central fossa pit, contributing to the formation of the developmental groove.

Fig 4-101 The mesiopalatal cusp is applied. The central lobe is triangular and large, pointing toward the central fossa pit, following the occlusobuccal groove between the buccal cusps. This lobe contacts the central lobe of the distobuccal cusp of the mandibular second molar. The lateral lobes are similar to those of the maxillary first molar. At this point, it is possible to visualize a developmental groove in the shape of the Mercedes-Benz symbol.

Fig 4-102 The occlusal surface is finished after the distopalatal cusp. This cusp is very small and often has a single, central lobe. Another lobe should be applied at the distal marginal ridge that has a triangular shape and points toward the distobuccal cusp of the mandibular second molar. After cusp placement, the occlusodistal groove becomes visible, in the shape of a curly bracket. Other important morphologic details should be reproduced as described in chapter 2.

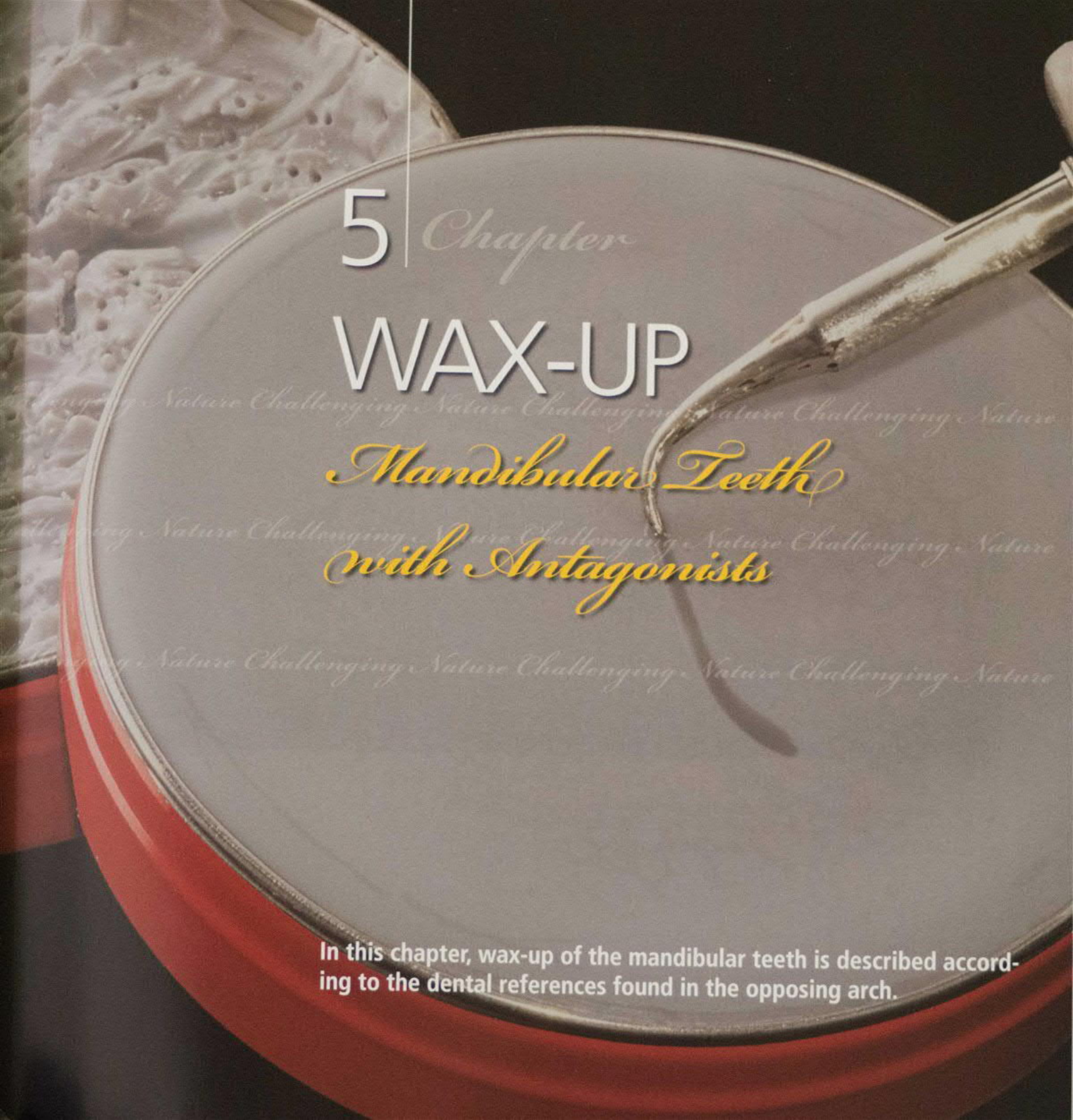
Fig 4-103 View of the finished premolars.

Fig 4-104 Palatal view of the finished wax-up of the maxillary teeth.

Fig 4-105 Buccal view of the finished wax-up of the maxillary teeth.

Fig 4-106 Occlusal view of the finished wax-up of the maxillary premolars.

Fig 4-107 Finished wax-up of the maxillary molars.



5 Chapter

WAX-UP

Mandibular Teeth with Antagonists

In this chapter, wax-up of the mandibular teeth is described according to the dental references found in the opposing arch.

Fig 5-1 First, maxillary and mandibular stone casts must be mounted in the semi-adjustable articulator according to the protocol described in chapter 4. Needless to say, precision is fundamental in order to adequately reproduce the tooth anatomy.

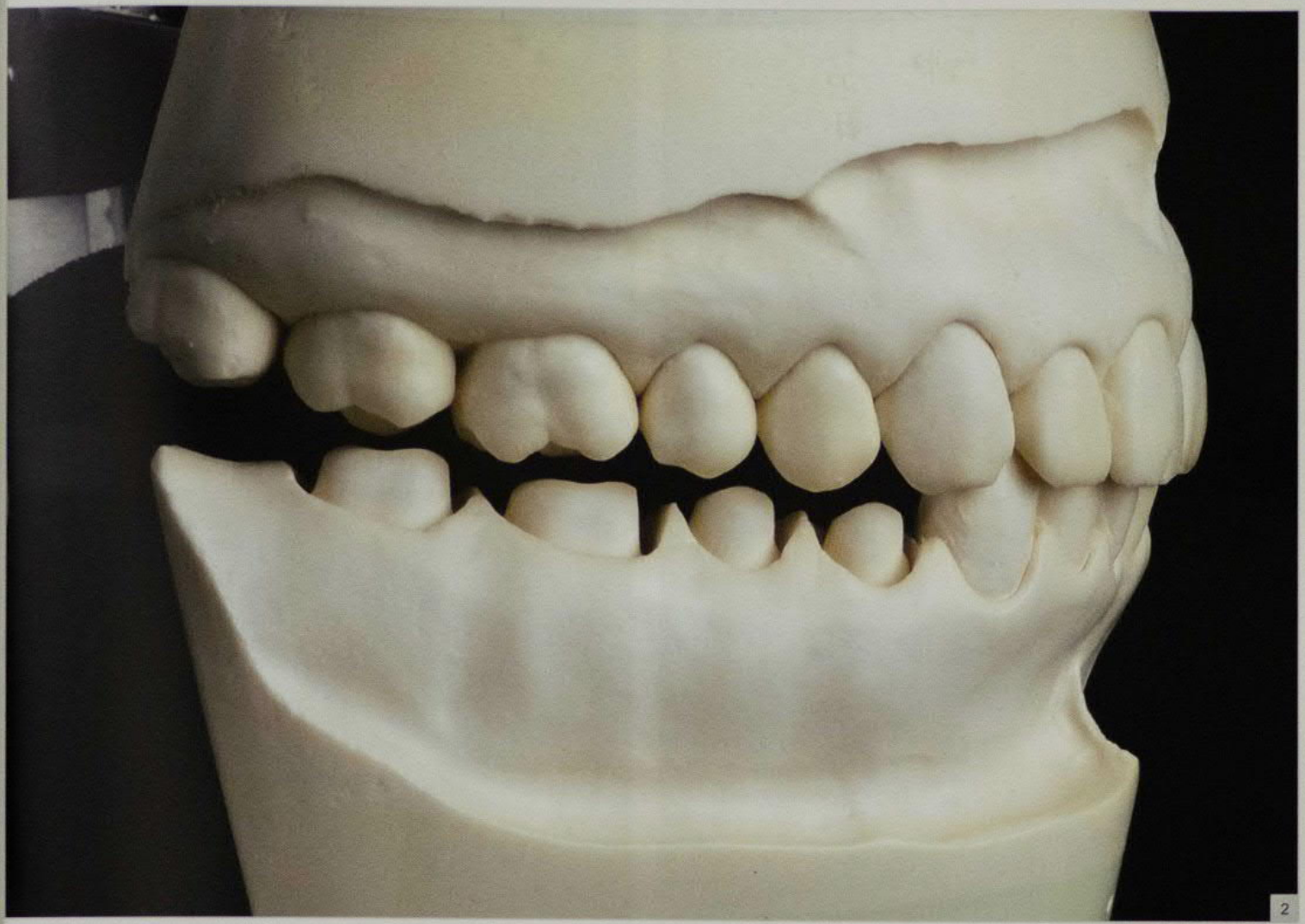
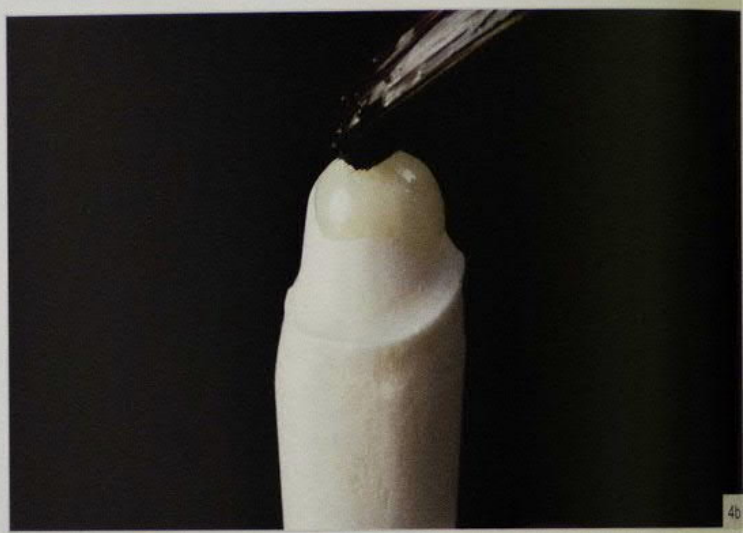


Fig 5-2 Lateral view of the articulated casts. The mandibular right teeth are prepared before the wax-up process.

Fig 5-3 Yellow dipping wax (Duro Dip, al dente Dentalprodukte GmbH, Germany) to be melted in the electric dipping pot for coping fabrication.



Figs 5-4a and 5-4b An insulating liquid is applied to the coronal portion of the maxillary right second premolar die. This procedure should be repeated for all dies before wax-up.

Figs 5-5a and 5-5b The coronal portion of the die should be dipped in the electric pot for wax copingfabrication, which serves as a reference for the wax-up.

Fig 5-6 The electric dipping pot (Hotty, Renfert) with the dipping wax melted according to manufacturer recommendations.

Fig 5-7 Occlusal view of the mandibular stone cast after fabrication of the wax coping.

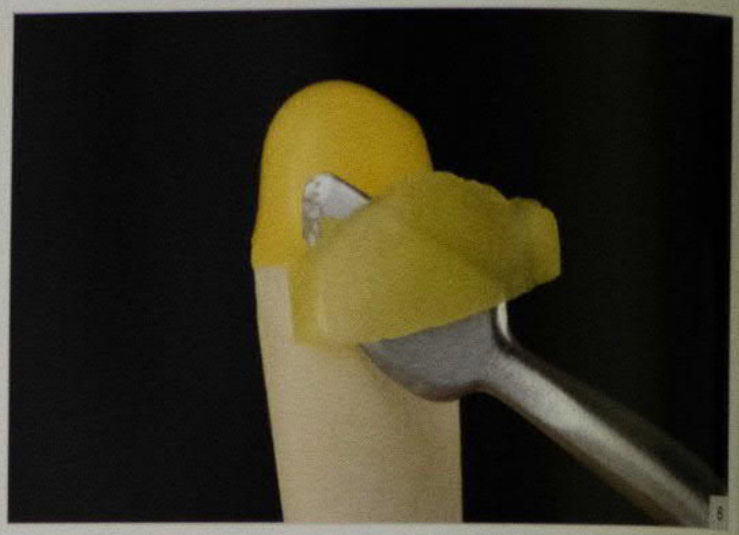


Fig 5-8 Remember: the excess wax beyond the coronal portion must be removed with a carving instrument to avoid error at the restoration margin.

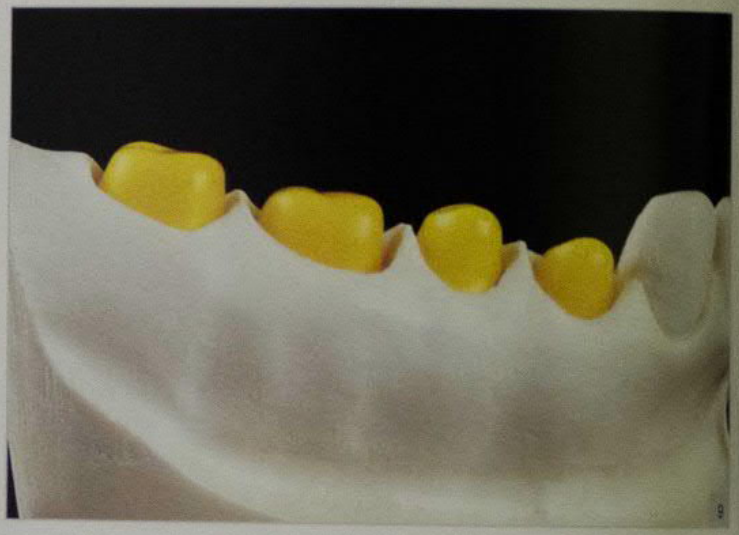
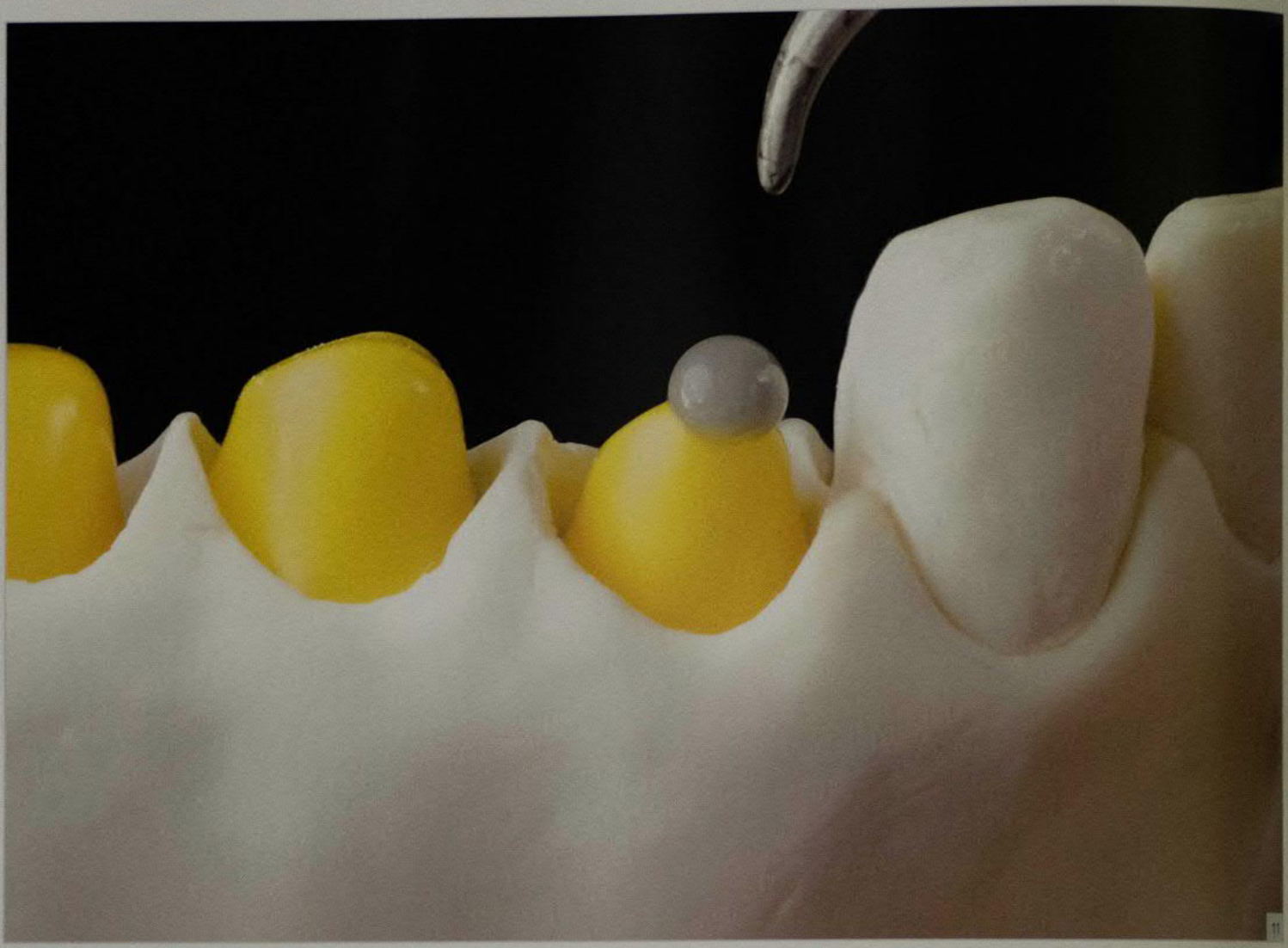


Fig 5-9 Buccal view of the mandibular teeth with the wax copings properly positioned in the stone cast.

Fig 5-10 Frontal aspect of the mandibular teeth after fabrication of the wax coping.



Buccal Surface

Fig 5-11 Here, the wax-up process starts at the buccal surface, because of the reference provided by the opposing teeth. A portion of wax is applied with a heated instrument at the buccal cusp of the mandibular first premolar. This orientation cone will help in the fabrication of the buccal surface.

Fig 5-12 The buccal wax cone of the mandibular first premolar.

Fig 5-13 This cone should be placed between the maxillary canine and the first premolar, or pointed toward the mesial marginal ridge of the maxillary first premolar.

Fig 5-14 When the cone is located between the maxillary teeth, no contact occurs in centric occlusion. On the other hand, contact does occur when the cone is pointed toward the mesial marginal ridge of the maxillary first premolar. This reference determines the cusp height.

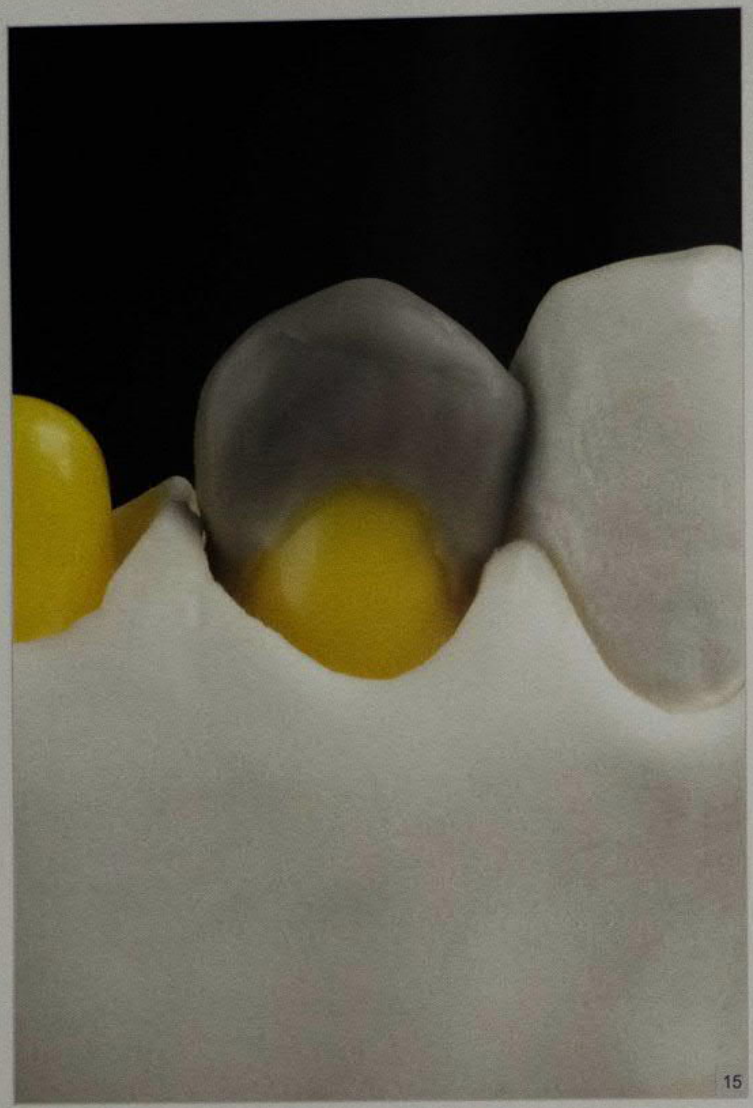


Fig 5-15 Next, the longitudinal mesial and distal slopes are developed to establish the width of the occlusal third of the buccal surface.

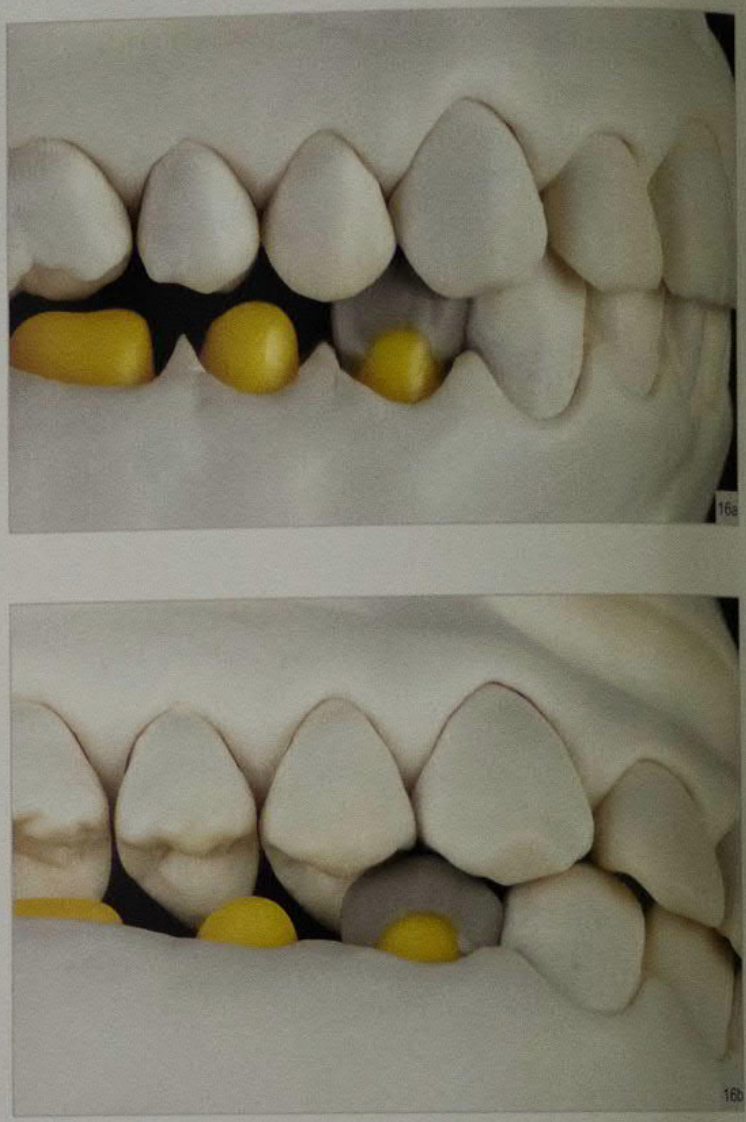
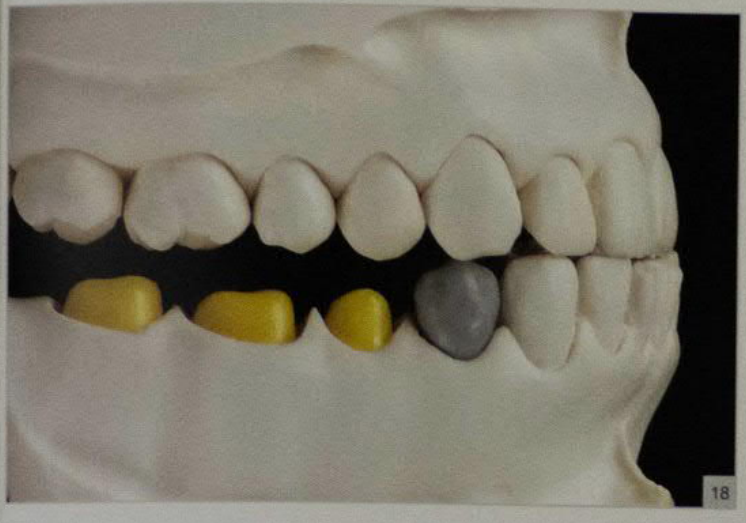


Fig 5-16a and 5-16b Occlusal relationships found between the longitudinal slopes and the antagonists. Observe that the mesial slope should extend from the cone tip to near the closest proximal contact with the mandibular canine, and the distal slope should extend from the cone tip to near the buccal cusp tip of the maxillary first premolar. When the cusp tip is pointed toward the ridge, the contact occurs at the cusp tip. When the tip is placed between the maxillary teeth, a contact should occur between the mesial marginal ridge of the maxillary first premolar and the distal slope of the buccal cusp of the mandibular first premolar near to its tip.



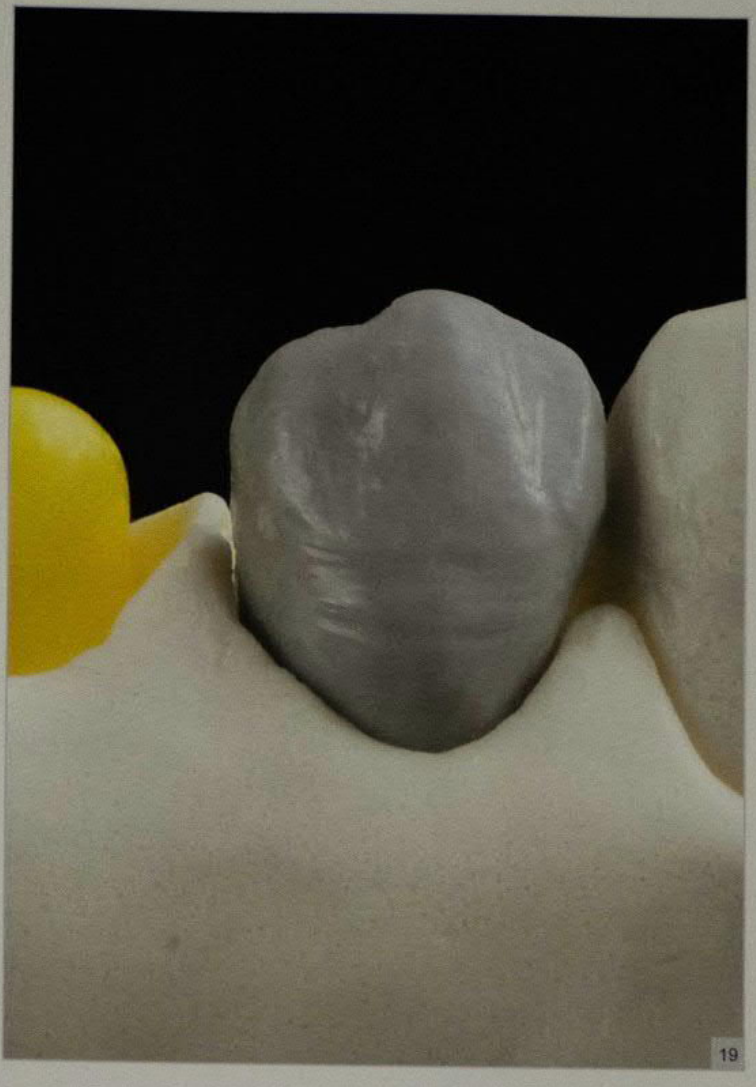
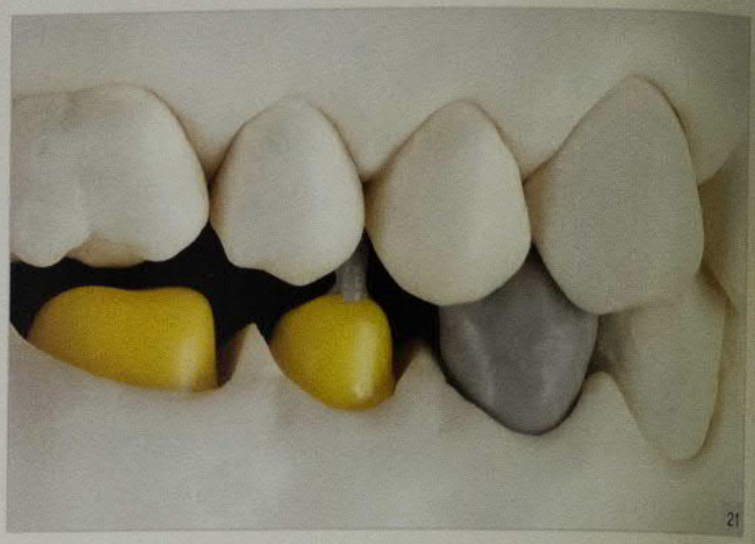


Fig 5-17 Lateral view of the occlusal relationships at the buccal surface of the mandibular first premolar.

Fig 5-18 It is important to highlight that at the beginning of mandibular excursions, contact will be found between the mesial incline of the buccal surface of the mandibular first premolar and the distopalatal aspect of the maxillary canine, which in many cases presents a wear facet. This contact occurs simultaneously with those found in the anterior teeth, in the absence of deleterious occlusal interferences. However, no contacts are seen at the end of these excursions, because of the disclosure path provided by the anterior and canine guidance.

Fig 5-19 The finished buccal surface. It has an ovoid shape, with a distinct cervical bulge. The developmental grooves are not so distinct. The cervico-occlusal convexity is determined by the relation with the antagonist teeth.



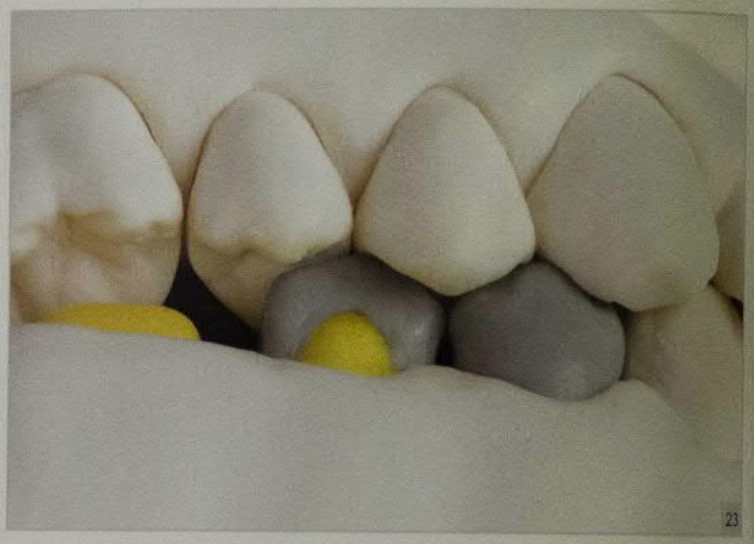


Fig 5-20 The buccal wax cone of the mandibular second premolar, using the opposing teeth as references.

Fig 5-21 This cone is placed between the marginal ridges of the maxillary first and second premolars, without having contact with the antagonists.

Fig 5-22 Next, the mesial and distal longitudinal slopes are positioned.

Fig 5-23 The occlusal relationships of the longitudinal slopes with the opposing teeth. Note that the mesial slope should extend from the cone tip to the region of the buccal cusp tip of the maxillary first premolar, while the distal slope should extend from the cone tip to the buccal cusp tip of the maxillary second premolar. At the mesial slope and near the tip, a contact occurs with the distal marginal ridge of the maxillary first premolar, while at the distal ridge a contact occurs with the maxillary second premolar.

Fig 5-24 The finished buccal surface. This surface presents an ovoid format, with a smaller cervical bulge and developmental grooves that are deeper than those of the mandibular first premolar. During the sculpting process, the cervical contours and the cervico-occlusal convexity must be determined according to the preparation finishing lines and the antagonist teeth, respectively.

Fig 5-25 Buccal view of the occlusal relationships between the buccal surfaces of the mandibular premolars and their antagonists.

Fig 5-26 During excursive movements, there should be no contacts at the buccal surfaces of the premolars because of the disocclusion provided by the anterior teeth.

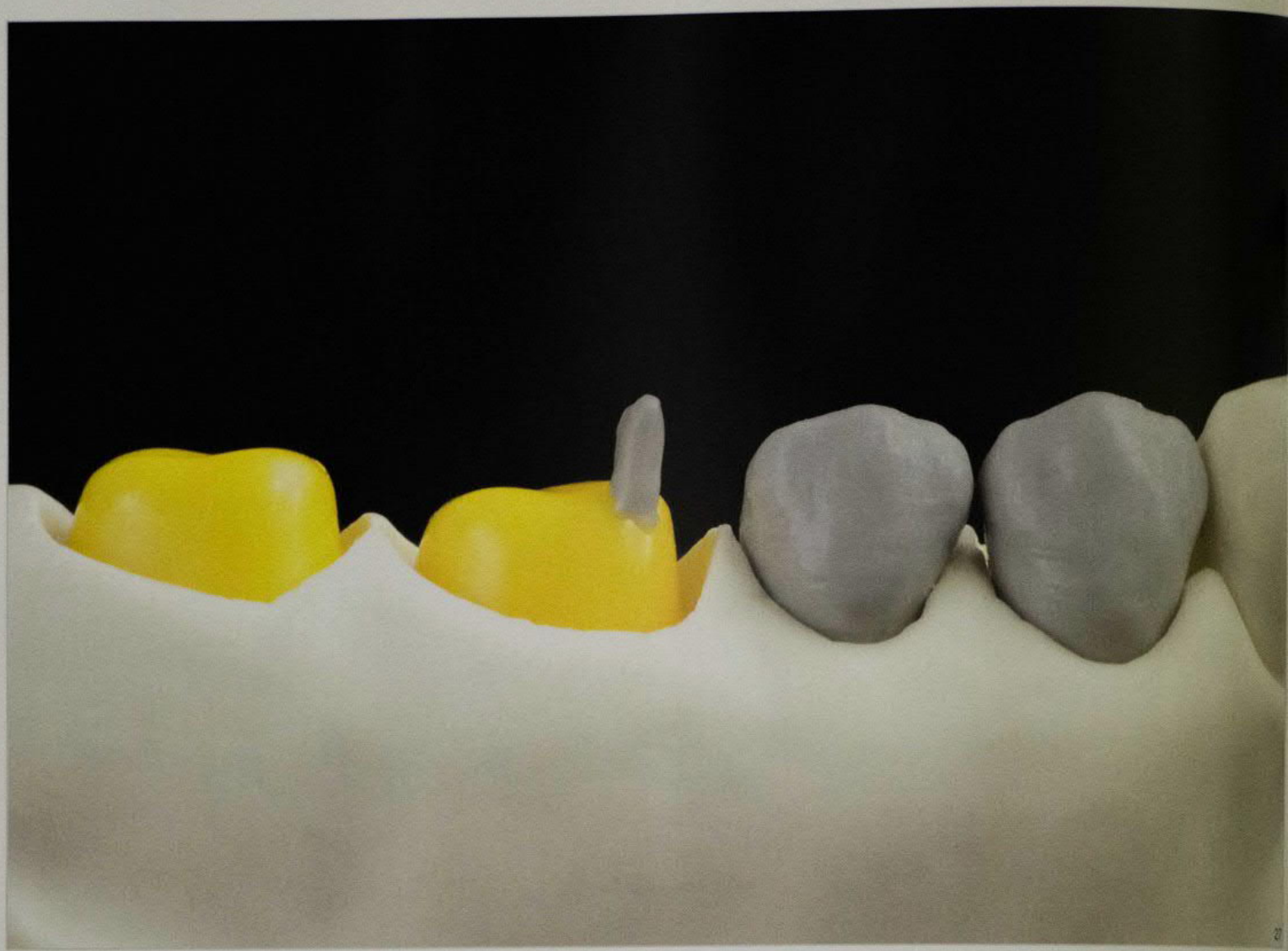
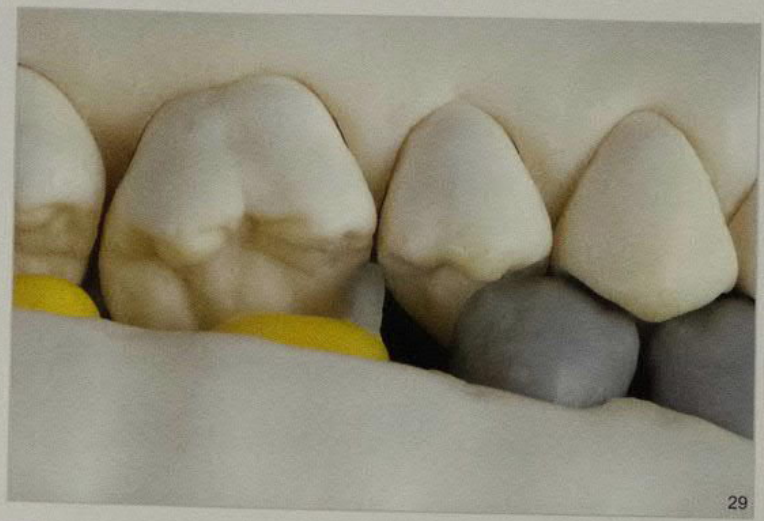


Fig 5-27 The mesiobuccal cusp cone of the mandibular first molar is developed with reference to the opposing teeth.



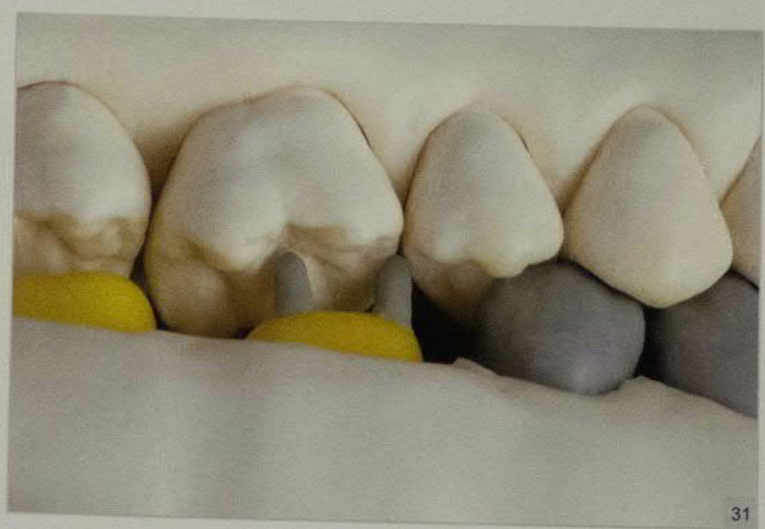
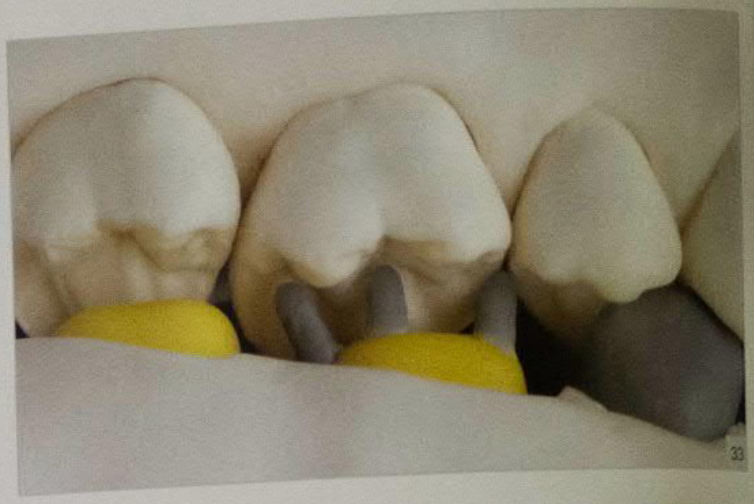


Fig 5-28 This cone should be placed between the marginal ridges of the maxillary second premolar and of the first molar.

Fig 5-29 The cone tip should be near the antagonist teeth but without any contact with them. This reference determines the cusp height.

Fig 5-30 Next, the midbuccal cone should be applied.

Fig 5-31 The midbuccal cusp cone should be pointed toward the central fossa of the maxillary first molar, without any contact with its antagonist, at the same height as the mesiobuccal cone.



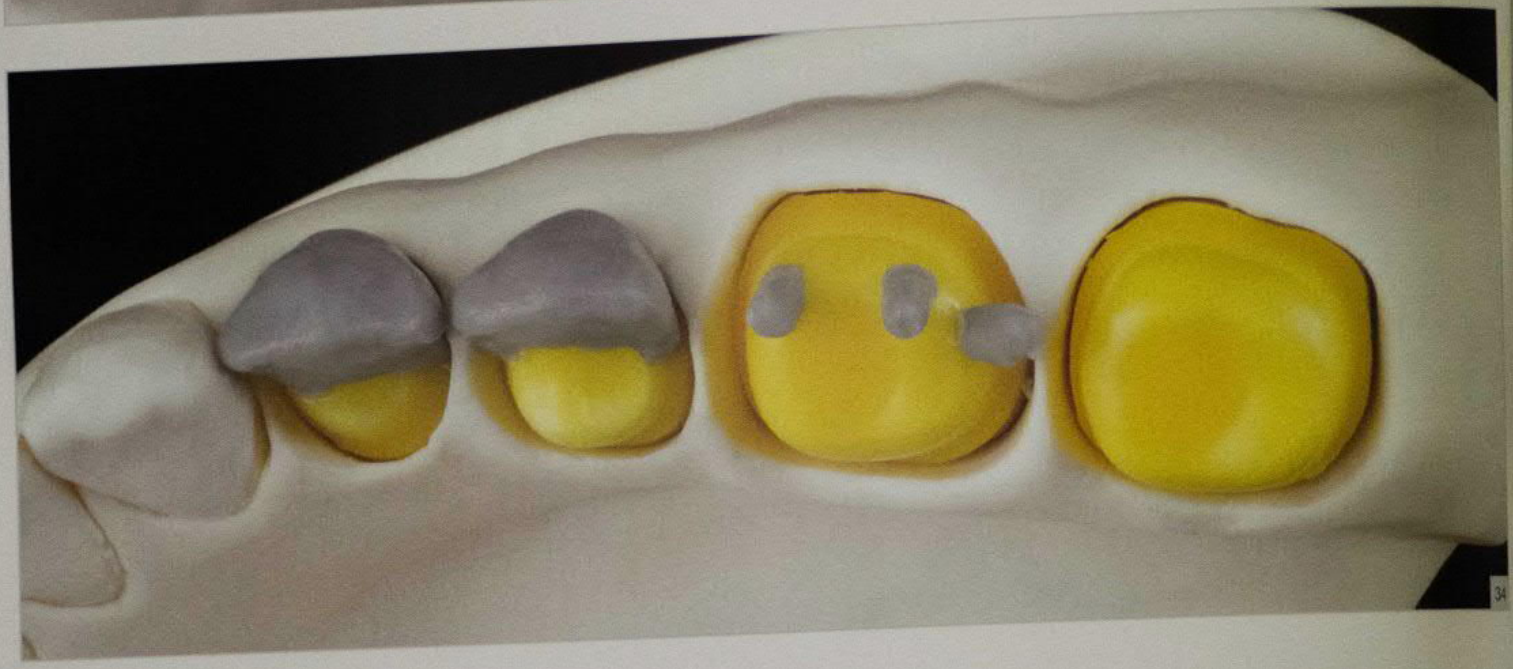


Fig 5-32 The distobuccal cone is developed.

Fig 5-33 This cone should point toward the distal fossa of the maxillary first molar, again without any contact.

Fig 5-34 The occlusal aspect of the buccal cones of the mandibular first molar. The mesio- and midbuccal cones should be in the same alignment in the mesiodistal direction, whereas the distal cone should be slightly toward the lingual aspect.

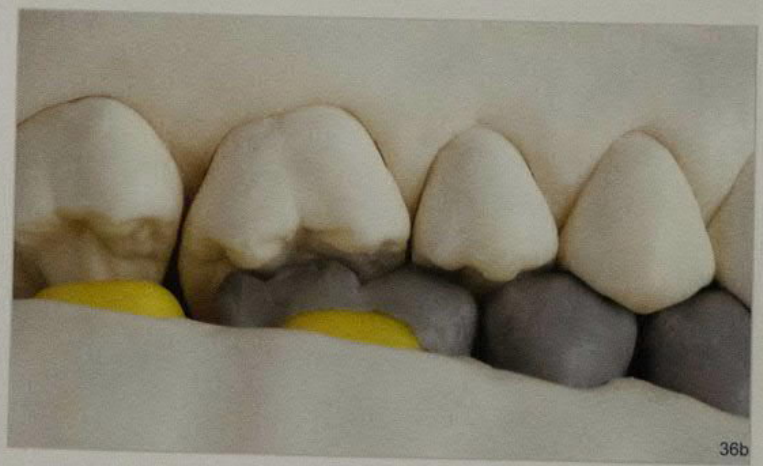


Fig 5-35 After positioning of the longitudinal slopes, the width of the occlusal third at the buccal surface is established.

Figs 5-36a and 5-36b In the mesiobuccal segment, the mesial and longitudinal slopes should extend from the cone tip to the buccal cusp tip of the maxillary second premolar and to the mesiobuccal cusp tip of the maxillary first molar, respectively. In the midbuccal segment, the mesial and distal slopes should extend from the cone tip to the mesiobuccal cusp tip of the maxillary first molar and to the distobuccal cusp tip of the maxillary first molar, respectively. Finally, at the distobuccal segment, the mesial slope should extend from the cone to the distobuccal cusp tip of the maxillary first molar and the distal slope from the cone to the distal outline of the maxillary first molar.

Figs 5-37a and 5-37b Occlusal relationships after wax-up of the mesiobuccal segment. Note that the distal outline of this segment is slightly toward the distal in relation to the cusp tip of the maxillary antagonist, contributing to the development of the mesiobuccal groove.

Fig 5-38 The lateral aspect of the occlusal relationships developed at the buccal surfaces. Here, certain occlusal contacts should be defined, as follows:

- The mesial longitudinal slope of the mesiobuccal cusp versus the distal marginal ridge of the maxillary second premolar
- The distal longitudinal slope of the mesiobuccal cusp versus the mesial marginal ridge of the maxillary first molar
- The mesial incline of the midbuccal cusp versus the central lobe of the mesiobuccal cusp of the maxillary first molar
- The distal incline of the midbuccal cusp versus the central lobe of the distobuccal cusp of the maxillary first molar

Observe that the occlusal contacts are delicate points, not surfaces.

Fig 5-39 Lateral excursion after finishing of the buccal surface. No contacts are found because of the canine guidance provided.

Fig 5-40 The buccal aspect of the mandibular first molar. It has an irregular, trapezoidal shape, which should present all the necessary details highlighted in chapter 2. Observe that the cusps have prominent buccal lobes. The mesio- and midbuccal cusps have similar heights and are separated by the mesiobuccal groove. A fine distobuccal groove separates the mid- and distobuccal cusps. A horizontal groove highlights the cervical bulge. An irregular, depressed delta configuration can be found at the intersection between the horizontal and the mesiobuccal grooves. As in the wax-up of the buccal surfaces of the premolars, it is important to observe the cervical limits and the cervico-occlusal convexity, both determined by the antagonist teeth.

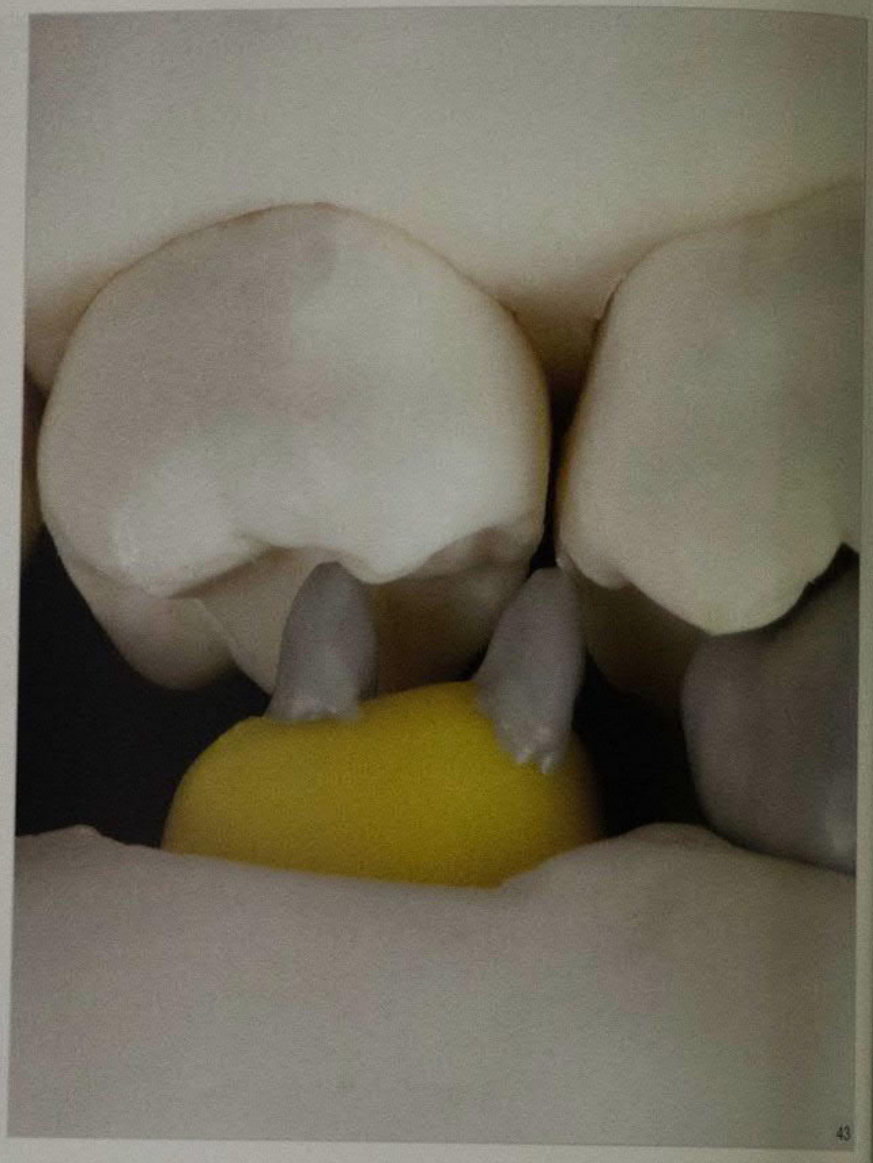
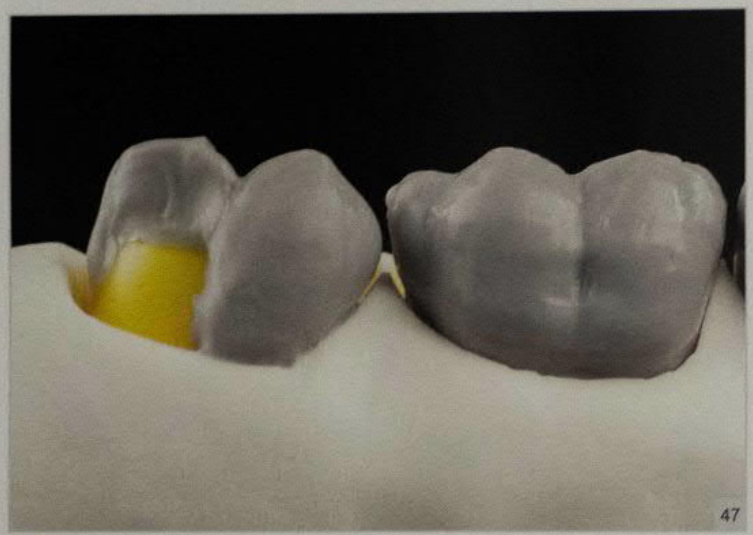


Fig 5-41 The mesiobuccal cone of the mandibular second molar is applied.

Fig 5-42 Next, the distobuccal cusp should be positioned. It remains slightly higher than the mesiobuccal cone because of the curve of Spee.

Fig 5-43 The buccal cones developed according to the opposing teeth. The mesiobuccal cone should be located between the marginal ridges of the maxillary molars, pointing toward the central groove. On the other hand, the distobuccal cone should be pointed toward the central fossa of the maxillary second molar.

Fig 5-44 Occlusal view with the buccal cones positioned. Observe the cone alignment in the mesiodistal direction.



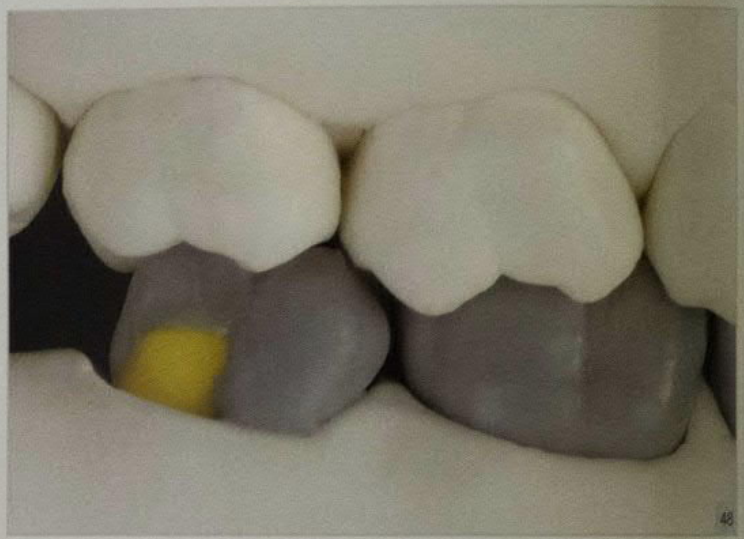


Fig 5-45 Development of the longitudinal slopes.

Fig 5-46 In the mesiobuccal segment, the mesial slope should extend from the cone tip to the distobuccal cusp tip of the maxillary first molar, while the distal slope should extend from the cone to the mesiobuccal cusp tip of the maxillary second molar. In the distobuccal cusp, the mesial slope should extend from the cone to the mesiobuccal cusp tip of the maxillary second molar, while the distal slope should extend from the cone to the distobuccal cusp tip of the maxillary second molar.

Fig 5-47 The mesial segment of the finished buccal surface.

Fig 5-48 At this stage, the occlusal contact between the mesial slope of the mesiobuccal cusp and the distal marginal ridge of the maxillary first molar must be refined, as well as that between the tip and/or distal slope of the mesiobuccal cusp and the mesial marginal ridge of the maxillary second molar.

Fig 5-49 The buccal aspect of the finished mandibular second molar. The occlusal outline has two cusps divided by the buccal groove. A horizontal groove highlights a prominent cervical bulge. A hallmark of the premolars is the inverted V shape on their occlusobuccal surfaces. On the other hand, a lower case *M* and an upper-case *M* are seen on the first and second molars, respectively. It is also important to observe the myriad surface details evidencing their anatomical characteristics, which should be reproduced as described in chapter 2. The spacing between the posterior teeth should be maintained, characterizing the lack of proximal contacts; these will be developed only after the marginal ridges are constructed.

Figs 5-50a to 5-50d Lateral view of the buccal surfaces of the mandibular teeth. *(a)* Centric occlusion. *(b)* Protrusive movement. *(c)* Right lateral excursion. *(d)* Left lateral excursion (nonworking side). No contact is made during excursive movements because of the disclosure path provided by anterior and canine guidance.

Fig 5-51 Note the cervico-occlusal convexities on the buccal surfaces of the molars, which are very similar to those found in the premolars. On the other hand, the mesiobuccal cusp of the first molar presents a more accentuated lingual inclination, whereas the midbuccal and distobuccal cusps have a straight path, the former being more toward the buccal. To achieve this configuration, the mesial and distal inclines of the mesiobuccal cusp should be well adjusted to determine this inclination. Similarly, the mesiobuccal cusp of the mandibular second molar presents a more lingual inclination, whereas the distobuccal cusp follows a straight path.

Fig 5-52 Occlusal view of the mandibular premolars after finishing of the buccal surfaces. No excess wax is seen in the copings.

Fig 5-53 Occlusal view of the mandibular molars after finishing of the buccal surfaces.

Fig 5-54 Lingual view of the mandibular premolars and molars after finishing of the buccal surfaces.

Fig 5-55 Lingual view of the occlusal relationships between the mandibular premolars and molars after finishing of the buccal surfaces.

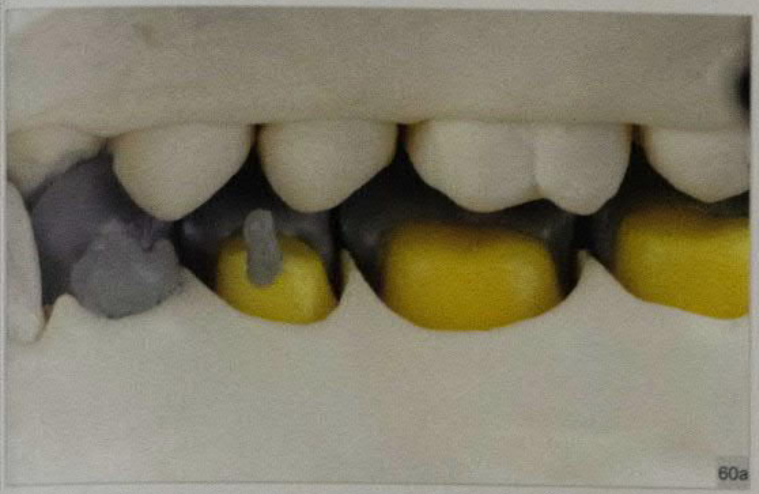
Lingual Surface

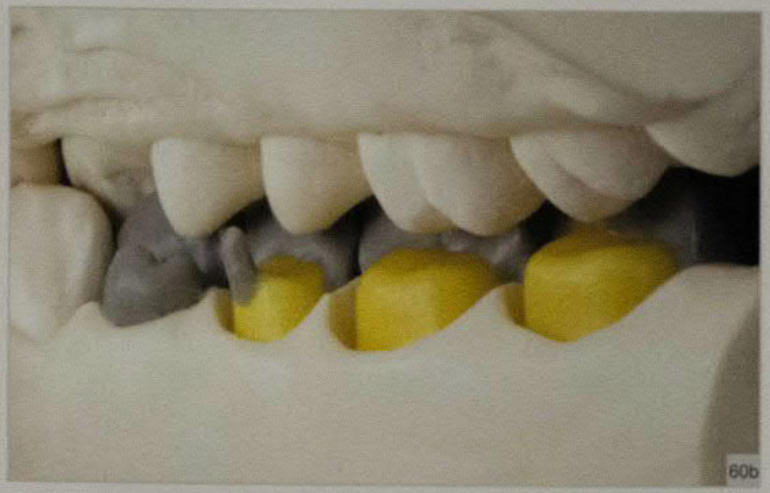
Fig 5-56 The next step is the development of the lingual surfaces. The figure shows the mesiolingual cusp cone at the mandibular first premolar, located between the maxillary canine and first premolar. When the stone casts are articulated, the cone tip should be at the same level as the cusp tip of the maxillary first premolar, which determines its height.

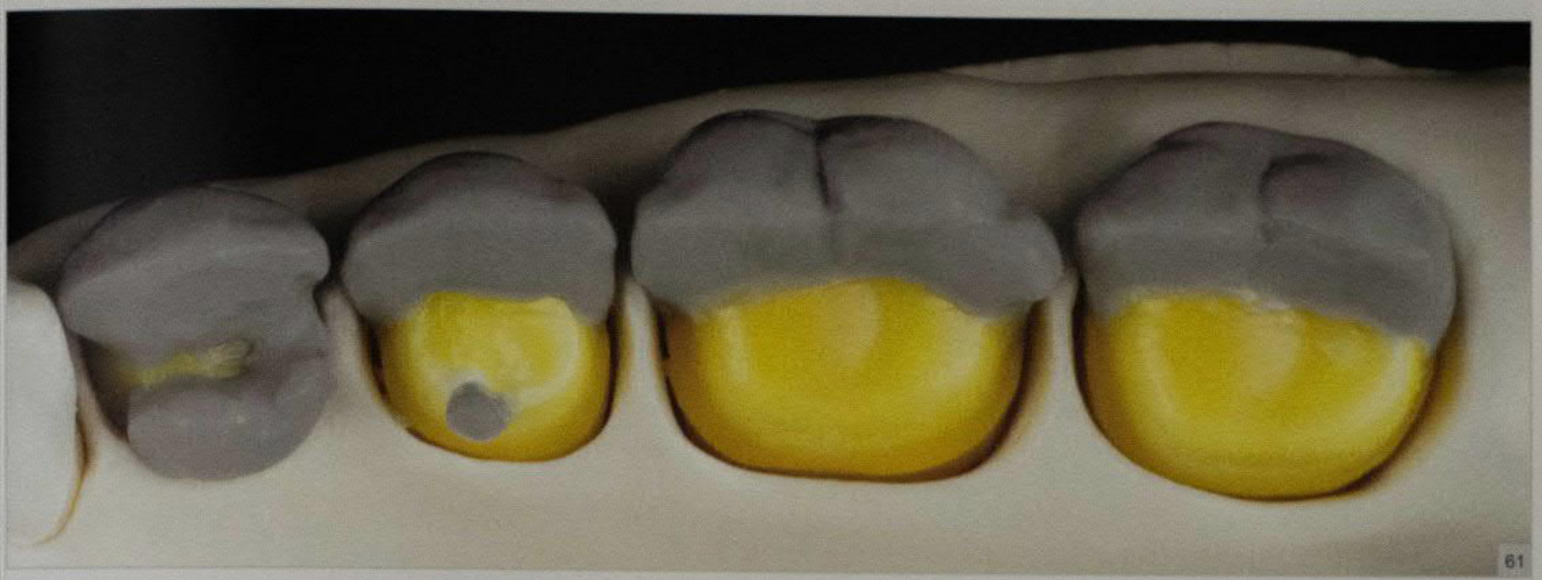
Figs 5-57a and 5-57b The lingual surface is finished after positioning of the distolingual cusp, which generates the lingual groove. Observe its reduced dimensions compared to those of the buccal surface. At this moment, it is important to highlight that the mesiolingual cusp tip is 3 mm lower than the buccal cusp tip.

Fig 5-58 Lingual surface of the mandibular first premolar, which is relatively flat; there is buccal inclination only at its occlusal third. No lobes or grooves are found in this surface.

Fig 5-59 The mesiolingual cone at the mandibular second premolar.







Figs 5-60a and 5-60b This cone is located between the maxillary first and second premolars. It should be 0.5 to 1.0 mm higher than the palatal cusp tip of the maxillary second premolar with the stone casts articulated.

Fig 5-61 Occlusal view of the lingual cone of the mandibular second premolar.

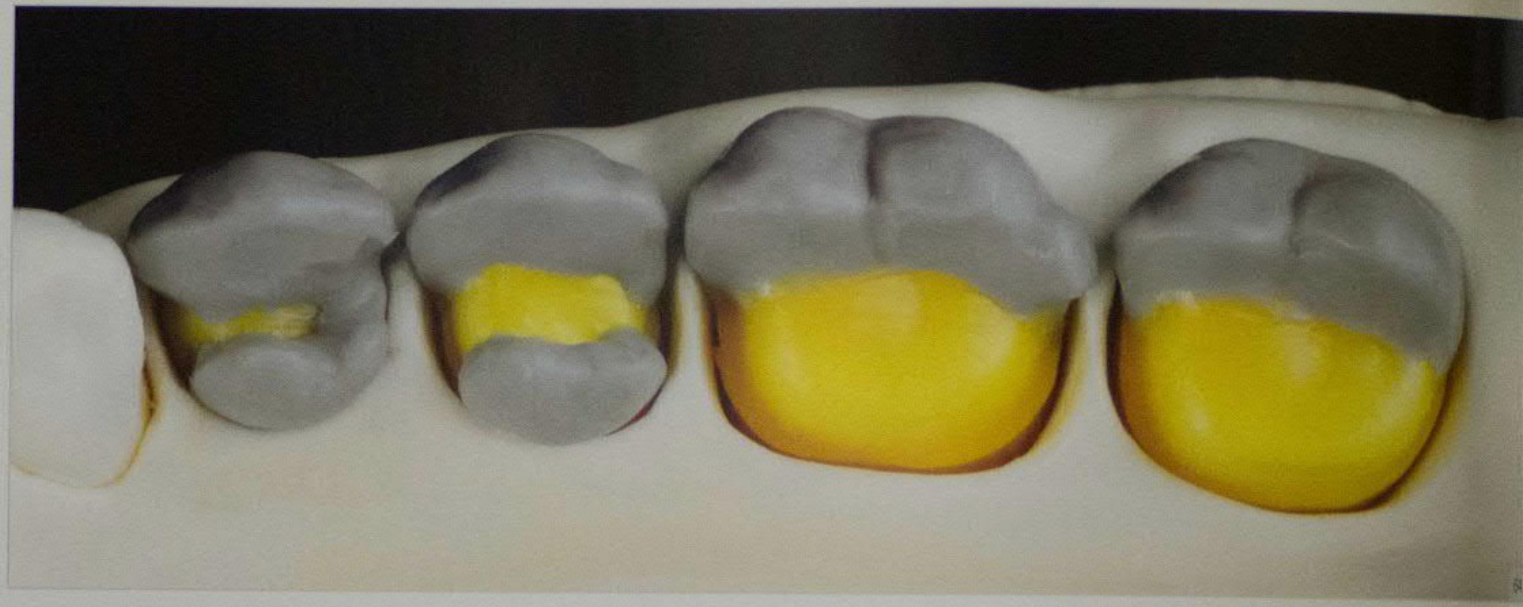
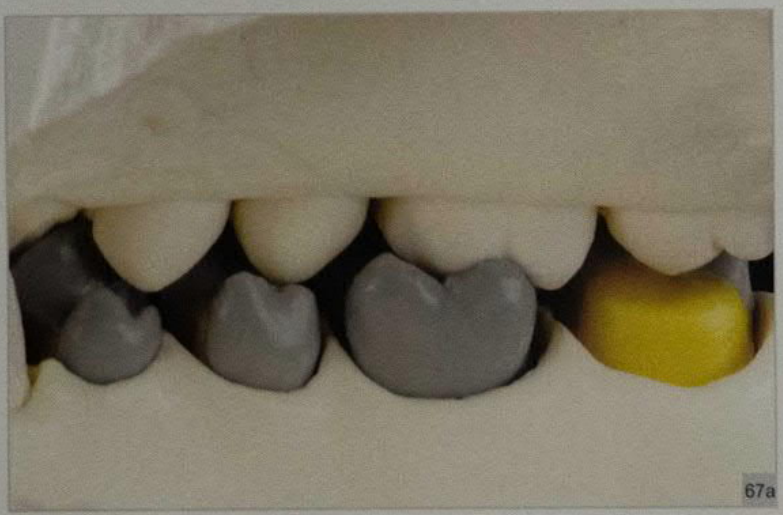


Fig 5-62 The distolingual cusp should be shorter than the buccal cusp. The lingual surface is finished after the development of the mesial and distal segments, which should be separated by the occlusolingual groove.

Fig 5-63 The occlusal relationships between the lingual surfaces of the mandibular premolars and their respective antagonists. In an anteroposterior view, the mild cervico-occlusal convexities are similar, with a more accentuated buccal inclination at the occlusal thirds.

Fig 5-64 The distance between the buccal and lingual cusp tips should be 5 mm for the first premolar and 5.5 mm for the second premolar. There should be no contacts during the excursive movements.

Fig 5-65 The mesiolingual cone of the mandibular first molar has been developed.



Figs 5-66a and 5-66b The distolingual cone is positioned. The mesiolingual cone should be placed between the maxillary second premolar and first molar, with its tip at the same level as the mesiobuccal cusp of the mandibular first molar, being 1.5 to 2.0 mm higher than the mesiopalatal cusp tip of the maxillary first molar. On the other hand, the distolingual cone should be pointed toward the palatal groove of the maxillary first molar and at the same level or slightly lower than the mesiolingual cone when the stone casts are fully articulated.

Figs 5-67a and 5-67b The occlusal relationships of the finished lingual surface of the mandibular first molar. On the mesial segment, the mesial and distal longitudinal slopes should extend from the cone tip to the distal outline of the maxillary second premolar and to the mesiopalatal cone tip of the maxillary first molar, respectively. On the distal segment, the mesial and distal slopes should extend from the cone tip to the mesiopalatal and distopalatal cusp tips of the maxillary first molar, respectively.

Fig 5-68 The finished lingual surface of the mandibular first molar, having an irregular, trapezoidal shape, with smaller dimensions than those of the buccal surface. The lingual cusps have the same height as the mesio- and midbuccal cusps and should be separated by a lingual groove. In this view, it is possible to see two cusps, having an M-shaped configuration at the occlusal outline.

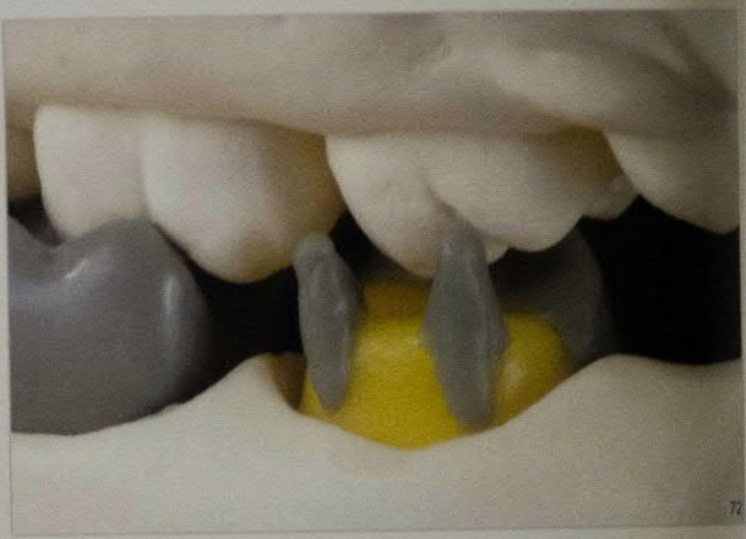


Fig 5-69 The mesiolingual cone of the mandibular second molar.

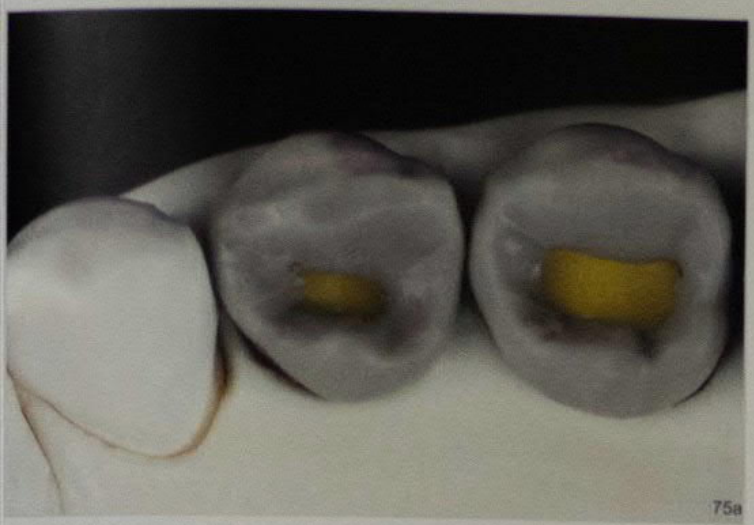
Fig 5-70 The mesiolingual cone should be placed between the maxillary first and second molars and be slightly lower than the mesiobuccal cusp of the same tooth.

Fig 5-71 Fabrication of the distolingual cusp, which should be 0.5 mm highe than the mesiolingual cone because of the tooth axis inclination in the dental arch

Fig 5-72 Lingual view showing the distolingual cone, which is pointed toward th palatal groove of the maxillary second molar.

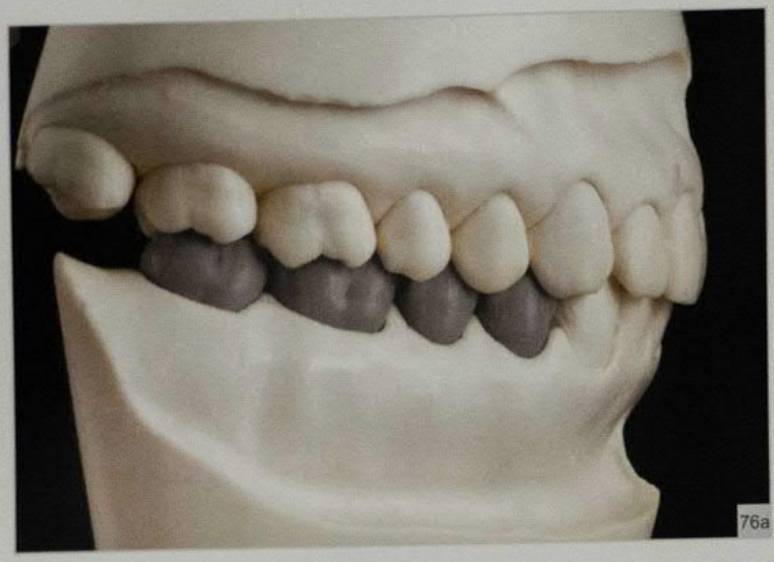
Fig 5-73 The lingual surfaces after finishing the mesial and distal segments, separated by the lingual groove.

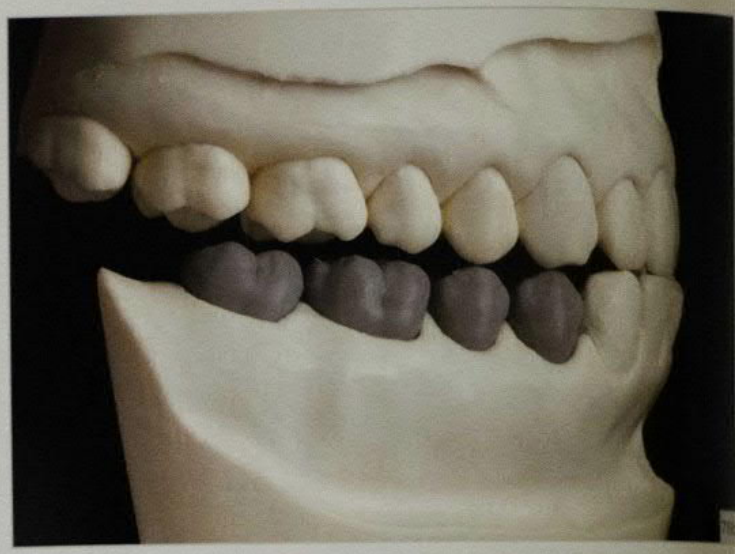
Fig 5-74 Lingual view of the occlusal relationships of the mandibular premolars and molars before positioning of the marginal ridges. The grooves found at the lingual surfaces of the premolars should be in the same direction as the palatal cusp tips of the maxillary premolars. On the mandibular molars, this grooving is in the same direction as the mesiopalatal cusp tips of the maxillary molars.

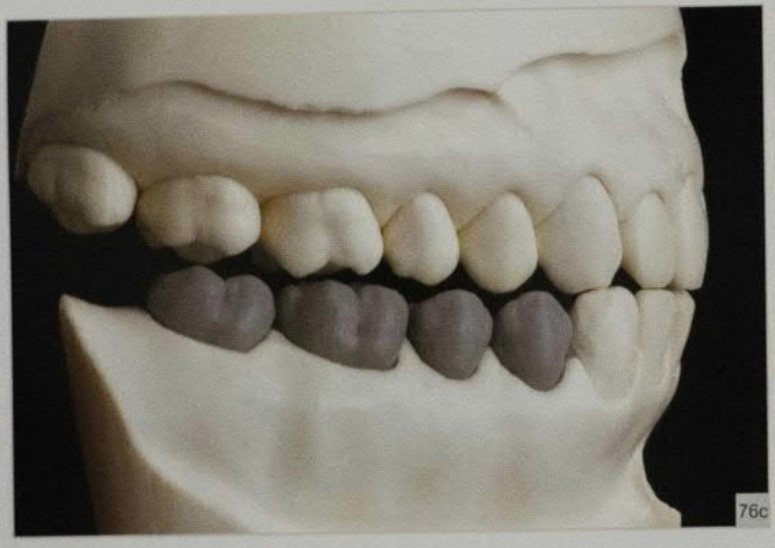


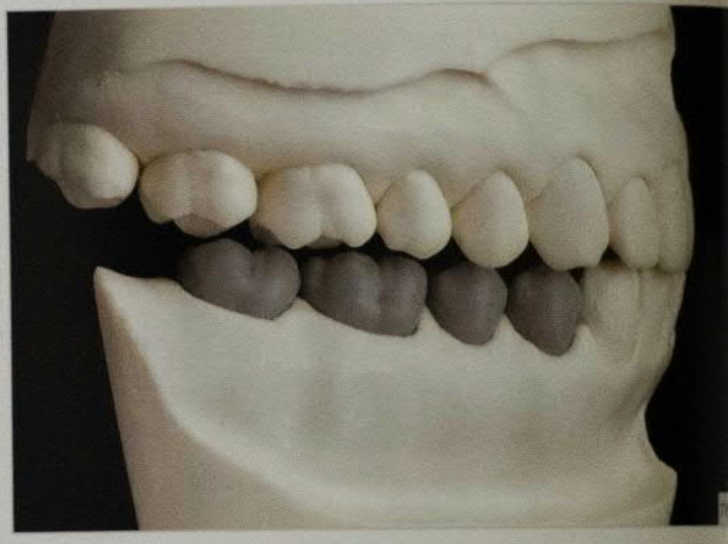
Marginal Ridges

Figs 5-75a to 5-75d Occlusal view of the marginal ridges. *(a)* Mandibular first premolar. The mesial marginal ridge is 45 degrees toward the cervical aspect, being more oblique in a mesiodistal direction. This characteristic better accommodates the tongue. *(b)* Mandibular second premolar. The marginal ridges have an irregular, horizontal fashion. *(c and d)* Mandibular first and second molars. Here, a detailed description of the mandibular marginal ridges does not apply, since no contacts are present in centric occlusion or during excursive movements. If any are found, they must be removed.









Figs 5-76a to 5-76d Occlusal relationship after the development of the marginal ridges during centric occlusion *(a)*, protrusive movement *(b)*, and right and left lateral excursive movements (working and nonworking sides, respectively) *(c and d)*. Contacts are observed neither in centric occlusion nor during excursive movements.

Fig 5-77 Lingual view of the mandibular posterior teeth in occlusion, where the relationships between the height of the marginal ridges and that of the adjacent teeth are as follows:

- The mesial marginal ridge of the mandibular second premolar is higher than the distal marginal ridge of the mandibular first premolar, which increases the likelihood of contact with the maxillary first molar during excursive movements. To prevent this, the palatal cusp of the maxillary first premolar must be pointed toward the distal fossa of the mandibular first premolar.
- The mesial marginal ridge of the mandibular first molar is higher than the distal marginal ridge of the mandibular second molar, which increases the likelihood of contact with the maxillary second premolar during excursive movements. To prevent this, the palatal cusp of the maxillary second premolar must be pointed toward the distal fossa of the mandibular second premolar.
- The mesial marginal ridge of the mandibular second molar is lower than the distal marginal ridge of the mandibular first molar, and sometimes even lower because of the curve of Spee. In such a case, the distopalatal cusp tip of the maxillary first molar is pointed toward the distal marginal ridge of the mandibular first molar. Absence of centric contact in this region is preferable.
- The distal marginal ridge of the mandibular second molar should be in the same direction as the distopalatal cusp tip of the maxillary second molar and, despite the proximity of these structures, no contacts should be observed during centric occlusion and/or excursive movements.

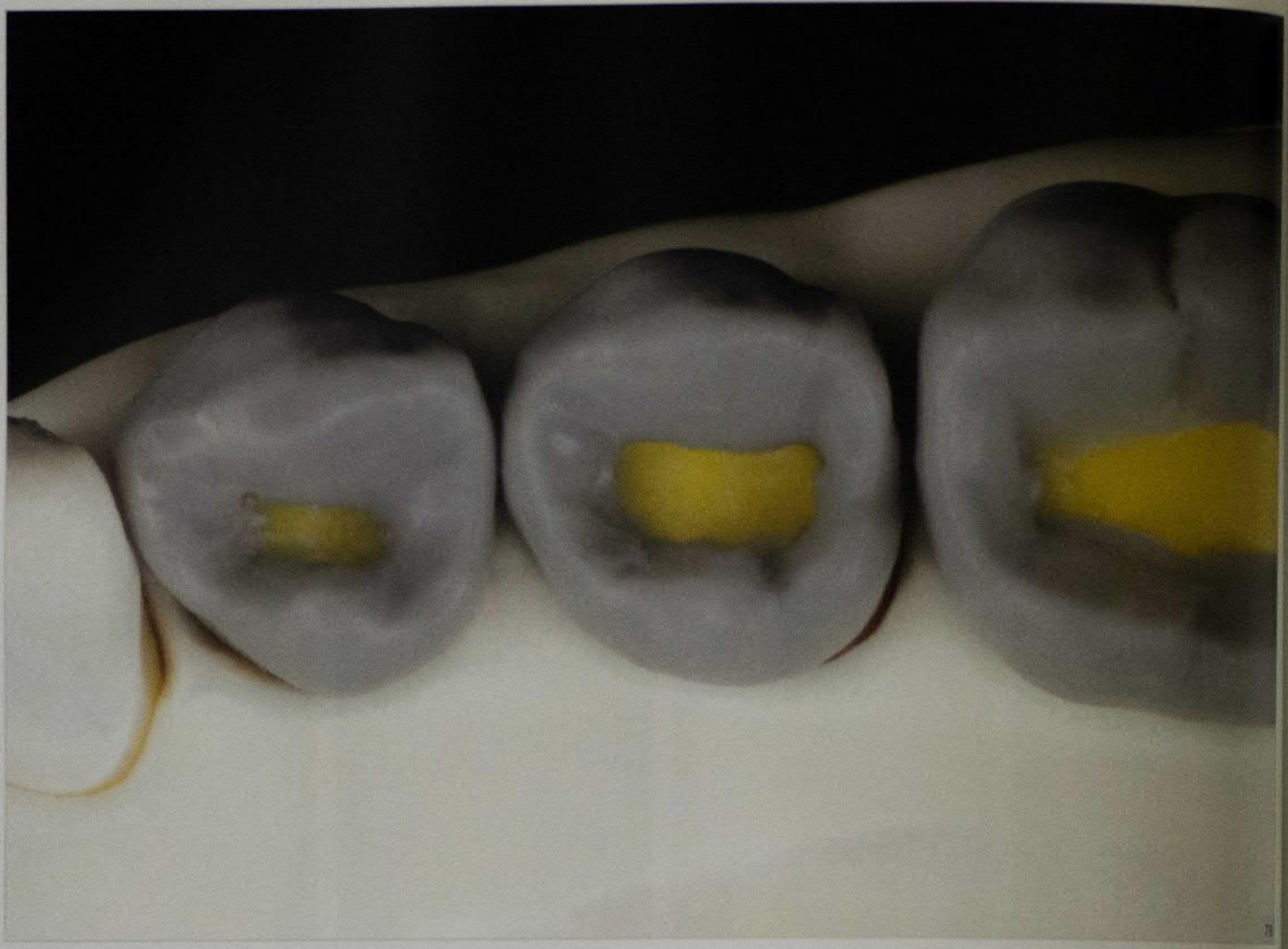
Figs 5-78a to 5-78c Before starting the wax-up of the occlusal surfaces, the cavity floor of the premolars and molars must be constructed by the addition of melted wax, in order to standardize the level of fossa and groove depths.

GROOVE DEPTH

The distance from the cusp tip to the fossa pit

Table 5-1 Groove depth is measured from the buccal cusp tip to the cavity floor as shown.

Mandibular First Premolar	Mandibular Second Premolar	Mandibular First Molar	Mandibular Second Molar
3.5 mm	3 mm	3 mm	3 mm



Occlusal Surface

Fig 5-79 Occlusal view of the mandibular premolars before the development of the occlusal surfaces.

Mandibular first premolar

Fig 5-80 The occlusal aspect of the mandibular first premolar after the development of the central lobe of the buccal cusp.

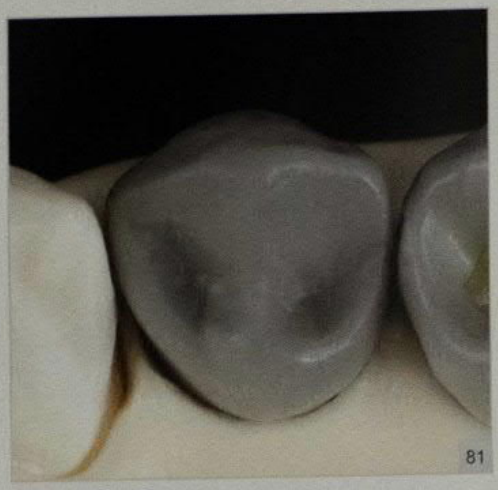


Fig 5-81 Observe that the central lobe of the buccal cusp should be more toward the lingual, making this cusp bulkier than its lingual counterpart. A fundamental characteristic is that this lobe is divided into transverse and oblique segments. The transverse segment is pointed toward the center of the tooth up to the principal groove. Next, the central lobe of the mesiolingual cusp should be transversely applied to the principal groove, which, along with the transverse segment of the buccal lobe, forms a peculiar anatomical characteristic called the *enamel bridge* that joins the cusps together. The enamel bridge delimits two occlusal fossae (mesial and distal), which can be identified by the glossier wax surface of the occlusal perimeter. The perimeter of the distal fossa looks like the letter *D*, and the mesial fossa has an backward D configuration.

Fig 5-82 Construction of the oblique segment of the central lobe of the buccal cusp pointed toward the distal fossa.

Fig 5-83 The refinement of the lobes should be performed at each step with carving instruments.

Fig 5-84 Construction of the distal lobe of the buccal cusp, pointed toward the center of the tooth up to the principal groove.

Fig 5-85 Observe the finished buccal cusp after the refinement of the lateral lobes.

Fig 5-86 The finished occlusal surface after developing the distolingual cusp, which has a small central lobe. The lateral lobes of the mesiolingual cusp should be small and extend to the principal groove. At this stage, it is important to finish the sculpting process with the carving instruments to define the slopes, marginal ridges, lobes, and grooves.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Mandibular second premolar

Fig 5-87 The central lobe of the buccal cusp of the mandibular second premolar. This lobe should be displaced toward the lingual and pointed toward the distal fossa, which has a convexity that can make contact with the convexity of the central lobe of the palatal cusp of the maxillary second premolar.

Fig 5-88 The lateral lobes of the buccal cusp. These lobes are narrow and pointed toward the center of the tooth without extending to the principal groove.

Fig 5-89 The central lobe of the distolingual cusp can make contact with the distal incline of the palatal cusp of the maxillary second premolar. Also, the lobe of the distal marginal ridge should be developed, with a triangular shape, pointed toward the central groove.

Fig 5-90 The central lobe of the mesiolingual cusp, with oblique and transverse segments. The transverse segment is pointed toward the transverse segment of the buccal cusp to form the enamel bridge. The region of the central lobe that points toward the distal aspect can make contact with the mesial incline of the palatal cusp of the maxillary second premolar. The contact points described in this region allow a tripod configuration with the antagonist teeth.

Fig 5-91 Wax is added for construction of the lobe of the mesial marginal ridge. In this tooth, the lobes of the marginal ridges are less distinct.

Fig 5-92 After positioning of the lobe of the mesial marginal ridge, pointed toward the mesial fossa, a refinement should be made with a carving instrument. During this procedure, lobes of different sizes should be reproduced and the grooves highlighted according to their depths and directions.

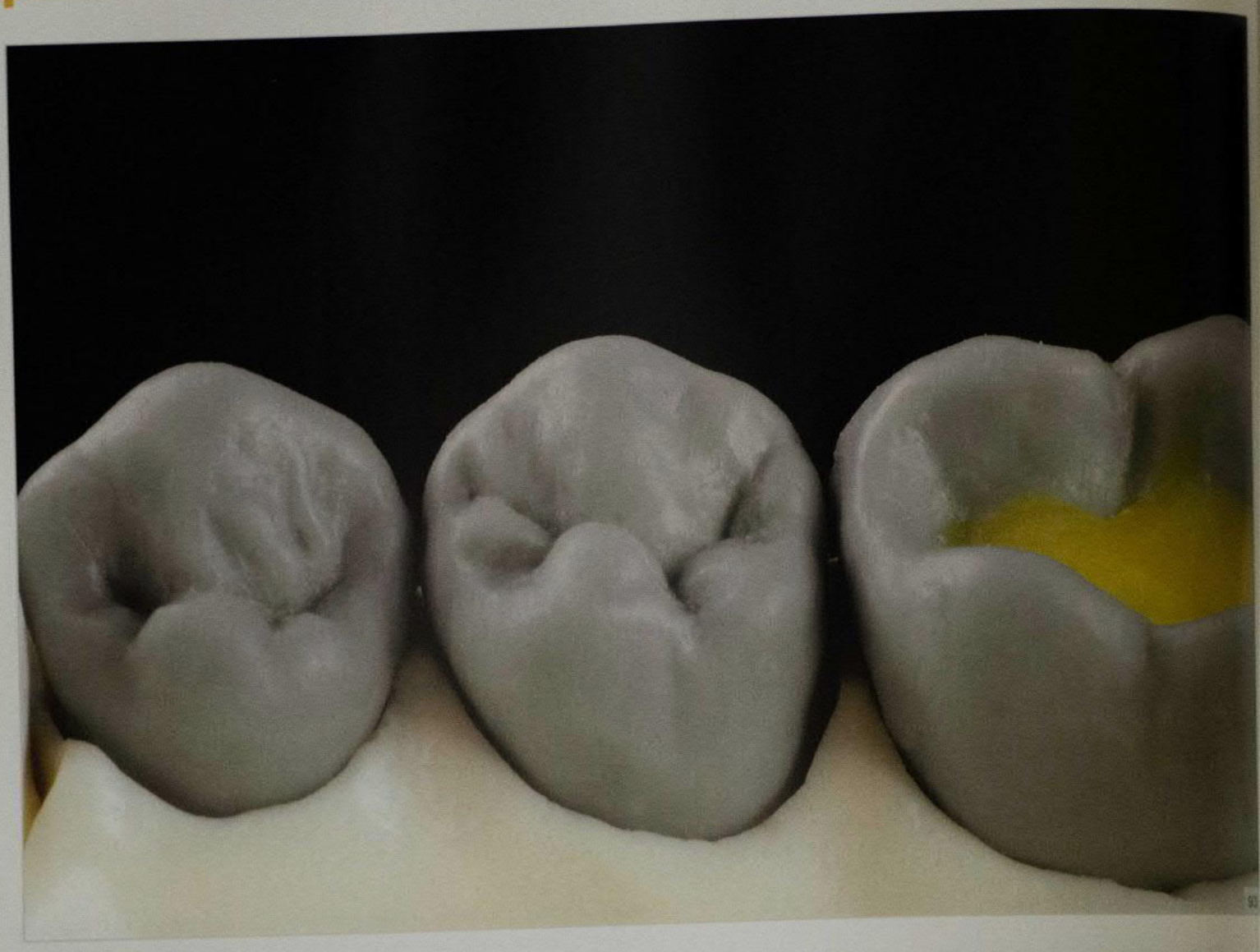
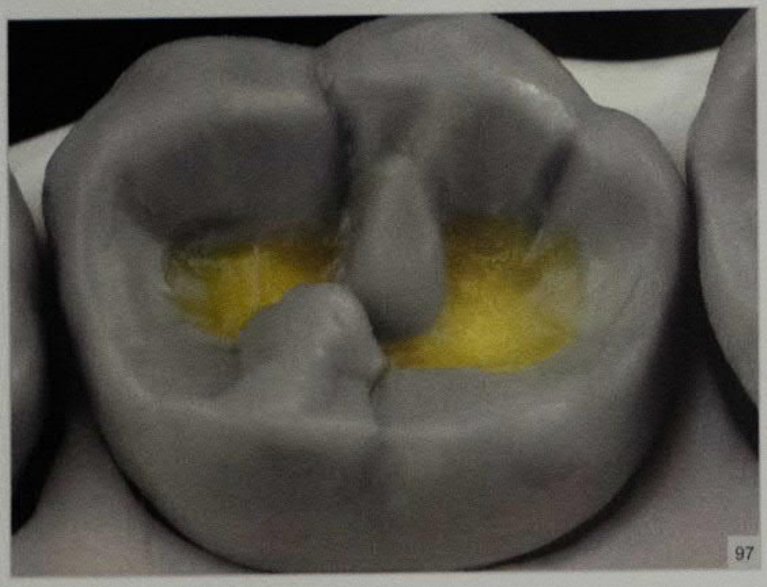
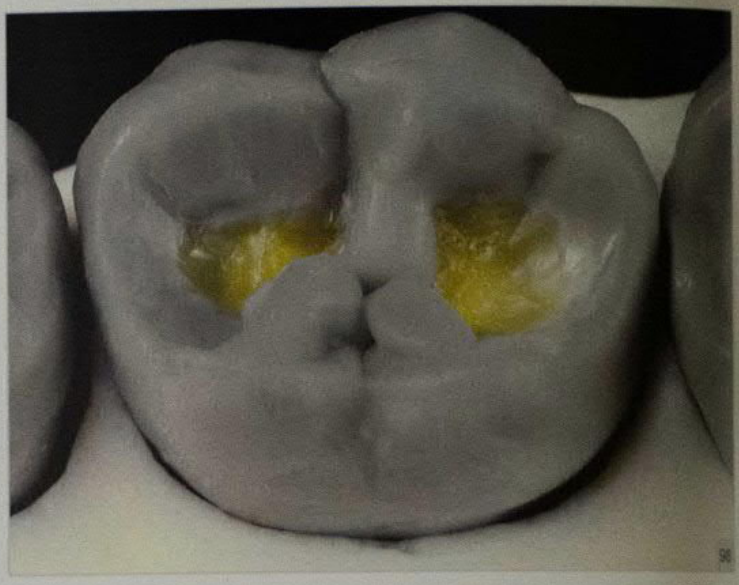


Fig 5-93 Occlusal view of the mandibular premolars after the wax-up process.

Fig 5-94 Observe that in the second premolar, the principal groove should be shifted toward the lingual because of the amplitude of the buccal cusp. The mesiodistal groove gives it an M shape. The association between the occlusolingual, occlusodistobuccal, and occlusomesiobuccal grooves is similar to a Y or calyx configuration. Regarding the fossae, the perimeter of the mesial fossa is similar to a backward letter *D*, whereas the perimeter of the distal fossa is similar to a crescent moon.





Mandibular first molar

Fig 5-95 In the mandibular first molar, the wax-up process starts with the development of the midbuccal cusp. Often, this cusp presents a triangular central lobe, transversally pointed toward the central fossa as far as the principal groove. When present, the lateral lobes are quite small. The distal limit of the midbuccal cusp contributes to the formation of the occlusodistobuccal groove. Here, one must pay attention to the determination of centric contacts, as will be described in the next figures.

Fig 5-96 A contact should occur between the central lobe of the midbuccal cusp and the central lobe of the mesiopalatal cusp of the maxillary first molar.

Fig 5-97 The mesiolingual cusp has been developed. Here, the central lobe is divided into two segments: oblique and transverse. This characteristic is specific to the mesial cusps of the mandibular teeth. This figure shows the wax-up of the oblique segment, pointed toward the central fossa, which can be extremely convex to allow contact with the mesial incline of the mesiopalatal cusp of the maxillary first molar. Now the distal lobe of this cusp can be defined; it should be small and pointed toward the center of the tooth without contacting the central groove.

Fig 5-98 The central lobe of the distolingual cusp, which runs oblique to the central fossa and determines the centric contact with the distal incline of the mesiopalatal cusp of the maxillary first molar. The mesial limit of this cusp contributes to the formation of the occlusolingual groove.

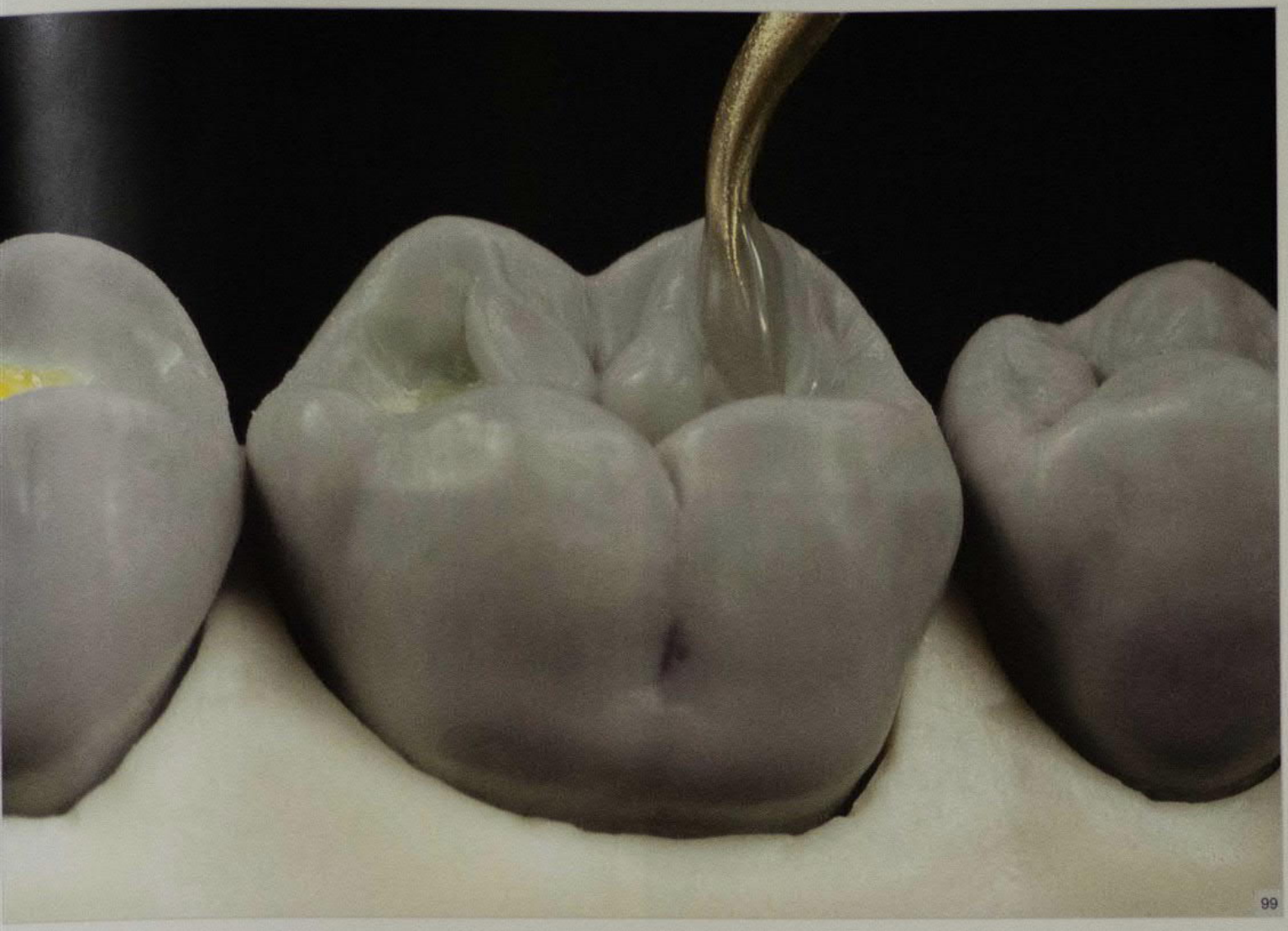
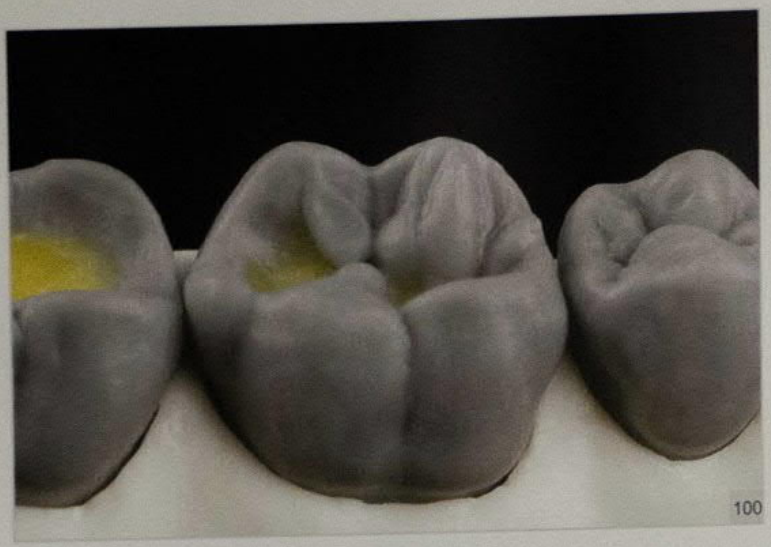
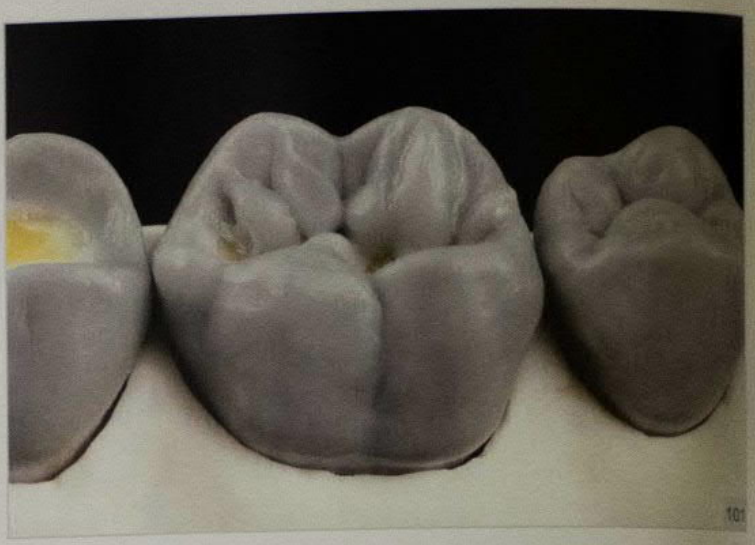


Fig 5-99 In a bucco-occlusal view, one can see the placement of melted wax for fabrication of the transverse segment of the mesiolingual cusp with the heated instrument.





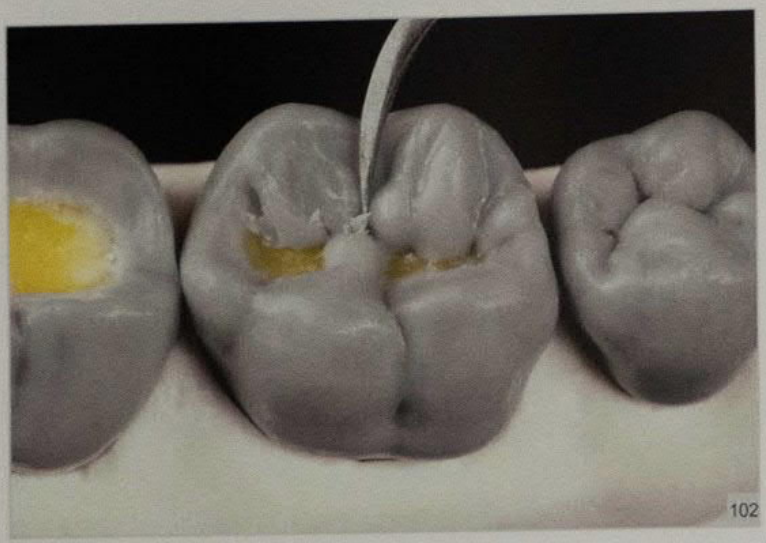
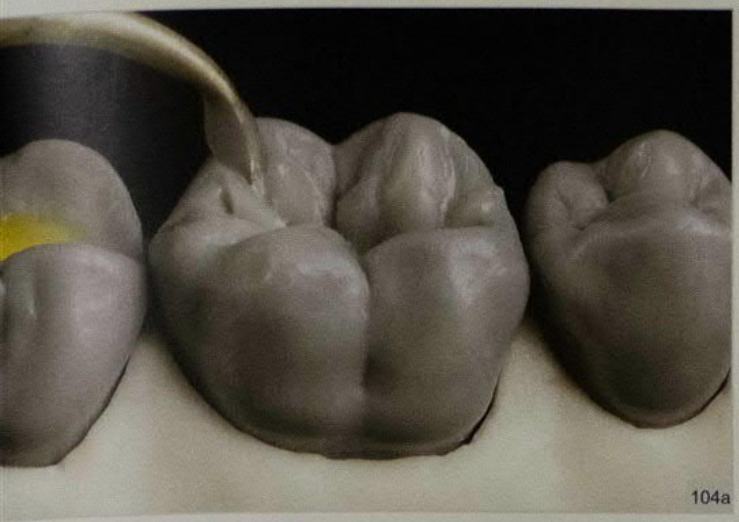


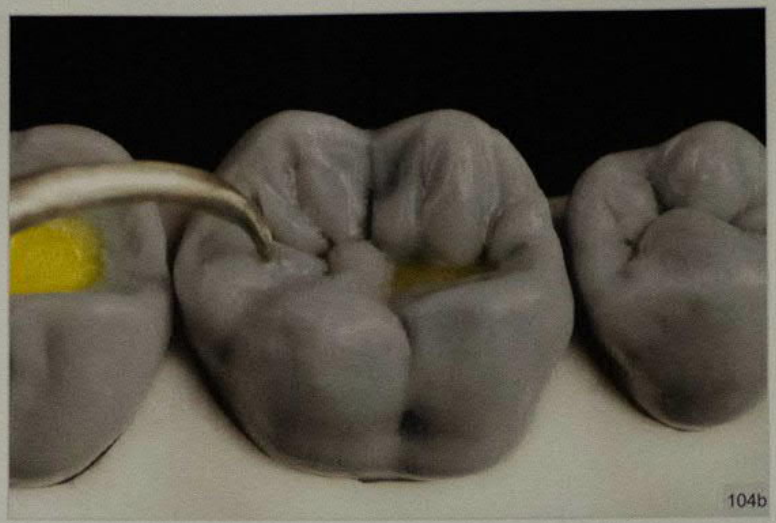
Fig 5-100 Note that the lateral lobes of the mesiolingual cusp are quite small and pointed toward the central fossa, without reaching the groove.

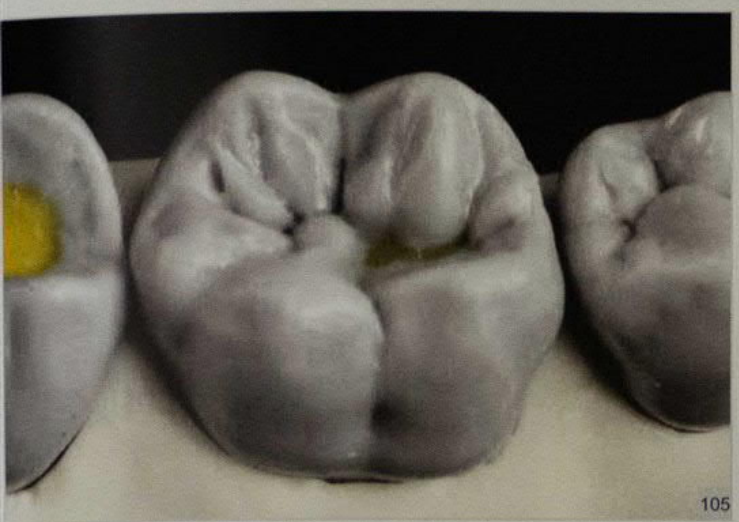
Fig 5-101 The distal lateral lobe of the distolingual cusp, which extends to the principal groove at the distal fossa. On the other hand, the mesial lobe is small and pointed toward the central fossa. It is important to make clear that the sizes of the lateral lobes are highly variable and that their reproduction determines the esthetics of the wax-up process.

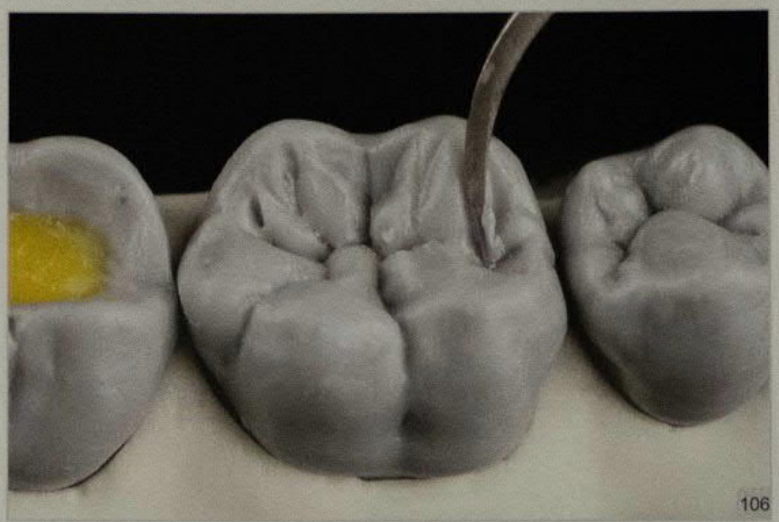
Fig 5-102 The lingual cusps are refined with a carving instrument to highlight the secondary lobes and grooves.

Fig 5-103 Occlusal view of the finished lingual cusps. Observe the formation of the occlusolingual groove.









Figs 5-104a and 5-104b The distobuccal cusp has been developed.

Fig 5-105 Frequently there is a single central lobe on the distobuccal cusp, pointed toward the distal fossa.

Fig 5-106 The central lobe of the mesiobuccal cusp is developed, according to the same technique already used for the mesiolingual cusp. The central lobe of this cusp can have either a prominent or a subtle configuration, sometimes divided into oblique and transverse segments.

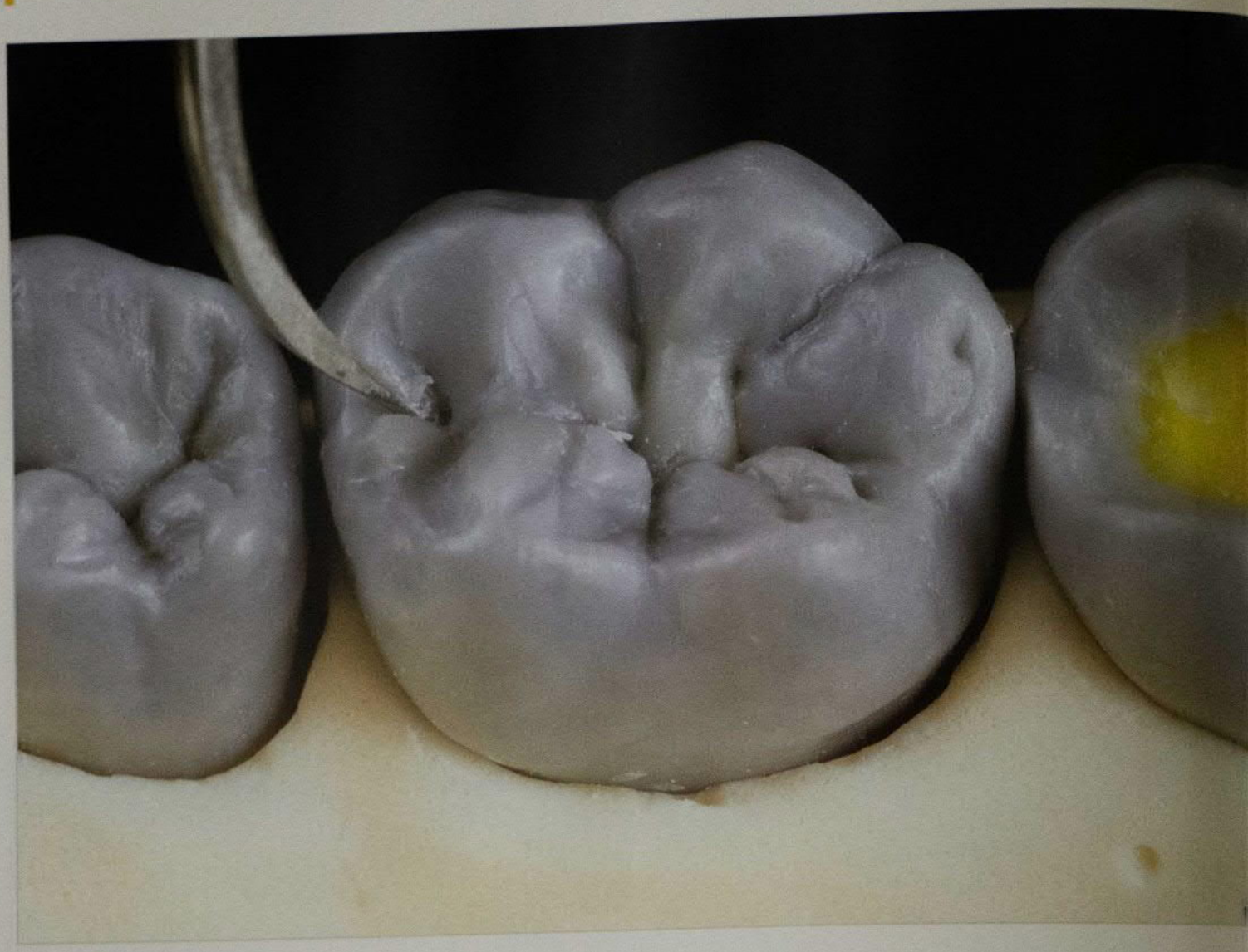
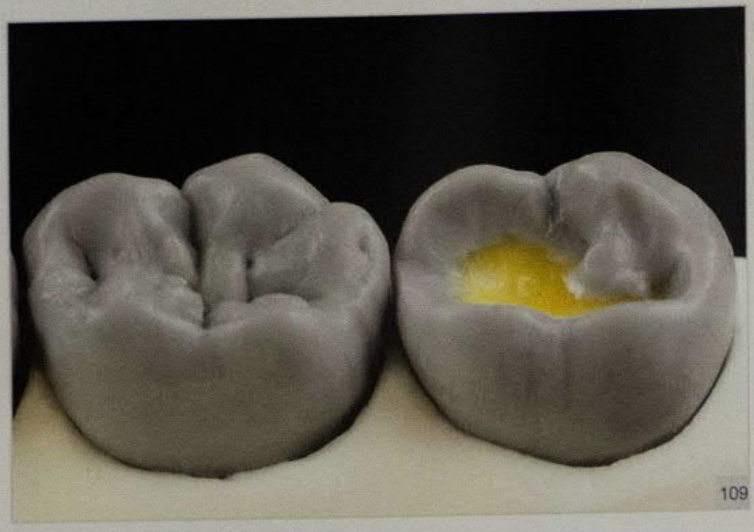
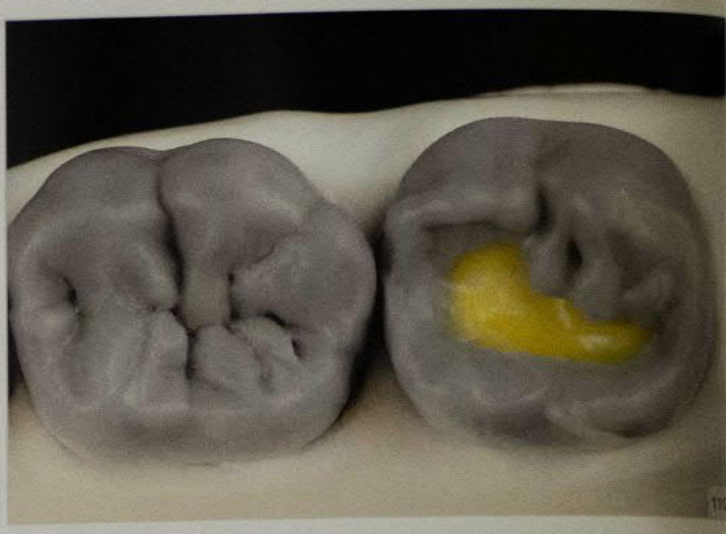
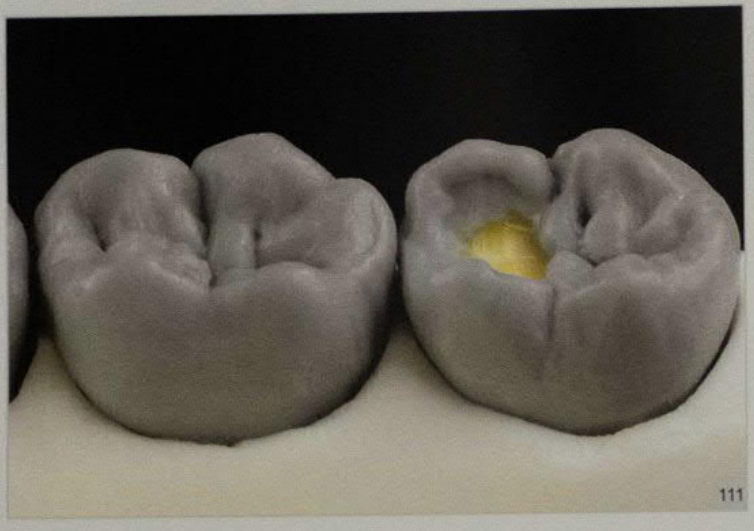


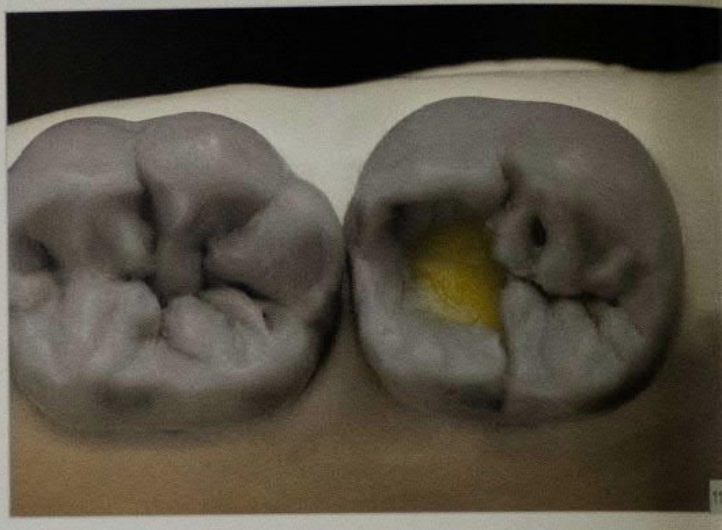
Fig 5-107 Refinement of the mesiobuccal cusp and grooves. The mesial and distal lobes are small and pointed toward the center of the tooth. Their distal limits determine the occlusomesiobuccal groove.

Figs 5-108a to 5-108c The occlusal surface is finished. Observe the anatomical characteristics reproduced according to the details presented in chapter 2. In the next stage, it is possible to visualize a sinusoidal principal groove. The union of the mesiodistal, occlusolingual, occlusodistolingual, and occlusomesiolingual grooves forms the letter *M*. Parts of the mesiodistal, occlusobuccal, and occlusodistobuccal grooves determine a Y-shaped configuration. There are three fossae: mesial, central, and distal. The perimeters of the mesial and distal fossae are shaped like a leaf. The central fossa looks like a spool.









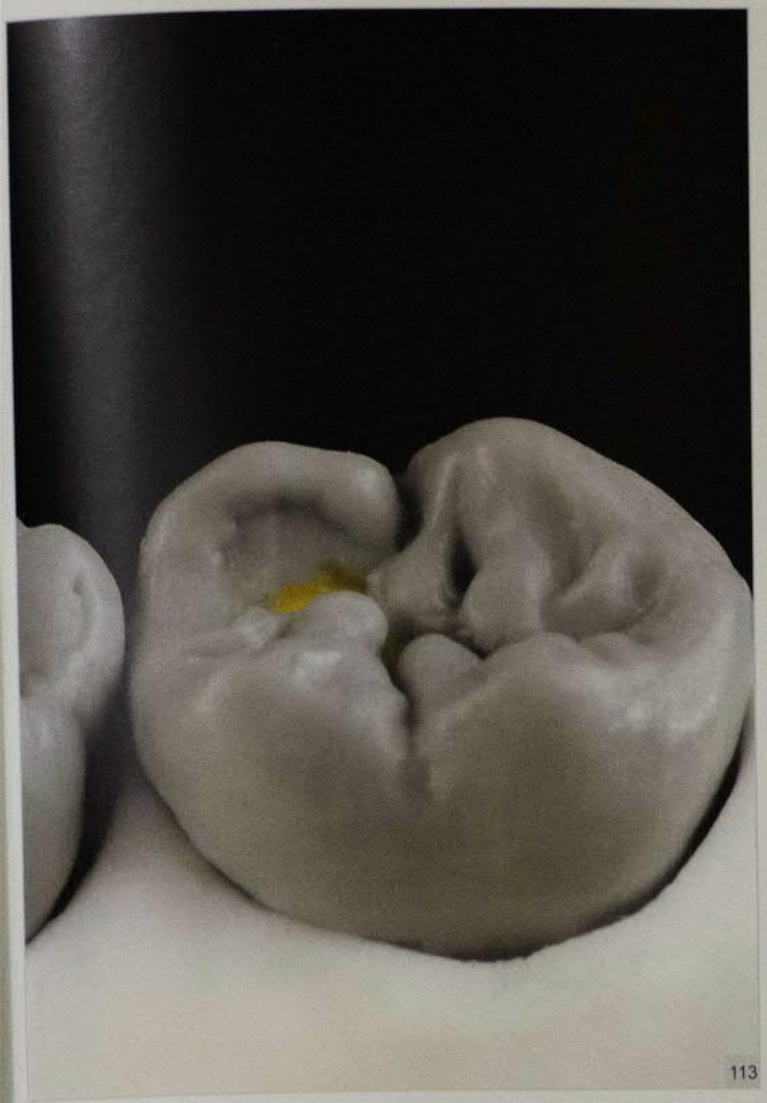
Mandibular second molar

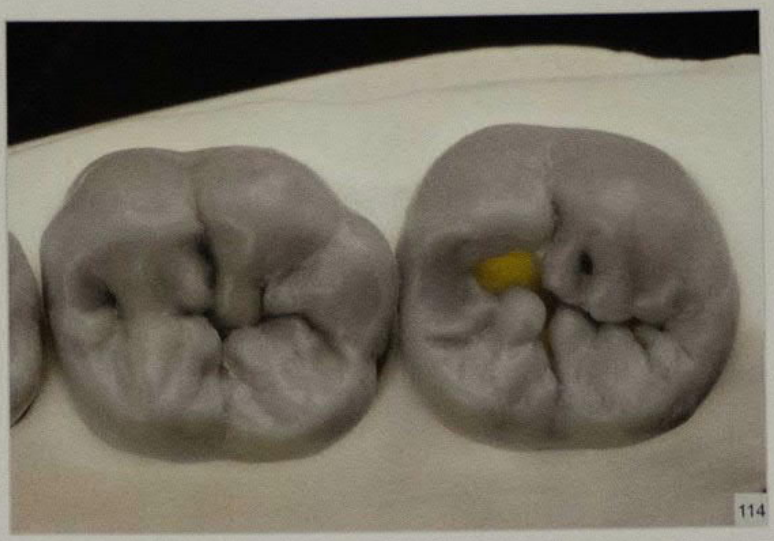
Fig 5-109 The central lobe of the distobuccal cusp of the mandibular second molar. This lobe should be transversely pointed toward the central fossa, making contact with the central lobe of the mesiopalatal cusp of the maxillary second molar.

Fig 5-110 The lateral lobes of the distobuccal cusp. Observe that the mesial lobe should be transversely pointed toward the central fossa, forming the occlusobuccal groove at its mesial limit. The distal lobe should be obliquely pointed toward the distal fossa.

Fig 5-111 Placement of the distolingual cusp.

Fig 5-112 On the distolingual cusp, the central lobe should be directed to t central fossa and should determine a contact with the distal incline of the mesi palatal cusp of the maxillary second molar. The lateral lobes are small, with the m sial lobe pointed toward the central fossa and the distal lobe toward the distal foss





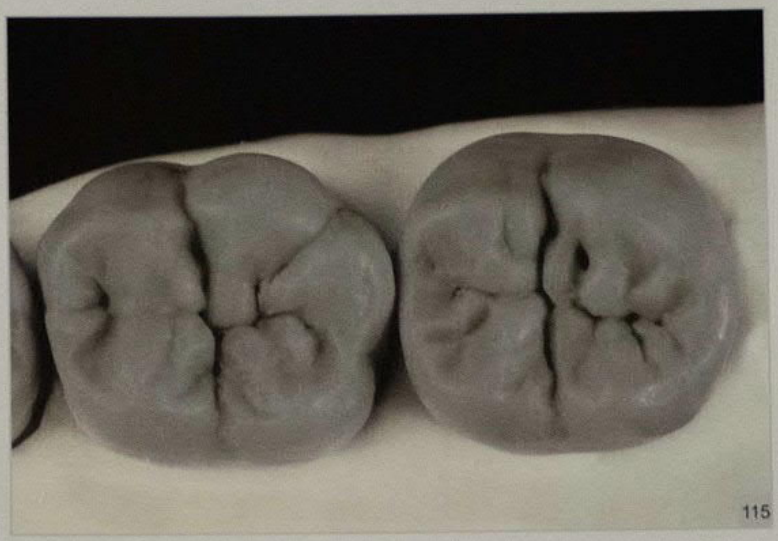


Fig 5-113 The mesiolingual cusp has been developed.

Fig 5-114 At the mesiolingual cusp, the central lobe is highly segmented, with an oblique and a transverse portion, also directed to the central fossa, forming a convexity that provides contact with the mesial incline of the mesiopalatal cusp of the maxillary second molar. The lateral lobes are small, the mesial being directed to the mesial fossa and the distal to the central fossa, without extending to the principal groove.

Fig 5-115 The fabricated mesiobuccal cusp. The central lobe can be either prominent or inconspicuous, pointed toward the principal groove. The mesial lobe is less bulky than its distal counterpart, which is more highly accentuated and pointed toward the central fossa. The distal limit of this cusp determines the occlusobuccal groove. Also, a small lobe should be fabricated on the mesial marginal ridge to finish the wax-up of the occlusal surface. Observe that on the second molar, the central groove has a discontinuous, cruciform shape. Like the mandibular first molar, it has three fossae: mesial, central, and distal. The perimeters of the mesial and distal fossae are shaped like a leaf. The central fossa looks like a spool.

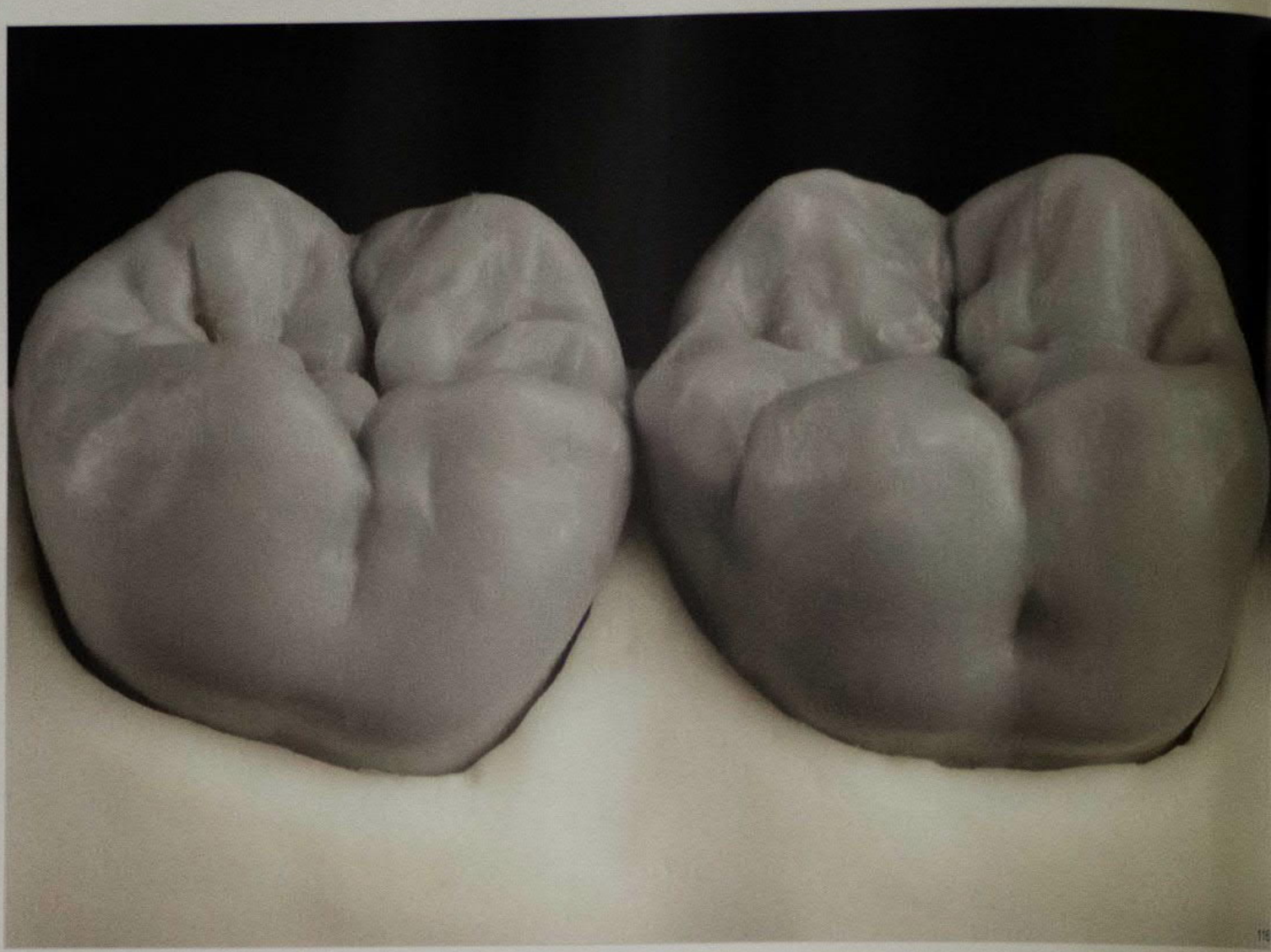


Fig 5-116 Occlusobuccal view of the finished mandibular molars. Observe the finishing and texturing process performed with carving instruments and polishing brushes.

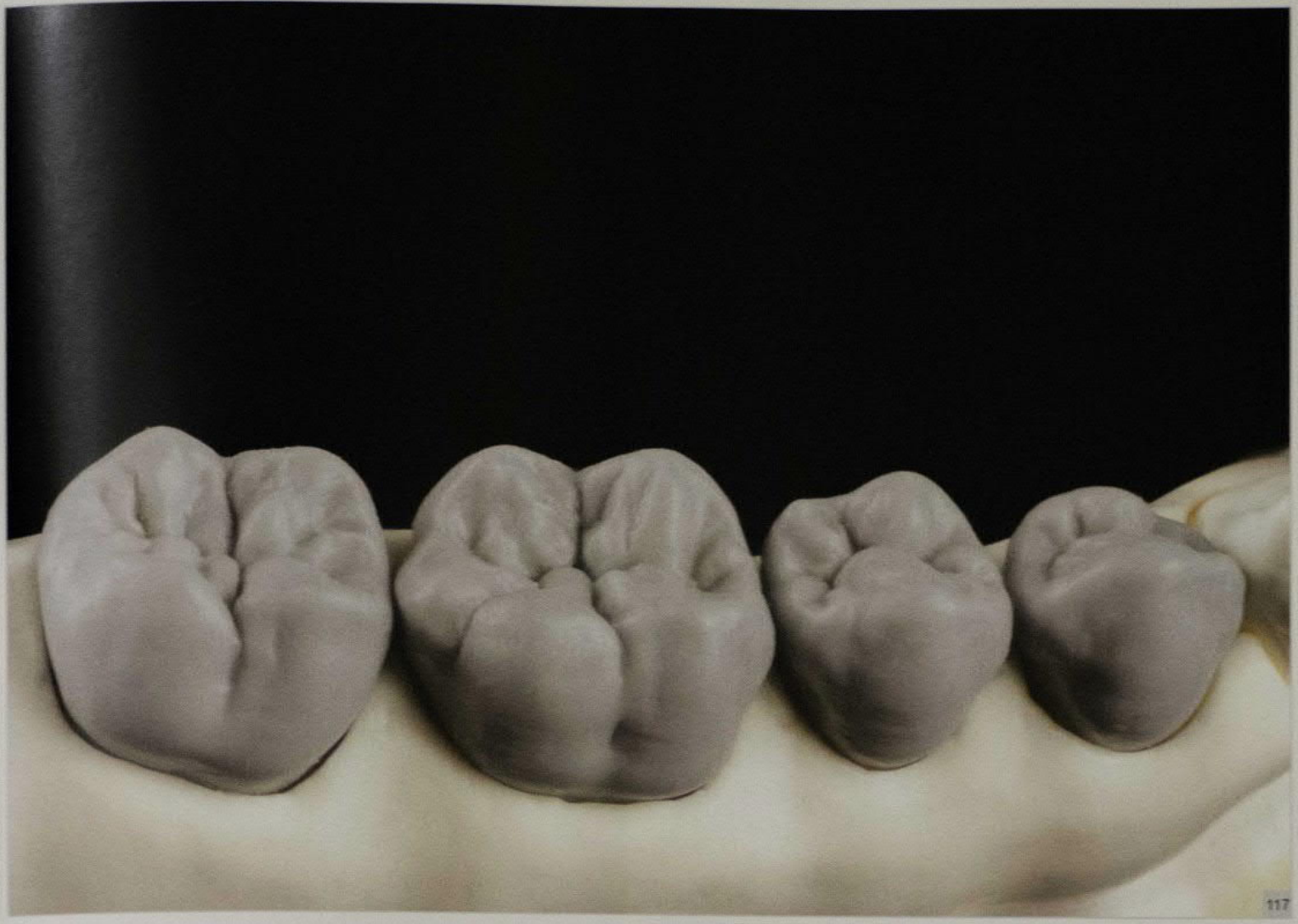
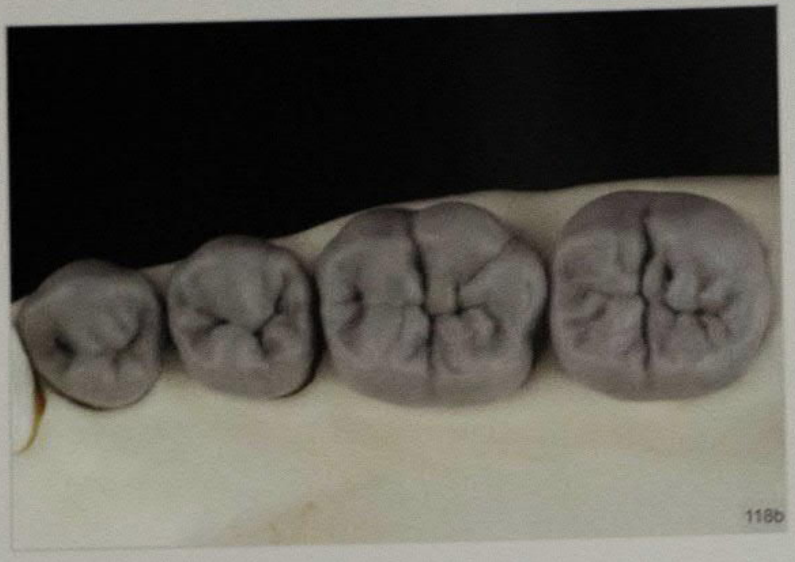
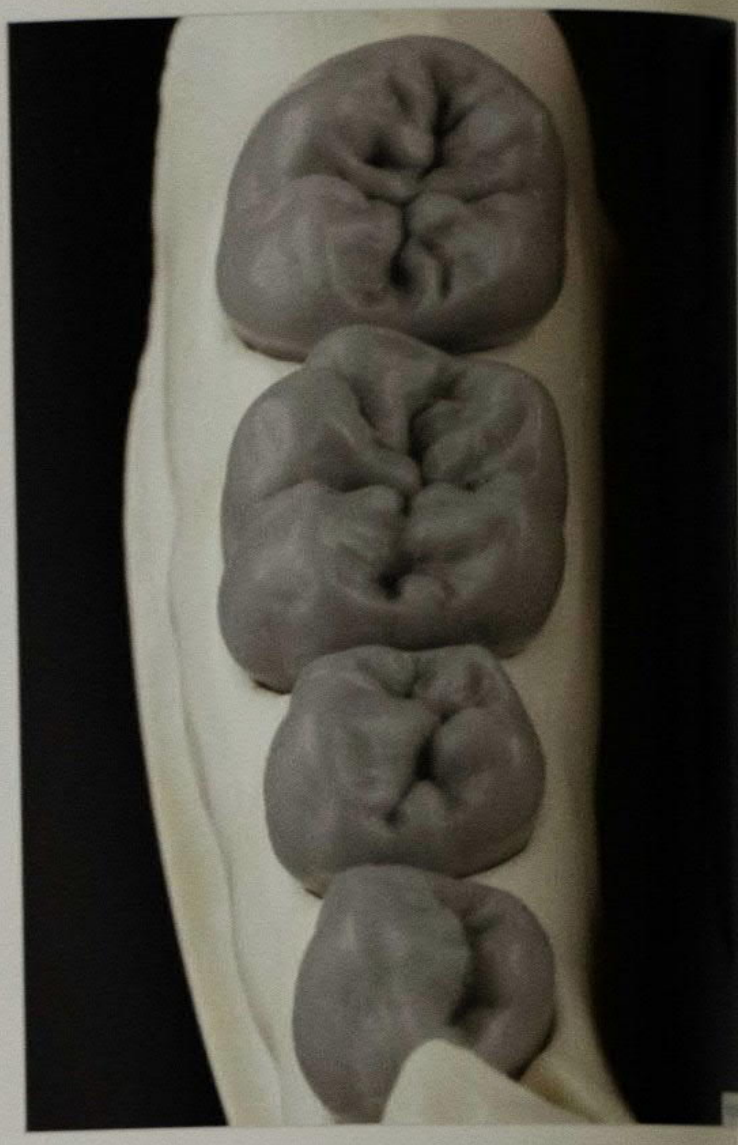


Fig 5-117 View of the finished mandibular premolars and molars.





Figs 5-118a to 5-118c The finished mandibular premolars and molars.

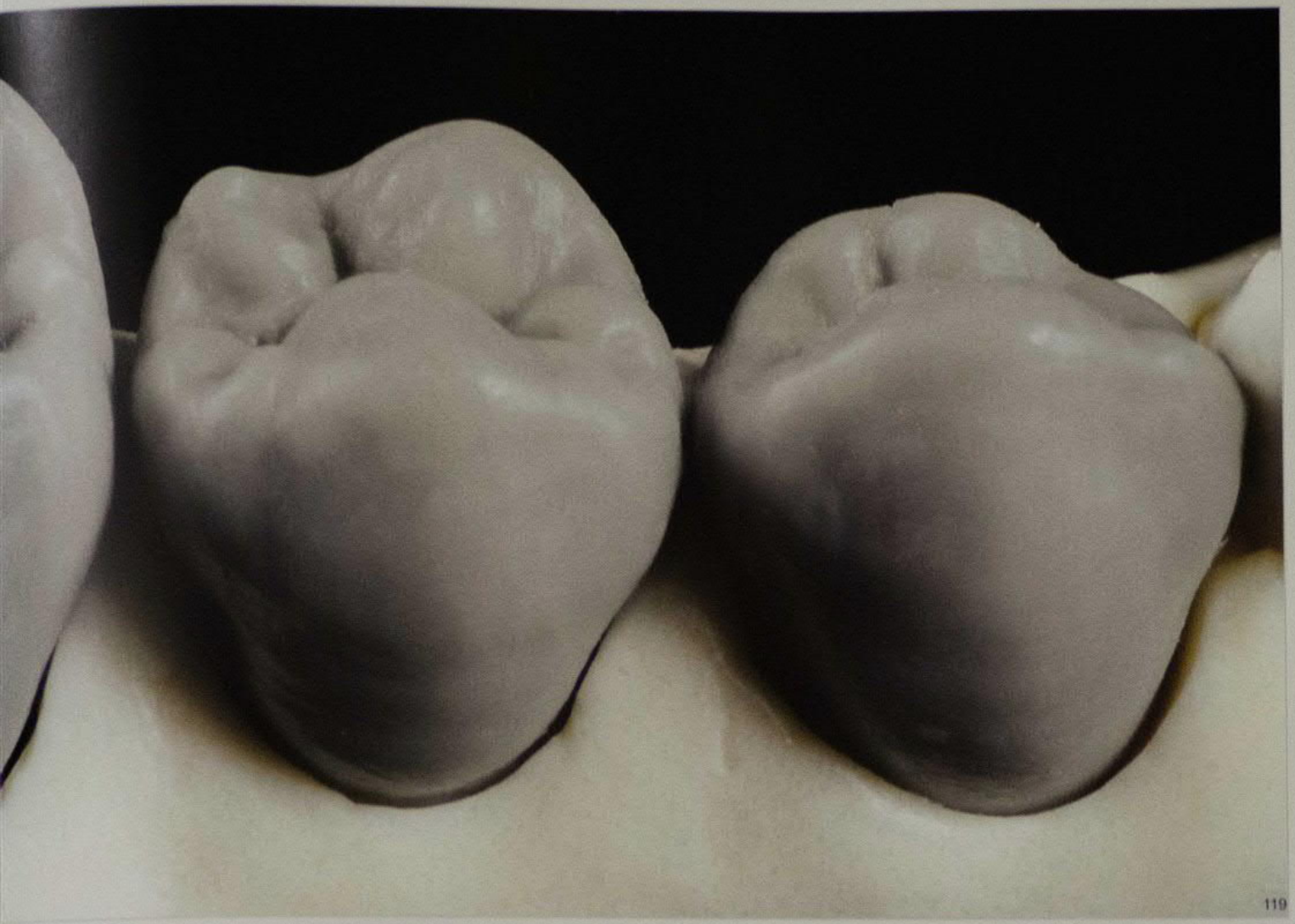
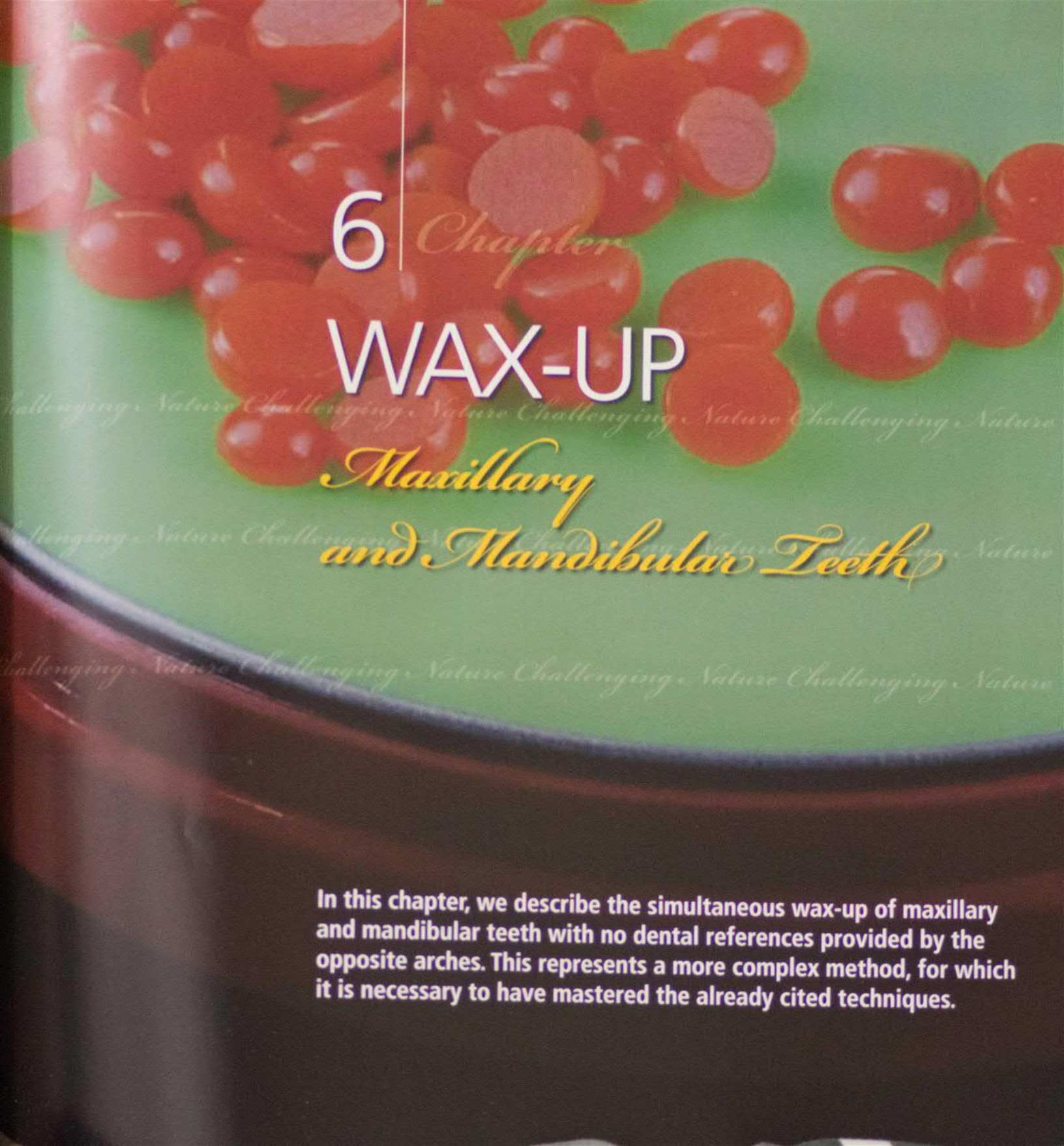


Fig 5-119 Occlusobuccal view of the finished mandibular premolars.



6 Chapter WAX-UP

Maxillary and Mandibular Teeth

In this chapter, we describe the simultaneous wax-up of maxillary and mandibular teeth with no dental references provided by the opposite arches. This represents a more complex method, for which it is necessary to have mastered the already cited techniques.

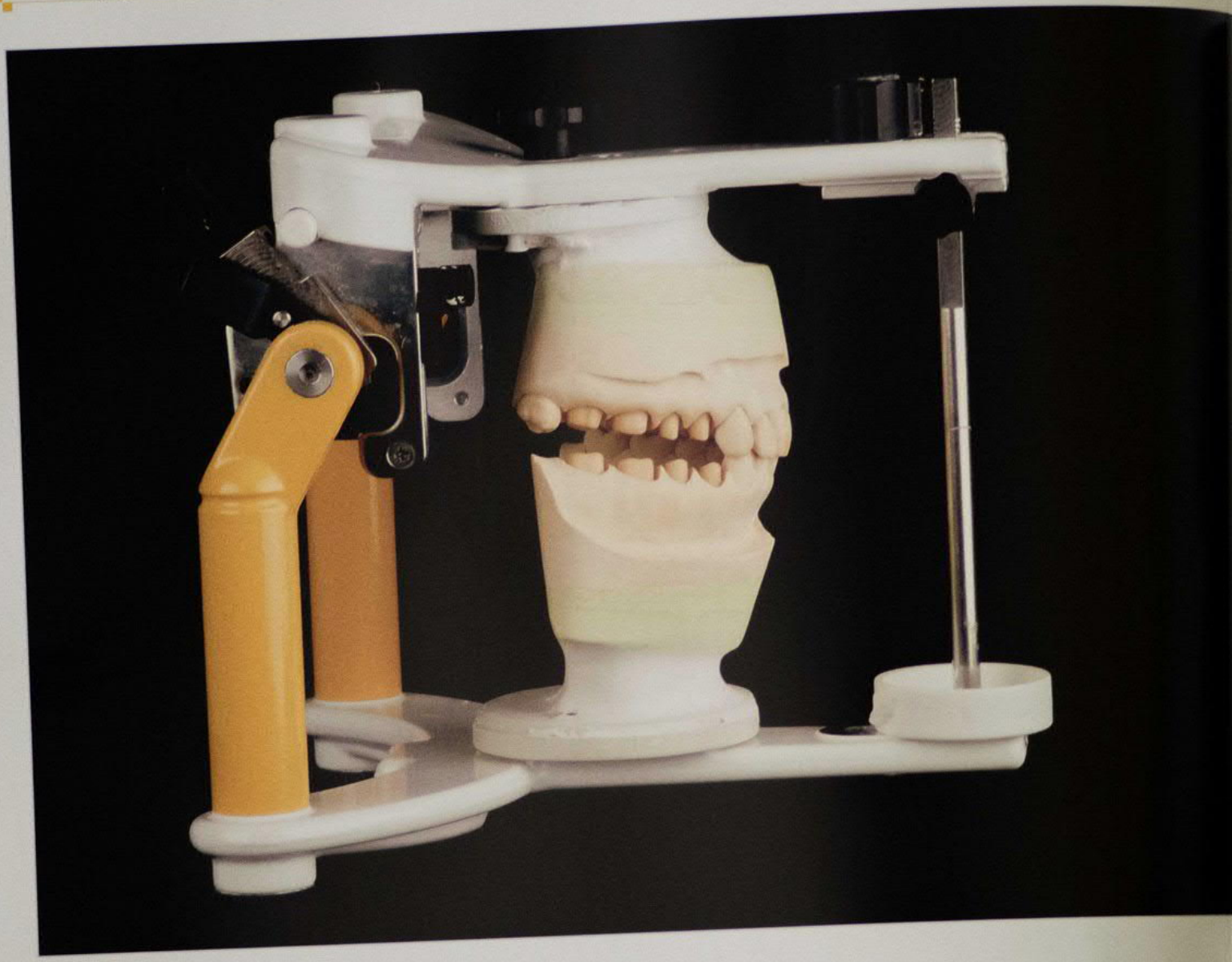


Fig 6-1 Similarly to the techniques already described in earlier chapters, the stone casts should be mounted in a semi-adjustable articulator to establish the appropriate occlusal contacts. Note here that only the right side is prepared for the wax-up process.

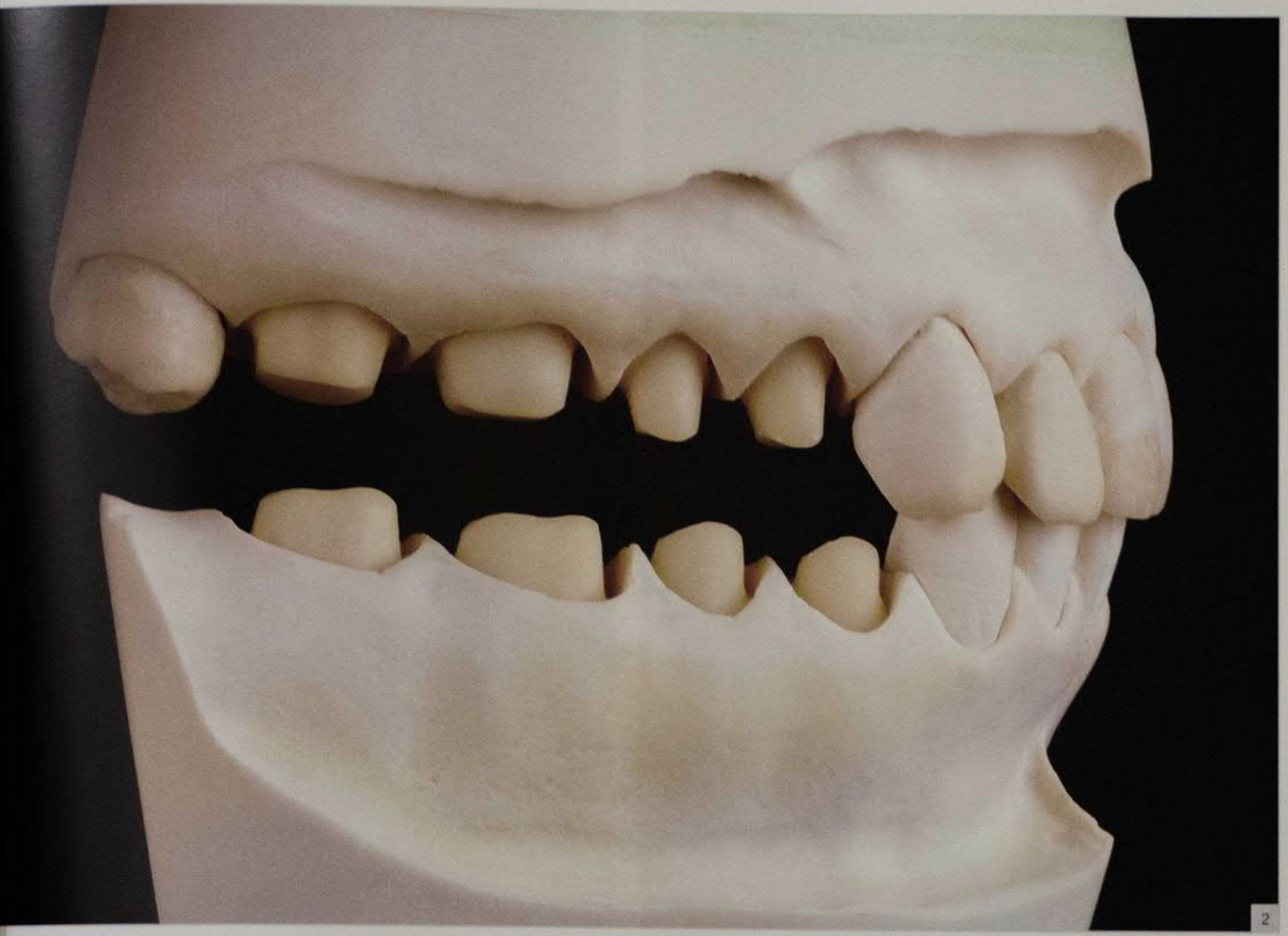


Fig 6-2 Lateral view of the articulated casts. There are no references in the antagonist teeth.

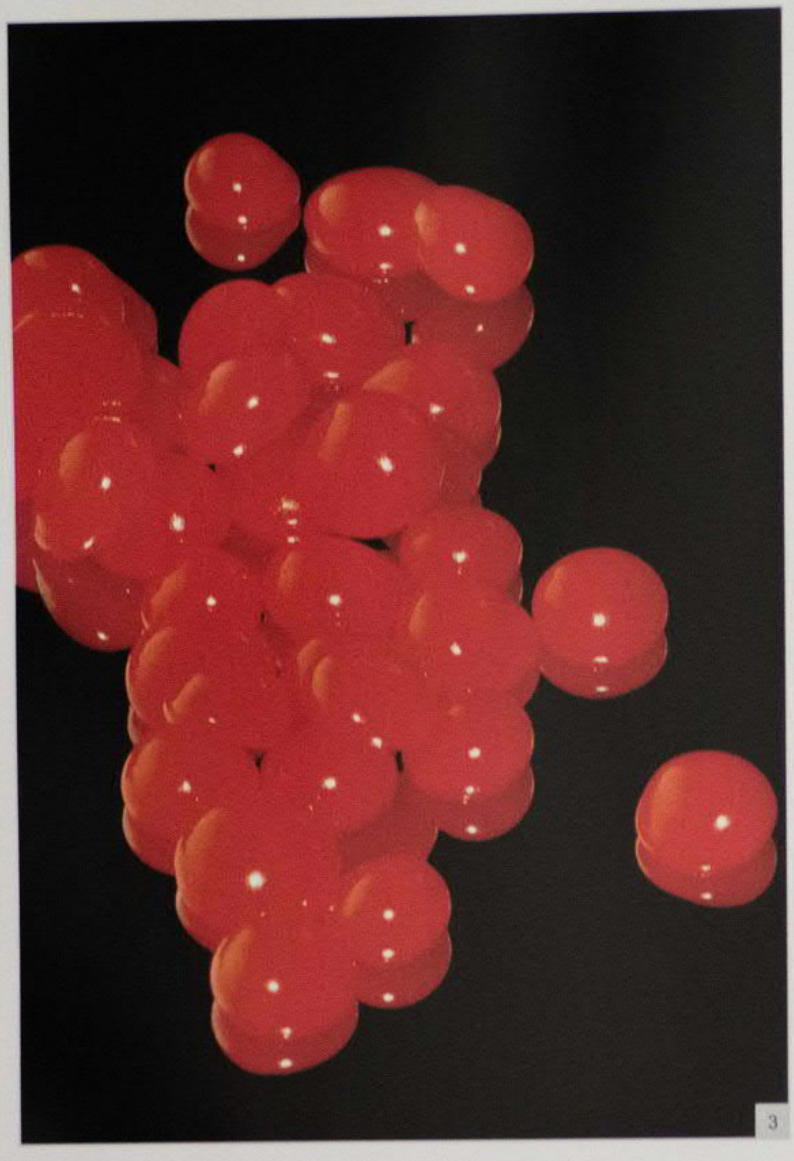


Fig 6-3 Red dipping wax (Duro Dip, all dente Dentalprodukte GmbH, Germany), which should be melted for wax coping fabrication. Another type of wax can be used in this procedure.

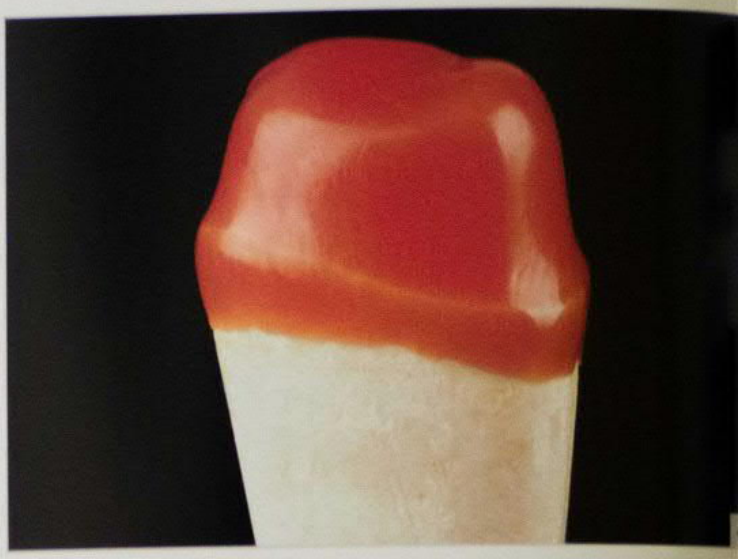


Fig 6-4 Die of the mandibular right first molar with excess wax. Remember 0.5-mm thickness of wax is necessary to maintain adequate space between copings.

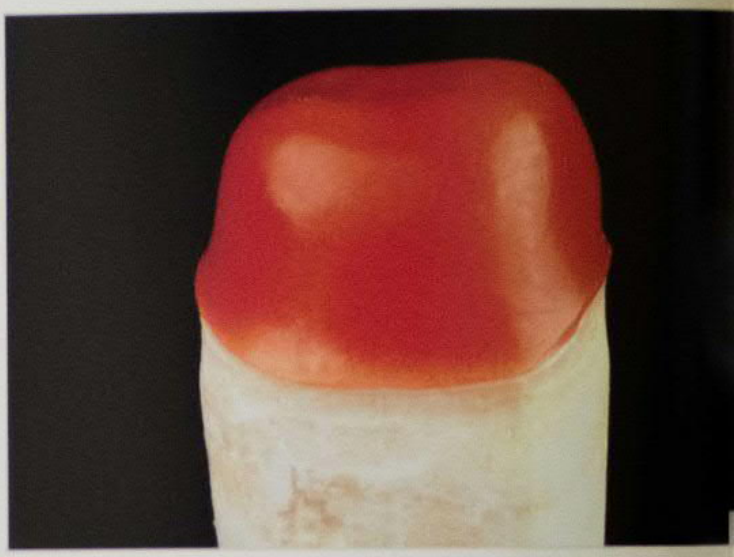


Fig 6-5 Finished wax coping of the mandibular right first molar.

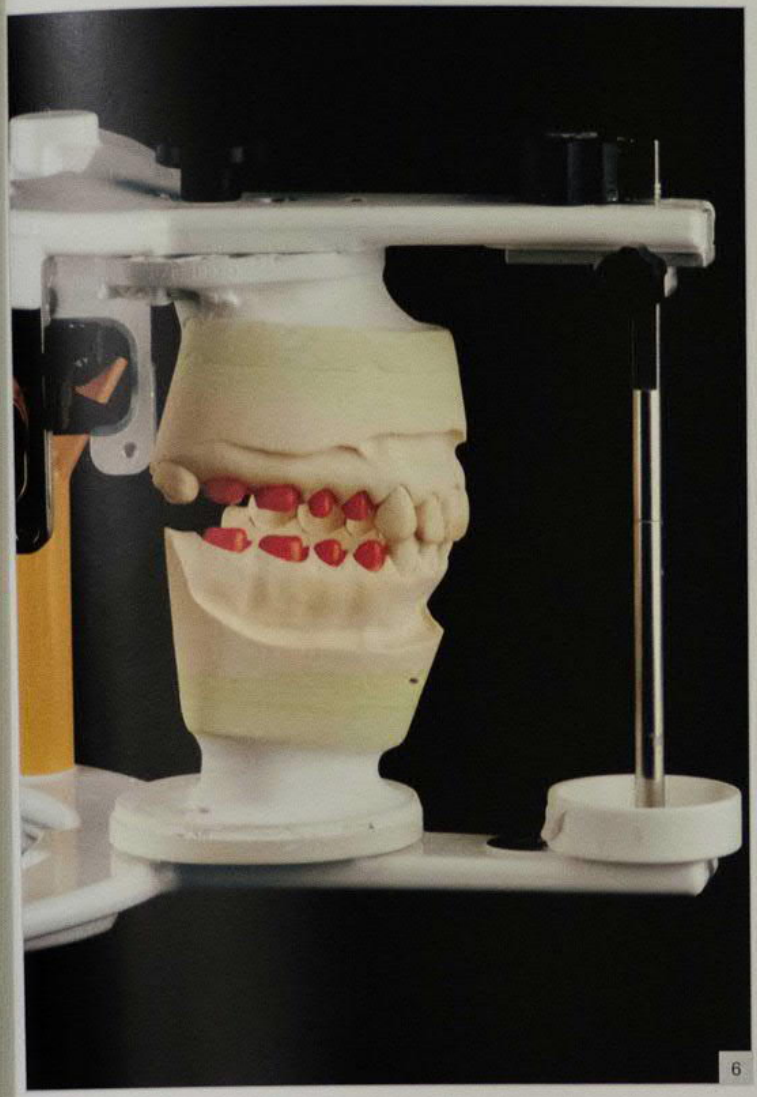


Fig 6-6 The articulated stone casts with their respective wax copings. Observe the interocclusal space between the opposing teeth.

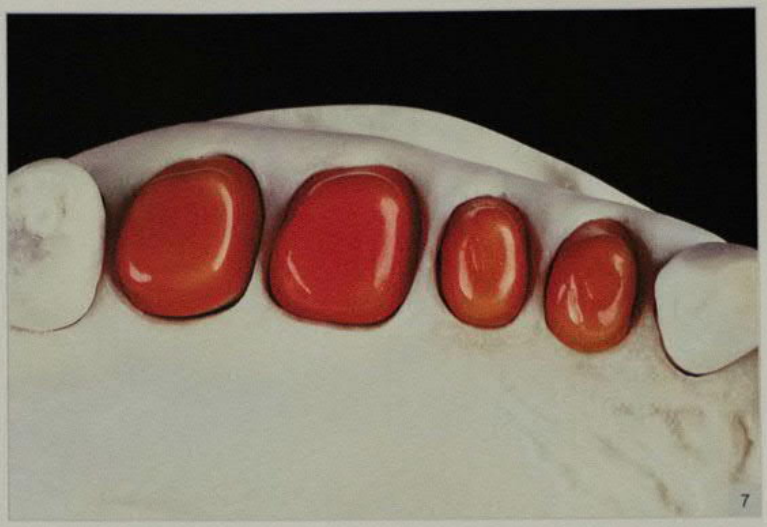


Fig 6-7 Occlusal view of the maxillary teeth after wax coping fabrication.

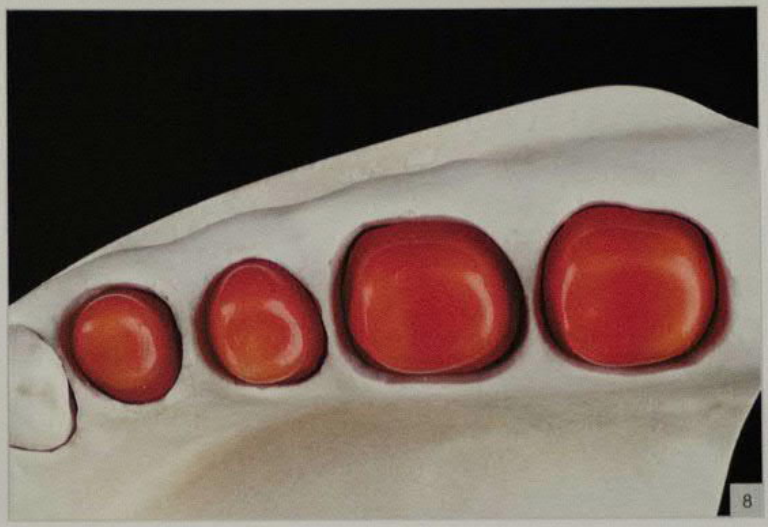
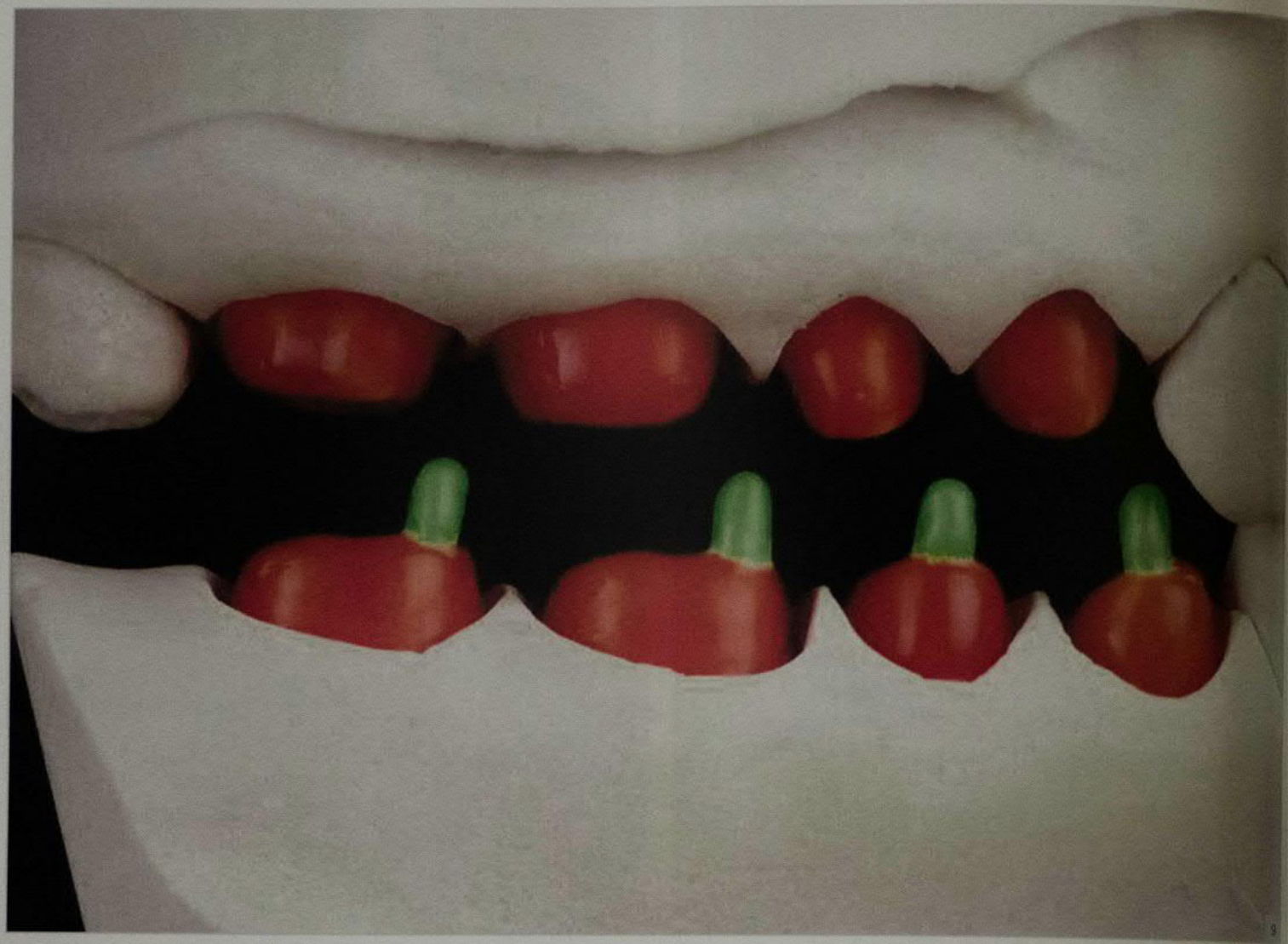


Fig 6-8 Occlusal view of the mandibular teeth after wax coping fabrication.



Mandibular Teeth – Buccal Surfaces

Fig 6-9 In this technique, the wax-up process should begin at the buccal surfaces of the mandibular teeth, based on the curve of Spee of the homologous teeth. This reference is easy to transfer when working with the stone casts. Conversely, the wax-up can be started with the buccal surfaces of the maxillary teeth, with the cusp tips following the smile line. However, the smile line is a visual reference that depends on other factors, such as the papillary line, commissural line, and other facial features. In this approach, the lack of opposing teeth increases the risk of augmenting the buccal surfaces of the maxillary teeth. Here, one can see the wax-up of the buccal and mesiobuccal cones of the premolars and molars, respectively. These cones should be pointed toward the midpoint of the buccal and lingual papillae of the antagonist teeth. The fabrication of the other molar cones is not applicable at this moment because they do not apply to references of the gingival papilla.

Fig 6-10 The height of the wax cones is similar to the height of the buccal cusps of the homologous teeth according to the curve of Spee.

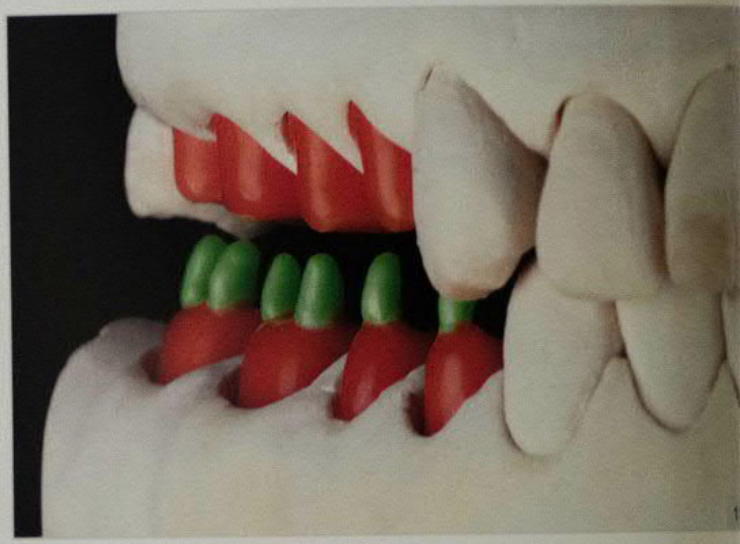
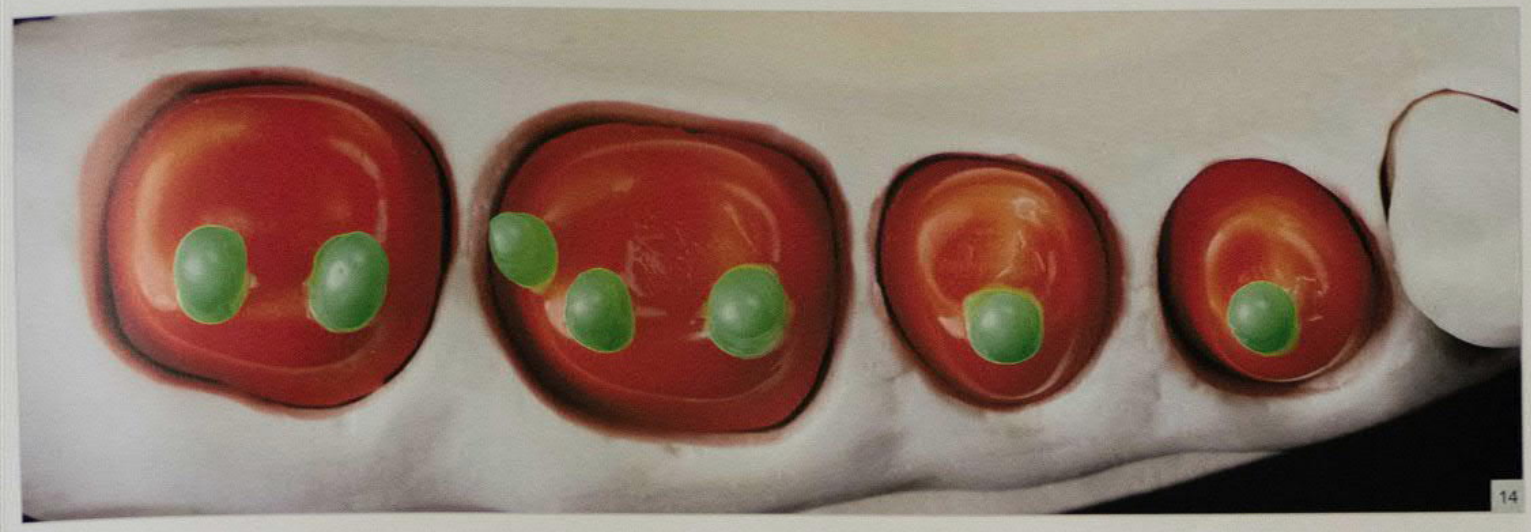


Fig 6-11 Next, the midbuccal and distobuccal cone cusps of the mandibular first and second molars, respectively, should be constructed. In the first mandibular molar, the midbuccal cone should be at the same height as the mesiobuccal cone. On the other hand, the distobuccal cone of the second mandibular molar can be slightly higher than the mesiobuccal cone, due to the lingual inclination of this tooth.

Fig 6-12 The midbuccal and distobuccal cones of the mandibular first and seco molars should be pointed toward the center of the crowns of the respective ant gonist teeth.

Fig 6-13 It is important to highlight that the buccolingual positioning of t buccal cones follows a parabolic curve that starts at the cusp tip of the mandibu canines.



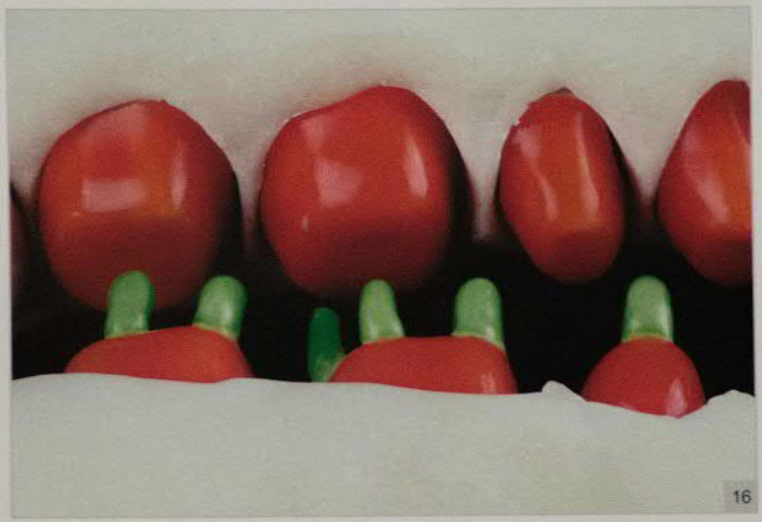


Fig 6-14 The distobuccal cone of the mandibular first molar does not follow the mesiodistal curve of the above-cited cones, which can be visualized in this occlusal view.

Fig 6-15 The distobuccal cone should be pointed toward the distal outline of the maxillary first molar and is slightly lower than the midbuccal cone.

Fig 6-16 Observe the buccolingual positioning of the distobuccal cone of the mandibular first molar. Its position varies according to the placement of the distal fossa of the maxillary first molar. To facilitate this procedure, it is necessary to imagine the shape of the developmental groove of the maxillary first molar (a Mercedes-Benz symbol) at the buccal longitudinal slopes of the mandibular first molar; the distobuccal cone should stay at the distal edge of this groove. The cusp is a little lower to prevent interference during excursive movements.

Fig 6-17 Here, the longitudinal slopes of the buccal cusp of the mandibular first premolar are developed.

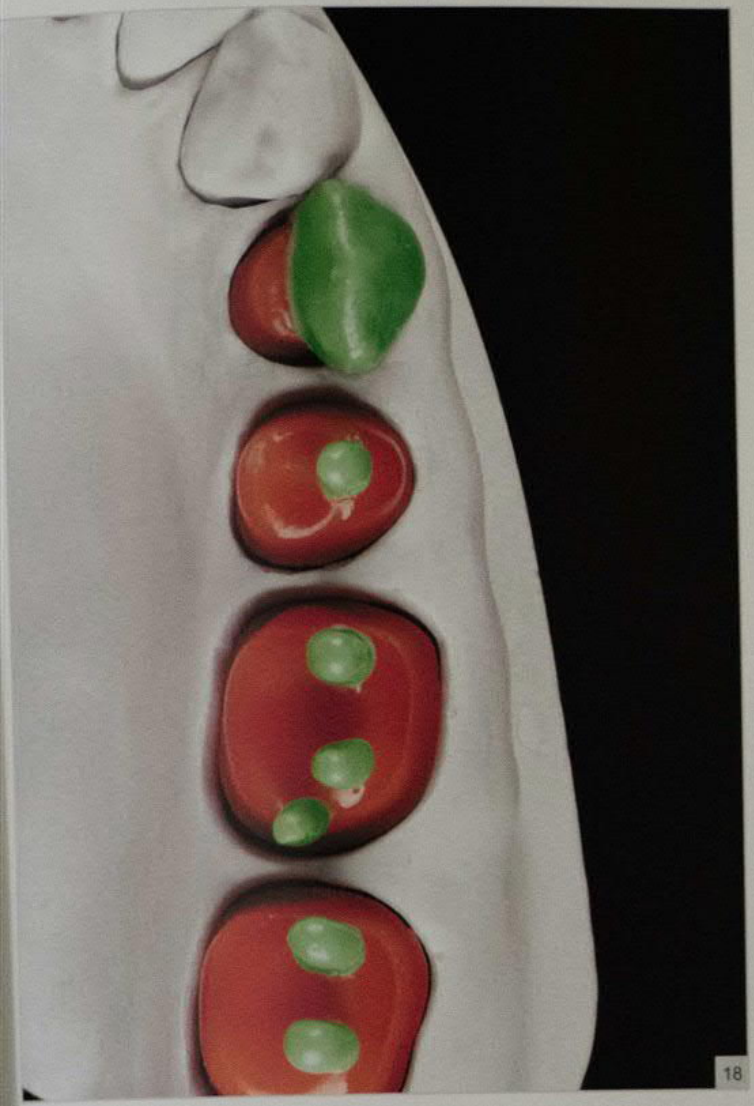


Fig 6-18 The finished occlusal aspect of the buccal surface. No excess wax is seen here, which could interfere in the development of the occlusal surface.

Fig 6-19 Finished buccal surface, with correct morphologic details (see chapter 2).

Fig 6-20 In the articulated stone casts, it is possible to see that the mesial outline of the buccal surface makes contact with the mandibular canine, whereas the distal outline is the center of the wax coping of the maxillary first premolar.

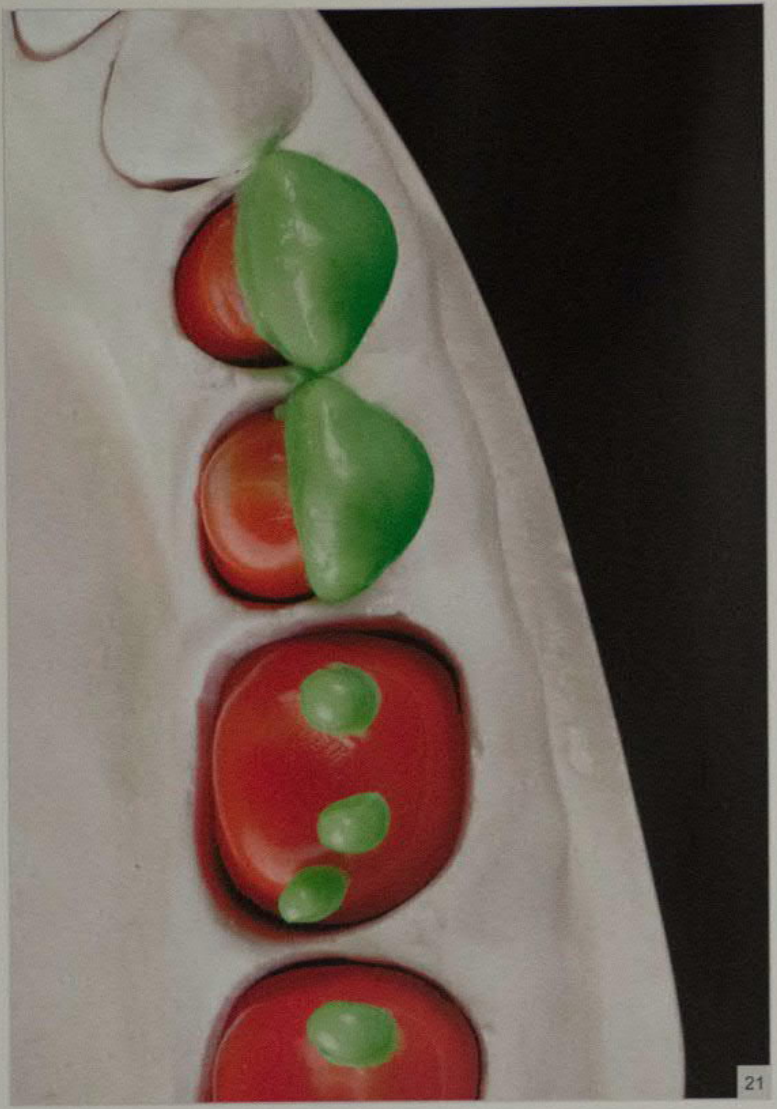
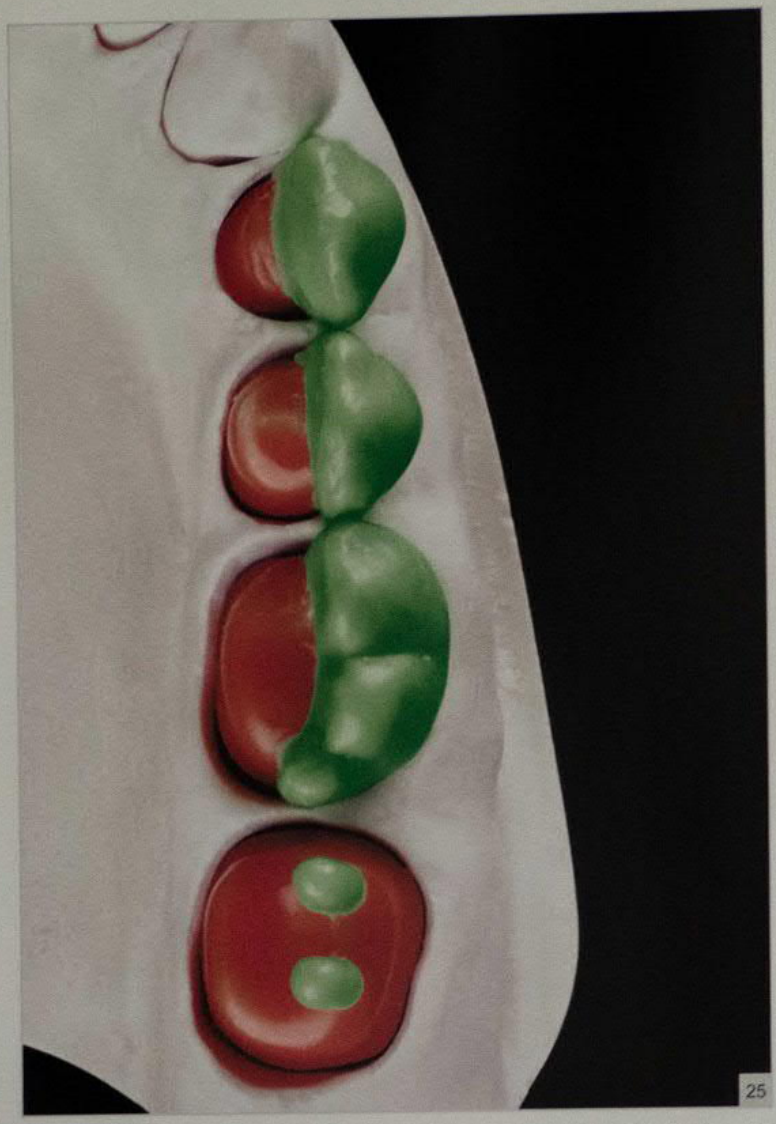


Fig 6-21 Occlusal view of the buccal surface of the mandibular second premolar. This surface extends mesially to the region near the point of contact with the mandibular first premolar. However, no proximal contact is formed at this stage.

Fig 6-22 Buccal surface of the mandibular second premolar, with correct morphologic details (see chapter 2).

Fig 6-23 When the stone casts are articulated, it is possible to see that this surface extends mesially to the center of the wax coping of the maxillary second premolar.

Fig 6-24 The buccal surfaces of the mandibular premolars should follow the path of an imaginary line that passes along the occlusal center of the antagonist teeth.



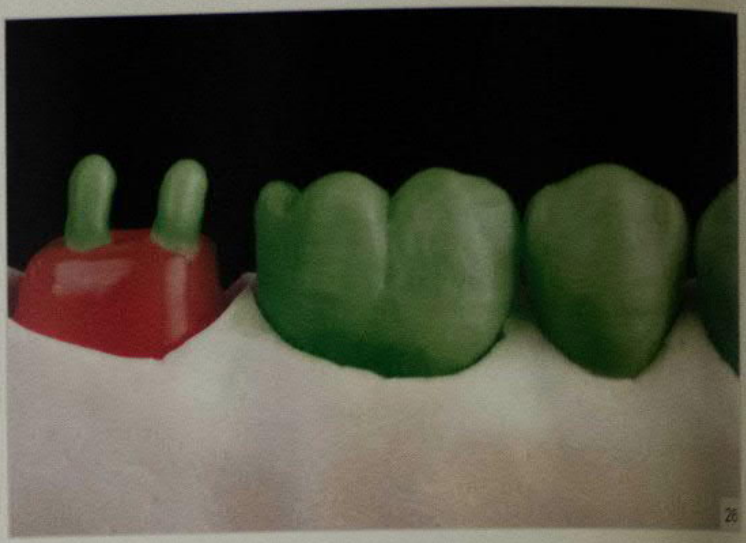
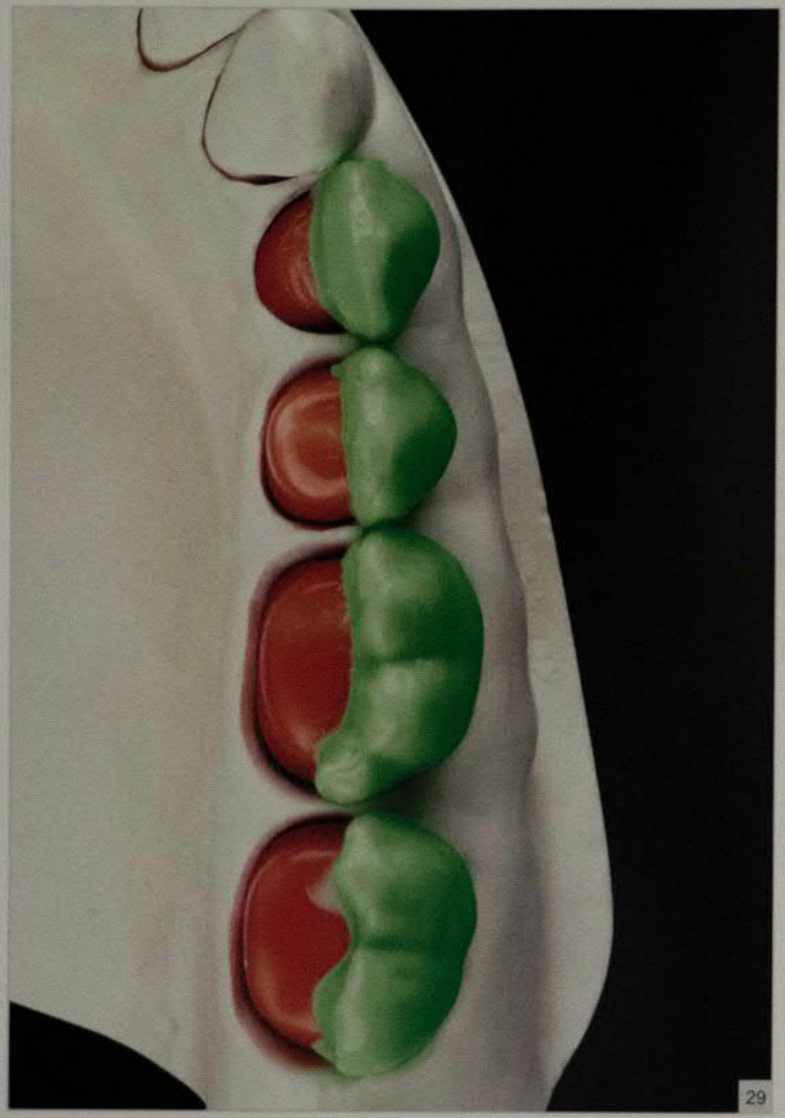


Fig 6-25 Occlusal view of the buccal surface of the mandibular first molar. Note that this surface extends mesially to the proximal contact point with the mandibular second premolar.

Fig 6-26 Finished buccal surface, with correct morphologic details (see chapter 2). It is important to highlight that two buccal grooves are found at this surface, the mesiobuccal and distobuccal grooves, which should be reproduced exactly in between the two adjacent cones.

Fig 6-27 It is possible, with the articulated stone casts, to see that the buccal surface of the mandibular first molar extends distally to the distal outline of the wax coping of the maxillary first molar.

Fig 6-28 The buccal surface of the mandibular first molar follows an imaginary line passing through the occlusal center of the antagonist teeth at the central groove.



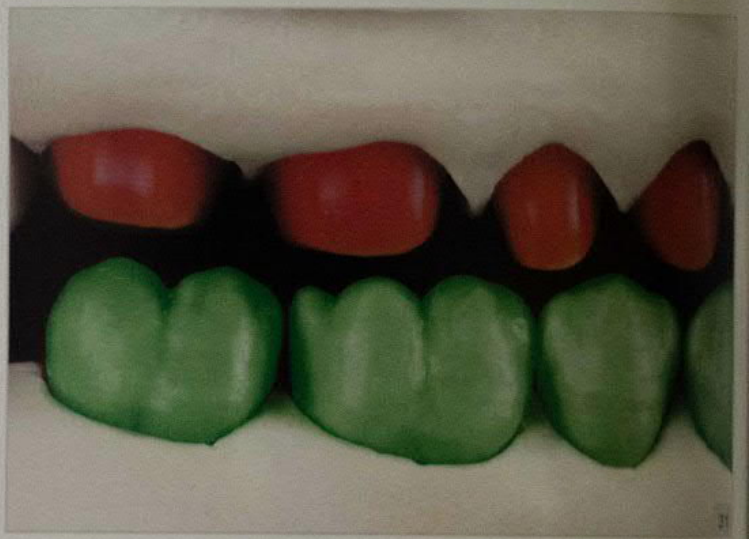


Fig 6-29 Occlusal view of the buccal surface of the mandibular second molar. Observe that this surface extends mesially to the region near the contact point with the mandibular first molar.

Fig 6-30 Finished buccal surface, with correct morphologic characteristics (see chapter 2). It is important to highlight that the buccal groove should be reproduced exactly in between the two buccal cones.

Fig 6-31 With the articulated stone casts, it is possible to see that the buccal surface of the mandibular second molar extends distally to the distal outline of the maxillary second molar.

Fig 6-32 The buccal surface of the mandibular second molar must follow an imaginary line passing through the occlusal center of the antagonist teeth, at the central groove.

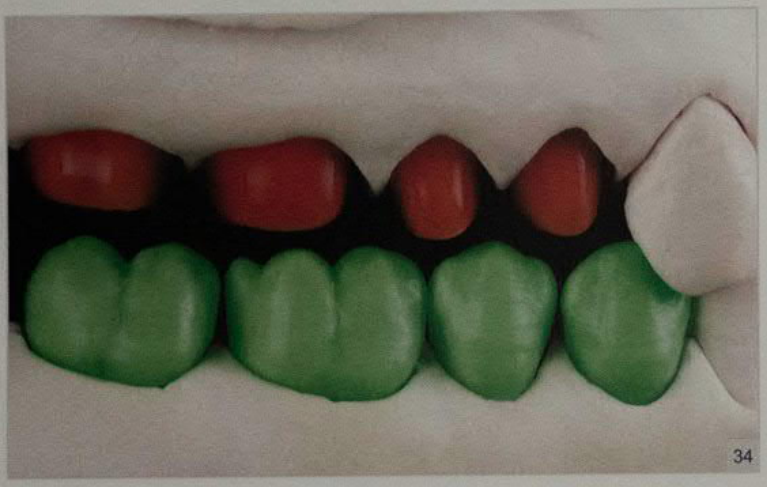


Fig 6-33 Finished buccal surfaces of the mandibular teeth. A noteworthy characteristic here is that the occlusal limit of this surface at the premolars has an inverted V shape. In the molars, a lowercase *m* and an uppercase *M* can be visualized in the first and second molars, respectively. Also, note the presence of small diastemata but the absence of interproximal contacts.

Fig 6-34 View of the mandibular teeth with the buccal surfaces finished.

Fig 6-35 Lingual view of the mandibular teeth with the buccal surfaces finished.

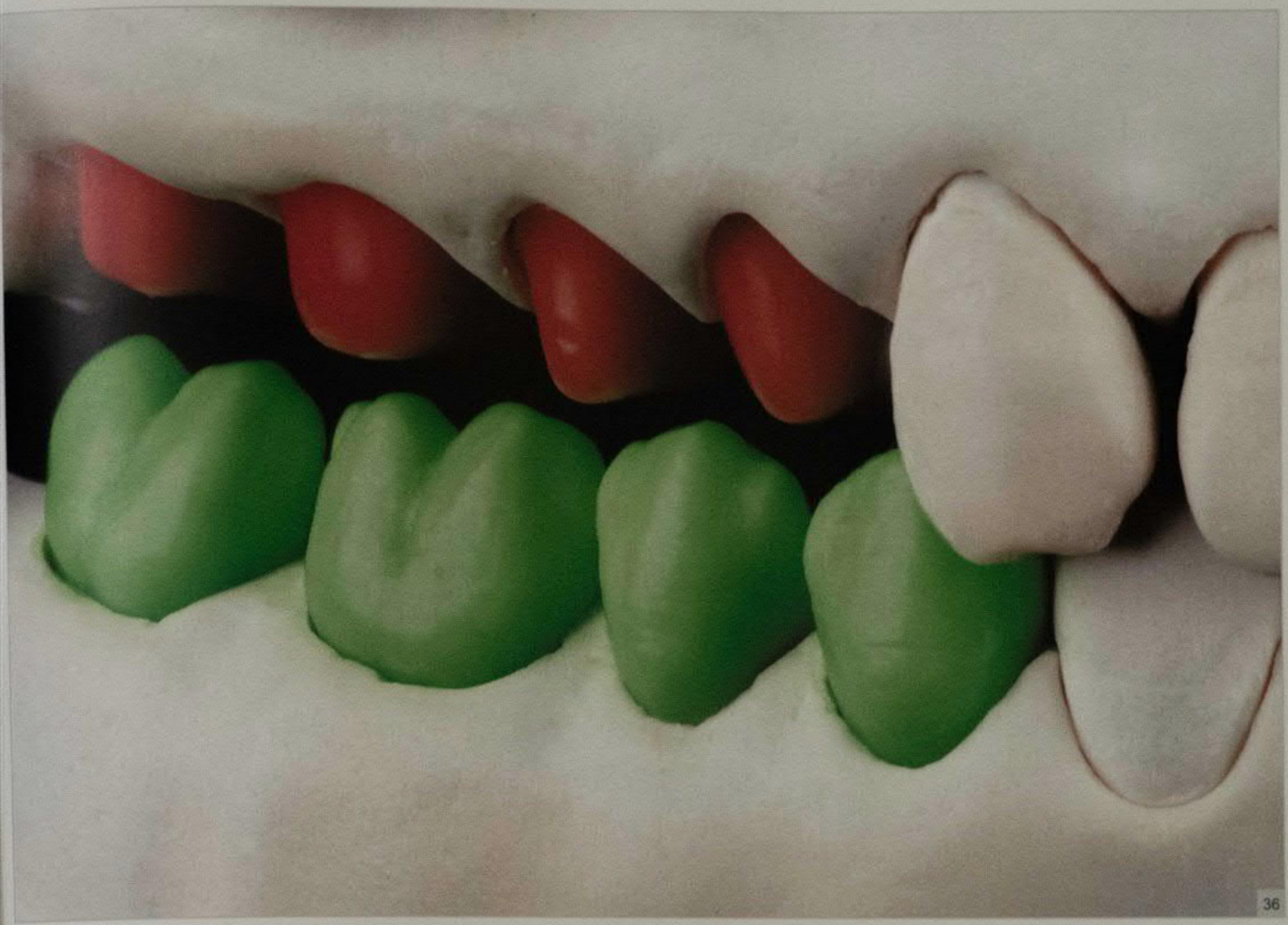
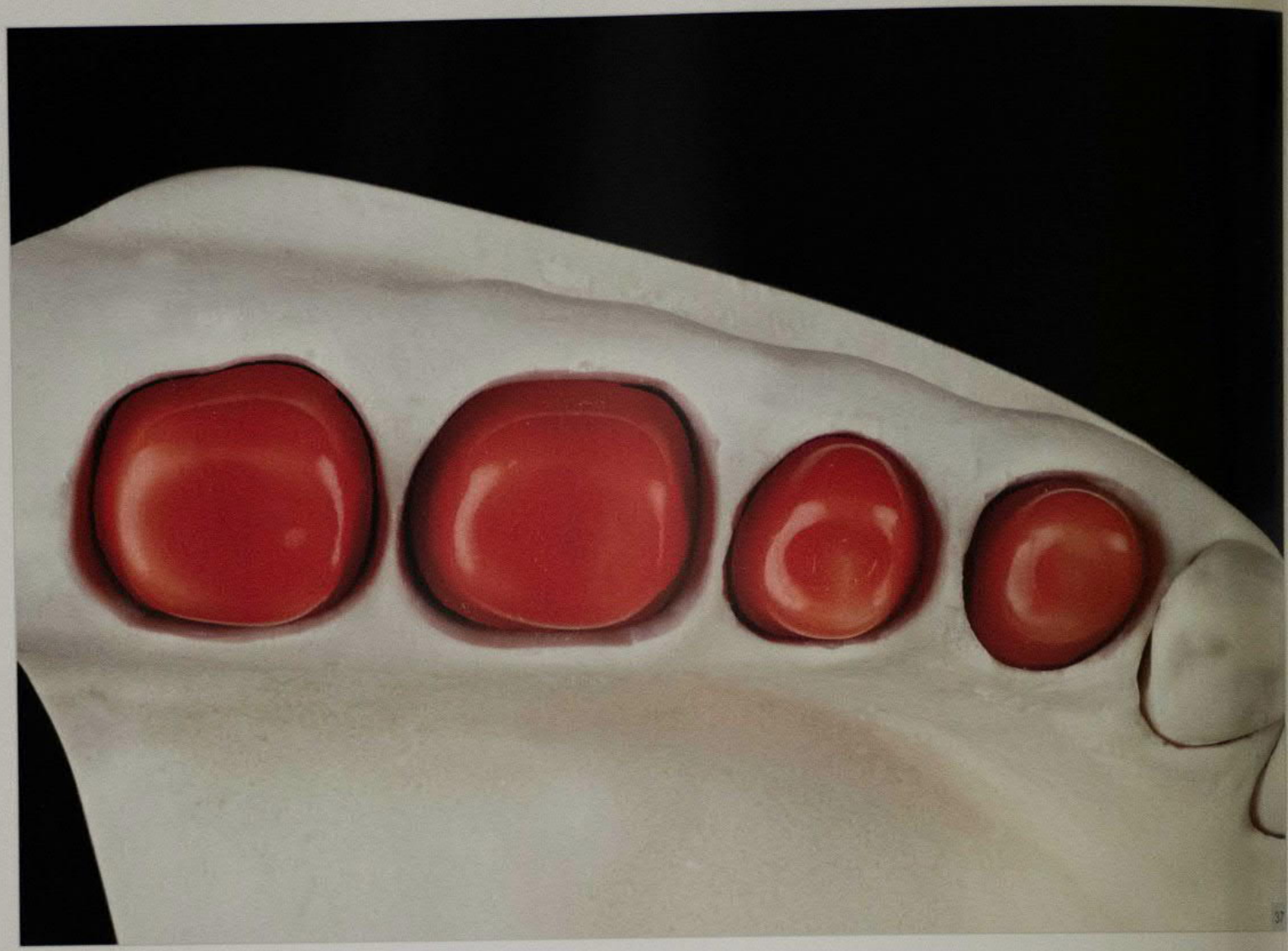
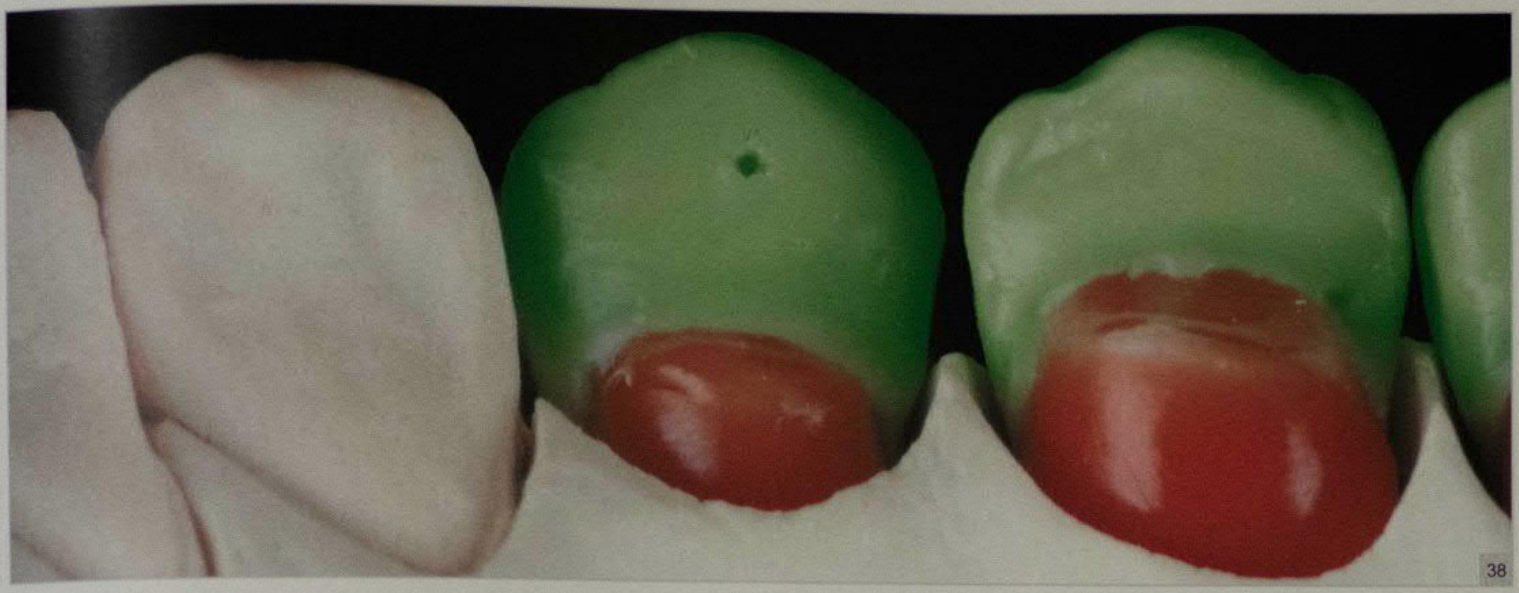


Fig 6-36 In regard to the cervico-occlusal convexities, the mandibular premolars should be similar to each other since both they have a prominent buccal bulge. The surface of the buccal bulge follows the curve of Spee, as determined in the anterior segment by the positioning of the buccal cones. In the first molar, the mesiobuccal segment is more lingually inclined, whereas the distobuccal and midbuccal segments are made more vertical, the latter being more toward the buccal. This occurs because the midbuccal cusp makes contact with the mesiobuccal inclines of the maxillary first molar. The mandibular second molar is pointed more buccally according to an arch curvature widened in the anteroposterior direction. This makes the mesiobuccal segment of the mandibular second molar more lingually positioned than that of the mandibular first molar. The distobuccal segment of the mandibular second molar is made more vertical than the mesiobuccal segment.



Maxillary Teeth – Palatal Surfaces

Fig 6-37 After finishing of the mandibular buccal surfaces, the palatal surfaces of the maxillary teeth should be developed. This is because earlier wax-up of the buccal surfaces would prevent observation of the relationship between the palatal cusps and the antagonist teeth on excursive movements. Here we see the occlusal aspect of the maxillary teeth before wax-up.



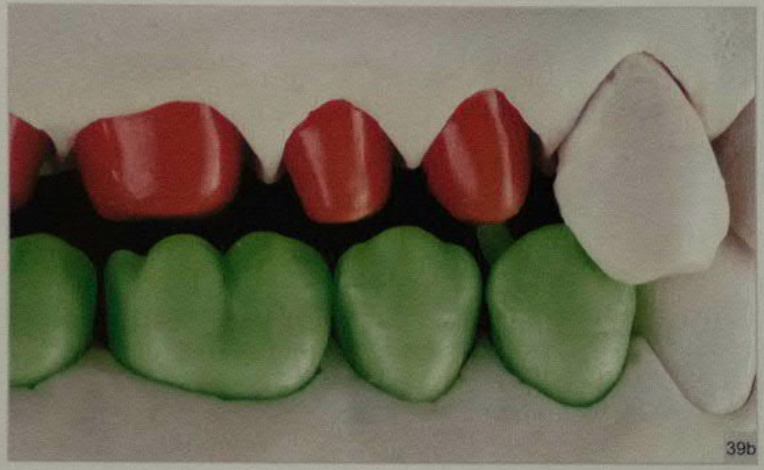


Fig 6-38 Due to the lack of the antagonist teeth, the development of the palatal aspect is performed according to reference points on the already sculpted buccal surface of the mandibular teeth. Here there is a marking 2.0 to 2.5 mm from the buccal cusp tip of the mandibular first premolar, which corresponds to the height of the palatal cone of the maxillary first molar in the articulated stone casts.

Figs 6-39a and 6-39b The palatal cone of the maxillary first molar should be well toward the mesial aspect, between the buccal cusp and the distal outline of the buccal surface of the mandibular first premolar. This region corresponds to the distal fossa of the mandibular first premolar.

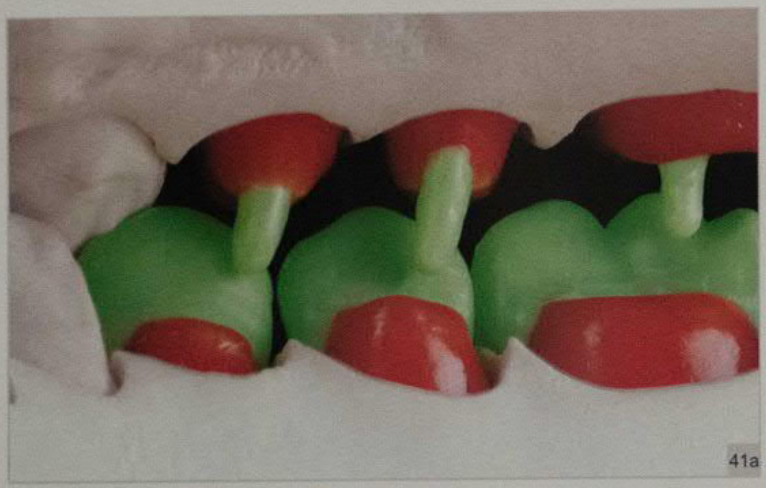


Fig 6-40 The palatal cone of the maxillary second premolar is placed 2.0 to 2.5 mm from the buccal cusp tip of the mandibular second premolar. This reference corresponds to the height at which the palatal cone should be extended, the stone casts being fully articulated.

Figs 6-41a and 6-41b Observe that the palatal cone should also be toward the mesial, with its tip between the buccal cusp tip and the distal outline of the buccal surface of the mandibular second premolar. This is where the distal fossa of the mandibular second premolar is to be developed.

Fig 6-42 Occlusal view of the palatal wax cones in the maxillary premolars.

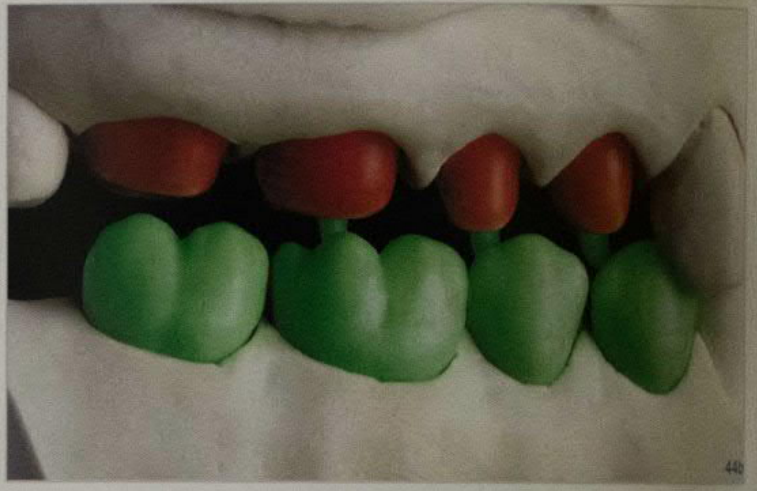


Fig 6-43 The mesiopalatal cone of the maxillary first molar should be placed 2.5 to 3.0 mm from the midbuccal cusp tip of the mandibular first molar. This reference corresponds to the height of this cone with the stone casts in occlusion.

Figs 6-44a and 6-44b This cone should be positioned vertically, pointed toward the midbuccal cusp tip of the mandibular first molar. In this region and near the mesiopalatal cone tip, the central fossa of the mandibular first molar is developed.

Fig 6-45 The distopalatal cone is placed 2.5 to 3.0 mm from the distobuccal cusp tip of the mandibular first molar. This reference corresponds to the height of this cone with the stone casts in occlusion.

Figs 6-46a and 6-46b The distopalatal cone is positioned vertically, pointed toward the distobuccal cusp tip of the mandibular first molar. In this region, close to the distopalatal cone tip, the distal marginal ridge of the mandibular first molar will be positioned. Note that in all the posterior teeth, the buccolingual distance between the palatal cusp tip and the buccal cusp tip of the antagonist tooth should correspond to half the buccolingual length of the occlusal table, ranging from 3.0 to 3.8 mm; this parameter should be confirmed in the homologous tooth. In the maxillary first molar, not only the homologous tooth but also the occlusal table of the adjacent teeth must be taken into consideration because the former has more wear.

Fig 6-47 The mesiopalatal cone of the maxillary second molar is placed 2.5 to 3.0 mm from the distobuccal cusp tip of the mandibular second molar, which corresponds to the height of this cone with the stone casts in occlusion.

Figs 6-48a and 6-48b This cone is positioned vertically and pointed toward the region between the buccal cusps of the mandibular second molar. In this area, close to the mesiopalatal cusp tip, the central fossa of the mandibular second molar is developed.

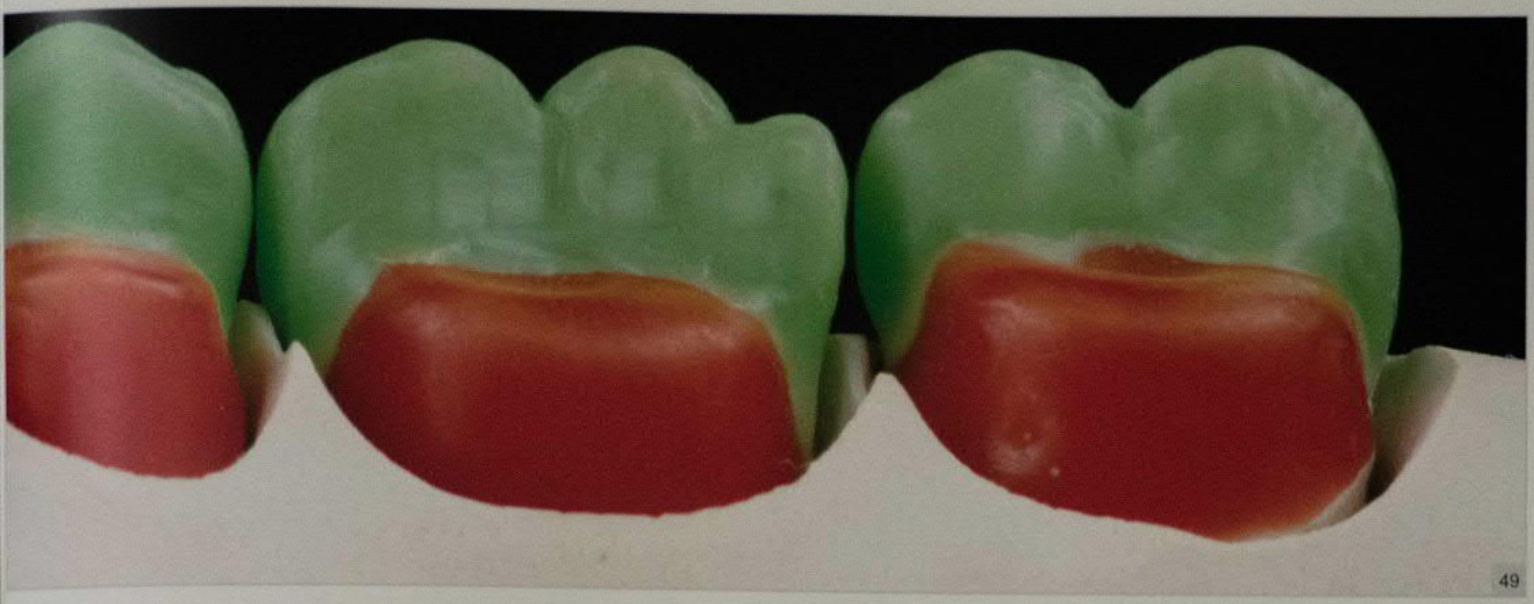


Fig 6-49 The distopalatal cone is placed 1.5 to 2.0 mm from the distobuccal cusp tip of the mandibular second molar. This reference corresponds to the height of this cone with the stone casts in occlusion.

Figs 6-50a and 6-50b This cone is positioned vertically and is pointed toward the distal outline of the mandibular second molar, where the distal marginal ridge will be constructed. In the maxillary second molar, the distopalatal cone should be positioned 0.5 mm more buccally than the mesiopalatal cone of the same tooth.

Fig 6-51 The palatal cones of the maxillary teeth should be parallel to the curve of Spee, with the exception of the distopalatal cone of the maxillary second molar, which is slightly displaced toward the buccal.

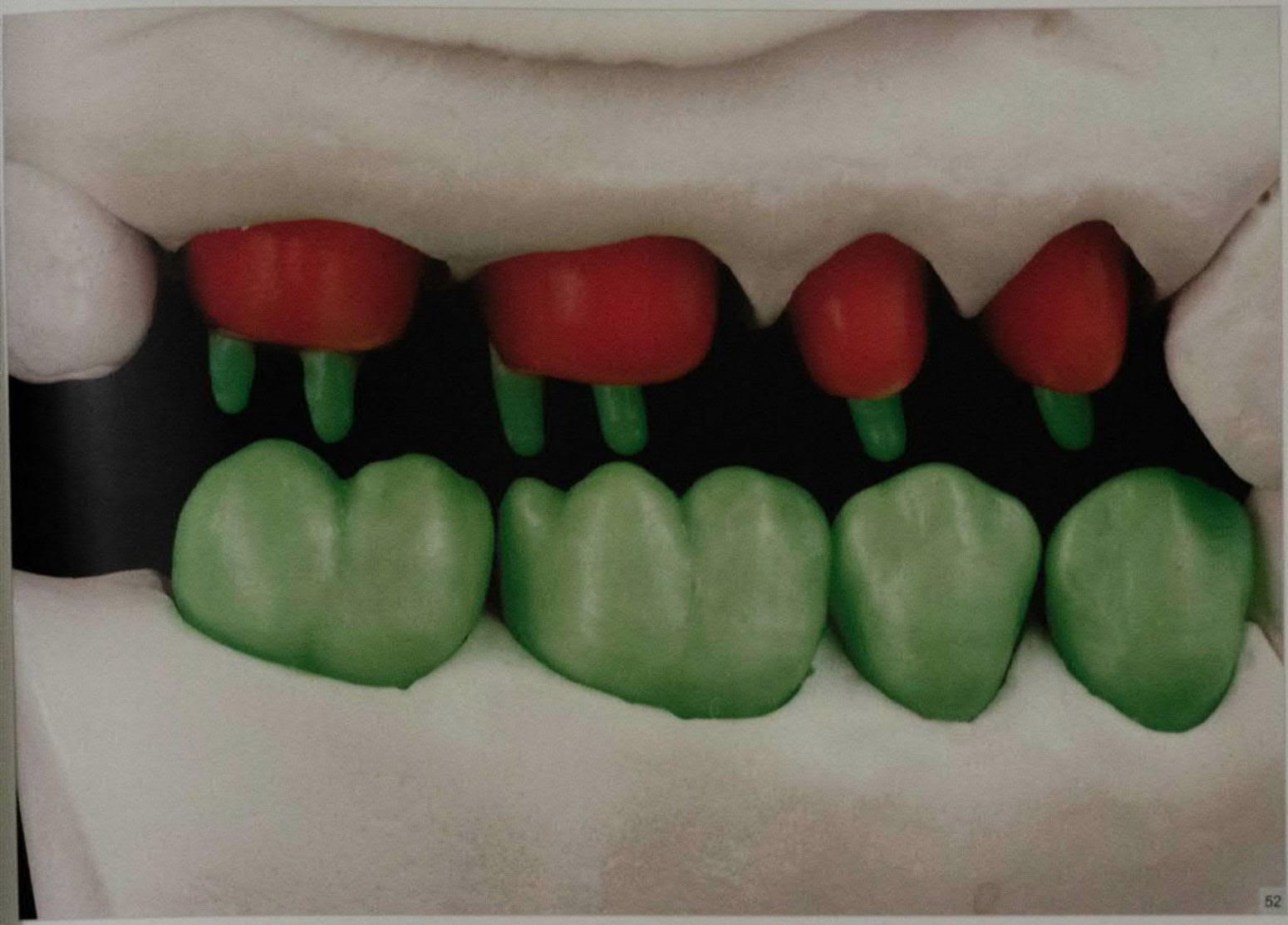


Fig 6-52 On excursive movements, no contact should be made between the palatal cones of the maxillary teeth and the antagonists.

Fig 6-53 View of the finished palatal cones.

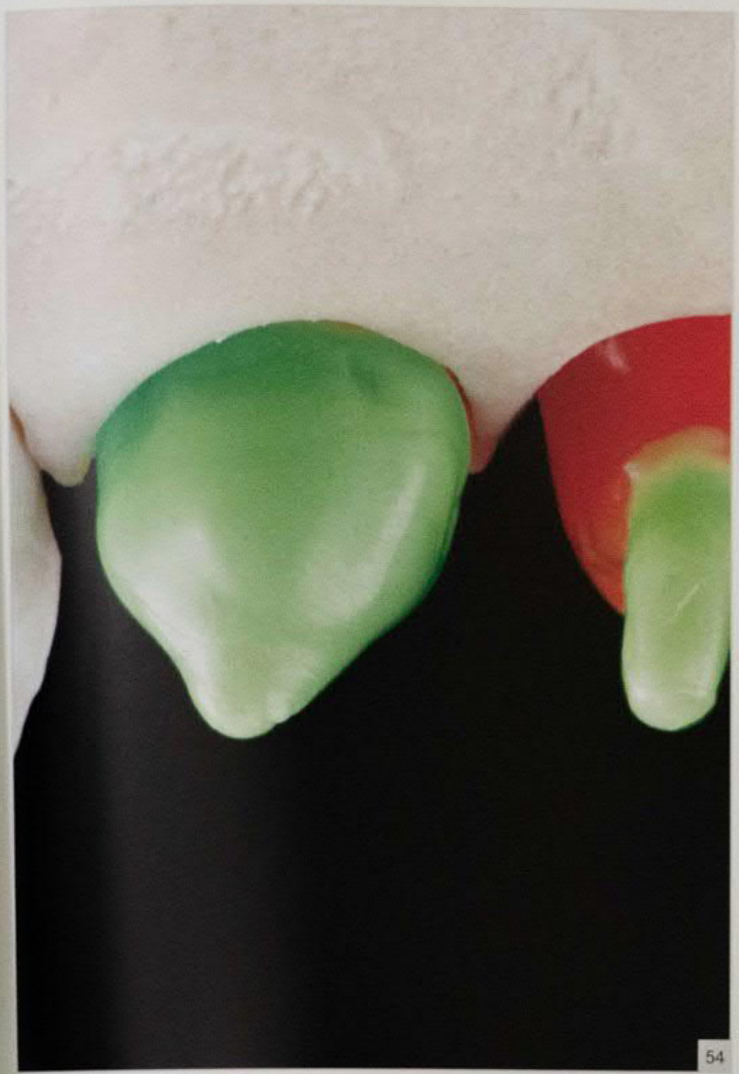


Fig 6-54 The palatal surface of the maxillary first premolar has an ovoid shape, is considerably inclined toward the mesial, and has less distinct morphologic characteristics.

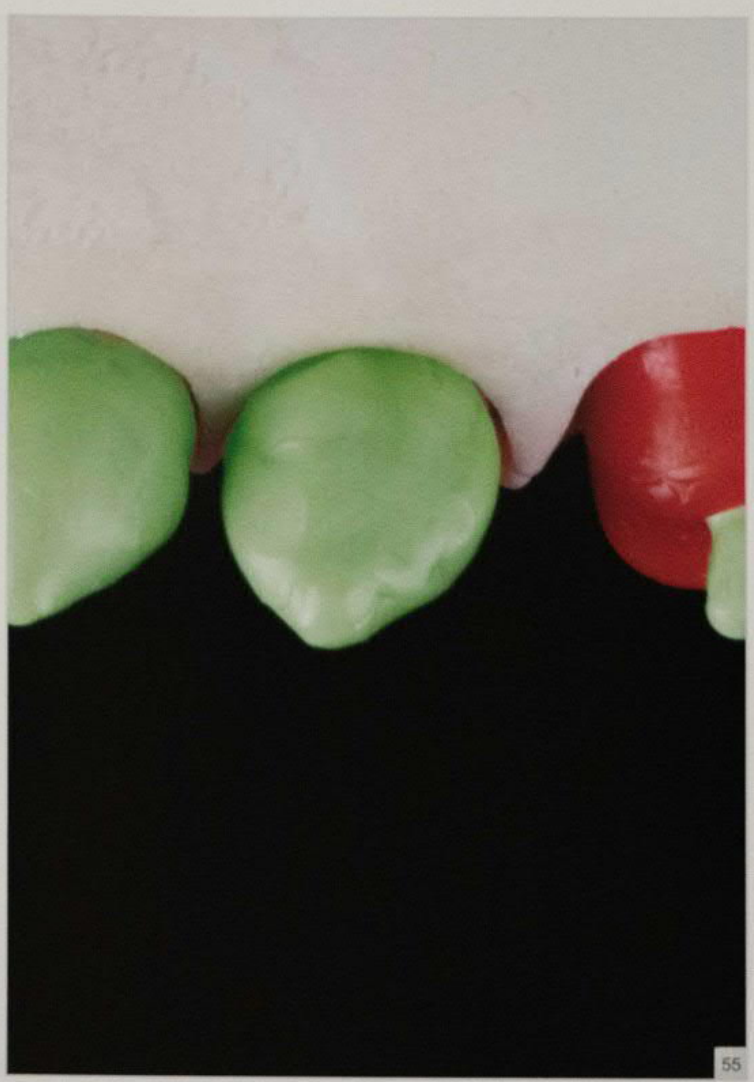


Fig 6-55 Next, the palatal aspect of the maxillary second premolar is constructed. Compared to the first premolar, this tooth is more ovoid, with a distinct mesial inclination. No lobes or grooves are formed along this surface.

Fig 6-56 It is important that the excursive movements be performed after finishing of all surfaces to prevent contacts between the palatal aspect of the maxillary premolars and the antagonist teeth.

Fig 6-57 Palatal surfaces of the maxillary premolars. Observe the presence of diastemata between the teeth.

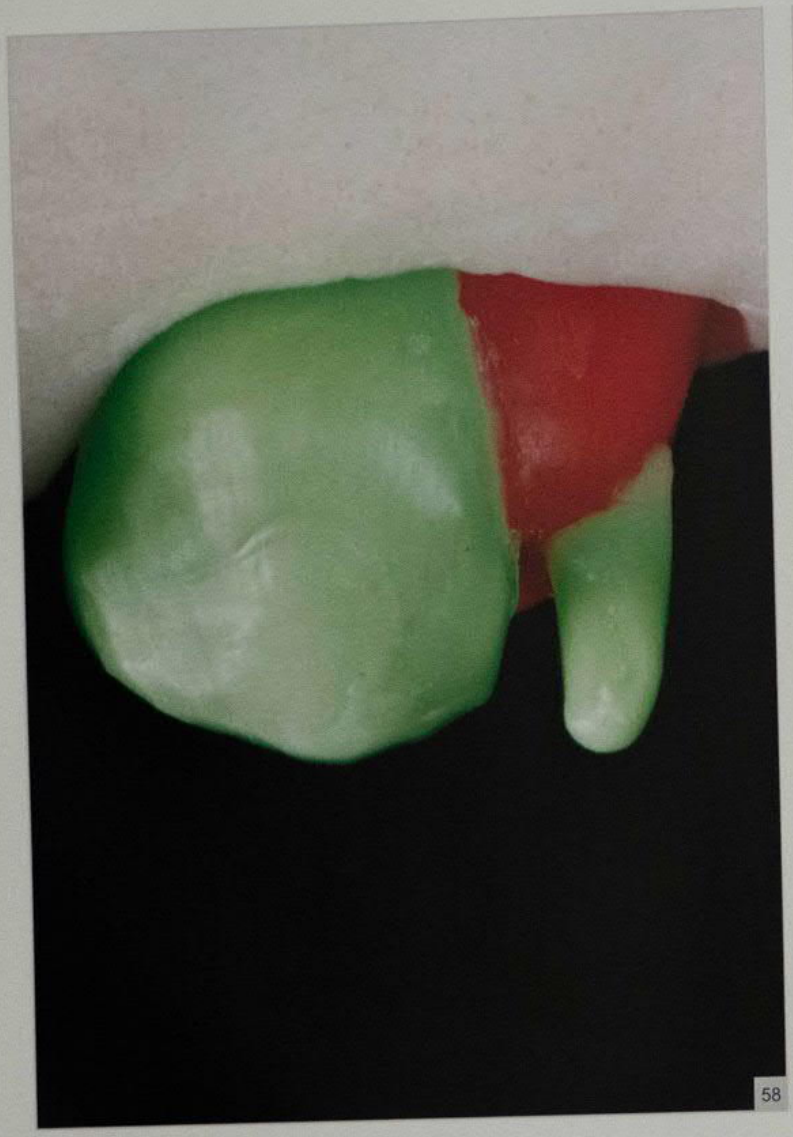


Fig 6-58 The mesiopalatal segment of the maxillary first molar is wider and presents a pentagonal shape.

Fig 6-59 Next, the distal segment should be developed; it also has a pentagon shape, but with reduced dimensions. These segments are separated by the palat groove, which presents a small curvature toward the distal that approaches t occlusal outline, which in turn makes the distal segment smaller.

Fig 6-60 During excursive movements, there should be no contact between the palatal aspect of the maxillary first molar and the antagonist teeth.

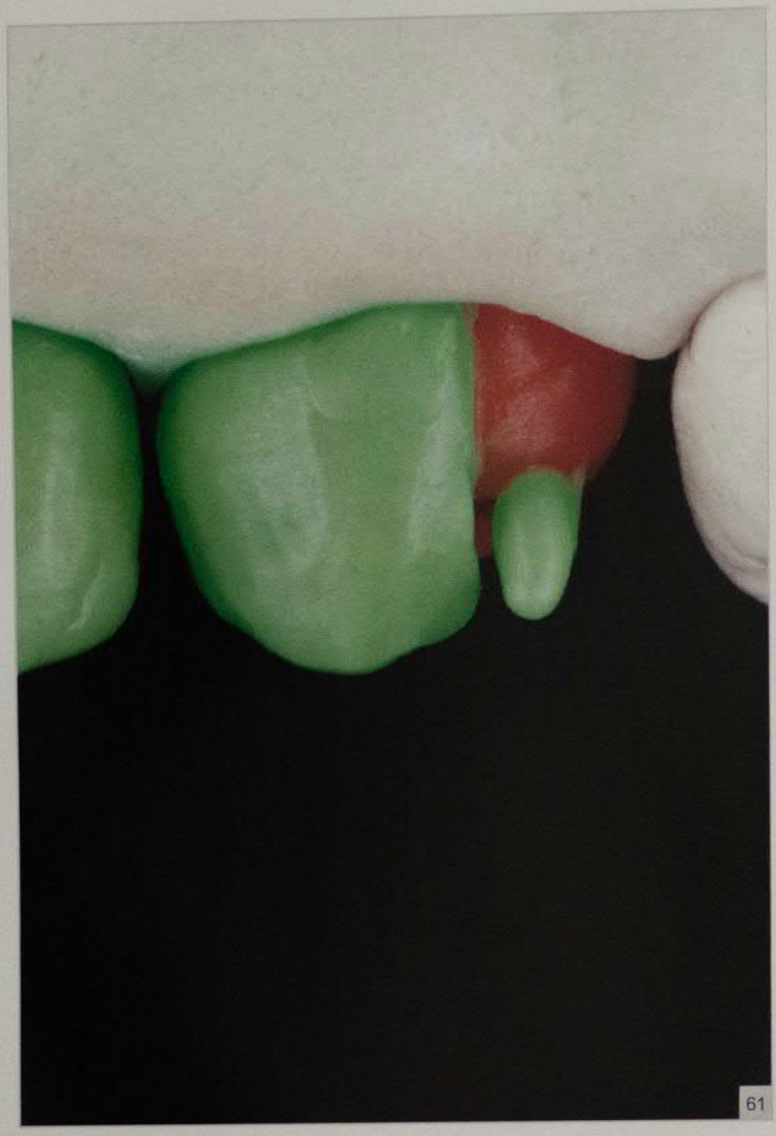


Fig 6-61 The mesial segment of the palatal surface of the maxillary second molar has been fabricated. It has a pentagonal shape with greater dimensions than both its distal segment and the same segment on the maxillary first molar. There should be no contact during excursive movements; however, the mesiopalatal cusp may make contact on the balancing side. If it does, adjustments are necessary.

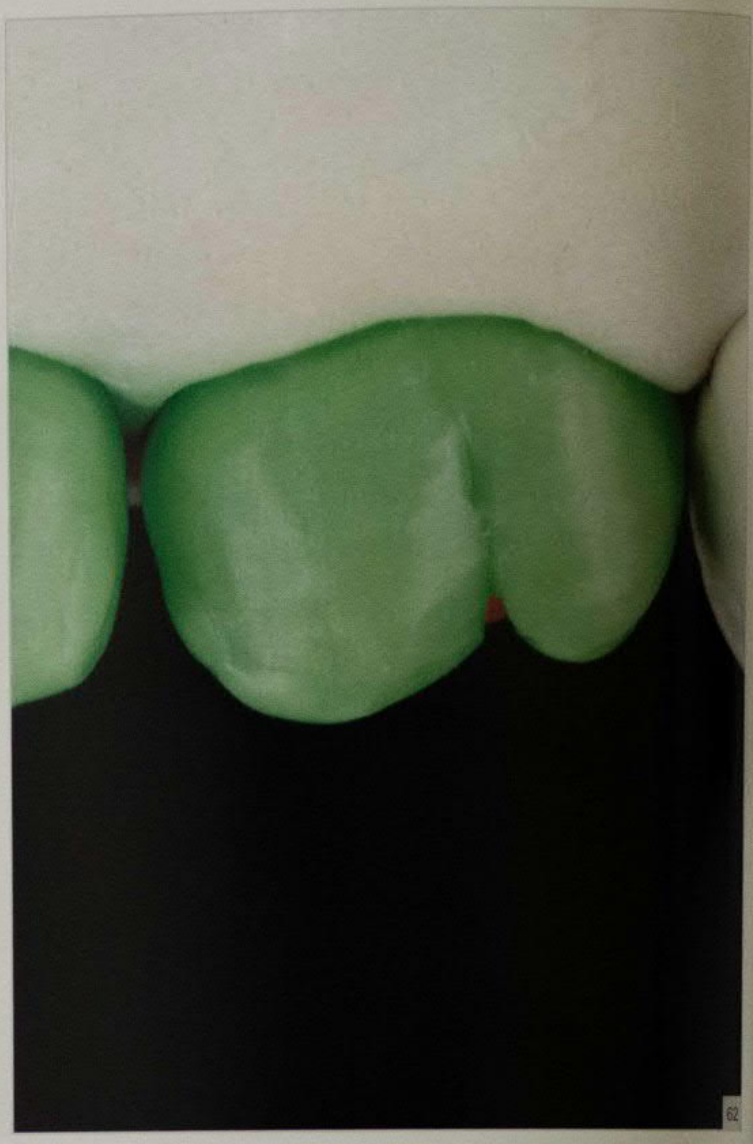
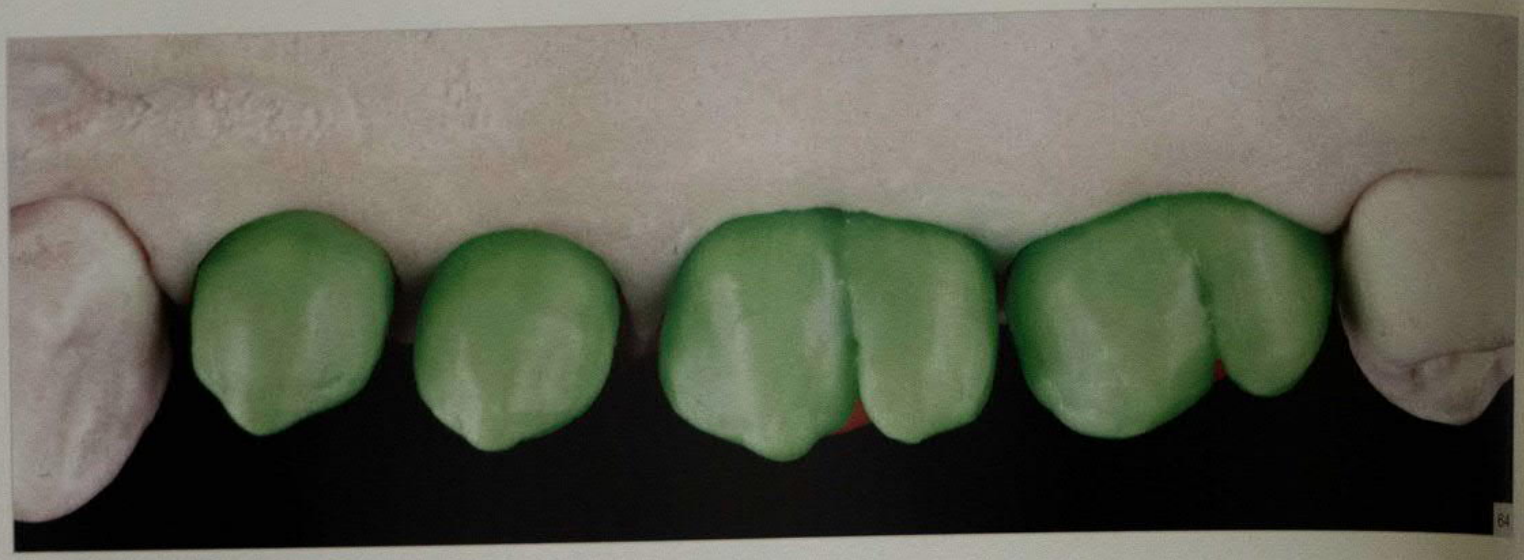
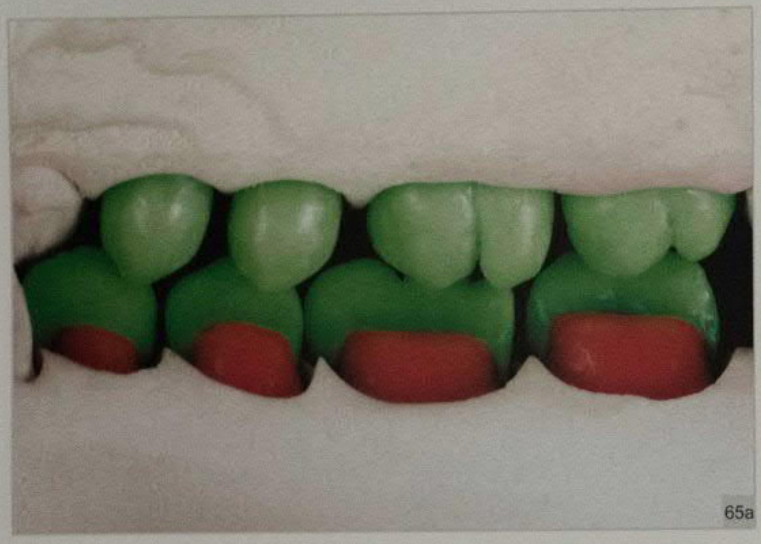


Fig 6-62 The distal segment is fabricated. It has an ovoid shape, with smaller dimensions than both those of its mesial segment and of the same segment on the maxillary first molar. The mesial and distal segments are separated by the palatal groove, whose occlusal outline points distally.

Fig 6-63 There should be no contact between the palatal surface of the maxillary second molar and the antagonist teeth. Note that a diastema should be maintained between the palatal surfaces, which characterizes the lack of interproximal contacts. Note that the mesial segment of the first molar has a more accentuated curvature toward the buccal, creating wider spacing between the first molar and the distal surface of the second premolar.





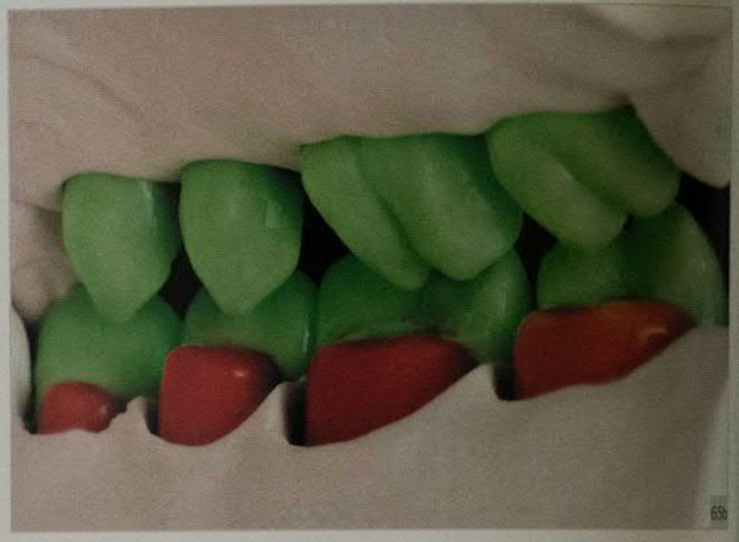
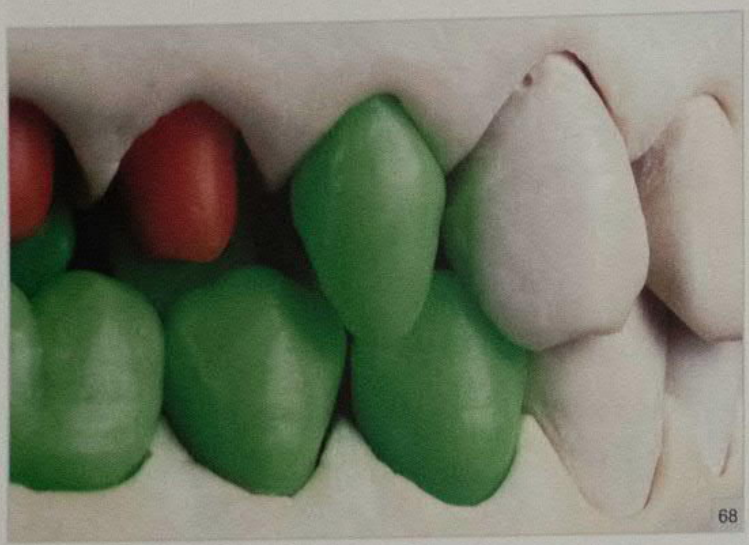
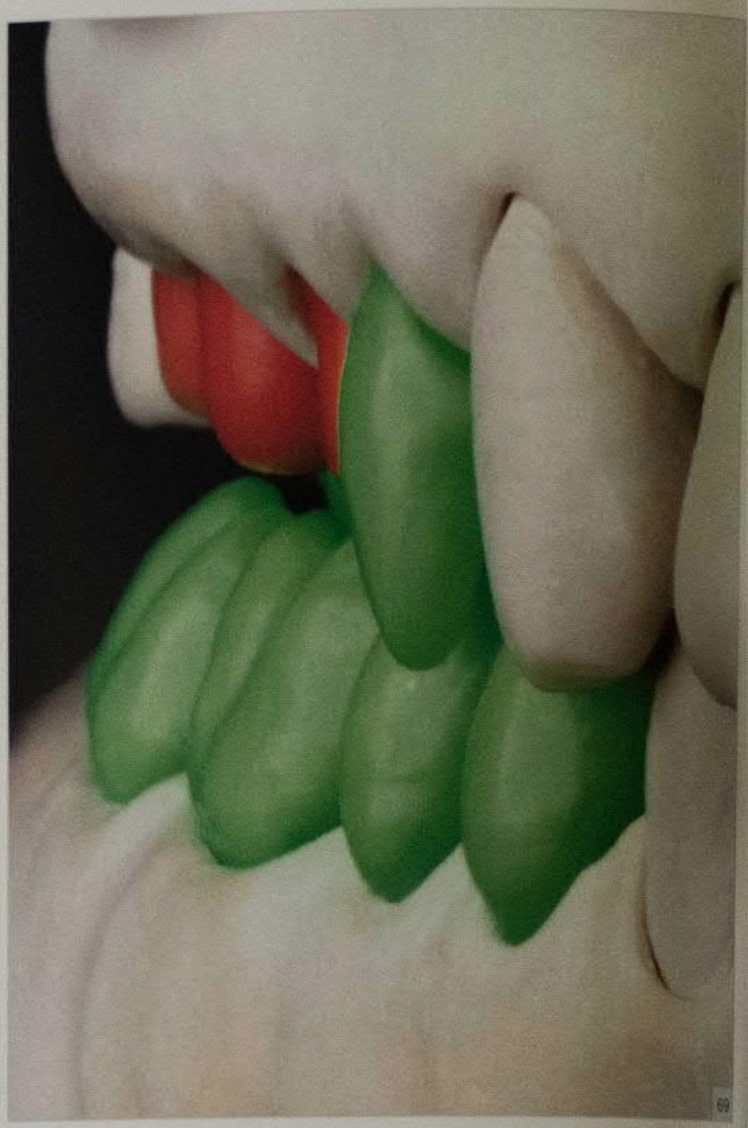


Fig 6-64 The finished palatal surfaces of the maxillary teeth. The occlusal outline of the premolars has a V shape, while the letter *W* is found in the molars.

Figs 6-65a and 6-65b Observe the relationship between the palatal surfaces of the maxillary teeth and their antagonists. A distance of 3.0 to 3.8 mm between the tips of the opposing cusps should be respected.

Fig 6-66 Occlusal view of the maxillary teeth after finishing of the palatal surfaces. The longitudinal slopes are more inclined toward the buccal.



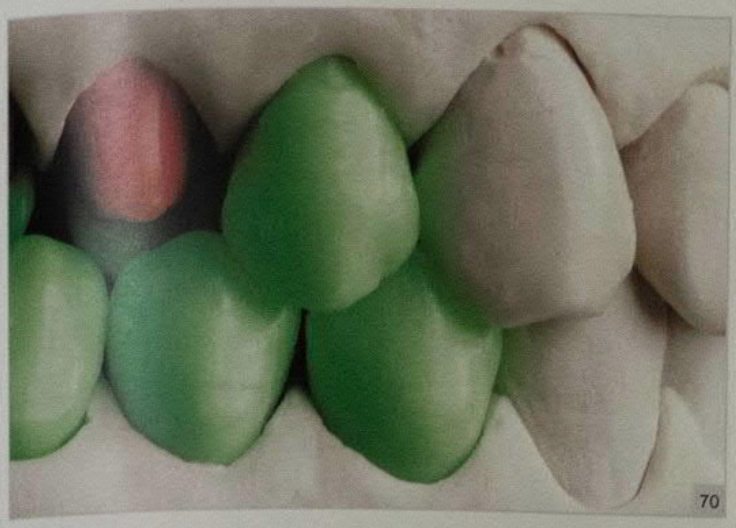


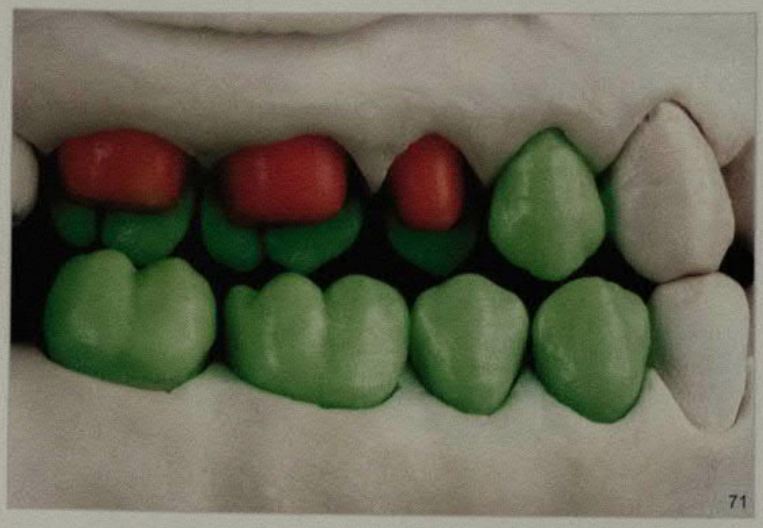
Maxillary Teeth – Buccal Surfaces

Fig 6-67 The next step is the development of the buccal surfaces of the maxillary teeth. Here, an alternative technique can be used to facilitate the process, in which the guiding wax cones arise from the cervical finishing lines. In the maxillary first premolar, this cone is found between the mandibular premolars, inclined slightly mesially, and its cusp is displaced 1 mm toward the palatal. The height of this cone is determined by the height of the canine and/or the homologous tooth. Another issue is that the cone tip should remain 2.5 to 3.0 mm above the cusp tip of the mandibular second premolar.

Fig 6-68 In this technique there is another option in the waxing process, in which these surfaces should be constructed by applying the lobes first and not the slopes. This figure shows the central lobe of the buccal surface of the maxillary first molar, which should be tapered and present a protuberance similar to that of the canine.

Fig 6-69 In this profile, it is possible to see that the cervico-occlusal convexities of the maxillary canines and of the premolars are similar. Remember that the distance between the buccal cusp tip and the buccal surface of the opposing tooth should be half the buccolingual dimension of the occlusal table, varying between 3.0 and 3.8 mm.





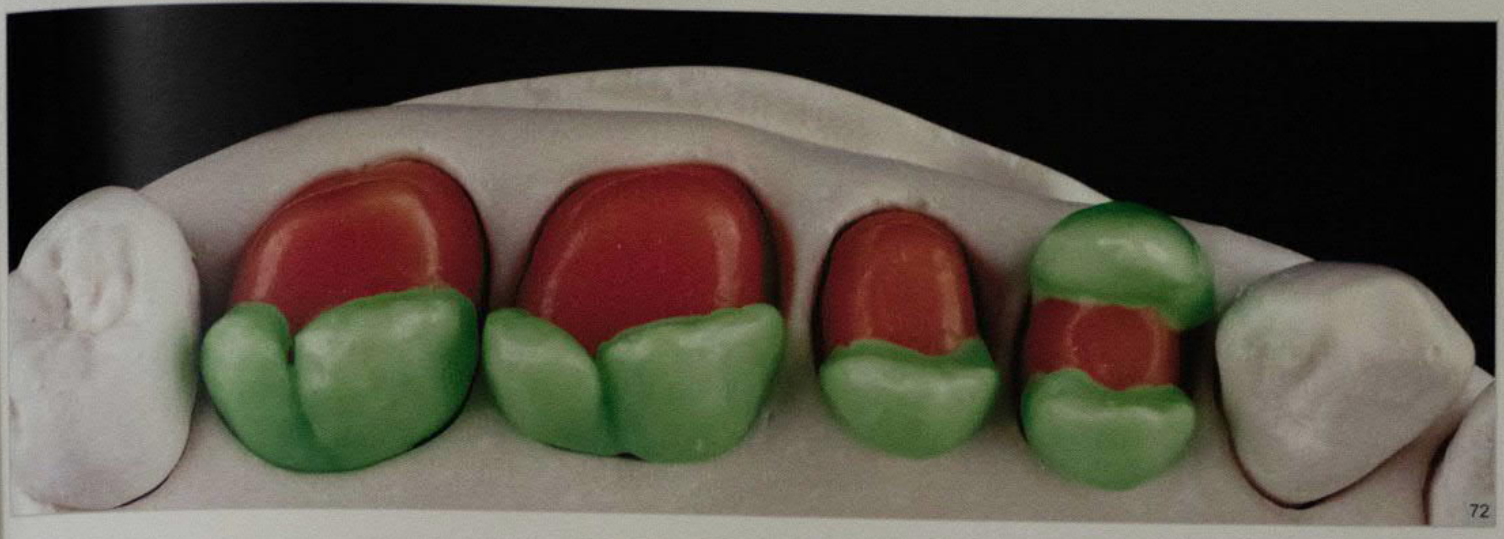


Fig 6-70 The finished surface after positioning of the lateral buccal lobes. It has an ovoid shape, in which its mesial outline follows the distal outline of the canine, and its distal outline is the buccal cusp tip of the mandibular second premolar. The characteristic morphology should be reproduced as described (see chapter 2).

Fig 6-71 When the patient has a canine-protected articulation disocclusion pattern, there can be no contacts between the buccal surface of the maxillary first premolar and the antagonists during excursive movements. In case of group function, the likelihood of contacts is higher, but this surface must remain below the canine's height to avoid premature contacts.

Fig 6-72 Occlusal view of the finished buccal surface.

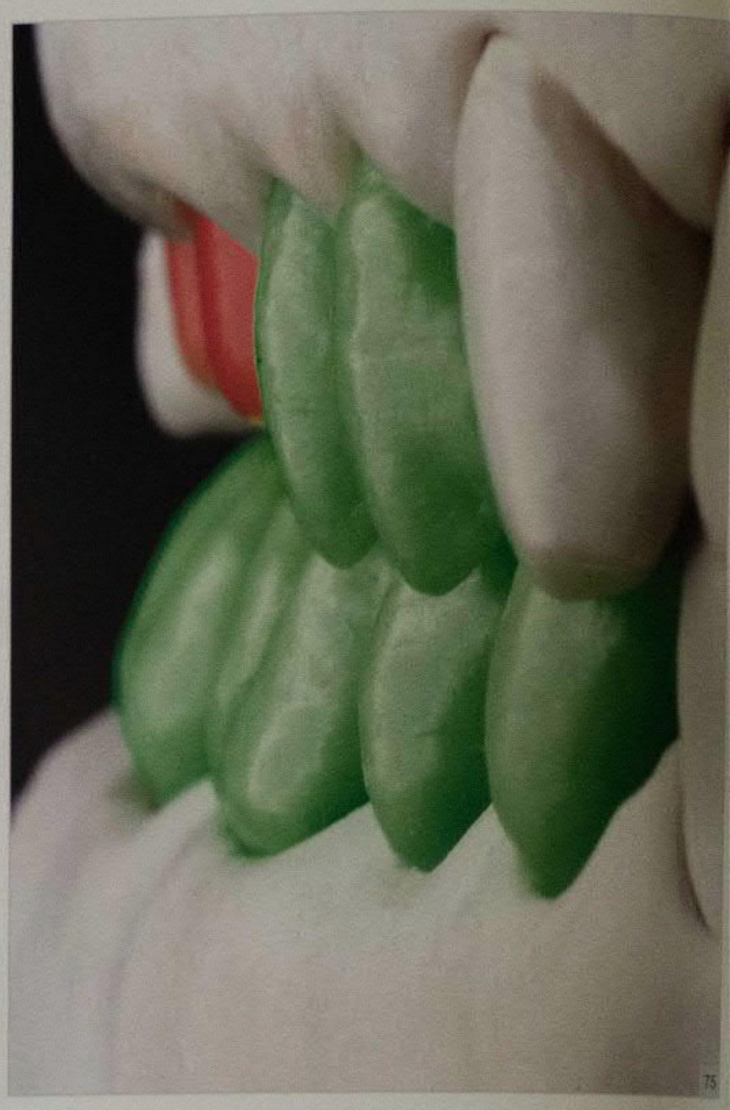


Fig 6-73 In the maxillary second premolar, the buccal cone should be positioned between the mandibular second premolar and the first molar, with a slightly mesial inclination and its cusp tip 1 mm palatal to the cervical finishing line. The height of this cone is determined by the height of the first premolar or of the homologous tooth, according to the smile line. Another reference is that this cone is 2.5 to 3.0 mm above the cusp tip of the mandibular second premolar.

Fig 6-74 The central lobe of the buccal surface should be tapered and have a less accentuated protuberance than the central lobe of the maxillary first premolar, but with a very similar cervico-occlusal inclination.

Fig 6-75 Note the similarities between the cervico-occlusal inclinations of the maxillary premolars.

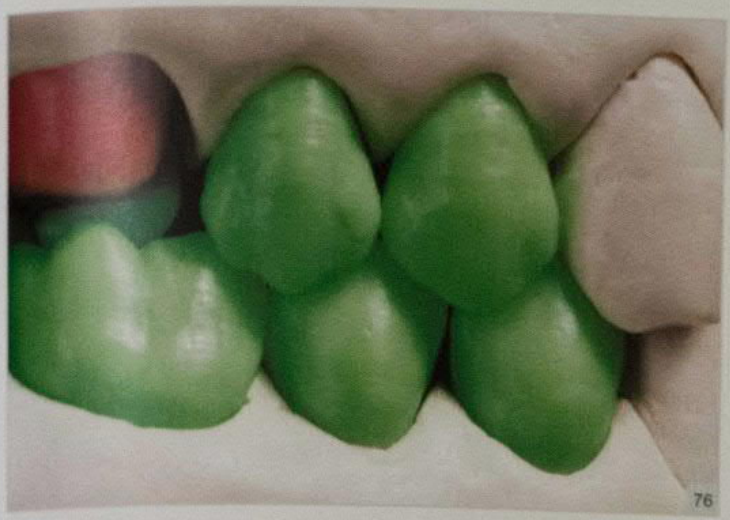


Fig 6-76 Observe that the mesial and distal lobes should be constructed to finish the buccal surface. These are more distinct than that in the first premolar, which gives rise to the mesial and distal developmental grooves. The mesial edge of this surface is the buccal cusp tip of the mandibular second premolar, while the distal edge is the mesiobuccal cusp tip of the mandibular first molar.

Fig 6-77 When the patient presents with canine-protected articulation, there should be no contact during excursive movements. In case of group function, a contact is possible; however, the height of this surface must remain above that of the canine to avoid premature contacts.

Fig 6-78 Occlusal view of the buccal surfaces of the maxillary premolars. Note their relationship with the antagonists.

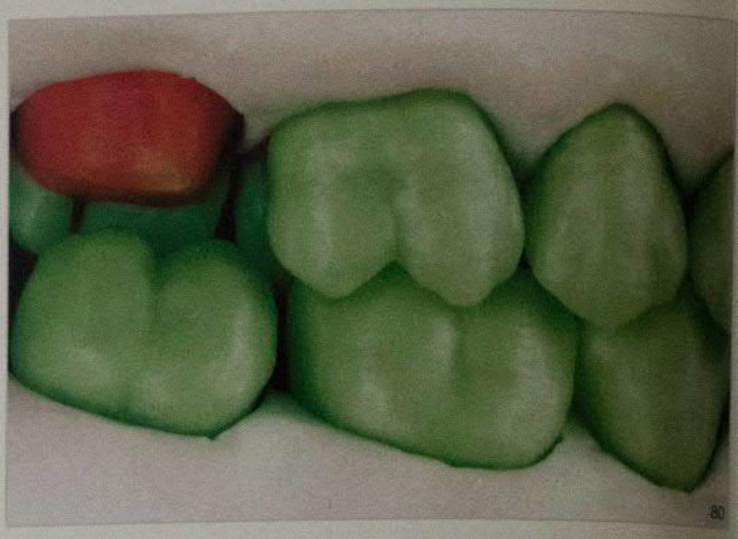


Fig 6-79 During construction of the maxillary first molar, the wax cones should be slightly toward the mesial, with the mesiobuccal cone tip pointing toward the mesiobuccal groove of the mandibular first molar, while the distobuccal cone tip points to the distobuccal groove of the same tooth. The height of these cones is determined by the height of the second premolar or of the homologous tooth, according to the smile line. The distobuccal cone is 2.5 to 3.0 mm above the midbuccal cone tip of the mandibular first molar. The mesiobuccal cone is a little shorter than its distobuccal counterpart. In the buccopalatal position, these cones should follow the same orientations described for the premolars.

Fig 6-80 Next, the mesial and distal segments are developed. In the mesial segment, the mesial outline of the mesiobuccal cusp tip, as well as the distal outline of the midbuccal cusp tip of the mandibular first molar, must be fabricated. The central lobe should have the same protuberance found in the premolars, whereas the distal lobe should point slightly toward the palatal. In the distal segment, the mesial outline is the midbuccal cusp of the mandibular first molar and the distal outline is the mesial edge of the mandibular second molar. These features are smaller than in the distal segment. As the distal lobe of the mesial segment is more inclined toward the palatal, the distal segment becomes more buccally positioned. These segments are separated by a buccal groove, pointed toward the midbuccal cusp tip of the mandibular first molar, which crosses in the region of the middle third, with a horizontal groove, resulting in a buccal fossa with a delta configuration. This horizontal groove highlights the cervical bulge.

Fig 6-81 Occlusal view of the buccal surface of the mandibular first molar. Note the outline and the relationship of this surface with the adjacent teeth.

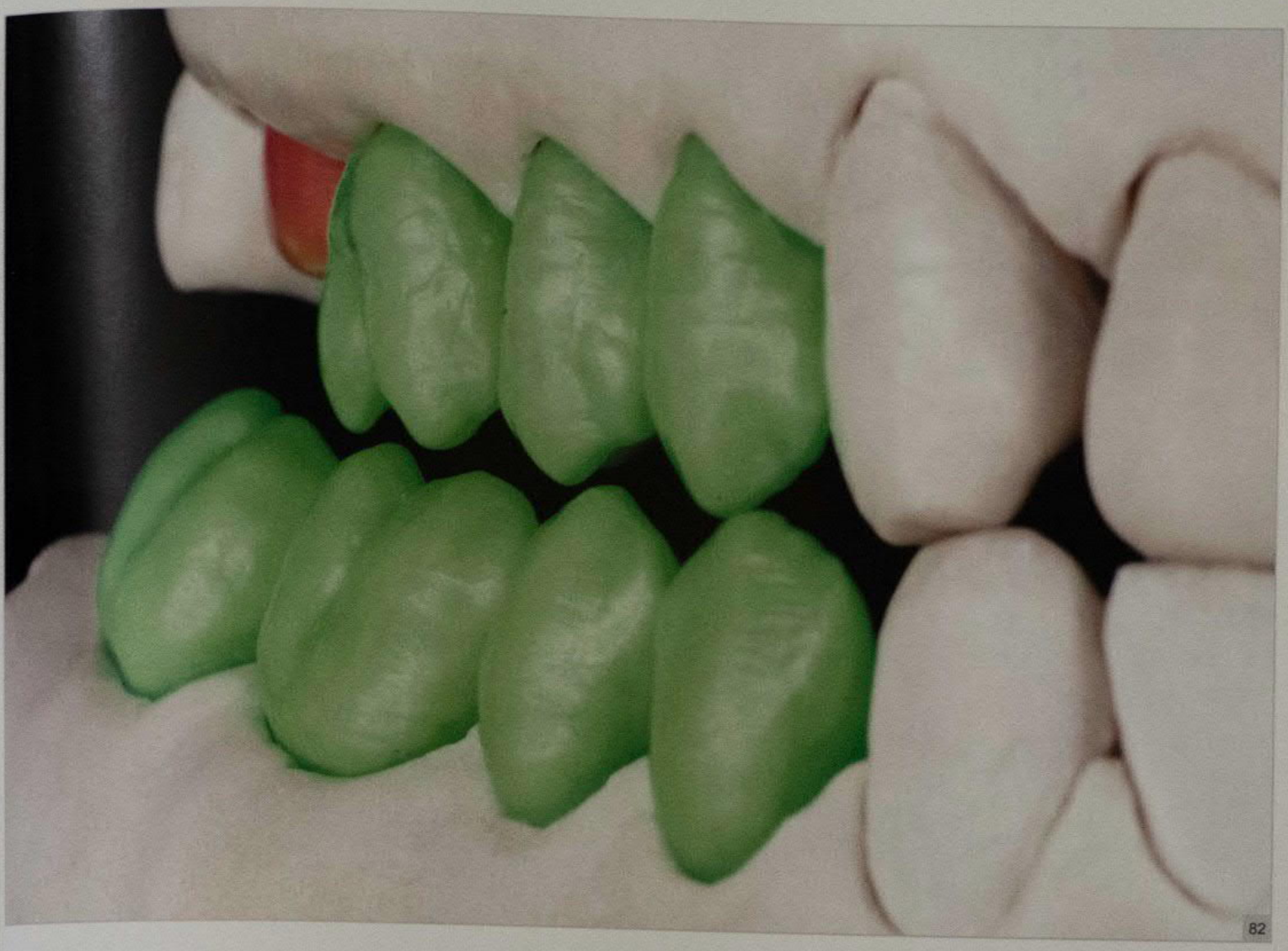
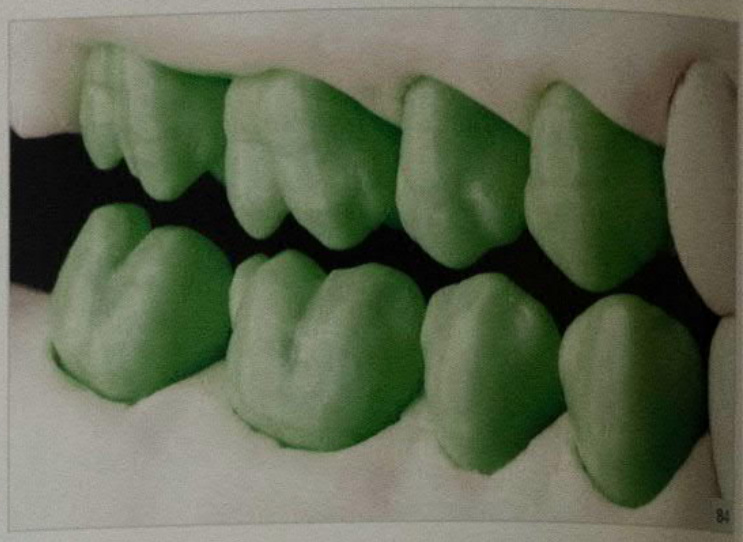


Fig 6-82 Observe the similarity between the cervico-occlusal inclination of the second premolar and that of the mesial segment of the maxillary first molar. Also, the distal segment of the maxillary first molar is positioned more buccally because of the palatal position of the distal lobe of the mesial segment. When canine-protected articulation is present, there should be no contacts in the buccal surface of the maxillary first molar during excursive movements.



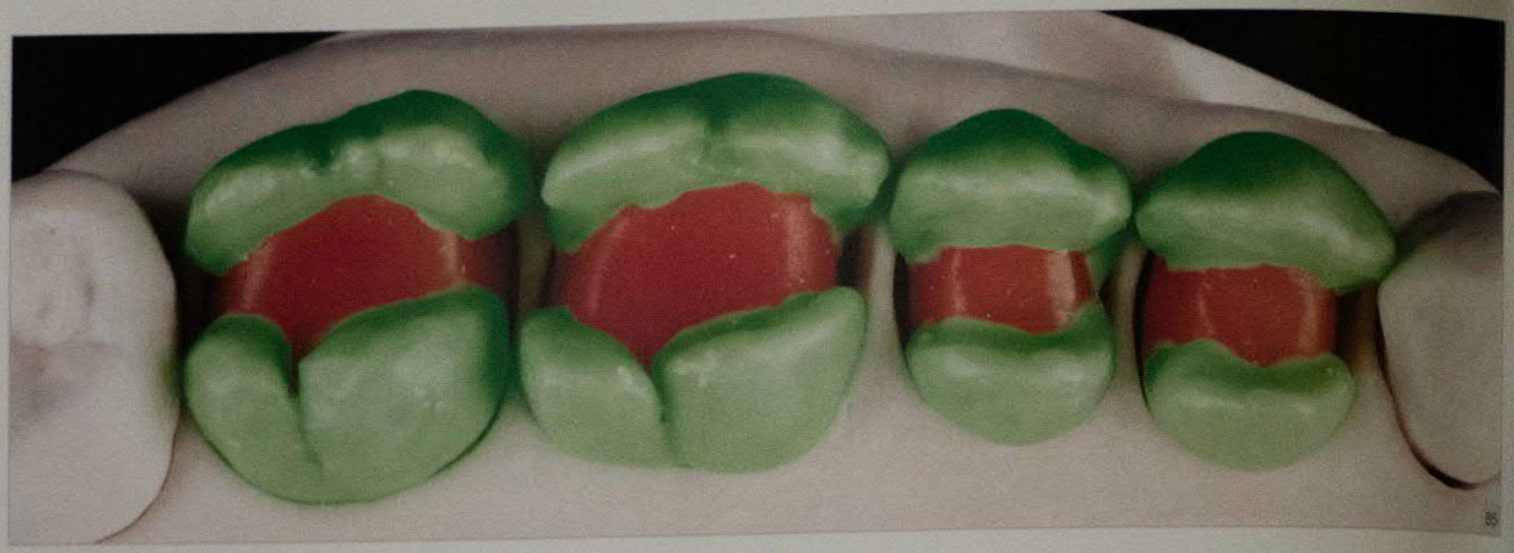


Fig 6-83 In the maxillary second molar, the mesiobuccal wax cone must be slightly mesial and pointed toward the buccal groove of the mandibular second molar, whereas the distobuccal wax cone should be pointed toward the mesial outline of the buccal surface of the mandibular second molar, slightly toward the mesial aspect. The height is determined by the maxillary first molar or the homologous tooth, according to the smile line. Another consideration is that the mesiobuccal cone should be 1.5 to 2.0 mm above the mesiobuccal cusp tip of the mandibular second molar; the distobuccal cone is a little shorter than the mesiobuccal one.

Fig 6-84 Next, the mesial and distal segments are fabricated. In the mesial segment, the mesial outline corresponds to the mesial margin of the mandibular second molar, and the distal outline is the distobuccal cusp tip of the mandibular second molar. On the distal segment, the mesial limit is the distobuccal cusp tip of the mandibular second molar, whereas the distal limit is located at the distal outline of the mandibular second molar. The mesial and distal segments are separated by the buccal groove, which is pointed toward the distobuccal cusp tip of the mandibular second molar. Its characteristic morphology is similar to that of the first molar but with smaller dimensions.

Fig 6-85 Occlusal view of the finished buccal surfaces. Observe the alignment of the longitudinal slopes of the premolars and molars.

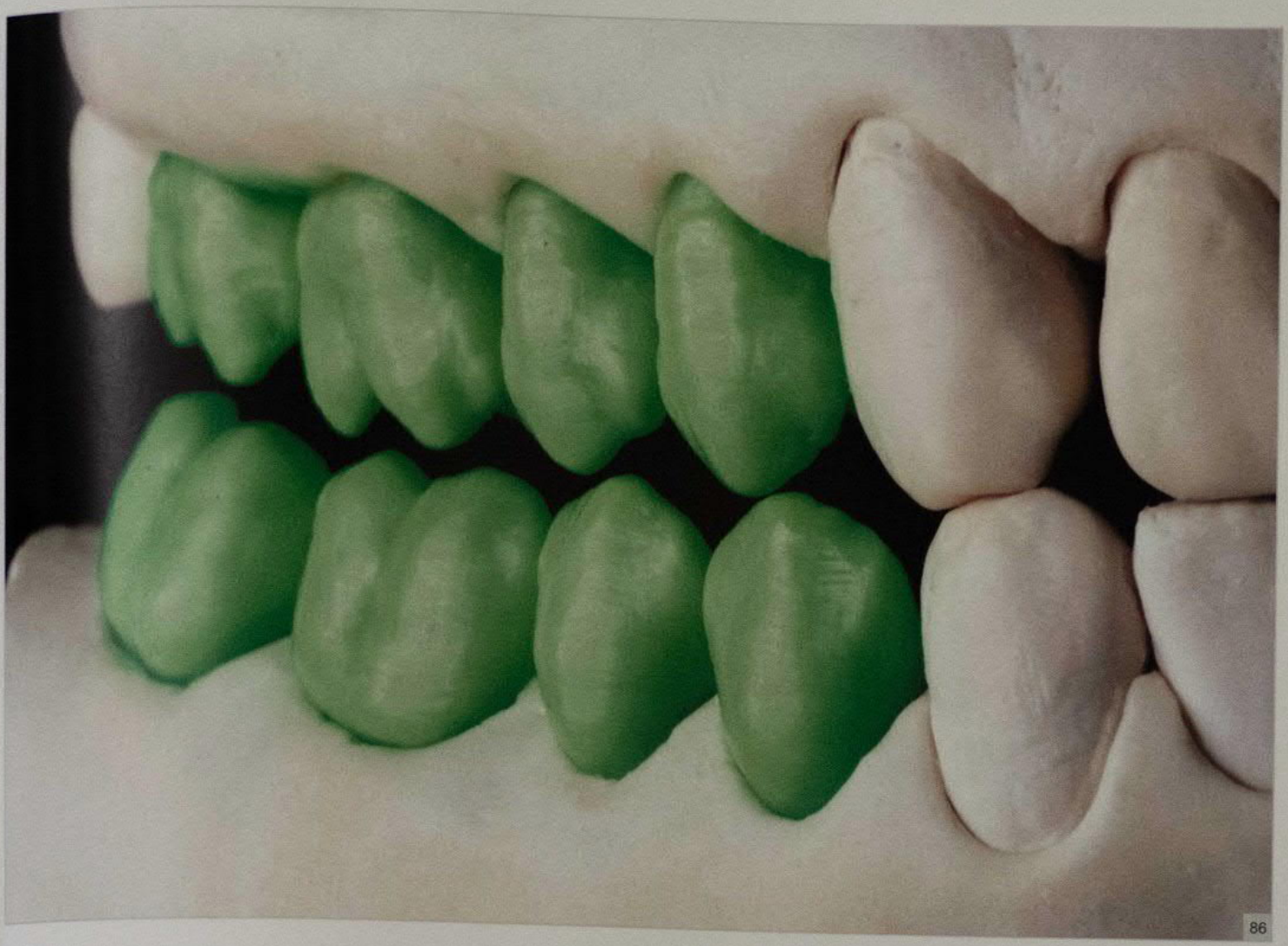


Fig 6-86 Observe that the cervico-occlusal inclination of the second molar should follow the inclination of the mesial segment of the maxillary first molar. It is possible to see that the distal segment of the buccal surface of the second molar appears to be positioned more buccally because of the palatal inclination of the distal lobe of the mesial segment. At this moment, it is important to verify whether the occlusobuccal reference line is similar to that of the homologous teeth. When canine-protected articulation is present, there should be no contact between the buccal surfaces and the antagonist teeth during excursive movements.

Fig 6-87 View of the finished buccal surfaces. Observe the morphologic details and surface texture obtained. The occlusal outlines of the premolars have a V configuration, whereas an M shape is found on the molars.

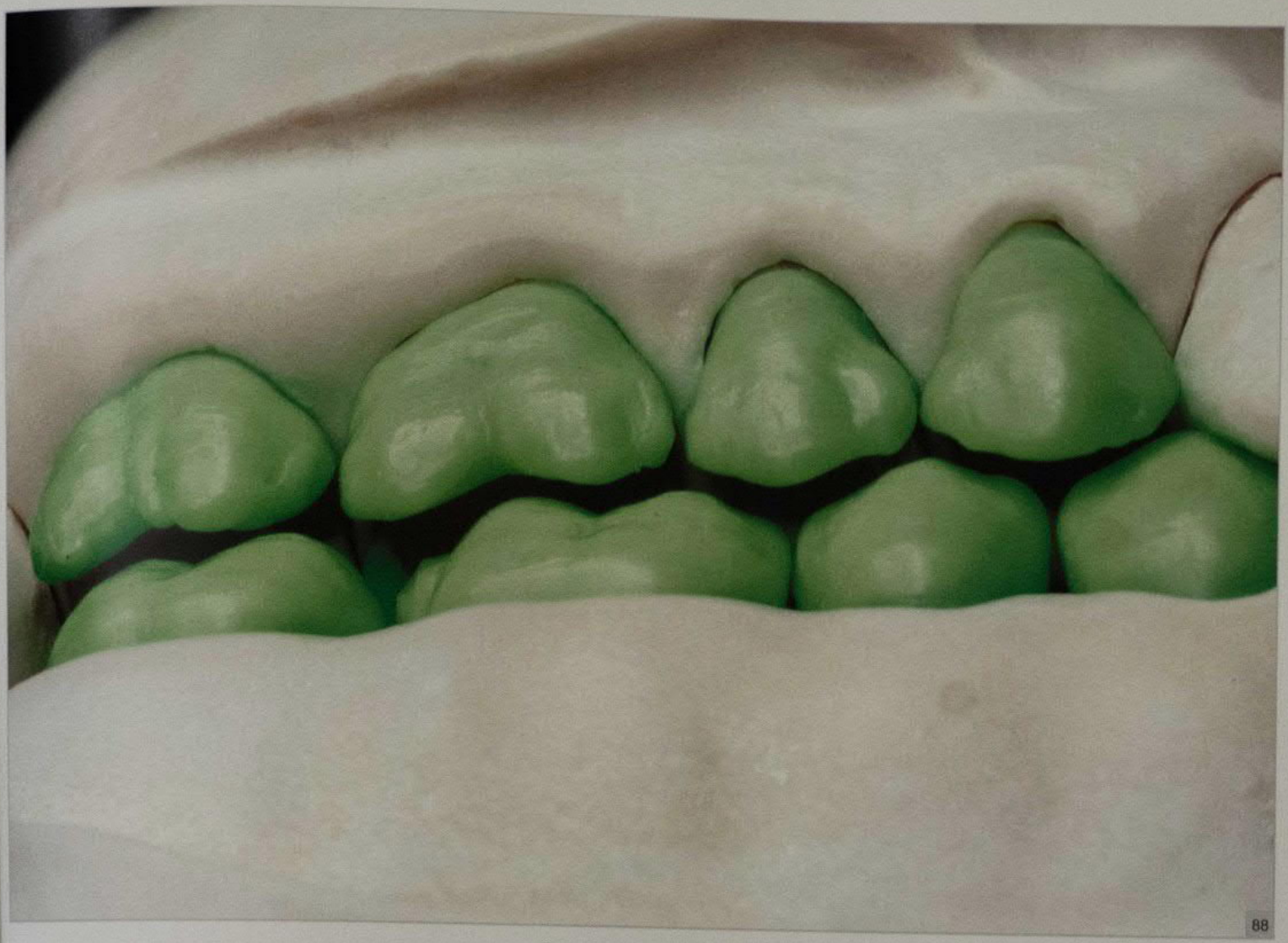
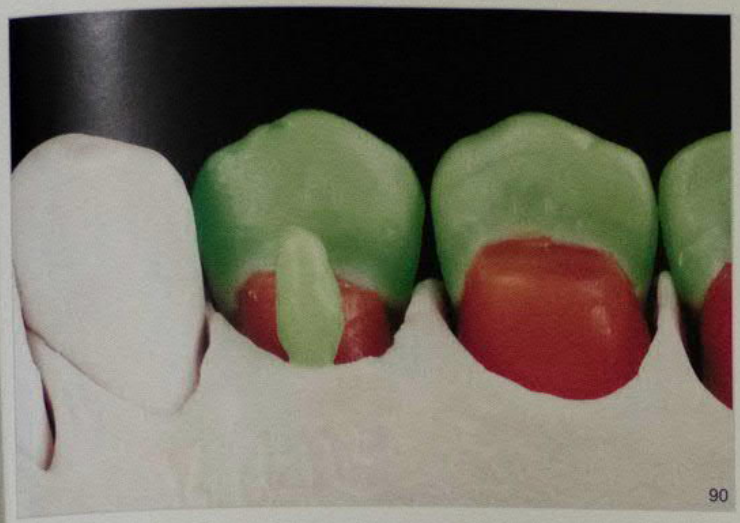
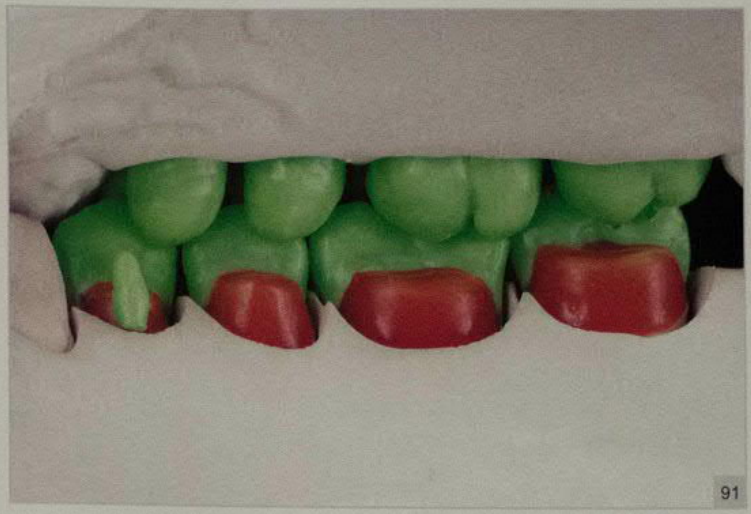


Fig 6-88 When the stone casts are articulated, it is possible to see the parallelism between the occlusobuccal maxillary and mandibular reference lines. It is also important to note the space between the buccal surfaces of the maxillary and mandibular teeth, which should range from 3.0 to 3.8 mm.

Mandibular Teeth – Lingual Surfaces

Fig 6-89 Next, the lingual surfaces should be waxed up. Here, an occlusal view of the lingual cone cusp of the mandibular first premolar.





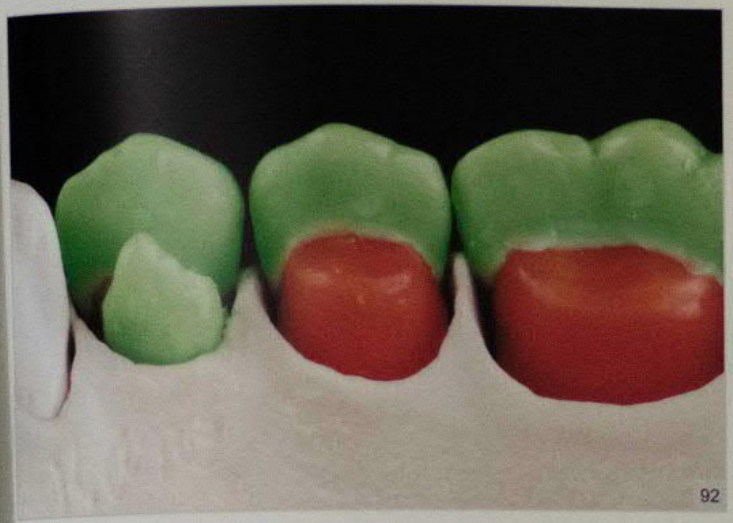


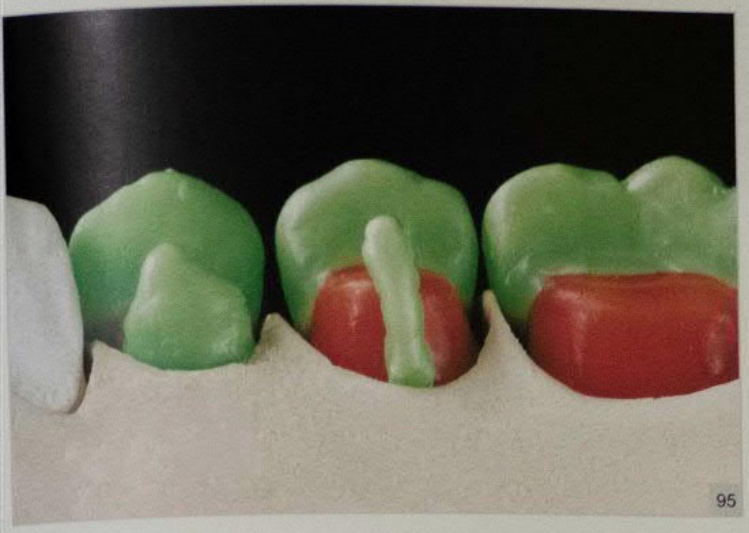
Fig 6-90 The lingual cone cusp should be positioned with reference to its buccal surface and the palatal surface of the maxillary first premolar. From a lingual view, it is possible to see that this cone should remain mesial to its buccal cusp tip.

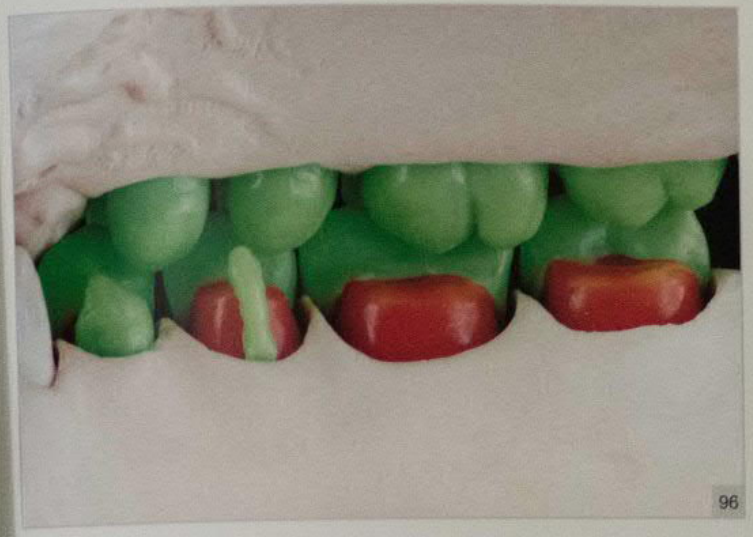
Fig 6-91 It should be no higher than the palatal cusp of the maxillary first premolar, a fact observed in the articulated stone casts.

Fig 6-92 View of the finished lingual surface. It has reduced dimensions and a tapered shape, the cusp tip being approximately 3 mm lower than the buccal cusp. The mesial longitudinal slope is shorter than the distal one, forming an inverted V shape at the occlusal outline.

Fig 6-93 View of the articulated casts after finishing of the lingual surface of the mandibular first premolar. There should be no contact during excursive movements.

Fig 6-94 Occlusal view of the mesiolingual cone of the mandibular second premolar.





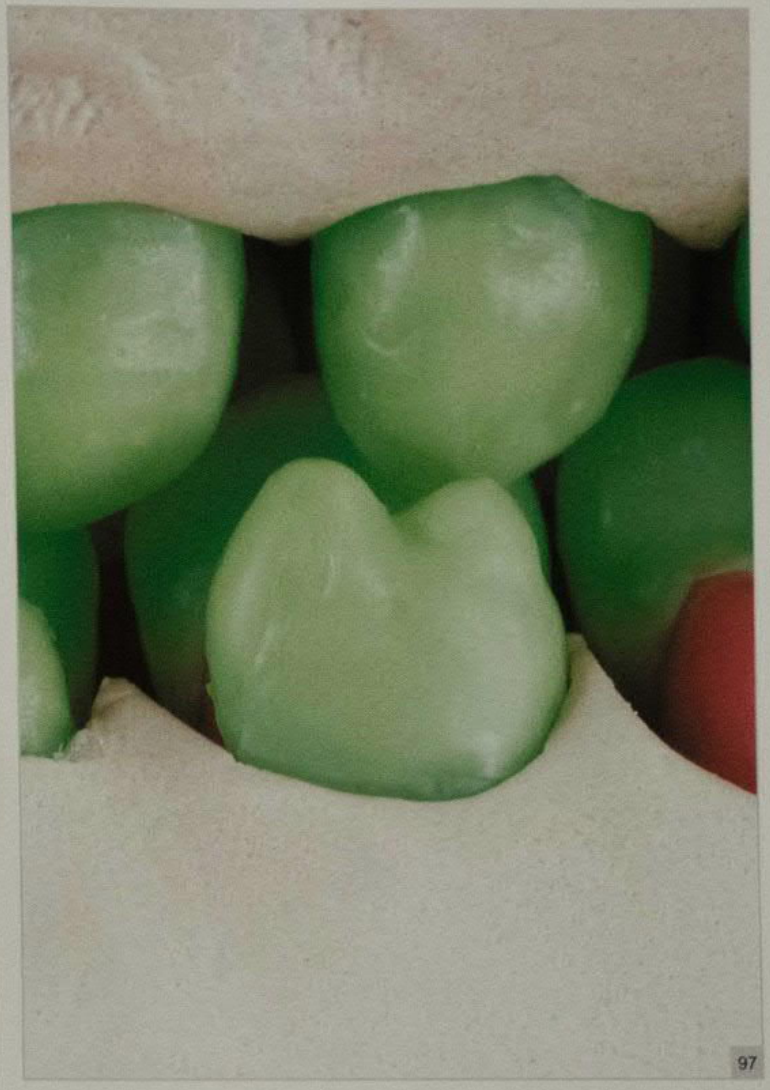


Fig 6-95 This cone is slightly inclined toward the mesial compared to the buccal cusp tip.

Fig 6-96 On the articulated stone casts, one can visualize that the height of the mesiolingual cone should be 0.5 to 1.0 mm above the palatal cusp tip of the maxillary second premolar and should be pointed toward the region of the maxillary premolars.

Fig 6-97 The articulated casts with the lingual surface waxed up, showing the existence of two segments that can be applied simultaneously, the distal being smaller than the mesial. The mesiolingual cusp tip should be positioned between the maxillary premolars, whereas the distolingual cusp tip should be slightly distal to the buccal cusp tip. These segments are separated by the occlusolingual groove, preventing contacts during excursive movements.

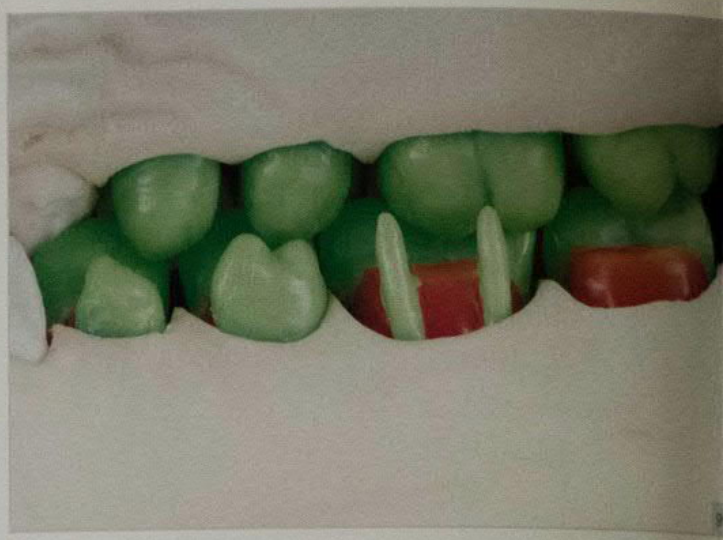
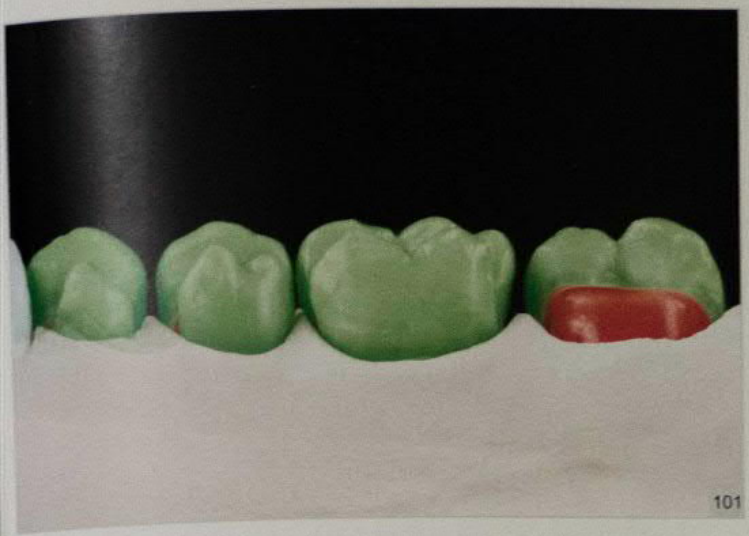


Fig 6-98 The cones of the mandibular first molar are positioned with reference to the buccal and palatal surfaces of the maxillary first molar.

Fig 6-99 The mesiolingual cone should be pointed toward the region between the maxillary second premolar and the first molar, with its tip at the same level as the mesiobuccal cone of the mandibular first molar. The distolingual cone has the same height as or is slightly lower than the mesiolingual cone, and it should be pointed toward the palatal groove of the maxillary first molar. At this point the heights of the buccal cusp tips and the lingual wax cones should be adjusted to be the same as the heights of the buccal and lingual cusps of the homologous tooth (see Fig. 6-10). There should be no contact during excursive movements.

Fig 6-100 Occlusal view of the lingual cones. It is important to observe the length of the occlusal table of the homologous teeth, which varies from 6.0 to 7.6 mm, to determine the buccolingual positioning of these cones.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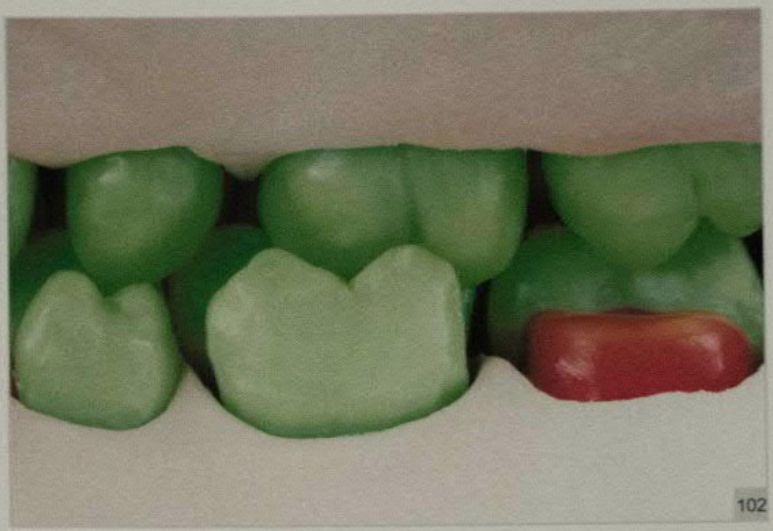
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Fig 6-101 The finished lingual surface, which has smaller dimensions than the buccal surface. The mesial and distal segments are pentagonal and separated by the lingual groove. The longitudinal slopes of these two segments determine a line similar to the letter *M*.

Fig 6-102 On the articulated casts, it is possible to see the mesial and distal limits of the lingual surface. The mesial limit is in the region of the distal outline of the palatal surface of the maxillary second premolar and the distal limit in the region of the distopalatal cusp tip of the maxillary first molar.

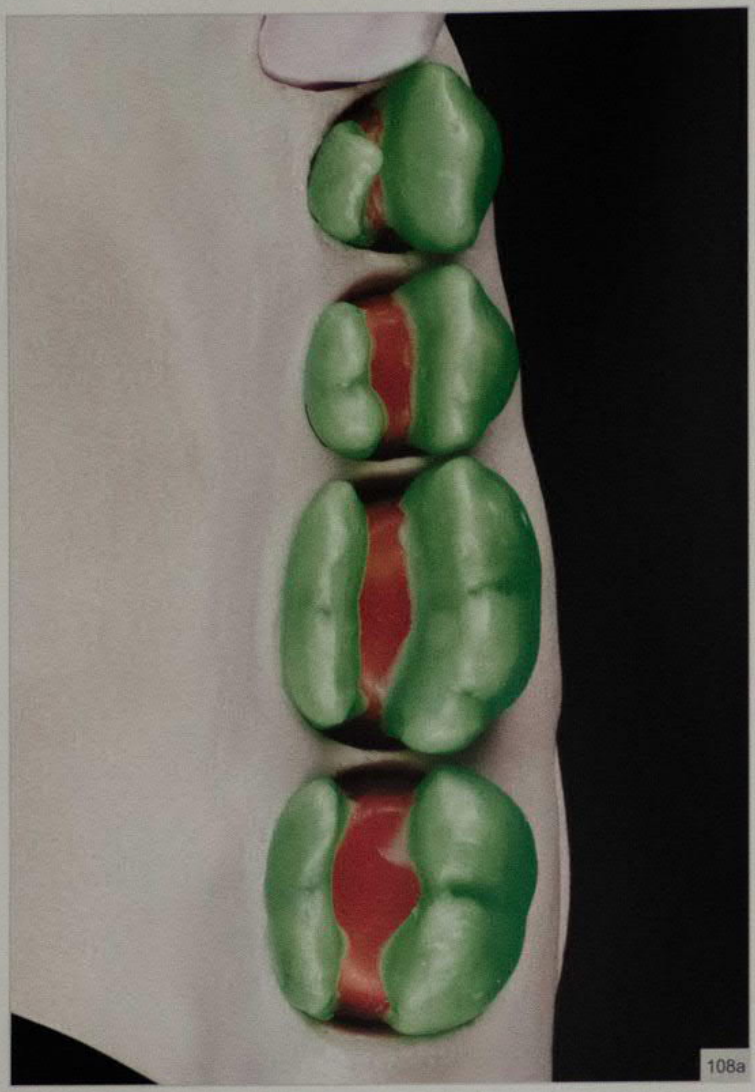
Fig 6-103 Occlusal view of the finished lingual surface of the mandibular first molar.

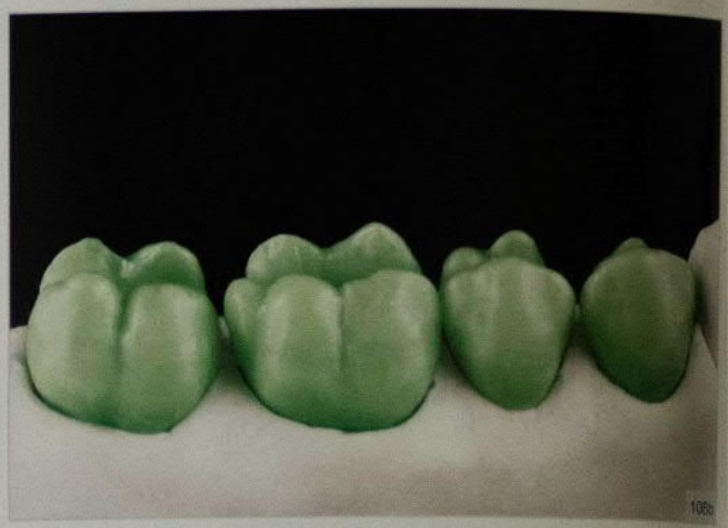
Fig 6-104 Fabrication of the mesial and distal cones of the lingual surface of the mandibular second molar. The mesiolingual cone is a little lower than the mesiobuccal cusp tip of the same tooth, according to the curve of Wilson. Because of its inclination in the dental arch, the distolingual cone is a little higher (0.5 mm) than the mesial cone.

Fig 6-105 With the stone casts in occlusion, the mesiolingual cone should be positioned between the maxillary molars, while the distal one should be pointed toward the palatal groove of the maxillary second molar.

Fig 6-106 View of the finished lingual surface after wax-up of the mesial and distal segments, separated by a shallow lingual groove. The mesial limit of this surface should be at the distal limit of the palatal surface of the maxillary first molar, and the distal limit should be near the distopalatal cusp tip of the maxillary second molar.

Fig 6-107 During excursive movements, no contact should occur between the lingual surfaces of the mandibular teeth and the antagonists.





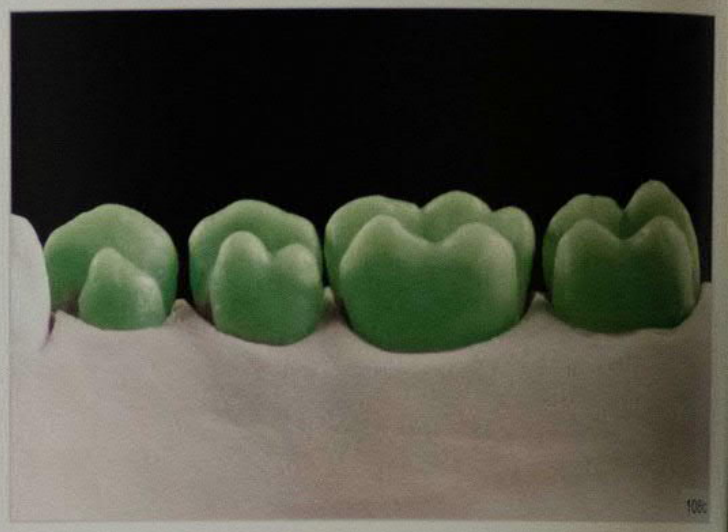
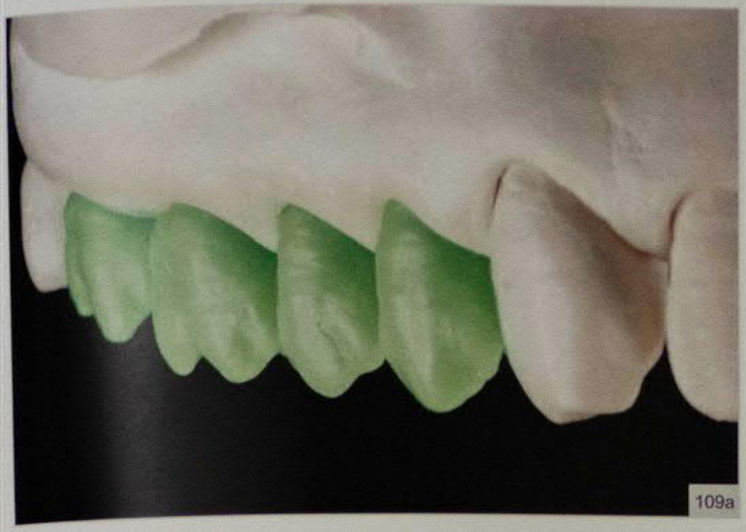


Fig 6-108a to 6-108c Buccal and lingual surfaces of the mandibular teeth, in occlusal *(a)*, buccal *(b)*, and lingual *(c)* views.



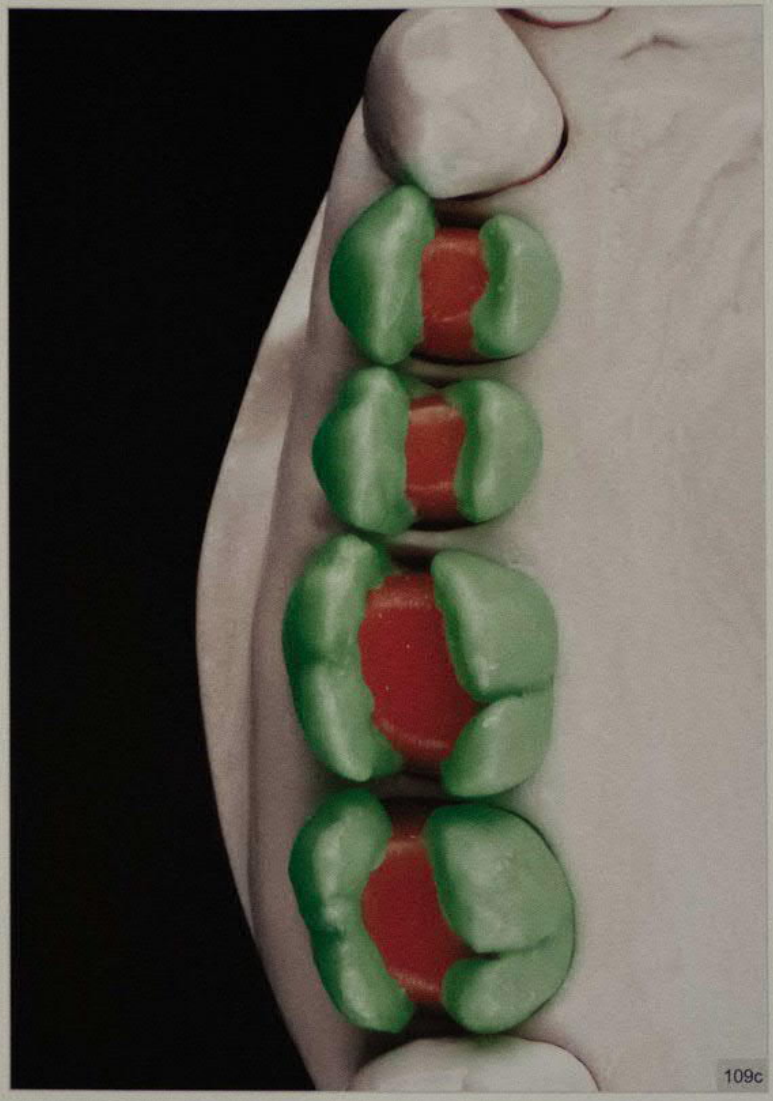
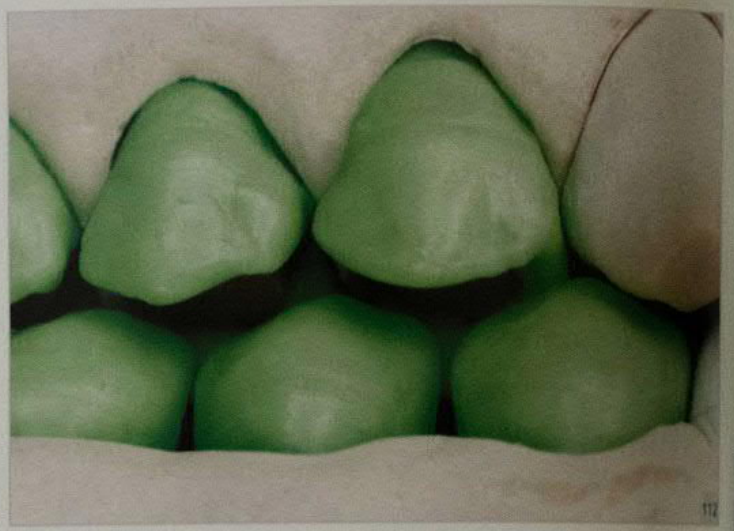


Fig 6-109a to 6-109c Buccal and palatal surfaces of the maxillary teeth, in buccal *(a)*, palatal *(b)* and occlusal *(c)* views.

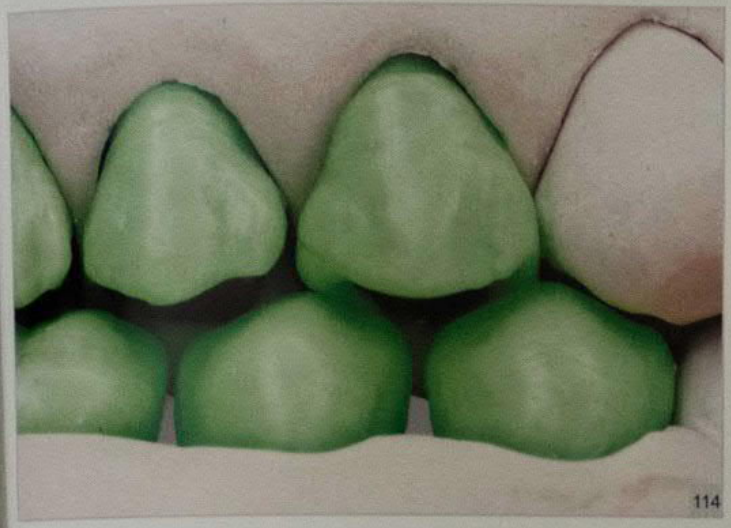


Maxillary Teeth – Marginal Ridges

Fig 6-110 The next step is the fabrication of the marginal ridges of the maxillary teeth, which should be constructed so as to provide axial positioning of occlusal loads during excursive movements. Here we see the mesial marginal ridge of the maxillary first molar, showing a proximal contact area in the region of the incisal third of the maxillary canine.

Fig 6-111 There is a contact between the mesial marginal ridge of the maxillary first premolar and the distal longitudinal slope of the buccal cusp of the mandibular first premolar. This contact can also occur between the ridge and the buccal cusp tip of the mandibular first premolar, determining its height.

Fig 6-112 Observe the contacts in the articulated casts. It is important to have a flat marginal ridge to prevent interference during excursive movements.



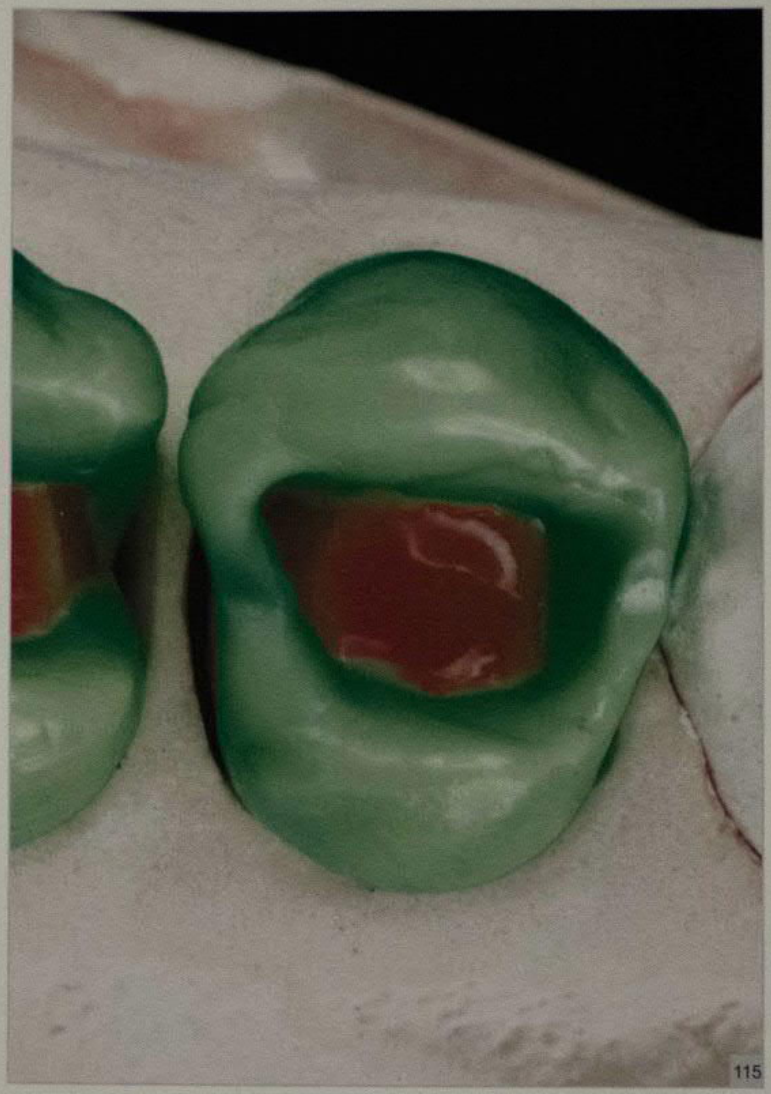


Fig 6-113 The articulated casts after wax-up of the distal marginal ridge of the maxillary first premolar.

Fig 6-114 Observe that the contact occurs between the distal marginal ridge and the mesial longitudinal slope of the buccal cusp of the mandibular second premolar.

Fig 6-115 Occlusal view of the marginal ridges of the maxillary first premolar. Now the occlusal adjustments should be performed to prevent interference during excursive movements.

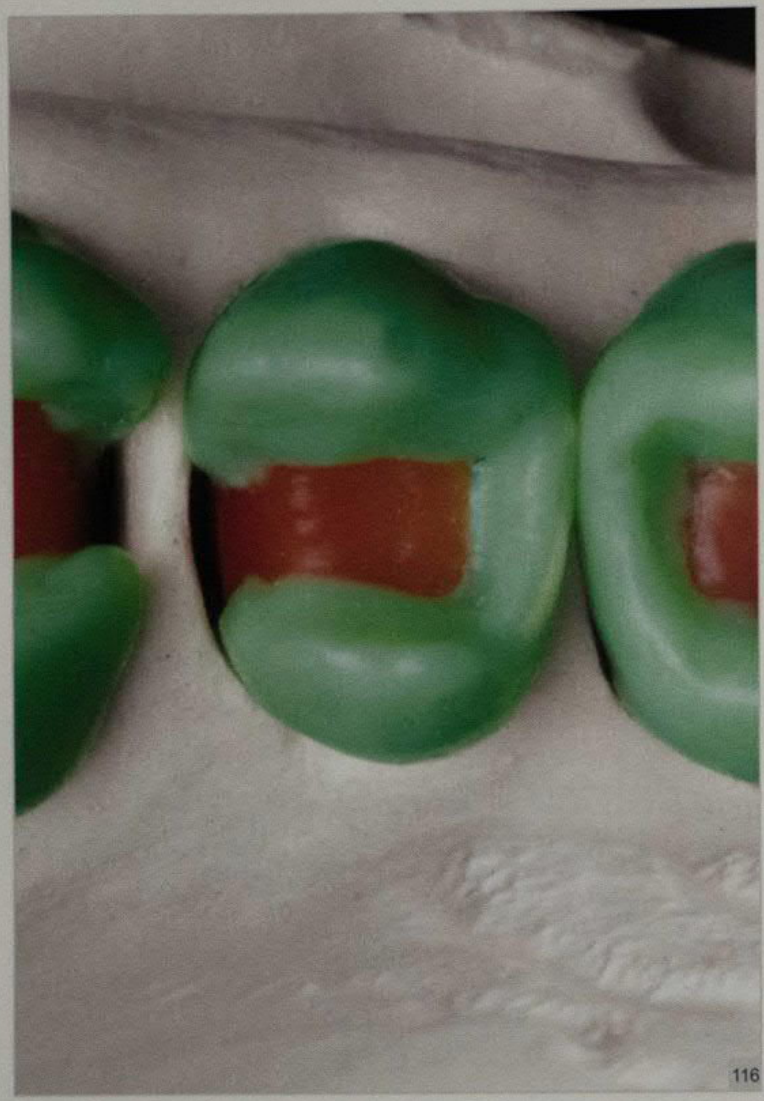


Fig 6-116 The mesial marginal ridge of the maxillary second premolar is fabricated, having a proximal contact area shifted toward the buccal with the distal surface of the maxillary first premolar because of the smaller dimensions of the palatal surface.

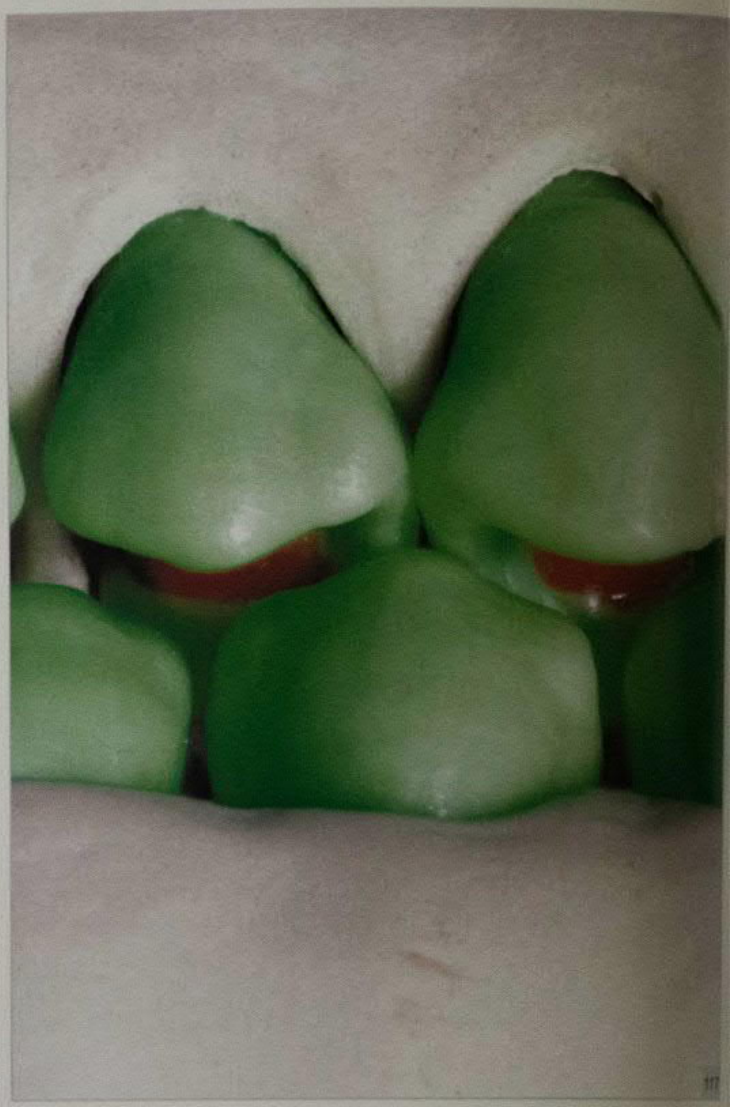


Fig 6-117 The mesial ridge should make contact with the distal longitudinal slope of the buccal cusp of the mandibular second premolar.

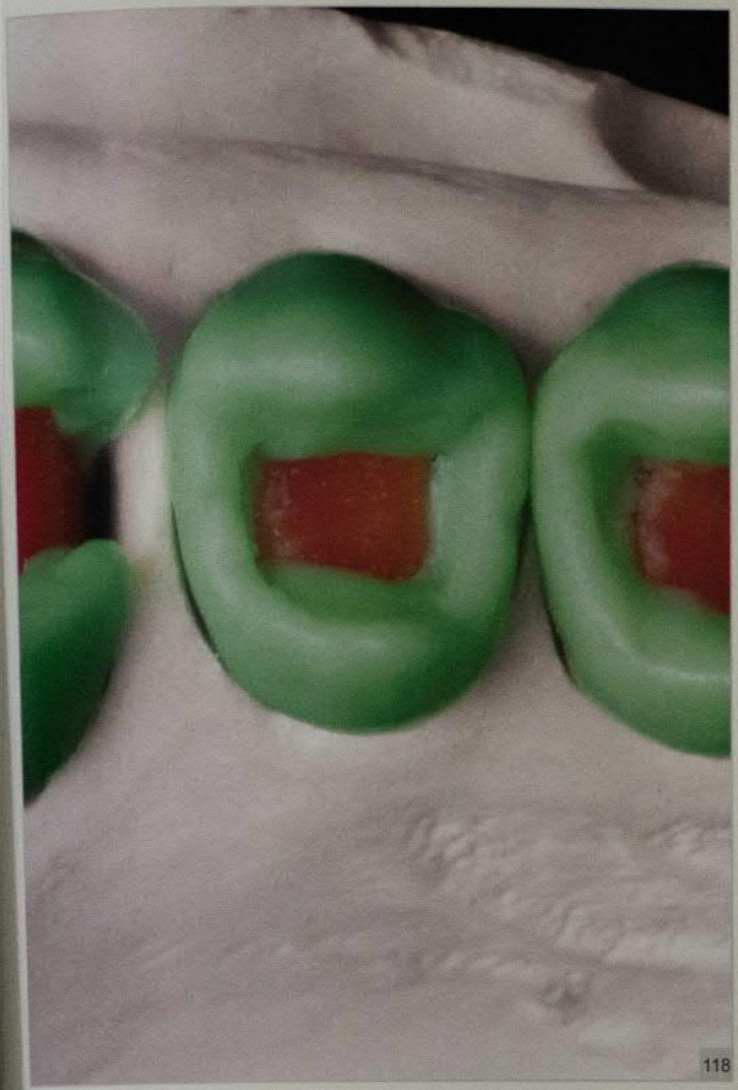


Fig 6-118 Occlusal view of the marginal ridges of the maxillary second premolar. Occlusal adjustments should be performed to prevent interference during excursive movements.

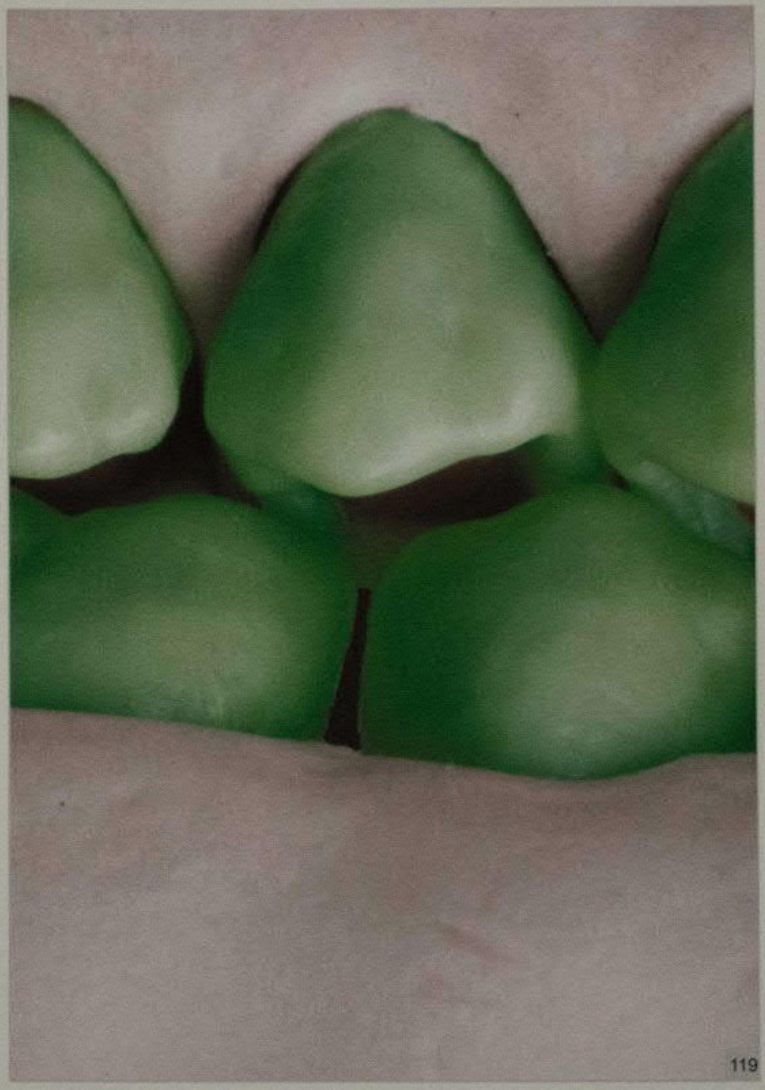


Fig 6-119 A contact occurs between the distal marginal ridge and the mesial longitudinal slope of the mesiobuccal cusp of the mandibular first molar.

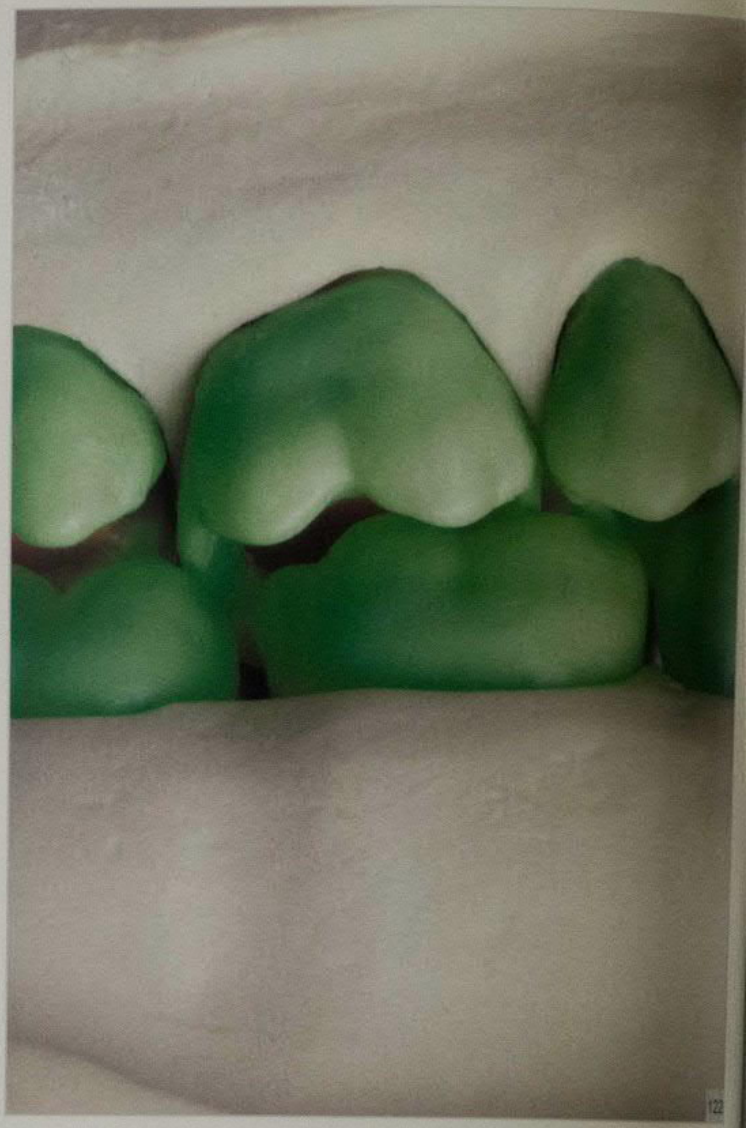


Fig 6-120 Fabrication of the mesial marginal ridge of the maxillary first molar. Its proximal contact area is shifted toward the buccal with respect to the distal surface of the maxillary second premolar because of the smaller dimensions of the palatal surface.

Fig 6-121 Occlusal view after fabrication of the distal marginal ridge.

Fig 6-122 Observe the contact between the mesial marginal ridge and the distal longitudinal slope of the mesiobuccal cusp of the mandibular first molar. It is also possible to see a contact between the distal marginal ridge and the mesial longitudinal slope of the mesiobuccal cusp of the mandibular second molar.

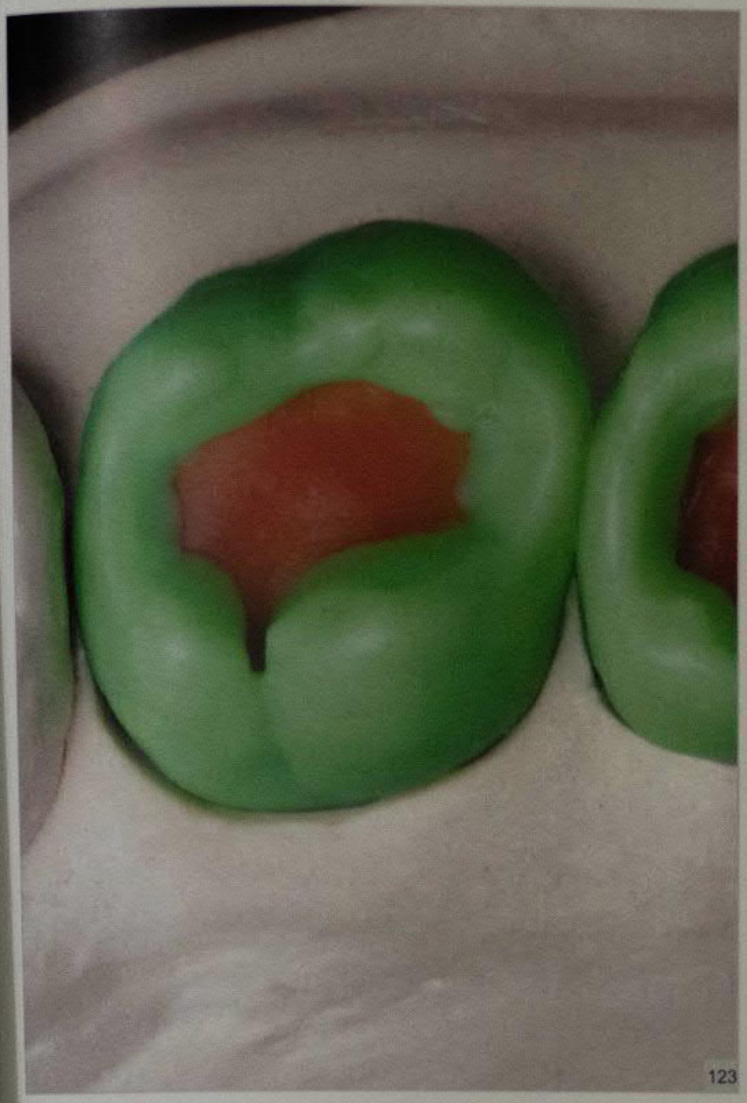
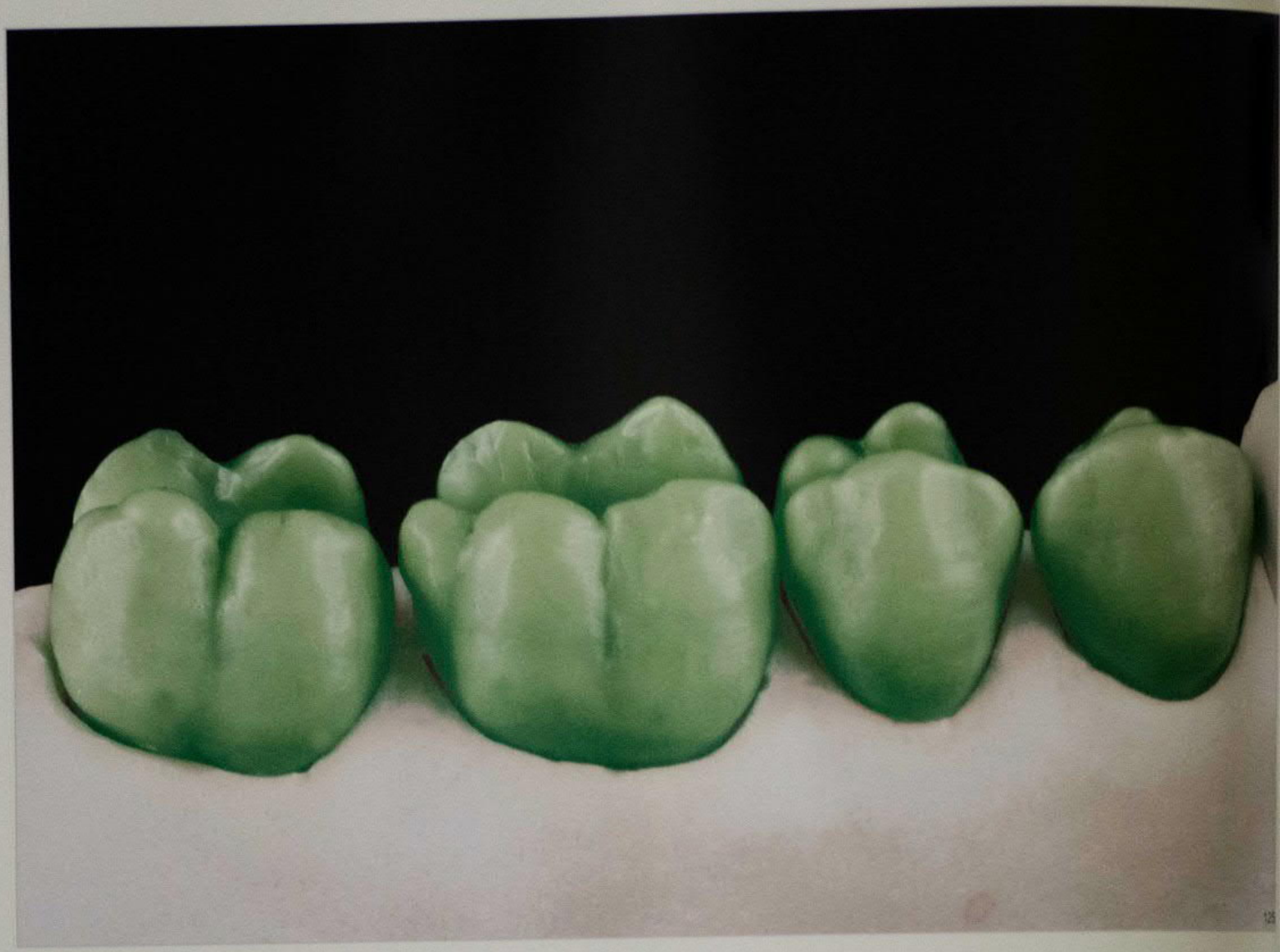


Fig 6-123 Occlusal view of the finished marginal ridges of the maxillary second molar.

Fig 6-124 Observe that there is a contact between the mesial marginal ridge and the distal longitudinal slope of the mesiobuccal cusp of the mandibular second molar. It is also possible to visualize that, because of the lack of the mandibular third molar, there is no contact in the region of the distal marginal ridge.



Mandibular Teeth – Marginal Ridges

Fig 6-125 Buccal view of the mandibular teeth before wax-up of the marginal ridges.

Fig 6-126 Occlusal view of the marginal ridges of the mandibular teeth, constructed the same way as those of the maxillary teeth, although there should be no contact with the antagonist teeth. The proximal contacts should be reestablished, and no diastemata should be seen after this step.

Fig 6-127 Lingual view of the mandibular marginal ridges. No contact should be found during excursive movements.

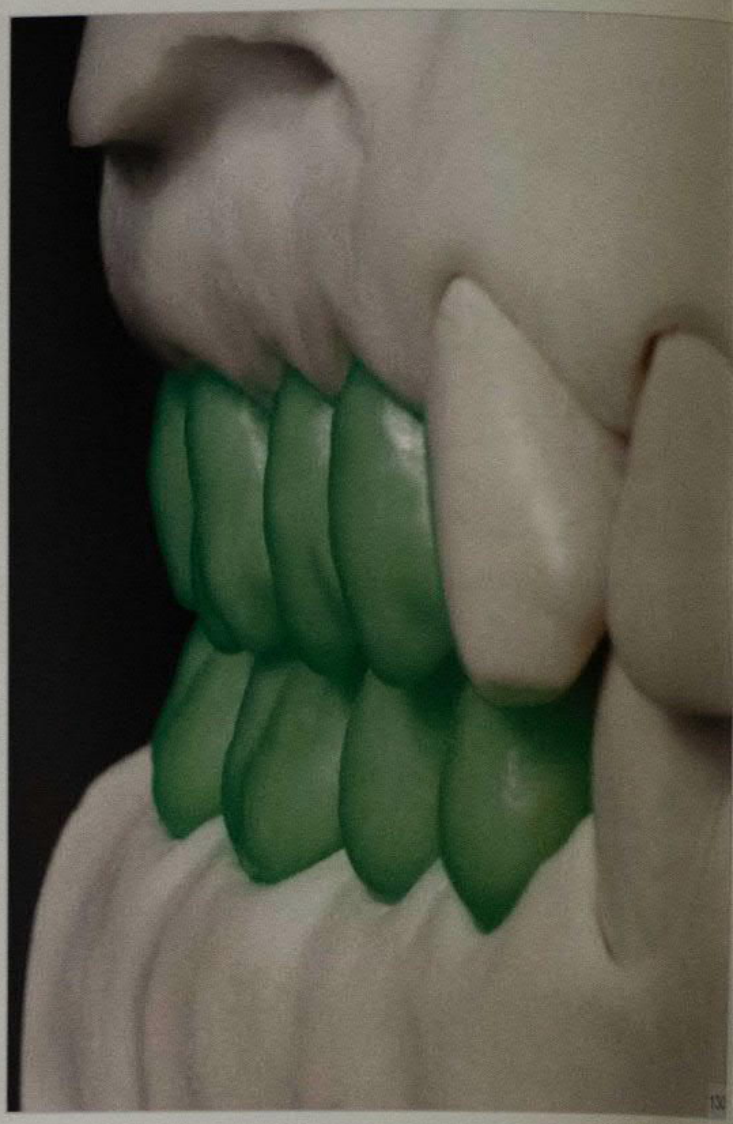


Fig 6-128 Buccal view of the occlusal relationship between the maxillary and mandibular teeth after fabrication of the marginal ridges.

Fig 6-129 Lingual view of the occlusal relationships between the premolars and molars. It must be remembered that:

- The mesial marginal ridge of the mandibular second premolar should be higher than the distal marginal ridge of the mandibular first premolar. To prevent interference, the palatal cusp of the maxillary first premolar should be pointed toward the distal fossa of the mandibular first premolar.
- The mesial marginal ridge of the mandibular first molar is higher than the distal marginal ridge of the mandibular second premolar.
- To prevent interference, the palatal cusp of the maxillary second premolar should be pointed toward the distal fossa of the mandibular second premolar.
- The mesial marginal ridge of the mandibular second molar is no higher than the distal marginal ridge of the mandibular first molar.
- Preferably, no centric contact should be found in this region.
- The distal marginal ridge of the mandibular second molar should be aligned with the distopalatal cusp tip of the maxillary second molar, and despite the proximity of these two structures, neither centric nor lateral contacts should be found at rest position or during excursive movements, respectively.

Fig 6-130 Profile view of the posterior teeth after wax-up of the marginal ridges. Observe the cervico-occlusal inclination of the wax surfaces.

Fig 6-131 Lingual view of the occlusal relationships between the posterior teeth after wax-up of the marginal ridges.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Occlusal Surfaces

Figs 6-132a and 6-132b Before wax-up of the occlusal surfaces, some wax must be applied to the cavity floor to standardize the grooves and fossae depths. Next the axial walls and the longitudinal slopes should be refined with manual carving instruments. These procedures should be applied to all teeth.

Fig 6-133 In this sequence, an alternative technique was performed in which the sculpting of the occlusal surface begins at the lateral lobes, which are less prominent than the central ones, making it easier to obtain this feature according to the proposed protocol. Here, the lateral lobes of the buccal cusp of the maxillary first premolar are fabricated in the region between the small mesial and distal angles, which are pointed toward the center of the tooth, without extending to the central groove area.

Fig 6-134 The central lobe of the buccal cusp, large and slightly extended toward the palatal, is constructed, making the buccal cusp wider than its palatal counterpart. It has a triangular shape with a straight base aimed toward the central groove, which determines its straight configuration. This lobe has an accentuated convexity, being more prominent than the marginal ridge; however, one should take great care to avoid causing interference in the canine-protected articulation.

Fig 6-135 The lateral lobes of the palatal cusp are made at the mesial and distal small, narrow angles, extending to the central groove. Small triangular lobes should be fabricated at the marginal ridges.

Fig 6-136 The central lobe of the palatal cusp, showing a triangular shape with a straight base, aimed toward the central groove. Because its convexity and length are less pronounced than those of the central lobe of the buccal cusp, the grooves that are present are shallow. The union of the principal groove with the lobes of the marginal ridges is similar to a cotton swab. The perimeters of the mesial and distal fossae should look like two mirror-image *D*'s.

Fig 6-137 The articulated stone casts after finishing of the occlusal surface of the maxillary first premolar. As the occlusal contacts were developed at the marginal ridges, occlusal adjustments should be made to remove other interferences. No contacts should occur during excursive movements.

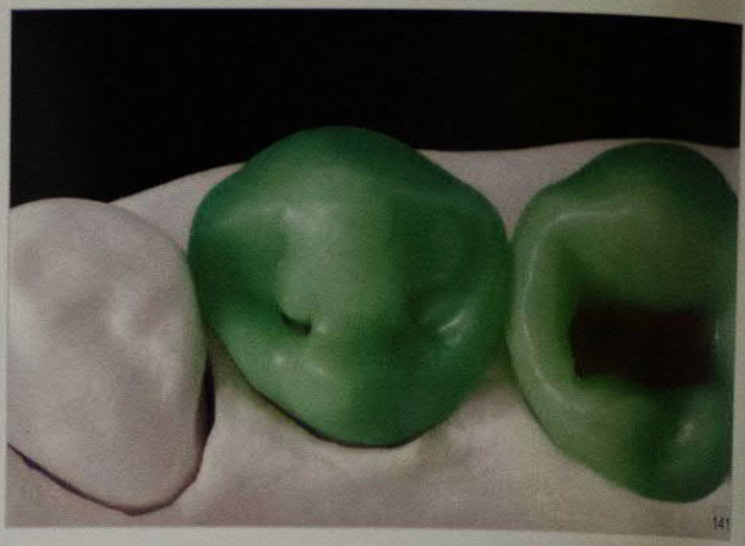


Fig 6-138 In this technique, occlusal wax-up of maxillary and mandibular teeth should be alternated. This allows morphologic reproduction according to the references found on the antagonist teeth. Next, the small lateral lobes of the buccal cusp of the mandibular first premolar are constructed in the mesial and distal angular regions.

Fig 6-139 Central lobe of the buccal cusp, which should be displaced more toward the lingual. It appears bifurcated, with a transverse segment toward the center of the tooth and an oblique segment toward the distal fossa. The transverse segment is one of the structures responsible for the fact that the enamel bridge joining the buccal and lingual cusps is more elevated than the marginal ridges.

Fig 6-140 Oblique segment of the central lobe of the buccal cusp. It has a triangular shape, with the apex toward the distal fossa. This lobe must have contact neither during centric occlusion nor during excursive movements.

Fig 6-141 Small lobes can be fabricated in the region of the marginal ridges before sculpting of the lobes of the lingual cusps. The lateral lobes of the lingual cusp should be small. The central lobe of the lingual cusp and the transverse segment of the central lobe of the buccal cusp form the enamel bridge, which delimits the mesial and distal fossae. The perimeters of these fossae have the shape of two mirror-image *D*'s.

Fig 6-142 Occlusal view of the finished mandibular first premolar.

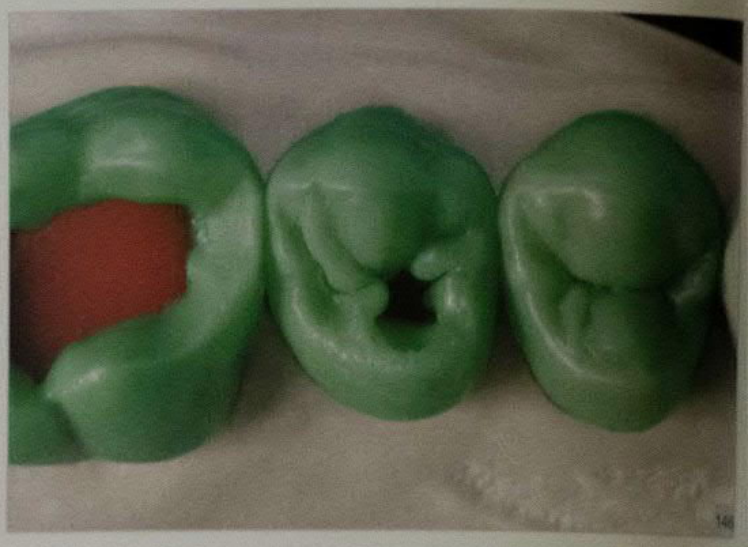


Fig 6-143 Beginning of the construction of the lateral lobes of the maxillary second premolar in the region of the mesial and distal angles.

Fig 6-144 The lateral lobes can extend to the principal groove, being better defined than those in the maxillary first premolar, a hallmark of the maxillary second premolar. Now the long, triangular lobe of the mesial marginal ridge should be fabricated.

Fig 6-145 Fabrication of the central lobe of the buccal cusp, with a triangular shape and rounded outlines; its apex is pointed toward the central groove but slightly toward the distal. The lobe also has a convexity with its highest point at the level of the marginal ridge. The configuration of these lobes determines a sinusoid groove in the mesiodistal dimension.

Fig 6-146 The lateral lobes of the palatal cusp are constructed in the region of the mesial and distal angles. These lobes are more distinct than the lateral palatal lobes of the first premolar and extend transversely to the developmental groove.

Fig 6-147 Occlusal view of the finished maxillary second premolar. The central lobe of the palatal cusp presents a triangular shape with the apex pointed toward the developmental groove. Its convexity is higher than that of the central lobe of the palatal cusp of the first premolar, having a possible contact with the central lobe of the buccal cusp of the mandibular second premolar. Excursive movements should be carried out to prevent interference.

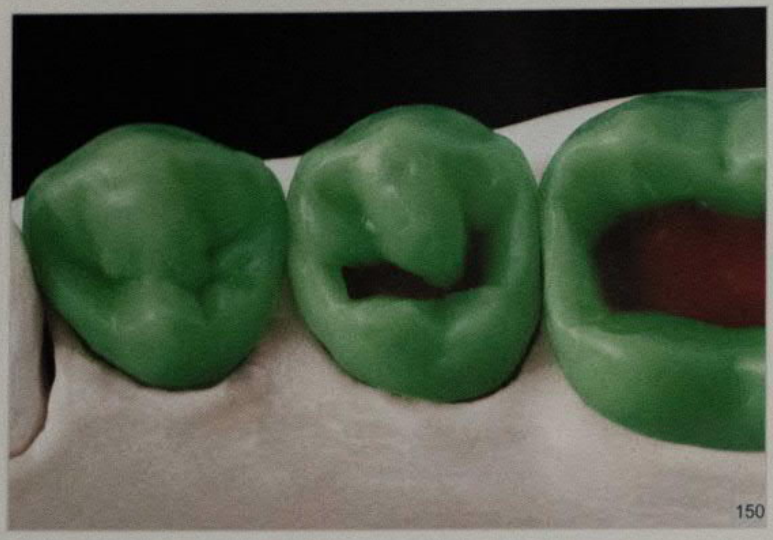


Fig 6-148 Occlusal view of the mandibular second premolar before wax-up of the occlusal surface.

Fig 6-149 Development of the lateral lobes of the buccal cusp in the region of the mesial and distal angles. These lobes are narrow and pointed toward the center of the tooth.

Fig 6-150 Construction of the central lobe of the buccal cusp, which can be bifurcated similarly to the mandibular first premolar. In this case, a single central lobe has been fabricated pointing toward the distal fossa. Near the central fossa this lobe has a convexity that can make contact with the central lobe of the palatal cusp of the maxillary second premolar. In some cases it is necessary to make adjustments at the antagonist lobe for a more precise contact.

Fig 6-151 Next, the central lobe of the mesiolingual cusp is fabricated, often bifurcated to form the enamel bridge. In this case, it was decided to construct a single lobe pointed both transversely and toward the distal fossa. The part of the central lobe pointed distally can make contact with the mesial incline of the palatal cusp of the maxillary second premolar. A small lobe should be fabricated, pointed toward the mesial fossa, in the region of the mesial marginal ridge.

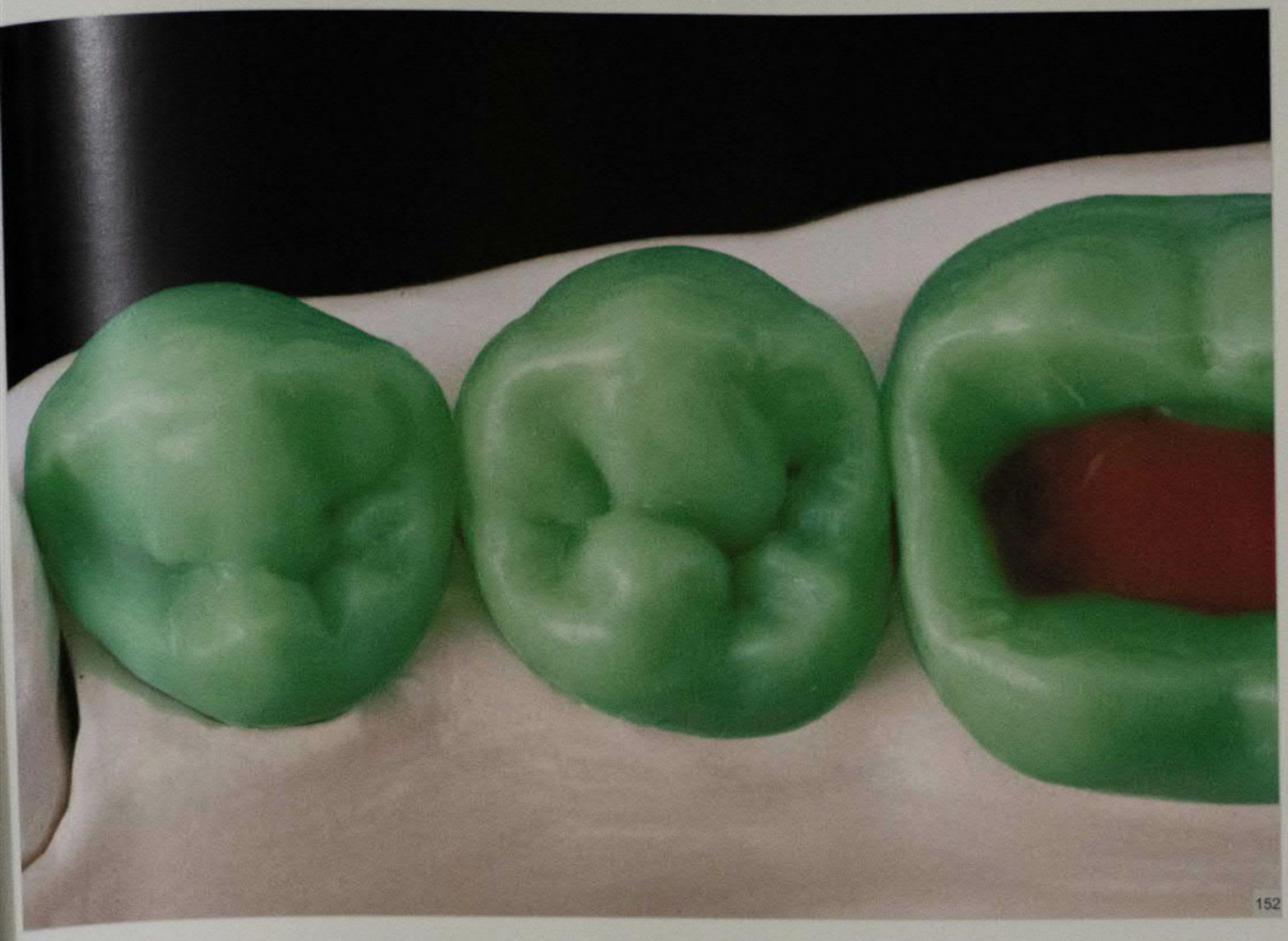


Fig 6-152 The waxing process should be finished by constructing the central lobe of the distolingual cusp, pointed toward the distal fossa. It can make contact with the distal incline of the palatal cusp of the maxillary second premolar. The contacts described in the region of the central lobes of the mandibular second premolar determine a tripodization with the antagonist tooth. This relationship can be established in the study casts; however, it is very difficult to reproduce in daily clinical practice because of the small size of the involved structures. In most cases, only one contact is found, but this is enough. A small lobe should also be fabricated, pointing toward the distal fossa, in the region of the distal marginal ridge. The mesiodistal groove should form a letter *M*, and the joining of the occlusolingual, occlusodistobuccal, and occlusomesiobuccal grooves should have a calyx configuration. The perimeter of the mesial fossa is similar to an inverted letter *D*, whereas that of the distal fossa looks like a crescent moon.

Fig 6-153 Occlusal view of the maxillary first molar before the occlusal surface is waxed up.

Fig 6-154 Wax-up starts with construction of the lateral lobes of the mesiobuccal cusp of the maxillary first molar in the region of the mesial and distal angles. These lobes are small.

Fig 6-155 Construction of the central lobe of the mesiobuccal cusp. It should point toward the central fossa.

Fig 6-156 The central lobe's convexity is set higher than the mesial marginal ridge, which determines a contact with the mesial incline of the midbuccal cusp of the mandibular first molar. Consequently, it is necessary to make adjustments at the cusp of the mandibular first molar to obtain a mesial inclined plane similar to a wear facet. It is necessary to verify its accuracy with the articulated stone casts.

Fig 6-157 Construction of a long lobe at the mesial marginal ridge, pointed almost horizontally toward the central fossa. This lobe has an outline that contributes to the development of the central groove, generating a Mercedes-Benz symbol. This lobe is a characteristic element of the maxillary first molar.

Fig 6-158 The mesial lobe of the distobuccal cusp should be constructed with a triangular configuration, parallel to the occlusobuccal groove, and pointing toward the central groove.

Fig 6-159 The distobuccal cusp has two surfaces: one pointing toward the central and the other toward the distal fossa. Here, the central lobe of the surface pointing toward the central fossa is fabricated.

Fig 6-160 Observe the contact between the central lobe of the distobuccal cusp and the distal incline of the midbuccal cusp of the mandibular first molar.

Fig 6-161 Next, the distal lobe of the distobuccal cusp should be fabricated, from the distal aspect to the central fossa, having an outline that contributes to the formation of the principal groove with the shape of the Mercedes-Benz symbol.

Fig 6-162 Construction of the lateral lobes of the mesiopalatal cusp. The mesial lobe is small and transversely pointed toward the principal groove. The most prominent part of the distal lobe forms a ridge, transversely pointed toward the central lobe of the distobuccal cusp, forming the enamel bridge. The path of this bridge coincides with the positioning of the occlusodistobuccal groove in the mandibular first molar.

Fig 6-163 The central lobe of the mesiopalatal cusp is applied. This lobe is wide, has a triangular shape, and points transversely toward the central fossa. It has an accentuated convexity where contact occurs with the central lobe of the midbuccal cusp of the mandibular first molar. After positioning of this lobe, it is possible to see the central groove with a Mercedes-Benz symbol configuration. At this moment, it should be possible to see the perimeter of the mesial fossa, witch has a heart shape.

Fig 6-164 First, the central lobe of the surface pointing toward the distal fossa of the distobuccal cusp should be waxed up. Next, a lobe is constructed at the distal marginal ridge pointing toward the distal fossa, forming a marginal groove at its buccal limit. Finally, the lateral lobes of the distopalatal cusp should be constructed and should be pointed toward the distal fossa. The central lobe should be small and have an oblique path to the distal fossa. The distal limits of the distobuccal and the mesiopalatal cusps contribute to the occlusodistal groove, parallel to the enamel bridge, which should form a curly bracket symbol. The perimeter of the distal fossa should have the shape of an irregular right triangle.

Fig 6-165 The wax-up of the occlusal surface of the mandibular first molar begins with the midbuccal cusp. The distal and mesial lobes should not be very distinct. The central lobe should be transversely directed to the central fossa. There should be a contact with the central lobe of the mesiopalatal cusp of the maxillary first molar. It is important to highlight that the distal limit of the midbuccal cusp determines the occlusodistobuccal groove of the mandibular first molar, which coincides with the ridge of the enamel bridge of the maxillary first molar.

Fig 6-166 Construction of the lateral lobes of the mesiobuccal cusp. The mesial lobe is smaller, whereas the distal one is larger and transversely pointed toward the central fossa. Its distal limit determines the occlusomesiobuccal groove.

Fig 6-167 Construction of the central lobes of the mesiobuccal and distobuccal cusps. At the mesiobuccal cusp, the central lobe can be either small or large, always pointed toward the mesial fossa. Often there is a single central lobe at the distobuccal cusp, which points to the distal fossa.

Fig 6-168 The distolingual cusp is fabricated. First, the small lateral lobes are developed. The mesial lobe is pointed toward the central fossa and the distal one toward the distal fossa. Afterward, the central lobe is constructed; it is pointed toward the central fossa and determines the centric contact with the distal incline of the mesiopalatal cusp of the maxillary first molar. The mesial limit of this cusp contributes to the formation of the occlusolingual groove.

Fig 6-169 To finish this step, the lateral lobes of the mesiolingual cusp are constructed, with the mesial lobe being pointed toward the mesial and the distal one toward the central fossa. Afterward, the central lobe should be fabricated to be pointed toward the central fossa; it can be extremely convex so it contacts the mesial incline of the mesiopalatal cusp of the maxillary first molar. The joining of the mesiodistal, occlusolingual, occlusodistolingual, and occlusomesiolingual grooves should delineate a letter *M*. Part of the mesiodistal, occlusobuccal, and occlusodistobuccal grooves should form the letter *Y*. The perimeters of the mesial and distal fossae should look like a leaf and that of the central fossa like a spool.

Fig 6-170 Next the maxillary second molar is developed. The lateral lobes of the mesiobuccal cusp should be formed in the region of the mesial and distal angles. These lobes are small, narrow, and pointed toward the center of the tooth.

Fig 6-171 Construction of the central lobe of the mesiobuccal cusp, pointed obliquely toward the central fossa.

Fig 6-172 Construction of the lobe of the mesial marginal ridge, extending horizontally toward the region of the central fossa. This lobe has an outline that contributes to the formation of the central groove and a shape like the Mercedes-Benz symbol.

Fig 6-173 On the articulated stone casts, observe that the convexity of the central lobe of the mesiobuccal cusp of the maxillary second molar determines a contact with the mesial incline of the distobuccal cusp of the mandibular second molar. This contact is higher than the mesial marginal ridge of the maxillary second molar.

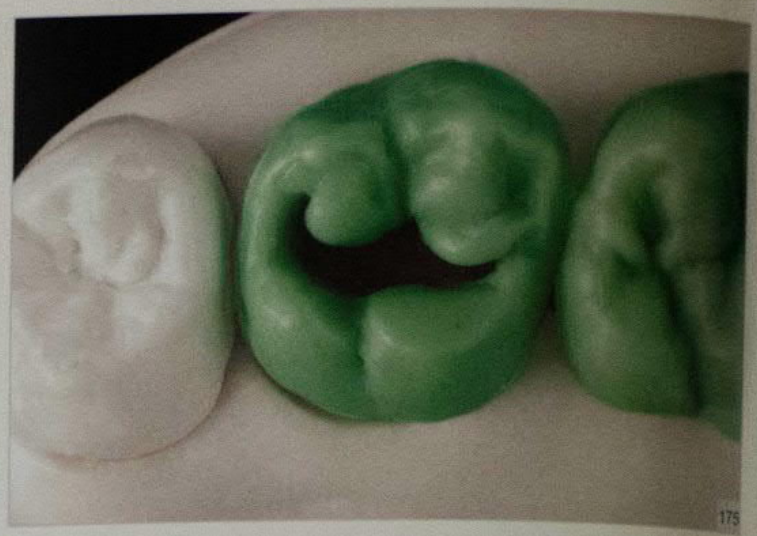


Fig 6-174 Now the mesial lobe of the distobuccal cusp is developed, having a long, rectangular shape, parallel to the occlusobuccal groove.

Fig 6-175 Similar to that of the first molar, this cusp is divided by the enamel bridge. The central lobe of this surface is pointed toward the central fossa of the distobuccal cusp. This lobe determines a contact with the distal incline of the distobuccal cusp of the mandibular second molar. It is important to highlight that the enamel bridge of the maxillary second molar is not too prominent, and often the distobuccal groove is not seen.

Fig 6-176 The distal lateral lobe of the surface is turned toward the fossa of the distobuccal cusp, pointed toward the central fossa, and has an outline that contributes to the formation of the central groove in the shape of the Mercedes-Benz symbol. Next, the mesiopalatal cusp is developed by first fabricating the lateral lobes, which are similar to those of the maxillary first molar. However, the enamel bridge here is not so pronounced. The central lobe of the mesiopalatal cusp has a triangular shape, with the apex toward the central fossa, and its accentuated convexity makes contact with the central lobe of the distobuccal cusp of the mandibular second molar. Now the central groove becomes visible, with the outline of the Mercedes-Benz symbol.

Fig 6-177 The distolingual cusp is fabricated. As there is little space for the distal fossa, only a few regions need to be filled in. Many times, the central lobe already occupies this space, along with the lobe of the distal marginal ridge and the surface of the distobuccal cusp pointed toward the distal fossa. Now the distal groove becomes visible, with the shape of a curly bracket. The perimeters of the mesial and distal fossae should determine a heart shape and an irregular triangle, respectively.

Fig 6-178 Finished maxillary second molar.

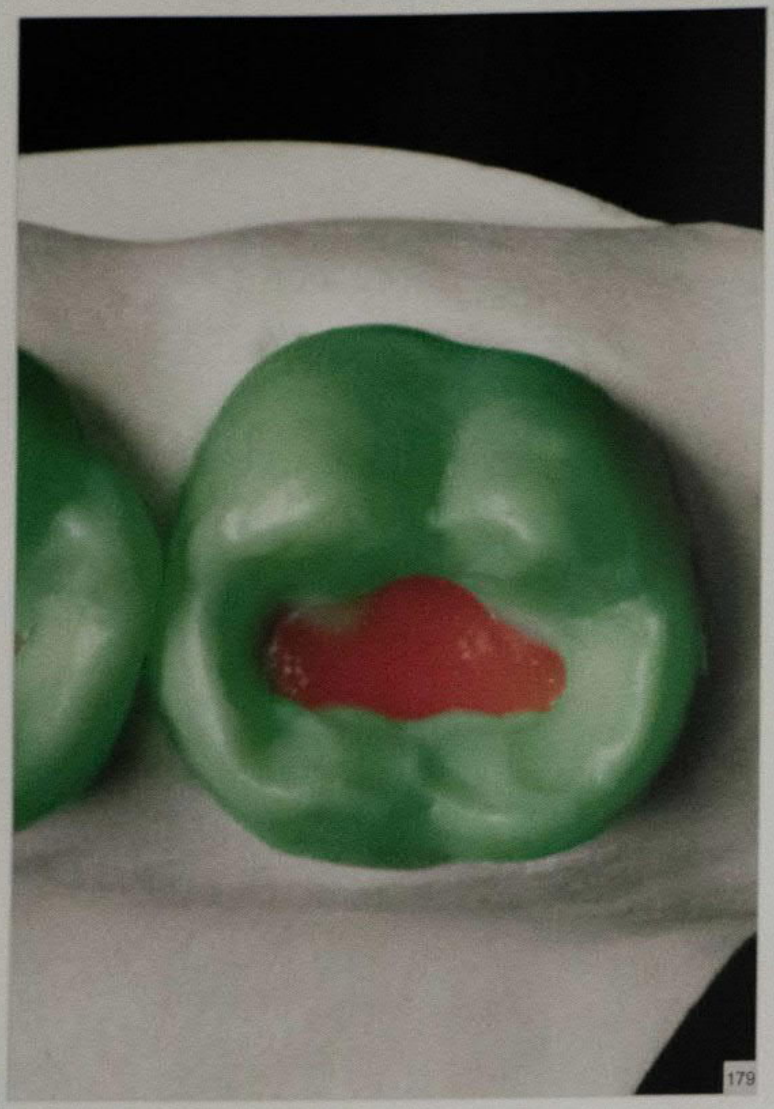
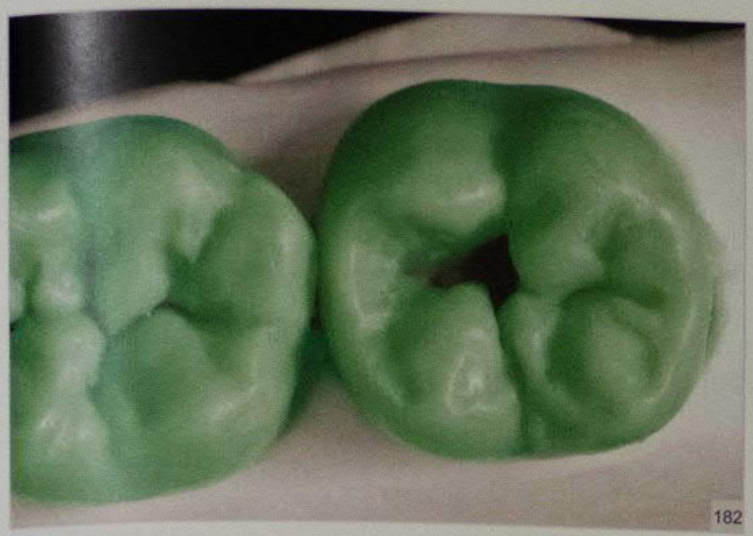


Fig 6-179 Mandibular second molar before wax-up of the occlusal surface.

Fig 6-180 Due to the contact with the antagonist tooth, the wax-up process begins at the distobuccal cusp. First, the lateral lobes are constructed. The mesial lobe is pointed toward the central fossa, the distal one toward the distal fossa. Next, the central lobe should be fabricated, which should have a triangular shape, be pointed toward the central fossa, and contact the central lobe of the mesiopalatal cusp of the maxillary second molar.

Fig 6-181 Now the distolingual cusp is fabricated. The mesial lobe is pointed toward the central fossa, whereas the distal one points toward the distal fossa. In some situations, these lobes can meet. Next, the central lobe is constructed, which should point toward the central fossa and determines a centric contact with the distal incline of the mesiopalatal cusp of the maxillary second molar. The mesial outline of this cusp contributes to the formation of the occlusolingual groove.



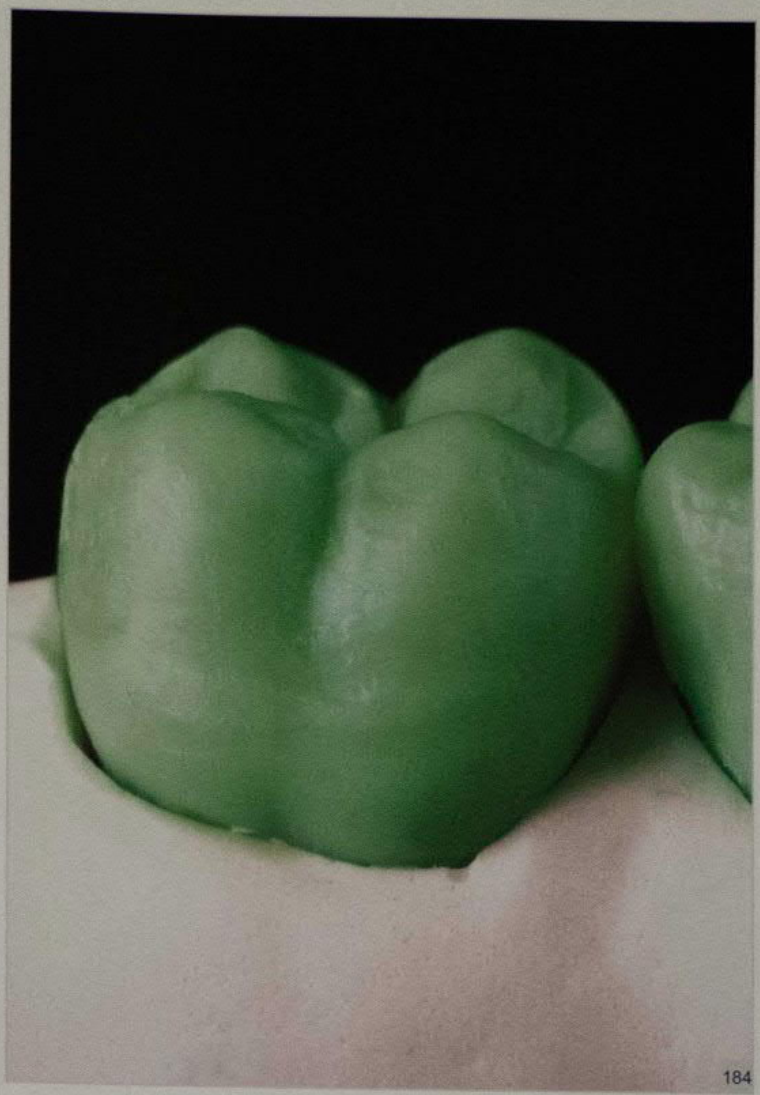
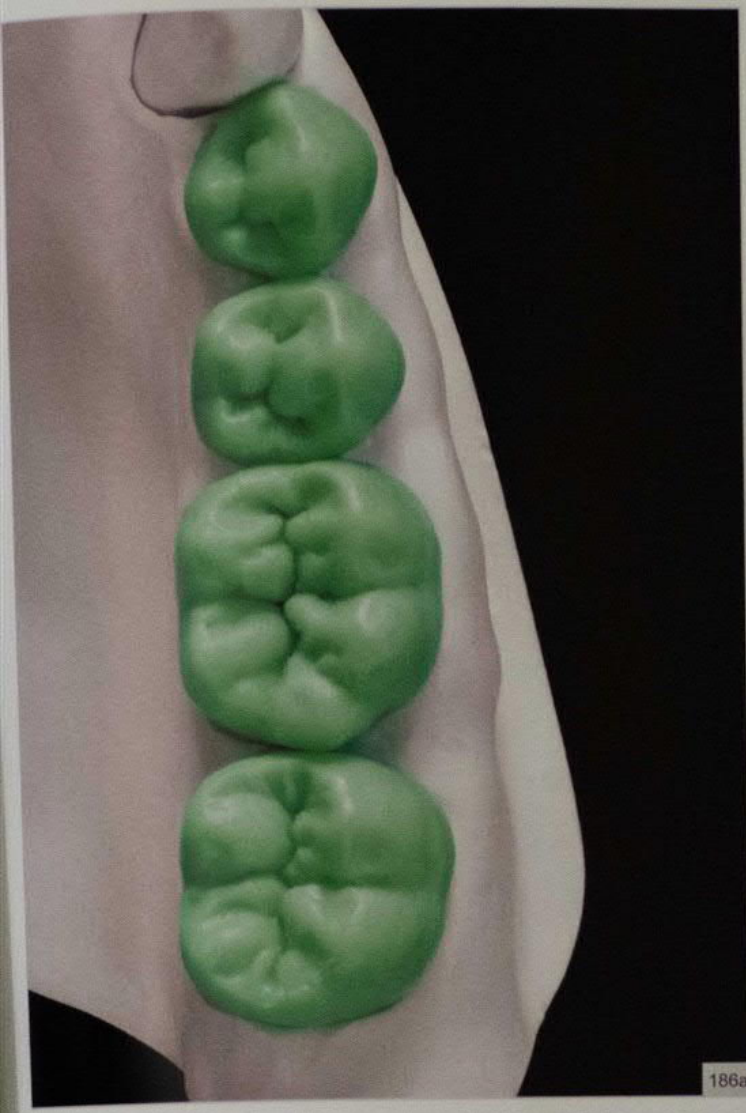


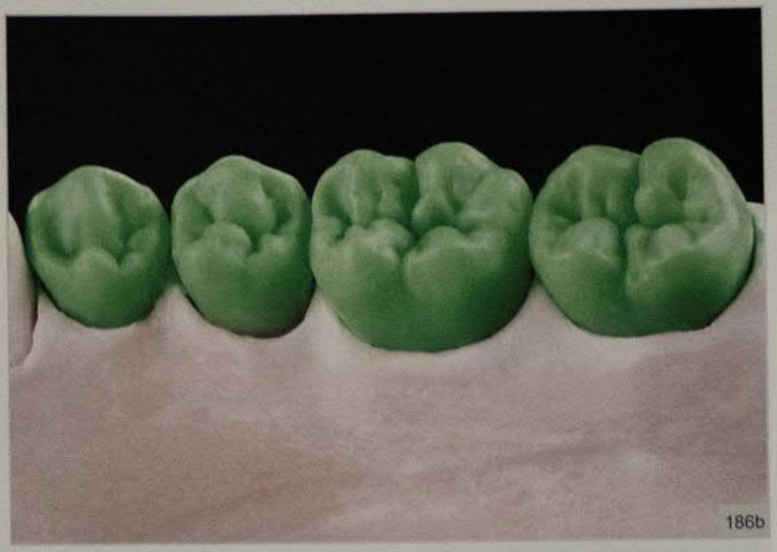
Fig 6-182 Fabrication of the mesiolingual cusp. Its mesial lobe is pointed toward the mesial and the distal one to the central fossa. Next, the central lobe should be waxed up and pointed toward the central fossa; it can be extremely convex so that contact occurs with the mesial incline of the mesiopalatal cusp of the maxillary second molar.

Fig 6-183 Finally, the mesiobuccal cusp is fabricated. The mesial lateral lobe is always smaller and less prominent than the distal one, which is fairly large and pointed toward the central fossa, being that its distal limit determines the occluso-buccal groove. The central lobe can be either prominent or small, always having a transverse direction toward the central groove. Last, the lobe of the mesial marginal ridge is constructed, pointing toward the mesial fossa. Observe that in the second molar, the principal groove has a discontinuous, cruciform shape. Like the mandibular first molar, it has three fossae: mesial, central, and distal. The perimeters of the mesial and distal fossae are leaf-shaped, while the central fossa looks like a spool.

Fig 6-184 Buccal view of the finished mandibular second molar.

Fig 6-185 Buccal aspect of the finished mandibular molars. Observe the finishing and texturing of this surface, highlighting their characteristic morphology.





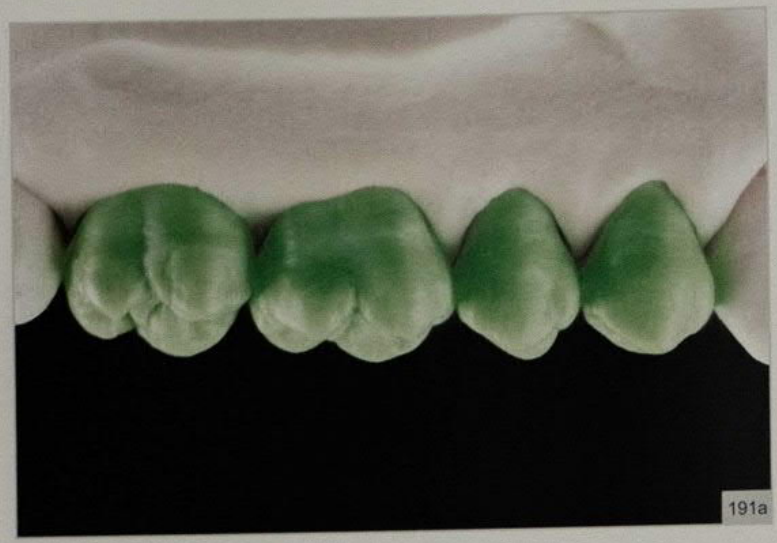
Figs 6-186a to 6-186c Finished mandibular premolars and molars: occlusal *(a)*, occlusopalatal *(b)*, and buccal *(c)* views.

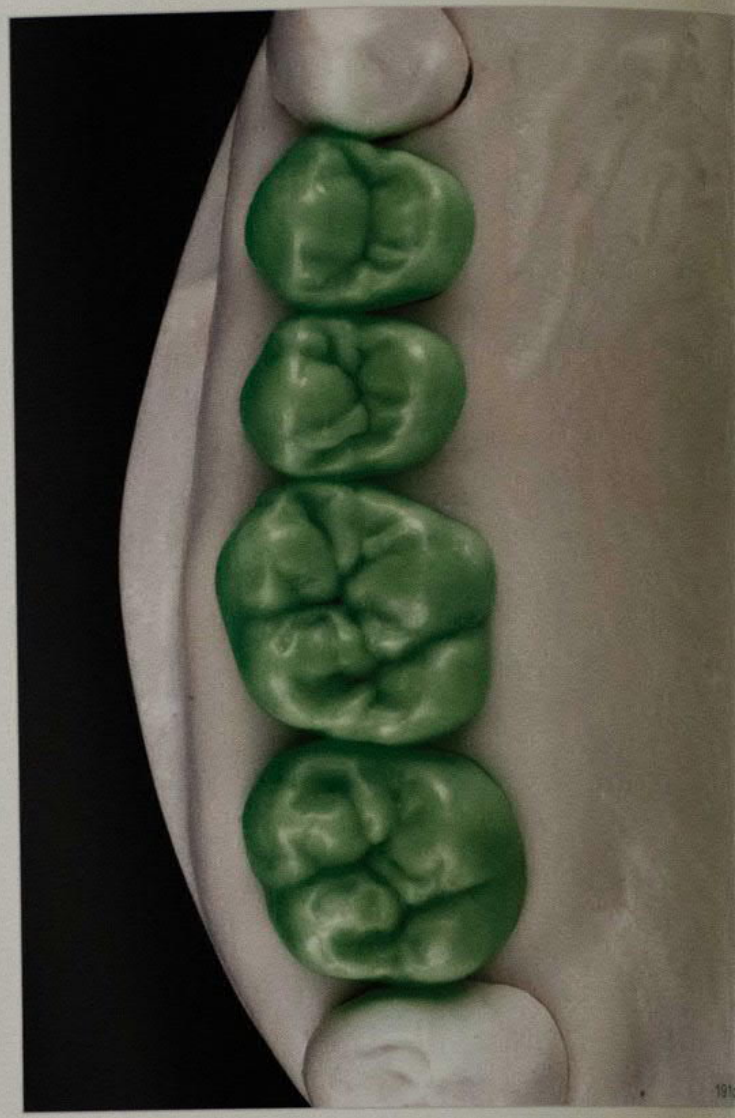
Fig 6-187 Occlusal relationship of the waxed-up posterior teeth.

Fig 6-188 Buccal view of the finished mandibular premolars.

Fig 6-189 Occlusobuccal view of the finished maxillary molars.

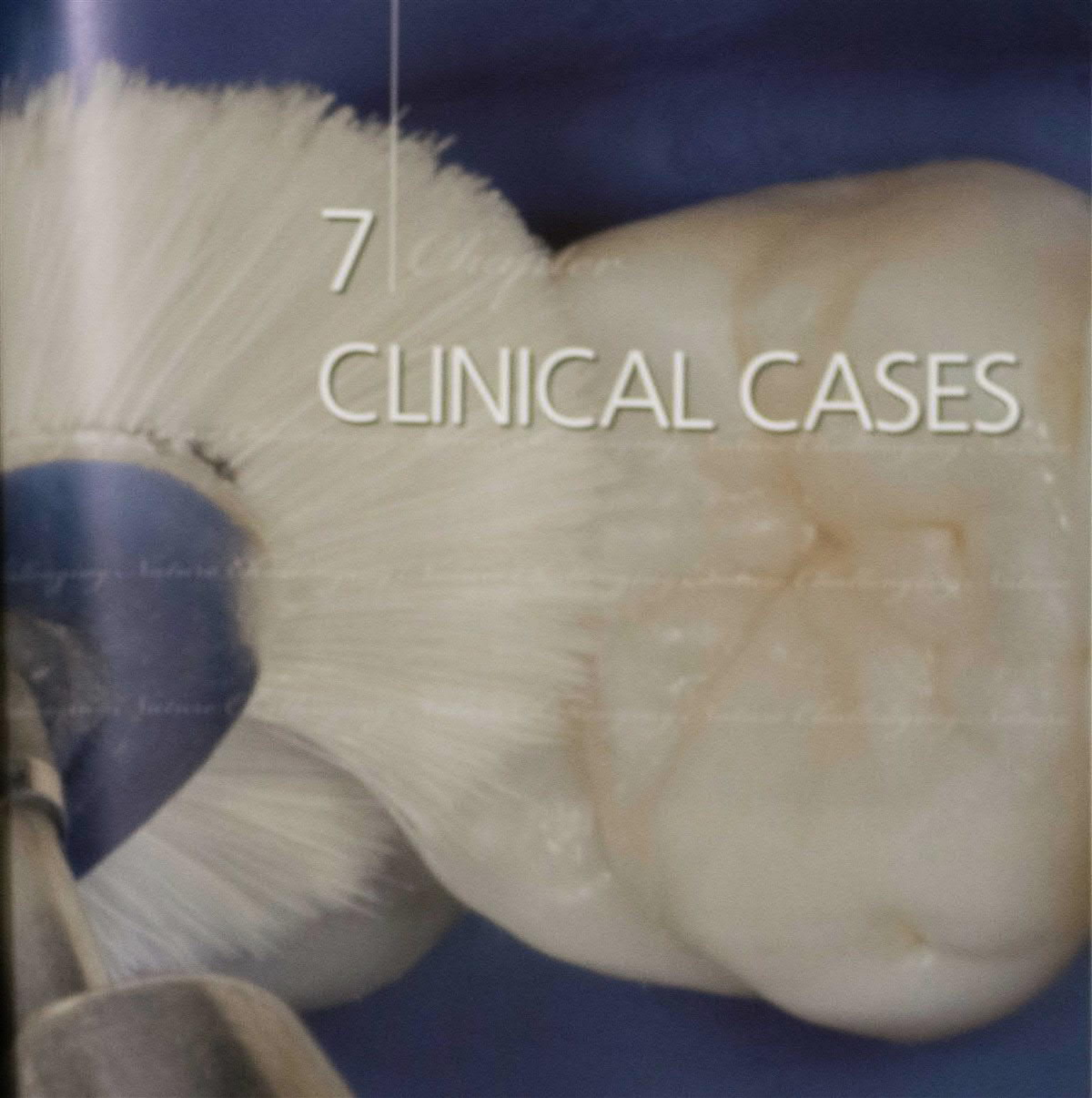
Fig 6-190 Occlusal relationship of the posterior teeth during lateral excursive movement.





Figs 6-191a to 6-191c Finished maxillary premolars and molars: buccal *(a)*, occlusopalatal *(b)*, and occlusal *(c)* views.

Fig 6-192 Occlusobuccal view of the finished maxillary premolars.



7 CLINICAL CASES

Clinical Case 1

Composite Resin Restoration on a Mandibular Posterior Tooth

Fig 7-1 Initial clinical view. The patient's chief complaint was sensitivity to cold stimulus on the mandibular right first molar.

Fig 7-2 Observe the inadequate amalgam filling, with gaps at the tooth-restoration margins, as well as color alterations at the mesial marginal ridge, due to the presence of caries.

Fig 7-3 The occlusal contacts are marked to avoid involvement and extensive restoration at these points.

Fig 7-4 The bitewing radiograph shows that the lesion does not extend to the pulp. The radiolucent area in the mesial region confirms the presence of a caries lesion under the amalgam.

Fig 7-5 Initial lateral view before cavity preparation.

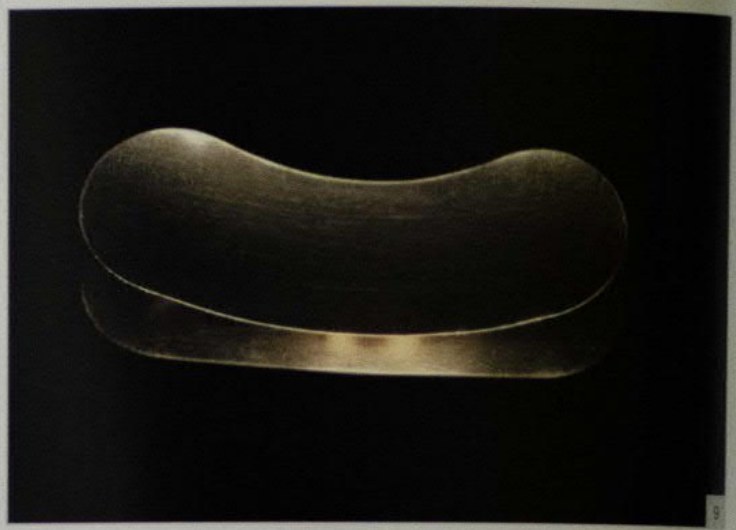


Fig 7-6 After rubber dam placement, the amalgam is removed and the caries lesion is inspected. Observe the thin, delicate dental tissue at the mesial aspect due to the carious process.

Fig 7-7 Cavity preparation after removal of the mesial marginal ridge. Finishing at the enamel margins was completed with manual carving instruments. The preparation is restricted to the removal of amalgam and caries.

Fig 7-8 Interproximal elastic wedges (TDV Dental) are used to stabilize the metallic matrix and for dental spacing.

Fig 7-9 Disposable partial metallic matrix band (TDV Dental) to determine the proximal contact.

Fig 7-10 The wedge and the matrix band are necessary to generate the proximal contact. The matrix band should be of adequate height; its fit and stabilization should be ensured by an interproximal wedge.

Fig 7-11 Occlusal view with the metallic matrix band and the interproximal elastic wedge. Observe the adaptation of the matrix to the cervical region.

Figs 7-12 and 7-13 To improve the fit of the matrix at the cavosurface angle and therefore the contours of the restoration, a clamp has been inserted.

Figs 7-14 and 7-15 The adhesive technique is performed meticulously to avoid sensitivity and marginal leakage. In this case, the enamel and the dentin have been etched with 37% phosphoric acid gel for 30 and 15 seconds, respectively.

Fig 7-16 After abundant rinsing with air-water spray for 60 seconds, the enamel is dried with air spray; the dentin is covered with a cotton pellet to avoid overdrying, which could compromise the adhesion process. The adhesive system is applied according to the manufacturer instructions, avoiding accumulation in the concave areas and at the matrix-tooth interface.

Fig 7-17 Occlusal view after incremental application of composite resin (4 Seasons A2D, Ivoclar Vivadent) at the proximal aspect.

Fig 7-18 Resin should be applied in 2-mm layers, with each layer photopolymerized for 40 seconds.

Fig 7-19 After reconstruction of the proximal contact, the wedge and the matrix are removed. At this point, the cavity floor is filled to standardize its depth and facilitate the sculpting of the cusps.

Fig 7-20 Dentin composite is applied to construct the midbuccal cusp, 1 mm beyond the preparation margin, leaving adequate space for the layer of enamel composite. Note that the cavity in the buccal surface is also filled with dentin composite.

Fig 7-21 Construction of the distolingual cusp. The central and lateral lobes are defined so as to ensure an artistic morphology to the restoration.

Fig 7-22 Construction of the mesiolingual cusp and the enamel layer of the midbuccal cusp. The occlusolingual groove has been defined.

Fig 7-23 Construction of the distobuccal cusp.

Fig 7-24 Construction of the mesiobuccal cusp and the lobe of the mesial marginal ridge. At this step, the occlusal morphology is defined. Observe the path of the grooves and the shape of the fossae.

Fig 7-25 For a more natural esthetic, a brown modifier has been applied with a sharp explorer at some regions of the central groove in order to reproduce the stains. This modification should be done only after informed consent is obtained from the patient.

Fig 7-26 View after photopolymerization of the modifier.

Fig 7-27 To guarantee the complete polymerization of the modifier, it is advisable to apply an antioxidant gel over the outer layer.

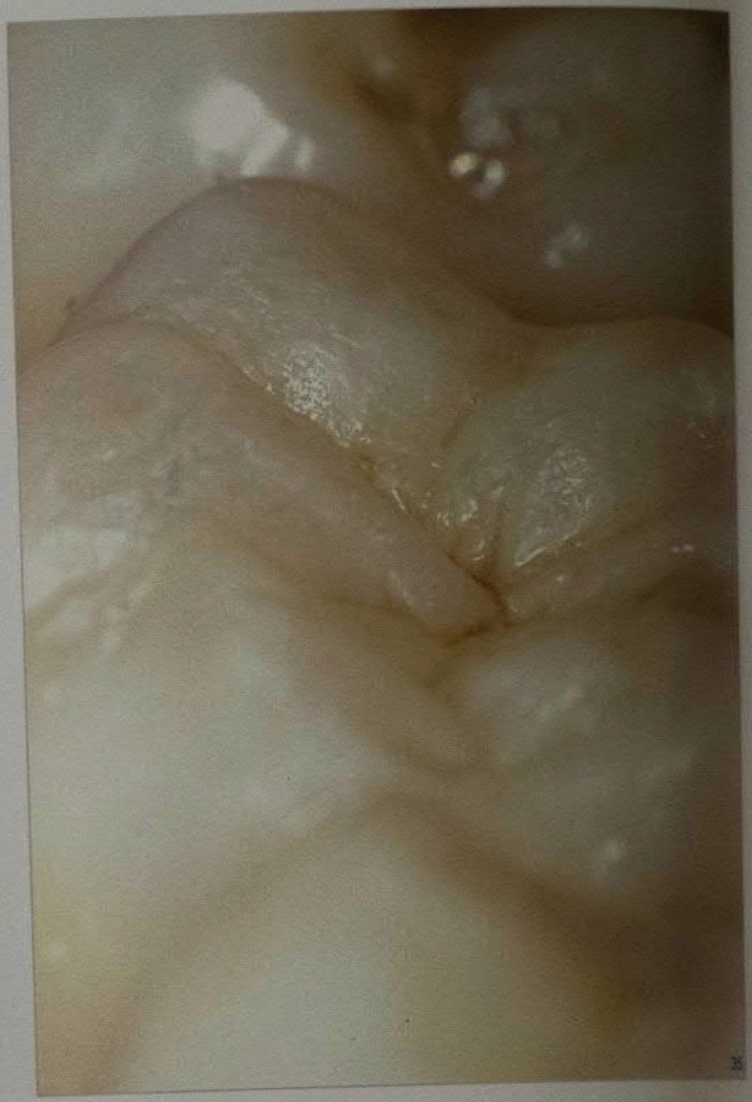
Fig 7-28 The antioxidant gel should extend across the surface of the restoration.

Fig 7-29 The modifier should be fully polymerized. The final polymerization lasts for 60 seconds.

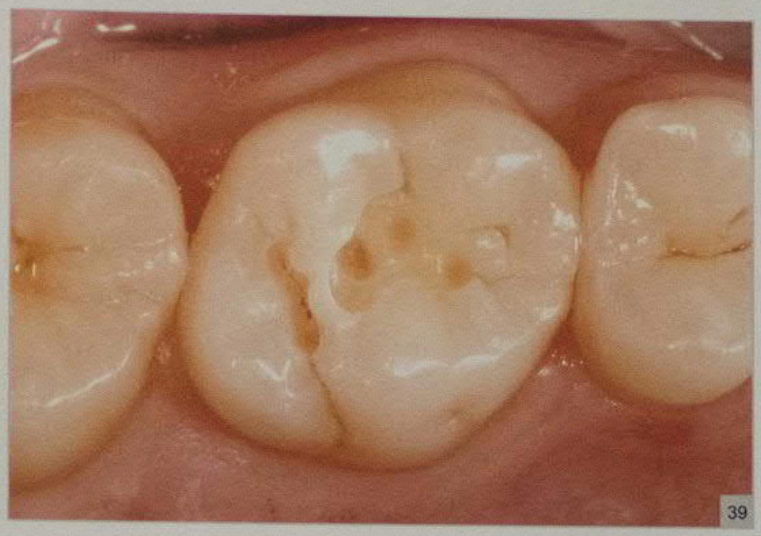
Fig 7-30 Polishing is done with a special brush (Astrobrush, Ivoclar Vivadent), which requires no polishing pastes.

Figs 7-31 and 7-32 Definitive restoration.

Fig 7-33 Close-up of the occlusal surface. After rubber dam removal, the occlusal contacts are marked to identify adjustments.



Figs 7-34 and 7-35 Definitive restoration.



Clinical Case 2

Composite Resin Restoration on a Maxillary Posterior Tooth

Fig 7-36 Initial clinical view of the maxillary right first molar with an inadequate amalgam restoration.

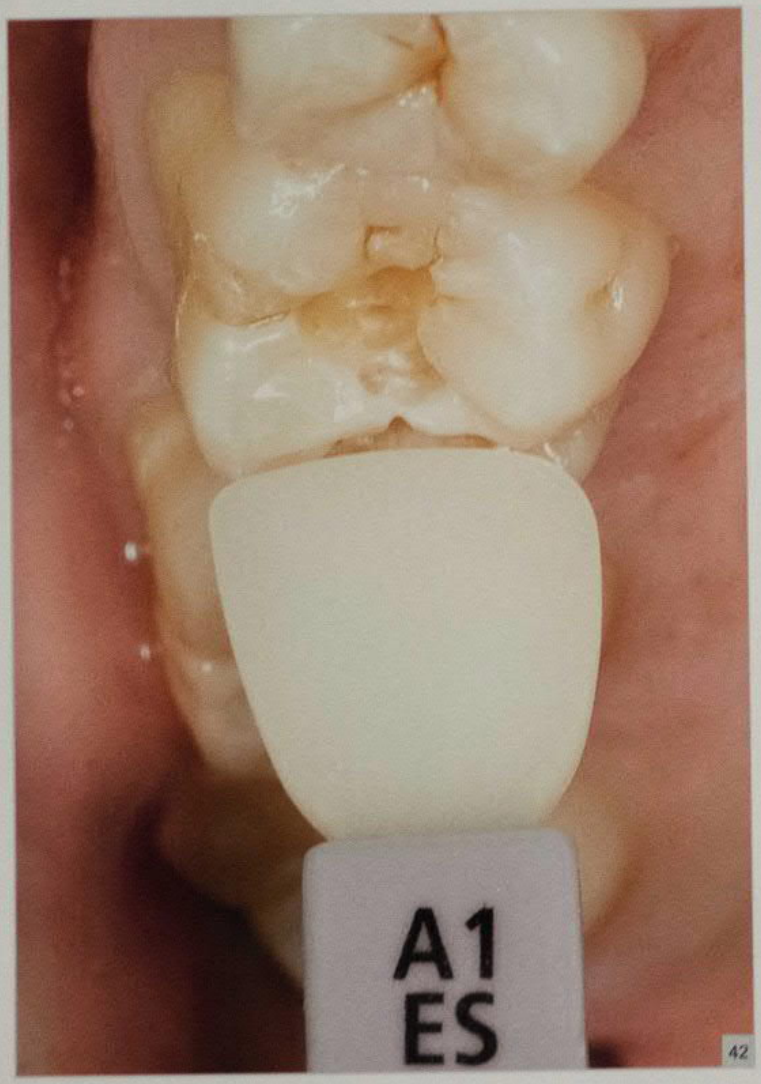
Fig 7-37 A marginal gap at the amalgam-tooth interface and intrinsic color alteration at the enamel bridge suggest the presence of caries. Radiographic examination confirms a caries lesion extending to the dentin that requires restorative intervention.

Fig 7-38 Occlusal view after amalgam removal.

Figs 7-39 Finished cavity preparation. The old restoration and the caries lesion have been removed with a minimally invasive technique to preserve as much healthy tooth structure as possible. This cavity is small and flat, which favors a direct composite resin restoration.

Figs 7-40 Close-up of the finished cavity preparation.

Fig 7-41 Color selection is made with the appropriate shade guide (4 Seasons). Because of the cavity preparation, there is direct access for selection of the dentin material. Shade A3 is selected.



Figs 7-42 to 7-44 Various shades of enamels are selected according to the shade guide (4 Seasons).

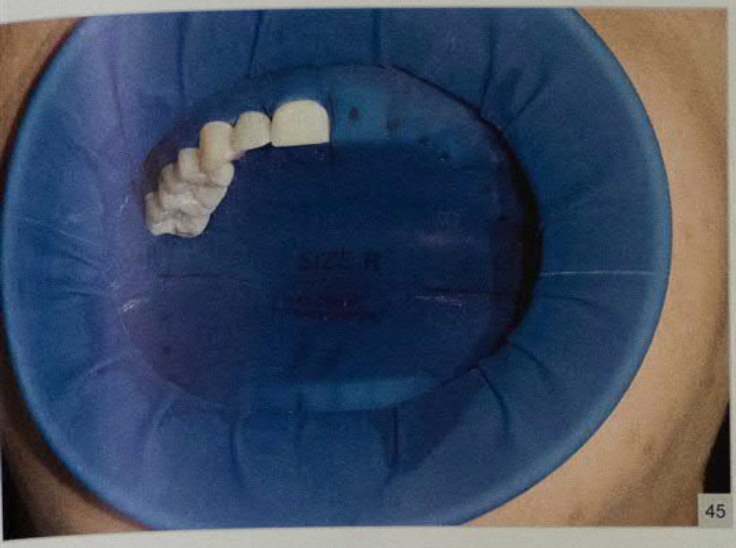


Fig 7-45 Rubber dam is placed to avoid contamination in the operative field that can compromise the longevity of the restoration.

Fig 7-46 Occlusal view of the cavity preparation.

Fig 7-47 The cavity is cleaned with a special brush (ICB, Ultradent) to prevent contamination during the adhesive procedures.

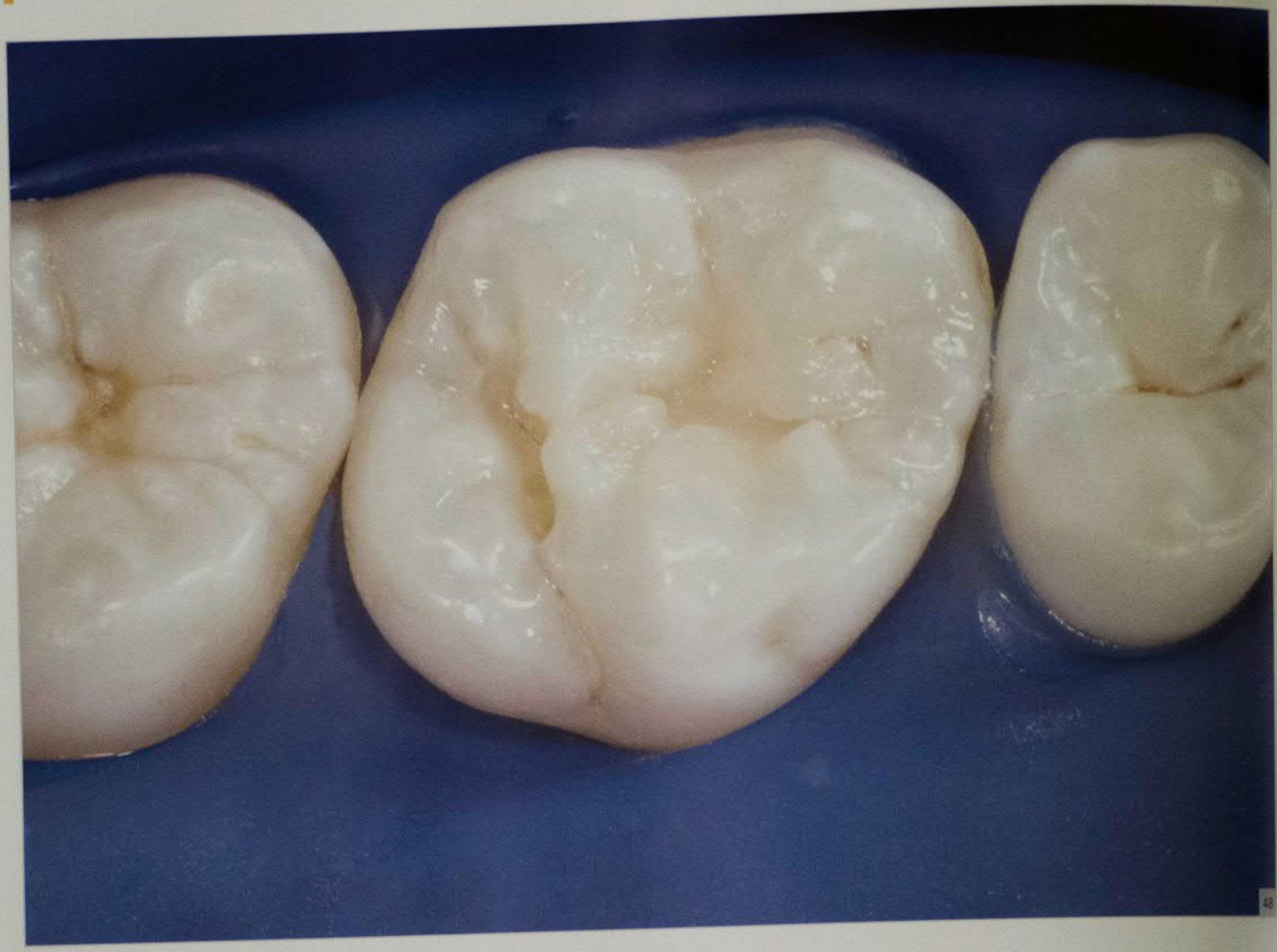


Fig 7-48 After total etching and adhesive application, small increments of resin are placed, with 40-second photopolymerization between each layer. This technique prevents resin contraction and facilitates the sculpting process. Here, the mesio- and distobuccal cusps are developed, forming the occlusobuccal groove. Note that each cusp has three lobes.

Fig 7-49 Mesio- and distopalatal cusps. At this point, the mesiodistal and occlusolingual grooves are determined. The occlusal anatomy is definitively established.

Fig 7-50 A brown intrinsic modifier is applied at the principal groove for a more natural effect. This can be done with an extra-fine brush or a sharp explorer.

Fig 7-51 View after modifier application.

Fig 7-52 An antioxidant gel is applied to ensure the complete polymerization of the outer resin layer and the modifier.

Fig 7-53 Occlusal view after final photopolymerization.

Fig 7-54 Initial polishing of the restoration is performed with a special brush without abrasive pastes.

Fig 7-55 Definitive restoration.

Fig 7-56 Rubber dam has been removed and the occlusal contacts adjusted using extra-fine diamond burs and surface polishing. Polishing is performed with a special brush (Astrobrush).

Fig 7-57 Definitive restoration.

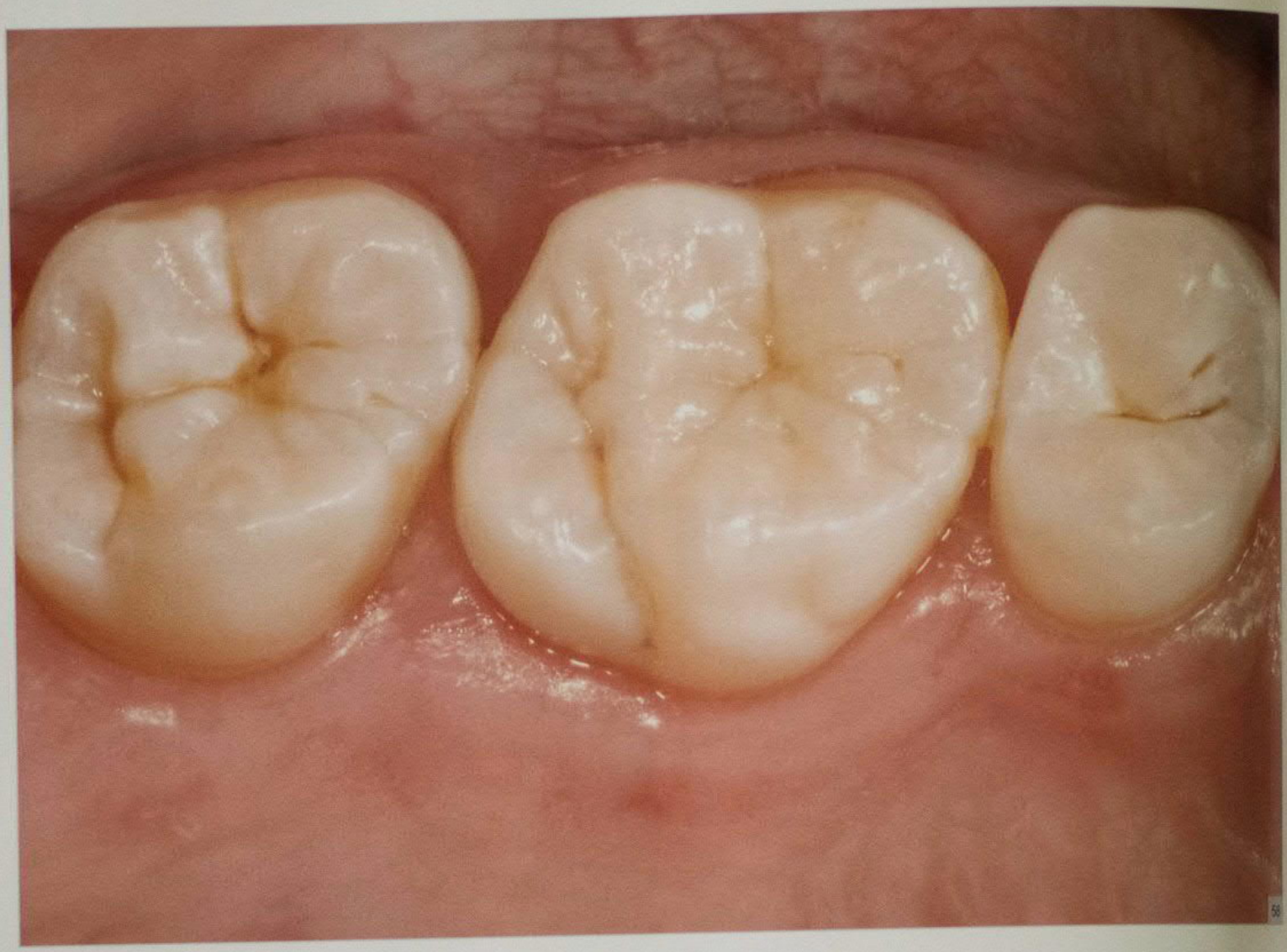


Fig 7-58 A closer look at the restoration.

Clinical Case 3

Ceramic Restorations

Fig 7-59 Metal-ceramic fixed partial prosthesis from the canine to the premolars. Observe the molarlike morphology of the abutment tooth, the second premolar (*far left*).

Fig 7-60 View of the occlusal relationships.

Fig 7-61 Occlusal view of the inadequate metal-ceramic restoration.

Fig 7-62 Initial clinical view. This 65-year-old female patient complained of a loose canine in her fixed partial prosthesis (maxillary right canine to second premolar) dating back 4 months.

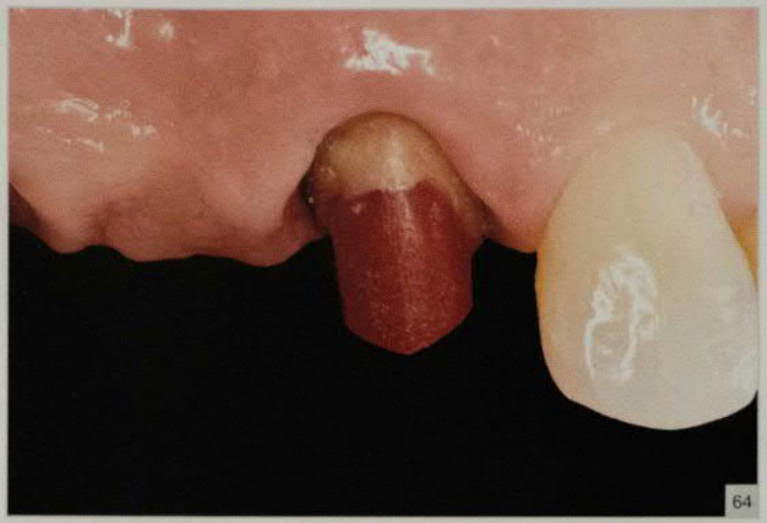


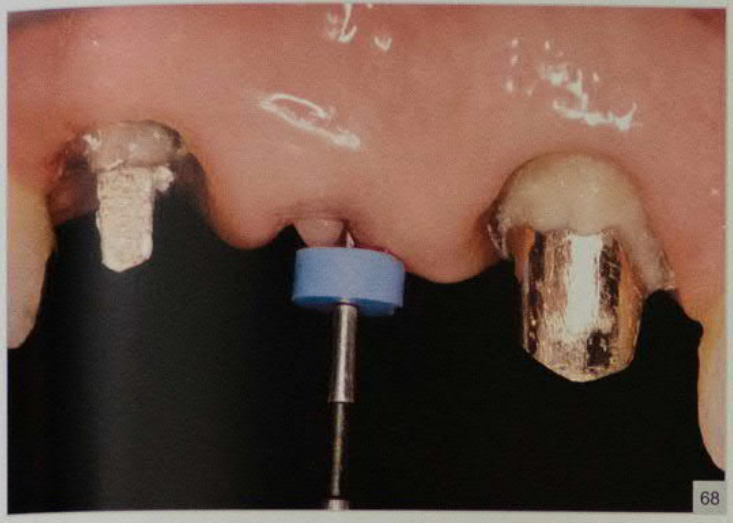
Fig 7-63 After removal of the prosthesis, a loose metal post in the maxillary right canine was immediately removed and a caries lesion noted at the cervical third of the root canal. The maxillary right second premolar also had an inadequate metal post, as observed clinically and radiographically.

Fig 7-64 Endodontic retreatment was completed, and gold posts were planned for the maxillary right canine and second premolar. Here, the direct modeling is taking place in acrylic resin to create the pattern for the canine post.

Fig 7-65 Cast gold post for the maxillary right canine.

Fig 7-66 The cast gold post for the maxillary right canine is cemented in place, while acrylic resin is used to model the post for the maxillary right second premolar. The first premolar area corresponding to the pontic is not esthetically adequate.

Fig 7-67 Provisional autopolymerized acrylic resin restorations follow the shape of the previous fixed prosthesis.



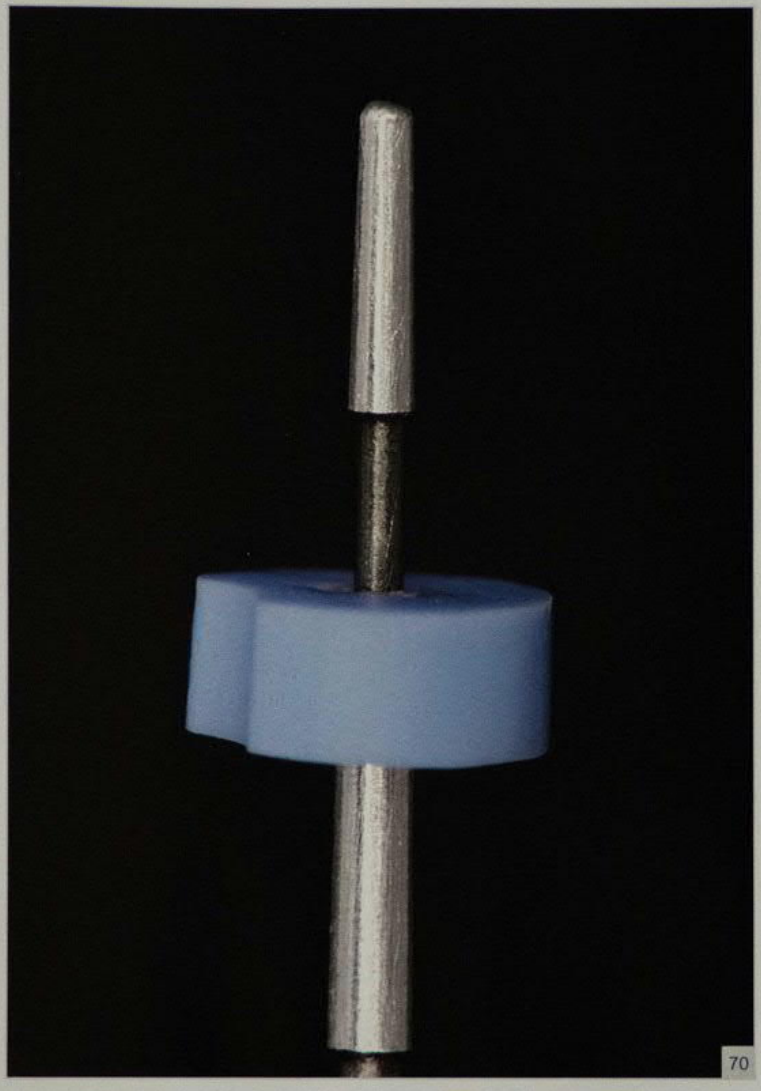


Fig 7-68 Measurement of gingival thickness can help in tissue management in the pontic region. Local anesthesia is used in this area before introducing a periodontal probe to the bone.

Fig 7-69 Radiographic view of probing depth to the periosteal layer.

Fig 7-70 Periodontal probe.

8

CEMENTATION

Adhesive Cementation

Adhesive Cementation

The increasing demand for indirect restorations along with the myriad available techniques and materials for luting procedures justify the need for a special chapter on adhesive cementation.

Conceptually, restorative dentistry addresses natural tooth loss by using artificial replacements to repair the functional and esthetic compromises of edentulism. However, when indirect restorations are used indiscriminately, early failures are observed.

It is easy to attribute desired dental characteristics to the ideal properties of these restorations. In addition, there is a trend to use materials with more tooth-like characteristics, mimicking both the mechanical and optical properties of natural teeth. The strength of the enamel is due to its intrinsic, highly organized, and dense mineral content that confers structural stability as well as fracture and wear r esistance, even in areas of extrinsic loads. Compared with enamel dentin has a lesser mineral content (ie, less strength) but higher organic nature, which provides resilience through force absorption and distribution. All these properties overcome the mechanical challenges found in the oral cavity. Nevertheless, these characteristics would not be enough without a solid cohesive bond at the dentinoenamel junction. Thus, when applying natural biomechanical principles to restorative techniques, a strong and reliable bond between the restoration and the remaining tooth structure is desirable and extremely necessary.

In restorative dentistry, the adhesive process is more important than the mechanical and biologic fulfillments because it strengthens the restoration and dental structure as a whole. It not only provides retention[1] (the better the marginal seal, the less the risk of microleakage[2]) but also increases the fracture resistance of teeth and the restorative material.[3]

Traditional, water-based cements (ie, zinc phosphate, polycarboxylate, and glass-ionomer cements) acquired popularity and were deemed clinically efficient for use with luting dental prostheses with metallic substructures, despite reports of higher solubility and lack of adhesion.[4,5] The evolution of ceramics materials created a need for more adequate cementation procedures to match the potential of this new restorative trend toward ceramics. Thus, resin cements have gained favor because they overcome the deficiencies found in conventional cements and improve the adhesive bond between restoration and the dental substrate. For example, ceramic inlays and onlays, porcelain veneers, metal-ceramic crowns, metal-free crowns, orthodontic brackets, indirect resin composite restorations, and intraradicular posts can be cemented with adhesive resin cements.

The biomechanical behavior of prostheses luted with adhesive cementation is more similar to that of the natural tooth structure when compared with the conventional cemented dental prostheses. The restoration-cement-tooth interface generates better force transmission and less stress concentration, reinforcing and stabilizing the tooth-restoration interface. Nonadhesive-cemented prostheses develop more stress concentration at the tooth-restoration interface and have an increased likelihood of retentive failures and structural compromises. In this way, the long-term success of indirect restorations greatly depends on the cementation procedures and techniques.

Restorative materials, like cementation materials, have particular features and oftentimes complex behaviors that dictate their use. It is necessary to understand the elements of the adhesive cementation to provide a predictable bond; these include the indications of resin cements, indirect restorative materials, and surface treatments at the joining interfaces.

Adhesive versus conventional cementation

Although the evolution of adhesive techniques coupled with the development of high-strength ceramics has led to conceptual changes in cementation, new biomechanical parameters for preservation of dental structure, and indirect restorative procedures, adhesive cementation by no means retires conventional cementation techniques.

There is no single luting material that is ideal for every clinical situation. Advantages and drawbacks of cements and cementation techniques must be weighed out to determine whether to use an adhesive or a nonadhesive procedure. Although less desirable when compared with the resin cements, conventional luting agents present several advantages in the clinical practice. They are user friendly and require no critical procedures such as interface surface treatments, judicious moisture control, or multi-staged adhesive procedures. Often, adhesive cementation cannot be justified when it makes the procedure more expensive and complicated.

When tooth preparation design ensures adequate retention, particularly for complete crowns, the use of adhesive cements must be disregarded with the aim to provide better retention. Although the overall resistance could be improved, the literature shows good survival data for conventional cemented dental prostheses after 8, 10, and 15 years of follow-up.[6–8]

The advantages of resin cements are restricted to a strong enamel adhesion at the preparation margins, which significantly minimizes microleakeage.[9,10] However, this property must be considered in areas where there is little (if any) enamel around the preparation margins, such as in subgingival configurations. In addition, the marginal seal at dentin surfaces is crucial when adhesives are employed,[9,11] and conventional cements have proved to be similarly effective in limiting microleakage of several molecules responsible for pulpal irritation, compared to the adhesive resin cements.[12,13] In this way, it becomes clear how the benefits of adhesive cementation are sometimes enhanced or nullified given the specific clinical situation to be treated.

Thus, conventional cements are still indicated for clinical situations where they will outperform resin cements, especially when *(1)* there is persistent sensitivity,[14] *(2)* crowns with opaque substructures will be used in posterior teeth, or *(3)* moisture control is not possible.

Adhesive cementation techniques

Adhesive cementation procedures vary according to the method used to remove the smear layer (ie, removal or dissolution) and the activation mode of the resin cements (ie, autopolymerizing, light-activated, or both).

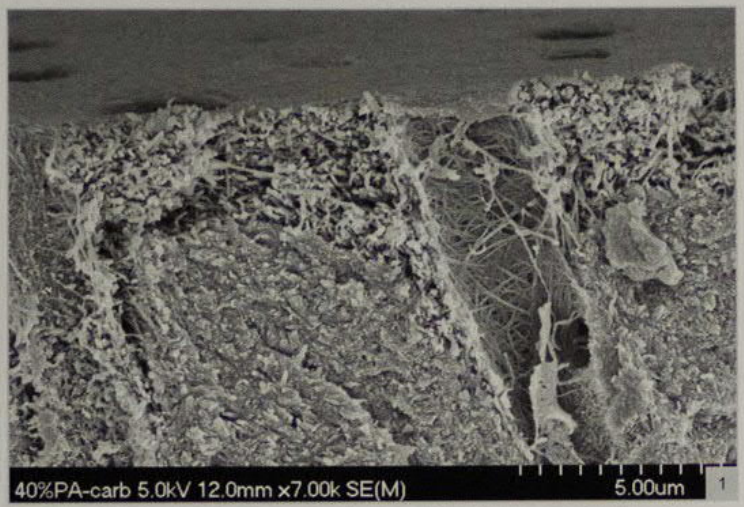
Adhesion of resin cements to dental structures occurs through micromechanical retention of the adhesive system to the conditioned substrates by means of resin interlocking at voids created on the enamel or of resin infiltration on the collagenous network through hydrophilic monomers comprising the hybrid layer as well as the resin tags (Figs 8-1 and 8-2). The resin cement bonds to the reactive layer of the adhesive during polymerization, generating the adhesive-cement interface (Figs 8-3 and 8-4).

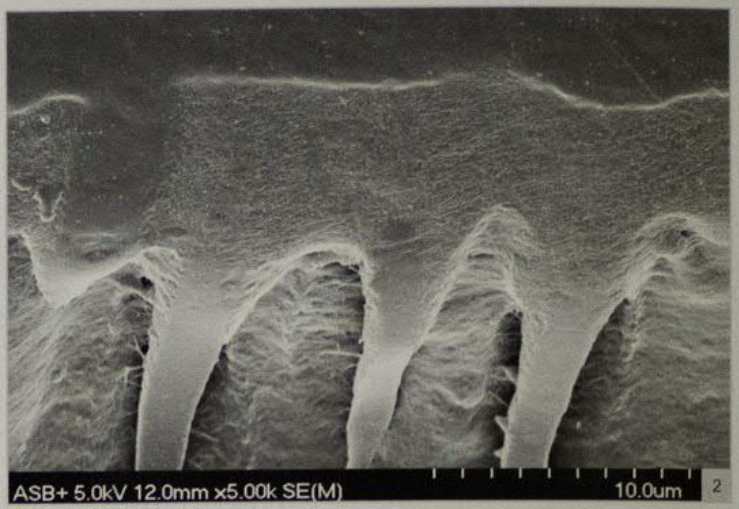
Most adhesive agents are adversely affected by moisture. Thus, rubber dam isolation limits resin or dental substrate contamination by saliva, blood, or sulcular fluid during adhesive procedures, which greatly diminishes the bond strength to the dentin surfaces. If the nonpolymerized adhesive is contaminated, the adhesive is rinsed off, the area dried, and the adhesive is applied again.[15–17] Rubber dam isolation is unnecessary for cementation of multiple complete crowns with deep subgingival margins. However, retraction cords can be used to block the sulcular fluid flow.

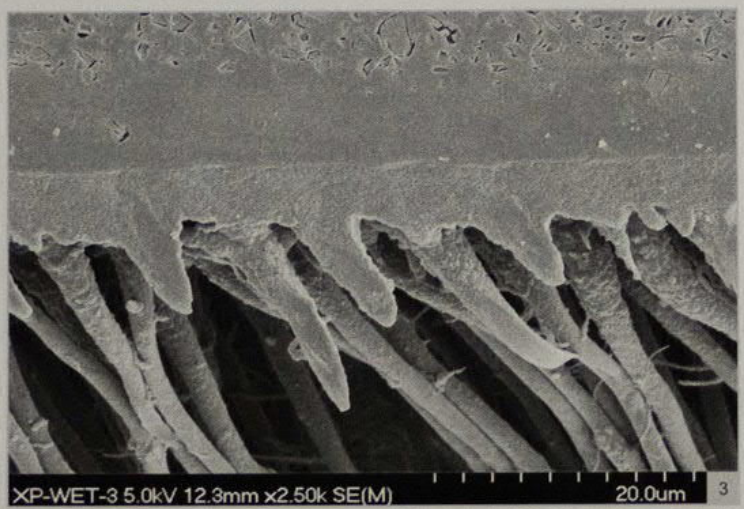
Before beginning any definitive cementation procedures, debris from provisional luting agents must be removed completely from the tooth surface. Despite a long-held belief that eugenol-free provisional cements could not influence the quality of adhesion to the dentin substrate, macroscopic residue can act as a barrier to resin infiltration and compromise adequate adhesion.[18–21] There are several techniques for cleaning prepared teeth. Although manual instruments have proved effective, sandblasting tooth preparations guarantees complete removal of debris, particularly on very rough surfaces.[18,22]

Try-in and adjustment must be performed after removal of provisional cement and before treatment of the restorative surfaces, avoiding contamination and unnecessary repetition of these procedures. Traditional thinking on adhesive cementation does not indicate light activation of the adhesive system before luting an indirect restoration because this procedure can increase the thickness of the resin layer, which can affect the seating and fit of restorations at the cavity preparation.[23] However, when the adhesive layer is light-activated at the same time as the resin cement, complete polymerization is not guaranteed, which further compromises the marginal fit and bond strength.[23,24] In actuality, the use of previous light activation can enhance bond strength of some adhesive systems and produces a film thickness from 5.7 to 14.8 µm. Such film thickness is lower than the overall cement thickness and results inacceptable performance conditions under rigorous.[24] Considering that the restoration is fabricated on a die that receives a spacer to compensate for the resin cement thickness, it seems illogical not to light-activate the adhesive layer alone. Even in cases were computer-aided design/computer-assisted manufacture (CAD/CAM) technology is employed, a space is programmed for the resin cement to guarantee complete seating of the definitive restorations.

In addition, the so-called immediate dentin sealing technique was recently introduced to overcome the compromised fit of restorations after light activation of the adhesive layer. The adhesive system can be applied and light-activated soon after preparation and before impression taking, though this technique has generated much debate in the literature.[25–27] In addition to preventing perioperative tooth sensitivity and interference with the internal adaptation of restorations, it is believed that the aging of this adhesive bond from provisionalization to definitive cementation can preserve bond integrity at the adhesive-substrate interface before the resin cement experiences shrinkage after light-curing. Although this technique has presented a significant increase in bond strength values in some studies, there is a lack of laboratory studies and no long-term clinical data, which prevents its widespread use in the clinical setting.







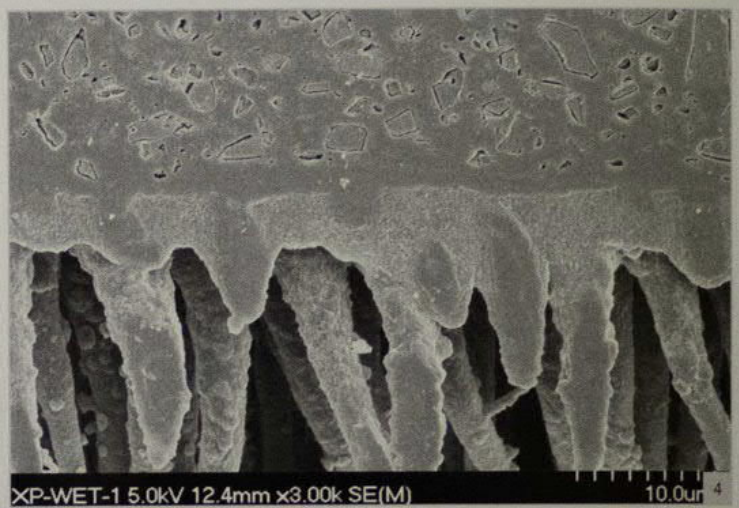


Fig 8-1 Scanning electron microscopy (SEM) image of a longitudinal section of a dentin substrate etched with 40% phosphoric acid. The smear layer was dissolved, and the underlying surface was demineralized, exposing the collagen fibers, which will later be infiltrated by the resin monomers.

Fig 8-2 SEM image of an adhesive interface, showing formation of a uniform hybrid layer with resin tags after monomer infiltration through the dentinal tubules opened by acid etching.

Figs 8-3 and 8-4 SEM image of an adhesive interface (resin cement/adhesive/dentin) showing the hybrid layer and resin infiltration into the tubular and peritubular dentin. The wetness of the dentin substrate after rinsing with phosphoric acid prevents the collapse of collagen fibers and allows better infiltration of hydrophilic monomers.

Figs 8-1 to 8-4 courtesy of Prof Jorge Perdigão.

Resin cements

Composition and characteristics of resin cements are similar to direct restorative composite resins. They are formed by inorganic glass and silica particles (50% to 70% by weight) within an amethacrylate organic matrix (ie, bisphenol glycidyl methacrylate [bis-GMA], triethylene glycol dimethacrylate [TEGDMA], and urethane dimethacrylate [UDMA]).

These cements are highly resistant to compression and fatigue, have a high elastic modulus, low internal porosity, low solubility in acidic and neutral environments, and a high bonding potential with several substrates.[28-38] These properties, in combination with their higher esthetic characteristics and versatility of use, make them the materials of choice for cementation of indirect restorations.

Resin cements can be classified according to their mode of activation, such as autopolymerizing (chemically activated), light-polymerizing, and dual mode (chemical/light-activated)[39] (Table 8-1). The light-activated cements have a longer working time that provides clinicians with more control over seating of restorations and removal of excess cement before hardening. Their versatility in working and shortening setting times make them very interesting for luting of indirect restorations, particularly in cases of laminate porcelain veneers. They are offered in many shades, opacities, and consistencies, which makes them ideal for highly translucent restorations.[39] However, they are indicated for indirect restorations with no more than 3 mm in thickness.[40]

Table 8-1 Resin cements, activation modes and manufacturers

COMMERCIAL NAME	ACTIVATION MODE	MANUFACTURER
Bistite II DC	Dual	J. Morita
Bistite II SC	Chemical	J. Morita
Calibra	Photo/dual	Dentsply/Caulk
C&B Cement	Chemical	Bisco
C&B-Metabond	Chemical	Parkell
Cement-It	Chemical	Jeneric Pentron
Choice	Photo/dual	Bisco
Choice 2	Photo	Bisco
Clearfil DC Cement	Dual	Kuraray
Comspan	Chemical	Dentsply/Caulk
Dual Cement	Dual	Ivoclar Vivadent
Duo Cement Plus	Dual	Coltène/Whaledent
Duo-Link	Dual	Bisco
EnForce	Dual	Dentsply/Caulk
Illusion	Dual	Bisco
Infinity	Dual	Den-Mat
Insure	Photo/dual	Cosmedent
LinkMax	Dual	GC America
Lute-It	Photo/dual	Jeneric Pentron
Multilink	Chemical	Ivoclar Vivadent
Nexus 2	Photo/dual	Kerr
Panavia F	Photo/dual	Kuraray
Panavia 21	Chemical	Kuraray
ParaCem	Dual	Coltène/Whaledent
PermaFlo DC	Dual	Ultradent
Rely X ARC	Dual	3M ESPE
Rely X Veneer	Photo	3M ESPE
Superbond C&B	Chemical	Sun Medical
Variolink II	Dual	Ivoclar Vivadent
Variolink Veneer	Photo	Ivoclar Vivadent

Conversely, autopolymerizing cements have a short working time and a longer setting time and are indicated for cementing thicker restorations (eg, endocrowns) and metal-ceramic or very opaque ceramic restorations (eg, Procera, Nobel Biocare, In-Ceram, Vita).

Dual cements were developed to create a luting material with properties of both auto- and light-activated cement. Thus, chemical and photo initiators were incorporated into this material, providing it with a reasonable working time and a higher degree of polymerization. The polymerization efficacy of dual resin cements oftentimes depends on the potential of chemical activation, particularly when the intensity of light activation is drastically reduced or when the restoration is too thick.[41,42] Lower potentials of chemical activation in dual resin cements can affect physical properties, adhesive capacities, and marginal sealing.[43,44] Thus, to solely rely on the chemical activation mode of dual cements is a risky and contraindicated option.

Most of the traditional resin cements do not adhere to the metallic, alumina-based (eg, In-Ceram Alumina, Procera AllCeram), and zirconia-based ceramic restorations (eg, In-Ceram Zirconia; LAVA; 3M ESPE; Procera AllZirkon) since these surfaces cannot be altered by acid conditioning.[45] Some luting agents (eg, Panavia 21, Superbond C&B, RelyX Unicem) have a modified organic matrix with functional phosphate monomer groups (4-methacryloxyethyl trimellitate anhydride [4-META] and methacryloyloxydecyl dihydrogen phosphate [MDP]) that adhere to metallic oxides.[34,46-48] Of these, the Panavia 21 cement has demonstrated good long-term bond results to these ceramics.[49-51]

Recently, a new category of resin cements, the so-called self-conditioning cements, was introduced in the market to simplify the adhesive cementation process (Table 8-2). These cements aim to eliminate steps prior to cement application and seating of restorations. Acid conditioning, priming, and adhesive application become unnecessary, which reduces chair time as well as the sensitivity of the technique. The cement itself provides these functions due to the multi-functional acidic monomers in its organic matrix, and thus the practitioner has only to treat the surface of the restoration.[24] Similar to the self-conditioning adhesive resins, these cements appear to present less postoperative sensitivity and do not trigger the same pulpal inflammatory responses when compared with resin cements used in the total-etching technique.[52] Some manufacturers state that these cements can be used without rubber dam isolation, a clinical advantage considering that humidity control is provided even in partial isolation (eg, cotton roll).[53]

Table 8-2 Current self-adhesive resin cements

RESIN CEMENT	MANUFACTURER
BisCem	Bisco
G-Cem	GC America
MaxCem	Kerr
MonoCem	Shofu
Multilink Sprint	Ivoclar Vivadent
RelyX Unicem	3M ESPE

Self-adhesive cements have demonstrated good laboratory results with bond strength values similar to the resin cements/self-etching adhesives combination or when used with the total-etching technique.[32] A higher bond strength has been found when these cements are applied over glass-ceramics, alumina-rich ceramics, and zirconia-rich ceramics.[34,54,55] However, because their mechanism is not completely elucidated and there is a lack of long-term studies, their use must be viewed with caution.

Compatibility between adhesive systems and resin cements

As a result of developments in the restoration and materials science, a trend toward simplified protocols has generated interest in the so-called self-conditioning systems. Some are available in a single bottle containing acid, primer, and adhesive, thus eliminating the need for rinsing, drying, and measures to avoid dentin dehydration. For this, acidic resin monomers capable of simultaneous dentin demineralization and infiltration were incorporated,[56] resulting in a significant pH reduction in the adhesive layer, comprising a highly reactive, acidic surface. When self-conditioning systems are coupled with resin cements that have tertiary amines as chemical activators, polymerization is inhibited, which reduces the bond strength between cement and adhesive.[57] This phenomenon had been reported for adhesive systems that use the two-step, total-etching technique (primer and adhesive in the same bottle); incorporation of the acidic monomers considerably diminishes the pH values.[57,58] Many restorations cemented with autopolymerizing or dual resin cements have shown premature failures such as loosening and marginal microleakage.

To overcome this problem, co-initiators of an oxidation reduction reaction (sulfinic acid salts) were incorporated into adhesive systems that are recommended for use with autopolymerizing and/or dual resin cements to guarantee polymerization even in adverse acidic environments.[59,60] Some manufacturers offer a separate bottle of co-initiators that can be mixed into the adhesive or, in some cases, applied over the preactivated adhesive to provide strength to the chemically activated resins.

These two categories of adhesive systems (single-bottle or total-etch and one-step or self-etching) still generate chemical incompatibility with autopolymerizing or dual resin cements because of their high concentration of hydrophilic monomers and their lack of an additional hydrophobic layer (ie, unfilled resin).[61,62] Single-step adhesives behave as semipermeable membranes even after polymerization.[61–66] Water diffusion from pulp tissues to dentin tubules is discernible when it reaches the adhesive layer and blisters the adhesive-cement interface, which prevents resin co-polymerization and affects bond strength even in the presence of co-initiators.[59,68]

To compensate for this incompatibility, single-step adhesives can be converted into two-step techniques by application of a hydrophobic agent (eg, Scotchbond MultiPurpose Plus, 3M ESPE) to ensure bond integrity at the adhesive-cement interface.[60,61] The use of a hydrophobic agent over the single-step, self-etching adhesive prevents water diffusion inside the adhesive interface and provides additional free radicals for the self-etching primers, which increases their rate of polymerization.[60] In this two-step technique with a self-etching adhesive system (ie, acidic primer and adhesive resin in separate bottles), the possibility of a lack of chemical bonding is minimal since the application of a solvent-free, hydrophobic adhesive layer makes it compatible with the chemically activated resins.

Esthetic properties

The esthetic characteristics of resin cements in use with ceramic restorations that demand a high degree of translucency overcome deficiencies of conventional luting agents. Several cements are available in multiple shades and opacities for cementation of highly translucent ceramic restorations for the anterior dentition, providing more control over the substrate color and, in some instances, subtle color corrections.[68] To facilitate color selection, some systems provide hydrosoluble pastes of corresponding colors for color evaluation and try-in at the seating of the restorations. Although interesting from a clinical perspective, the use of try-in pastes must be exercised with caution since their colors often vary from the actual cement shades.[69] When no try-in pastes are provided, the cement can be used before the actual adhesive procedures. In both cases, a thorough cleaning is mandatory (with phosphoric acid or acetone-alcohol solvents) because organic residues found at the interface can diminish bond strength and must be removed before the adhesive protocol.[70,71]

Although widely recommended for use with all-ceramic crowns or porcelain veneers in the anterior region, dual resin cements must not be employed with restorations less than 1.5 mm in thicknes for which the cement shade is important.[72] The chemical that accelerates the polymerization reaction degrades over time and yellows.[73,74] Extremely thin restorations, such as porcelain veneers, with high translucency are vulnerable to color change of the substrate or cement film. For this reason, light-activated resin cements are preferred because of their higher color stability. In addition, medium-viscosity, universal composite resins or low-viscosity resins can also be used for adhesive cementation of thin, translucent all-ceramic restorations.

Surface treatments

Two adhesive interfaces are created during cementation: *(1)* the surface at the substrate (tooth and/or another buildup material), and *(2)* the inner restorative surface. In order to produce a strong and long-term bond, the challenge of adequately treating both surfaces must be completed with success.

The internal surfaces of indirect restorations can be treated by means of abrasion with rotary instruments, sandblasting with alumina oxide particles, acid conditioning, silanation, or silicatization.[33,75–84] Selection of treatment is determined by the chemical composition of the restorative materials.

Two types of materials are used for indirect ceramic restorations: high- and low-silica materials (Table 8-3). Silica-rich ceramics, such as feldspathic porcelain and glass-ceramics, are used in the veneering of metal substructures (eg, metal-ceramic restorations), the veneering of high-strength ceramic copings (eg, IPS Empress II), the fabrication of all-ceramic restorations by the stratification method (eg, porcelain veneers), and finally, the use of heat-pressed ceramics (eg, IPS Empress).

These ceramics have a glassy matrix with high silica content (SiO_2) that surrounds the crystalline portion (feldspar, leucite, mica, alumina, and lithium dissilicate crystals). When etched with hydrofluoric acid, these surfaces undergo a significant micromorphologic alteration; an affinity between the hydrofluoric acid and the silica in the glassy matrix creates voids several micrometers deep between the crystals[82] (Figs 8-5 and 8-6). With the superficial corrosion at the glassy matrix, surface defects such as microcracks in the matrix that present after cooling are also dissolved, which limits crack propagation and by extension early failure of ceramic restorations.[85,86]

Table 8-3 High- and low-silica materials

CLASSIFICATION	COMMERCIAL NAME	MANUFACTURER
High silica content	Cerinate	Den-Mat
	Creation	Jensen
	Dicor	Dentsply
	Duceram	Dentsply
	Finesse	Dentsplay
	Hi-Ceram	Vident
	IPS e.max Press	Ivoclar Vivadent
	IPS Empress	Ivoclar Vivadent
	IPS Empress II	Ivoclar Vivadent
	Noritake	Noritake
	Optec	Jeneric Pentron
	ProCad	3M ESPE
	Vitablocs	Vita
	Vitadur Alpha	Vita
	VMK 68	Vita
Low silica content	Cercon	Dentsply
	In-Ceram Alumina	Vita
	In-Ceram Spinell	Vita
	In-Ceram YZ	Vita
	In-Ceram Zircônia	Vita
	IPS e.max ZirCAD	Ivoclar Vivadent
	LAVA	3M ESPE
	Procera AllCeram	Nobel Biocare
	Procera AllZirkon	Nobel Biocare

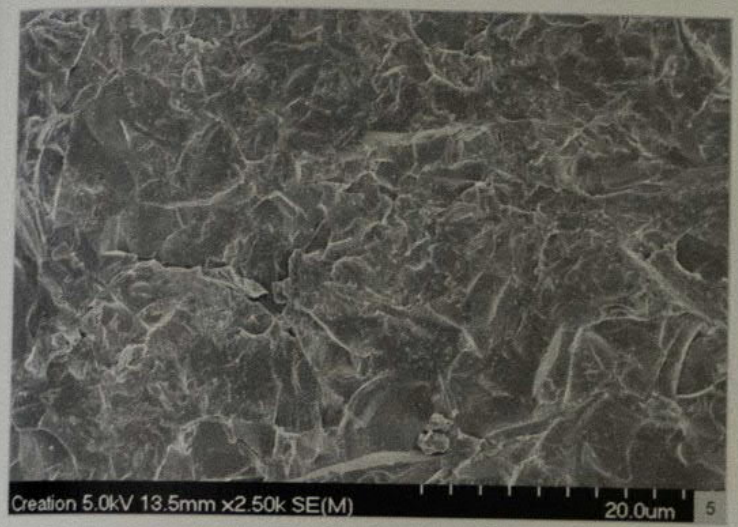


Fig 8-5 SEM image of a feldspathic ceramic (Creation). The crystalline portion is encased in a silica-rich matrix easily dissolved by hydrofluoric acid.

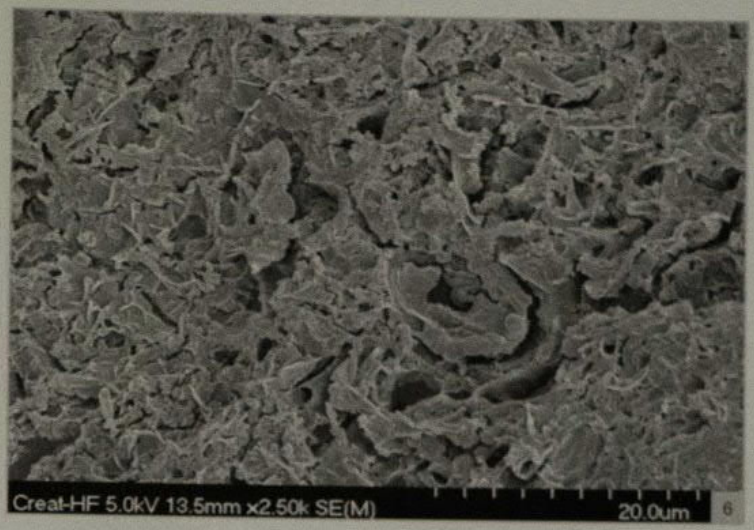


Fig 8-6 SEM image of the same ceramic after conditioning with hydrofluoric acid. The silica-rich vitreous matrix is dissolved, forming microretentive portions among the crystals. These areas are further infiltrated by silane coupling agents or adhesive resin monomers, which increases the strength of the resin cement-restoration interface.

The etching time for silica-rich ceramics varies according to the manufacturer.[81] The recommended protocols for IPS Empress and IPS Empress II are 60 and 20 seconds, respectively.[87] When no indication is provided, it can be assumed that acid application for 2 to 3 minutes is sufficient to obtain adequate microretentive features.[88]

The voids created by the acid-etching process are further infiltrated by functional coupling agents (silanes) or by unfilled resin used for cementation. Although the hydrofluoric acid-etching improves the bond strength of silica-rich ceramics, further use of a silane coupling agent increases superficial energy and also provides more adhesive strength and durability to resin cements.[77,82,89–91] Silanes are bifunctional molecules with one extremity linked to the ceramic surface and the other to the resinous organic matrix.[92,93] The use of silanes for silica-rich ceramics is fundamental for adequate bonding with resin cements.[89,94]

By contrast, silica-poor ceramics (less than 15%), such as alumina or zirconia systems, do not undergo superficial changes when etched by hydrofluoric acid, and there is no affinity with silane coupling agents (Figs 8-7 and 8-8). Thus, these ceramics must receive different treatments. Luting of ceramics with a high content of metallic oxides (ie, aluminum and zirconium oxides) must take into consideration their adhesive incompatibility with traditional resin cements and must follow two distinctive approaches: *(1)* silica incorporation at the inner surfaces and the use of a traditional resin cement or *(2)* the use of modified resin cements with good adhesive potential to metallic oxides. In the former, a tribochemical process called silicatization is undertaken, whereby the surface is blasted by alumina oxide particles lined with silica. These particles, accelerated under high pressure, melt to the ceramic substrate to create a silica-rich, microretentive surface. The silicatization process can be accomplished in the laboratory with the Rocatec system (3M ESPE), or chairside with the CoJet (3M ESPE) set for intraoral application. After silica incorporation, a silane agent (chemically coupled to silica) must be applied to obtain a reactive surface to the hydrophobic monomers of the adhesive system.[33] The use of silanes after silicatization can provide a durable resin bond between cements and glass-infiltrated alumina (eg, In-Ceram Alumina), as well as to densely sintered ceramics (eg, Procera AllCeram) and zirconia-based systems (eg, LAVA, Procera AllZircon).[33,34,50,95–97] Although silicatization is a proven surface treatment for metallic oxides, the silica-lined alumina particles do not mix as well with zirconia as they do with alumina-rich ceramics.[33]

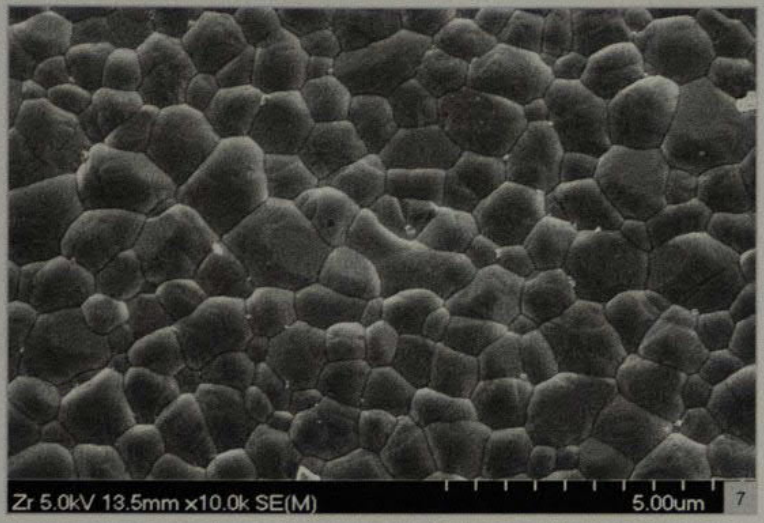


Fig 8-7 SEM image of a zirconia ceramic with low silica content (Procera). The elevated density of the polygonal structures minimizes the amount of vitreous matrix, making these high-strength ceramic materials.

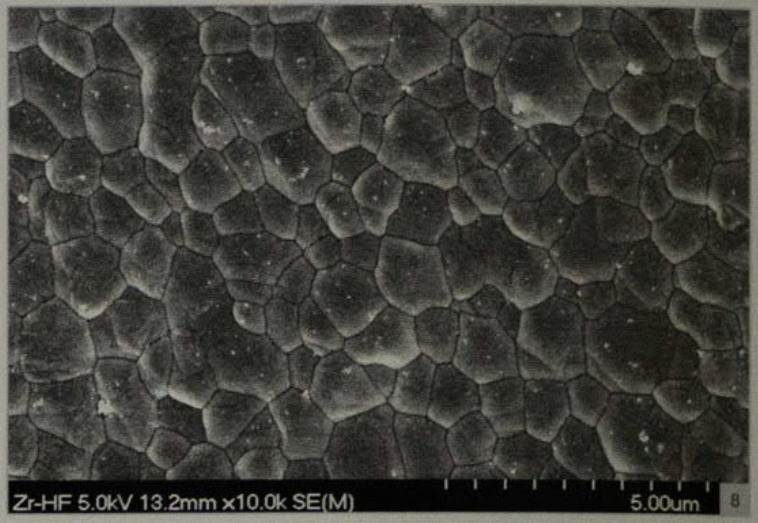


Fig 8-8 SEM image of the same surface after etching with hydrofluoric acid. No major superficial alteration is seen when the protocol used for silica-based ceramics is followed.

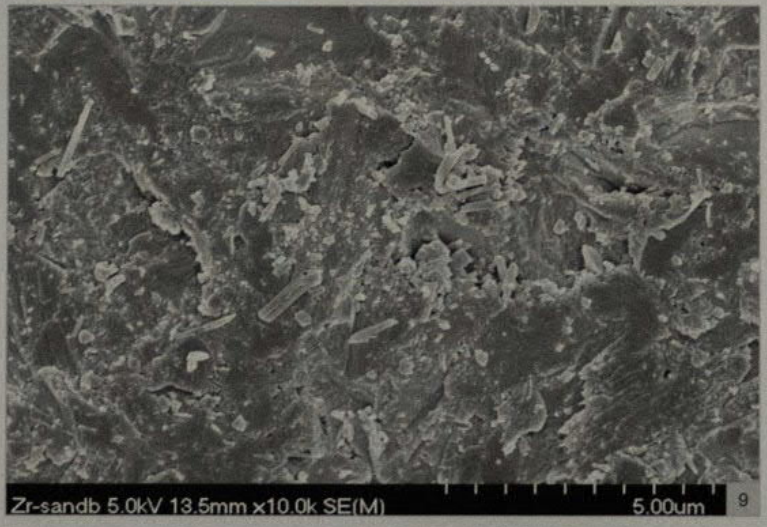


Fig 8-9 SEM image of an aluminum oxide ceramic (Procera) after airborne abrasion with aluminum oxide. This treatment is indicated to create surfaces rich in metallic oxide particles for luting with modified resin cements.

An alternative approach would be the use of modified resin cements with bonding potential to metallic oxides. Such modified cements (eg, RelyX Unicem, Superbond C&B, Panavia F, Panavia) have phosphate monomers (4-META or MDP) that bond chemically to metallic oxides, and thus a silica-rich or silanated surface is not necessary.[21] The only surface treatment necessary is sandblasting with aluminum oxide particles to generate a microretentive, highly activated surface (Fig 8-9). Bonding of these modified cements to silica-poor ceramics is so efficient that it overcomes the bond strength of any other surface treatment, including silicatization.[34,46,48,98]

According to the ceramic-selective affinities to hydrofluoric acid etching, silica-rich and silica-poor ceramics are classified as etch and nonetch ceramics, respectively. Recommended surface treatments for etch and nonetch ceramics are summarized in Table 8-4.

Protocols for adhesive cementation of metal-ceramic prostheses follow the same rules as for nonetch ceramics.[99,100] However, in case of metal-ceramic crowns with porcelain shoulder margins, both treatments must be made (eg, the shoulder must be conditioned and silanated). From a practical viewpoint, the use of modified resin cements in this example is an interesting option.

The inner surfaces of indirect inlay/onlay composite restorations must be sandblasted with aluminum oxide particles and silanated before cementation.[32]

Finally, the substrate must have similar treatments applied to enhance the bond strength at the restoration-resin cement interface. Sometimes, its complex nature (eg, enamel, dentin, sclerotic dentin, resin and/or metallic core, ceramic or hybrid [metal-ceramic] core), demands more than one protocol for adhesive cementation.

Table 8-4 Recommended surface treatments for etch and nonetch ceramics

CLASSIFICATION	SURFACE TREATMENT
Etch	Etching with hydrofluoric acid (2.5% to 10%) for 20 s to 3 min (according to ceramics) + silane bonding agent + adhesive agent + resin cement (conventional or modified)
Nonetch	Silicatization (Rocatec system) + silane bonding agent + adhesive agent + conventional resin cement Grit-blasting with aluminum oxide particles (Al_2O_3) (50–100μm, 2.5 bar) + adhesive agent (if necessary) + modified resin cement

Treatment Protocol for Adhesive Cementation

Substrate

Enamel

- Professional cleaning or sodium bicarbonate jet
- Etching with 37% phosphoric acid for 30 seconds
- Rinsing and drying with air-water spray
- Use of an hydrophobic adhesive layer (eg, Scotchbond MultiPurpose Plus)

Sound dentin

- Cleaning of tooth preparation with aluminum oxide sandblasting
- Enamel etching (if present) with 37% phosphoric acid for 30 seconds, dentin for 15 seconds
- Rinsing and drying (taking care to avoid dentin desiccation)
- Application of an adhesive layer (primer and adhesive); mild drying with air spray
- Light curing according to manufacturer recommendations

Sclerotic dentin

- Cleaning of tooth preparation with aluminum oxide sandblasting
- Enamel (if present) and dentin etching with 37% phosphoric acid for 30 seconds
- Rinsing and drying (taking care to avoid dentin desiccation)
- Application of an adhesive layer (primer and adhesive); mild drying with air spray
- Light curing according to manufacturer recommendation

Cast post cores

- Cleaning of tooth preparation with aluminum oxide sandblasting
- Sandblasting with 50 µm aluminum oxide particles for 15 seconds at 4 to 5 bar
- Enamel etching (if present) with 37% phosphoric acid for 30 seconds, dentin for 15 seconds
- Rinsing and drying (taking care to avoid dentin desiccation)
- Application of an adhesive layer (primer and adhesive) over the cast post core and tooth substrate; mild drying with air spray
- Light curing according to manufacturer recommendations

Composite resin buildup cores

- Cleaning of tooth preparation with aluminum oxide sandblasting
- Rinsing for 30 seconds and drying
- Sandblasting with 50-µm aluminum oxide particles for 15 seconds at 4 to 5 bar
- Enamel etching (if present) with 37% phosphoric acid for 30 seconds, dentin for 15 seconds
- Rinsing and drying (taking care to avoid dentin desiccation)
- Silane application left undisturbed
- Application of an adhesive layer (primer and adhesive) over the post and the tooth substrate followed by mild drying with air spray
- Light curing according to manufacturer recommendations

Ceramic or hybrid post cores

- After try-in, application of phosphoric acid for 15 seconds to remove contaminants
- Rinsing for 30 seconds and drying
- Sandblasting with 50-µm aluminum oxide particles for 15 seconds at 4 to 5 bar
- Enamel etching (if present) with 37% phosphoric acid for 30 seconds, dentin for 15 seconds
- Rinsing and drying (taking care to avoid dentin desiccation)
- Silane application left undisturbed
- Application of an adhesive layer and removal of excess
- Mild air spray
- Light curing according to manufacturer recommendations

Restoration

Silica-rich ceramics (etchable ceramics)

- After try-in, application of phosphoric acid for 15 seconds to remove contaminants
- Rinsing for 30 seconds and drying
- Application of ethyl alcohol left undisturbed
- Application of 10% hydrofluoric acid for 20 seconds to 3 minutes, according to the ceramic substrate
- Rinse thoroughly
- Ultrasound bath in 95% ethyl alcohol for 10 minutes and drying
- Silanation, air drying, and new application repeated 2 to 3 times
- Application of an adhesive layer and removal of excess (light activation here depends on ceramic thickness)

Silica-poor ceramics (nonetchable ceramics) and metal-ceramic crowns

With conventional luting agents

- Tribochemical process with silica-lined aluminum oxide particles (50 to 100 µm, 2.5 bars) (Rocatec system)
- Application of phosphoric acid for 15 seconds to remove contaminants
- Rinsing for 30 seconds and drying
- Application of ethyl alcohol and left undisturbed
- Application of the silane agent (preactivated), air drying, and repeated 2 to 3 times
- Application of an adhesive layer and removal of excess

With modified resin cements

- Sandblasting with 50-µm aluminum oxide particles for 15 seconds at 4 to 5 bar (at the laboratory)
- After try-in, application of phosphoric acid for 15 seconds to remove contaminants
- Rinsing for 30 seconds and drying
- Application of ethyl alcohol left undisturbed
- Application of the adhesive system of the modified resin cement kit

With indirect resin composites

- Sandblasting with 50-µm aluminum oxide particles for 15 seconds at 4 to 5 bar (at the laboratory)
- After try-in, application of phosphoric acid for 15 seconds to remove contaminants
- Rinsing for 30 seconds and drying
- Application of ethyl alcohol left undisturbed
- Application of adhesive layer and removal of excess

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