Principles of DESIGN and FABRICATION in Prosthodontics

Arnold Hohmann
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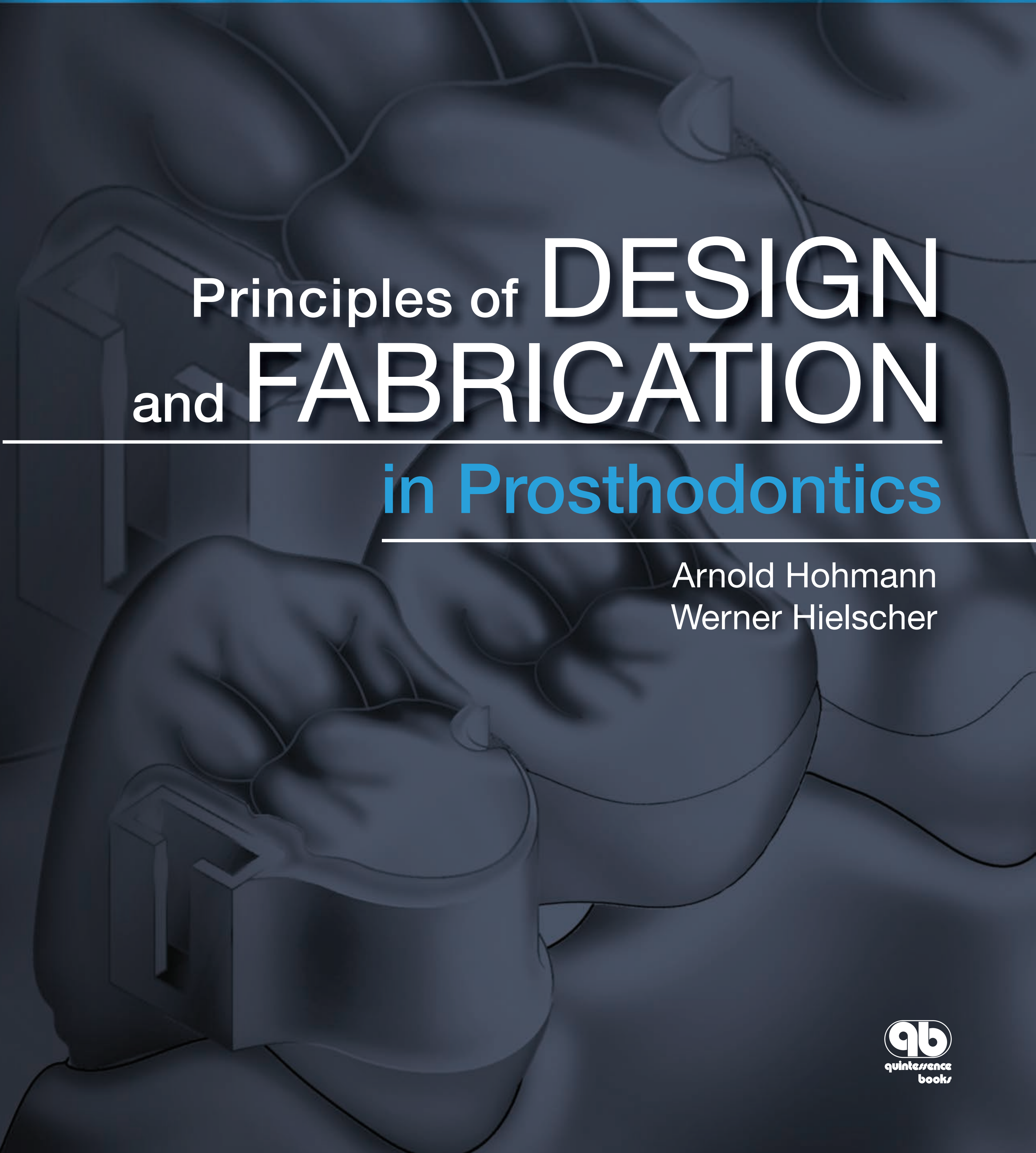

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Contents

Introduction

This textbook is designed for the specialized teaching of advanced dental students and technicians. It is written and illustrated by people who have a passion for their craft and take joy in passing on their knowledge. The text describes the philosophy behind prosthodontic design and systematically details all of the working steps in designing and fabricating restorations and dentures. Unlike other prosthodontic texts, this one is written from a design perspective first and foremost, explaining the rationale behind the most minute of design considerations, such as different extension arms in removable partial denture clasps. Because prosthodontists must possess the skills required to physically fabricate restorations, the book includes comprehensive instructions on fabrication, clearly delineating the clinical work from the laboratory work. It also presents each technique as an illustrated algorithm with detailed legends; these algorithms provide a quick orientation and visual aid for the reader. Multiple working methods for complete denture fabrication are presented, and the final chapter describes how to incorporate sound prosthodontic design into implant therapy. Armed with this book, the dental student will be well prepared to create esthetic, stable, and durable restorations.

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Preprosthetics

Functional Disorders After Tooth Loss

The masticatory system is a unit made up of functionally oriented tissue parts, and it only functions properly if all parts of the system are present and working smoothly. If normal functioning of the masticatory system no longer exists—whether because of loss or because disease has changed one part of the system—this is referred to as a *functional disorder*, *malfunction*, or *dysfunction*. In relation to the position and size of an edentulous space between teeth or a shortened dental arch, changes in facial expression and articulation may be observed as well as effects on masticatory function, the muscles of mastication, and the temporomandibular joints (TMJs). Above all, however, there is an adverse effect on the remaining dentition.

If there is an edentulous space, the supporting function of the closed dental arch afforded by the approximal contact points is lost and the teeth migrate into the space (Fig 1-1). Under the pressure of tooth migration, the bony alveolar wall opposing the edentulous space is broken down. At the same time, the alveolar bone beneath the space is resorbed. The consequence is the formation of a periodontal pocket in the area bordering the edentulous space. In addition, the approximal contacts with adjacent teeth become loose. As a result, the interdental areas open up and are no longer protected against food particles, which can become trapped there. This is followed by the formation of approximal caries and inflammation, which will damage the marginal periodontium.

As a result of the tipping of teeth, the normal occlusal contacts with the opposing teeth are lost. The occlusal surface inclines toward the normal occlusal level, so that some occlusal points migrate beyond the normal level and others fall below what is normal. The antagonists then overerupt until they regain occlusal contact, giving rise to severe malocclusions.

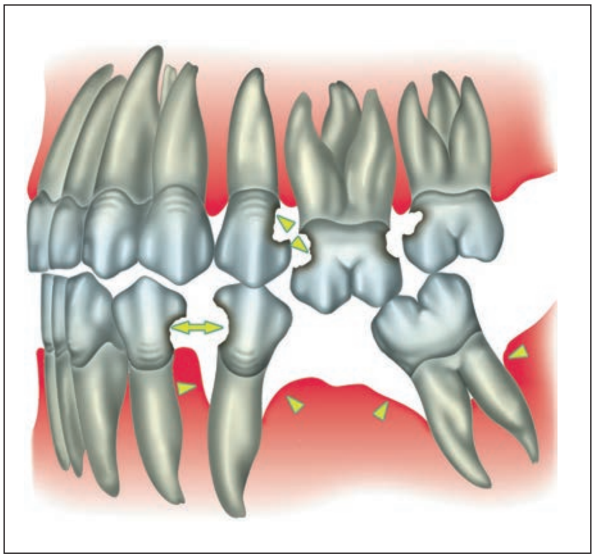


Fig 1-1 If a tooth is missing within an arch, the remaining teeth migrate into the edentulous space. As a result, the supporting function is lost, the interdental papillae are no longer protected, and caries develops in the approximal areas. In areas bordering the space, pocketing occurs at the marginal periodontium. In addition, the opposing tooth overerupts into the space, potentially causing tooth mobility, loss of support, and approximal caries in that arch as well.

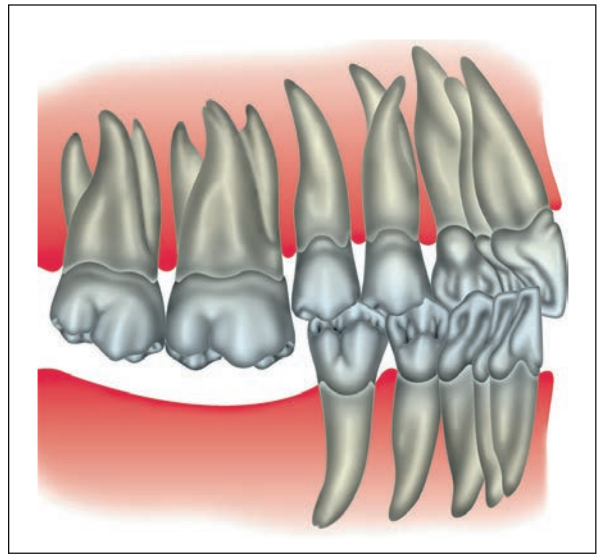


Fig 1-2 If the antagonists are missing, the teeth overerupt until they are stopped by the opposing jaw. This overeruption looks like lengthening of the tooth and is referred to as *elongation*. This exposes the cervical areas of the teeth so that cervical caries may develop. Prosthetic restoration becomes difficult under these conditions.

The elongation (lengthening) of teeth may be due to the reactive behavior of the periodontal tissues (Fig 1-2): If the tooth is not pressed into the socket by masticatory force, the pressure in the blood vessels lifts the tooth out of the socket. The gentle but continuous pull on the ligamentous apparatus acts as a stimulus on the alveolar bone, which grows in the direction of the pull until the tooth is held by antagonist contact or the opposing jaw.

The overeruption of an antagonist has two repercussions. First, in the dental arch from which the tooth is overerupting, all of the teeth become more mobile, bringing consequences such as loss of sagittal support, opening of the interdental spaces, approximal caries, and damage to the marginal periodontium. Second, the elongation gives rise to an occlusal disorder as the overerupting tooth interferes with gliding movements (Fig 1-3). Smooth occlusal gliding out of centric occlusion is no longer possible.

Enlargement of edentulous spaces means that the stresses on the residual teeth become greater and the periodontal damage more pronounced. Deterioration of the dentition progresses rapidly (Fig 1-4).

Malocclusions in a partially edentulous dentition arise because the continuous masticatory field is interrupted and sagittal or occlusal support contacts are lost. As a result, centric stops no longer meet simultaneously in their contact areas: some have premature contact and others no contact at all. This brings about uneven distribution of forces in the masticatory field: some teeth are overloaded and others underloaded. Because the sagittal support is missing, tipping and migration of teeth will occur whereby the tipped and migrated teeth are loaded eccentrically and hence nonphysiologically.

In all lateral or protrusive movements, all the mandibular teeth glide downward and forward on the posterior sloping surfaces of their maxil-

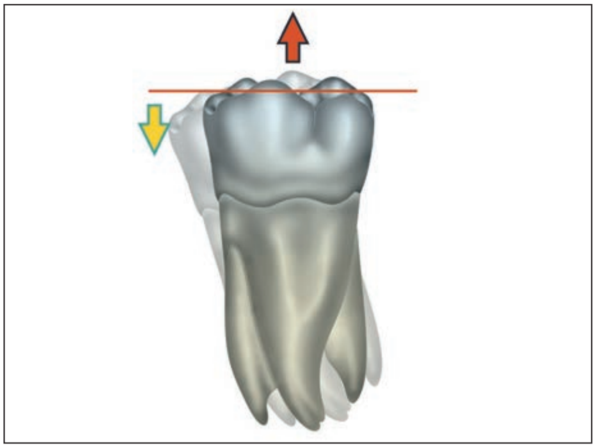


Fig 1-3 As a result of tipping, the distal occlusal points migrate beyond the occlusal line and the mesial points migrate below it. Consequently, the stress relationships for the affected teeth are also altered. Interference with gliding movements within the dental arch occurs during mandibular movements.

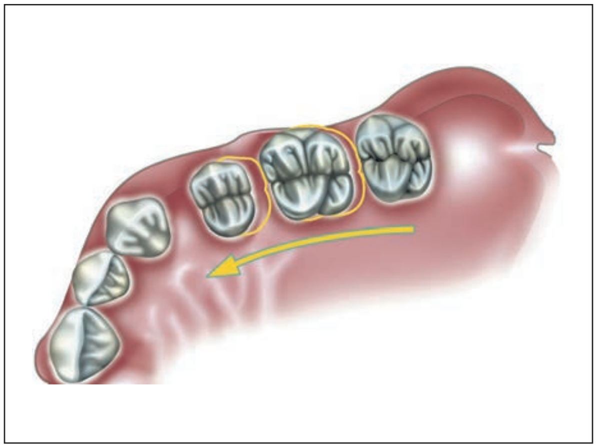


Fig 1-4 Early signs of destruction of a partially edentulous dentition can be seen from the migration of posterior teeth, which results in loss of interdental support. Tipping of teeth and hence a change in occlusal relationships are always associated with tooth migration.

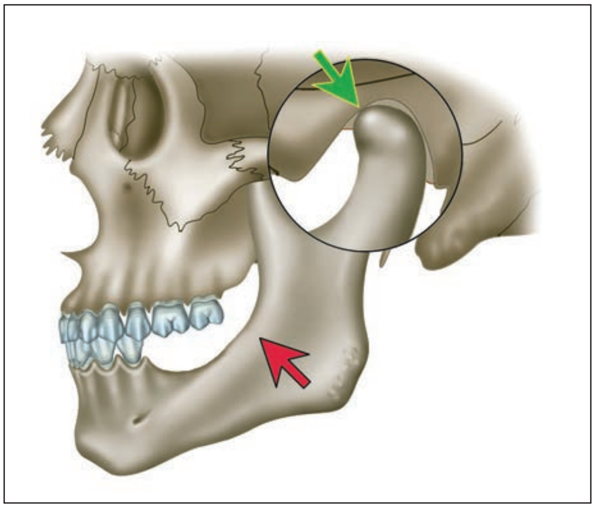


Fig 1-5 In the fully dentate dentition, the condyle is in a neutral position in the fossa when in centric occlusion. If the supporting function of the teeth is lost because of shortening of the dental arch, there is inevitably abnormal loading of the TMJs. The condyle is pressed into the mandibular fossa by the activity of the masticatory muscles. This leads to traumatic changes to the TMJs.

lary antagonists because of condylar, neuromuscular, and tooth guidance. If the cuspal paths are no longer arranged in the right spatial inclination because of tipping of teeth, the centric stops lose their antagonist contact.

Condylar and neuromuscular guidance are therefore abnormally stressed, which may result in TMJ and muscle diseases (Fig 1-5). Joint damage is often evident as disc dislocation with acute joint clicking when the disc pops out of its normal position beyond the edge of the mandibular fossa. This will result in pain of varying severity on loading.

Myopathies are diseases of the neuromuscular system that are evident initially as muscle tension and induration and later as disorders of metabolic breakdown and associated muscle pains.

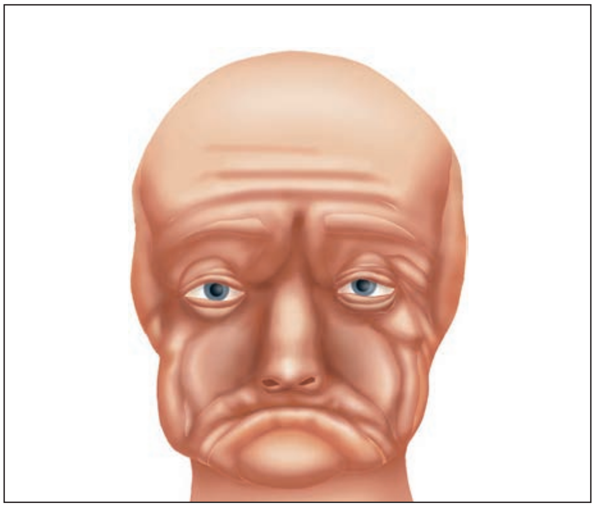


Fig 1-6 In the face of an aged edentulous patient, the extreme wrinkling around the sunken mouth becomes pronounced, the nose appears to lengthen, the cranial fossae at the sides are also sunken, and the slack buccal muscles cause the cheeks to sag. The facial proportions are therefore shifted.

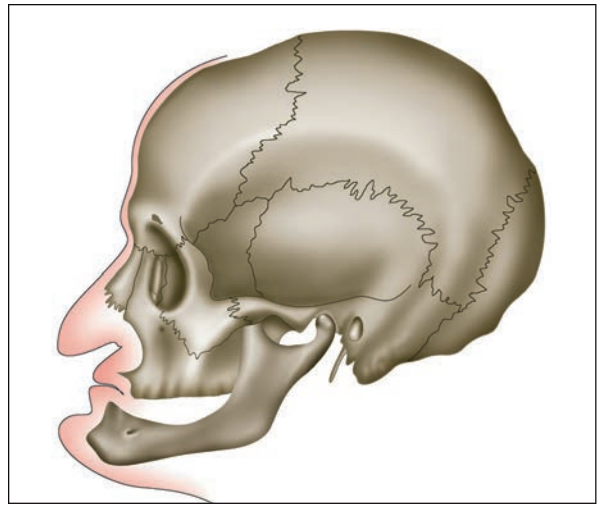


Fig 1-7 Changes to the masticatory system and face are most striking in complete edentulism: The alveolar ridges and bony tissue for the muscle attachments are resorbed, the mandible moves closer to the maxilla, lip support is lost, the vermilion of the lips disappears, and the face looks more aged.

Functional Disorders and Loading of Residual Dentition

Abnormal loading of the TMJs and the masticatory muscles appears when the supporting function of the posterior teeth is lost and the muscles of mastication press the condyle into the mandibular fossa. The abnormal loading of the masticatory muscles leads to displacement of the bite position; the mandible is shifted forward, which accelerates deleterious changes in the TMJ.

Displacement of the bite position influences the residual dentition. Either the remaining anterior teeth are moved labially by occlusal pressure, or an edge-to-edge bite arises with severe abrasion of the incisal edges. This results in severe mobility of teeth and even complete deterioration of the dentition.

The progressive destruction of a partially edentulous dentition may be delayed over prolonged periods. For instance, given normal loading and a resistant periodontium, a dentition may even make up for the loss of several molars itself. In most cases, however, the described symptoms occur within a few years and quickly lead to loss of all the teeth if the deterioration is not halted by prosthetic treatment.

The changes are most striking in complete edentulism. As a result of complete tooth loss, the mandible or maxilla collapses, lip support is lost, and the vertical dimension of occlusion is reduced, which inevitably pushes the mandible forward. All of these changes cause the lips to cave in; in addition, the vermilion of the lips disappears, the mouth becomes thin, and the lower part of the face is shortened. This results in an aged facial appearance with pronounced wrinkles around the mouth area caused by general slackness of the muscles of mastication and the perioral musculature, because normal masticatory function no longer places any load on these tissue parts (Figs 1-6 and 1-7). The bony areas to which the masticatory muscles attach are also resorbed.

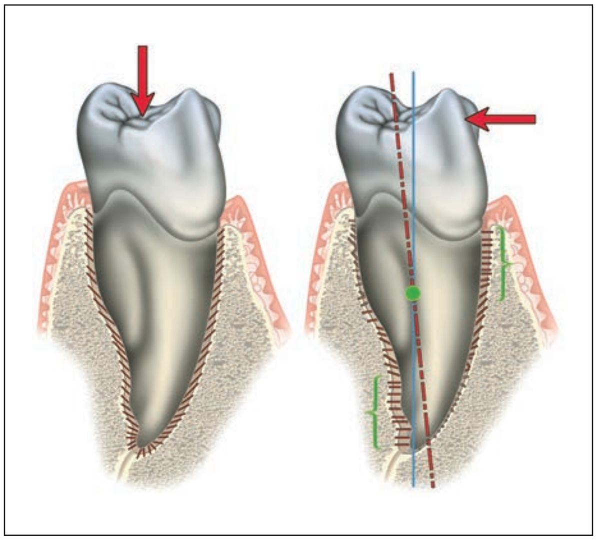


Fig 1-8 If a force hits the tooth centrally, the whole periodontium is physiologically under tension. On transverse loading and tooth tipping, only a third of the periodontal fibrous surface is physiologically under tensile stress *(green bracket)*, a third remains neutral and unloaded, and a third is nonphysiologically compressed.

Impaired masticatory function affects the entire digestive process. The inability to crush food properly, together with insufficient insalivation and predigestion, will initially lengthen the time food stays in the stomach; the stomach muscles slacken, and diseases of the intestinal tract develop because of the abnormal decay and fermentation processes.

The consequences of tooth loss that impairs function suggest that prosthetic replacement of missing teeth is indispensable. The prosthetic replacement has to be anchored to the residual teeth that are still present or supported on the mucosa, which is unsuitable for absorbing masticatory forces.

Periodontal tissues are far better suited to absorbing masticatory forces than the mucosal and bony foundation for a denture base (Fig 1-8). The cells of the periodontal tissue have differentiated to absorb forces: Sharpey fibers convert pressure into tension, stabilizing the alveolar cortical bone, which can dissipate force effectively. Bone is known to grow in the direction of pull and is broken down under pressure—a functional relationship that is exploited to achieve orthodontic tooth movements.

The mucosal and bony base can absorb moderate masticatory force because of shifts of fluid in the soft tissue. The mucosa transfers masticatory force to the bone, for which a moderate masticatory force is favorable because the periosteum here is stimulated by fibrous anchorage of the attached mucosa. The bone will atrophy if there is complete inactivity. However, even at masticatory forces that are normal for the periodontium, the bone is subject to compressive loading to such an extent that it is resorbed; this has to be corrected by constant rebasing.

If the loading of the residual dentition is greater than normal because of the prosthetic replacement, there is a pronounced increase in the Sharpey fiber bundles, and hence periodontal loading capacity is higher. It is important that the higher load contacts the periodontium centrally and does not tip the tooth, causing nonphysiologic loading of the fibrous tissue.

In a fully dentate dentition, tipping of the teeth is compensated for by the sagittal support from approximal contacts, tissue interlinking, double interlocking with antagonists, and the neuromuscular reflex arc. In a partially edentulous dentition, sagittal support, tissue interlinking, and antagonist contacts are largely lost; only the reflex arc remains. However, the arc only works when there is overloading and not with below-threshold continuous loads. This can give rise to and explain specific denture requirements.

Function of Dental Prostheses

The term *prostheses* refers to all mechanical devices that serve as a functional or cosmetic replacement for lost anatomical tissue. Hence every tooth replacement—whether a crown or a partial denture—is a prosthesis. The term *partial prosthesis* is actually a tautology because any prosthesis is essentially a partial replacement. The following grouping of teeth replacements is useful in distinguishing the different types of prostheses, and their names emphasize the design features of the specific replacements (Fig 1-9):

- A *crown* replaces hard dental tissue in a wide variety of fixed designs; in the broadest sense, this also includes restorative treatment.
- A *fixed partial denture* replaces teeth, dental hard substance, and alveolar bone; this fixed prosthetic replacement is firmly spanned between abutments, which is why they are also called *bridges*.
- A *removable partial denture* is a removable tooth replacement that replaces single teeth and alveolar bone in a partially edentulous dentition.
- A *complete denture* is a removable full denture that replaces all the teeth and missing alveolar bone.

Depending on the amount of time a prosthesis is used, a distinction is made between interim/provisional or immediate prostheses and definitive prostheses. The terms *immediate prosthesis* and *interim prosthesis* denote the instant prostheses used for a specific indication.

An immediate prosthesis is fabricated according to a model prepared before extraction of the teeth that are going to be replaced. The teeth are ground on the model and replaced by a prosthesis construction. An immediate denture is inserted directly after extraction of the teeth.

An interim prosthesis is a provisional removable tooth replacement that is fabricated and inserted immediately after tooth extraction as a form of wound closure and is used until the definitive replacement is inserted. After tooth extraction, an impression is taken, models are made, and the prosthesis is fabricated with the same design features and functions as an immediate prosthesis.

Interim prostheses offer good wound closure and better adaptation of the alveolar ridge tissue to loading. Researchers have observed that patients who are fitted with interim prostheses experience less shrinkage of the alveolar ridge than those who are not. Interim prostheses offer an esthetic replacement until the definitive restoration is inserted; they maintain the vertical dimension of occlusion, allow natural chewing movements, and as spacers prevent any displacement of teeth bordering edentulous spaces. Another advantage of these interim prostheses lies in the recording of the maxillomandibular relationship for the definitive prosthesis, especially in the case of complete dentures. Furthermore, speech function is preserved for the patient. Definitive prostheses are the form of tooth replacement that is intended to be in place in the long term.

The aim of prosthetic treatment is to replace lost tissue and avoid, or at least reduce, all the functional disorders that occur because of tooth loss. The specific functions of a tooth replacement can thus be identified as follows (Fig 1-10):

- *Biomechanical function* involves restoring the closed dental arch by replacing the missing tissue parts. The aim is to secure the supporting function within the dental arch, create a normal occlusal situation, and enable physiologic loading of the available tissue.
- *Therapeutic function* involves halting any deterioration of the dentition that has already started. This also relates to delaying or preventing changes to other tissue parts of the masticatory system by means of correct prosthetic design.
- *Prophylactic function* means stopping secondary damage resulting from the prosthetic replacement and preventing future pathologic changes.
- *Regulating function* concerns prosthetic measures intended to improve or establish the functioning of a masticatory system. This includes esthetic aspects and unimpaired phonetics.

Design principles and the criteria of functional testing can be deduced from this general description of functions. Descriptions of specific prostheses in the following sections not only explain the constructional measures but also cover the functional references of the tooth replacement. Possible errors that may result are examined in detail.

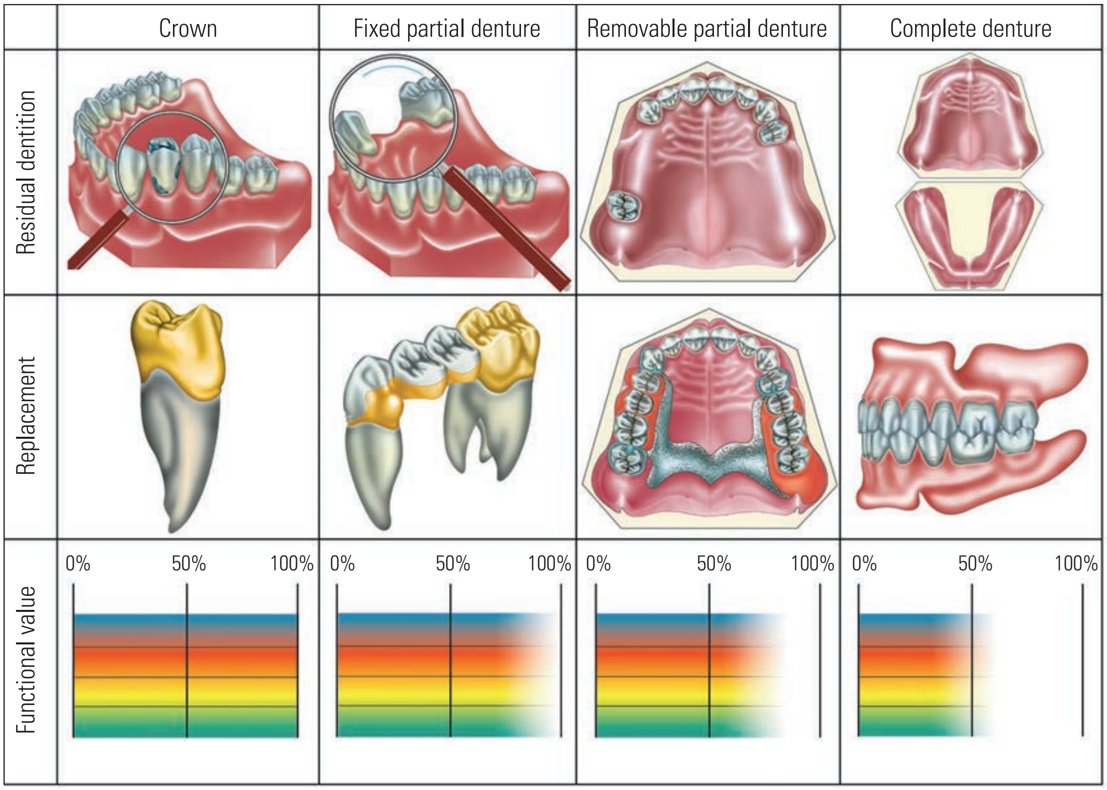


Fig 1-9 The possible functional value that can be achieved by a dental replacement in the ideal situation can be correlated with the different prosthesis and tooth replacement groups. A functional value of 100% in single-tooth rehabilitation can be achieved by dentistry and dental technology methods, whereas severe loss of masticatory function can be expected in the case of complete prostheses.

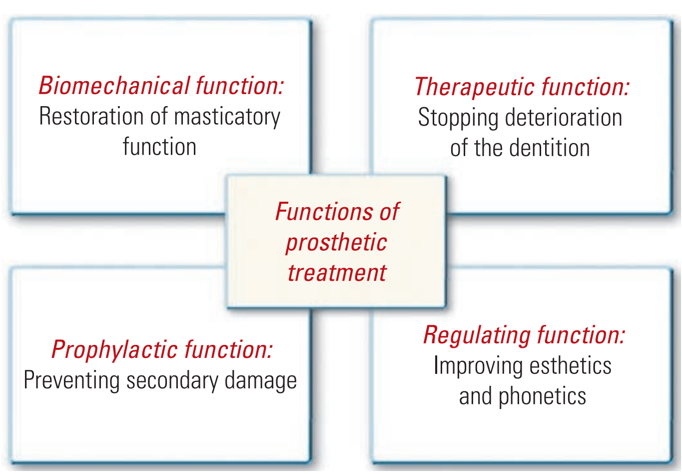


Fig 1-10 The functions of prosthetic treatment can be broken down into four functional areas for teaching purposes. No area has particular priority, and all functions need to be accomplished equally.

Restorative Treatment

Restorative treatment refers to a single-tooth restoration in which the diseased dental hard substance is replaced by tissue-compatible material. Restorative treatment becomes necessary for dental defects resulting from chipping of the teeth during trauma, caries lesions, or abrasive wear.

Restorations are intended to restore the original morphology of the tooth and to be resistant to conditions in the oral cavity, dimensionally stable, and tissue compatible. Their color should not differ from that of the natural tooth, and restorations should be cost-effective to produce. The margins of the restoration are placed in areas that are accessible to mechanical oral hygiene measures or subject to self-cleaning. The restoration must withstand masticatory loads and must not fall out. Restorations can be classified according to the following:

- The extent of dental destruction or the dimensions of the tooth surfaces to be replaced
- The nature of the restorative material (ie, plastic or metal)
- The nature of the fabrication process (ie, direct or indirect fabrication)

Cavity or *tooth preparation* refers to preparing the tooth to receive a restoration. The process involves removing the caries or preparing the defect in the dental tissue and treating the wound in the dentin. To remove the soft carious tissue with a low-speed drill, the hard enamel layer is first removed at high speed under water cooling. Tooth preparation is intended to spare hard dental tissue, provide permanent retention for the restoration, and prevent new caries from developing. It is done with rotary instruments at low or normal speed (4,500 rpm and above) and under water cooling and is not extended to the gingival margin.

The cavity to receive a restoration has the following basic features (Fig 1-11):

- The cavity floor is the interface directed toward the pulp, which must be a minimum of 1.5 mm from the tooth surface in order to create high enough walls for the restoration.
- The cavity walls are the lateral borders to the enamel and dentin. The transitions between the floor and wall are rounded. For plastic restorative materials, the cavity walls are slightly undercut. For metal restorative materials, the floor and wall form a nearly 90-degree angle.
- The cavity margin, or the border between the cavity wall and the tooth surface, forms the subsequent restorative margin. For cast restorations and adhesive restorations made of composite, the cavity margin is beveled in the enamel.
- Extension surfaces are the cavity walls that border the vertical pulpoaxial cavity floor on the approximal surfaces.

Caries lesions are subdivided into five classes according to Black's classification (Fig 1-12):

- *Class I caries* refers to occlusal lesions in the area of the pits and fissures in molars and premolars. The term is used for fissure caries that starts in spots in the fissures and runs along the dentinoenamel junction. Any overhanging enamel areas that arise will break off under masticatory pressure.
- *Class II caries* describes approximal lesions in premolars and molars. An approximal defect in posterior teeth in a closed dental arch can only be prepared occlusally so that a multisurface cavity is formed. A box-shaped preparation with rounded transitions is required to restore an approximal caries lesion. The approximal-cervical shoulder lies perpendicular to the crown axis or slopes slightly from the outside inward.
- *Class III caries* refers to approximal cavities in anterior teeth without involvement of the incisal edge. The small, round cavity opening in the area of the anterior teeth is prepared from the lingual, and the cavity margins are extensively beveled to achieve a wide retentive surface on the dental enamel.
- *Class IV caries* relates to approximal defects in anterior teeth involving damage to the incisal edge. Loss of the incisal edge necessitates extensive beveling of the enamel (1 to 2 mm), which is mainly restored with a tooth-colored restoration retentively fixed to the dental enamel by the enamel etching technique.
- *Class V caries* denotes defects close to the gingiva on the labial and buccal tooth surfaces. Cervical cavities are surrounded by enamel on all sides.

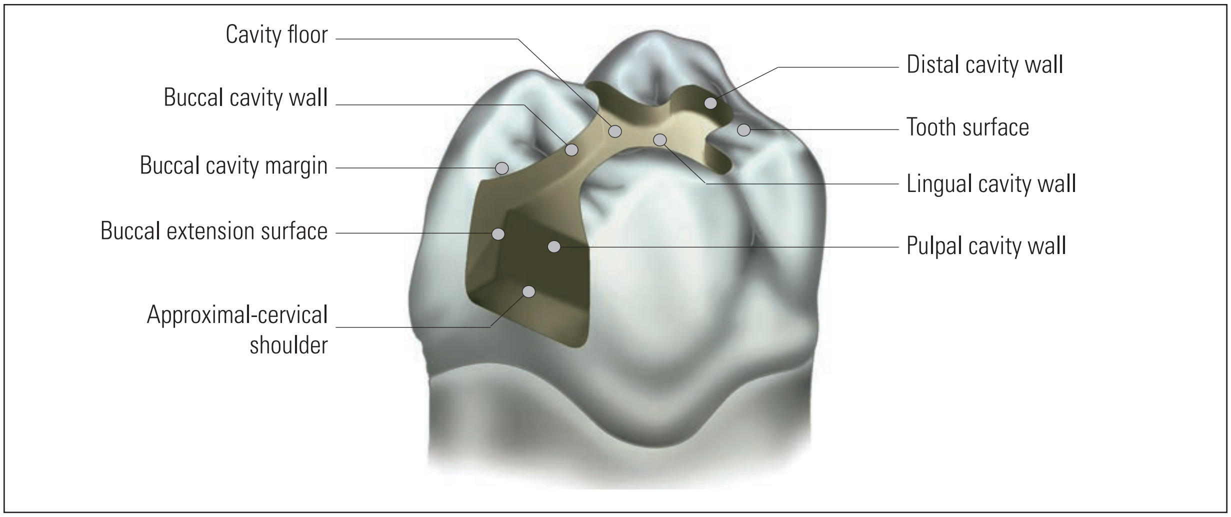


Fig 1-11 Tooth preparation removes carious dental hard substance and shapes a cavity to receive a restoration.

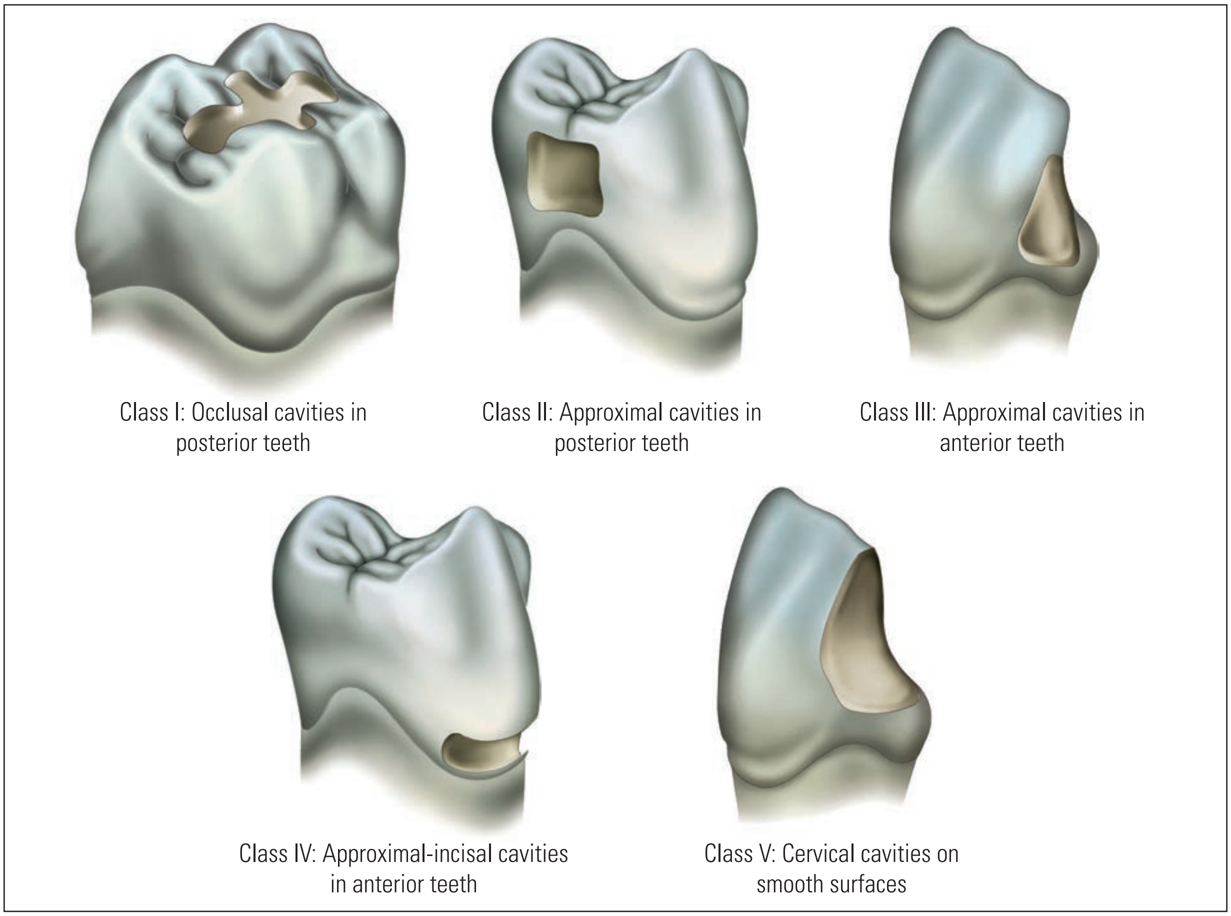


Fig 1-12 Caries classes I through V can be distinguished based on Black's systematic classification.

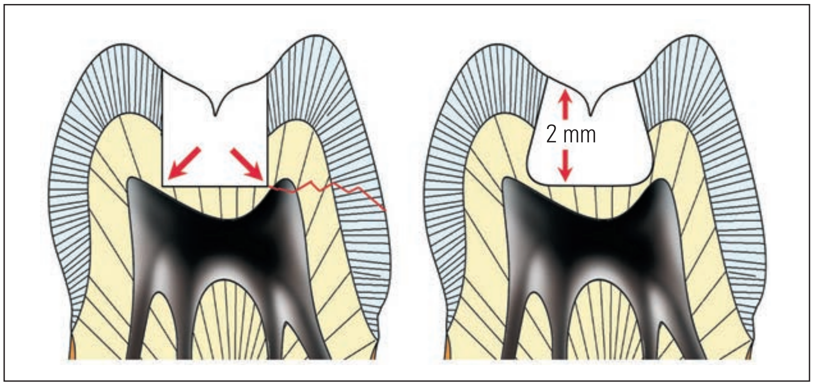


Fig 1-13 The buccal and lingual cavity walls for an amalgam restoration are prepared slightly undercut. The minimum cavity depth is 2 mm. The transitions are rounded at the cavity floor to prevent a notching effect with the dental tissue.

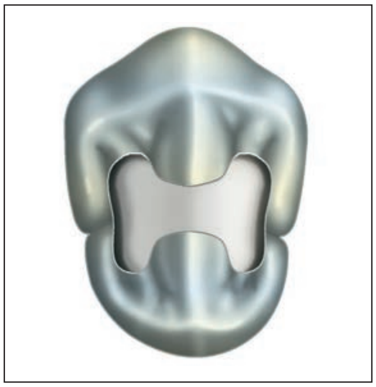


Fig 1-14 The approximal cavity walls for an amalgam restoration are prepared slightly divergent, in an occlusal direction, so that the marginal ridge areas cannot break. The buccal and lingual walls are slightly undercut to give the restoration material sufficient retention.

Restorative Materials

Restorations made from plastic restorative material are fabricated by the dentist in the patient's mouth using the direct method. A distinction is made between a provisional restoration as a temporary seal and the definitive restoration for the long-term restoration. Hardening substances in the form of ready-to-use mixtures of zinc and calcium sulfate from tubes, zinc oxide–clove oil with additives, and heat-deformable gutta-percha are used as temporary restorative materials.

Amalgam, composites, glass-ionomer cements, and gold leaf or crystalline gold (sponge gold) are used for definitive restorations. Tooth preparation is performed as described, depending on the restorative material used.

Amalgam restorations for caries treatment in conservative dentistry are made of a heterogeneous alloy of mercury with other metals. They are used in the occlusion-bearing posterior region and to build up cusps (Figs 1-13 and 1-14); amalgam restorations are not used for anterior restorations for esthetic reasons. The liquid mixture of mercury and other metals can be readily packed into the cavity before it hardens into its solid form. The ready-to-use amalgam alloy is mechanically blended from two components at a 1:1 ratio of liquid mercury and powdered amalgam particles. Correctly prepared amalgam restorations are extremely durable and leak only small amounts of mercury. However, because of this leakage, amalgams are suspected of being deleterious to health. Measurements of mercury in saliva, blood, and urine show a correlation between the concentration of inorganic mercury compounds and the number of teeth filled with amalgam. Therefore, amalgam restorations are unsuitable for children younger than 6 years, pregnant women, and patients with kidney disease. Owing to the hazard posed by mercury vapors and their chemical affinity for precious metals, amalgams are rarely used. Similarly, amalgam in direct contact with metallic crowns will release mercury because of electrogalvanic corrosion.

Composite restorations are made of tooth-colored acrylic resin reinforced with inorganic fillers. The composite is packed into the cavity in its liquid state and sets chemically or under ultraviolet light. Composite is not as mechanically durable as amalgam because it shrinks during curing and has high thermal expansion. Composites are not as suitable for posterior restorations as they are for the anterior region. They can be

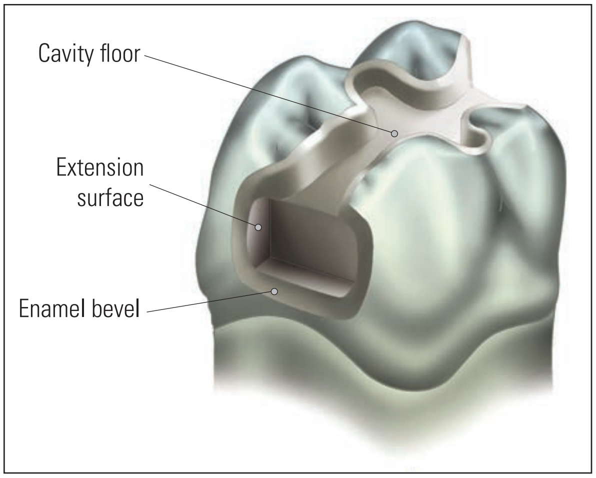


Fig 1-15 In a multisurface cavity for a composite restoration, the cavity floor is at least 2 mm deep. The approximal extension surfaces are clearly directed in a lingual and buccal direction. The cavity margin is encircled by an enamel bevel. Conditioning with an etchant gel is performed in this enamel area.

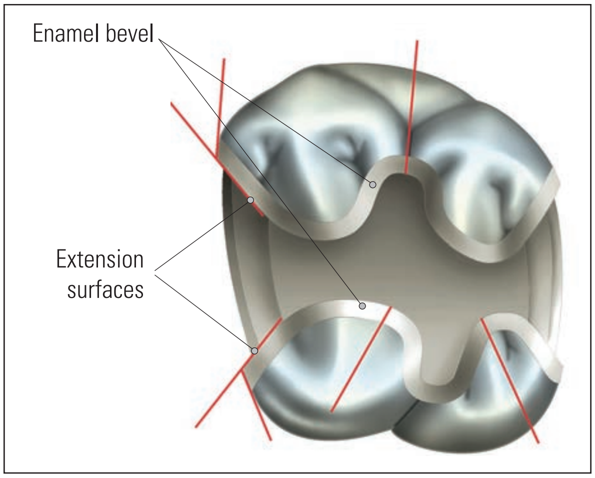


Fig 1-16 For a multisurface cavity, a gold inlay restoration is generally made; the same design is chosen as in Fig 1-15, with a depth of 2 mm, the extension surfaces, and the enamel bevel. The occlusal antagonist contacts must always lie outside the cavity margin.

used for small occlusal cavities if the antagonist contacts lie on the natural dental hard substance. Composite restorations are adhesively and retentively bonded to the dental enamel by the enamel etching technique, for which an absolutely dry cavity must be maintained (rubber dam).

The marginal integrity of composite restorations is ensured by the preparation of mechanical retentions (grooves, adhesive points) and with dentin bonding agents. In addition, a tight, acid-resistant cavity lining is placed to protect the pulp against the acrylic resin monomer or phosphoric acid (etching gel). The composite material is applied layer by layer, finished, and polished and thus provides esthetically superior restorations with a tight marginal seal (Fig 1-15).

Glass-ionomer cement restorations may be used for small caries lesions. Glass-ionomer cements bond well to dentin and enamel so that a restoration with marginal integrity is produced. Cements cannot be polished, are light impermeable, and are not abrasion resistant. Their use is confined to cervical caries lesions bordered by enamel as well as caries lesions in the cementum. Glass-ionomer cement is mainly used as a tooth preparation lining material and for buildups on crown stumps.

Gold compaction restorations are very rarely fabricated for small occlusal and approximal caries lesions. Tooth preparation must be box shaped with sharp edges. The cavity walls are parallel or undercut to provide sufficient retention (Fig 1-16). The restorative material consists of a special gold foil (gold leaf) or crystalline gold. The core of the restoration is built up with the crystalline gold, which is coated on the outside with gold leaf. The gold is packed in portions into the cavity and cold-welded with hammer blows so that it wedges into the cavity with a tight marginal seal. Fabrication is time-consuming and costly but does produce long-lasting, dimensionally stable inlay restorations that are appropriate when a patient is allergic to other restorative materials and their ingredients.

Inlay Restorations

Inlay restorations made from metal, ceramic, or composite can be used to restore occlusal, approximal, or approximal-incisal cavities caused by carious defects, fracture, or other damage after they have been prepared. Inlay restorations are only indicated for patients who have good oral hygiene, minimal susceptibility to caries, and healthy periodontal conditions. Inlay restorations can be placed over several surfaces and may be retained by shoulders and pins (Fig 1-17). They differ depending on the amount of tooth structure to be replaced (Fig 1-18). The term *inlay restorations* encompasses inlays, onlays, overlays, and onlay partial crowns.

While an inlay is fixed entirely intracoronally without covering the occlusal surface of a tooth, an onlay covers the entire occlusal surface, and an overlay encompasses the occlusion-bearing cusps and includes both approximal surfaces. There is a smooth transition from overlay to partial crown when the cervical area of the tooth and the occlusal and approximal defects need to be restored.

The design for inlay restorations is extended and demands plenty of dental hard tissue, especially if a metal and porcelain restoration covering the occlusal surface is to be placed. The cavity walls are not undercut occlusally, in contrast to the preparation for plastic restorative materials (Fig 1-19). Cavity walls close to the pulp are coated with a lining so that even undercut areas are blocked out. The cavity walls and the liner should be smoothed, and then an impression is taken. The prepared teeth are fitted with a temporary acrylic resin restoration until an inlay restoration has been made in the dental laboratory.

Inlay restorations are fabricated using dental technology measures. First an impression is taken of the cavity, and the restoration is made indirectly on a model by the following methods:

- Cast in metal using the lost wax technique
- Milled out of a ceramic block using computer numeric controlled (CNC) technology
- Compressed in ceramic by the extrusion technique
- Ceramic fired onto galvanic carrier layers
- Cured in composite using the layering technique

After fabrication, inlay restorations are inserted with cement or special bonding agents. They adhere to the cavity walls by a gripping effect and static friction.

Metal inlay restorations are made from gold alloys; other metal alloys (non–precious metal and palladium alloys) are rarely used. A working model and opposing jaw model are first fabricated from artificial stone and placed in the articulator. By the traditional method, the inlay restoration is carved in wax, sprued, invested, and cast. Metal inlay restorations can also be milled out of a full metal block using CNC technology.

Composite and ceramic inlay restorations can be fabricated by the indirect technique using an impression and plaster cast and adhesively fixed in the cavity by the acid-etching technique.

Various methods are used for fabricating ceramic inlay restorations. In the sintering method, a split model made of plaster and a duplicate model made of castable material are prepared, onto which the restoration is sintered. If the ceramic inlay restoration is made of castable ceramic (eg, glass-ceramic) or pressed ceramic, the restoration must be carved out of wax on the working model and invested. For fabrication by computer-controlled techniques, an optical impression of the prepared cavity must be made using special imaging methods. On the basis of this impression, the inlay restoration is ground out of a compact ceramic block using CNC techniques. In the copy-grinding method, a restorative block made of acrylic resin is mechanically scanned, and a ceramic duplicate is milled out of a ceramic block.

Composite inlay restorations are made of composite with a high proportion of inorganic fillers. They can be fabricated directly in the mouth or by indirect fabrication on a working model in the dental laboratory.

In the case of electroformed inlays, tooth-colored ceramic is fired onto a thin carrier layer of electroformed gold. A thin gold layer is electrogalvanically deposited on the model die in order to fire on a ceramic layer. These inlay restorations have very good accuracy of fit and are inserted using phosphate cement. A thin gold margin remains visible, which is esthetically unsightly.

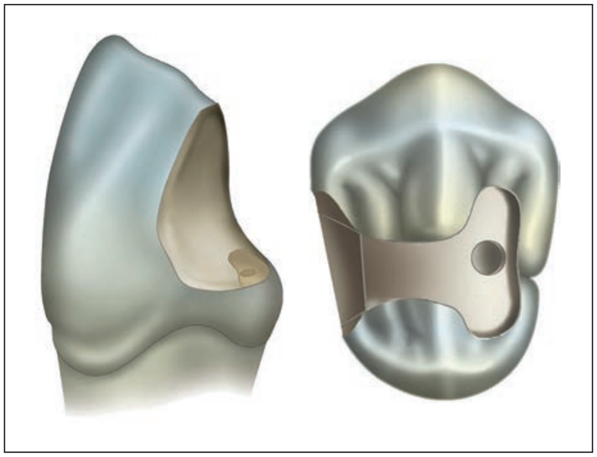


Fig 1-17 An extensive cavity restoration can be created with additional retentions in the form of pinholes. Short pins engage in these holes to secure the restoration. The term *pinlays* is used for restorations that mainly gain their retention in the dental tissue by means of pinholes or pins.

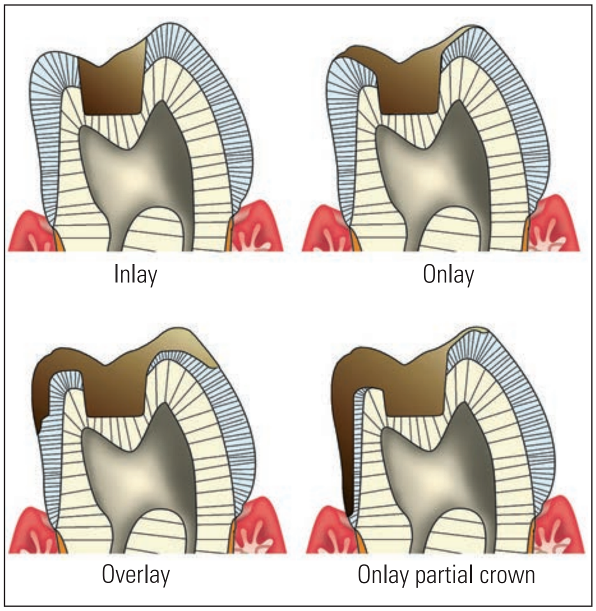


Fig 1-18 The term *inlay restoration* encompasses restorations made of metal in differing dimensions; they are classified according to the amount of dental substance to be replaced—inlays: intracoronal cavities; onlays: cavities on occlusal surfaces; overlays: cavities on occlusal surfaces and the occlusion-bearing cusps; onlay partial crowns: cavities involving the vertical smooth surfaces outside the portion visible from the vestibular view.

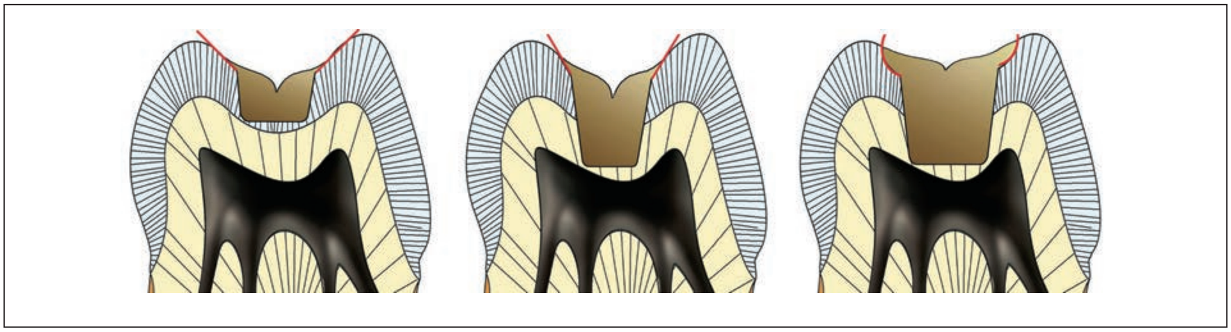


Fig 1-19 The bevel of the cavity margins for metal inlay restorations is designed differently, depending on the cavity volume: A flat cavity is given 45-degree bevels; a very deep cavity is given steeper bevels; and very deep and wide cavities are prepared with round bevels.

Occlusal inlays

For occlusal inlays, the width of the cavity is half the intercuspal distance in order to maintain the stability of the dental substance and leave the occlusal contacts on the natural dental tissue. An occlusal cavity is 1.5 mm wide and deep and includes the main fissures. The cavity walls have a common path of insertion without undercuts. The inner edges of the cavity are rounded, and

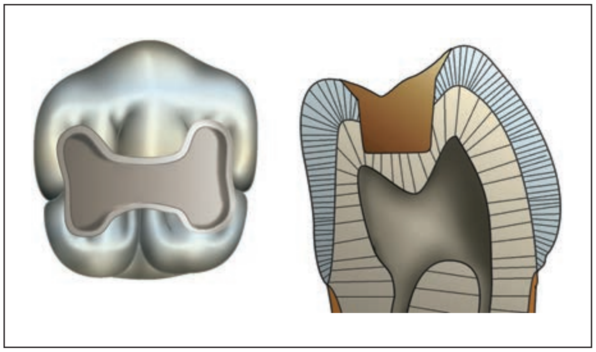


Fig 1-20 The cavity for a single-surface metal inlay has a minimum depth of 1.5 mm; preparation is slightly divergent, and there are no undercuts. The cavity margin does not lie in the area of occlusal contacts and is prepared with an enamel bevel.

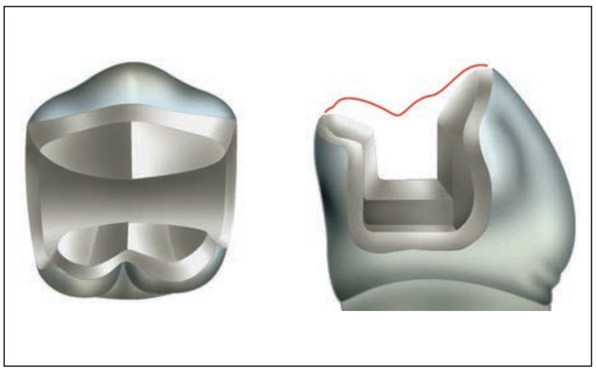


Fig 1-21 An onlay incorporates the whole occlusal surface and extends into the approximal surfaces. The approximal extensions run lingually or vestibularly; an approximal-cervical shoulder is usually prepared. An enamel bevel is prepared around the cavity margin.

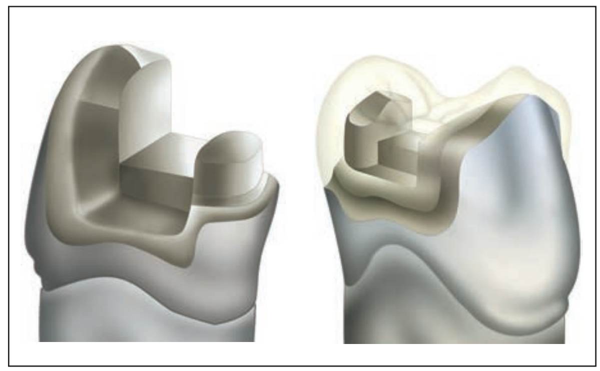


Fig 1-22 The overlay replaces the occlusal surface and fully encompasses the occlusion-bearing cusps. A shoulder is usually prepared around these cusps, while the nonsupporting cusp is surrounded by a simple enamel bevel.

the occlusal margin is beveled so that the margin of the metal restoration can be refined by reworking (Fig 1-20). Antagonist contacts lie either completely on the natural dental substance or on the surface of the restoration.

Inlay splints refer to cast restorations that are soldered together; they are used to fix mobile teeth to adjacent teeth and stabilize them. Inlays can be used to anchor partial dentures, but they offer less retention to abutment teeth than the use of crowns.

Onlays and overlays

Onlays or overlays are prepared when the dental hard tissue is weakened by large caries lesions and occlusal corrections are also necessary. For an onlay, preparation involves the occlusal surface, including the cusp tips, and usually extends into both approximal surfaces (Fig 1-21). Overlay preparation incorporates the bearing cusps and ends in a shoulder preparation with bevel. The preparation margin runs level with the height of the contour and extends into both approximal surfaces. There is a smooth crossover between overlays and partial crowns (Fig 1-22).

A core buildup made of plastic restorative materials (glass-ionomer cement or composite) becomes necessary for badly damaged teeth before the onlay or overlay preparation can be started. All restorative margins must lie within healthy dental hard substance and not in the buildup material. Such core buildups are anchored with parapulpal pins in the form of root canal screws unless a cast post and core is being fabricated.

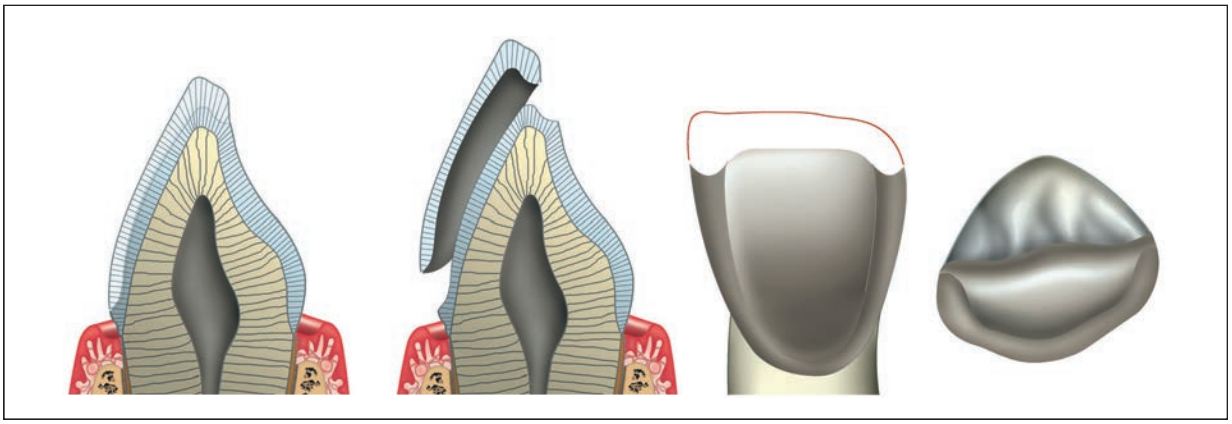


Fig 1-23 Veneers replace the labial facet of an anterior tooth. For this purpose, a consistent layer approximately 0.8 mm thick is ground out of the enamel into the approximal areas; the incisal edge is prepared into the lingual area. The approximal crown width is retained, and undercuts are avoided. The prepared surface is conditioned by acid etching to receive the ceramic veneer and therefore must lie solely within the enamel area. A composite bonding agent is used to achieve the adhesive bond.

Veneers

Veneers, also known as *laminates* or *facings*, are fabricated when circular preparation of dental crowns is to be avoided in order to preserve ample natural dental tissue as well as esthetics. Veneers can be made individually out of acrylic resin, composite, and ceramic directly in the mouth or in the dental laboratory, or they can be milled out of prefabricated ceramic blocks using CNC machining. Veneers are indicated for discolored facets or large anterior restorations, enamel cracks or chips, and morphologic or positional corrections.

To prepare a veneer stump, the labial enamel and the incisal edge into the approximal surfaces are removed to a thickness of about 0.5 mm without exposing the dentin. The preparation surface is slightly curved in the horizontal and vertical direction and should be smooth without undercuts. The approximal surfaces can be incorporated as far as halfway; if the approximal areas are intact and not discolored, the approximal contact made of natural dental tissue can remain unchanged.

The veneers are retained on the dental enamel by micromechanical adhesive means. For the purposes of micromechanical retention, the enamel is conditioned at the cavity margin using the acid-etching technique, which enlarges the surface of this enamel area and renders it wettable (Fig 1-23). The inside of the veneer is also conditioned (porcelain veneers are etched with hydrofluoric acid) and prepared with adhesive silane as a bonding agent to the composite. Adhesive cementation can be done with self-curing dual cement or light-curing composite cement.

The acid-etching technique is used to condition the surface of the enamel for adhesive cementation of ceramic or composite inlay restorations. The enamel surfaces intended for adhesive bonding are cleaned and treated with orthophosphoric acid (H_3PO_4) or phosphoric acid gel so that the apatites of the enamel prism cores partially dissolve. After 30 to 60 seconds, the etchant and dissolved enamel constituents are rinsed off. This leaves surface roughness between 5 and 8 µm deep, creating an enlarged surface with pores for micromechanical retention of the cementing acrylic resin. The roughened cavity margins and the restoration etched on the underside are silanized and cemented in place with a composite bonding agent. During acid etching and insertion with the composite bonding agent, irritation of the pulp and prolonged hypersensitivity of the restored tooth can arise if dentin areas are touched. Therefore, the cavity margins for adhesively cemented inlay restorations must lie within the area of etchable enamel.

2

Coronal Restoration

Definition and Classification

Single-tooth rehabilitation is a significant area of dental technology work. When an individual tooth is so damaged by caries, fractures, or other harmful factors that other dentistry measures are no longer able to preserve the tooth, an artificial crown may be placed on the prepared tooth like a cap. With this type of prosthetic single-tooth restoration, the masticatory function and health of the existing teeth can be maintained and restored.

An artificial dental crown must take on the functions of a natural crown and must accurately reproduce the ideal functional form of the natural tooth shape. Accurate knowledge of tooth morphology is therefore an essential requirement for dental technicians when fabricating a coronal restoration. Every tooth has specific functional shape characteristics that must be addressed by coronal restoration. Artificial crowns have many important functions, as outlined below. Figure 2-1 provides an overview of the various types of artificial crowns.

The occlusal surfaces of artificial crowns adapted to the antagonists should do the following:

- Achieve full functional contact
- Stop jaw movement
- Allow transfer of forces to the periodontium during mandibular movements with tooth contact (Fig 2-2)
- Allow interference-free gliding without overloading the periodontium

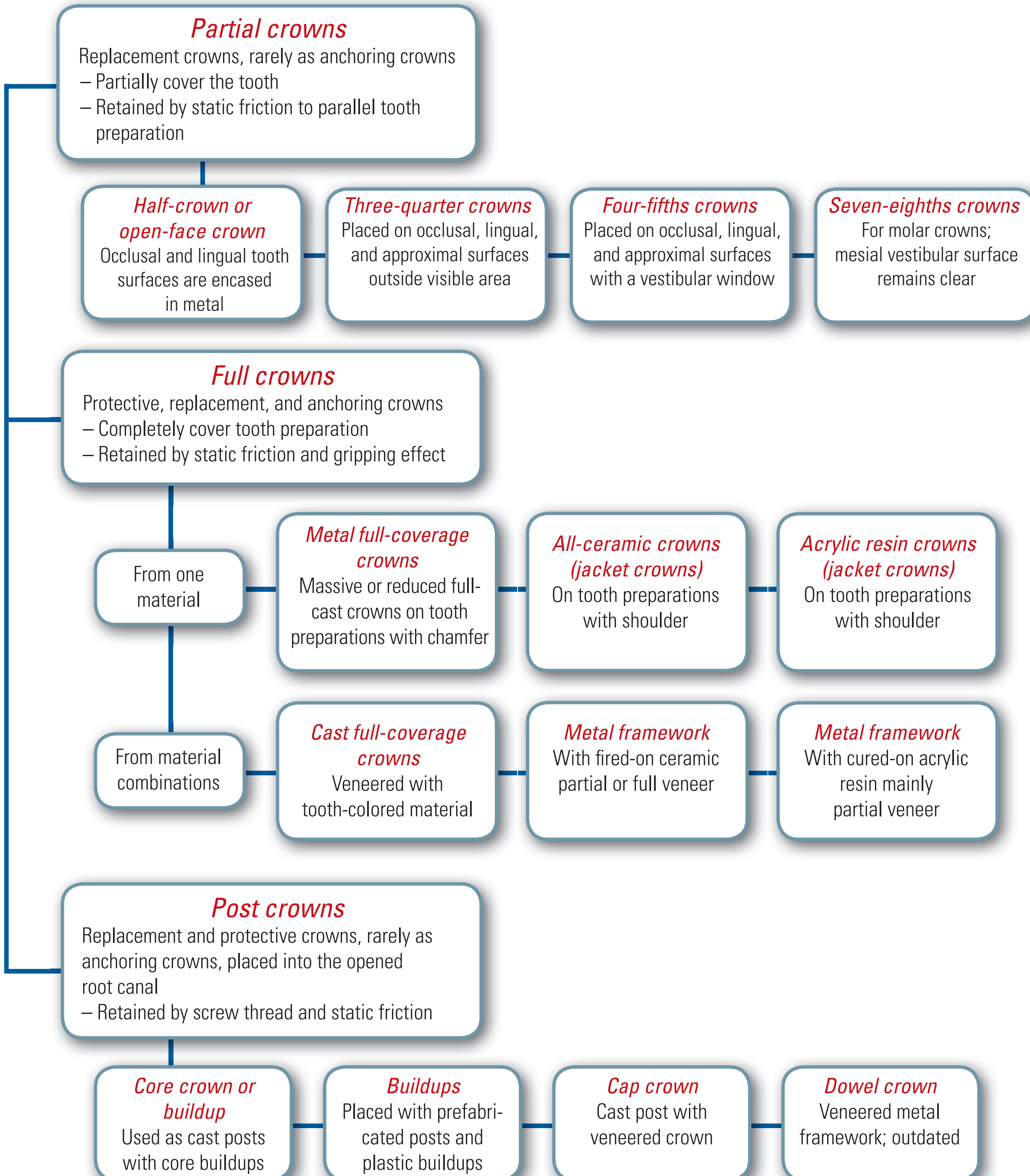


Fig 2-1 Diagram of crown types.

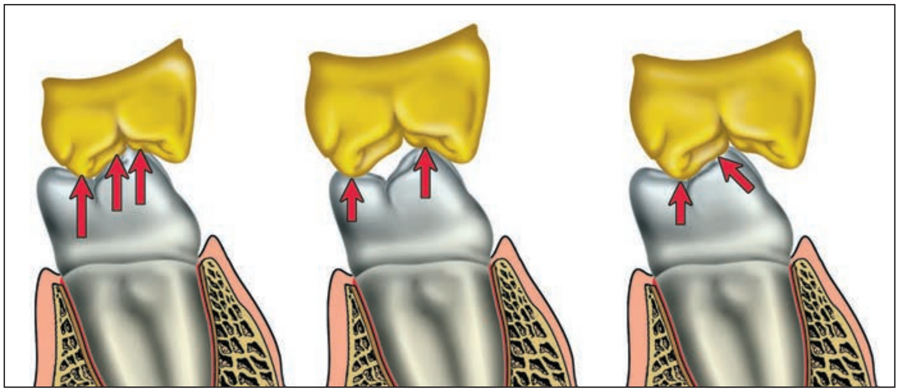


Fig 2-2 When fabricating an artificial occlusal relief, the functional surfaces must be adapted to the antagonists to ensure precise transfer of forces. Incorrect contouring of occlusal surfaces leads to faulty contacts and harmful transverse thrust. A lack of occlusal contacts can result in displacement of teeth.

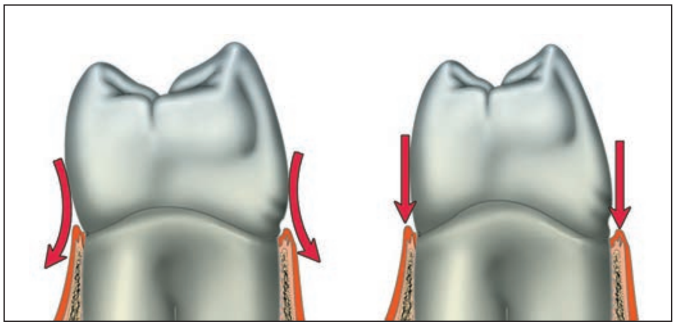


Fig 2-3 The anatomical surface bulges are functional shape characteristics that must be reproduced in artificial crowns. The so-called vertical curvature characteristics serve to protect the marginal periodontium; excessive curvatures produce undercuts that inhibit self-cleaning of the teeth. The horizontal curvatures of the vestibular surfaces also have to be reproduced to ensure that no niches are formed where contaminants may accumulate.

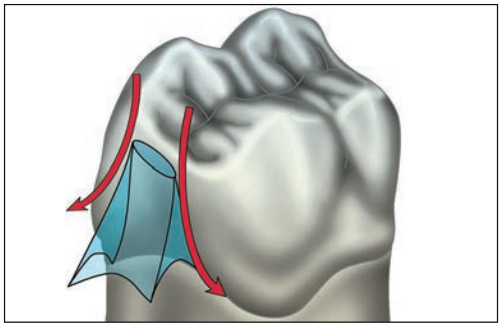


Fig 2-4 The approximal surfaces form the approximal contact point that covers and protects the interdental papilla. When this contact is reproduced in artificial crowns, space must be created for the interdental papilla.

The precise anatomical surface curvature of the artificial crown does the following:

- Protects the marginal periodontium (Fig 2-3)
- Creates approximal contacts
- Protects the interdental papilla (Figs 2-4 to 2-7)
- Guarantees support in the dental arch
- Aids self-cleaning of the masticatory system (Figs 2-8 and 2-9)
- Fulfills esthetic demands
- Supports phonetic functions

A precise and accurate fit enables the artificial crown to do the following:

- Form a unit with the prepared tooth
- Preserve the tactile sense (Fig 2-10)
- Prepare food for digestion

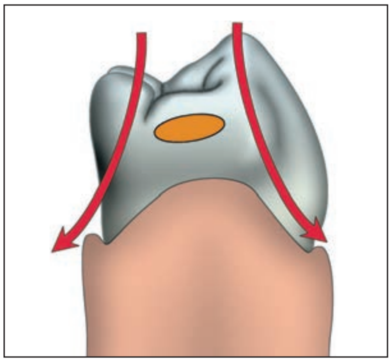


Fig 2-5 If the interdental papilla is well preserved, punctate shaping of the approximal contact is enough to maintain the protective function.

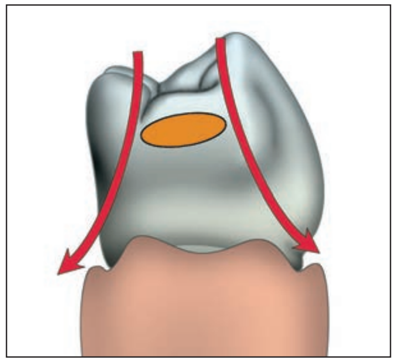


Fig 2-6 If the interdental papilla is reduced, the approximal contact must have a wider shape to secure the protective function.

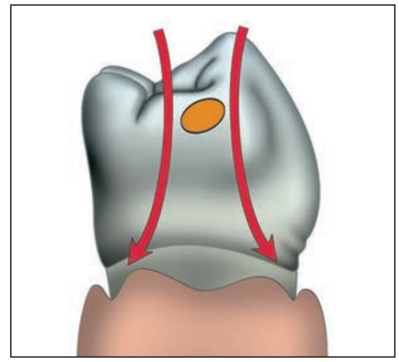


Fig 2-7 If the interdental papilla is reduced and shaping of the approximal contact is punctate, food is no longer deflected away from the interdental space.

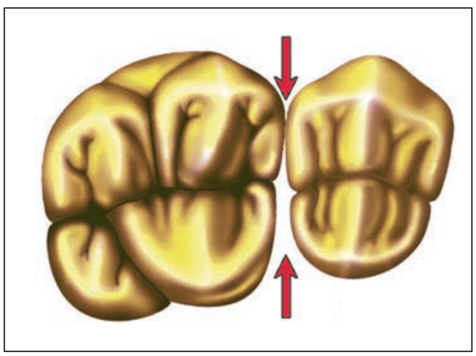


Fig 2-8 The approximal contact points viewed occlusally lie in the direction of the buccal cusps so that smaller niches are formed on the vestibular rather than the lingual side. The lingual areas of the teeth are easier to clean because of the action of the tongue.

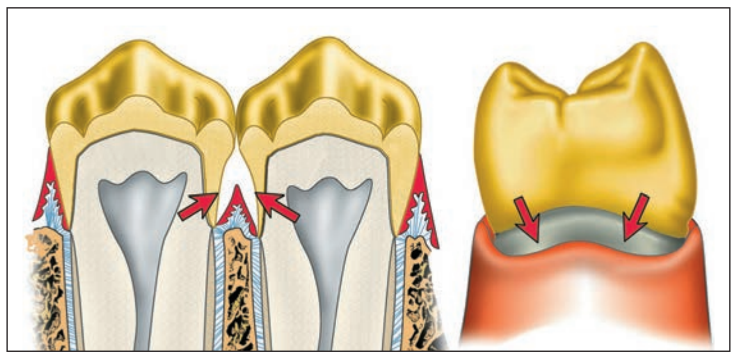


Fig 2-9 Contact points that overhang too much will create large interdental niches that are no longer filled with tissue. Deposits can accumulate because self-cleaning is prevented. This can result in chronic inflammation, and damage to the periodontal tissue cannot be ruled out.

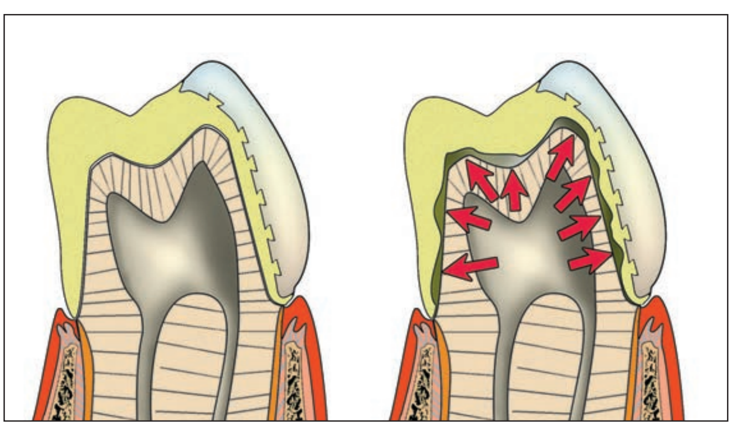


Fig 2-10 Accuracy of fit is not merely a requirement that sets the standard for technical expertise but also a functional necessity. Precise accuracy of fit allows the tooth to preserve a tactile sense and, as a mechanical unit, allows smooth transfer of forces. In the marginal area, accuracy of fit prevents damage to the marginal periodontium.

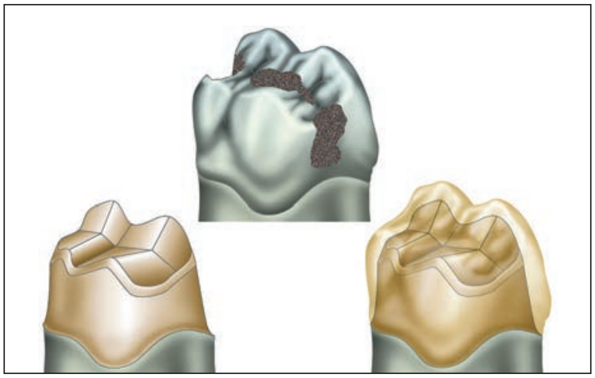


Fig 2-11 Artificial crowns replace lost hard tissue from teeth. If natural dental crowns are partly destroyed by caries and a tooth needs to be protected against further harmful influences, a protective crown should be fabricated that fully covers the natural dental crown.

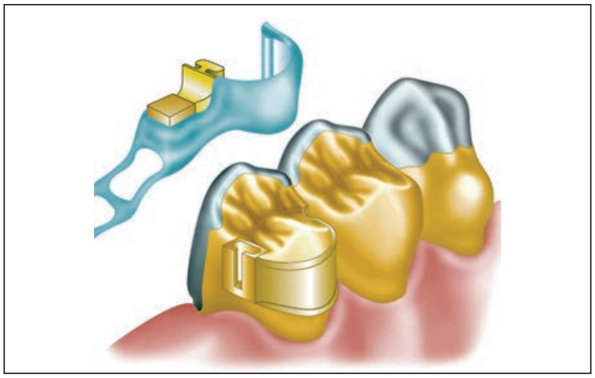


Fig 2-12 Artificial crowns can be used to bear retention parts. They are also used to protect teeth that will receive clamps. Generally speaking, anchoring crowns are associated with parallel fits, tapered designs, or prosthetic auxiliaries.

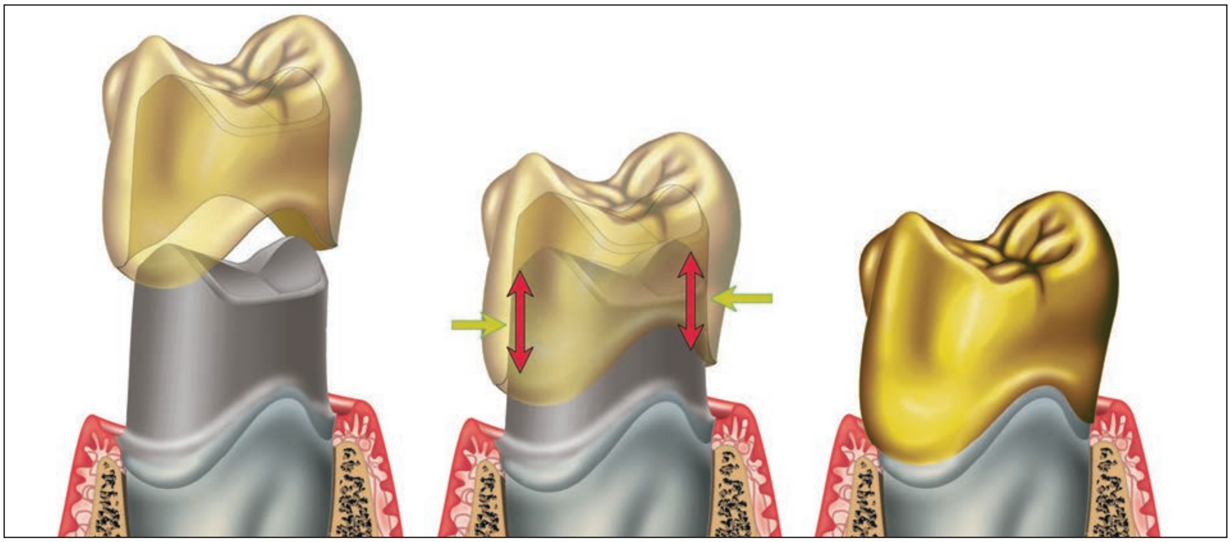


Fig 2-13 Retention of artificial crowns onto the tooth preparation can be achieved by two physical mechanisms: static friction and a gripping effect. Both are produced by the complete enclosure involved in a full crown and guarantee secure retention of the crown.

All of these functions are equally important and must be fulfilled within the broad range of applications for artificial crowns.

Classification of artificial crowns is based on their specific range of functions:

- *Replacement crowns* replace lost hard substance of the tooth, which can no longer be restored by other (conservative) dentistry measures.
- *Protective crowns* protect the tooth preparation against harmful influences (caries or defects caused by clamps) by completely covering the organic dental substance (Fig 2-11).
- *Supportive or anchoring crowns* support and anchor fixed partial dentures and partial prostheses as abutments or carriers for attachments or prosthetic auxiliaries (Fig 2-12); they are fixed to the prepared tooth.
- *Full crowns* cover the clinical tooth preparation completely, while fixation (retention) is achieved by static friction resistance and a gripping effect (Fig 2-13).

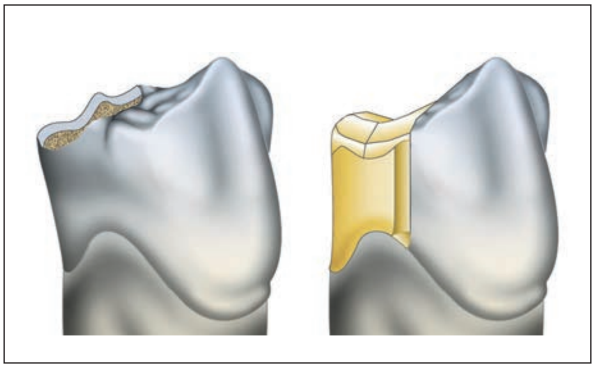


Fig 2-14 If a dental crown is destroyed by fractures only in isolated places, the missing hard substance can be replaced by a partial crown. These partial crowns do not cover the tooth completely but only individual surfaces of the dental crown.

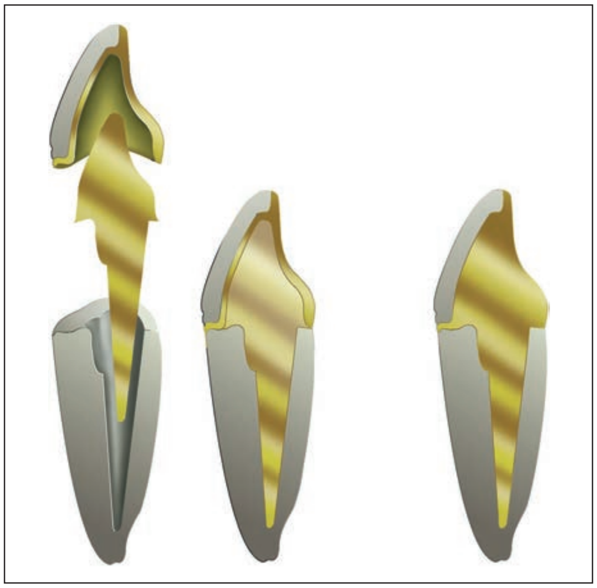


Fig 2-15 If the dental crown is completely destroyed, a post crown can be fabricated by inserting a post that will bear the replacement crown into the opened root canal. A long, accurately fitting post creates adequate static friction. The post with the core buildup and the replacement crown are fabricated separately.

- *Partial crowns* only partially cover the prepared tooth—usually lingually, occlusally, and approximally—in order to preserve the natural dental substance and color in the labial and buccal area (Fig 2-14). Retention is achieved by static friction resistance of parallel surfaces, grooves, and pins.
- *Post crowns* come in the form of dowel crowns and cast coping crowns or (root) buildups. These constructions involve inserting a post into the exposed pulp canal, which seals the root canal and bears a core buildup for the actual crown (Fig 2-15). The post is held in the root canal via a screw thread, static friction resistance, and a gripping effect.

Full and partial crowns are made from a variety of materials:

- Metal (full-coverage cast)
- Ceramic (fired, pressed, milled)
- Acrylic resin (polymerized)

Full and partial crowns (including post crowns) made from combinations of materials are veneered metal frameworks with fired-on ceramic or cured-on acrylic resin.

Indications for Coronal Restoration

Coronal restoration is indicated whenever the biomechanical and hence supportive function within the dental arch has to be secured. Similarly, coronal restoration is performed as a therapeutic function to stop any deterioration of the dentition that has already begun. A coronal restoration should also fulfill prophylactic functions, stop secondary damage, and prevent disease-related changes, thus taking on a protective function. Coronal restoration can improve or restore the function of the masticatory system and therefore has a regulating function (see Fig 1-10).

Substance loss from a tooth due to caries or fractures makes coronal restoration necessary. The remaining tooth preparation must be stable and offer adequate retention, while the periodontium must not be damaged. In this situation, the artificial crown mainly performs a protective function against advancing organic decline and replaces lost tissue. Abrasion of the incisal edges and the occlusal relief requires coronal restoration if the entire occlusal field needs to be corrected. Here the artificial crown takes on a replacement and supporting function if missing supports from centric occlusion need to be built up again.

Completing an interrupted dental arch with a fixed or removable partial replacement can be done by coronal restoration. The artificial crown may be a fixed partial denture abutment, a telescopic anchoring crown, a protective crown for clamps, or an anchoring crown for attachments. In this process, the artificial crown takes on a protective or supporting function in combination with several teeth.

Coronal restoration is also carried out when there are esthetic concerns (eg, morphologic defects, discoloration, or positional anomalies) if orthodontic measures are ruled out. In this situation, the artificial crowns take on regulating tasks because they fulfill replacement, protective, and supportive functions. Faulty tooth shapes are always associated with functional deficiencies, while discolorations may be an indication of destroyed pulp. Positional corrections help to preserve the periodontium, support the self-cleaning function, and restore the function of the closed dental arch.

A risk-benefit assessment should be undertaken for every dental procedure. If an artificial crown is being fabricated, a sufficient quantity of natural dental tissue has to be removed, which means pulp damage may have already occurred when the tooth was being prepared. Thus, coronal restoration is contraindicated, for instance, for adolescent teeth with a large pulp cavity and wide dentinal tubules as well as incomplete root growth. Coronal restoration is also contraindicated if the tooth has characteristics of disease such as pathologic apical processes, incomplete endodontic treatment, or inflammatory changes to the marginal periodontium. These problems must first be treated and cured.

Tooth mobility, gingival and bony pockets, and resorption of a socket beyond the apical third of the root are also regarded as contraindications, as is excessive loss of substance from the tooth preparation, because there is no longer sufficient mechanical retention to hold the crown in place.

For esthetic reasons, fabrication of a full-metal crown may be contraindicated in the anterior region. Certain types of crown may thus be contraindicated, although this is subject to the dentist's own judgment and is not necessarily discernible on a working model. Determining when a coronal restoration is indicated remains a matter of the dentist's expert diagnosis, but dental technicians should be aware of the general criteria for using coronal restorations.

Poor oral hygiene is always a contraindication for coronal restoration because deposits (plaque) lead to caries and periodontal disease. Before coronal restoration is considered, the patient must first be motivated to take adequate oral hygiene measures after receiving suitable dental education and instruction.

Fabrication of a crown is the result of collaborative teamwork between the dentist and the dental technician. The tooth is first prepared, and an impression is taken so that the technician can prepare a working model; adjust it in an articulator; and carve, cast, and finish the artificial crown. The dentist cements the finished crown in place on the tooth preparation.

Preparation of a Tooth

If a tooth is to be fitted with a crown, it must be prepared; that is, enough dental tissue must be removed to enable the artificial crown to be pushed over the tooth. Pushing a thin metal sleeve over an unprepared tooth would enlarge the natural tooth by the thickness of the metal plate. It would then interfere with the opposing dental arch, protrude out of the arch, and, if the sleeve could actually be pushed over the approximal contact points, cause faulty relationships. Furthermore, the sleeve would not fit closely in undercut areas. This is why a tooth needs to be prepared before receiving a crown.

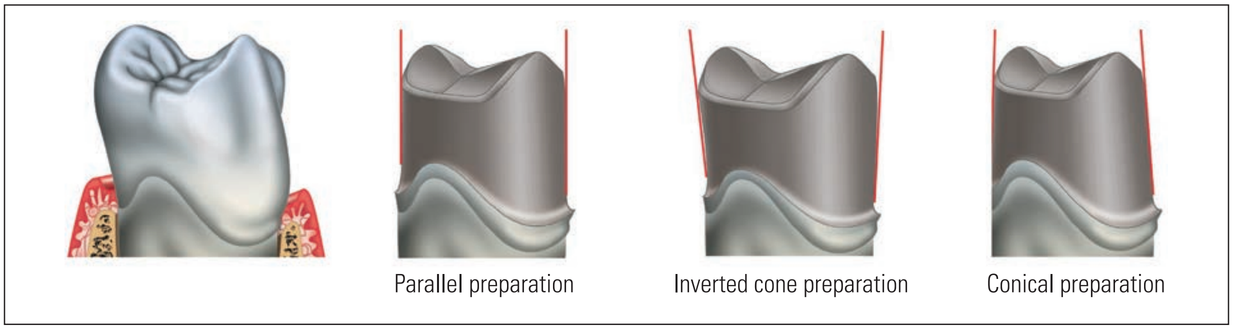


Fig 2-16 Preparation of a cylindric stump is at the limit of what is technically feasible because precise parallelism cannot be seen with the naked eye. The preparation shapes illustrated here are achieved by chance.

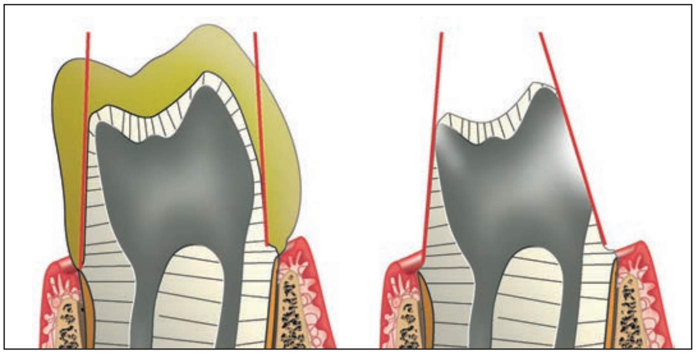


Fig 2-17 A preparation with parallel walls requires less loss of hard substance than a tapered preparation, and the risk to the pulp is also lower.

The aim of preparation is to remove the damaged dental substance and, if necessary, remove enough healthy dental tissue to ensure that the widest circumference of the tooth lies at the lowest point on the tooth preparation. An attempt is made to smooth the area around the tooth without creating any undercuts.

One approach to preparation is to create a cylindric preparation that would have almost parallel walls and would result in the least amount of hard tissue loss (Figs 2-16 and 2-17). As exact parallelism is impossible to see with the naked eye, this kind of fabrication would be at the limit of what is technically feasible. Furthermore, errors would arise when taking an impression and cementing the crown in place because of the piston effect of a parallel fit.

A better preparation design is a slightly conical (ie, tapered) preparation with a preparation angle between 3 and 8 degrees toward the occlusal surface. This design allows interference-free, accurate impression-taking and guarantees adequate retention due to static friction and a gripping effect (Figs 2-18 to 2-21). When the restoration is being cemented in place, the cement is able to flow away more easily until tactile contact of all surfaces is achieved, leaving a minimum thickness of cement equivalent to its grain size, which increases the friction and gripping resistance.

A basic tooth preparation has the following characteristics:

- At its widest circumference, it meets the preparation margin.
- There is sufficient height for mechanical retention.
- The shape is slightly conical and has an angle of 3 to 8 degrees.
- The preparation surfaces are not undercut.
- An interocclusal rest space is prepared.

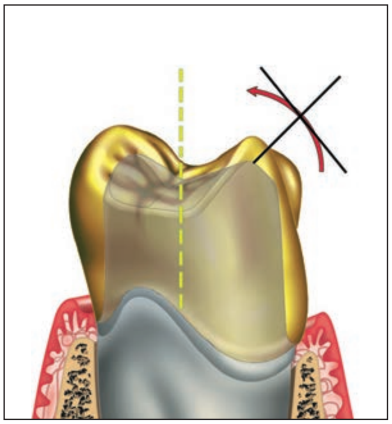


Fig 2-18 A tall tapered preparation with a preparation angle up to 6 degrees offers the best retention for a coronal restoration. The crown cannot tip off the preparation even with eccentric loading.

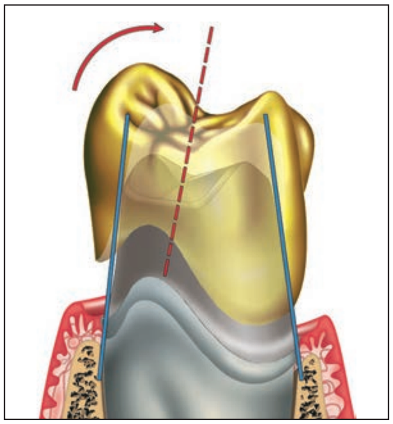


Fig 2-19 A very steeply tapered preparation with a preparation angle greater than 6 degrees offers less retention for the coronal restoration. The crown can tip off the preparation if exposed to eccentric loading.

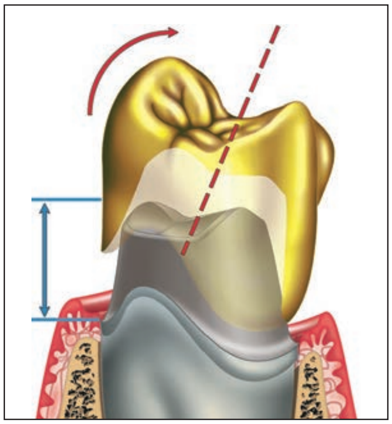


Fig 2-20 A very tapered and very short preparation offers the least retention for a coronal restoration. Even slight eccentric loading will tip the crown off the preparation.

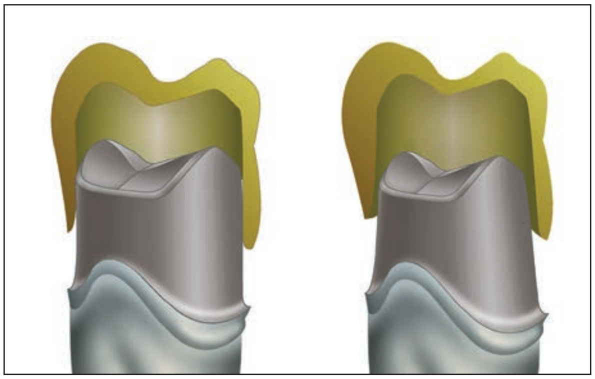


Fig 2-21 A cylindric preparation with parallel walls will result in a so-called piston effect during impression-taking and crown placement, making these processes extremely difficult if not impossible. An impression can easily be taken of a tapered preparation, and the crown can be placed and cemented in place with equal ease, without causing any buildup of cement.

Shaping the Preparation Margin

The preparation margin is the border between the prepared and unprepared tooth surface (Figs 2-22 to 2-24). It is the responsibility of the dentist to make a clear preparation margin, and it is the responsibility of the dental technician to ensure that the crown margin ends exactly at the preparation margin. Thus, the technician is less focused on how far a tooth is prepared at the neck or how deep or high the preparation margin is in relation to the marginal periodontium. However, if the crown margin lies above the preparation margin, caries will ensue. If it lies below the preparation margin (ie, in the gingiva) damage to the gingival margin will occur.

For the purposes of accurate and safe fabrication, a supragingival preparation margin is chosen, which is markedly above the gingival crevice. This means that the crown margin is kept clear of the periodontium and cannot damage the

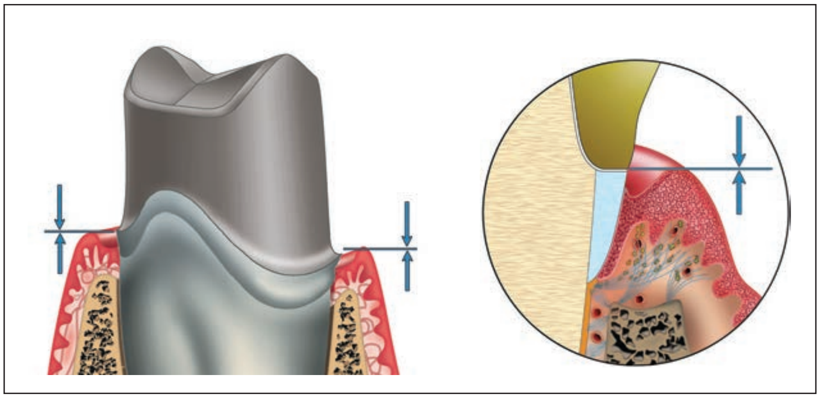


Fig 2-22 A gingival preparation margin runs level with the gingival margin but not deep in the gingival crevice. As a result, the marginal periodontium is untouched and undamaged. The eventual crown margin can be clearly seen and is usually esthetically satisfactory.

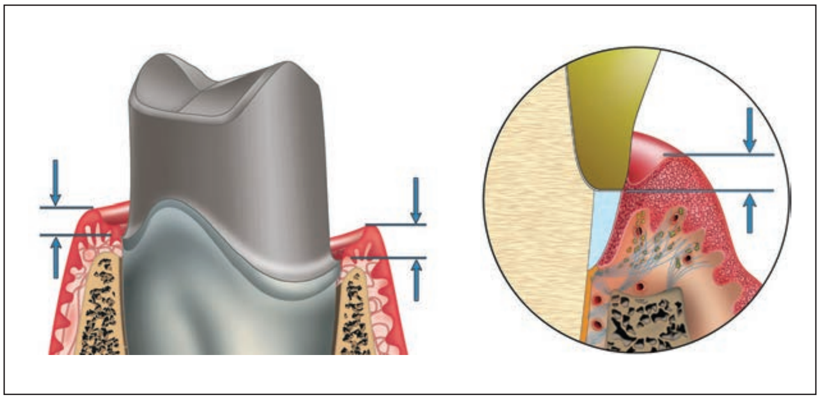


Fig 2-23 A subgingival preparation margin runs deep in the gingival crevice and affords very good caries prevention provided the position of the crown margin fits accurately. Because it is difficult to check the crown margin, however, irritation of the marginal periodontium and even gingival retraction may occur.

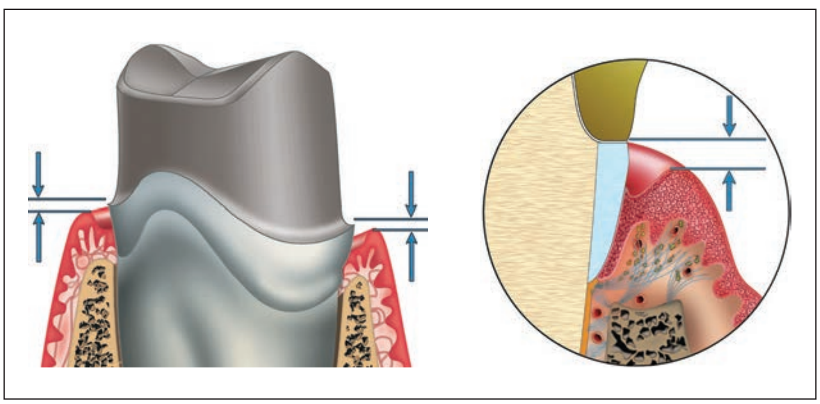


Fig 2-24 A supragingival preparation margin lies well above the gingival margin. This course is very beneficial for periodontal hygiene but unsatisfactory esthetically, and it provides no protection against caries in the presence of plaque.

periodontal tissue, the critical area can be kept clean, and it is easier to take an impression of the preparation margin.

However, supragingival preparation has serious drawbacks: If the margin is placed too high, the tooth preparation becomes too short and does not offer enough mechanical retention for the crown. If the finish line is in the visible region, the esthetics will be unsatisfactory. For cervical defects, the preparation must follow an infragingival course, just as infragingival finish lines offer better caries protection in dentitions with active caries.

During crown fabrication, special attention must always be paid to the crown margin, which is defined by the preparation margin. The quality

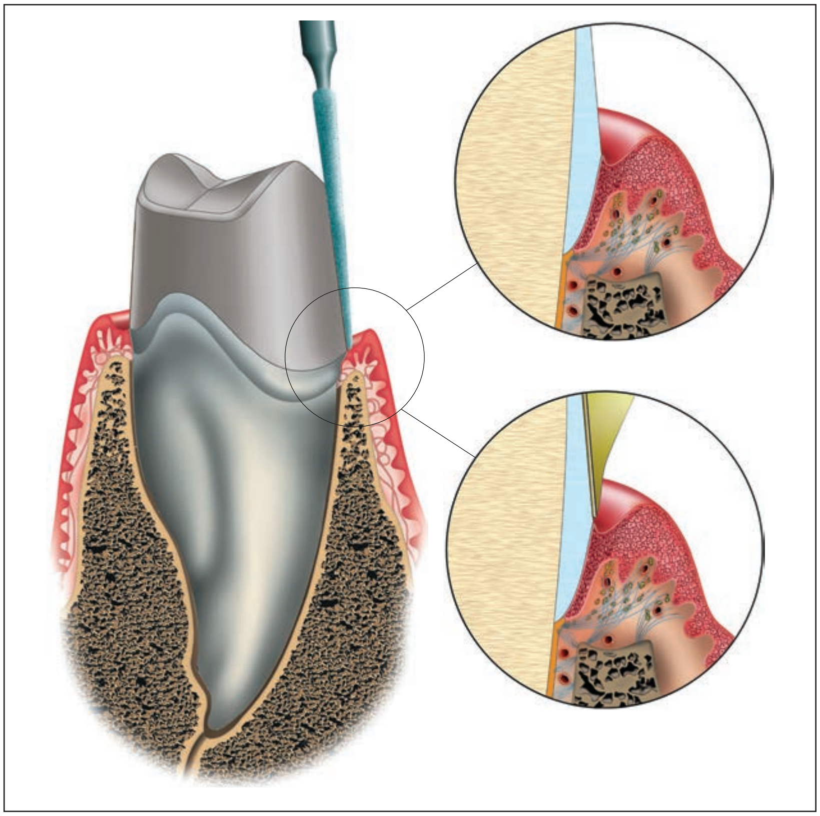


Fig 2-25 In tangential preparation, the widest circumference of the conical preparation and the preparation margin coincide. The coronal restorative material overlaps the tooth and can displace the marginal periodontium in some circumstances. If the crown margin is shaped like a tapered margin, it runs razor-sharp into the depth of the gingival crevice. This tapered margin is rarely stable enough not to deform when the crown is fitted.

of the transition from tooth to coronal restorative material is determined by how accurately the crown margin fits the preparation margin. The accuracy that is achievable depends on the shaping of the finish line. At the preparation margin, the crown material should not overlap the tooth preparation but should be sunk into the tooth.

Three forms of preparation margin are used: *(1)* tangential preparation, *(2)* chamfer preparation, and *(3)* shoulder preparation.

Forms of Preparation Margin

A tangential preparation is ground like a tapered margin (Fig 2-25). Tangents can be placed in a vertical direction all over the basic conical shape of the tooth preparation. Ideally, the preparation margin should describe the root cross section and the crown margin finish line. The preparation margin finish line should lie at the bottom of the gingival crevice; subgingival preparation is only done for protective crowns in dentitions with active caries.

Given this preparation finish line, the crown margin must taper off sharply and evenly while fitting closely; the crown must then be given a convex shape above the gingival crevice. The crown itself must have an occlusal support so it is not pushed beyond the preparation margin.

The coronal restorative material overlaps the tooth preparation. However, as it has to taper thinly, it may become frayed and bend upward. The artificial crowns have to be overcontoured at the preparation margin, thereby forming a step that encourages plaque accumulation.

The tangential finish line is easy to prepare and requires the least loss of dental substance. This preparation finish line is barely visible in the mouth and not at all visible on the working model. A precise crown margin cannot be created and

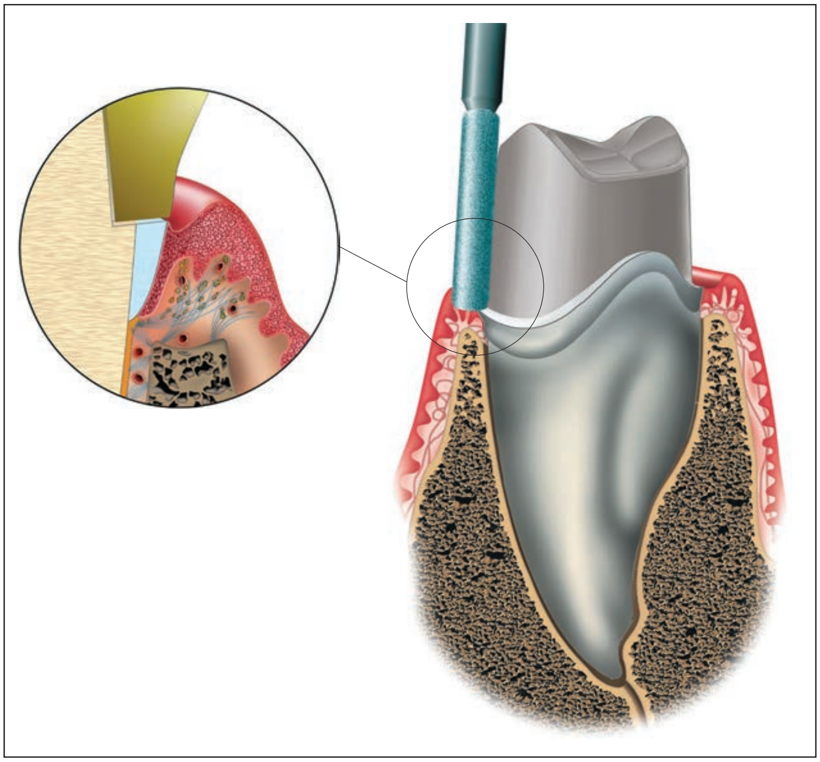


Fig 2-26 To sink the coronal restorative material into the tooth preparation, a shoulder is created for the preparation margin. The coronal restorative material ends flush with the tooth, usually in the depth of the gingival crevice. The crown margin does not occupy any more space than the natural dental substance. To ensure stability, the shoulder slopes slightly inward toward the tooth. If the crown is pressed onto the tooth by masticatory pressure, the crown material will slip inward like an inclined plane and will be pressed against the tooth.

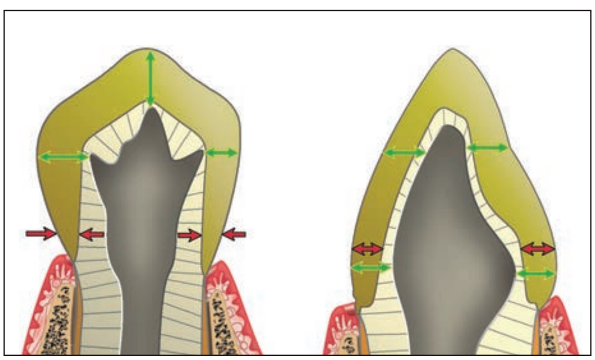


Fig 2-27 The thickness of dental hard tissue over the pulp of a canine. The dental tissue is considerably reduced by shoulder preparation, which can damage the pulp. In general, this means the tooth is mechanically weakened.

only happens by chance. This approach is used for young teeth with a large pulp chamber so that acrylic resin crowns can be made as temporary replacements.

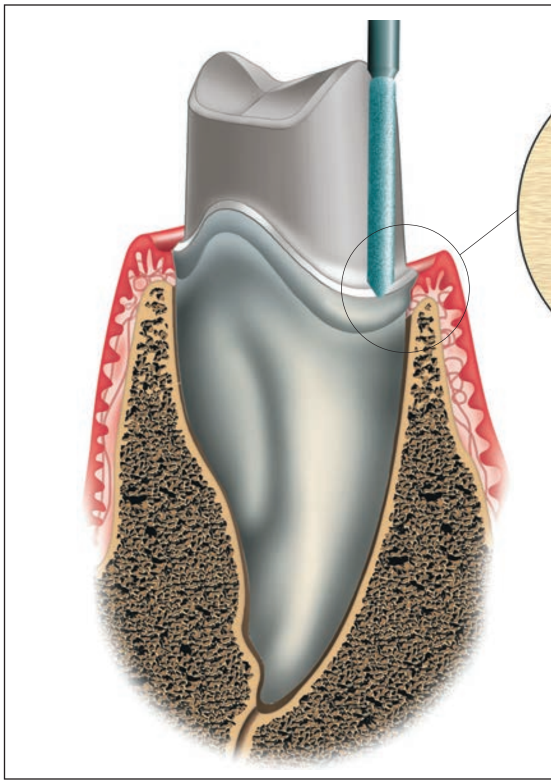
Owing to the lack of available space, this form of preparation is not suitable for metal-ceramic restorations, all-ceramic restorations, or for full-cast crowns. The tangential form of preparation cannot offer static support against occlusal forces.

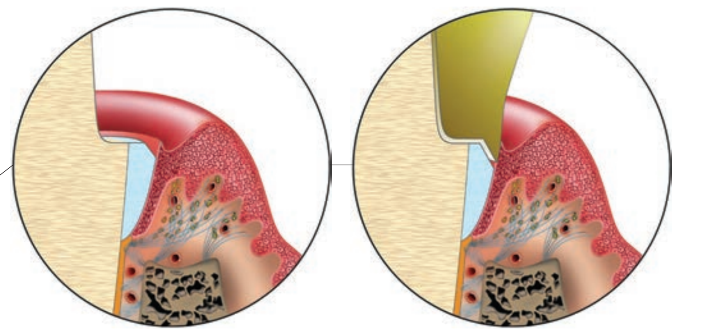
Shoulder preparation forms a circular step around the conical tooth preparation. This offers static support to the coronal restorative material, which is particularly valuable for ceramic or acrylic resin crowns. The material for the artificial crown is sunk into the dental tissue and forms a flush transition between tooth and coronal restoration (Fig 2-26).

The preparation margin can be clearly seen on the model and thus allows for precise working. A shoulder preparation is easy to produce because the preparation tools have a cervical guide.

In the case of shoulder preparation, the tooth preparation becomes much smaller than the root cross section, and there is considerable loss of substance from the tooth. The stability of the tooth preparation may be reduced, putting the pulp at risk (Fig 2-27). To prevent a buildup of cement on insertion, the start of the shoulder is chamfered to the tooth preparation.

The edge of the shoulder can be beveled slightly to the gingival crevice to optimize the marginal





Figs 2-28 Modern shoulder preparation involves shaping the transition to the preparation wall as a chamfer to avoid any buildup of cement on insertion of the crown, which can happen with a sharp-edged preparation. The shoulder margin is also beveled to reduce the marginal gap.

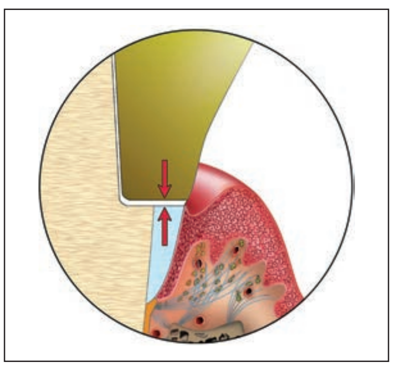


Fig 2-29 If a shoulder preparation is straight, a vertical marginal gap defect will occur because the crown cannot be lowered as far as the shoulder due to the thickness of the cement. The cement will also be washed out by normal teeth-cleaning in a horizontal shoulder arrangement.

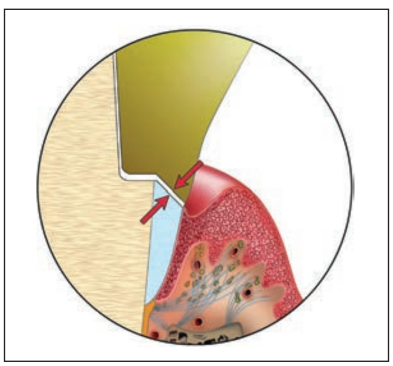


Fig 2-30 With a 45-degree bevel to the shoulder, the vertical marginal gap defect is markedly reduced, and the cement cannot be washed out as easily. This bevel is sufficiently identifiable in the mouth and is visible enough on the model so that the preparation margin can be readily exposed.

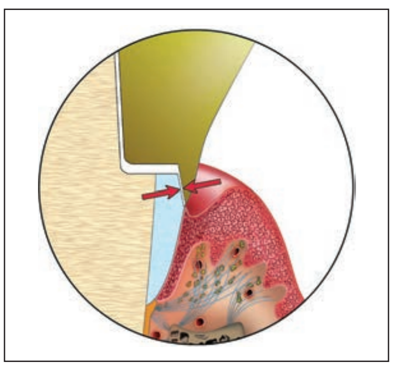


Fig 2-31 The vertical marginal gap defect is the smallest with a very steep bevel (more than 45 degrees). The exact path of the preparation margin of the bevel is very difficult to identify, similar to tangential preparation.

fit, reduce the interface between tooth preparation and crown, and move it out of the visible area (Figs 2-28 to 2-31). Preparation of the bevel is difficult and can blur the exact borderline on the model.

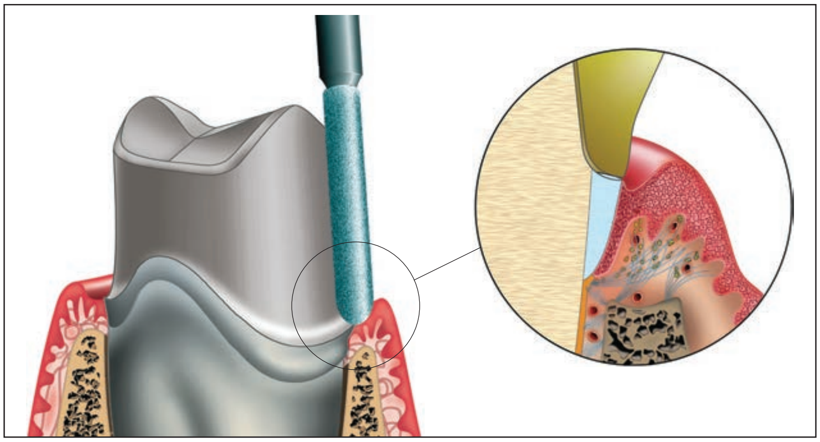


Fig 2-32 Chamfer preparation is a proven compromise between tangential and shoulder preparation. This form of preparation margin is used for full-cast crowns and veneer crowns, although the area to be veneered is prepared in a shoulder design. Chamfer preparation does not require as much substance loss as the shoulder form and produces a similarly precise marginal course that is clearly visible on the model and allows precise working.

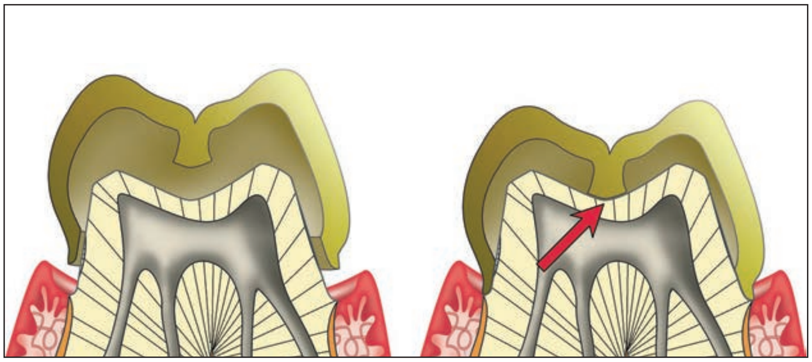


Fig 2-33 Chamfer preparation does not provide good static support to the crown over the crown margin and cannot prevent a reduced crown from sinking, so an occlusal stop is added for a reduced full-cast crown. This crown will not sag occlusally on loading.

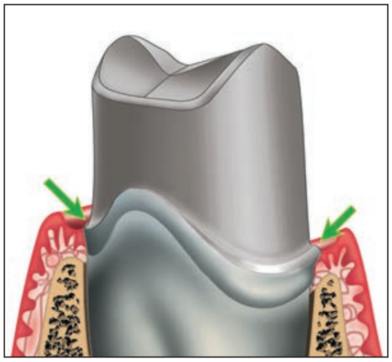
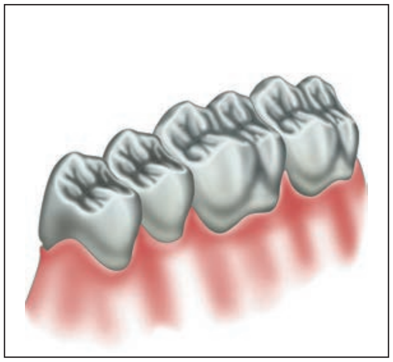


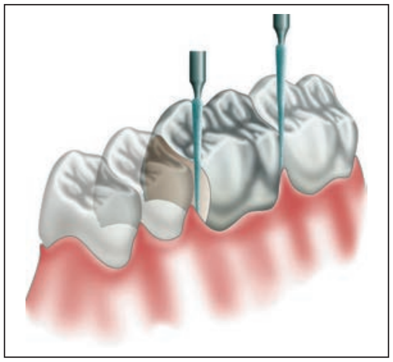
Fig 2-34 For veneer crowns, the tooth structure in the area of the veneer surfaces should be prepared with a shoulder that turns into a chamfer approximally and incorporates the lingual surfaces. As a result, less tooth substance is removed lingually, and the tooth preparation is more stable. This mixed form of chamfer and shoulder preparation is the usual approach for anterior and posterior teeth.

Shoulder preparation is generally necessary when jacket crowns are being fabricated from acrylic resin or ceramic. These materials need a specific minimum thickness at the crown margin for reasons of stability and color quality. Shoulder preparation is also appropriate for veneer crowns. The crown margin always ends flush with the shoulder, does not protrude horizontally, and does not sit too narrowly on the shoulder. Under no circumstances should the crown margin extend beyond the shoulder.

Chamfer preparation or veneer preparation happens when the conical tooth preparation is worked with suitably shaped abrasive tools so that a gentle circular chamfer is created (Figs 2-32 and 2-33). As a result, the coronal restorative material is moved into the tooth and ends flush. More dental substance is removed than with tangential preparation; consequently, the preparation finish line is clearly visible in the mouth and on the working model.

The chamfer offers adequate material thickness for metal frameworks, but there is not enough space for full crowns made of acrylic resin or ceramic. This preparation is suitable not only for veneer crowns—when a pronounced shoulder must be dispensed with because of the greater loss of substance—but also for full-cast crowns.





Figs 2-35 and 2-36 Preparation is done under water cooling, and the buccal and lingual vertical surfaces are prepared first.

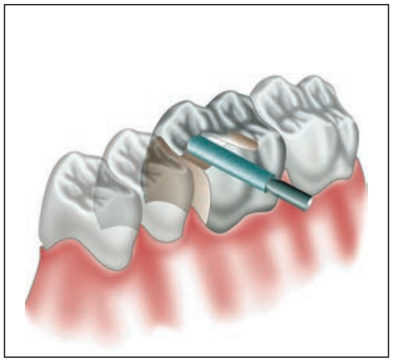


Fig 2-37 Separation: The approximal surfaces are prepared to obtain a gently conical tooth preparation. The adjacent teeth must not be damaged in the process.

The mixed form of chamfer and shoulder preparation results from a shoulder preparation that follows a vestibular course and turns into a chamfer approximally, which is then continued lingually (Fig 2-34). This method results in less loss of substance from the tooth preparation than with shoulder preparation alone. Mixed preparation is mainly used for veneer crowns to sink the material into the tooth in the visible vestibular region.

Phases of Tooth Preparation

Tooth preparation is not part of the work of a dental technician. The following description is for informational purposes only; it gives an overview of what a dentist does and should enhance understanding of the collaborative relationship between dentist and dental technician.

The tooth is prepared under water cooling with specially designed rotary instruments, usually diamond-tipped burs of varying grit size. Standardized preparation kits contain cylindric preparation tools with working parts approximately 4 to 8 mm long and special shapes such as pointed conical, needle-shaped separator, rounded bud-shaped, and ball-shaped burs. The instrument shafts are designed for micromotor-driven contra-angle handpieces or for ball-bearing or air-bearing turbines.

Preparation is done in the high-speed range (160,000 to 450,000 rpm), at which only minimal working pressure is required, no vibrations occur, and the treatment time can be very short. High-speed instruments require water-spray cooling. Use of a rotary instrument without water cooling would result in pulp damage due to friction heat. Even briefly exceeding a temperature of 51.6°C causes protein coagulation. Following is a brief outline of the phases of tooth preparation.

1. Preparation of the approximal surfaces

A needle diamond (separator) is used to separate the approximal surfaces. The purpose of this phase is to separate or clear a space around the tooth being prepared in the dental arch so that the adjacent teeth are not accidentally damaged during subsequent preparation (Figs 2-35 to 2-37).

2. Marking of depth

In order for the dentist to know how much dental substance to remove in subsequent phases of preparation without injuring the pulp, depth is marked with a groove-cutting or step bur. These instruments have a depth marking or a depth stop. They are used to create one or more 1-mm-deep grooves over the entire occlusal surface and onto the vestibular and lingual surfaces as far as the height of contour.

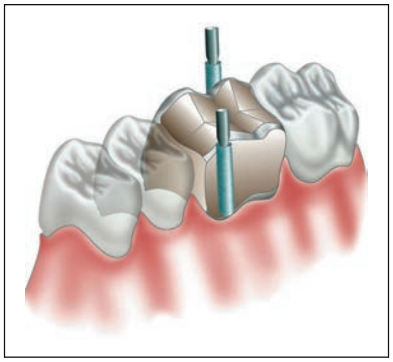


Fig 2-38 Occlusal preparation: The transitions between the occlusal and vertical surfaces are ground, creating an occlusal bevel.

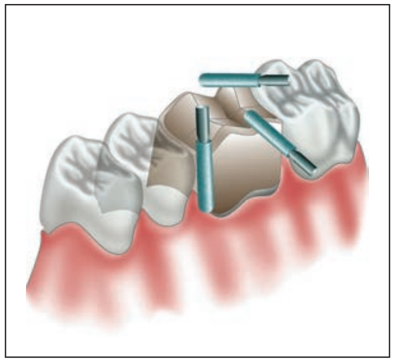


Fig 2-39 The occlusal surface is ground down. Adequate interocclusal rest space should be created and the angle of cuspal inclination maintained.

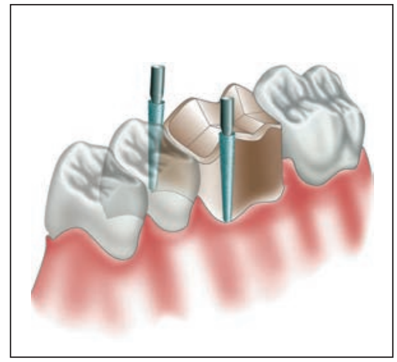


Fig 2-40 Lowering and precise regrinding of the path of the preparation margin is done with a suitable abrasive tool, in this case a tapered torpedo.

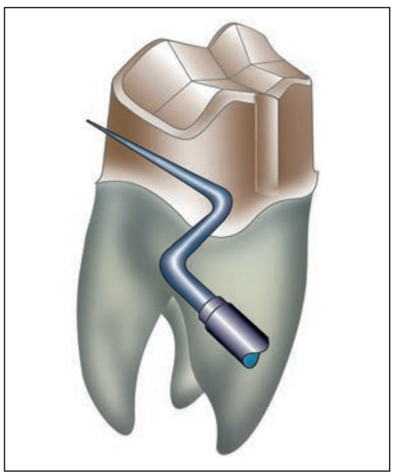
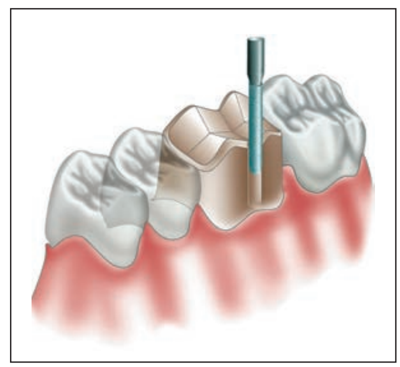


Fig 2-41 *(left)* The preparation target is checked with a probe. There must be no undercuts on the vertical surfaces. A conical preparation with a maximum preparation angle of 6 degrees is created.

Fig 2-42 *(right)* Insertion groove parallel to the path of insertion for clear-cut fixation of the crown on eventual insertion.



3. Preparation of the occlusal surface

The occlusal surface is removed as far as the depth marking without injuring the adjacent teeth (Figs 2-38 and 2-39). Depending on the design and the material used for the artificial crown, adequate interocclusal rest space should be created. The occlusal relief should retain its basic morphology (eg, cusp size, fissure configuration). The dental arches are checked in working and balancing positions to ensure that the preparation is adequate.

4. Preparation of buccal and oral surfaces

A cylindric bur that is angled or rounded at the tip is used for gentle conical reduction of the buccal and oral surfaces to just above the gingival crevice. This vertical circulatory preparation follows the curved path of the gingival attachment.

5. Preparation of the cusp bevel

The cusp bevel at the transitional surfaces to the vertical surfaces is prepared with special tapered