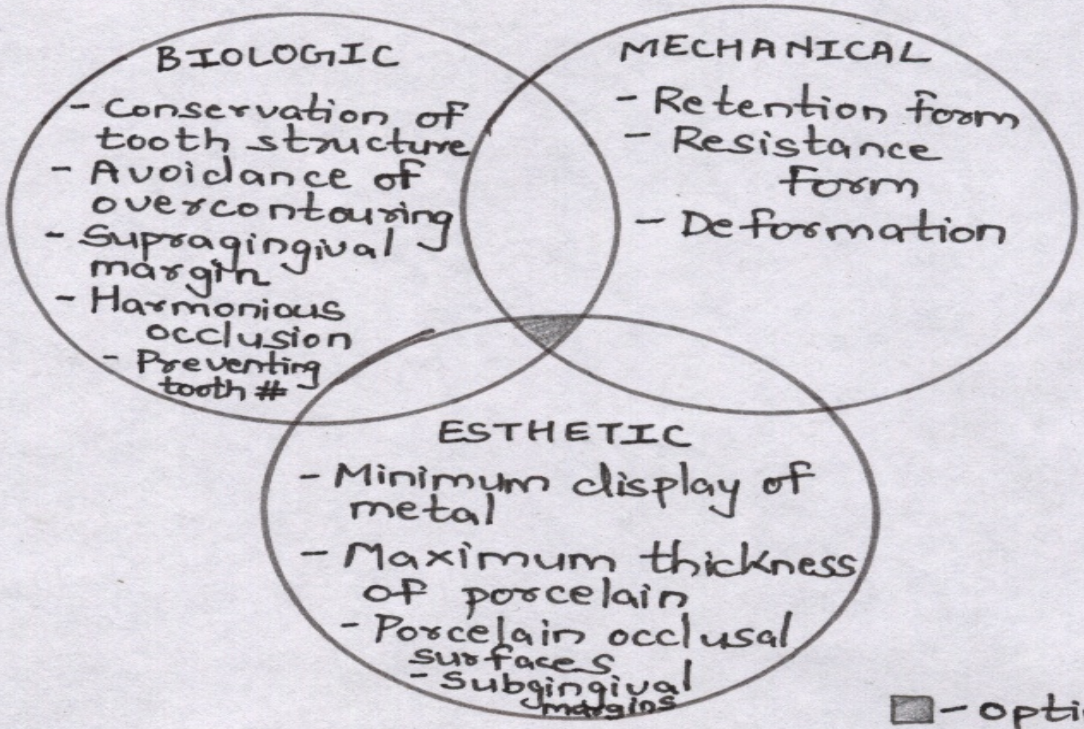
PRINCIPLES OF TOOTH PREPARATION

PREPARED BY : Dr. HEMAL AGRAWAL (M.D.S.)
Associate Professor
DEPT. OF PROSTHODONTIA
G.D.C.H
AHMEDABAD

- Teeth do not possess the regenerative ability found in most other tissues. Therefore, once enamel or dentin is lost as a result of caries, trauma, or wear, restorative materials must be used to reestablish form and function.
- Teeth require preparation to receive restorations, and these preparations must be based on fundamental principles from which basic criteria can be developed to help predict the success of prosthodontic treatment.

- The principles of tooth preparation may be divided into three broad categories :

1. **Biologic considerations**, which affect the health of the oral tissues.
2. **Mechanical considerations**, which affect the integrity and durability of the restoration.
3. **Esthetic considerations**, which affect the appearance of the patient.



THE OPTIMUM RESTORATION SHOULD SATISFY, BIOLOGIC, MECHANICAL, AND ESTHETIC CONSIDERATIONS

BIOLOGIC CONSIDERATIONS

- Surgical procedures involving living tissues must be carefully executed to avoid unnecessary damage. The adjacent teeth, soft tissues, and the pulp of the tooth being prepared are easily damaged in tooth preparation.
- **PREVENTION OF DAMAGE DURING TOOTH PREPARATION**
- **Adjacent Teeth** : Iatrogenic damage to an adjacent tooth is a common error in dentistry. Even if a damaged proximal contact area is carefully reshaped and polished, it will be more susceptible to dental caries than the original undamaged tooth surface.

- This is presumably because the original surface enamel contains higher fluoride concentrations and the interrupted layer is more prone to plaque retention. The technique of tooth preparation must avoid and prevent damage to the adjacent tooth surfaces.
- A metal matrix band around the adjacent tooth for protection may be helpful, however the thin band can still be perforated and the underlying enamel damaged.
- The preferred method is to use the proximal enamel of the tooth being prepared for protection of the adjacent structures. Teeth are 1.5 to 2 mm wider at the contact area than at the cementoenamel junction, and a thin, tapered diamond can be passed through the interproximal contact area to leave a slight lip or fin of enamel without causing excessive tooth reduction or undesirable angulation of the rotary instrument.

- **Soft tissue** : Damage to the soft tissued of the tongue and cheeks can be prevented by careful retraction with an aspirator tip, mouth mirror.
- **Pulp** : Great care also is needed to prevent pulpal injuries during fixed prosthodontic procedures, especially complete crown preparation. Extreme temperatures, chemical irritaiton, or microorganisms can cause an irreversible pulpitis, particularly when they occur on freshly sectioned dentinal tubules. Tooth preparations must take into consideration the morphology of the dental pulp chamber. Pulp size, which can be evaluated on a radiograph, decreases with age.

Causes of Injury

- **Temperature :** Considerable heat is generated by friction between a rotary instrument and surface being prepared. Excessive pressure, higher rotational speeds, and the type, shape, and condition of the cutting instrument, may all increase generated heat. With a high-speed handpiece, a feather-light touch allows efficient removal of tooth material with minimal heat generation. Nevertheless, even with the lightest touch, the tooth will be overheated unless a water spray is used. This must be accurately directed at the area of contact between tooth and bur. It will also remove debris and prevent desiccation of the dentin.

- **Chemical Action** : The chemical action of certain dental materials (bases, restorative resins, solvents, and luting agents) can cause pulpal damage particularly when they are applied to freshly cut dentin. Cavity varnsih or dentin bonding agents will form an effective barrier in most instances, but their effect on the retention of a cemented restoration is controversial.
- **Bacterial Action** : Pulpal damage under restorations has been attributed to bacteria that either were left behind or gained access to the dentin because of microleakage. All carious dentin should be removed before placing a restoration that will serve as a foundation for a fixed prosthesis.

- **CONSERVATION OF TOOTH STRUCTURE**
- One of the basic tenets of restorative dentistry is to conserve as much tooth structure as possible consistent with the mechanical and esthetic principles of tooth preparation. This will reduce the harmful pulpal effects of the various procedures and materials used.
- The thickness of remaining dentin has been shown to be inversely proportional to the pulpal response, and tooth preparations extending deeply toward the pulp should be avoided.

- Tooth structure is conserved by using the following guidelines :

1. Use of partial-coverage rather than complete coverage restorations.
2. Preparation of teeth with the minimum convergence angle (taper) between axial walls.
3. Preparation of the occlusal surface so reduction follows the anatomic planes to give uniform thickness in the restoration.
4. Preparation of the axial surfaces so tooth structure is removed evenly; if necessary, teeth should be orthodontically repositioned.
5. Selection of a conservative margin compatible with the other principles of tooth preparation.
6. Avoidance of unnecessary apical extension of the preparation.

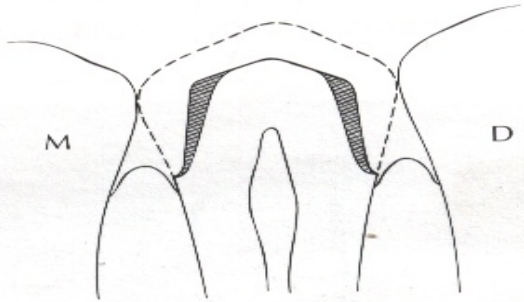
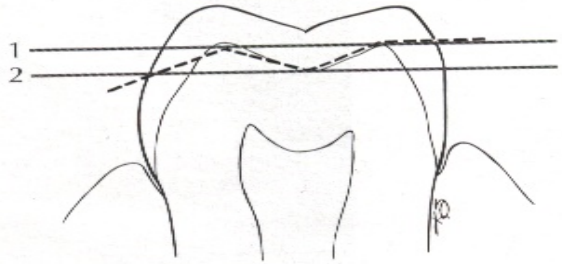


Fig. 7-9. Excessive taper results in considerable loss of tooth structure *(shaded area)*.



Minimally required clearances:
Buccal cusp—1.5 mm
Lingual cusp—1.0 mm
Marginal ridges and fossae—1.0 mm

Fig. 7-10. An anatomically prepared occlusal surface results in adequate clearance without excessive tooth reduction. A flat occlusal preparation will result in either *(1)* insufficient clearance or *(2)* an excessive amount of reduction.

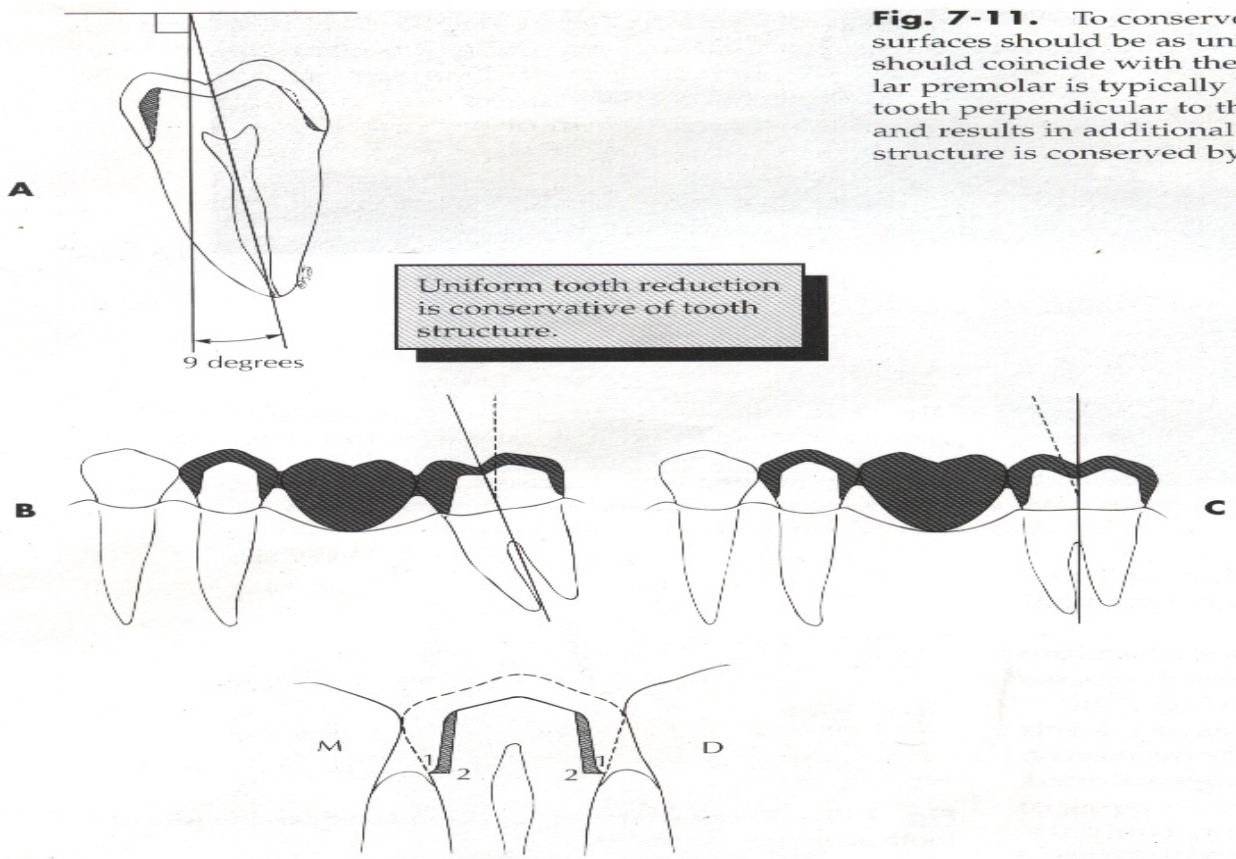
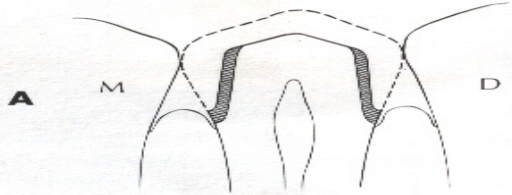


Fig. 7-11. To conserve tooth structure, the preparation of axial surfaces should be as uniform as possible. **A,** The path of withdrawal should coincide with the long axis of the tooth, which for a mandibular premolar is typically inclined 9 degrees lingually. Preparing the tooth perpendicular to the occlusal plane is a commonly seen error and results in additional tooth reduction *(shaded area)*. **B** and **C,** Tooth structure is conserved by uprighting a tilted FPD abutment.

Fig. 7-12. A shoulder margin *(2)* is less conservative than a chamfer *(1)*.



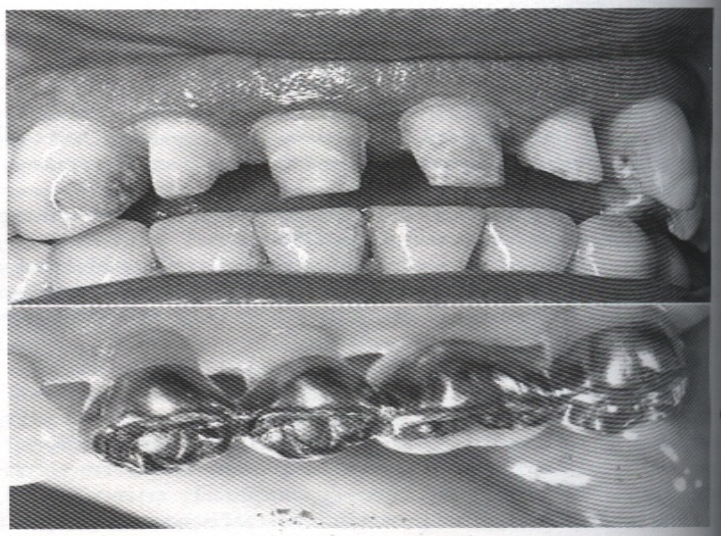


Fig. 7-13. **A,** Apical extension of the preparation can necessitate additional tooth reduction. **B,** Preparations for periodontally involved teeth may necessitate considerable reduction if the margins are to be placed subgingivally for esthetic reasons. **C,** Supragingival margins are preferred where applicable.

- **CONDITIONS AFFECTING FUTURE DENTAL HEALTH**
- **Axial Reduction** : Gingival inflammation is commonly associated with crown and FPD abutments having excessive axial contours, probably because it is more difficult for the patient to maintain plaque control around the gingival margin. A tooth preparation must provide sufficient space for the development of good axial contours. This will enable the junction between the restoration and the tooth to be smooth and free of any ledges or abrupt changes in direction.

- **Margin Placement** : Whenever possible, the margin of the preparation should be supragingival. Subgingival margins of cemented restorations have been identified as a major factor in periodontal disease, particularly where they encroach on the epithelial attachment. Supragingival margins are easier to prepare accurately without trauma to the soft tissues. They can usually situated on hard enamel, whereas sub-gingival margins are often on dentin or cementum.

- **Advantages of supragingival margins :**

1. They can be easily finished.
2. They are more easily kept clean
3. Impressions are more easily made, with less potential for soft tissue damage
4. Restorations can be easily evaluated at recall appointments.

- However, a **subgingival margin** is justified if any of the following pertain :

1. Dental caries, cervical erosion, or restorations extend subgingivally, and crown-lengthening procedure is not indicated.
2. The proximal contact area extends to the gingival crest.
3. Additional retention is needed.
4. The margin of a metal-ceramic crown is to be hidden behind the labiogingival crest.
5. Root sensitivity cannot be controlled by more conservative procedures, such as the application of dentin bonding agents.
6. Modification of the axial contour is indicated.

- **Margin Adaptation** : The junction between a cemented restoration and the tooth is always a potential site for recurrent caries because of dissolution of the luting agent and inherent roughness. The more accurately the restoration is adapted to the tooth, the lesser the chance of recurrent caries or periodontal disease. Although a precise figure for acceptable margin adaptation is not available, a skilled technician can make a casting that fits to within 10 um and a porcelain margin that fits to within 50 um, provided the tooth is properly prepared. A well–designed preparation has a smooth and even margin. Rough, irregular, or stepped junctions greatly increase the length of the margin and substantially reduce the adaptation of the restoration.

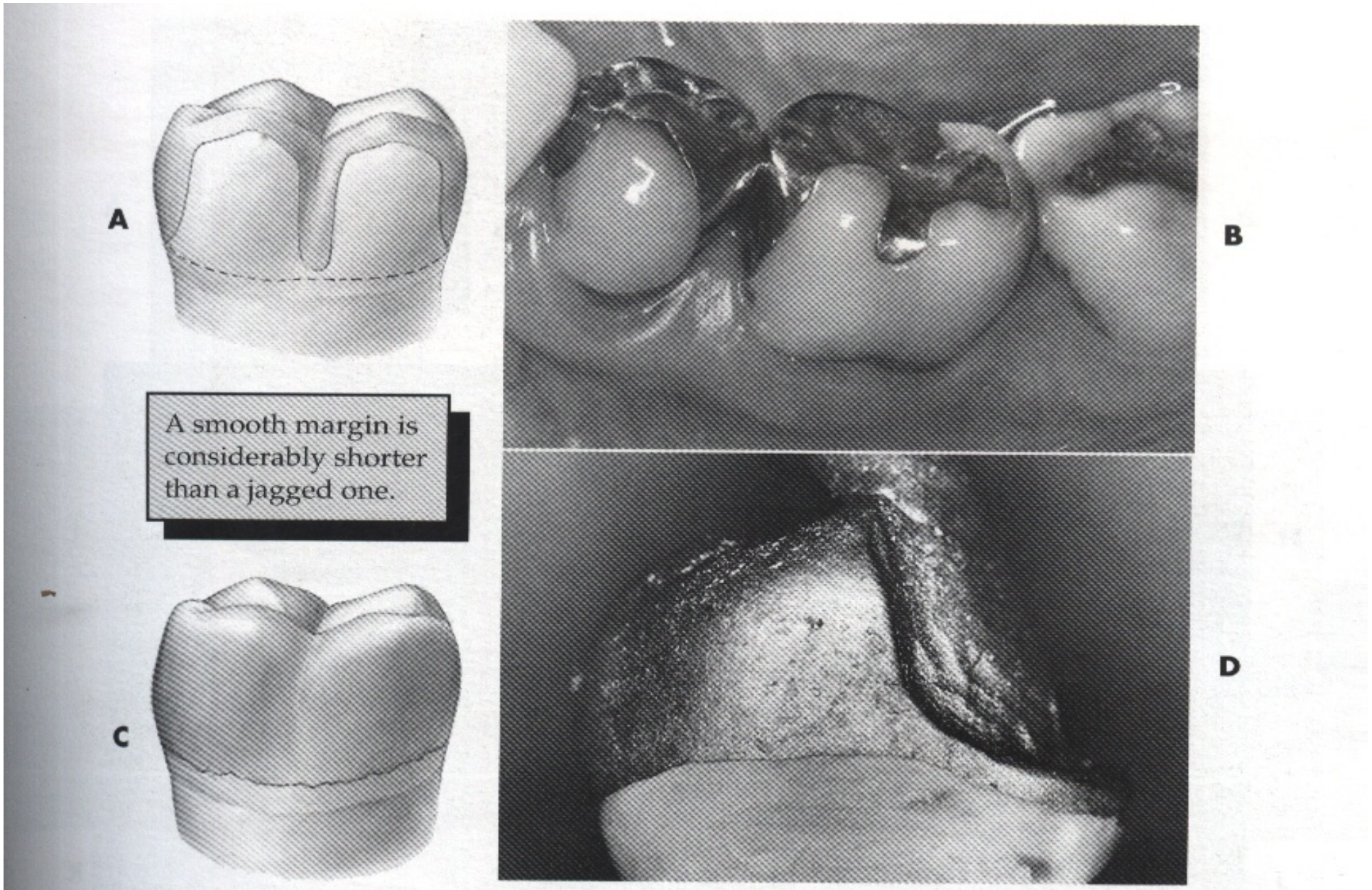


Fig. 7-16. **A** and **B,** Poor preparation design, leading to increased margin length. **C,** A rough, irregular margin will make the fabrication of an accurately fitted restoration almost impossible. **D,** An accurately fitting margin is possible only if it is prepared smoothly.

- **Margin Geometry** : The following guidelines for margin design should be considered :

1. Ease of preparation without overextention or unsupported enamel.
2. Ease of identification in the impression and on the die.
3. A distinct boundary to which the wax pattern can be finished.
4. Sufficient bulk of material.
5. Conservation of tooth structure.

Advantages and Disadvantages of Different Margin Designs

TABLE 7-2

	Advantages	Disadvantages	Indications
Featheredge	Conservative of tooth structure	Does not provide sufficient bulk	Not recommended
Chisel edge	Conservative of tooth structure	Location of margin difficult to control	Occasionally on tilted teeth
Bevel	Removes unsupported enamel, allows finishing of metal	Extends preparation into sulcus if used on apical margin	Facial margin of maxillary partial-coverage restorations and inlay/onlay margins
Chamfer	Distinct margin, adequate bulk, easier to control	Care needed to avoid unsupported lip of enamel	Cast metal restorations, lingual margin of metal-ceramic crowns
Shoulder	Bulk of restorative material	Less conservative of tooth structure	Facial margin of metal-ceramic crowns, complete ceramic crowns
Sloped shoulder	Bulk of material, advantages of bevel	Less conservative of tooth structure	Facial margins of metal-ceramic crowns
Shoulder with bevel	Bulk of material, advantages of bevel	Less conservative, extends preparation apically	Facial margin of posterior metal-ceramic crowns with supragingival margins

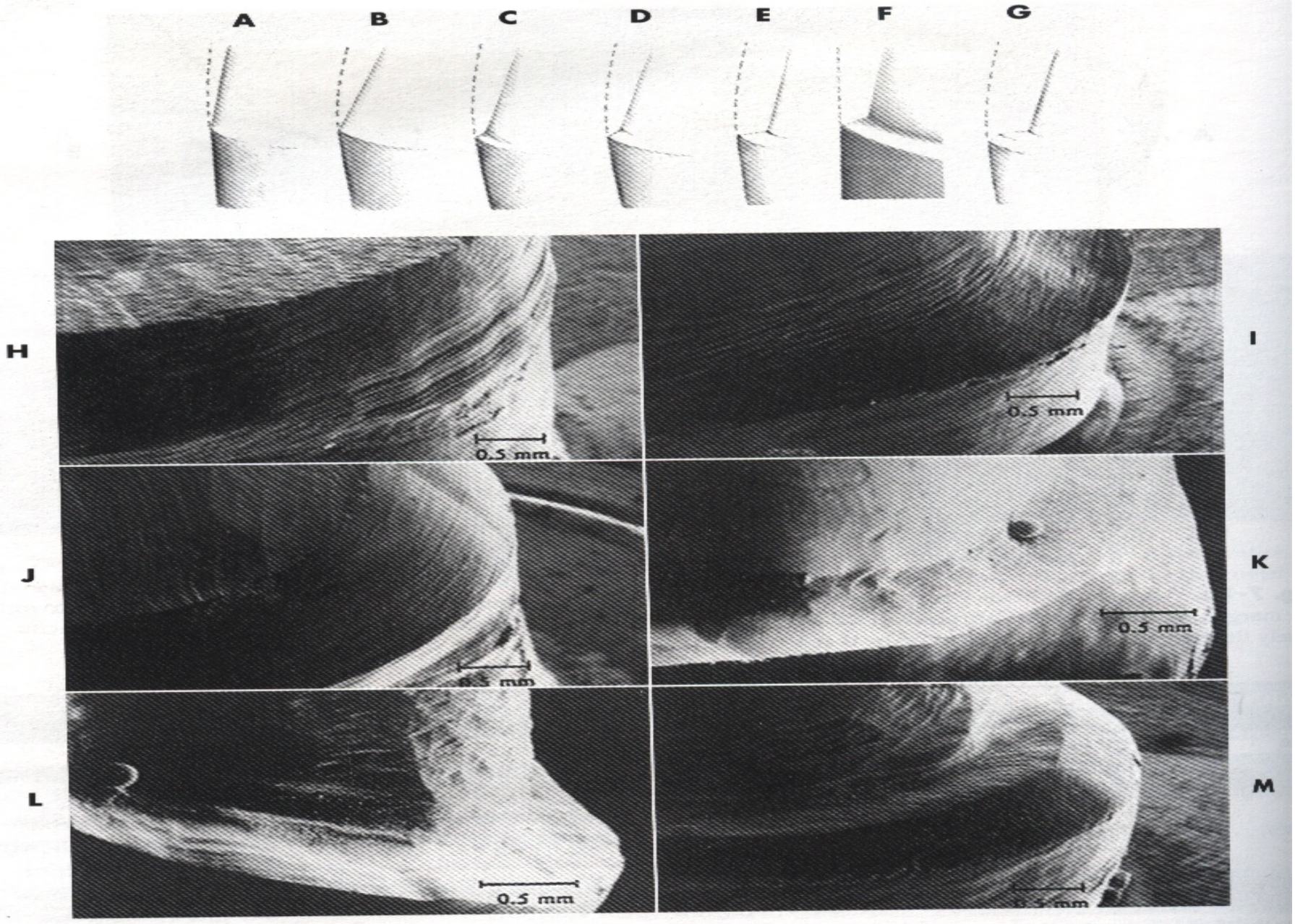
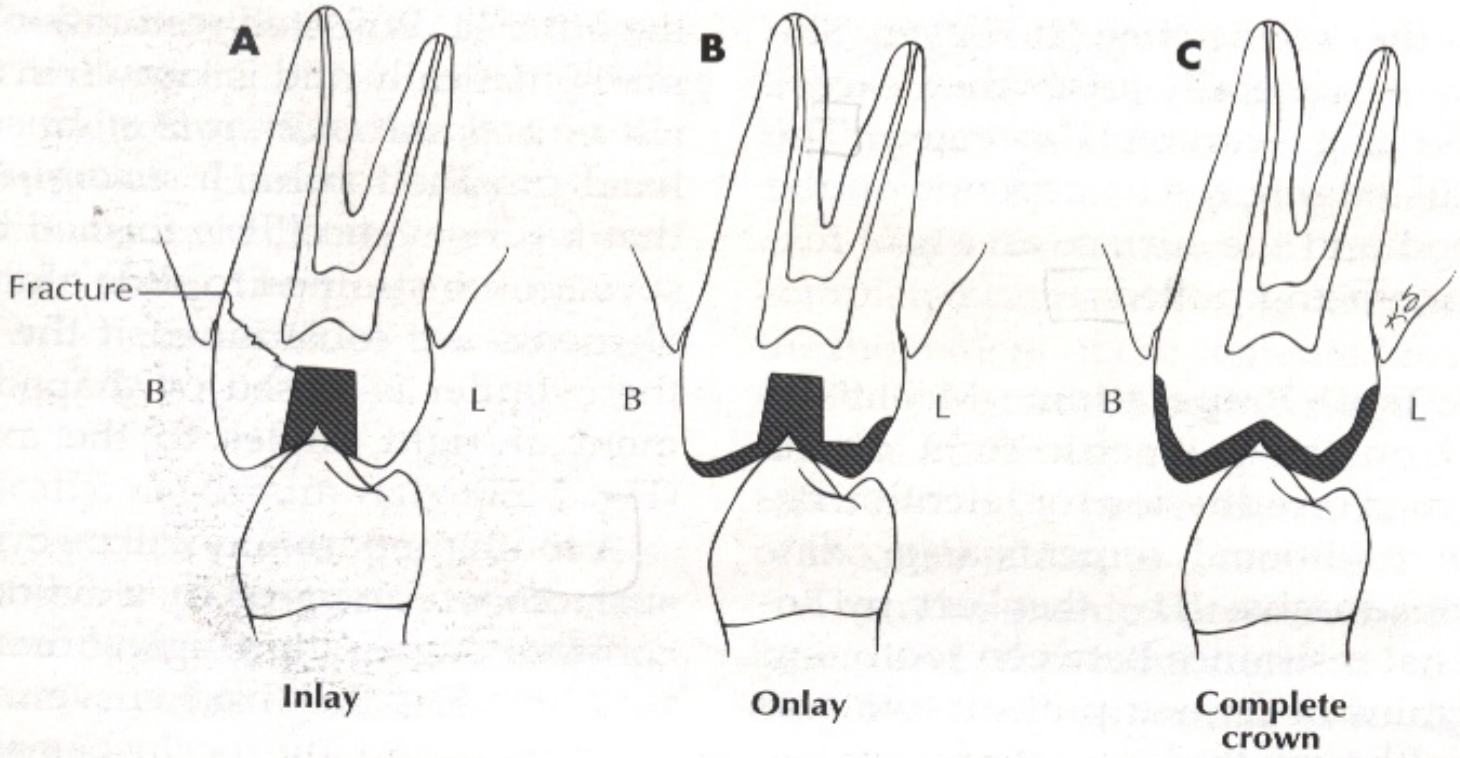


Fig. 7-17. Margin designs: **A,** Featheredge. **B,** Chisel. **C,** Chamfer. **D,** Bevel. **E,** Shoulder. **F,** Sloped shoulder. **G,** Beveled shoulder. Scanning electron micrographs. **H,** Feather-chisel edge. **I,** Chamfer. **J,** Bevel. **K,** Shoulder. **L,** Sloped shoulder. **M,** Beveled shoulder.
(Courtesy Dr. H. Lin.)

- **Occlusal Considerations** : A satisfactory tooth preparation should allow sufficient space for developing a functional occlusal scheme in the finished restoration. Sometimes a patient's occlusion is disrupted by supraerupted or tilted teeth. When these teeth are prepared for restoration, the eventual occlusal plane must be carefully analyzed and the teeth reduced accordingly. Sometimes even endodontic treatment is necessary to make enough room.

- **Preventing Tooth Fracture** : The likelihood that a restored tooth will fracture can be lessened if the tooth preparation is designed to minimize potentially destructive stresses. Providing a cuspal coverage restoration (onlay) rather than an inlay lessens the chance of such fracture. However, although not conservative of tooth structure, a complete crown is often a better solution, because it offers the greatest protection against tooth fracture, tending to hold the cusps of the tooth together.



Cuspal protection becomes more important as the structural durability of the cusps is compromised.

Fig. 7-25. **A,** An intracoronal cast restoration (inlay) can act as a wedge during cementation or function. If the cusps are weakened, fracture will occur. **B,** A cuspal-coverage onlay provides better protection but often lacks retention. **C,** A complete crown provides the best protection against fracture. It also has the best retention, but it can be associated with periodontal disease and poor esthetics.
(Redrawn from Rosenstiel SF: In Rayne J, editor: General dental treatment, *London, 1983, Kluwer Publishing.)*

MECHANICAL CONSIDERATIONS

- The design of tooth preparations for fixed prosthodontics must adhere to certain mechanical principles; otherwise, the restoration may become dislodged or may distort or fracture during service.
- Mechanical considerations can be divided into three categories :

1. Providing retention form
2. Providing resistance form
3. Preventing deformation of the restoration

- **RETENTION FORM**
- The quality of a preparation that prevents the restoration from becoming dislodged by forces parallel to the path of withdrawal is known as retention.
- The following factors must be considered when deciding whether retention is adequate for a given fixed restoration :

1. Magnitude of the dislodging forces
2. Geometry of the tooth preparation
3. Roughness of the fitting surface of the restoration
4. Materials being cemented
5. Film thickness of the luting agent

- **Magnitude of the Dislodging Forces** : The magnitude of the dislodging forces depends on the stickiness of the food and the surface area and texture of the restoration being pulled.
- **Geometry of Tooth Preparation** : Most fixed prostheses depend on the geometric form of the preparation rather than on adhesion for retention because most of the traditional cements are non adhesive. Cement is effective only if the restoration has a single path of withdrawal (i.e. the tooth is shaped to restrain the free movement of the restoration). The relationship between a nut and a bolt is an example of restrained movement. The nut is not free to move in any direction but can move only along the precisely determined helical path of the threads on the bolt.

Minimizing taper effectively limits the number of directions in which a cast crown can be dislodged.

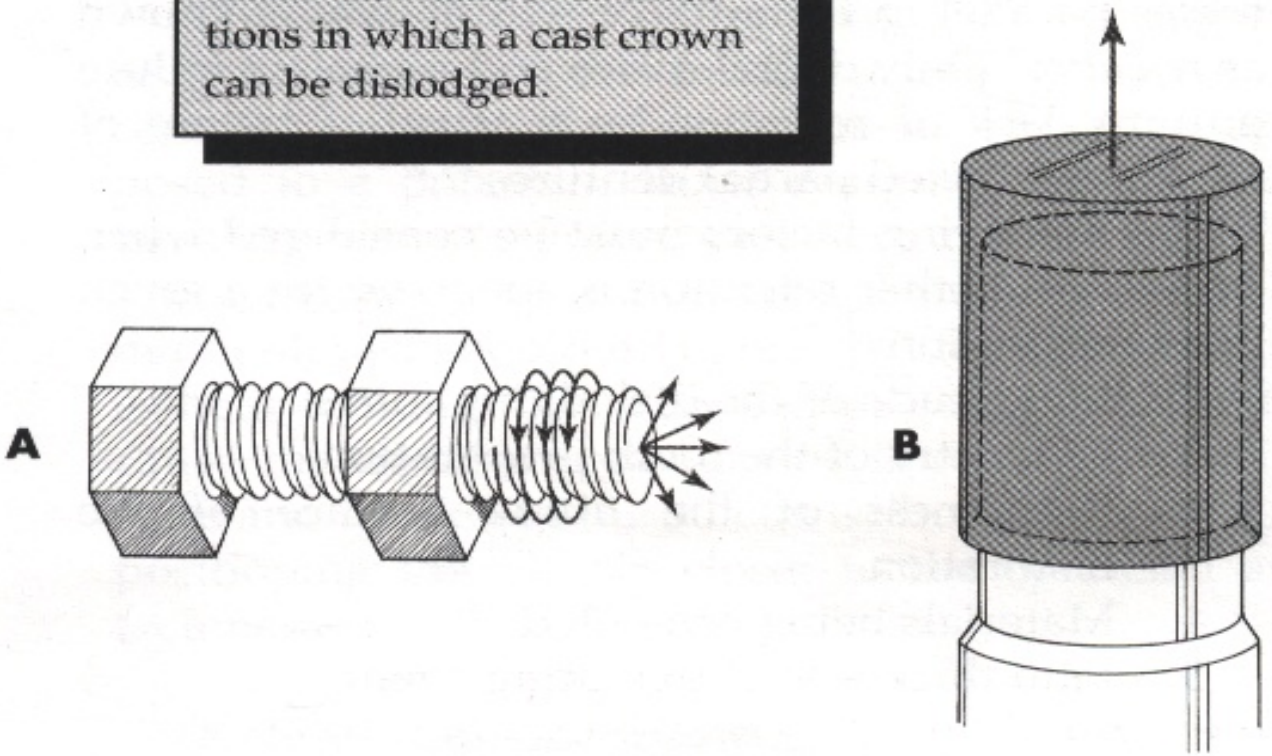


Fig. 7-26. **A,** The relationship of a nut and a bolt is an example of restrained movement; the nut must move along a precisely defined helical path *(arrows)*. **B,** For effective retention, a tooth preparation must constrain the movement of a restoration. For this to occur, it must be cylindrical. (See Figure 7-27.)

- The relationship between two bodies, one (in this case a tooth preparation) restraining movement of the other (a cemented restoration), has been studied mathematically and is known in analytical mechanics as a closed lower pair of kinematic elements.
- In fixed prosthodontics, a sliding pair is the only pair that has relevance. It is formed by two cylindrical surfaces constrained to slide along one another.

- **Taper** : Theoretically, maximum retention is obtained if a tooth preparation has parallel walls. However, it is impossible to prepare a tooth this way using current techniques and instrumentation; slight undercuts are created that prevent the restoration from seating.
- An undercut is defined as a divergence between opposing axial walls, or wall segments, in a cervical-occlusal direction.
- A slight convergence, or taper, is necessary in the completed preparation. As long as this taper is small, the movement of the cemented restoration will be effectively restrained by the preparation and will have what is known as a limited path of withdrawal. As the taper increases, however, so does the free movement of the restoration, and retention will be reduced.
- Selection of the appropriate degree of taper for tooth preparation involves compromise. Too small a taper may lead to unwanted undercuts; too large will no longer be retentive. **The recommended convergence between opposing walls is 6 degrees**, which has been shown to optimize retention for zinc phosphate cement.

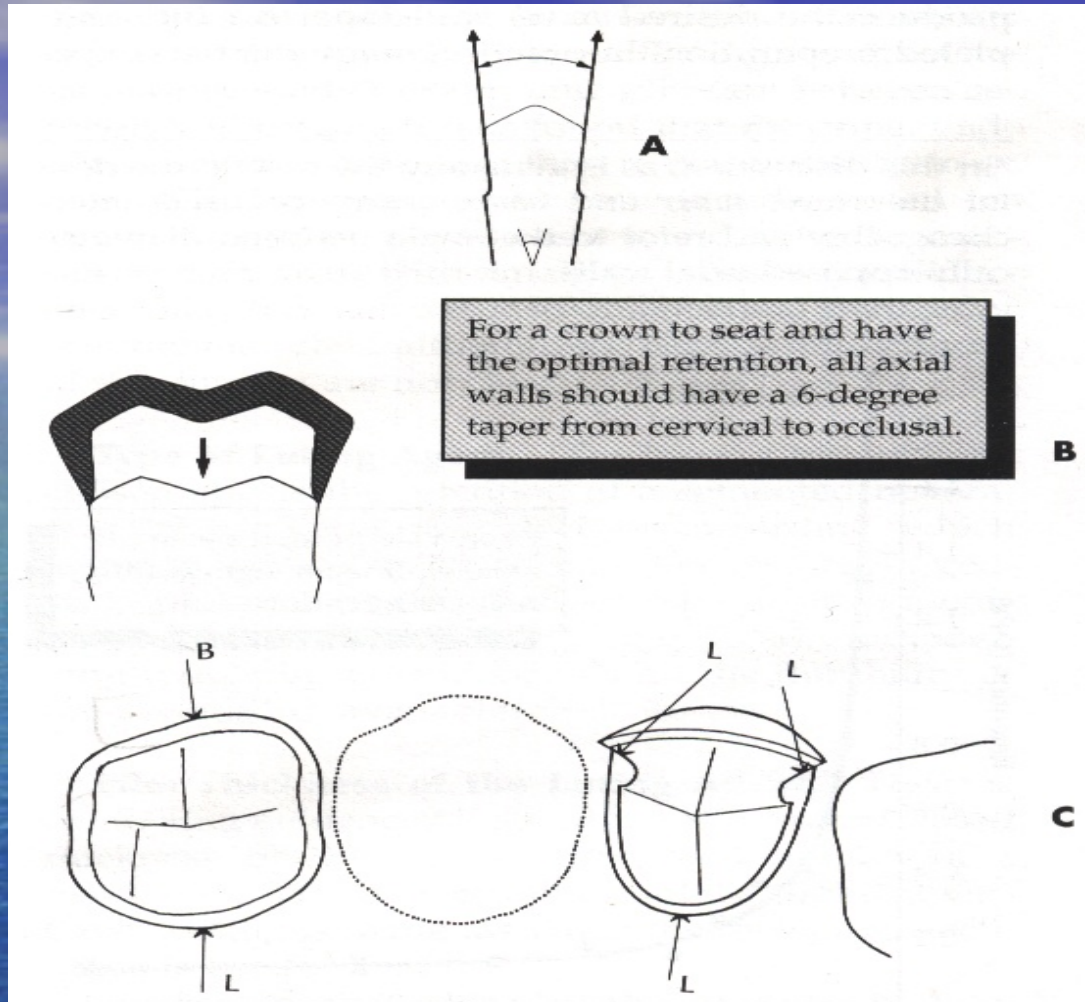
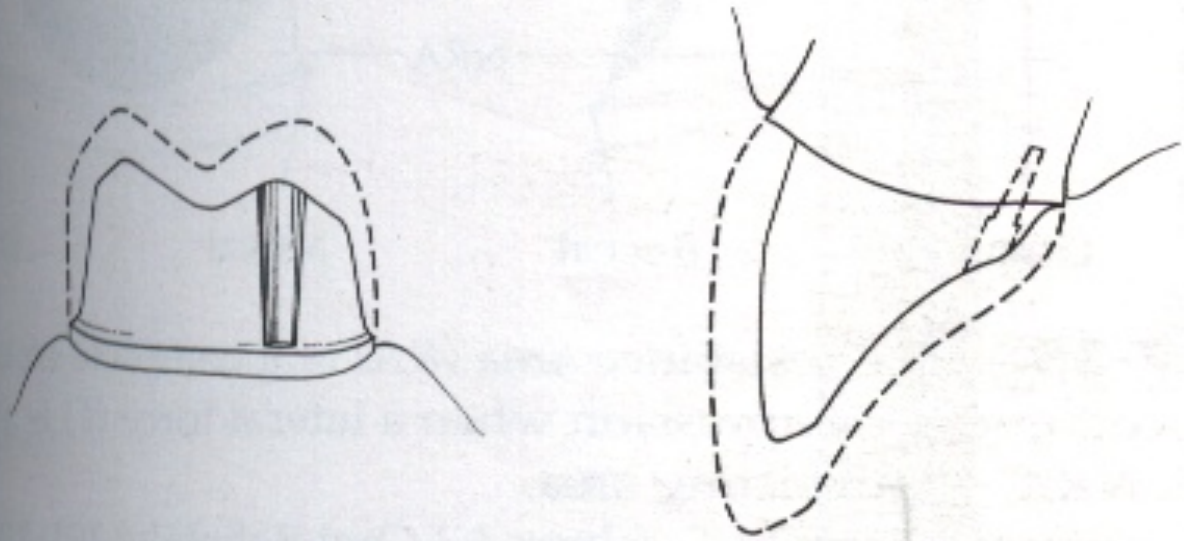


Fig. 7-29. **A,** An undercut is formed if opposing walls diverge. **B,** A crown is prepared, because an undercut preparation cannot "seat," since it cannot pass over the divergent walls. **C,** Undercuts are possible in other locations when fixed partial dentures or restorations with preparation features such as grooves or boxes are prepared. Here one buccal facing wall *(B)* can be undercut relative to (four) lingual facing walls *(L)*.

- **Surface Area** : Provided the restoration has a limited path of withdrawal, its retention depends on the length of this path or, more precisely, on the surface area in sliding contact. Therefore, crowns with long axial walls are more retentive than those with short axial walls, and molar crowns are more retentive than premolar crowns of similar taper.

- **Stress Concentration** : A computerized analysis of stresses reveals that they are not uniform throughout the cement but are concentrated around the junction of the axial and occlusal surfaces. Changes in the geometry of the preparation may (e.g. rounding the internal line angles) may reduce stress concentrations and thus increase the retention of the restoration.
- **Type of Preparation** : Different types of preparation have different retentive values that correspond fairly closely to the surface area of the axial walls, as long as other factors (taper) are kept constant. Thus the retention of a complete crown is about double that of partial-coverage restorations.



Internal features effectively increase resistance.

Fig. 7-33. Retention form of an excessively tapered preparation can be increased by adding grooves or pinholes, because these will limit the paths of withdrawal.

- **Roughness of the Surfaces Cemented** : When the internal surface of a restoration is very smooth, retentive failure occurs not through the cement but at the cement-restoration interface. Under these circumstances, retention will be increased if the restoration is roughened or grooved.
- **Materials Being Cemented** : Retention is affected by both the casting alloy and the core or buildup material. Lab testing results have yet to be confirmed by longer-term clinical studies, but it appears that the more reactive the alloy is, the more adhesion there will be with certain luting agents. Therefore, base metal alloys are better retained than less reactive high-gold content metals.

- **Type of Luting Agent** : In general, the data suggest that adhesive resin cements are the most retentive, although long-term clinical evidence about the durability of the bond is not available.
- **Film Thickness of the Luting Agent** : There is conflicting evidence about the effect of increased thickness of the cement film on retention of a restoration. This may be important if a slightly oversized casting is made.

- **RESISTANCE FORM**
- Lateral forces tend to displace the restoration by causing rotation around the gingival margin. Rotation is prevented by any areas of the tooth preparation that are placed in compression, called resistance areas.
- Adequate resistance depends on the following :

1. Magnitude and direction of the dislodging forces
2. Geometry of the tooth preparation
3. Physical properties of the luting agent

When quantifying resistance, ask yourself the following question: How much tooth structure needs to break, or how much does the crown have to deform in order to dislodge this restoration?

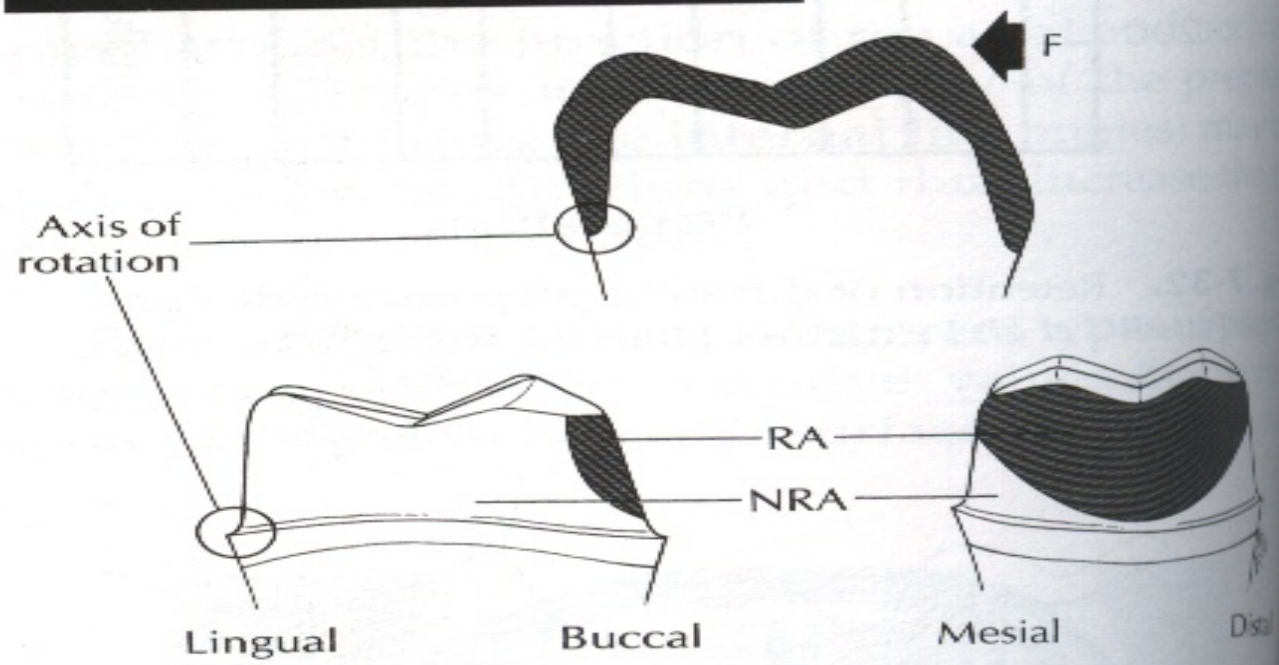


Fig. 7-35. The resistance area *(RA)* of a complete crown is placed under compression when a lateral force *(F)* is applied. *NRA*, Nonresisting area.
(Redrawn from Hegdahl T, Silness J: J Oral Rehabil 4:201, 1977.

- **Magnitude and Direction of the Dislodging Forces** : In a normal occlusion, biting force is distributed over all the teeth; most of it is axially directed. If a fixed prosthesis is carefully made with a properly designed occlusion , the lodad should be well distributed and favorably directed.
- **Geometry of Tooth Preparation** : The tooth preparation must be shaped so that particular areas of the axial wall will prevent rotation of the crown. A partial-coverage restoration may have less resistance than a complete crown because it has no buccal resistance areas.

- **Physical Properties of the Luting Agent :** Resistance to deformation is affected by physical properties of the luting agent, such as compressive strength and modulus of elasticity. To satisfy ADA/ANSI specification no.96 the compressive strength of zinc phosphate cement must exceed 70 MPa at 24 hours. Glass ionomer cements and most resins have higher compressive strength, whereas polycarboxylates have similar values.

- **DEFORMATION**
- A restoration must have sufficient strength to prevent permanent deformation during function. Otherwise it will fail (typically at the restoration-cement, or the metal-porcelain interface). This may be a result of inappropriate alloy selection, inadequate tooth preparation, or poor metal-ceramic framework design.

ESTHETIC CONSIDERATIONS

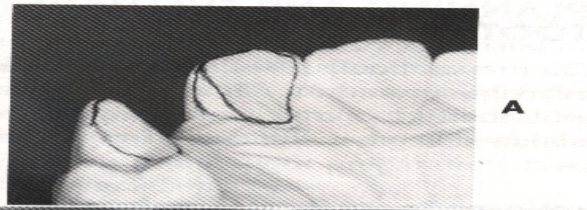
- Patients prefer their dental restorations to look as natural as possible. However, care must be taken that esthetic considerations are not pursued at the expense of a patient's long-term oral health or functional efficiency.
- At the initial examination it is important to make a full assessment of the appearance of each patient, noting which areas of which teeth show during smiling, talking, and laughing. The patient's esthetic requirements must be discussed and related to oral hygiene needs and the potential for disease. The final decision regarding an appropriate restoration can then be made with the full cooperation and informed consent of the patient.

PLANNING AND EVALUATING TOOTH PREPARATIONS

- **DIAGNOSTIC TOOTH PREPARATIONS**
- Diagnostic tooth preparations are performed on articulated casts before the actual clinical preparation. They yield information with regard to the following :

1. Selecting the appropriate path of withdrawal for a FPD.
2. Determining the best location for the facial and proximal margins of a partial-coverage restoration so the metal will not be visible.
3. Deciding on the amount of tooth reduction necessary to accomplish a planned change in the occlusion.

- **Diagnostic Waxing Procedures** : For all but the most straightforward prosthodontic treatment plans, a diagnostic waxing procedure should be performed. This is done on diagnostic tooth preparations and establishes the optimum contour and occlusion of the eventual prosthesis. The procedure is of particular benefit if the patient's occlusal scheme or anterior (incisal) guidance requires alteration.



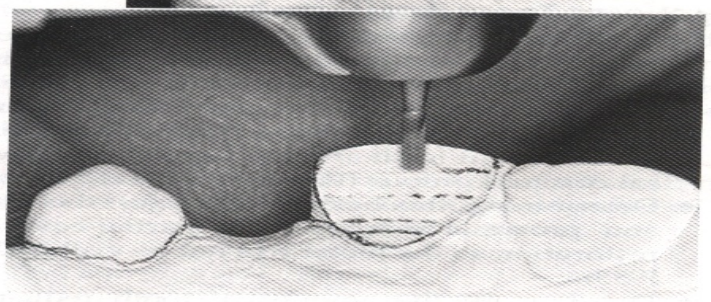


Fig. 7-55. Diagnostic tooth preparations are extremely helpful in determining the ideal reduction for esthetic partial-coverage restorations.

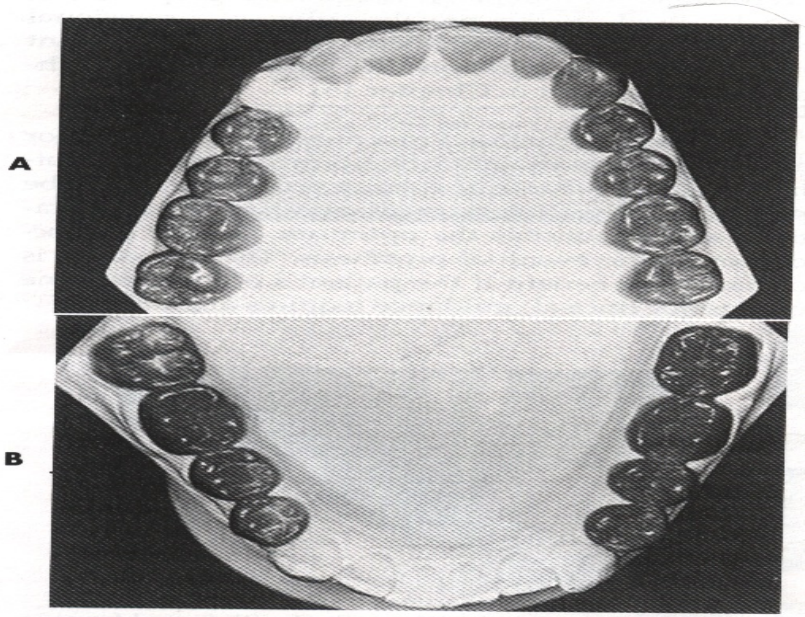


Fig. 7-56. A, B, Diagnostic waxing procedure. *(Courtesy Dr. M. Chen.)*

SUMMARY

- The principles of tooth preparation can be categorized into biologic, mechanical, and esthetic considerations. Often these principles conflict, and the practitioner must decide how the restoration should be designed.
- Experience will help in determining whether preparations are “complete”. Each tooth preparation must be measured by clearly defined criteria which can be used to identify and correct problems.


THANK YOU