

Biomechanical Principles of Tooth Preparation

The design of the preparation of a tooth for cast metal or porcelain restorations is limited by five principles:

- 1- Preservation of tooth structure.
- 2- Retention and resistance form.
- 3- Structural durability of the restoration.
- 4- Preservation of periodontium.
- 5- Marginal integrity.

1. Preservation of the tooth structure

The preparation of the tooth must be conservative, minimal amount of tooth structure must be removed. Excessive amount of tooth structure removal, in addition to be destructive phenomenon, it has many harmful effects:

- Excessive reduction will lead to thermal hypersensitivity, pulpal inflammation and necrosis may result from approaching to the pulp closely.
- The tooth might be over tapered or shortened and this might affect the retention and resistance of the prepared tooth.

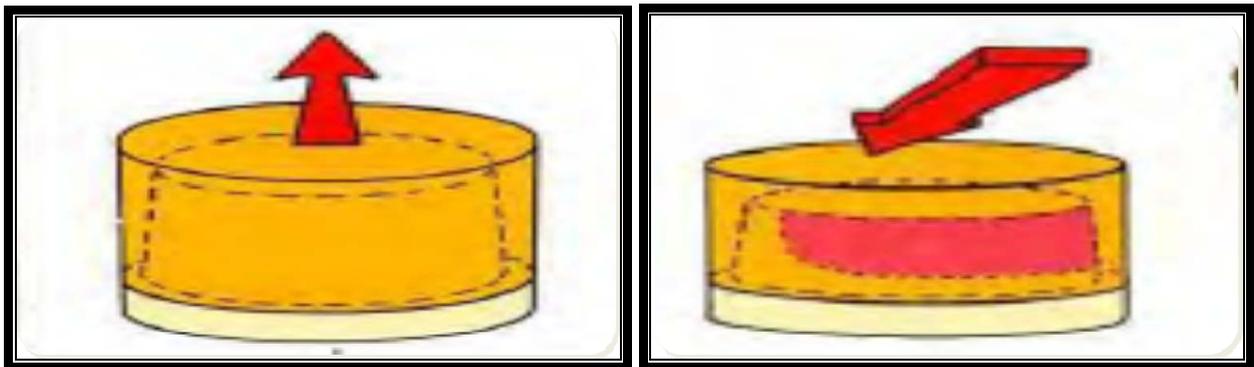
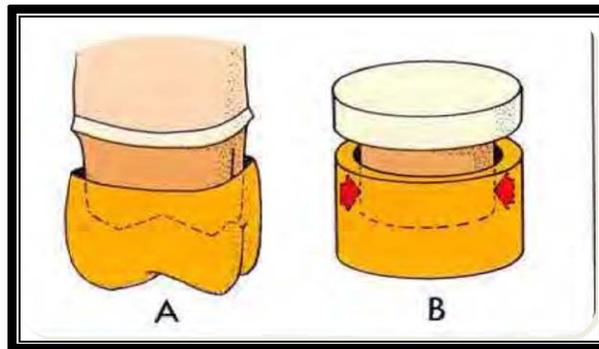


Excessive tooth reduction: The tooth is over tapered and shortened and this will affect the retention and resistance of the prepared tooth.

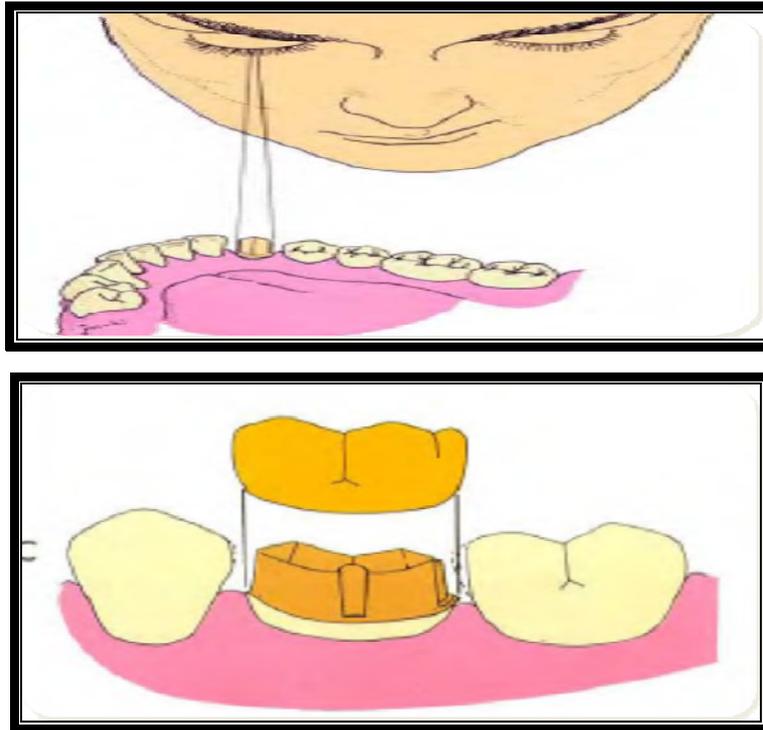
2. Retention and resistance form

Retention is the ability of the preparation to resist the dislodgment of the crown restoration by forces directed along its path of insertion.

Resistance is the ability of the preparation to resist the dislodgment of the restoration by forces directed obliquely or horizontally to the restoration.



Path of insertion is an imaginary line along which the restoration can be inserted and removed without causing lateral forces on the abutment. The crown restoration should have a single path of insertion to be retentive. Most of the time, the path of insertion of the crown restoration is parallel to the long axis of the tooth, but this is not a rule as in three-quarter crown for the anterior teeth where the path of insertion should be parallel to the incisal two-thirds of the crown not to the long axis.



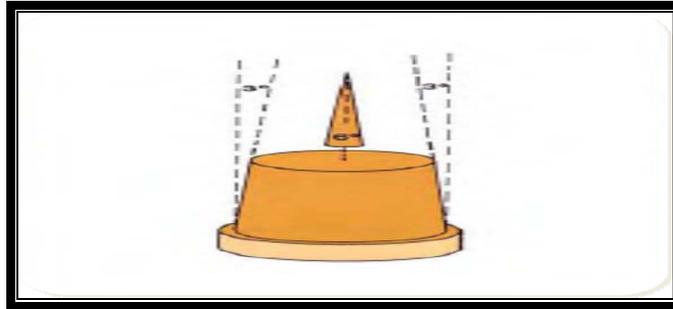
By limiting the path of withdrawal of the restoration, the retention is improved.
A preparation with unlimited freedom of displacement is much less retentive.

Factors affecting retention and resistance

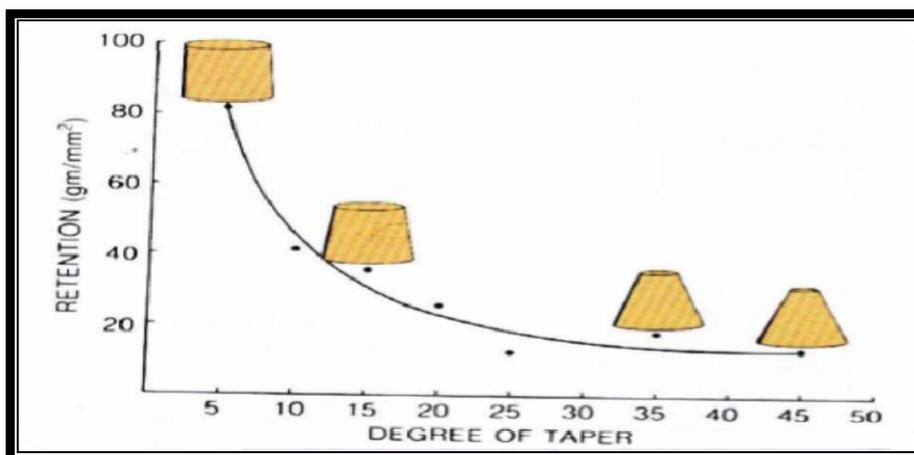
1. Taper of the preparation.
2. Surface area of the preparation.
3. Length and height of the preparation.
4. Diameter of the tooth (tooth width).
5. Texture of the preparation.
6. Accessory means.

1. Taper of the preparation

Convergence angle is the angle that is formed between each two opposing axial walls of a tooth prepared to receive a crown restoration. It determines the convergence (taper) of the prepared tooth.



The magnitude of retention depends on the degree of this angle, the greater the taper the less the retention. The degree of the convergence angle is one of the factors that determine the amount of axial and non-axial forces which can be tolerated without leading to loss of the crown restoration. 5-6 degrees convergence angle is mostly used to provide the needed retention. The more nearly parallel the opposing walls of preparation, the greater will be the retention, but parallel walls are difficult to be obtained inside the patient's mouth without creating undercuts and might lead to difficulty in seating of the crown restoration, thus 5-6 degrees convergence angle is mostly used to provide the needed retention.

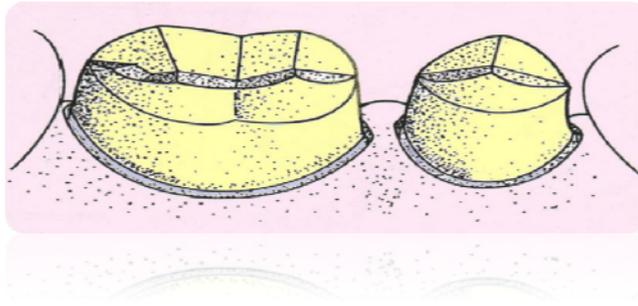


Taper and Resistance: The more parallel the axial walls of the preparation, the more will be the resistance of crown restoration. The walls of a short wide preparation must be kept nearly parallel to achieve adequate resistance from.

2. Surface area of the preparation

Increasing the surface area will increase the retention. The factors that influence the surface area are:

(a) Size of the tooth: The larger the size of the tooth, the more will be the surface area of the preparation, and thus the more will be the retention. In this issue, a full metal crown on a molar tooth will definitely be more retentive than that on a premolar tooth.

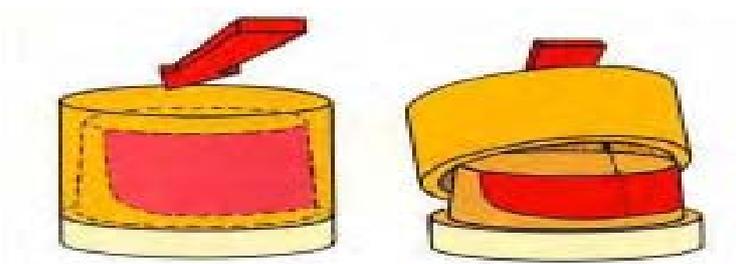


(b) Extent of tooth coverage by the restoration: The more the area that will be covered by the crown restoration, the more will be the retention. Thus full metal crown on a molar tooth is more retentive than a three-quarter crown on the same tooth.

(c) Accessory features: such as boxes, grooves, and pin holes.

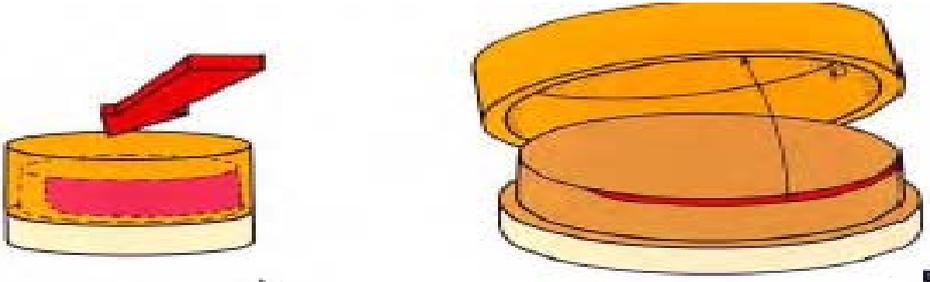
3. Length (height) of the preparation

Increasing the length of the preparation will increase the retention and resistance and vice versa.



4-Diameter of the tooth (tooth width)

Under some circumstances, a crown on a narrow tooth can have greater resistance to tipping than the one on a wider tooth. This occurs because the crown on the narrower tooth has a shorter radius for rotation resulting in a lower tangent line and a larger resisting area.

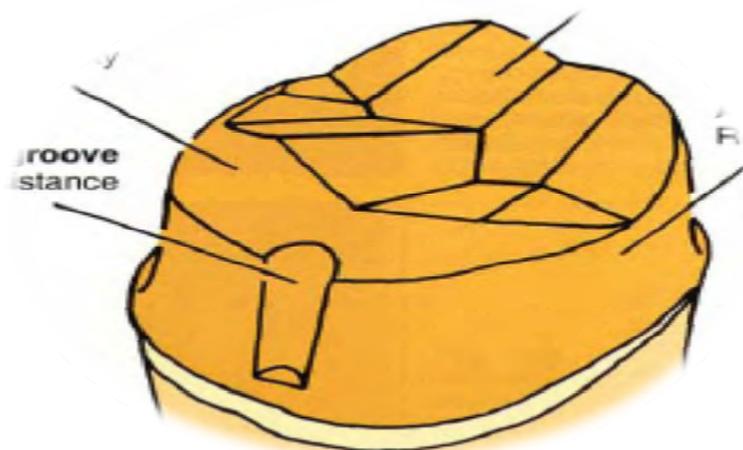


5. Texture of the preparation

Depending on the type of luting cement, the texture of the preparation might affect the retention of cast crown. Smooth surfaces are less retentive than the rough (mechanical interlocking).

6. Extra retention means

The retention of the preparation can be greatly enhanced by the addition of grooves, pin holes or boxes.

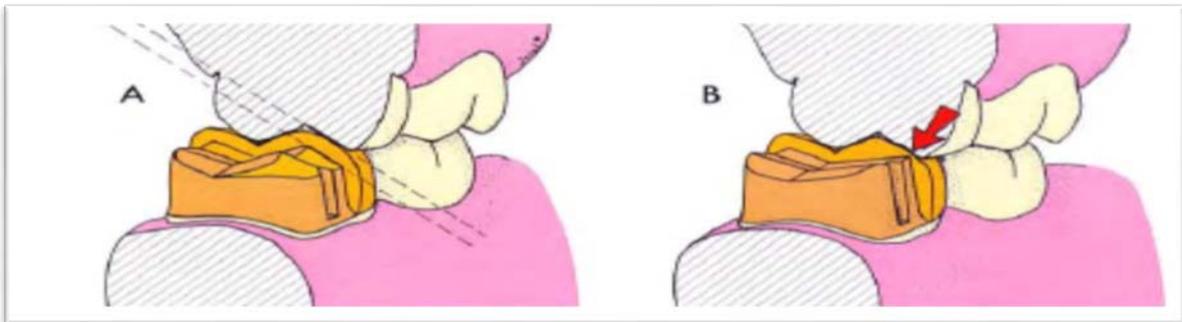


3. Structural Durability

The preparation must be designed so that it can provide structural durability to the restoration. i.e. the crown restoration must be rigid enough to not flex, perforate (if made of metal) or even fracture (if made of plastic material).

For the restoration to be rigid it needs bulk. To provide enough bulk to the crown restoration, sufficient tooth structure must be removed from the prepared tooth to create enough space. By doing so, the restoration will be allowed to withstand the forces of occlusion, preventing wearing holes in the metal and allowing proper contouring and carving of occlusal anatomy in the restoration. The preparation features related to structural durability are:

(1) *Occlusal reduction*: Enough tooth structure must be removed from the occlusal surface so that the restoration can be built back to ideal occlusion and thick enough to prevent wearing or distortion (1-1.5mm).

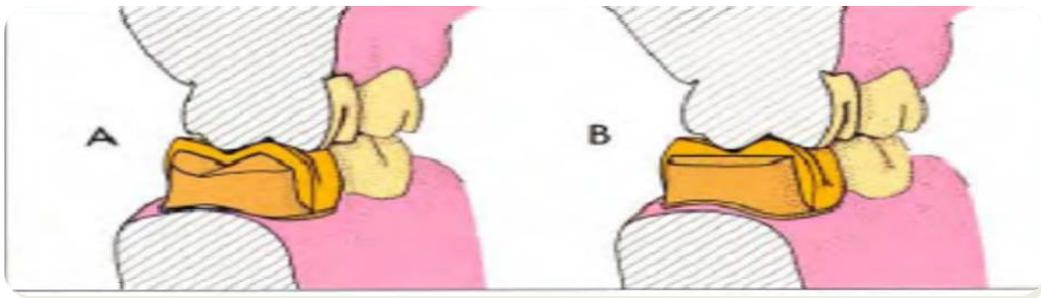


Occlusal clearance: is the space between the occlusal surface of the prepared tooth and that of opposing tooth. It should be evaluated in centric and eccentric relation. Enough tooth structure must be removed occlusally so that when the restoration is built back to ideal occlusion it will be thick enough to prevent wearing or distortion.

Functional cusps: are the cusps that give centric stops of occlusion (Palatal of upper posterior teeth and buccal of lower posterior teeth).

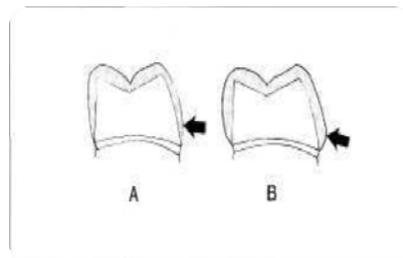
Occlusal reduction must reflect the geometric inclined planes of the occlusal surface (the so called "planar occlusal reduction" or "anatomical occlusal reduction").

When doing occlusal reduction, we should avoid creating steep planes with sharp angles because it will lead to stress. On the other hand, flat occlusal reduction will lead to too thin metal and this will lead to perforation of the crown restoration in the future. Meanwhile, lowering the entire occlusal surface in an attempt to provide sufficient space might lead to tooth structure destruction (non-conservative preparation) which interferes with the first principle of tooth preparation which is the conservation of tooth structure. In addition, lowering the entire occlusal surface will shorten the axial walls of the prepared tooth which definitely will affect the retention-resistance features of the preparation.



Functional cusp bevel (FCB): is a wide bevel placed on the functional cusps of posterior teeth to provide structural durability. It allows adequate thickness of restoration at this critical area without undue scarfing of tooth structure. If FCB is omitted, the restoration is likely to be too thin in this stress bearing area. In the absence of FCB, the laboratory technician overbuilds the crown restoration in attempt to provide structural durability for the restoration; this will lead to premature contact with the opposing tooth.

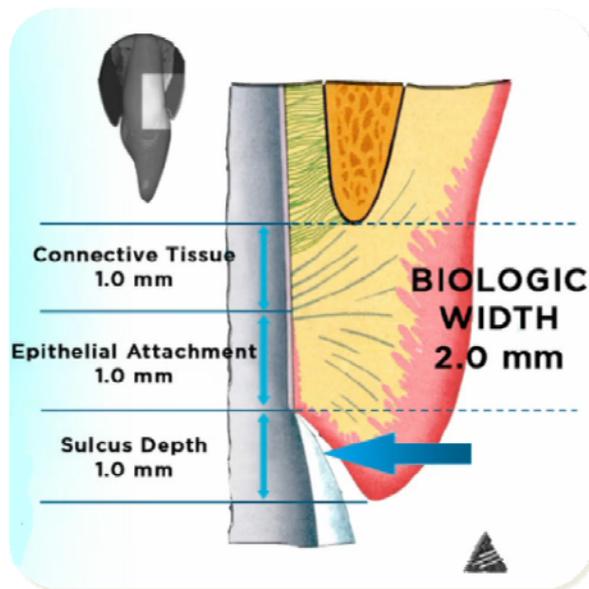
(2) *Axial reduction*: Sufficient axial reduction is important to provide sufficient space so that the restoration can be built with sufficient thickness. This will prevent flexing of the crown restoration when the occlusal forces act on.



4. Preservation of the periodontium

For the preservation of the periodontium, the following points should be considered:

- (a) Whenever possible, the margin of the preparation should be placed supra-gingivally.
- (b) The crown restoration should have proper contact, embrasure form, occlusion and a healthy occluso-gingival contour.



Margin placement (finishing line placement): The finishing line of the preparation can be placed either supra-gingivally, sub-gingivally, or equi-gingivally (with the level of the gingiva).

Placing the margin of the preparation above the gingival tissue offers the following advantages:

- a- can be easily prepared and finished by the operator.
- b- to provide good vision for the operator during preparation.
- c- the impression can be easily made.
- d- the patient can keep the area clean more easily.
- e- most of the time such a position is situated on hard enamel.
- f- less destructive

So, as mentioned above and for the reasons formerly mentioned, it is better to place the margin of the preparation supra-gingivally whenever possible. However, there are some situations which require sub-gingival placement of the finishing line as listed below:

- a- for esthetic.
- b- when we need extra retention as in teeth with short crowns.
- c- when there is caries or filling at the area of finish line (the preparation margin should be placed on sound tooth structure).

5. Marginal Integrity

The restoration can survive in the biological environment of the oral cavity only if the margin is closely adapted to the preparation margin. The configuration of the finishing line determines the shape and bulk of the restoration margin that will affect both marginal adaptation and the degree of seating of the restoration. The restoration margin should have the following requirements:

- (a) it must fit as closely as possible against the finishing line of preparation.
- (b) it must have sufficient strength.
- (c) whenever possible, it should be placed in an area where the dentist can finish easily and the patient can clean properly.