Review Article

Retention in Conventional Fixed Partial Dentures: A Review

Dentistry Section

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ABSTRACT

The long-term clinical outcome of fixed prosthodontic treatment depends on guidelines that promote the creation of mechanically, biologically, and aesthetically sound tooth preparations. Successful tooth preparation and success of subsequent restoration depend on important factors like retention and resistance form. The quality of a preparation that prevents the restoration from becoming dislodged by such forces parallel to the path of withdrawal is known as *retention.* For good retention in fixed prosthesis, there are various factors starting from the size of the teeth, magnitude of dislodging forces, geometry of tooth preparation, roughness of fitting surface, cement to be used and the film thickness of luting agent. The purpose of this article is to review and enumerate all the retention factors, which are necessary to increase the clinical longevity of the restoration that could be considered permanent in the traditional sense.

Key Words: Retention form, Tooth preparation, All Ceramic Restoration, Luting Cement

KEY MESSAGE

- The principles, factors and guidelines identified in this article can help dentists to better understand in order to design, assess, and modify the modes of retention in fixed partial denture prosthesis to ensure clinical success for the treatment of a variety of fixed prosthsis/restorations.

INTRODUCTION

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 in predicting the success of prosthodontics treatment [1-3]. Through a review of the dental literature, several critical aspects of retention form in tooth preparation have been identified. This article presents various fundamental principle considerations, factors and guidelines for the role retention in fixed partial dentures, based on current scientific evidence and literatures.

"Retention is defined as the quality inherent in a prosthesis acting to resist the forces of dislodgement along the path on insertion". Thus retention is a resistance to removal in a direction opposite to that on insertion. Teeth require preparation to receive restorations and the preparations must be based on fundamental principles from which basic criteria can e developed that held predict the success of prosthodontic treatment. A good preparation will ensure that subsequent techniques e.g. provisionalization, impression making, pouring of dies and casts, waxing etc. can be readily accomplished.

MECHANICAL PRINCIPLES OF RETENTION IN TOOTH PREPARATION [2]

For the restoration to be retentive, acceptable and long lasting there are certain principles of tooth preparation which should be taken into consideration [4].

Among these principles include:

1. **Biologic considerations:** These affect the health of the oral tissues which includes conservation of tooth structure, avoidance of overcontouring, supragingival margins, harmonious occlusion, and protection against tooth fracture.
2. **Mechanical consideration:** These affect the integrity and durability of the restoration.
3. **Esthetic consideration:** These affect the appearance of a patient.

MECHANICAL CONSIDERATIONS

Mechanical considerations can be divided into, providing retention form, resistance form and preventing deformation of the restoration.

RETENTION FORM

Forces develop on teeth from a myriad of angles. A force placed on a retainer can result from mastication, bruxism, dietary intake and also a log of unpredictable stresses. So this element of the Fixed Partial denture must not be compromised otherwise it can lead to failure and the restoration. The following factors must be considered in deciding whether retention is adequate for a given fixed restoration. These include:

1. Magnitude of dislodging force
2. Geometry of the tooth preparation
3. Taper
4. Surface area
5. Stress concentrations.

6. Type of preparation
7. Roughness of the fitting surfaces of the restorations
8. Materials being cemented.

1. Magnitude of Dislodging Forces

Forces that tend to remove a cemented restoration along path of withdrawal are small as compared to those that tend to unseat it or tilt it e.g. pulling with floss under the connectors. Generally the greatest removal forces arise when exceptionally sticky food, e.g. bubble gum is eaten or chewed. The magnitude of the dislodging forces depends on the stickiness of the food and the surface area and texture of the restoration being pulled.

2. Geometry of the Tooth Preparation

Fixed prosthesis depend on the geometric form of the preparation rather than on adhesion for retention. The cement is effective only if the restoration has a single path of withdrawal i.e. the tooth is shaped in a manner to restrain the free movement of the restoration. A preparation is cylindrical only if the two horizontal cross sections of the prepared axial tooth surfaces are coincident. A partial denture will be retentive if the sections are coincident and perpendicular movement is prevented by grooves [5]. However, if one wall of the complete crown preparation is over tapered, it will no longer be cylindrical and the cemented restoration will not be constrained by the preparation because the restoration then has multiple paths of withdrawal. Under these circumstances, the particles of the cement will tend lift away from rather than slide along the preparation and the only retention will be a result of the limited adhesion of the cement [4].

3. Taper

Selection of the appropriate degree of taper for tooth preparation is very important. Too small taper may lead to unwanted undercuts and too large will no longer be retentive. The recommended convergence between opposing wall is 6 degrees. The tooth should be prepared with a instrument of the desired taper that is held at a constant angulation [1].

4. Surface Area

Provided the restoration has a limited path of withdrawal, its retention is dependent 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 crown of same taper are more retentive than premolar crown of the same taper.

5. Stress Concentration

When a retentive failure occurs, cement is often found adhering to both the tooth preparation and the fitting surface of the restoration. In these cases, cohesive failure has occurred through the cement layer because the strength of the cement was less than the induced stress. It has been proved that changes in the geometry of the preparation (e.g. rounding of the internal line angles) reduces stress concentrations and hence increases the retention of the restoration.

6. Type of Preparation

Different types of the preparations have different retentive values and these correspond to the surface area of the axial walls, provided other factors (e.g. taper are kept constant). Thus the retention of a complete crown is almost double of partial coverage restoration.

7. Roughness of the Surface Being Cemented

When the internal surface of a restoration is very smooth, retentive failure occurs not through the cement but rather at the cement restoration interface. Air abrading has been shown to increase the retention of the castings by 64%.

8. Materials Being Cemented

Retention will be affected by both the casting alloy and the core or buildup material. It is said that more retentive the alloy, the more adhesion there will be with the luting agents. Therefore the base metal alloys i.e. nickel, cobalt and chromium are more retentive and better retained than less reactive high gold content metals.

ADDITIONAL METHODS OF GAINING RETENTION [6]

One method of increasing retention without lengthening axial surfaces is with grooves or boxes. Pins are also used to increase retention. Four ways to resist displacing forces and increase retention are:

1. Preparing a Suitable Gingival Finish Line

Whenever possible, the finish line should be placed in an area where the margins of the restorations can be finished by the dentist and kept clean by the patient. Placement of the finishing lines creates a barrier by preventing the cement to come in contact with the oral fluids and thus these finishing lines help in preventing microleakage and ultimately the retention and longevity of the restoration is increased. They also provide support to the metal and porcelain or acrylic used in restoration. There are four basic types of finishing lines shoulder, bevel shoulder, chamfer and knife-edge.

2. Contouring and Placing Suitable Contact Areas

3. Incorporating Occlusal Locks i.e. Dovetail, Boxes and Grooves

4. Adding Tapered or Parallel Pins

FACTORS AFFECTING RETENTION IN FIXED PARTIAL DENTURES

1. Length of Span

In addition to the increased load placed on the periodontal ligament by long span bridge, the longer spans are less rigid and so less retentive.

2. Curvature of Arch

Arch curvature has its effect on stresses occurring in a fixed bridge. When pontics lie outside the inter abutment axis line, the pontics act as a lever arm which will produce a torquing movement which leads to loss of retention of bridge.

3. Type of Bridge

There are two types of bridges made according to the prevalent condition and position of abutments in the arch.

a. Rigid connector
b. Non-rigid connector.

A completely rigid restoration is not indicated for all situations requiring a fixed prosthesis. In many instances, an edentulous span will occur on both sides of a tooth creating a lone free standing pier abutment. The use of a form of non-rigid connector can lessen these hazards. The non-rigid connector is a broken stress

mechanical union of the retainer and pontic instead of usual rigid solder joint.

4. Occlusion

Interference with undesirable occlusal contacts produce deviation during closure of maximum intercuspation, hinder smooth passage to and from the intercuspation position and lead to deflective occlusal force on the bridges which may lead to damaging effects on abutment and also on the retention of the casting. There are four types of occlusal interferences, centric, working, non-working and protrusive. All these interferences should be removed on suitable articulator and a harmonious occlusion should be achieved in the final casting.

5. Periodontal Condition

The abutment tooth must be able to provide good support for the bridge. This support is related to both the amount of root and the amount of bond present.

6. Tooth or Teeth Being Replaced

A bridge replacing a maxillary canine is subjected to more stresses than the mandibular since forces are transmitted outward (labially) on the maxillary arch against the inside of the curve (its weakest point).

When a cantilever pontic is employed to replace a missing tooth, the forces applied to the pontic have an entirely different effect on the abutment tooth. The pontic acts as a lever which tend to be depressed under forces with a strong occlusal vector.

7. Type of Retainer Used

There are two types of retainers which are generally used

- Intra coronal
- Extra coronal

In the intra coronal retainers, the retention is obtained between the inner wall of the tooth preparation i.e. the internal wall of the prepared cavity and the casting.

On the other hand, in extra coronal retainers, the retention is obtained between the outer wall of the tooth preparation and the inner wall of the retainer.

7. Materials Employed in the Construction of Retainers

The material used in the construction of the fixed partial dentures calls for certain requirements which help to increase the longevity of the restoration.

Cobalt chromium or nickel chromium alloys generally used for making fixed bridges fulfill majority of these ideal requirements. On the other hand acrylic is generally weak, is not rigid and cannot provide strong connectors. It also has lower compressive and tensile strength compared to other alloys and is thus easily subjected to fracture. Hence acrylic is used for interim on temporary restorations in the mouth.

8. Arch Position of the Abutment Teeth and Retention

When the abutment teeth are more or less parallel to each other, complete or partial crown retainers can be made. If the abutment teeth are not parallel, complete crown retainers with a common path of insertion are not feasible.

9. Spring Cantilever Bridges and Retention

This bridge provides a method of supporting a pontic at some distance from the retainers. This type of bridge is both tooth and tissue supported. A gold bar which fits in contact with the palatal mucosa connects the pontic to the retainers.

DIFFERENT TOOTH PREPARATION AND WAYS OF ACHEIVING RETENTION IN EACH

Complete Cast Crown Preparation

Ways of Gaining Retention While Tooth Preparation:

After the occlusal reduction is completed, the guiding grooves are placed on the axial walls. When these guiding grooves are placed, the dentist should be sure that the shank of the diamond is parallel to the proposed path of withdrawal of restoration. A diamond taper bur with a taper of 3-6° should be used and thus an identical taper on the preparation wall will result. Place the cervical chamfer concurrently with axial reduction. Width of the chamfer should be approximately 0.5mm which will allow adequate bulk of metal at the margin [7, 8].

The Metal Ceramic Crown Preparation

Factors affecting retention that should be taken into consideration while preparation

1. The completed reduction of the incisal edge on an anterior tooth should allow 2mm of adequate material thickness to permit translucency in the completed restoration. Caution must be used here to prevent over reduction because excessive occlusal reduction shortens the axial wall and thus is a common cause of inadequate retention and resistance form of completed restoration [3].
2. Labial reduction of 1.5mm should be done for the adequate retention of metal and porcelain and the shoulder preparation should have a 90° butt joint.
3. Reduction of the proximal and linguo-axial surfaces should be done with a diamond held parallel to the path of withdrawal of the restoration giving an approximate taper of 6°. If this is not followed, a slightly more taper or discrepancy in taper of two walls will result thus affecting retention.
4. In a completed restoration, all the line angles and point angles should be rounded. This will help in reducing the stress concentration and thus will enhance retention.

THE PARTIAL VENEER CROWN PREPARATION

Posterior Teeth Three Quarter Crown

1. During axial reduction place grooves for axial alignment in the centre of the lingual surface and in the mesiolingual and distolingual transitional line angles. These grooves should be made parallel to the long axis of tooth.
2. During proximal reduction the proximal grooves are placed parallel to the path of withdrawal. The groove should not be deeper than 1mm and is best done with a tapered carbide bur. The grooves prepared should resist lingual displacement of the periodontal probe.
3. If additional bulk is needed to ensure rigidity of the restoration it can be provided with an occlusal offset. This V-shaped groove extends from the proximal grooves along the buccal cusp.

Anterior Partial Veneer Three Quarter Crown Preparation

With the advent of metal ceramic restorations the use of partial veneers on anterior teeth has lessened somewhat during recent years. However two types of partial veneer anterior crown preparations are still done.

1. Maxillary canine three quarter crown.
2. Pin ledge preparations.

To enhance the retention and resistance form of the preparation a slightly exaggerated chamfer on the lingual aspect of the tooth should be placed and a guiding groove in the middle of the cingulum wall.

The mesial and the distal proximal grooves provide most of the retention form for the anterior partial veneer crowns. They are made with a 170L carbide bur and converage at an angle of 3-5° degree.

Pin Ledge Preparation and Retention

A pin ledge is occasionally used as a single restoration generally to re-establish anterior guidance, in that case only the lingual surface is prepared. More commonly, however, it is used as a retainer for an fixed partial denture or to splint periodontally compromised teeth [9].

RETENTIVE REATURES FOR ALL CERAMIC RESTORATION

An all ceramic restoration remains the most aesthetic restoration for duplicating individual anterior teeth. Adequate tooth reduction is created to achieve space for the porcelain bulk required for the strength of the restoration.

RETENTIVE FEATURES TO BE TAKEN INTO CONSIDERATION DURING EACH STEP OF THE PREPARATION

Incisal Reduction

There should be an adequate incisal reduction of 2mm otherwise brittle failure of the material occurs.

Facial Reduction

The facial reduction is performed with a coarse flat end diamond to remove the labial surface while establishing a preliminary shoulder. The incisal 2/3rd of the facial surface should be inclined lingually to provide uniform porcelain and ensure suitable aesthetics. Insufficient tooth reduction on the facial surface can lead to either a tooth thin coverage contoured restoration. This can also lead to the failure of the restoration.

Proximal Reduction

Excessive taper of the proximal surface should be avoided which can also lead to loss of retention by decreasing the surface area and also the parallelism of walls.

Lingual Reduction

Proper lingual reduction is very important for the strength and retention of the restoration. The lingual surface of the tooth is generally reduced in two planes. First cingulum shoulder is placed with a flat ended tapered diamond to crest a 0.75mm shoulder in the cingulum with a 2-5° taper. The cingulum reduction is now completed.

A flame shaped or wheel shaped diamond is used to form the lingual concavity of the anterior teeth.

Inadequate tooth reduction of the lingual surface can lead to loss of clearance and also diminished strength for the porcelain which can over all lead to loss of retention of the restoration.

Proper Finish Line

A proper marginal finish line is very important for the retention. Inadequate finish line in some areas of the preparation can lead to microleakage thus leading to the loss of retention [10].

Sharp Points and Undercuts

All the sharp points and undercuts should be removed or rounded off to prevent the accumulation of the stresses and thus prevent the subsequent failure of the restoration.

RETENTION IN ENDODONTICALLY TREATED TEETH

It has been demonstrated experimentally that endodontically treated teeth are weaker and more brittle than vital teeth. So for this reason attempts have been made to strengthen the teeth by removing part of the root canal filling and replacing it with a metal post [11].

Also when the teeth will be serving as an FPD abutment, a complete crown becomes mandatory. Under these circumstances, the retention and support most be derived from within the root canal [12].

Canal Retention

It is recommended that the root canal should be enlarged only to amount necessary to enable the post to fit snugly for strength and retention.

RETENTION IN PORCELAIN LAMINATE VENEERS

To ensure a uniform thickness and the retention of the laminate veneer, the following criteria must be met: [13]

a. There should be a uniform reduction on the labial surface of the tooth and the preparation should remain within the enamel whenever possible.
b. The margin of the porcelain laminate veneer should generally be hidden within the embrasure area.

A modified chamfer finish line ensures correct enamel preparation exposing correctly aligned enamel rods for increased bond strength at the cervical margin thus increased retention.

It also ensure an adequate bulk at the margins and hence it increases the strength [14].

Etching the porcelain is also said to be a predominated factor in producing the retention.

RETENTION FOR CERAMIC INLAYS AND ONLAYS

Ceramic inlays and onlays provide a durable alternative to posterior composite resins for patients demanding aesthetic restoration [15].

For maximum retention following points should be taken cared of:

- The outline and the reduction of the tooth is governed by the existing restorations and caries. Now here is resin bonding, the axial wall undercuts can be blocked out with GI cement preserving additional enamel for adhesion and thus the increased retention of the restoration.
  However undermined and weakened enamel should always be removed.
- The outline should avoid occlusal contacts. Areas to be onlayed need 1.5mm of clearance in all excursions to prevent ceramic fracture and thus increase the longevity of the restoration.

- In this preparation, it is preferred that the margin is kept supragingival, if this is not possible, crown lengthening is advisable.
- All the internal line angles should be rounded to prevent stress concentration and to thus enhance retention.
- A 90° butt joint should be given for ceramic inlay margin. Bevels are contraindicated because bulk is needed to prevent fracture and thus increase the longevity.
- Final retention is achieved during the bonding of the inlay as it is done with a resin luting cement. In this procedure acid etching is done which creates micro tags and help in mechanical retention.

RETENTION IN RESIN BONDED BRIDGES

The retention of this prosthesis depends on the adhesive bonding between the etched enamel and the metal casting. To enhance retention in these restorations, significant clinical crown length should be present. If there is insufficient moisture control, retention is minimized. Short clinical crown and narrow embrasures are also a contra indication for resin retained FPD because in these type of teeth, surface area is reduced and thus the retention. If a patient has parafunctional habits, this restoration should not be given because they lead to early failure of the restoration [5,16].

ROLE OF LUTING CEMENTS IN RETENTION

The type of luting agent chosen affects the retention of cemented restoration.

Five kinds of luting agents are most commonly used:

1. Zinc Phosphate
2. Zinc Polycarboxylate
3. Glass ionomer
4. Zinc oxide eugenol
5. Resin bonded cement.

The Retention of restorations has been achieved primarily by mechanical interlocking of the cement into irregularities on the internal surface of the fabricated restoration and the tooth preparation.

Polycarboxylate and glass ionomer cements adhere directly to calcified tissues by chemical attraction to calcium ions in addition to mechanical interlocking [17].

True adhesion between cement and tooth is desirable because of potential to reduce microleakage between the tooth and the restoration [18].

Retention failure has been shown if the internal surface of the surface of the restoration is very smooth [19]. So it is recommended to air abrade the internal surface of the casting with 50µm alumina. Retention has been seen to be more with more reactive alloys i.e. nickel, cobalt and chromium are more retentive and better retained than less reactive high gold content metals.

Film Thickness of the Luting Cement

There is a conflicting evidence on the effect of increased thickness of cement film on retention of the restorations. But its proved there, a uniform thickness of cement between restoration and tooth provides more retention than a non-uniform thickness.

A film thickness of 2.5µm or less has been preferred for successful restoration.

CONCLUSION

Retention in fixed partial denture, is one of the important factor in the success of fixed partial dentures. There is no single factor on which retention is totally dependent. In fact retention comprises of a list of factors, all of which have to be taken into consideration during all the stages starting from tooth preparation to the final cementation. Even if a single factor is neglected it can affect the retention of the casting which further has a direct influence on the longevity of the restoration.

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