Principles of Tooth Preparation - Review Article

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Abstract

Adequate tooth preparation is essential for the fit of fixed prosthodontics. Insufficient tooth preparation appears to be responsible for premature failures due to biological aspects, such as caries and endodontic or periodontal disease complications. The purpose of a fixed prosthodontic therapy may vary from the restoration of a single tooth to the rehabilitation of the complete occlusion. Successful preparations can be obtained by systematically following these steps. It is important to critically evaluate each step before proceeding to the next step to ensure an optimal quality final restoration, which will serve the patient for a long time.

Keywords: *Finish lines, taper, resistance, retention, structural durability*

Introduction

Crowns and fixed partial dentures are the major prosthodontic treatment modalities for past several decades with factors like esthetics, contact points and pontics playing an important role in varying their design[1]. The purpose of a fixed prosthodontic therapy may vary from the restoration of a single tooth to the rehabilitation of the complete occlusion. A single tooth can be fully restored both functionally and aesthetically. A missing tooth can be replaced by a fixed prosthesis, increasing patient masticatory competence and maintaining or improving dental arches function, often elevating patient's self-image.

There is a general recognition that adequate tooth preparation is essential for the fit of fixed prosthodontics. Insufficient tooth preparation appears to be responsible for premature failures due to biological aspects, such as caries and endodontic or periodontal disease complications[2]. In the case of finish lines, different recommendations have been made to improve esthetics, minimize marginal fitting irregularities, and reduce stress concentration at the margins[3].

Tooth preparation should have specific geometrical characteristics to provide necessary retention and resistance to the vertical and lateral forces acting on the restoration. The most important element of retention is the presence of two opposing vertical surfaces. The axial walls of the preparation should taper slightly to allow the cementation of the artificial crown. The more parallel are the axial walls the greater is the retention[4].

OBJECTIVES OF TOOTH PREPARATION

The main objectives of tooth preparation

- Reduction of a tooth in miniature to provide retainer support.
- Preservation of healthy tooth to secure resistance form.
- Provision for acceptable finish lines.
- Performing pragmatic axial tooth reduction to encourage favourable tissue responses from artificial crown contours

TOOTH PREPARATION CAN BE STUDIED UNDER[5]

A. 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.

B. Mechanical consideration: These affect the integrity and durability of the restoration.

C. Esthetic consideration: These affect the appearance of a patient.

BIOMECHANICAL PRINCIPLES OF PREPARATIONS

The designs and preparations of a tooth for a cast metal or porcelain restorations are limited by five principles:-

1. Preservation of tooth structure.
2. Retention and resistance from.
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; the minimal amount of the tooth structure must be removed. Excessive removal of the tooth structure has many harmful effects: -

- Excessive reduction 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.

2. Retention and resistance form

Retention: is the ability of the preparation to resist the crown restoration from removal 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: An imaginary line along which the restoration can be inserted and removed without causing lateral force 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 crown restorations is parallel to the long axis of the tooth except in ¾ crown for anterior teeth where the path of insertion should be parallel to the incisal 2/3 of the tooth crown (not to the long axis). By limiting the path of withdrawal, retention is improved

Factors affecting retention and resistance:

a. Taper of the preparation.
b. Surface area of the preparation,
c. Length and height of the preparation.
d. Diameter of the tooth (tooth width).
e. Texture of the preparation.
f. Accessary mean.

a. Taper of the preparation (5-6) degree 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 wall is difficult to be obtained in the patient mouth without undercuts, also parallel walls might lead to difficulty in seating of the crown restoration, thus (5-6) degree convergence angle is mostly used to provide the needed retention.

Taper and Resistance: The more parallel the axial walls 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.

b. Surface area of the preparation: Increasing the surface area increase retention. Factors that influence surface area are:

- Size of the tooth The larger the size of the tooth the more will be the surface area of the preparation, the more will be the retention thus full metal crown on molar tooth definitely more retentive than that on premolar tooth.
- Extend of coverage by restoration: The more the area that will be covered by the crown restoration, the more will be the retention, thus full metal crown on molar is more retentive than 3/4 crown on the same tooth.
- Accessory feature such as boxes, grooves and

pin holes.

c. Length (height) of the preparation: Increasing the length increase retention and resistance and vice versa.

d. Diameter of the tooth (tooth width): Under some circumstances, crown on narrow tooth can have grater resistance to tipping than a crown on a wider tooth, this occur because the crown on the narrower tooth has shorter radius for rotation resulting in a lower tangent line and a larger resisting area.

e. Texture of the preparation. Depending on the type of cementation agent, texture of the preparation might effect on the retention of cast crown. Smooth surfaces are less retentive than rough (mechanical interlocking).

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

3. Structural Durability (SD): The preparation must be designed so that it provide S.D. to the restoration, i.e. the crown restoration must be rigid enough to not flex, perforate (metal) or even fracture (plastic). For a restoration to be rigid it need bulk, so 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 allowed to withstand the forces of occlusion, prevent wearing holes in the gold and allow proper contouring and carving of the restoration.

Preparation features related to Structural Durability:-

a. Occlusal reduction. Enough tooth structure must be removed from occlusal surface so that the restoration can be built back to ideal occlusion & 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 through or distortion.

Functional cusps: 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 occlusal surface.
- Avoid creating steep planes with sharp angles, because it lead to stress.
- Flat occlusal reduction lead to thin metal, this will lead to perforation of the crown restoration in future.
- Lowering the entire occlusal surface in attempt to providing sufficient space might lead to tooth structure destruction (non-conservative preparation) &shortening of the axial wall of prepped tooth which defiantly will affect the retention-resistance potential of the preparation.

Functional cusp bevel (FCB) Wide bevel should be placed on the functional cusps of posterior teeth to provide structural durability (it allows adequate thickness of restoration at this critical area without structure destruction). If FCB is omitted, the restoration is likely to be thin in this stress bearing area. If the restoration thickness is achieved by over tapering, this will compromise the retention. In the absence of FCB --- technician will overbuild the crown restoration in attempt to provide structural durability for the restoration this will lead to super-occlusion or premature contact with the opposing tooth.

b. Axial reduction: Sufficient reduction is important to provide sufficient space so that the restoration can build with sufficient thickness, this will prevent flexing of the crown restoration when occlusal force is acting on it.

c. Reinforcing struts: the features that serve to provide space for the metal that will improve the durability and the rigidity of the restoration: Offset the occlusal shoulder, the isthmus, the proximal grooves, and the box. Isthmus connects the boxes, and the offset ties the grooves together to enhance the reinforcing "truss effect".

4. Preservation of periodontium

Margin Placement Wherever possible, the margin

of the preparation should be supragingival. Subgingival margins of cemented restorations have been identified as major factors in periodontal disease particularly when the encroach upon the epithelial attachment.

Advantages of supragingival margins

- They can be easily finished
- They are more easily kept clean.
- Impressions are more easily made with less potential for soft tissue damage.
- Restorations can be easily evaluated at recall appointment.

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

- Dental caries, cervical erosion, or restorations subgingivally and a crown-lengthening procedure is not indicated.
- The proximal contact area extends to the gingival crest.
- Additional retention is needed.
- The margin of a metal ceramic crown is to be hidden behind the labiogingival crest.
- Root sensitivity cannot be controlled by more conservative procedures.
- Modification of the axial contour is indicated.
- High D.M.F. rate of younger patients.

Gingival Termination of Tooth Preparation

The gingival finish lines are very controversial when it comes to tooth preparations. The precious recommendation was to extend crown margins into the intracrevicular space because the gingival crevice was thought to be immune to caries. In spite of the strong evidence that supported supragingival margins, subgingival margins were still used. Generalities as to where finish lines should be placed for an optimal contour require analysis. The subgingival area is not an immune area.

Supragingival Versus Subgingival Margins

Ideally the most innocuous position of the margin for soft tissue health is above the gingival crest. An esthetic position for anterior restorations would be subgingivally between the epithelial attachment and the crest of the gingival,I he area above the gingival crest is desirable but considered offensive by some patients. Supragingival margins are usually advocated for restorations placed subsequent to periodontal surgery and for elderly patients who exhibit a normal recession.

5. Marginal integrity

The restoration can survive in the biological environment of the oral cavity only if the margins are closely adapted to the cavosurface finish line of the preparation. The configuration of the preparation finish line dictates the shape and bulk of restorative material in the margin of the restoration It also can affect both marginal adaptation and the degree of seating of the restoration

TYPES OF FINISH LINES

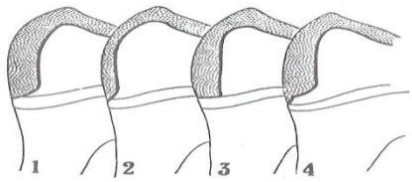
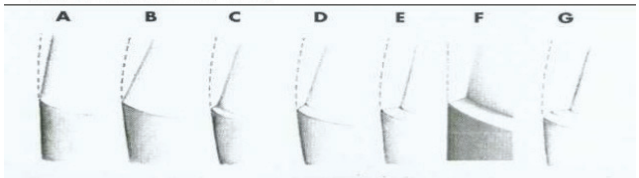


Fig. 5-21. Types of finish lines. 1, Chamfer provides bulk at the finish line. 2, Knife-edge provides minimal reduction. 3, Shoulder used for porcelain jacket crowns. 4, Chamfer or shoulder with bevel used for porcelain fused-to-metal crown. (Courtesy D.A. Kaiser, San Antonio, Tex.)



A. Featheredge, B. Chisel, C. Chamfer, D. Bevel, E. Shoulder, F. Sloped Shoulder, G. Beveled shoulder

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TYPES OF FINISH LINES

Chamfer finish line: The preferred finish line for the veneer metal restorations is the chamfer. This finish line has been shown experimentally to exhibit the least stress, so that the cement underlying it will less likelihood of failure. It can be cut with the tip of a round end diamond, while the axial reduction is being done with the side of that instrument. However, a torpedo diamond is less likely to produce a butt joint. The margin of the cast restoration that fits against it combines an acute edge with a nearby bulk of metal

Heavy chamfer finish line: A heavy chamfer is used to provide a 90-degree cavosurface angle with a large radius rounded internal angle. It is created with a round end tapered diamond. In the hands of an unskilled operator, this instrument can create an undesirable fragile lip of enamel at the cavosurface. The heavy chamfer provides better support for a ceramic crown than does a conventional chamfer, but it is as good as a shoulder. A bevel can be added to the heavy chamfer for use with a metal ceramic restoration.

Shoulder: The shoulder has long been the finish line of choice for the all-ceramic crowns. The wide ledge provides resistance to occlusal forces and minimizes stresses that might lead to fracture of the porcelain. It produces the space for healthy restoration contours and maximum esthetics. However, it does require destruction of more tooth structure than any other finish line, the sharp 90-degree internal line angle associated with the classic variety of this finish line concentrates stress in the tooth and is conductive to coronal fracture. The shoulder generally is not used as a finish line for cast metal restorations.

Shoulder with bevel: The shoulder with a bevel is a used as a finish line in a variety of situations. It is utilized as the gingival finish line on the proximal box of inlays and onlays, and for the occlusal shoulder of onlays and mandibular three quarter crowns. This design can also be used for the facial finish line of metal ceramic restorations where gingival esthetics is not critical. It can be used in those situations where a shoulder is already present, either because of destruction by caries or the presence of previous restorations. It is also a good finish line for preparations with extremely short walls, since it facilities axial walls that are nearly parallel.

Knife-edge: The knife-edge margin provides for an acute margin of metal. But its use can create problems. Unless it is carefully prepared, the axial reduction may fade out instead of terminating in a definite finish line. The thin margin of the restoration that fits this finish line may be difficult to accurately wax and cast. It is also more susceptible to distortion in the mouth when the casing is subject to occlusal forces.

Featheredge: A featheredge finish line is unacceptable because it is not sufficiently distinct and results in so little cervical tooth reduction that the restoration must be over contoured to possess adequate rigidity. Also, since a feather edge is more difficult to see visually, occlusocervical undulations and irregularities in the finish line are more likely to be present, making it much more difficult to fabricate a restoration that fits accurately

MECHANICAL CONSIDERATIONS

3 factors

1. Retention form
2. Resistance form
3. Preventing deformation of restoration

1. Retention Form

The quality of the restoration that prevents the restoration from being dislodged by force parallel to the path of withdrawal called as retention form.

a. Magnitude of dislodging forces:-

Forces can be exerted with a floss under the connectors but mainly force is exerted by adhesiveness of foods. The magnitude of dislodging force depends on

- Stickiness of food
- Surface area of restorations
- Texture of restoration being pulled

b. Geometry of tooth preparation

Most fixed prosthesis depend on the geometric form of tooth preparation rather than on adhesion tooth retention as most of the dental cements are non-adhesive and act by increasing the frictional resistance between tooth and restoration. Cement is effective only if the restoration has a single path of withdrawal.

Taper

Parallel walls give maximum retention but sometimes undercuts may be created (undercut is defined as a divergence between opposing occlusal walls or wall segments in cervico-occlusal direction).

The relationship between taper and magnitude of retention was demonstrated by Jorgensen in 1955. He cemented brass caps of different tapers and measured

retention. The relation was found to be hyperbolic i.e. retention decreased as taper increased. E.g. Retention of GALILTH with 10° taper was half that of 50 taper. Recommended taper is 5-8° with a rotary instrument held at constant angle.

Surface Area

- Crowns with long axial walls are more retentive than crowns with short axial walls.

- Molar crowns are more retentive than premolar crowns of similar taper.

Stress Concentration

- Cohesive failure occurs within the cement as the stress within cement is less than that of induced stresses. Stresses are seen to concentrate around the junction of axial and occlusal surfaces.

- Modifications like rounding of internal line angles will reduce the stress concentration and increase retention of the restoration.

- It is seen that retention of complete crowns is almost twice as that of partial coverage. Grooves or boxes in a preparation which limit the path of withdrawal enhances the retention.

c. Roughness of Surface being cemented

- If fitting surface made very smooth failure seen to occur at the cement restoration interface thus castings are delibrately roughened at the fitting surface and this has shown to increase retention. E.g. Roughening the surface by air abraiding with 50 fm alumina increases retention by 64%.

- Failure rarely occurs at the cement tooth interface thus roughening the tooth in an attempt to increase retention is not recommended.

d. Materials being cemented

Retention is affected by both casting metal and core build up material. It is seen that the more reactive the alloy is the more will be retention with certain luting agents.So, base metal alloys are more reactive than the less reactive high gold content metals. A study examining adhesion between cement and core materials found that cement adhered better to amalgam than composite or cast gold.

e. Type of luting agents

Adhesive resin cements are supposed to be most durable although long term clinical evidence about the durability of bond is not yet available.

2. Resistance Form

Restorations are also subjected to horizontal or oblique forces. E.g. mastication/ parafunctional habits. Lateral forces tend to displace the restoration by causing rotation around the gingival margins. This rotation is prevented by areas of the preparation that are placed under compression called as Resistance areas. Many such areas make up the resistance form. Adequate resistance depends on:-

- Magnitude and direction of dislodging forces

- Geometry of tooth preparation

- Physical properties of luting agents.

a. Magnitude and direction of dislodging forces

In normal occlusion biting force distributed over all the teeth. Similarly in FPD, occlusal load should be well distributed and favourably directed. In patients with pipe smoking, bruxism habits, oblique forces are exerted over FPDs. Thus, an ideal restoration should be able to withstand these forces as well as the normal axial forces.

b. Geometry of tooth preparation

Particular areas of axial walls help prevent rotation of the crown. Hegdahl and Silness analyzed how these resisting areas alter as changes are made in geometry of tooth preparation. They demonstrated;

- Increase preparation taper and rounding of axial walls decreased resistance.

- Shorter tooth preparation with large diameter - little resistance form.

- Partial coverage crown has less resistance than a complete coverage (as no buccal resistance areas).

- Resistance can also be improved by placing grooves and boxes especially with walls being perpendicular to the direction of applied forces.

- U-shaped grooves better than V-shaped. These grooves and pinholes interfere with rotational movement and subject other areas of luting agent to compression.

Additional Resistance and Retention

Grooves or boxes e.g. in 7/8- or 3/4- crowns. Pins increase retention by increasing surface area tapered. 5 ways to resist displacing forces

- 4-10° axial taper
- Suitable gingival finish lines
- Contouring and placing suitable contact areas
- Incorporating occlusal locks, dove tails, boxes
- Tapered and parallel pins.

ESTHETIC CONSIDERATIONS

The restorative dentist should develop skill in determining the esthetic expectations of the patient. Patients prefer their dental restorations to look as natural as possible. However, care must be taken that the esthetic considerations are not preserved at the expense of the patient's long term oral health or functional efficiency. Whenever possible, accomplishment of an esthetically acceptable result without the use of metal-ceramic crowns is preferred, not only because tooth structure is conserved but also because no restorative material can approach the appearance of intact tooth enamel.

Conclusion

The principles of tooth preparation can be categorized as biologic mechanical and esthetic, often these principles conflict and operator must decide the design of the restoration. Each tooth preparation must be measured by clearly defined criteria, which can be used to identify and correct problems. It is important to understand the pertinent theories underlying each step. Successful preparations can be obtained by systematically following these steps. It is important to critically evaluate each step before proceeding to the next step to ensure an optimal quality final restoration, which will serve the patient for a long time.

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Conflict of Interest – Nil

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