A clinical view of mandibular premolars in removable partial denture design

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Mandibular premolars are used as a model to discuss various strategies for the design of removable partial dentures. Factors that must be taken into consideration as the prosthesis is designed, such as coronal and radicular anatomy of the abutment teeth, the relationship of the abutment teeth to other teeth, and the presence of existing restorations, are also identified. (Quintessence Int *1990;21:21–26.*)

Introduction

The essence of removable partial denture (RPD) design is that of variation; the analysis of any partially edentulous arch will produce a multitude of potential prosthetic designs. Several factors must be considered when the design of the removable partial denture is being planned by the practitioner. This article describes these factors using mandibular premolars as a basis for discussion.

Mandibular premolars as RPD abutments

Mandibular premolars are important abutments in the fabrication of an RPD. Patterns of tooth morbidity often leave either the first or second premolars as terminal abutments when the mandibular molars are lost to dental caries or periodontal disease. Premolars may be used as either primary or secondary abutments for the retention and support of the RPD. A primary abutment is a tooth that receives the clasp assembly. A secondary abutment is a tooth that receives a rest only and provides vertical support for the restoration or serves as an indirect retainer. The following is a description of those factors that must be considered in the design of RPDs as it relates to the mandibular premolars.

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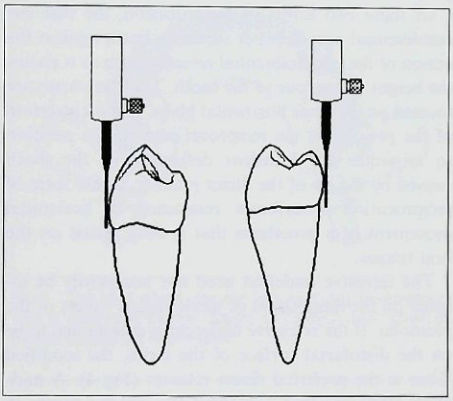

Fig 1 Distal views of mandibular first and second premolars with analyzing rods indicating the heights of contour on the teeth.

Tooth anatomy — coronal form of the tooth

The surveyed height of contour of mandibular premolars provides a retentive surface that is generally on the lingual aspect (Fig 1). Application of a circumferential clasp necessitates recontouring the distolingual portion of the tooth to use the mesiolingual undercut or a mesiolingual recontour when the distolingual undercut is employed. The low height of contour on the facial surface is a natural location for reciprocation.

However, the situation that develops most often clinically is just the opposite. With judicious tilting of the surveyor,[1] an appropriate undercut may be obtained on the facial surface of the tooth that provides retention (classically the mesiofacial undercut is used with wrought wire), and the lingual surface is used for reciprocation. In this instance, reciprocation is best obtained by extending the linguoplate along the lingual slope of the lingual cusp (Fig 2).

When the mesiodistal dimension of the premolar is especially narrow, adequate flexibility for a lingually placed direct retainer cannot be developed because of the shortness of the clasp arm. This situation will again necessitate the use of facial retention, and reciprocation is provided by a lingual cast circumferential arm (Fig 3) or the superior border of the linguoplate (Fig 2).

Of these two forms of reciprocation, the cast circumferential arm is better suited to brace against the action of the circumferential retentive arm as it passes the height of contour of the tooth. The clasp arms are located on the same horizontal plane, and on insertion of the prosthesis, the reciprocal arm is in a position to minimize the transient deflection of the tooth caused by the tip of the direct retainer. Either form of reciprocation contributes resistance to horizontal movement of a prosthesis that is fully seated on the oral tissues.

The retentive undercut need not necessarily be located on the mesiofacial or mesiolingual aspect of the premolar. If the retentive undercut is determined to be on the distofacial surface of the tooth, the modified T-bar is the preferred direct retainer (Fig 4). A midfacial undercut that is located low on the tooth, in combination with an attempt to maximize esthetics, indicates the use of the I-bar direct retainer (Fig 5).

Tooth anatomy — root

The crown-root ratio must be considered to arrive at a reasonable prognosis for the tooth serving as an abutment. This ratio must exceed 1:1, concurrent with minimal tooth mobility, for the tooth to be suitable as an abutment for the RPD.[2] A marginal crown-root ratio is not necessarily a reason to abandon a potential abutment, as long as the tooth has minimal mobility.

Teeth with large, multiple, noncircular cross-sectional roots are better abutments than those teeth with the opposite characteristics. The roots of mandibular premolars are of reasonable length, are only rarely multiple, but are circular in cross section. The latter characteristic leaves the teeth especially susceptible to rotational forces.

The periodontal status of the abutments should be stable, specifically, there should be no untreated periodontal disease. Probeable pocket depths should not exceed 2 to 3 mm and should be free of bleeding. There should be an absence of inflammation.

If the mandibular anterior teeth exhibit some degree of mobility, the major connector of choice is the linguoplate. The superior border of this connector is located along the lingual surfaces of the teeth and provides some degree of stabilization not provided by the lingual bar.

Relationship of the tooth to those in the same arch

Frequent sequelae to extraction of mandibular molars, without subsequent provision of dental restorations, are loss of posterior support, increasing prognathism and anterior positioning of the mandible, and tipping of the premolars into linguoversion. This tipping leaves the height of contour on the facial surface of the premolars at the level of the free gingival margin (an ideal situation for reciprocation, especially when taken out of context), but places the height of contour near the lingual cusp tip, making retention difficult. Placement of a rest on this tooth and the subsequent occlusal forces, which are not directed along the long axis of the tooth, can be destructive periodontally.

Occasionally mandibular premolars are rotated. When the rotation brings the buccal aspect of the abutment into contact with the distal surface of the adjacent tooth, rest placement is on the lingual surface, in what is anatomically the mesio-occlusal surface of the tooth. This takes advantage of the concavity provided by the mesio-occlusal fossa and helps direct forces along the long axis of the tooth. A retentive undercut is usually placed on what is now the facial aspect of the tooth, but is anatomically the distal surface of the premolar. Reciprocation is provided by the minor connector, which is continuous with the lingual rest (Fig 6).

A terminal abutment serving as a primary abutment, and isolated some distance from the remainder of the dental arch, must be dealt with carefully. Its free-standing nature, without the benefit of adjacent teeth for support, subjects it to stress from all directions. The isolated terminal abutment must be provided with occlusal rests in both fossae to assure that occlusal loads are directed along the long axis of the tooth (Fig 7).

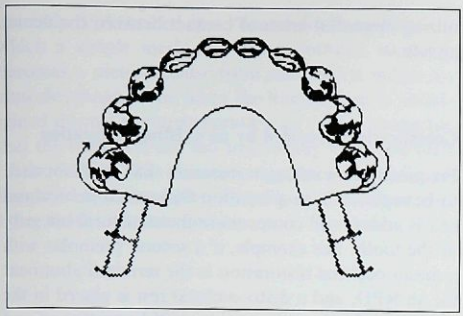

Fig 2 Reciprocation in this case is provided by the superior border of the linguoplate. Wrought wire circumferential direct retainers *(arrows)*.

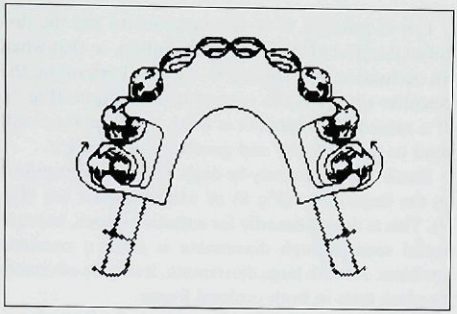

Fig 3 Reciprocation in this case is provided by cast circumferential arms. Wrought wire circumferential direct retainers *(arrows)*.

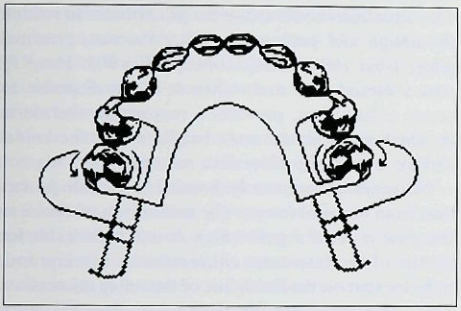

Fig 4 The modified T-bar direct retainer *(arrows)* may be employed when the retentive undercut is on the distofacial surface of the tooth.

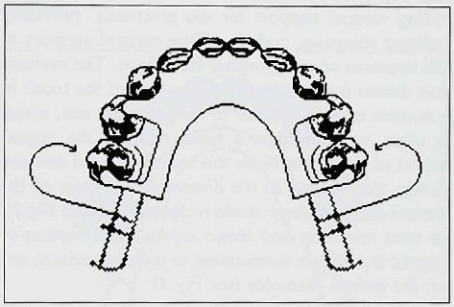

Fig 5 The I-bar direct retainer *(arrows)* may be employed with a gingivally placed height of contour and when esthetics should be maximized.

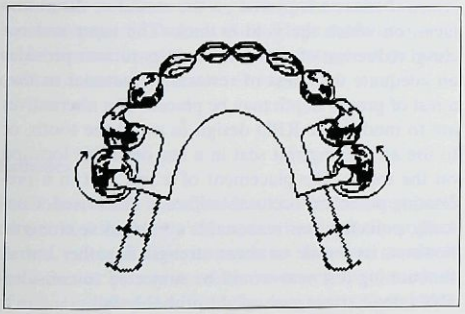

Fig 6 Rotated premolars are an occasional sequelae to the extraction of adjacent teeth. Wrought wire circumferential direct retainers *(arrows)*.

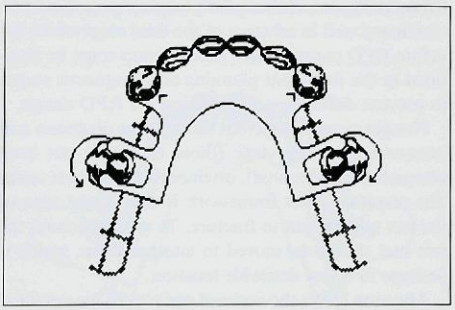

Fig 7 Reciprocation in this case is provided by the minor connectors continuous with the mesio-occlusal and disto-occlusal rests. Wrought wire circumferential direct retainers *(arrows)*. An alternative would be to obtain retention on the mesiofacial surface of the canines with wrought wires; thus the isolated premolars are not subjected to additional stress from the clasps.

If it is possible, it is advantageous to use the distofacial aspect of the tooth for retention, so that when an occlusal load is applied to the distal extension, the retentive tip will break contact with the tooth (Fig 7). If a mesiofacial undercut is used, a similar force will tend to tip the tooth and gradually subluxate it.

Small diastemata may be dealt with by interruptions in the linguoplate (Fig 8) or with a lingual bar (Fig 9). This is done primarily for esthetic reasons, because metal seen through diastemata is often a cosmetic problem. As with large diastemata, it may be advisable to place rests in both occlusal fossae.

Thin enamel and difficult access to the lingual surface of mandibular canines indicate use of the mesio-occlusal fossa of the first premolar as a rest seat. This rest and rest seat often serve several functions: providing vertical support for the prosthesis, providing indirect retention, and providing vertical support at the terminus of a linguoplate (see Fig 3). The occlusal rest directs forces along the long axis of the tooth in a manner superior to that of the cingulum rest, which is often no more than a small nick on the lingual aspect of the tooth. From this mesio-occlusal rest, the design may extend to the disto-occlusal fossa of the second premolar to provide reciprocation (see Fig 2), or pass inferiorly and blend into a short section of lingual bar, before terminating in a disto-occlusal rest on the second premolar (see Fig 3).

Relationship of the tooth to those in the opposite arch

Cusps in hyperocclusion and plunger cusps should be eliminated well in advance of the final stage of design before RPD construction. Interferences must be identified in the treatment planning and diagnostic stages to prevent difficulties in finalizing the RPD design.

Plunger cusps that persist through the diagnosis and treatment planning stage (those that have not been adequately recontoured), often occlude into rest seats. The resulting RPD framework is thin in the area of the rest and subject to fracture. To avoid fracture, the rest seat should be moved to another fossa, which is perhaps in a less desirable location.

Abrasion leaves the occlusal surfaces of the potential abutment teeth flat, allowing the forces of mastication to be concentrated on those teeth. It is important to make sure that the rest seat in the tooth is deep enough so that opposing teeth are not in hyperocclusion with the rest and to provide a degree of anatomic contour to the metal rest to establish sluiceways, thus minimizing large, flat areas of contact between the dental arches.

Complications provided by an existing restoration

Frequently, an existing restoration that does not need to be replaced is in a location that, when an occlusal rest is added, will compromise the structural integrity of the tooth. For example, if a second premolar with a mesio-occlusal restoration is the terminal abutment for an RPD, and a disto-occlusal rest is placed in the tooth, the distal marginal ridge will be weakened and subject to fracture. Such placement violates a basic rule of rest seat design: avoiding placement of a rest seat partially in enamel and partially in a restoration. This situation should cause the practitioner to rethink the design and perhaps to utilize the rest, proximal plate, I-bar (RPI)[3] clasp concept (Fig 10). The RPI uses a mesial rest, and, when it is not desirable to create a distal rest, provides a reasonable alternative in which the rest seat may be placed on the mesial surface, entirely in restorative material.

Weakened cusps must be hooded to provide protection from occlusal forces. The restoration of choice in this case is often a gold onlay. It is not desirable for the tips of the clasp arms, either retentive or reciprocal, to be located on the finish line of the onlay restoration. This situation allows the clasp tip to lever the restoration from the tooth. It is therefore necessary to locate the clasp tips entirely on either the tooth or gold.

A rest seat may be added safely to an existing gold crown if the rest is placed on the mesial or distal surfaces, on which the gold is thick. The taper and occlusal reduction of most crown preparations provides an adequate thickness of restorative material so that a rest of proper depth may be placed. The alternatives are to modify the RPD design to avoid the tooth, or to use an existing rest seat in a less desirable location on the tooth. The placement of a rest seat in a preexisting porcelain occlusal surface is ill advised. Clinically, porcelain has reasonable compressive strength; however, its tensile or shear strength is rather low. A functioning rest seat would be subjected to considerable lateral stress and would probably fail.

If the restoration must be replaced, and an additional surface added to support the rest (eg, a mesio-occlusal restoration converted to a mesio-occlusodistal for the distal rest), great care must be taken, especially with mandibular premolars, to avoid weakening the lingual or the buccal cusp. This situation

can only be described as a "dental domino effect," in which a simple mesio-occlusal restoration suddenly becomes a mesio-occlusodistal and then a mesio-occlusodistolingual one when the lingual cusp is undermined during cavity preparation or even a crown (so that the tooth will not fail structurally under the load of the RPD). This situation may be avoided by an insightful treatment plan that places the rest on another tooth or tooth surface.

Restorative material considerations

Gold is the best contact and support surface for the clasp assembly (which includes clasp arms, rests, and minor connectors). Its compressive strength and resistance to abrasion are almost ideal characteristics for use with the RPD. However, the expense of gold will often force the practitioner to choose other materials for rest seats.

Modern silver amalgams have excellent compressive strengths and may be used with confidence as rest seats. Amalgam shortcomings are in the area of abrasion resistance; guiding planes as well as surfaces in contact with clasp arms abrade as the patient functions with the prosthesis. At present, the use of composite resin as a rest seat material is not advised because of its relatively low compressive strength.

It is not uncommon to place porcelain-fused-to-gold restorations in the mandibular premolar region to enhance the esthetic result of the case. However, neither the rest seat or the guide plane surface should be in contact with the porcelain. These surfaces should be fabricated in gold to take advantage of its wear resistance and compressive strength.

Esthetics

Premolars in the mandibular arch, for the most part, do not rank highly on the scale of esthetically critical teeth. Certain situations may arise, however, in which the esthetics of a restoration involving these teeth is of major concern. Additionally, as a patient ages, more of the mandibular teeth tend to be visible as the orbicularis oris muscle of the lower lip loses its tone. Esthetics can be enhanced by the selection of a survey line as low on the facial aspect as possible, or by selection of the more esthetic I-bar, which may be kept low on the surface of the tooth.

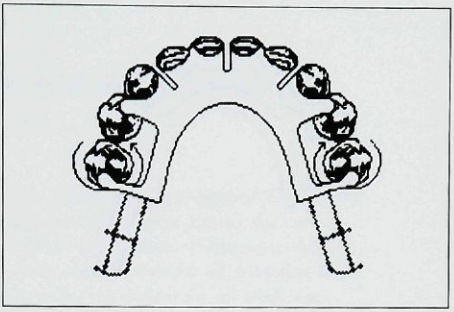

Fig 8 The interrupted plate is useful when the major connector would be visible through diastemata. In this figure, the retentive undercut is located on the mesiolingual aspect of the tooth. Wrought wire circumferential direct retainers *(arrows)*.

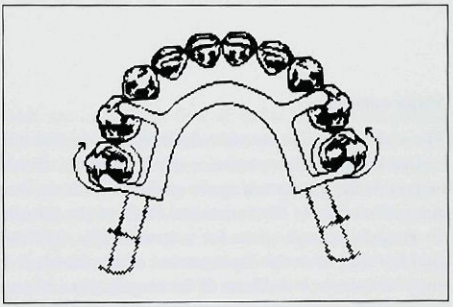

Fig 9 The lingual bar major connector requires 10 to 13 mm of space between the functional floor of the mouth and the free gingival margin. Wrought wire circumferential direct retainers *(arrows)*.

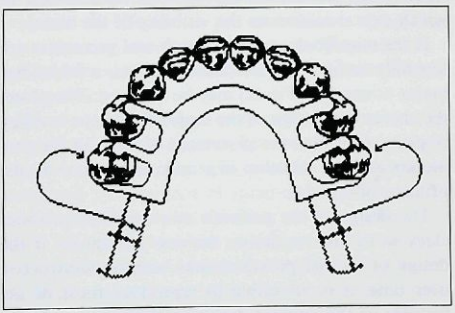

Fig 10 The RPI clasp design system employs a mesial rest, a distal guide plane, and an I-bar *(arrows)*. The minor connectors in the mesio-occlusal surfaces of the first premolars function as indirect retainers.

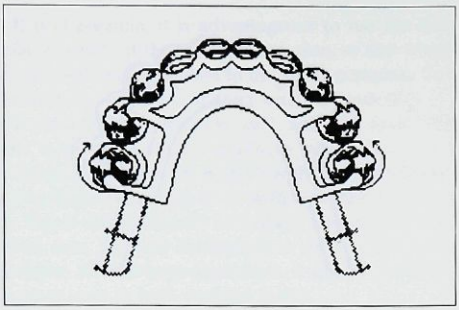

Fig 11 The Kennedy bar covers a minimum of the lingual surface of the mandibular anterior teeth. Its superior bar provides the same stabilizing effect as a linguoplate. Wrought wire circumferential direct retainers *(arrows)*.

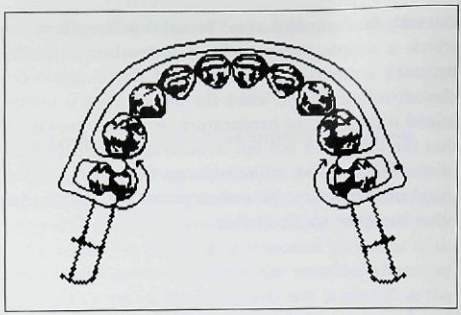

Fig 12 The labial bar major connector is applied when the mandibular teeth are inclined lingually. The location of the connector in the facial peripheral roll may be uncomfortable for the patient. Wrought wire circumferential direct retainers *(arrows)*.

Major connector

The controlling factor that determines whether the lingual bar major connector or the linguoplate should be used is the amount of space available from the free gingival margin to the functional floor of the mouth. To provide enough space for a structurally rigid lingual bar and to avoid impingement of the friable free gingival tissues or the floor of the mouth, 10 to 13 mm is required. If there is insufficient space, either the linguoplate major connector of Kennedy bar (Fig 11) must be chosen. The Kennedy bar (also referred to as the double lingual bar) becomes additionally valuable when there are diastemata between the incisors, in which case it minimizes the visibility of the metal.

If the mandibular anterior teeth and premolars are lingually inclined (as described earlier), a labial bar major connector (Fig 12) may be required. Therefore, the choice and design of the major connector in many respects determine the placement of rests on the premolars and the selection of a retentive surface on the primary abutments.

The design of the patient's existing RPD provides clues as to how to design the new prosthesis. If the design of the old prosthesis has been nondestructive over time, it is advisable to reproduce most of the features of the existing design in the new prosthesis. This is done less for the preservation of tissue, than for patient acceptance, because the patient is accustomed to the feel and appearance of the old RPD.

Indirect retention

When properly positioned, rests on the mesio-occlusal and disto-occlusal surfaces of the premolars also function as indirect retainers. A placement that resists the lifting forces placed on the distal extension of the RPD should be planned in advance and dictates in many instances the location of the borders of the major connector or even the style of major connector.

Conclusion

This article attempts to delineate and to expand on those factors that must be identified as the practitioner designs a removable partial denture.

Acknowledgments

Credit is given to Dr Robert W. Loney, University of Saskatchewan, Saskatoon, Canada, from whose arch graphics the dental portion of these figures were scaled.
Portions of Fig 1 were digitized from Kraus BS, Jordan RE, Abrams L: *Dental Anatomy and Occlusion*, Baltimore Williams and Wilkins Co, 1969, and subsequently scaled and embelished.

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