A simplified and evidence-informed approach to designing removable partial dentures.

Part 2. The biomechanical basis of support

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SUMMARY

For many decades the literature has regularly reported that there is a discrepancy between what is taught in dental school and what is practised, especially in the field of removable partial dentures. Not only that, but for more than 60 years reports from around the world have shown that, usually, the majority of clinicians abdicate their responsibility to design a removable partial denture (RPD) and instead leave this to the dental technician, who has no knowledge of the clinical condition of the patient and works only from a cast. Most patients around the world who require RPDs to improve aesthetics and chewing can only afford a removable prosthesis simply because the majority are poor. But RPDs can improve these aspects and contribute to an improved quality of life.

The purpose of this series of articles is to derive the basic, evidence-informed principles of partial denture design and to suggest a simplified explanation and application of those principles in the hope that clinicians will increasingly take responsibility for the design of partial dentures. Part 1 summarised studies revealing what can only be described as the malpractice of abdication of responsibility for design by clinicians, and then explained the evidence-informed basic principles of design; Part 2 will look at the biomechanical basis of those principles in terms of support; Part 3 will do the same for the biomechanical basis of retention; Part 4 will provide a simple seven-step approach to design, applied to an example of an acrylic resin-based and a metal framework-based denture for the same partially edentulous arch; and Part 5 will provide examples of designs for RPDs that have been successfully worn by patients, for each of the Kennedy Classifications of partially dentate arches. Much of this is referenced from an electronic book on the Fundamental of removable partial dentures.[1]

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THE BIOMECHANICAL BASIS OF SUPPORT IN RPDS

Mucosa versus teeth

Residual ridge mucosa varies in thickness but is mostly spongy and responds characteristically to pressure. This response is visco-elastic and the original studies on this response were carried out a long time ago in the 1970s.[2] A sudden load induces an immediate displacement and then a slower continued displacement. Removal of the load induces an immediate recovery but then a very delayed recovery (Figure 1).

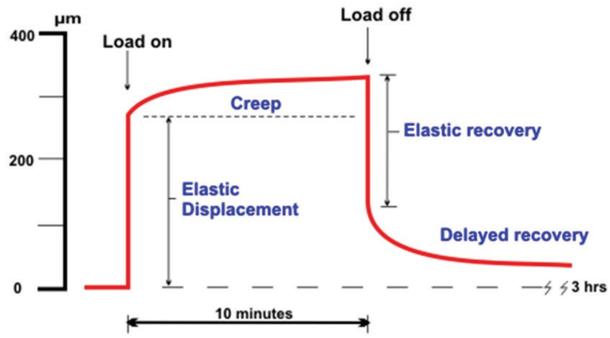

Figure 1: Displacement of mucosa under constant load for 10 minutes (redrawn after[2]).

More importantly, under functional conditions in the mouth, loading varies with each chew and, with successive chews, there is a progressive displacement, but also a progressive failure to recover, so that equilibrium at a displaced position relative to the starting position is reached. This progressive failure to recover becomes longer with age, mostly because of a decrease in mucosa thickness with age.

So residual ridge mucosa, as many a complete denture wearer will tell you, is not great for support. In a partial dentition, the use of only the mucosa for support means that it is not only residual ridge mucosa that is used but, of course, also the gingival margins around any teeth that the denture base contacts. Covering gingival margins is not a good idea. And because the denture contacts the teeth and teeth have slopes, there is an added danger of applying a force to the teeth every time the denture is pressed down by the opposing teeth during function and parafunction. So, with mucosa-borne partial dentures two of the worst consequences will be gingival pathosis (hence the term "gum stripper" for these dentures) and tooth movement (Figures 2 and 3).

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Figure 2 (left): The partial denture was originally festooned around the teeth, and must have contacted them. Occlusal pressure on the denture has produced an intermittent vector of force which has acted as an orthodontic appliance and pushed the teeth away.
Figure 3 (above): The gingival margins have obviously been adversely affected by a "gum-stripper" type of denture base.

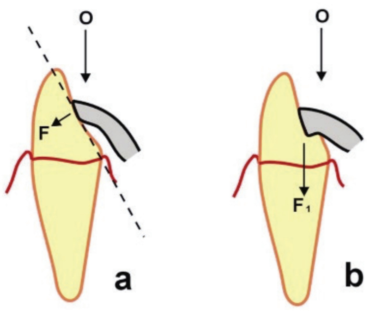

Figure 4a: Without a rest seat the occlusal force O produces a force vector F in an unfavourable direction; b: the rest seat now allows a force vector F_1 to be in an axial direction.

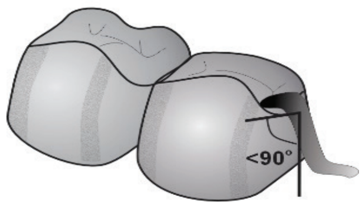

Figure 5: The rest seat should be less than 90° to the path of insertion.

The only conclusion that can be made is that relying on mucosa alone for support is simply unacceptable. The solution, of course, is to make use of the remaining teeth. The attachment mechanism of tooth to alveolar bone is designed to withstand surprisingly large forces. It does this optimally when the force is directed along the long axis of the tooth, as the force is then evenly distributed by the periodontium. This would seem to be blindingly obvious and, as was shown in Part 1, was first suggested in 1817![3] Yet, many RPDs are still made without tooth support[4,5] or without tooth preparation for rests.[6] (Table 1, Part 1 of this series[7].)

Principles of rest seats

To distribute forces axially, rests should be prepared on the occlusal surface of posterior teeth or on the cingulum area of anterior teeth. The size and shape of the rest seats will vary, depending on a number of factors:

1. The principle governing all rest seats is that the occlusal force should be directed axially (Figure 4). This determines the angle of the rest seat: it should be less than 90° to the path of insertion (Figure 5).

2. The material used for the RPD determines the shape of the posterior rest seat: an acrylic-based RPD must use wrought wires for a posterior rest and that requires that the rest preparation conforms to the shape of the wrought wire (half-round wire is used) (Figure 6); but for framework-based dentures, whether cast, milled, sintered or printed, the cast rest can conform more to the anatomy of the tooth's rest seat preparation (Figure 7).

3. Anterior rest seats rely on the shape of the cingulum irrespective of the material: either acrylic or metal will conform to the preparation (Figure 8).

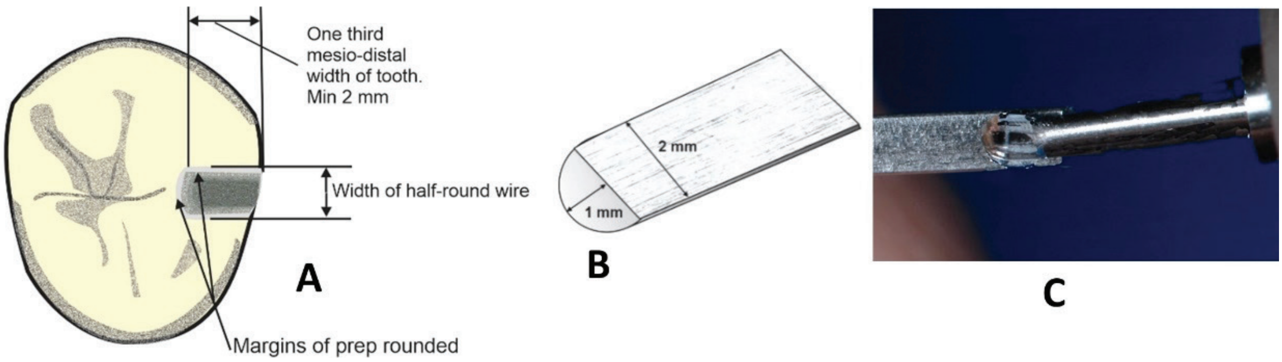

Figure 6A: The dimensions of a posterior rest seat for a half-round wire rest. B: the recommended size of the half-round wire. C: choose a bur slightly smaller than the width of the wire, ie a .018 round bur.

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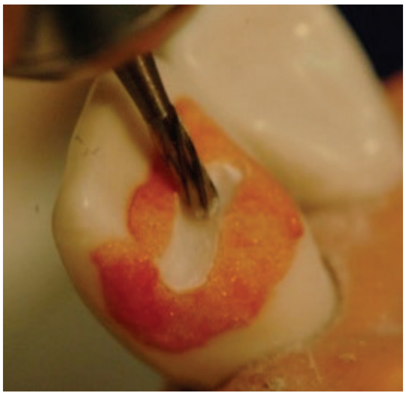


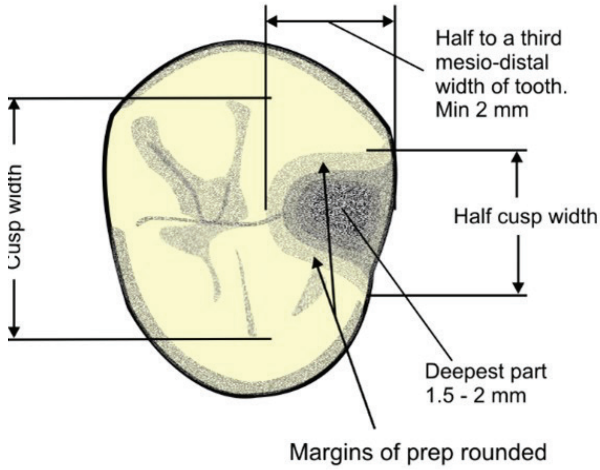


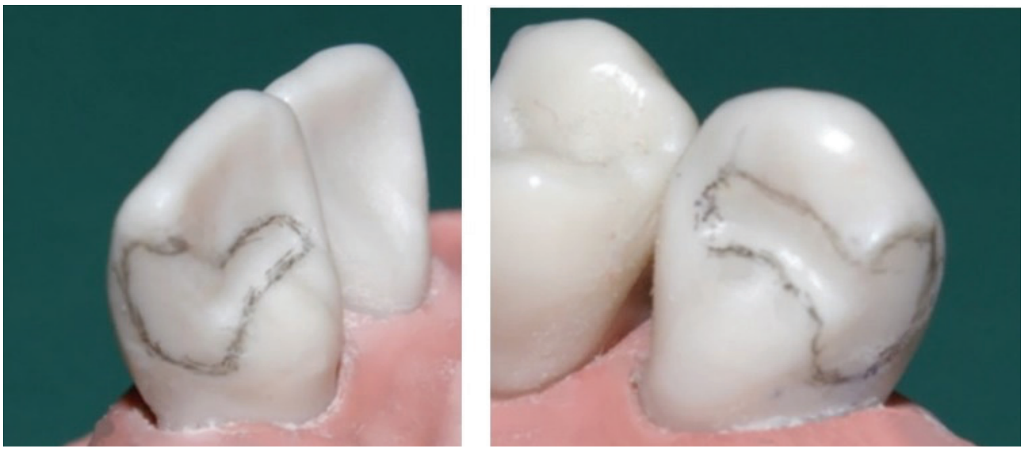
Figure 7 (above): Demonstrating the preparation of a cingulum rest on typodont tooth. A round-ended straight fissure bur is recommended.
Figure 8 (right): The dimensions of a posterior rest seat for a cast rest. The seat should be spoon-shaped.

4. If the tooth to receive a rest is adjacent to an edentulous space, then it should also have a guide plane and so the rest should be continuous with the guide plane: this applies to both anterior and posterior teeth (Figure 9).
5. All preparation margins must be rounded, with no sharp edges. This is particularly important for frameworks to be cast, as the refractory model has a large grain size and any sharp edges will not be reproduced, with the result that the framework will not seat properly (Figure 10).

Preparation

It should be self-evident (but appears not to be) that the RPD design must be decided based on the primary diagnostic models prior to the preparation in the mouth and the final impression, whether that is analogue or digital. All preparations should ideally be kept in enamel but, on occasion, the palatal cingulum area of anterior teeth may require the placement of a restoration first.

Figure 9: Cingulum rests should be continuous with the guide plane as illustrated on these typodont teeth.



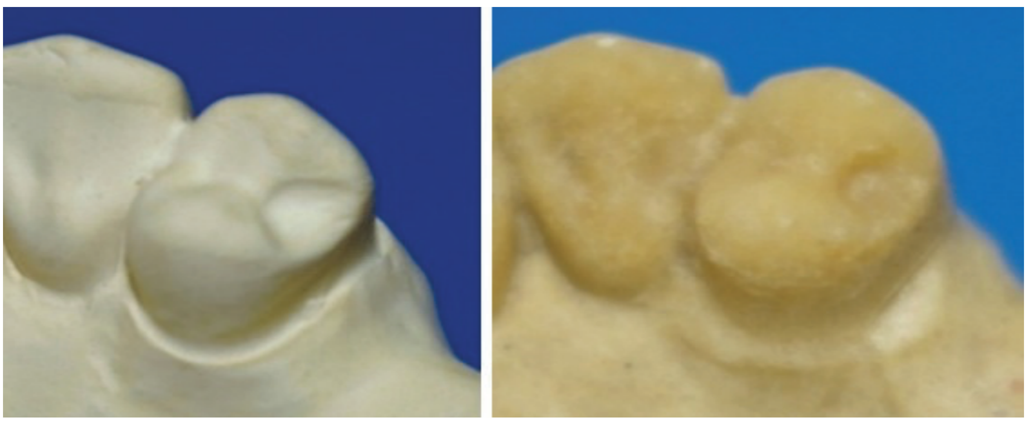


Figure 10 :The difference between a smooth gypsum cast on the left and the refractory cast on the right.

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Position

The position of rest seats is determined by the design principles and will be covered in Part 4 of this series. The only contentious issue seems to be in the case of distal extension dentures, where laboratory studies have not been shown to have any credibility from a clinical point of view.

Guidelines for rests

1. The angle of the rest seat should be less than 90° to the path of insertion.
2. An occlusal rest for acrylic-based RPDs should be shaped to accommodate half-round wire.
3. An occlusal rest for framework-based RPDs should be spoon-shaped.
4. A cingulum rest must conform to the shape of the cingulum.
5. All rest preparations should have smooth, rounded edges.
6. All rests should ideally be in enamel: if not, a restoration may be required.
7. If the tooth is adjacent to an edentulous space the rest should be continuous with the prepared guide plane.
8. At least three rests are required, as widely spaced as possible.
9. Each edentulous space being replaced should have a rest on either side; if a distal extension, one of the rests will be on the abutment.

Summary

Support is essential to resist occlusally directed forces and should not only be provided by mucosa. Tooth support is ideal, but there are situations were a combination of both tooth and mucosal support is necessary. All rest seats should be prepared to best direct the forces axially and so that there is no interference with the occlusion. Occasionally an opposing tooth may require adjustment, but the patient should be informed of this in advance, lest they believe you are making their mouth fit your denture, which will hardly engender confidence.

The next part will deal with how the denture resists the opposite force, that of removal away from the teeth, ie the biomechanical basis of retention.

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