Biomechanics of Removable Partial Dentures

Removable partial dentures are not rigidly attached to teeth, so the control of movement under functional load is critical to providing the best stability and patient accommodation. Designing a removable partial denture is characterized by being open ended and each partially edentulous arch may have more than one design for a removable appliance for that arch.

Biomechanical Considerations

The supporting structures for removable partial dentures (abutment teeth and residual ridges) are living things that are subjected to forces. Whether the supporting structures are capable of resisting the applied forces depends on:

(1) Typical forces require resistance.
(2) Duration and intensity of these forces.
(3) Capacity the teeth and/ or mucosae have to resist these forces.
(4) How material use and application influence this teeth-tissue resistance.
(5) Whether resistance changes over time.

It is bone that provides the support for a removable prosthesis through the alveolar bone by way of the periodontal ligament of the teeth and the residual ridge bone through its soft tissue covering. If potentially destructive forces can be minimized within the physiologic limits of the supporting structures than pathologic changes will not occur.

The forces that occur with removable prosthesis function can be widely distributed and directed, and their effect minimized by appropriate design of the removable partial denture. Thus, an understanding of simple machines applied to the design of removable partial dentures is necessary to help in preservation of oral structures. Without such understanding, a removable partial denture can be mistakably designed as a destructive machine.

Machines may be classified into two general categories: simple and complex. Complex machines are combinations of many simple machines. The six simple machines are lever, wedge, screw, wheel and axle, pulley, and inclined plane. Of the simple machines, the lever, the wedge, and the inclined plane ***should be avoided*** in the design of removable partial dentures.

The inclined plane can be seen when the floor of the occlusal rest preparation inclines apically toward the marginal ridge of the abutment tooth (Fig. 1) creating an angle greater than 90 degrees with its supporting minor connector.

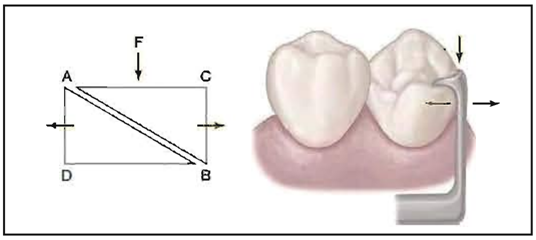

Figure 1: An occlusal rest without proper preparation can act as an inclined plane, greater than 90 degree angle between the occlusal rest and supporting minor connector.

In its simplest form, a lever is a rigid bar supported somewhere along its length. It may rest on the support or may be supported from above. The support point of the lever is called the ***fulcrum*** (F) (▲), and the lever can move around the fulcrum where (R) ( ) is the resistance and (E) (↑) is the effort or force (Fig. 2).

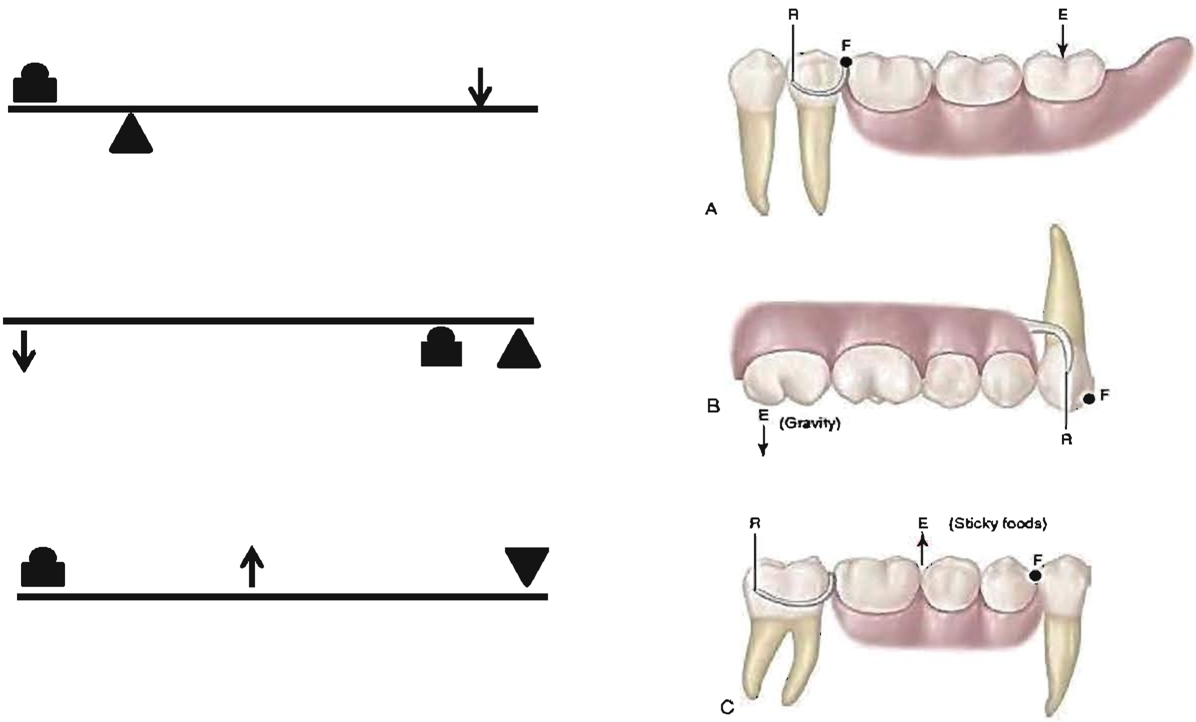

Figure 2: Three types of levers are used: first (A), second (B), and third class (C)

A tooth is better able to tolerate vertically directed forces than non-vertical, torqueing, or horizontal forces. This is because more periodontal fibers are activated to resist the application of vertical forces to teeth than are activated to resist the application of non-vertical forces (Fig. 3).

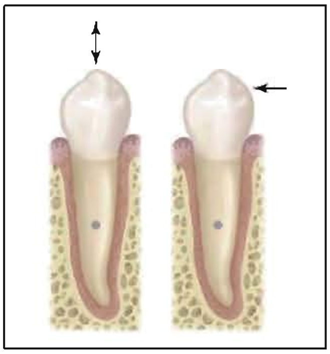

Figure 3: More periodontal fibers are activated to resist forces directed vertically on the tooth than are activated to resist horizontally directed force.

A distal extension removable partial denture rotates when forces are applied to the artificial teeth attached to the extension base.

Because this rotation must create non-vertical forces, the location of support and retentive components in relation to the horizontal axis of rotation of the abutment is extremely important.

Lever force may be placed on abutment teeth with free end extension dentures even though the actual movement may be small. A destructive design often seen for a distal extension removable partial denture (Fig. 4) is when a cast circumferential direct retainer engages the mesio-buccal undercut and is supported by the distal occlusal rest.

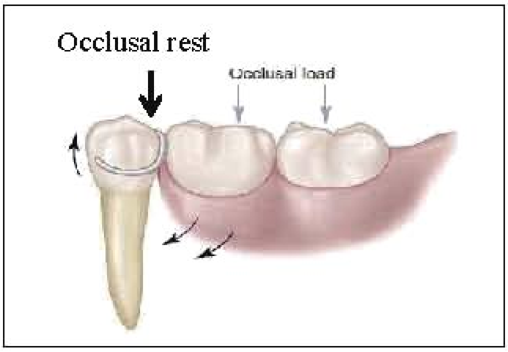

Figure 4: Cantilever design due to improper position of occlusal

This could be considered a cantilever design, and first-class lever force may be transmitted to the abutment if tissue support under the extension base allows vertical movement toward the residual ridge. A cantilever is a beam supported at one end that can act as a first-class lever (Fig. 5). A cantilever design should be avoided.

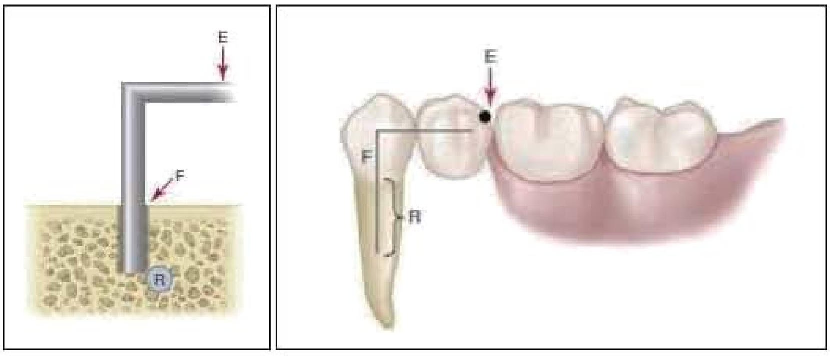

Figure 5: Cantilever effect of a distal extension removable partial denture

The occlusal rest should be placed mesially to the abutment to avoid or minimize this destructive potential (Fig. 6). This will allow the retentive tips of the direct retainers to disengage the undercut areas of the abutments when the distal extension moves towards the residual ridge. A mesial rest can be seen in the RPI & RPA systems of direct retention in which the I-bar clasp arm is used in the RPI system while the Akers clasp is used for the RPA system in which the clasp originates from the distal proximal plate.

The most efficient means of eliminating the effects of a lever is to provide support at the distal end and this can be achieved by placing an implant. This is the most beneficial use of dental implants in conjunction with removable partial dentures (RPDs) and should be considered with distal extension dentures.

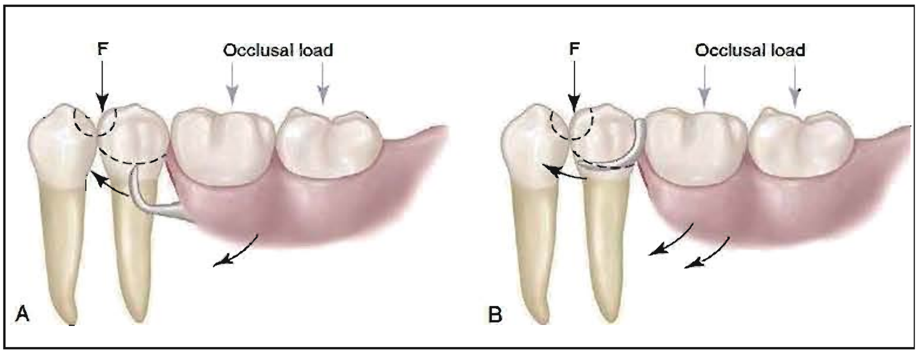

Figure 6: Proper design with a mesial rest on the distal abutment.

Possible Movements of Partial Dentures

A. Tooth-tissue–supported prosthesis

The greatest movement is found in the tooth-tissue supported prosthesis.

The ***first movement*** is rotation about an axis through the most posterior abutments (Fig. 7). This axis, known as the *fulcrum line*, is the center of rotation as the distal extension base moves toward the supporting tissue when an occlusal load is applied. Vertical tissue-ward movement of the denture base is dependent on 1) the quality of that tissue, 2) the accuracy and extent of the denture base, and 3) the applied load.

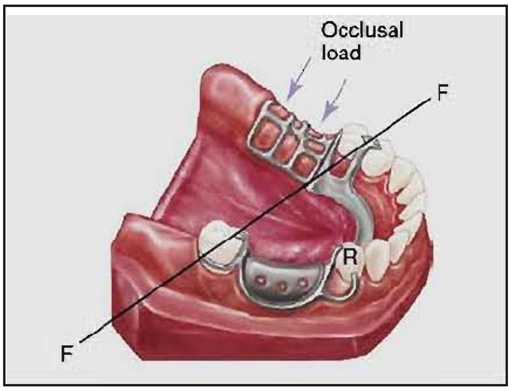

Figure 7: Fulcrum line in distal extension base dentures.

The base moves away from the supporting tissue when vertical dislodging forces act on the partial denture. These dislodging forces result from the 1) vertical pull of food between opposing tooth surfaces, 2) the effects of moving border tissue, and 3) the forces of gravity against a maxillary partial denture. Movement of the base away from the residual ridge is resisted by the action of the retentive clasp arms on abutments and the action of the indirect retainers (Fig. 8).

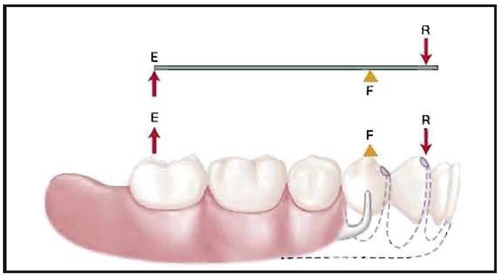

Figure 8: Denture base movement away from ridge and activation of clasp and indirect retainer.

A ***second movement*** is rotation about a longitudinal axis as the distal extension base moves in a rotary direction about the residual ridge (Fig. 9). This movement is resisted by the rigidity of the major and minor connectors.

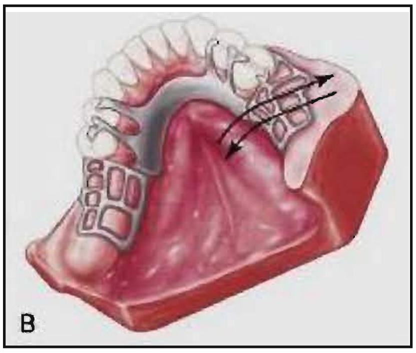

Figure 9: Rotation around a longitudinal axis formed by the crest of the residual ridge.

A ***third movement*** is rotation about an imaginary vertical axis located near the center of the dental arch (Fig. 10). It is resisted by stabilizing components, such as reciprocal clasp arms and minor connectors that are in contact with vertical tooth surfaces. Stabilizing components on one side of the arch act to stabilize the partial denture against horizontal forces applied from the opposite side. It is obvious that rigid connectors must be used to make this effect possible.

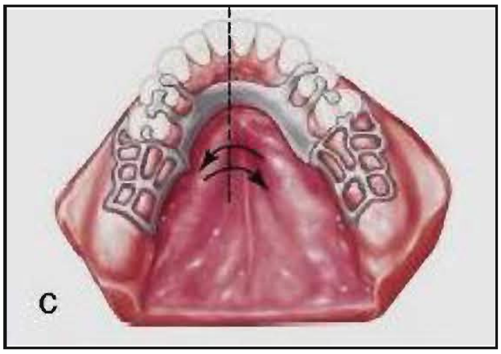

Figure 10: Rotation around a vertical axis located near the center of the arch.

B. Tooth-supported partial denture

In a tooth-supported partial denture, the ***first movement*** of the base toward the edentulous ridge is prevented primarily by the rests on the abutment teeth. Movement away from the edentulous ridge is prevented by the action of direct retainers on the abutments that are situated at each end of each edentulous space.

The ***second possible movement***, which occurs along a longitudinal axis, is prevented by the rigid components of the direct retainers on the abutment teeth and by the ability of the major connector to resist torque.

The ***third possible movement*** occurs in all partial dentures. Therefore stabilizing components against horizontal movement must be incorporated into any partial denture design.

Occlusal Rest Seat Preparation & Denture Movement

For prostheses capable of movement in three planes, occlusal rests should provide occlusal support only to resist tissue-ward movement. All other movements of the partial denture should be resisted by components other than occlusal rests. Entrance of the occlusal rest into a stabilizing function would result in direct transfer of torque to the abutment tooth. Because movements around three different axes are possible in a distal extension partial denture, an occlusal rest for such a partial denture should not have steep vertical walls or locking dovetails. This rest design is characterized by lack of free movement, which could cause horizontal and torqueing forces to be applied intracoronally to the abutment tooth.

Impact of Implants on Movements of Partial Dentures

The major functional demand of an implant in combination with a removable prosthesis is chewing, so the greatest benefit of implant use involves resisting instability by improving support. Therefore, selection of the most advantageous position of the implant(s) to minimizing rotation about an axis in a Kennedy Class I or II arch, or any long modification span, is important to consider.

References:

- Carr, A.B., Brown, D.T. (2011) McCracken's Removable Partial Prosthodontics.12th ed. St. Louis, Missouri: Mosby, Inc., Elsevier Inc.