REVIEW ARTICLE

# A review on stresses-induced by removable partial dentures

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## Abstract

The proportion of partially dentate adults who wear removable partial dentures (RPDs) is increasing in many populations. The main objective in such patients is to provide prosthodontic rehabilitation with avoidance of further tooth loss. This narrative literature review aims to consider the stresses-induced by RPD and various methods to reduce them. An extensive review of the literature was performed using Medline/PubMed database to study various articles detailing role of RPD appliance designing in stresses-induced during their function. RPDs can have a negative influence on the health of oral tissues. The stresses-induced by it are important factors in the success of this particular type of prosthesis. This article analyzes each stress and suggests clinical and construction procedures with main emphasis on appliance designing, appliance size, its relationship to the gingivae and effect of torsional forces for bringing about the most effective of the RPDs.

**Keywords:** Designing of removable partial dentures, removable partial denture, stresses in partial dentures

## Introduction

Every dental prosthetic treatment is associated with the placement of a foreign object (the prosthesis) in the mouth of the patient. As a direct consequence of such placement, the burden on the oral cavity tissues will be increased.[1] The proportion of partially dentate adults who wear removable partial denture (RPD) is increasing in many populations. A major public health challenge is to plan oral healthcare for this group of patients in whom avoidance of further tooth loss is of particular importance.[2] The science of removable partial prosthodontics has progressed far beyond the purely mechanical stage of yesteryear. Restorations of this type involve not only materials, leverages and physics but also the hard and soft living tissues which provide the dynamic foundation for the support of partial dentures.[3] A properly designed and fabricated RPD is of paramount importance both for the functional and biological requirements. This article discusses in detail the various factors influencing the proper functioning of RPDs with the main emphasis on appliance designing, appliance size, its relationship to the gingivae and effect of torsional forces.

## Review and Discussion

The extent and direction of movement of RPDs during its function are influenced by the nature of the supporting structures and the design of the prosthesis. The service expectancy of a partial denture will be proportional to the degree of control of various stresses-induced by it. This is such an important factor in the success of this particular type of prosthesis that it should be emphasized by analyzing each stress and suggesting clinical and construction procedures for bringing about the most effective control.[4] Functional stress stimuli, within certain limits, are necessary for the maintenance of the supporting structures. Beyond an optimal amount, which may vary to a considerable degree, stress may become an irritant, however, and may actually cause retrogressive changes to begin. Since forces are transmitted to abutment teeth through rests, guide planes, and direct retainers during functional movements, optimum design based on the best available research data will preserve the health of abutment teeth and their supporting structures.

The principal stresses, which are induced by RPD are stresses:

i. Resulting from an inaccurate appliance design;
ii. Stresses caused by an inaccurate appliance size;

iii. Stresses, which may cause impingement of the gingival structure; and
iv. Stresses, which torque or twist the abutment.[5]

## Appliance Designing

RPD design has been reported to be a determinant of such denture dynamics, which in turn affects the distribution of force between abutment teeth and residual alveolar ridges.[6] An inadequate RPD design may lead to an increase in abutment tooth mobility or may contribute to residual ridge resorption under the denture saddle.[7] The extent and direction of movement of RPDs during function is influenced by the nature of the supporting structures and the design of the prosthesis.[8] Rehabilitation of partially edentulous cases in the absence of distal abutments is notably troublesome for both the prosthodontist and the patient. Although there are numerous factors that influence success, stress control is a fundamental requirement for a physiologic prosthesis.[9]

### Special requirements of distal extension RPD

In the unilateral distal extension spaces, the removable prostheses restoring such space normally require support from the teeth of both sides of the arch. Without this support, the denture and its abutment stand little chance of resisting forces causing the base to warp.[10] It is used to be argued that under occlusal load, the tooth and mucosa supported part of the prostheses might be displaced more than the tooth supported part, thereby inducing more unfavorable forces on the abutment teeth.

The design used for the management of the unmodified unilateral free end saddle usually comprise rigid clasp placed as far distally on the dentulous side to provide support and cross arch stabilization.[11] Many extra coronal attachments with stress releasing properties can be used with unilateral distal extension bases such as Dalbo, Ceka, ERA, and Tach-EZ semi precision plunger, which produce equal stress distribution between the abutments and the residual alveolar ridges.[12]

In the bilateral distal extension RPD, the functional force applied to the denture base creates an axis of rotation around the most distal abutment teeth. This problem occurs mainly in the mandible since it has less supporting tissue.

Three types of stresses are induced on the abutment teeth by a bilateral distal extension RPD. The stresses are induced as vertical, horizontal and oblique stress where the abutment becomes a fulcrum. Therefore, mechanical and biomechanical aspects are generally agreed to be significant, particularly during the planning of restorative treatments and design of prosthetic application.[13] Telescopic crown systems were initially introduced as retainers for RPD.[14] The system is currently used as the conus crown. The conus crowns have a double crown system, which consists of exactly fitting conical inner (primary) that provides retentive force by the angle of inner crown and outer (secondary) crowns.[15] The significance of design of different components of RPD is discussed as under:

*Occlusal rests*

Occlusal rests are essential for conventional RPDs. Most of the occlusal forces are distributed to the abutment through the occlusal rests to the rest seats in tooth-supported RPDs.[16] During stress production; the occlusal rest in a posterior tooth-bounded RPD behaves like a cantilever beam under a uniform load. Occlusal rest should have adequate width to minimize the bending stresses, thus avoiding a thicker rest seat for compensation and hence dentin exposure.[17]

A cuspid tooth when used for abutment service transfers unfavorable occlusal loads. The lingual anatomy of the valuable cuspid abutment is frequently steeply inclined. In fact, some mandibular cuspids present almost a vertical lingual surface. Applying rests on such surfaces would result in a very unfavorable leverage on the abutments, with areas of impaction on the periodontal membrane. An abutment support cannot accept this destructive overload, even when the host is capable of normal bone maintenance under moderate stress loads. Second unfortunate sequelae of applying a partial denture loading on an inclined surface is the possibility that the appliance will slip as the occlusal load is applied. Appliance movement of this kind can easily induce the gingival irritation.[18]

The bicuspids and the molars (especially those with single or fused roots) are also subjected to similar damage unless the rest recess is favorably formed. In some mandibular distal extension base partial dentures, the placement of a distal occlusal rest on a surface, which slopes cervically toward the edentulous area may result in repeated impingement of the sub-basal pad at the retro molar periphery of the base. This is produced when the prosthesis slips posteriorly on the inclined surface of the abutment.[19]

Stress, which would be caused by locating an occlusal rest on cervically sloping abutment surface can be prevented only by considerable clinical effort. Specific measures to be taken in the direction of avoiding damage from this source can be accomplished at the time of preparing the mouth for partial denture service. The first and the most frequent method is the making of an adequate occlusal rest recess in bicuspid or molar abutments. Of primary significance in stress, control is that the floor of the prepared recess must slope from the abutment margin toward its center. This forms an acute angle between the rest floor and the vertical minor connector. Thus, under stress, the abutment rests firmly against the vertical guiding plane of the minor connector, thus preventing any side pressure, which would cause periodontal impingement.[20]

In the situation of the cuspid abutment, the form of this tooth will seldom be suitable to place an adequate occlusal rest. The reshaping of this tooth can be done best by the placement of a three-quarter veneer crown restoration, in which a groove is placed on the lingual surface just above the raised cingulum.[18]

The use of secondary (auxiliary) occlusal rest may be suggested for the posterior tooth where an ideal rest recess cannot be executed. This will compensate for any pressure in the mesial direction which would be generated by the use of the rest on the distal incline.

*Major connector*

A major connector plays an important role in distributing the occlusal forces applied on a RPD across the dental arch. A connector transmits the force on the artificial teeth to the contralateral side and to successfully perform this action; a major connector should be rigid. There is a great importance of rigidity of major connectors in reducing stresses on abutment teeth and residual alveolar ridges under denture bases.[21] Studies suggest that a rigid major connector can distribute the occlusal force across the dental arch, thereby decreasing the load on the side ipsilateral to the loading point.[22]

If the major connector is not rigid, work load may cause it to flex. When these loads are sufficient to cause an extension base to move lingually, the non-rigid connectors (particularly the lingual bar type) may be forced to flex toward the sub-basal structures at the weakest point in its anterior arc (between the right and left abutments), and the flexible bar may repeatedly press against the mucosal covering. Localized inflammation followed by edema increases this pressure and soon the underlying bone is involved. This lesion is not usually very painful and may escape the notice of both the patient and dentist unless the area is carefully examined. If allowed to continue, this type of impingement may eventually produce a perforation of the mucosal pad. The small hole thus produced is quite smooth and well defined. Through this aperture, one may probe the bone, which may be denuded with the periosteum detached in an area much larger than the tiny opening. Infrequently a sequestrum may be exfoliated.[23] It can be prevented by (i) using a cast connector and employ a less flexible alloy; (ii) increasing the bulk when the connector is long; and (iii) use of a half pear form instead of half round or flat. Major connecter should include two planes to get more rigidity and less flexibility.[24]

A second type of major connector impingement may follow a lateral shifting of the appliance. This, too, is more commonly seen in the mandibular prosthesis. The effect of "major connector" on the denture movement is significant in the mesiodistal direction.[25] A lateral shift of the partial denture may tend to occur in certain conditions, with the result that there is pinching of the tissue beneath the major connectors. If this trauma continues, the chronic irritation may result in bone necrosis.

It can be prevented by providing a slight space beneath the lingual bar by placing a thin block - out material before duplicating the master cast. More rigid stabilizing units (reciprocal clasp arms, auxiliary occlusal rests, indirect retaining units, etc.) must be employed. Since this type of lesion is associated with lateral appliance movement, it is doubly urgent that the mandibular base be extended to maximum flange length, especially on the lingual side. If the ridge height is subnormal and there is a sharp lingual edge, preprosthetic surgery should be utilized to make possible of a longer lingual flange by recontouring the area. There is no adverse effect on abutment teeth if the RPD design includes rigid major connectors along with other essential requirements.[26,27]

*Direct retainer*

The design of a direct retainer is considered a prominent factor that controls the forces applied to the abutment teeth.[28] Studies conducted under a simulated condition have suggested that clasp-retained designs produce less torque on abutment teeth than intracoronal attachments.[29] When at rest, clasp should be passive and should not exert any force on the teeth. Improper designing of the clasp will introduce detrimental forces on the abutment tooth on which the clasp was provided.[13] Research done by Clayton[30] shows that the use of an improperly designed supra-bulge or circumferential clasp exerts a great deal of force on the abutment tooth. Rigid direct retainers are associated with less mobility of the abutment teeth and less force on the residual ridge. Rigidity of the direct retainers also has a significant effect on the distribution of the occlusal force. Non-rigid retainers cannot distribute the force applied on the artificial tooth efficiently, resulting in a greater load on the residual ridge.[31,32]

## Appliance Size

When a RPD is either oversize or too small, these will exert continuous pressure on all teeth and other structures in contact. The first effect of this stress will be orthodontic in nature. Usually, the tooth so affected will respond to the pressure, as in intentional orthodontic therapy, and will alter its position enough to release the pressure. As a result of the induced movement, a relation of malocclusion will usually be produced as a secondary effect of the inaccuracy of appliance fit. This has quite serious potentialities unless it is soon rectified. Unrelieved occlusal prematurities of this type can result in periodontal disturbances, not only about the tooth moved but also about those in adjacent and/or occlusal contact. Such pressures are capable of causing compression areas in the periodontal membranes of the affected teeth and may easily lead to destruction of the enveloping alveolar bone. Inaccuracy in appliance size can be because of faulty impression, improper water/powder ratio of investment, surface abrasion of the cast and excessive polishing.[33]

## Appliance Relationship to the Gingivae

The gingivae are the most susceptible to injury from the stress-induced by a removable prosthesis. Even minor contacts seem to promote an unfavorable reaction in these areas. Inflammation in the areas of contacts made by the units, which must cross the gingiva is soon followed by edema. As the structure becomes distended, the pressure increases and the vicious circle of retrogressive change get established. The end result is a resorptive loss of the adjacent alveolar process with a pocket formation. Loosening of the abutment follows, and as the bone level is lowered, the tilting and twisting stresses on the abutment become more and more of an overload. As the abutment tilts, the impingement of the periodontium in areas of compression will closely follow.[33,34] To avoid this, during the first visit the patient should be thoroughly examined regarding presence of subgingival calculus. Such deposits are at times the cause of this irritation because as the gingivae are pressed away from the cervical area by the accumulating mass, they are pressed against the overpassing units of the prosthesis. Proper subgingival scaling and root planning should be performed.[35] Other preventive step considered is the proper occlusal rest preparation. Without adequate occlusal rest stops, there can be gingival impingement in these crossing areas.[36] The gingival response to various types of RPDs depict that the denture made with no gingival relief had the most associated pathology.[37] At the time of construction, a slight relief should be made at each gingival crossing. Particular care should be given to the matter of rounding the edges of the prosthesis, which are adjacent to or cross the gingivae.[37]

## Effect of Torsional Forces

The stresses, which produce torque on the abutment are seen in the partial denture having a distal extension base and not in tooth borne appliances. It is because the prosthesis with the free end produces twisting and tilting forces because of its lever action.[38] The term "torque" designates that stress, which tends to twist or turn an abutment in its alveolus, as distinguished from a force, which leads to the tilting of the abutment laterally or proximally. Lateral movement of the extension base becomes aggravated when the sub-basal ridge is low and flat in form. This movement results principally from inadequate flange length. It also may be increased by the presence of a flabby, movable pad of mucosal structures over the ridge.[39]

Another factor in the development of torque stresses is the presence of high cuspal inclines, especially if there are surfaces, which are not in occlusal balance. On such teeth, the cuspal height and inclination are both excessive as compared to that which exists on the remaining teeth, which have had no abrasive wear. When such teeth govern the excursive movements of the jaw, then the supplied teeth cannot possibly be in the harmonious balance until their surfaces also have been made to conform.[40]

The torque stresses are most destructive (i) when the occlusal loads are heavy; (ii) when the abutment has a round, tapered root; (iii) when the abutment root is single (fused); (iv) when there has been previous alveolar bone loss about the abutment teeth; (v) when the occlusal table is long, and the number of remaining teeth are few; and (vi) when the patient has a well-established habit of bruxism.

If the direction of the load line lies within the lateral border of the root of abutment tooth, stress is directed vertically on the periodontium; if the load is directed outside the root, then lateral or tipping stresses are induced.[41] The axis of rotation can be changed by taking care of various factors discussed above in the RPD designing so as to alter the direction and magnitude of the stresses applied to the abutment teeth during function.

Intraoral scanning technology can be used to record hard and soft tissue morphology and to create a stereolithographic file that will be subsequently imported into a computer-aided design software program for the digital/virtual design of a partial denture framework. The resultant appliance accuracy will be increased.[42]

## Conclusion

Judicious dispersal of the forces by limited loading in selected areas is deemed essential. It is generally felt that designs, which provide for broad bases, rigid connectors, multiple rests, and properly selected retainers are most likely to affect favorable distribution of force and maintain the integrity of the periodontal and the ridge tissues.

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