Review Article

JRAD Journal of Research and Advancement in Dentistry

J Res Adv Dent 2017;6:2:127-133.

Stress Optimization in Distal Extension Removable Partial Denture: Revisited

Neha Jain[1*] Chetan Pathak[2] Arpit Sikri[3] Piyush Tandan[4] Monika Tandan[5] Tarun Gupta[6]

[1]Reader, Department of Oro-Maxillofacial Prosthodontics, Crown & Bridge and Oral Implantology, Sudha Rustagi College of Dental Sciences & Research, Faridabad, Haryana, India.
[2]Senior Lecturer, Department of Oro-Maxillofacial Prosthodontics, Crown & Bridge and Oral Implantology, Sudha Rustagi College of Dental Sciences & Research, Faridabad, Haryana, India.
[3]Senior Lecturer, Department of Oro-Maxillofacial Prosthodontics, Crown & Bridge and Oral Implantology, Sudha Rustagi College of Dental Sciences & Research, Faridabad, Haryana, India.
[4]Professor, Department of Oro-Maxillofacial Prosthodontics, Crown & Bridge and Oral Implantology, Manav Rachna Dental College, Faridabad, Haryana, India.
[5]Reader, Department of Conservative Dentistry and Endodontics, Sudha Rustagi College of Dental Sciences & Research, Faridabad, Haryana, India.
[6]Professor and Head, Department of Conservative Dentistry and Endodontics, Vyas Dental College, Jodhpur, Rajasthan, India.

ABSTRACT

Background: For many years, removable partial dentures have been designed from a pure mechanical point of view only to fail through a lack of appreciation of the biological factors involved. This is especially true in case of distal extension partial dentures. In these cases, support is provided by tooth on one end and mucosa covering the bone on the other end. This causes an uneven or unequal balance of movement leading to undue stresses on abutment teeth and residual ridge because the mucosal support allows more movement of the prosthesis than does the tooth supported portion of the prosthesis. The magnitude and direction of stresses will depend on the type of partial denture and the design of its parts in relation to the anatomic and functional form of the supporting structures. By means of precise diagnosis, treatment planning and designing of partial denture, the stresses can be optimized within physiological limits.

Keywords: Stress, Removable partial denture.

INTRODUCTION

A distal extension or a free end saddle partial denture is the one which replaces the missing teeth posterior to the remaining natural teeth with no posterior abutment teeth remaining. It receives two entirely different sources of support viz. teeth and residual ridge. The real difference between the two is the manner in which the intervening structures transfer occlusal forces passing through them.[1]

- Masticatory load passes from abutment roots via the periodontal ligament fibres to the lamina dura of the alveolar walls. These fibres are stretched from a relaxed state as functional loads are received and transferred. When an overload is approached, stimuli proceed from the proprioceptors in periodontal membrane to the muscles of mastication which produce involuntary reflex and deter from applying excessive force.
- Occlusal forces falling on the saddle area are passed to the underlying mucosa which is mostly fibroelastic in nature covering the underlying bone. But instead of being stretched, it gets

Received: Jan. 11, 2017: **Accepted:** Mar. 12, 2017

***Correspondence Dr. Neha Jain.**
Department of Oro-Maxillofacial Prosthodontics, Crown & Bridge and Oral Implantology, Sudha Rustagi College of Dental Sciences & Research, Faridabad, Haryana, India.
Email: Not Disclosed

pISSN 2278-0076
eISSN 2321-9270

compressed enough to convey the stresses to the adjacent bone. Due to the absence of proprioceptors, there is no deterring mechanism to prevent excessive forces on residual ridge.

Stresses in distal extension partial denture: The difference in support provided by tooth and residual ridge leads to movement of the denture both during and outside of masticatory function leading to some degree of permanent displacement of the mucoperiosteum underlying the distal extension saddle.[2] Frechette A[3] found that cast circumferential clasps combined with distal rests torque the abutment in a distal direction when a vertical force is applied to the distal extension saddle.

The factors that influence the magnitude of stresses transferred to the abutment teeth include:

1) Length of edentulous span
2) Quality of denture bearing tissues
3) Type and design of clasp
4) Occlusion

Steffel VL[4] proposed three philosophies regarding the control of stresses from distal extension removable partial dentures-physiologic basing, stress-breakers and extensive stress distribution. Osborne and Lammie[5] stated three ways of countering the torquing forces acting on the abutment teeth viz. by decreasing size of occlusal table, by distributing load between teeth and ridge or by distribution of the load widely.

Methods of stress optimization in distal extension removable partial denture:

A) By minimizing mobility of the abutment teeth:

1) Equilibrating the occlusal plane: Defective contacts in the centric path of closure are removed eliminating mandibular displacement from the closing position. Interferences on working and non-working side are observed as well and if present, eliminated.

2) Splinting abutment teeth: An abutment tooth with a single root of short length and excessive taper or bone loss results in unfavourable crown-root ratio. In such instances, splinting of weak abutment teeth to the adjacent results in increase in the periodontal ligament attachment area and stress distribution over a larger area of support.

3) Preparing and positioning guiding planes properly: Guiding planes provide resistance against dislodgement of the prosthesis in a direction other than parallel to path of removal and also provide stabilization against horizontal rotation. A complete contact of guiding planes with tooth surface should be avoided as it can cause potential damage to the abutment teeth.[6]

4) Designing and positioning rests properly: A rest should be placed on a positive rest seat instead of a sloping surface to prevent tipping, mobility and drifting of the abutment tooth. Anterior placement of occlusal rest alters the Class I lever situation to Class III lever situation favouring a more even distribution of stresses between abutment teeth and edentulous ridge. According to the mesial occlusal rest concept, the arc of movement of the saddle under the applied load will be more perpendicular to the mucosa throughout its length due to presence of mesial rather than distal fulcrum (Fig 1).[7] Krol[8] advocated RPI concept which includes a mesial rest along with a proximal plate on the distal to contact the distal guiding plane on its inferior margin and I-bar clasp.

5) Taking care of the reciprocal arm of clasp assembly: Bates JF[9] emphasized the need for the reciprocating arm to be in continuous contact with the tooth surface throughout movement of the retaining arm in order to avoid the possible damaging effect of the forces by the clasps and the loss of retention due to the tooth movement.

B) By accurate recording of the support ability of residual ridge:

1) Taking impression by physiological impression technique: This can be achieved by functional impression or selective pressure impression technique. With functional impression technique, mucosa is captured in its functional form so that the base can be related to the metal framework in the same relationship that exists between the

abutment tooth and the supporting mucosa when an occlusal force is applied to the base. The altered cast impression technique (Fig 2a, 2b, 2c) provides least movement of extension bases under an occlusal load.[10] Selective pressure impression technique has the added advantage of directing the force to the portions of ridge that are most capable of withstanding the force.

2) Maximizing coverage of the residual ridge: According to the snow-shoe principle the broad coverage provides the best support with the least load per unit area. The denture flanges must extend into the vestibule to resist the horizontal movements and provide seal with the border tissues.

3) Timely relining or rebasing of prosthesis: Loss of support for distal extension bases results from the changes in residual ridge form over a period of time. This will result in a loss of occlusal contact between the artificial teeth and opposing dentition and a return to heavy occlusal contact between the remaining natural teeth. Also, the denture base will rotate along the fulcrum line with indirect retainers lifting from their seats as the distal extension base presses against the ridge tissues under occlusal forces. Hence, timely relining or rebasing of the denture is required to minimize stresses.

C) By reducing the stresses on abutment teeth and residual ridge:

1) Reducing the number of posterior artificial teeth: Omitting the most distal tooth on the saddle will reduce the abutment tooth movement caused by the denture as the magnitude of distal load is reduced.

2) Reducing the bucco-lingual width of the artificial teeth: A large food table has the potential of transmitting considerably more pressure on both the residual ridges and the abutment teeth than does a narrow occlusal table.

3) Maintaining sharpness of the cusps: The occlusal pattern of the posterior teeth influences the amount of stress as cuspless teeth generate more loads on the denture base than sharp cusp teeth because of the increased power needed to masticate the food bolus.

D) By favourable stress distribution between abutment teeth and residual ridge:

1) Having a rigid removable partial denture design: If the framework is rigid, the occlusal rests on the side opposite to the application of lateral force tend to resist vertical rotation and prevent harmful tipping of the abutment teeth.[11] The major and minor connectors should be rigid in order to prevent building up of stress concentration in a particular area in distal extension partial denture. When the minor connector passes through the interdental embrasure, the deepest portion of the embrasure should be blocked otherwise the minor connector will produce a wedge-like effect.

2) Selecting a type of clasp assembly that will minimize stresses: Following types of direct retainer assemblies can minimize stresses:

a) Distobuccal undercut engaged by one half T-type bar clasp;

b) I-bar clasp placed in undercut at the middle of buccal surface;

c) Interproximal ring clasp engaging disto-buccal undercut when bar type retainer cannot be used because of tissue undercuts inferior to buccal surface of abutment;

d) Wrought-wire circumferential retainer arm engaging mesio-buccal undercut;

e) Having precision attachments: They have a key and keyway mechanism, one part of which is attached to the abutment tooth and the other to the metal framework. They can be intracoronal or extracoronal, rigid or resilient eg. CEKA, Dalbo, ERA attachments. Intracoronal precision attachment (Fig 3) is located deep within the confines of the tooth and directs the stresses along the long axis of the tooth which are resisted by virtually all of the fibres of the periodontal ligament. They are especially indicated in anterior region, malaligned and crowded teeth.[12]

3) Having a stress-breaking prosthesis design: During function, the torsional forces transmitted to the abutment teeth can be reduced by dividing the load between ridge and teeth with the help of stressbreaker.[13] It is interposed between the denture base and clasp or framework and permits movement of the base independently of the clasp. Eg. wrought wire clasp, split major connector and hinge attachments. Retentive arm made of wrought wire can serve as a stressbreaker since it can flex in all directions because of circular cross- section.[14]

4) Having indirect retainers: Mc Dowell GC[15] found that the presence of indirect retainers reduces stresses at the apex of the alveolar bone surrounding the primary abutment teeth bilaterally as well as on the crest of the residual ridge on the non loaded side. It also reduces stress on the lingual shelf of the residual ridge bilaterally. Indirect retention exploits the mechanical advantages of leverage in the control of stress.[16] The farther to the fulcrum line it is placed, the more effective will be its influence because lengthening the counterbalance magnifies its neutralizing effect and the load is distributed to several teeth. Eg. Auxiliary occlusal rest, canine extension from the occlusal rest, canine rest, continuous bar retainer and lingual plate.

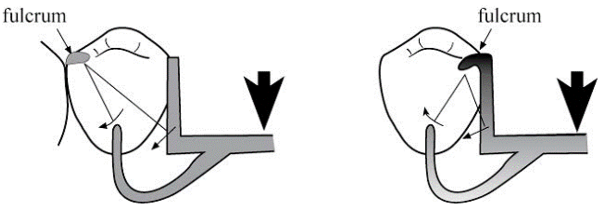

Fig 1: Mesial occlusal rest applying more vertical forces on mucosa.

DISCUSSION

In designing the partial denture, it is necessary to analyze the stresses anticipated to seek their causes and control and to consider the

Fig 2a: Sectioned master Cast.

Fig 2b: Beading and boxing of functional impression with master cast.

Fig 2c: Altered master cast.

character of the tissues against which they may be directed. Parfitt GJ[17] suggested that teeth are not firmly embedded in bone but are connected to the bone through periodontal membrane which enables the teeth to move into their sockets when vertical forces are applied and move sideways when

Fig 3: Attachments.

horizontal forces are applied. According to Elbrecht's[18] classification of residual ridges viz horizontal, distal descending, distal ascending and ascending-descending, it has been found horizontal ridge to be most favourable and distal descending ridge to be least favourable in terms of stress distribution in distal extension removable partial dentures. Farrell J[19] found that distal extension dentures after resorption of saddle bearing area rotate around supporting occlusal rests. Model studies done by Hekneby M[20] showed that a vertical loading of the distal part of the free end saddle causes the supporting rest to be lifted away from the abutment tooth whereas a similar loading of the middle part of the saddle will transmit part of the load to the abutment tooth and cause rotation of removable partial denture around the supporting rest. Hence, the load transmitted to abutment tooth will increase as the point of application of force is moved mesially. A rigid design of major connectors is always favourable for stress distribution. Ben-Ur Z et al[21] found that among the maxillary major connectors anteroposterior palatal bar was the most rigid and U-shaped design was the most flexible. In mandibualr arch, rigidity depends more on the cross-sectional shape of the major connector. Half-pear shaped design was the most favourable one. Kaires AK[22] did a study on bilateral force distribution in free end saddle cases and concluded that the reduction of the size of occlusal table reduces the vertical and horizontal forces acting on partial denture and lessens stresses on the abutment teeth and supporting structures. The most favourable distribution of forces on abutment teeth is obtained using either a mesial rest in conjunction with a buccal I-bar retainer or a combination of a wrought wire clasp with a cast lingual arm.[23] Cecconi BT[24] conducted a laboratory study and concluded that as related to force transmission to abutment teeth, the depth of rest is a more significant factor than the type of the rest. Monteith BD[25] recommended four possible treatment modalities for stress management in distal extension partial dentures: stressbreakers, floating denture base impression technique, mucofunctional impression technique and osseointegrated implants. According to Mc Lean, partial denture stabilization is possible by equalizing resilient and non resilient support which can be achieved by functional impression technique. Impression of saddle areas is made under biting stresses and then, assembled with teeth by means of hydrocolloid impression made overall. The magnitude of forces on abutment teeth is greatly reduced when an altered cast technique is used in the construction of distal extension removable partial dentures.[26] Greater stresses are transferred to the abutment teeth when a distal extension partial denture is retained with rigid precision attachments compared to a clasp retainer.[27] Splinting abutment teeth becomes more important when using extracornal precision attachments as retainers in distal extension removable partial dentures as it leads to wider distribution of stresses.[28] Pellizzer EP et al[29] conducted a finite element analysis on hemimandible models to study biomechanical behaviour of distal extension removable partial dentures supported by implants with different retention systems and found lowest stress values were found with respect to implants along with resilient attachment systems such as ERA and O rings. Ku YC et al[30] concluded that the extracoronal resilient attachments provided resiliency in a vertical direction and stress relief to the abutment teeth in distal extension removable partial dentures. The use of dental implant as a distal abutment can convert a distal extension removable partial denture from a tooth-and tissue-supported prosthesis to a tooth-and implant-supported prosthesis that will reduce the saddle movement which is often associated with a tooth-and tissue-supported distal extension removable partial denture.[31] Grossman Y et al[32] found that implant supported removable partial dentures provide a predictable and stable prosthesis as an alternative wherever it is not possible to give a fixed prosthesis. Ohkubo C et al[33] conducted an in-vivo study to evaluate implant supported distal extension removable partial denture and found that one implant in each edentulous area along with attachments significantly improves stability and minimizes rotational movement of the denture. Herman MAM et al[34] found that in combination syndrome cases, where mandibular bilateral distal extension partial denture opposes maxillary complete denture due to bone changes under free end saddle, there is overloading of anterior maxillary region. This can be minimized by placing implants under the saddle providing a stable occlusion. Studies have found greater patient satisfaction in implant supported distal extension partial denture compared to conventional dentures.[35,36] Greater implant length and diameter play a significant role in reducing the displacement and tensile stresses of implant supported distal extension removable partial denture.[37]

CONCLUSION

In free end saddle cases, the stresses are greatly augmented because in its movement the partial denture acts as a lever. Preventing such stress magnification is one of the most important phases of prosthesis design and construction. Distal implant presents a good stress minimizing option for the patients who can afford this treatment modality. The basis of good restorative dentistry consists of establishing equilibrium of forces so that stresses are conducive to developing a physiological continuum rather than pathosis.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

REFERENCES

1. Applegate OC. An evaluation of the support for the removable partial denture. J Prosthet Dent 1960;10:112-23.

2. Wills, Maderson. Biomechanical aspects of the support of partial dentures. J Dent 1977;5:310-8.

3. Frechette A. Influence of partial denture design on the distribution of force on abutment teeth. J Prosthet Dent 1956;6:195-212.

4. Steffel VL. Fundamental principles involved in partial denture design. J Am Dent Assoc 1951;42:534-44.

5. Osborne J, Lammie GA. Partial dentures, 4th edition, Oxford, Blackwell Scientific Publications, 1974.

6. Holt JE. Guiding planes: When and where. J Prosthet Dent 1981;46:4-6.

7. Kratochvil FJ. Influence of occlusal rest position and clasp design on movement of abutment teeth. J Prosthet Dent 1963;13:114-24.

8. Krol. Clasp design for extension base removable partial dentures. J Prosthet Dent 1973;30:408-15.

9. Bates JF. Retention of partial dentures. Brit Dent J 1980;149:171-4.

10. Holmes JB. Influence of impression procedures and occlusal loading on partial denture movement. J Prosthet Dent 1965;15:474-81.

11. Weinberg LA. Lateral force in relation to the denture base and clasp design. J Prosthet Dent 1956;6:785-800.

12. Preiskel HW. Precision attachments in prosthodontics: The applications of intracoronal and extracoronal attachments, Vol 1, Chicago, Quintessence Publication Co, 1984.

13. Levin B. Stressbreakers: A practical approach. Dent Clin N Amer 1979;23:77-86.

14. Mc Cracken. A comparison of tooth borne and tooth- tissue borne partial dentures. J Prosthet Dent 1953;3:699-710.

15. Mc Dowell GC. Force transmission by indirect retainers during unilateral loading. J Prosthet Dent 1978;39:616-21.

16. Davenport JC, Basker RM, Heath JR, Ralph JP, Glantz PO, Hammond P. Prosthetics: Indirect retention. Brit Dent J 2001;190:128-32.

17. Parfitt GJ. Measurement of physiological mobility of individual teeth in axial direction. J Dent Res. 1960;39:608-18.

18. Pellizzer EP, Ferraço R, Tonella BP, Oliveira BJ, Souza FL, Falcón-Antenucci RM. Influence of ridge type on mandibular distal extension removable partial denture. Acta Odontol Latinoam 2010;23:68-73.

19. Farrell J. Wrought wire retainers a method of increasing their flexibility. Brit Dent J 1971;131:327.

20. Hekneby M. Distribution of load with free end partial denture. Acta Odontol Scand 1969;27:55-8.

21. Ben-Ur Z, Mijiritsky E, Gorfil C, Brosh T. Stiffness of different designs and cross-sections of maxillary and mandibular major connectors of removable partial dentures. J Prosthet Dent 1999;81:526-32.

22. Kaires AK. Partial denture design and its relation to force distribution and masticatory performance. J Prosthet Dent 1956;6:672-83.

23. Thompson WD, Kratochvil FG, Caputo AA. Evaluation of photoelastic stress patterns produced by various designs of bilateral distal extension removable partial denture. J Prosthet Dent 1977;38:261-73.

24. Cecconi BT. Effect of rest design on transmission of forces to abutment teeth. J Prosthet Dent 1974;32:141-51.

25. Monteith BD. Management of loading forces on distal extension partial denture prosthesis. Part- I Evaluation of concepts for design. J Prosthet Dent 1984;52:673-81.

26. Maxfield JB, Nicholls JI, Smith DE. The measurement of forces transmitted to abutment teeth of removable partial dentures. J Prosthet Dent 1979;41:134-42.

27. Saito M, Miura Y, Notani K, Kawasaki T. Stress distribution of abutments and base displacement with precision attachment- and telescopic crown-retained removable partial dentures. J Oral Rehab 2003;30:482-7.

28. El Charkawi HG, El Wakad MT. Effect of splinting on load distribution of extracoronal attachment with distal extension prosthesis in vitro. J Prosthet Dent 1996;76:315-20.

29. Pellizzer EP, Verri F, Falcon- Antenucci RM, Goiato MC, Filho HG. Evaluation of different retention systems on a distal extension removable partial denture associated with an osseointegrated implant. J Craniofac Surg 2010;21:727-34.

30. Ku YC, Shen YF, Chan CP. Extracoronal resilient attachments in distal-extension removable partial dentures. Quint Int 2000;31:311-7.

31. Carr AB, Brown DT. McCracken's removable partial prosthodontics, 12th edition, St Louis, Mosby, 2011.

32. Grossman Y, Nissan J, Levin L. Clinical effectiveness of implant supported removable partial dentures: A review of the literature and retrospective case evaluation. J Oral Maxillofac Surg 2009;67:1941-6.

33. Ohkubo C, Kobayashi M, Suzuki Y, Hosoi T. Effect of implant support on distal-extension removable partial dentures: in vivo assessment. Int J Oral & Maxillofac Implants 2008;23:1095-101.

34. Keltjens H MAM, Käyser AF, Hertel R, Battistuzzi P GFCM. Distal Extension Removable Partial Dentures Supported by Implants and Residual Teeth: Considerations and Case Reports. Int J Oral Maxillofac Implants 1993;8:208-13.

35. Wismeijer D, Tawse-Smith A, Payne AG. Multicentre prospective evaluation of implant-assisted mandibular bilateral distal extension removable partial dentures: Patient satisfaction. Clin Oral Implants Res 2013;24:20-7.

36. De Freitas RFCP, Dias KDC, Carreiro ADFP, Barbosa GAS, Ferreira MAF. Mandibular implant-supported removable partial denture with distal extension: A systematic review. J Oral Rehab 2012;39:791-8.

37. Verri FR, Pellizzer EP, Rocha EP, Pereira JA.Influence of Length and Diameter of Implants Associated With Distal Extension Removable Partial Dentures. Implant Dent 2007;16:270-80.