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STUDY OF CHANGES IN STRESS DISTRIBUTION IN ALVEOLAR BONE DUE TO TILTING OF TOOTH

KEY WORDS: tilting of tooth, stress distribution, alveolar bone

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ABSTRACT

Background- It is common in the dental practice that the teeth adjacent to the lost teeth tend to tilt if the edentulous space has not been restored in time that may attribute to the influence of mesial components of occlusal force.

Aim- To conduct photoelastic study of changes in stress distribution in alveolar bone due to tilting of tooth.

Methods- In this study the masticatory load was shifted to an anatomic model of mandible where first molar was missing and second molar was tilted in various degrees was simulated. Induced stress in alveolar bone was investigated using three dimensional photoelastic technique.

Results- Highest fringe order in alveolar bone at various degrees of tilt of mandibular second molar tooth was recorded around the roots of second premolar, mesial root of second molar and distal root of second molar. In region 3, where maximum shear stress was lowest of the three at 00 tilt, the values were low for three regions. At 200 tilt, rise in shear stress was seen. Stress neither increased or decreased at all the other angles. In region 1, tilting showed reduction in values for 200 where the value of maximum shear stress was above the baseline. Shear stress was low at other angles.

Conclusion- Findings of present study suggest that stresses were centered around the mesial root. Tooth looses its strength due to vertical bone loss along the mesial root. Hence the teeth having tilt >250 should not be used.

INTRODUCTION

A common prosthetic and periodontal problem is tilted molar. Loss of a lower first molar or second premolar produces a space and allows the molar, distal to the space, to tilt mesially. Opposing occlusion produces the tilting force.[1] Although a tightly locked occlusion can prevent excessive movement, once the tooth begins to tilt, the vector of force tends to increase the tilting. The severity of both prosthetic and periodontal problems is directly related to the amount of tilting and treatment becomes complex when adjacent teeth begin to migrate.[2,3]

The intensity of the forces and moment to force ratios needed to be applied during an orthodontic treatment must be adapted to obtain the same movement as in a tooth with a healthy periodontal support.[4] Excessive Orthodontic force with advanced periodontal bone loss may traumatize the periodontium, create increased areas of hyalinization or may subject the tooth to increased chances of root resorption (depending on the magnitude & distribution of this stress), that affects the Orthodontic tooth movement.[5,6]

It is common in the dental practice that the teeth adjacent to the lost teeth tend to tilt if the edentulous space has not been restored in time that may attribute to the influence of mesial components of occlusal force. Therefore we planned to conduct photoelastic study of changes in stress distribution in alveolar bone due to tilting of tooth.

METHODS

This study was conducted at Department of Prosthodontics of a dental hospital and teaching hospital of Jammu region. In this study the masticatory load was shifted to an anatomic model of mandible where first molar was missing and second molar was tilted in various degrees was simulated. Induced stress in alveolar bone was investigated using three dimensional photoelastic technique.

In this study we used Zelgon to produce negative mold of segment of the mandible and poured in wax. Acrylic replicas of the teeth were mounted onto the wax pattern of alveolar jaw bone in such a way that first molar was missing in every model and second molar was tilted to various degrees beginning from 15^0 in the first model and increasing the tilt to 20^0, 25^0, 35^0 and 35^0 in the models. In control second molar was tilted to 0^0 tilt.

Replicas were the taken out from the wax pattern of alveolar bone without disturbing the impression of the socket. Wax pattern of alveolar bone was then invested into plaster mold for burnout. After the burnout the models were cast into bifringent photoelastic material. The thickness of periodontium was maintained within the socket of the teeth with a layer of relief metal sheet wrapped around roots of acrylic replicas of the teeth. These were fitted in the socket of the modeling wax to represent the periodontium and the position of teeth to alveolar bone in the photoelastic model.

For casting, the Araldite was heated to 80^0C to expel all the air bubbles, and the cooled to room temperature. For proper mixing, this solution was stirred for 5 minutes only in one direction by a wire stirrer. It was checked that no air bubbles remained inside the mixture. The temperature of the solution rose to 55^0C. Before compound could harden, it was poured in the mold allowing any air bubble to remain inside.

Calibration of photoelastic material used in this study was calibrated for its material fringe value. The loaded models were placed in stress freezing oven and the temperature was raised up to 80^0C relatively rapidly from 28^0C. The loaded models ware soaked at this temperature for four hours for freezing of stresses. The temperature of oven was brought to room temperature slowly in three hours.

The stresses were observed in the stressed photo- elastic models through the analyzer, in the light field, in the form of fringes. The fringe order values were determined by viewing the stress frozen models through an analyzer. The zero order fringes were marked on the photographs by viewing the models in monochromatic light, it appeared as black fringe. The maximum shear stress in these areas was calculated.

The collected data was entered in Microsoft Excel. Coding of the variables was done. SPSS version 11.5 was used for analysis. Interpretation of the collected data were done by using appropriate statistical methods like percentage, mean, median and inter quartile range. Informed consent was taken and complete confidentiality was ensured to the students.

RESULTS

Highest fringe order in alveolar bone at various degrees of tilt of mandibular second molar tooth was recorded around the roots of second premolar, mesial root of second molar and distal root of second molar. In region 3, where maximum shear stress was lowest of the three at 0^0 tilt, the values were low for three regions. At 20^0 tilt, rise in shear stress was seen. Stress neither increased or decreased at all the other angles. In region 1, tilting showed reduction in values for 20^0 where the value of maximum shear stress was above the baseline. Shear stress was low at other angles. On comparing the ratio of stresses around the mesial and distal root of second molar at different degrees of tilt of mandibular second molar, equal amount of stresses were found along both the roots for model 1 with 0^0 tilt, the ratio being one.

The ratio raised in the other models when the tilt increased higher than 25^0. After 25^0 tilt of second molar, the ratio of stresses around the mesial and distal root of second molar raised to 2.4 for model-5 and 3.2 for model 6 at 30^0 tilt and 35^0 tilt respectively. Stresses are shifted from the distal root of second premolar to mesial root of second molar with tilting if first molar is not at its place.

DISCUSSION

Earlier, various methods have been used to study stress concentration in the tooth structures namely, photo-elastic studies (photomechanical investigations), strain gauge studies, etc.[7,8] Finite element analysis (FEA) is one of the more commonly used techniques for stress analysis.[9] This basic concept of this technique is the visualization of actual structure as an assembly of a finite number of elements. FEA divides the problem domain into a collection of smaller parts (elements). An overall approximated solution to the original problem is determined. Three post systems from different manufacturers were used in maxillary central incisors (virtual model) and were subjected to forces so as to elicit data regarding their tensile strength. Varied biomechanical behavior under different stresses is expected as the post systems used are significantly dissimilar in their design, taper, and modulus of elasticity.[10]

Finite element analysis is a mathematical analysis of designs which can demonstrate the amount of stress generated on application of forces and site of fracture and application of this technology in dentistry is very important which can reduce operator's bias during sample preparation for in vitro studies.[11]

Estimating the magnitude and location of stress in the periodontal ligament is very much essential to enhance the predictability of physiologic orthodontic tooth movement. Force magnitude in relation to the amount of alveolar bone height and necessary modification of moment to force ratio has been implicated by various authors to be important in planning force system in these scenarios.

Various studies have shown an increase in stress with alveolar bone loss.[12,13] Alveolar bone loss makes the tooth more prone to tipping & alveolar bone height affects the patterns of initial tooth displacements and hence the type of tooth movement. The reason for increase in stress as a result of alveolar bone loss has been cited in literature by different authors. A considerable argument exists that because of the reduced bony support and PDL area, the same magnitude of load on the crown causes more pressure in the PDL than without bone loss.[2,7] Further, as the length of the root embedded in alveolar bone decreased with the amount of alveolar bone loss, this caused an increase in the resultant stress. Another factor put forth in the literature is that with alveolar bone loss the tipping tendency of the tooth increases, leading further to the increase in stress.[14]

In this study, we observed highest fringe order in alveolar bone at various degrees of tilt of mandibular second molar tooth was recorded around the roots of second premolar, mesial root of second molar and distal root of second molar. In region 3, where maximum shear stress was lowest of the three at 00 tilt, the values were low for three regions. Another study by Yang and Thompson VP[15] has shown similar results. Tilting of molar abutment induced additional stress on the mesial side of the root. Reynolds MJ[16] advised in his study not to use teeth with tilt greater than 25^0 as abutment for fixed partial denture.

CONCLUSION

It was found that stresses were centered around the mesial root. Tooth looses its strength due to vertical bone loss along the mesial root. Hence the teeth having tilt >25^0 should not be used.

REFERENCES

1. Miyakawa O, Shiokawa N, Matsuura T, Hanada K. A new method for finite element simulation of orthodontic appliance - teeth - periodontium alveolus system. Journal of Biomechanics. 1985;18(4):277–84.
2. Keesee SM, Baty DL, Cameron SM, Lefler TB, Morris WJ. A technique for achieving prerestorative minor tooth movement with orthodontic separators. J Prosthet Dent 2002;88:544–547.
3. Lundgren D, Kurol J, Thorstensson B, Hugoson A. Periodontal conditions around tipped and upright molars in adults. An intra-individual retrospective study. Eur J Orthod 1992;14:449–455.
4. Davidovitch M, Papanicolaou S, Vardimon AD, Brosh T. Duration of elastomeric separation and effect on interproximal contact point characteristics. Am J Orthod Dentofacial Orthop 2008;133:414–422.
5. Ona M, Wakabayashi N. Influence of alveolar support on stress in periodontal structures. J Dent Res. 2006;85:1087–91.
6. Cobo J, Argüelles J, Puente M, Vijande M. Dentoalveolar stress from bodily tooth movement at different levels of bone loss. Am J Orthod Dentofacial Orthop. 1996;110(3):256–62.
7. Wehrbein H, Diedrich P. Mesio-marginal findings at tilted molars. A histological-histomorphometric study. Eur J Orthod 2001;23:663–670.
8. Narayanaswamy S. Finite element analysis of stress concentration in class V restorations of four groups of restorative materials in mandibular premolar. J Conserv Dent 2008;11:121-6.
9. Roscoe MG, Meira JB, Cattaneo PM. Association of orthodontic force system and root resorption: A systematic review. Am J Orthod Dentofacial Orthop. 2015;147(5):610–26
10. Moammadi N, Kahnamoii MA. Effect of fiber post and cusp coverage on fracture resistance of endodontically treated maxillary premolars directly restored with composite resin. J Endo 2009;35:1428-32.
11. Asmuseen E, Peutzfeldt A. Class I and class II restorations of resin composite: An FE analysis of the influence of modulus of elasticity on stresses generated by occlusal loading. Dent Mater 2008;24:600-5.
12. De Jager N, Pallav P. The influence of design parameters on the FEA- determined stress distribution in CAD-CAM produced all-ceramic dental crowns. Dent Mater 2005;21:242-51.
13. Ash MM. The Permanent Maxillary Incisor. Wheeler. Textbook of anatomy, physiology and occlusion, 6 ed. New Delhi: Saunders Publishers; 1998. p. 118-37.
14. Ricardo J. Influence of the remaining coronal structure on the resistance of teeth with intraradicular retainer. Braz Dent J 2005;16:197-201.
15. Yang HS, Thompson VP. A two- dimensional stress analysis comparing fixed prosthodontic approaches for tilted molar abutment. Int. J Prosthodont 1999; 4(5): 416-424.
16. Reynolds MJ. Abutment selection for fixed prosthodontics. J Prosthet Dent 1968;19(5): 483-88.