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Stress distribution of maxillary first molar PDL with highpull headgear traction; A finite element analysis

Shirin Shahnaseri [a], Mohammad Farahani [b], Majid Ghasemianpour Bavandi [b], Shervin Bagherieh [c], Seyed Amir Mousavi [d,*]

[a] *Dental Implant Research Center, Department of Oral and Maxillofacial Surgery, Dental School, Isfahan University of Medical Sciences, Isfahan, Iran*
[b] *Department of Orthodontics, Dental School, Shahid Beheshti University of Medical Sciences, Tehran, Iran*
[c] *Dental Research Center, Dental School, Isfahan University of Medical Sciences, Isfahan, Iran*
[d] *Dental Research Center, Department of Endodontics, Dental School, Isfahan University of Medical Sciences, Isfahan, Iran*

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ABSTRACT

Statement of the problem: Headgear is most commonly used to correct anteroposterior discrepancies. Headgear can also be used to make more space for teeth to come in. In this instance the headgear is attached to the molars, via molar headgear bands and tubes, and helps to draw these molars backwards in the mouth, opening up space for the front teeth to be moved back using braces and bands. Stress on PDL of molars teeth and soreness of teeth when chewing, or when the teeth touch, is typical. Adults usually feel the soreness 12–24 h later, but younger patients tend to react sooner.

Purpose: Application of heavy forces to maxillary dentition during treatment with headgear, induces high concentration of stresses in periodontal tissue. Quantification of this stress is of great concern in orthodontics. This study was designed to investigate the quantity and quality of stress response in the PDL of maxillary first molar which was subjected to highpull headgear traction using Finite Element Method.

Materials and method: In an experimental study, a three-dimensional finite element model of maxillary dentition, consisting of 17096 elements & 23013 nodes, was developed based on a young human skull. The forces were applied to the maxillary first molar in the stabilized arch by means of a rectangular full size arch wire in (022) slot bracket. Mechanical properties of this model were based on previous studies. A 350 g force was used for high pull headgear to affect the dentition (+30°) and stress distribution was investigated in buccal, palatal, mesial and distal side and in cervical, middle, apical sections of the PDL. The quantity of stresses were expressed as principal stresses, while the negative and positive signs indicated compressive and tensile stresses respectively.

Results: The buccal surface of PDL of mesiobuccal root and the buccal, palatal, and distal surface in cervical regions of PDL of distobuccal root and the distal surface of the PDL of palatal root had received a great deal of stresses, in addition, the over all stress distribution in roots of molar had intrusive nature.

Conclusion: The distribution of high stress concentration areas observed after using high pull headgear is limited to some root surfaces specially the distobuccal root.

1. Introduction

The epidemiologic investigation shows the prevalence of Cl II in ages between 12 and 17 the most after Cl I malocclusion [1,2]. Meanwhile, there is no doubt that headgear forces need to be used in conjunction with all contemporary mechanotherapy modalities for the highest quality and most stable correction of Cl II malocclusion [3]. Since the introduction of orthopedic headgear by the pioneer American orthodontist "Norman W.Kingsly", Various

* Corresponding author.
E-mail addresses: Shahnaseri@dnt.mui.ac.ir (S. Shahnaseri), MFarahani@sbmu.ac.ir (M. Farahani), MGhasemianpour@sbmu.ac.ir (M.G. Bavandi), Shervinbagherieh@dnt.mui.ac.ir (S. Bagherieh), Mousavi@dnt.mui.ac.ir (S.A. Mousavi).

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Table 1
Material constants of tooth, PDL, alveolar bone and steel.

Material	Young's modulus (kg/mm^2)	Possion's ratio
Tooth	2.031×10^4	0.3
PDL	50	0.3
Alveolar bone	1×10^4	0.33
Steel	2.031×10^5	0.3

studies have been conducted to investigate morphological, biological and biomechanical changes of the complex area of craniofacial, incident to orthopedic headgear treatment [3,4].

The biological response of PDL is determine by the strain-stress levels induced to tooth [5].

In orthodontics, many attempts have been made to model the reaction of teeth and PDL during application of orthopedic forces. Models such as mathematical – mechanical modeling that the value of such studies is limited by the fact that the mechanical properties of the surrounding tissues could differ from those of actual human tissues. Hence, the results depend on the physical features of the artificial substitute for the PDL [6].

The strain – gauge technique for registration of tooth movement has been demonstrated as a precise and valid method. A disadvantage, however is that the method is invasive [7]. The Finite Element Method is a powerful computer – simulation tool in determining Stress–strain level in the mechanics of structures in engineering [8,9]. FEM is an approximation method that divides the entire region of the structure into a set of elements. The application of FEM in dentistry has been found at the late 70's.

In Rubin et al. studies a 3D finite element model has been developed for analyzing the stress distribution in human mandibular right first molar [10].

Tanne et al. had investigated the stress distribution in PDL of lower first premolar after orthodontic force application, using a 3D

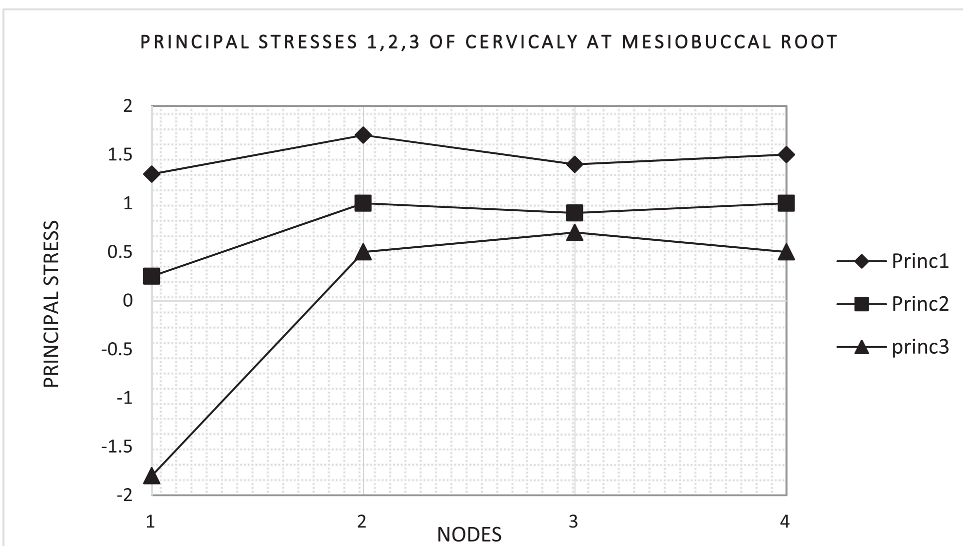

Fig. 1. Stress distribution in PDL cervical section of mesiobuccal root of first maxillary molar after loading by headgear.

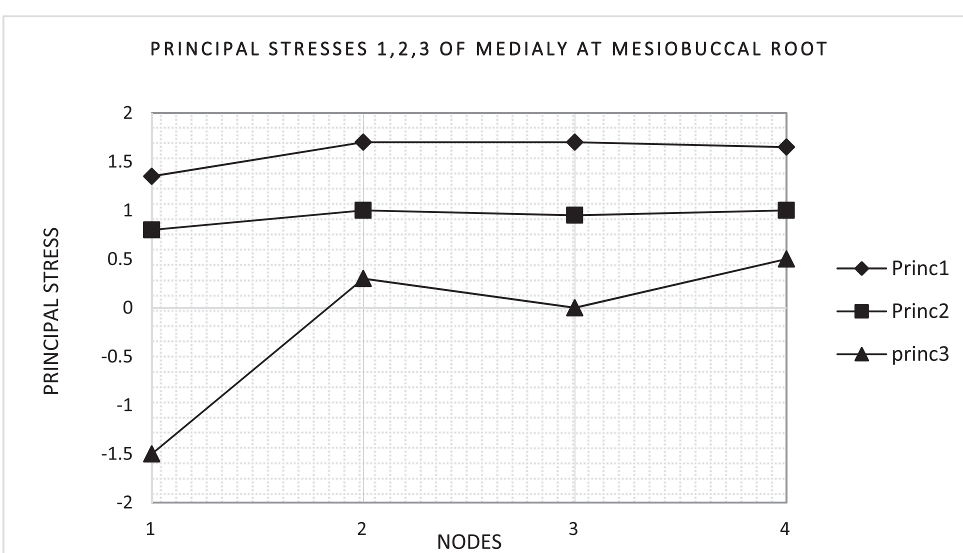

Fig. 2. Stress distribution in PDL middle section of mesiobuccal root of first maxillary molar after loading by headgear.

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