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Orthodontic Tooth Movement Of A Finite Element Model In Apical Force Distribution

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Abstract

Aim

The differences in biomechanics of intrusion movement in Labial and Lingual Orthodontics using finite element method (FEM).

Materials and methods

The maxillary right central incisor was used for the FEA as it best represents intrusion movement and most commonly involved tooth for intrusion. An intrusive force of 15g was applied on the labial and lingual surfaces of the maxillary right central incisor 4 mm from the incisal edge. In this study,

Results

Also, stress is maximum at the apex in lingual mechanics than that of labial mechanic. Intrusion forces applied in both labial and lingual orthodontics resulted in maximum stress at the root apex.

Conclusion

Within the limitations of this study, it can be concluded that lingual orthodontics holds better biomechanical significance than labial orthodontics.

Keywords

lingual orthodontics, intrusion, finite element analysis, FEM.

Introduction

This is achieved when an optimum force is delivered to get the desired tooth movement with minimal damage to the surrounding periodontal support.[1,2] Several studies have shown than different types of orthodontic tooth movement may produce different mechanical stress at varying locations within the root.

If a particular force system produces bodily displacement of tooth in LaO, crown tipping will occur in LiO and vice-versa.[5] Furthermore, lingual technique is more esthetic than the labial from patient point of view.[6]

Intrusion is one of the common procedure carried out for the correction of a deep bite or gummy smile. In case of vertical forces, the Center of Resistance (Cres) of the tooth is closer in LiO. Besides providing good esthetics, this biomechanical advantage demands lesser force or moment values, which will be more within the biological limit.

It is a computer aided technique which is used in predicting or simulating the response of a physical system or an object when subjected to external stimuli. FEM is an engineering resource which is widely used in biomedical research.

Materials and Methods

The simple reduction in the number of nonparametric faces leads to great distortion of the model, quite often. In order to enable further edition without significant distortion, the models should be parameterized using Solidworks Premium software "scan to 3D" (Dassault Systemes, Solidworks Corps, USA, thereby making the transformation of nonparametric models into parametric models with NURBS faces (Non Uniform Rational Bases Splines), with minimum distortion, possible. Orthodontic components such as the bracket was virtually reconstructed with the aid of digital calipers and a digital microscope.

The extremities of each element present as points, or bonds that connect the elements to each other resulting in the formation of an arranged mesh. It is these bonds that transmit information such as forces and stress distribution between elements.

In this study, an intrusive force of 15g was applied on the labial and lingual surfaces of the maxillary right central incisor 4 mm from the incisal edge [Figure 1].[19,20] In this study, the maxillary right central incisor was used for the FEA as it best represents intrusion movement and most commonly involved tooth for intrusion.

Results

Shows stress distribution in the teeth comparing labial and lingual mechanics and figure 3 and 4 shows the pattern of stress distribution in the bone. The stress patterns indicate that stress is directed more towards the apex of the root. There appears to be moderate stress distributed along the middle third of the root. The results also show that stress is maximum at the apex in labial mechanics than that of lingual mechanics.

Discussion

Geron et al.[1] considered the distance of bracket slot from tooth surface in their mathematical model of maxillary central incisor in LaO and LiO. But, the above study was limited to theoretical approach only and finite element analysis was not performed. Whereas, Lombardo et al did a finite element analysis for intrusion of lower central incisors in labial and lingual mechanics. [14]

From a mathematical model of maxillary central incisor, it was observed that M:F ratio was dependent on the horizontal distance (D) between Cres and bracket slot. Indeed, it was the horizontal distance between C res and point of force application (Pf). The distance D was different in LaO and LiO. As the distance (D) was greater in LaO (Fig. 5A) than in LiO (Fig. 5B), the required M:F ratio was grater in LaO. The value of D was considered to be dependent upon incisor inclination i.e. inclination of long axis of incisor, position of Cres, distance of bracket slot from tooth surface and height of bracket slot from incisal edge.

In this study, for light force of 15g, the stress concentration at the root apex was more in lingual

orthodontics compared to that of the labial. The maximum stress concentration is towards to apex. This is in accordance to the study conducted by Mascarenhas et al and Wilson et al.

Conclusion

Within the limitations of this study, it can be concluded that lingual orthodontics holds better biomechanical significance than labial orthodontics. This in turn is dependant several factors such as the length and inclination of the tooth, position of the bracket, morphology of the tooth.

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