PLACEMENT OF MINI-IMPLANTS FOR THE INTRUSION OF MAXILLARY MOLAR – A FEM STUDY

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Abstract

Aim: To determine the amount of intrusion of maxillary molar achieved with the placement of mini-implants.

Material & method: A computer simulation of three-dimensional model of maxillary first molar with its periodontal ligament and alveolar bone is constructed. Bucally, a bracket 0.022" slot is positioned over the center of the clinical crown and palatally, an attachment is placed in the center. Two mini-implants were placed bucally and one palatally for the purpose of intrusion. Both the attachments are to be used for the purpose of applying force through mini-implant and NiTi closed coil spring. The boundary condition is kept at the base of the maxilla.

Result: Overall maximum Occluso-gingival displacement of maxillary first molar is 0.002mm.

Keywords: Intrusion, mini implants, NiTi coil spring, FEA (finite element analysis).

Introduction

Malocclusion can happen in three planes of space namely, sagittal, transverse and vertical plane. Dental vertical relationships are categorized into four groups: anterior open bite, anterior deep bite, posterior open bite, and posterior collapsed bite.

Overlapping of the mandibular arch by the maxillary arch occurs since maxillary arches are wider. This overlapping occurs in both vertical as well as horizontal direction. The horizontal overlap is termed as overjet while the vertical overlap is termed as overbite. Some amount of vertical overlap is a customary feature of the human dentition. But if this overlap is excessive or deficient that is a matter of concern for both, the patient and for the clinician, from the point of facial esthetics and disturbed normal occlusion and function. Such a condition where there is deficient vertical overlapping of the mandibular anteriors is termed as open bite. This condition can arise as a result of skeletal discrepancy or dental problems. Thus, it is important to first diagnose correctly the cause behind the open bite. One of the many treatments of this condition is the intrusion of the posterior segment.

Methods of posterior intrusion [1]

Extruded posterior teeth can be intruded orthodontically, by other methods, such as:

- With the use of Inter-maxillary device
- By applying Sectional mechanics
- Removable appliance can be fabricated
- Trans-palatal bar can be inserted
- Anchorage from mini-plates
- Temporary anchorage devices, which is the current trend in orthodontics
- Magnets
- Use of Titanium mini screw Implants for Maxillary Molar Intrusion
- Posterior segment intrusion is considered as a difficult orthodontic tooth movement. Numerous factors, such as magnitude and direction of the forces and orientation of the anchorage units, should be taken into account during posterior intrusion to avoid unwanted movement and root resorption.[2] The use of temporary anchorage devices has also eliminated the need for orthognathic surgeries in moderate open bite cases.[3-4]
- In the field of dentofacial orthopedics, finite element model has been used to estimate the stress distribution-induced within the craniofacial complex during the application of protraction headgear, orthopedic chin cup forces and conventional headgear forces.
- With this in mind, this FEM study aimed to simulate the stress response in the periodontium and the displacement achieved in the maxillary molar with the use miniscrew implants separately.

Aims and objectives

The goal of this study is to check the effects of placement of miniscrew implants in the maxillary arch on the intrusion of molars.

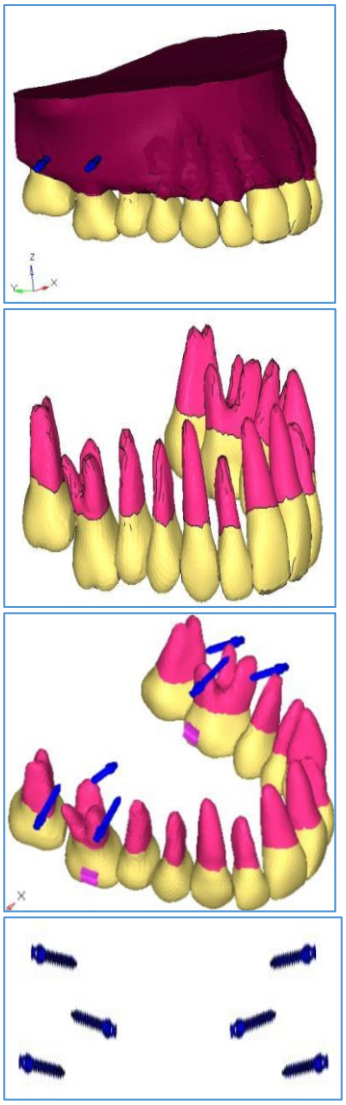
Materials and method

In the present study, a 3-dimensional finite element model of the first maxillary molar with its periodontal ligament, alveolar bone and teeth was constructed, and the stresses from 200g of intrusion forces exerted on them with the help of varying number of mini screw implants and a NiTi closed coil spring were determined.

Steps involved in the finite element model preparation:

1. Construction of the Geometric model of the maxillary first molar with its periodontal structures (periodontal ligament, alveolar bone and teeth).
2. Conversion of the geometric models to a finite element model.
3. Incorporation of material properties of tooth structure and periodontium.
4. Defining boundary condition.
5. Loading configuration.

Model -1 :



Results

As a result of 200gm of force applied for the purpose of true intrusion of the first maxillary molar, the following results are obtained.

The following observations are made from the analysis' results:

MODEL : (Three mini-implant system)

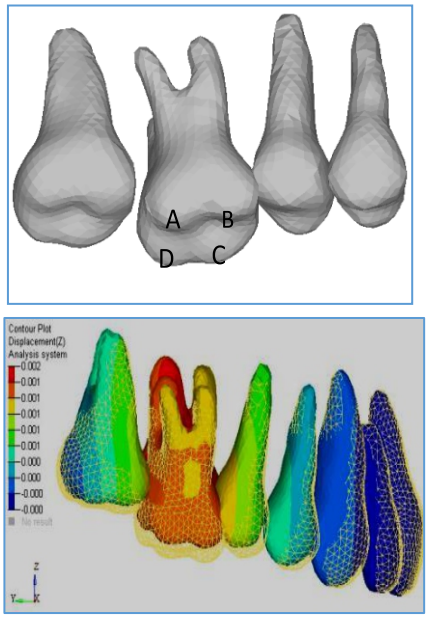
Displacement seen in model

The maximum amount of occluso-gingival (along the Z axis) Initial displacement or intrusion in this case is observed in the mesio-buccal cusp, mesio-palatal cusp, and disto-palatal cusp of first maxillary molar of 0.002mm. An initial displacement of 0.001 mm is observed in the disto-buccal cusp of maxillary first molar. No displacement is seen in X and Y axis except for 0.001 mm displacement of the disto-buccal cusp of maxillary first molar along the X axis (bucco-lingual movement). The maximum amount of deformation seen is of 0.007mm in Z (Occluso-gingival) direction in hard bone, which is confined to the area of the implant. Whereas, the minimum amount of displacement contour is seen in the teeth and PDL of 0.002mm which is confined to the area of the palatal root.

Von Mises stress of model

Maximum amount of von Mises stress of 26.46 MPa, is seen in the Hard Bone confined to the peri-implant area. The nature of the stress changes from tensile around the mini-implant to compressive away from the mini-implant. For Soft Bone the von Mises stress observed was 2.33 MPa, in the peri-implant area which is tensile in nature. The least amount of von Mises stress of 0.005 MPa, was observed in the PDL, in the furcation region of the roots of the first maxillary molar. For Teeth, the von Mises stress recorded was 2.133MPa at the site of palatal root of maxillary first molar, in close proximity to the furcation area of the root.

Displacement of Teeth in the X, Y & Z plane in model 1(three mini-implant system)



Initial displacement achieved in the model

Plane	Displacement of each cusp of maxillary first molar (In mm)			
	Disto-Buccal (A)	Mesio-Buccal (B)	Mesio-Palatal (C)	Disto-Palatal (D)
X(Bucco-Lingual)	0.001	0	0	0.001
Y(Mesio-Distal)	0	0	0	0
Z(Occluso-Gingival)	0.001	0.002	0.002	0.002

Discussion

Intrusion of maxillary molar is considered as a reliable treatment option for correction of an anterior open bite or

an occlusal interference created as a result of supra-eruption of maxillary molar due to missing antagonist tooth. Many clinical studies on molar intrusion or posterior intrusion for correction of an anterior open bite or supra-erupted maxillary molars with mini screws have been documented till date. Lin et al [5] had published a case report on intrusion of over-erupted maxillary molars with mini screw anchorage. They concluded that mini screw implants were relatively simple and non-invasive. They also stated that TADs provided direct skeletal anchorage, with no need for extra laboratory work or chair time to fabricate or adjust a trans-palatal bar. Intrusion of molars by conventional methods is always associated with unwanted side-effects. Control of reaction forces is the key to a successful orthodontic treatment. Mostly, these reaction forces are undesirable and need to be intercepted or neutralized. Although the anchorage can be augmented extra-orally, yet the success depends entirely on the patients' compliance. A force element is needed to exert forces via mini screws on the teeth or tooth involved. Kravitz et al[6] in his study used two mini screw implants to intrude maxillary molar, one on the buccal side & the other palatally and applied a force of 150-200g via NiTi closed coil spring. The use of NiTi closed coil spring allows for the delivery of a more constant force, preventing the need for continual replacement and subsequent reactivation of the elastic chain, reducing the number of treatment appointments, and increasing the length of treatment intervals. Control of reaction forces is the key to a successful orthodontic treatment. Mostly, these reaction forces are undesirable and need to be intercepted or neutralized. Although the anchorage can be augmented extra-orally, yet the success depends entirely on the patients' compliance. Proffit, Fields and Sarver[7] drew attention towards the key to successful intrusion which according to them is light continuous force directed toward the tooth apex. Gianelly and Goldman[8] recommended 15 to 50 g of force for small teeth. For molar intrusion, Umemori et al[9] recommended an initial force of 500 g. Kalra et al[10] suggested about 90 g per tooth for molar intrusion in growing children, and Melson and Fiorelli[11] used about 50g buccolingually to intrude maxillary molars in adult patients. Considering the number and the surface area of posterior tooth roots, it is reasonable to apply intrusion forces 2 or 3 times greater than those applied on anterior teeth. Yao et al[12] in their case report applied a medium intrusive force (150-200g) on the molar via power chains pulling upward from the buccal tube and lingual sheath of the molar attachments on the miniplate and the miniscrew, respectively. They concluded that normal overjet and overbite and good intercuspation remained unaltered. A functional occlusion was established.

Finite element analysis (FEA) or Finite Element method (FEM), introduced by Farah in 1973, is an engineering research technique to study the internal stresses and strain generated in geometric and material structures in response to a load applied and ultimately help in predicting the possibility of material failure. A net force of 200g was applied for the intrusion of the maxillary first molar in both the models. The division of forces was such that 100g was applied from the buccal side and another 100g from the palatal side. The preliminary findings of this FEM study indicate that TADs are an effective means of bringing about tooth movement specifically intrusion of molars in a controlled manner by producing acceptable stresses in the periodontal ligament.

Conclusion

Based on the 200g of intrusion force applied to the maxillary molar in the model for analysis, the following conclusion can be drawn.

1. The maximum deformation is of 0.007mm in occluso-gingival direction. Initial intrusion achieved with is 0.002mm.
2. The maximum von Mises stress of alveolar bone and PDL in the maxillary molar is recorded below their respective ultimate tensile strength in both the models. Hence the said structures are safe with 200g of intrusive forces.

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