THE PERIODONTAL EFFECTS OF AN OPTIMAL INTRUSIVE FORCE ON A MAXILLARY CENTRAL INCISOR. A FEM EVALUATION

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ABSTRACT

Introduction. Proffit's experience shows that orthodontic treatment is an option even after severe periodontal problems occurred. He claims that if an optimal control of the periodontal condition is maintained then we will not experience any additional bone loss. Although the exact magnitude of the orthodontic forces is difficult to be determined in clinical practice, the literature recommends around 0.2 N as an optimal value for an intrusive force.
Material and method. We used FEM Catia V5R16 software in order to create an accurate model of a maxillary arch and of an upper central incisor.The upper central incisor was designed in such a way that it will respect in the smallest details the real characteristics.We applied and optimal intrusive force with the magnitude of 0.25 N at the level of maxillary central incisor with no periodontal disease.
Results and discussion. We can remark that under the effect of an oprimal force, σ ech inside the complex tooth-PDL-alveolar bone is similar both for the case with no periodontal disease and for the one with 33% HBL.The tension on the direction of the force (σ c) shows a very light inscrease of 5,97% in the case of 33% HBL compared to the case of no HBL.Analyzing the results of the tooth movement (f) registered during loading with a 0,25 N intrusive force, we can state that f stays constant in the case of no HBL and in the case of 33% HBL.
Conclusions. Intrusion of maxillary central incisors using an optimal force showed to be a strong alternative of treatment in the periodontal cases.

Keywords: FEM, periodontal ligament, intrusion, periodontal disease, HBL

Introduction

Contemporary orthodontics is focusing not only on aligning teeth but also on preserving the periodontal condition. If only until a decade ago the orthodontic treatment of the periodontal patient was a controversial topic, nowadays we are establishing new protocols regarding the applicability of the this kind of treatment in improving the attachment and implantation of teeth.

According to Saga et al., intrusion movement of maxillary incisors is often necessary. Saga conducted an investigation in order to evaluate the initial distribution patterns and magnitude of compressive stress in the periodontal ligament (PDL) in a simulation of orthodontic intrusion of maxillary incisors, considering the points of force application.[1]

According to Proffit et al. in the case of severe periodontal involvement, it is highly

recommended to keep the orthodontic forces to an absolute minimum because the PDL has a significantly reduced area and otherwise we will create an area of intense pressure. [2]

Proffit suggests as well that a hopeless tooth can be useful in order to help supporting an orthondontic appliance that will contribute in saving other periodontally affected teeth. [2]

Proffit's experience shows that orthodontic treatment is an option even after severe periodontal problems occurred. He claims that if an optimal control of the periodontal condition is maintained then we will not experience any additional bone loss. [2]

Although the exact magnitude of the orthodontic forces is difficult to be determined in clinical practice, the literature recommends around 0.2 N as an optimal value for an intrusive force.[2]

Material and Methods

We used FEM Catia V5R16 software in order to create an accurate model of a maxillary arch and of an upper central incisor. (Fig. 1a-1b)

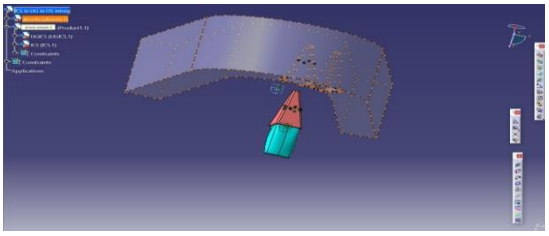

Fig. 1a – Maxillary model

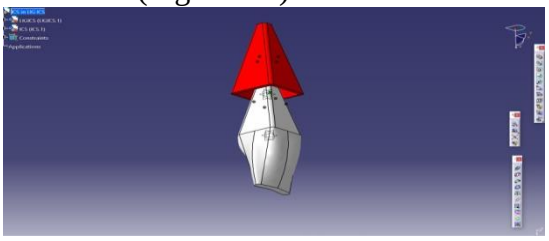

Fig. 1b- Upper central incisor with PDL

The upper central incisor was designed in such a way that it will respect in the smallest details the real characteristics. (Table 1)Table 1 – Dimension of Upper Central Incisor [3,4]

Upper Central Incisor (LCI)	
Crown length	10,5 mm
Root length	13 mm
Total length	23,5 mm
M-D diameter of the crown	8.5 mm
M-D diameter of the crown at the cervical level	7 mm
F-O diameter of the crown	7 mm
F-O diameter of the crown at the cervical level	6 mm

We used reliable previous studies in order to set the values of the mechanical characteristics like Young's Modulus and Poisson Ratio. These two parameters referred to the tooth,

alveolar bone and periodontal ligament. (Table 2)

Table 2 - Mechanic characteristic after [5,6]

Material	Young'sModulus	Poisson Ratio
Tooth	20000	0,30
Alveolar bone	13800	0,30
Periodontal ligament	0,68	0,49

Two additional models were designedin order to simulate periodontal disease with horizontal bone loss of 33% and 66% around the tooth. (Fig. 2a-2b)

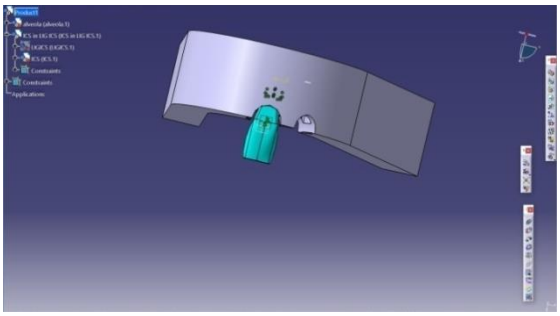

Fig. 2a- Maxillary with 33% bone loss

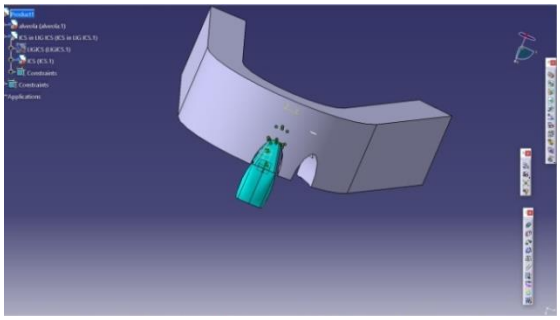

Fig. 2b- Maxillary model with 66% bone loss

The periodondal ligament was designed in such a way that it respects the shape of the root and it will have 0,5 mm thickness. We decided for the thickness of 0,5 mm because we wanted to prevent any potential errors that can occur during the analysis. [7]

We applied and optimal intrusive force with the magnitude of 0.25 N at the level of maxillary central incisor with no periodontal disease. Furthermore we applied the same force in the case where he had 33% horizontal bone loss (HBL) and 66% horizontal bone loss (HBL).

Abaqus software that was attached to CATIA V5R16 has been used to perform the analysis with finite elements with minimal errors. [8,9]

Results and Discussion.

Consecutive to the application of an optimal 0,25 N intrusive force we took in consideration three parameters: the equivalent tension inside the structure formed by the tooth-periodontal ligament-alveolar bone (σ ech), the tension that was registered on the direction of the force (σ c) and the tooth movement that was recorded (f). (Table 3)

Table 3- The comparative results after applying an intrusion force of 0.25 N

Force	No horizontal bone loss	33% horizontal bone loss	66% horizontal bone loss
0.25N	σ ech=0,117 MPa	σ ech=0,117 MPa	σ ech=0,146 MPa
0.25 N	σ c=0,0184 MPa	σ c=0,0195 MPa	σ c=0,0399 MPa
0.25 N	f=0,014 mm	f=0,0143mm	f=0,0167 mm

We can remark that under the effect of an oprimal force, σ ech inside the complex tooth-PDL-alveolar bone is similar both for the case with no periodontal disease and for the one with 33% HBL.

In the case of severe periodontal disease (66% HBL) we can notice that σ ech is increasing with 24,78%. (Fig. 3)

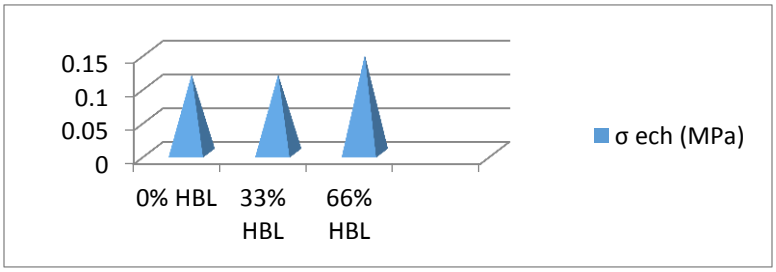

Fig. 3 –Variation of σ ech under a loading of 0,25 N

The tension on the direction of the force (σ c) shows a very light inscrease of 5,97% in the case of 33% HBL compared to the case of no HBL.

When we tested the model with 66% HBL we identified a significant increase of 116% of σ c value compared to the situation with no periodontal disease. (Fig. 4)

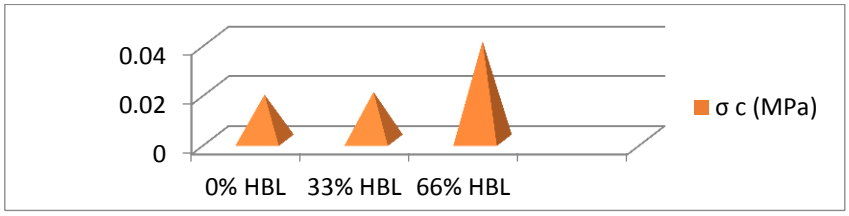

Fig. 4 -Variation of σ c under a loading of 0,25 N

Analyzing the results of the tooth movement (f) registered during loading with a 0,25 N intrusive force, we can state that f stays constant in the case of no HBL and in the case of 33% HBL.

In the case of severe periodontal disease (66% HBL) we can noticed an increased value of the tooth movement with 19,28% compared to the scenario of no periodontal disease. Even if this value is percentually increased when we analyze the absolute values expressed in mm and when we correlate them with clinical reality this variation is not highly significant. [10-12] (Fig. 5)

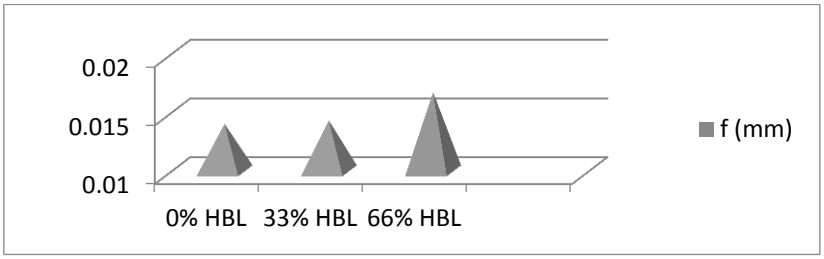

Fig. 5. Variation of f under a loading of 0,25 N

Conclusions

Intrusion of maxillary central incisors using an optimal force showed to be a strong alternative of treatment in the periodontal cases. Our results proved that there is no significant variation in the analyzed parameters, especially between the case of no HBL and the case with moderate (33%) HBL. The higher values of stress registered when loading the model with severe periodontal disease can be clinically correlated with the reduced size of the PDL.

References:

1. Saga AY, Maruo H, Argenta MA, Maruo IT, Tanaka OM.*Orthodontic intrusion of maxillary incisors: a 3D finite element method study*. Dental Press J Orthod. 2016; 21(1):75-82.
2. Proffit WR, Fields HW, Sarver D, *Contemporary Orthodontics, 4th edition,* St. Louis, Mosby Elsevier Publishing House, 2009, p. 660-662.
3. Bhalajhi SI. *Dental Anatomy-Histology and Development*, New Dehli: Arya Publishing House, 2009, p.51-139.
4. Scheid C, Weiss G, *Woelfel's Dental Anatomy*, Wolters Kluwer Publishing House 2012, pp. 42-66.
5. Chen J, Li W, Swain M, Darendeliler MA, Li Q. *A periodontal ligament driven remodeling algorithm for orthodontic tooth movement.* J Biomech 2014; 47:1689-1695.
6. Caballero GM, Carvalho Filho OA, Hargreaves BO, Brito HH, Magalhães Júnior PA, Oliveira DD. *Mandibular canine intrusion with the segmented arch technique: A finite element method study.* Am J Orthod Dentofacial Orthop. 2015; 147(6):691-7.
7. Melsen B, Cattaneo PM, Dalstra M, Kraft DC. *The Importance of Force Levels in Relation to Tooth Movement*, Sem Ortho 2007; 13(4): 220-233.
8. Ko CC, Passos Rocha E, Larson M.*Past, Present and Future of Finite Element Analysis in Dentistry*.www.intechopen.com
9. Prasad Konda, Tarannum S A. *Basic principles of finite element method and its applications in orthodontics*. JPBMS 2012, 16(11).
10. Vata LI. D*istalizarea – o metodă de reglare a deficitului de spațiu. Posibilități și limite.*Teza Doctiorat, UMF Tg Mureș, 2012.
11. Luchian I., Țanculescu O., Rudnic I., Tatarciuc M., Martu S.*The analyze by finite element of strains in periodontal ligament and alveolar bone during orthodontic tooth movement*. Romanian Journal of Oral Rehabilitation 2012; 4(1):35-39.
12. Luchian I, Vata I, Stirbu C, Martu I, Tatarciuc M, Martu S. *The effects of a moderate intrusive force on affected periodontal tissues. A fem study*. Romanian Journal of Oral Rehabilitation, 2015; 7(3): 91-96