Engineering and Biomechanics in the Orthodontic Treatment of Periodontally Compromised Adult Patients

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Abstract: - This study was undertaken to determine the optimal force system that should be used in the orthodontic treatment of periodontally compromised patients. For this we analyzed the biomechanics of the system formed by the reduced periodontal support – tooth – force delivered from the fixed orthodontic aplliance trough the bracket. The analysis of tensions was done by means of the finite element method (FEM) for a normal case and for reducing the periodontal support bone with 4mm. The force was applied in the center of the vestibular clinical crown (the L.A. point) and 3 mm more gingivally. The advantages of placing the brackets more gingivally are discussed. The manufactures of the bracket systems should improve their design in order to fit better for this clinical situations.

Key-Words: - **loss of alveolar bone height, center of resistance, tipping moment, finite element method, optimal force system, brackets design, orthodontic tissue regeneration**

1 Introduction

In the last years a significant development has taken place in the orthodontic treatment of adult patients. Adult orthodontics is different than that for children because in adults there is virtual no more growth and because the lost of alveolar bone.

The reasons for considering the "periodontally compromised" patients separately are: they are more prone to further bone loss; the reduced periodontium cannot sustain further loss without the potential loss of teeth; there is frequently an aquired malocclusion unique to this group; the reduced periodontal support dictates altered treatment design, mechanics and retention [1].

The special biomechanics and the engineering of the bracket systems are the subjects of this study.

2 Problem Formulation

In order to have a better understanding of the orthodontic biomechanics we will present, in brief, the usual physical terms.

A tooth moves because the force delivered by the orthodontic aplliance is applied on the tooth mainly trough an bracket. The force is usually measured in weight units of grams or ounces.

The center of resistance is a point at wich resistance to movement can be concentrated for mathematical analysis. The center of resistance for a tooth is at the approximate midpoint of the embedded portion of the root (i.e., about halfway between the root apex and the crest of the alveolar bone) [2].

When a force acts at distance from the centre of resistance it creates an moment. This force will not only tend to translate the object but it also will tend to rotate the object around the center of resistance. The equation for calculating the moment is $M = F \times d$ where M is the moment, F is the force and d is the perpendicular distance from the point of force application to the center of resistance. This is the typical situation for a tooth where the force is applied to the crown of the tooth and the center of resistance is at the first third of the root.

2.1 Biomechanics in periodontally compromised adult patients

Adult patients with periodontal disease have a reduced alveolar bone and the periodontal ligament (PDL) area decreases. Consequently the same force against the crown produces greater pressure in the PDL of a periodontally compromised tooth than a normally supported one [2]. Also the center of resistance moves closer to the root apex. All this have a lot of biomechanical consequences that influence the design of the orthodontic appliance and treatment sequences in each clinical case.

In the design of the appliance we must take into consideration the recomandations of Prof. Dr. Birte Melsen: Optimizing treatment also means moving teeth directly from the original position to the one defined by the treatment goal. This implies a minimum treatment time and a minimum of iatrogenic damage. The appliance should therefore be designed to deliver a force system as close to the ideal as possible [3].

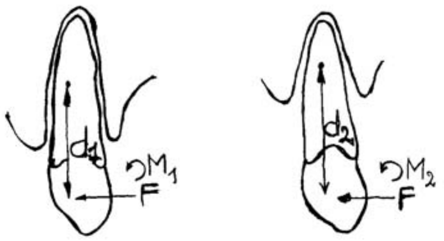

Fig.1 At a tooth with a reduced periodontium the center of resistance moves more apically

When we apply the same force (F) to the teeth from Fig.1 then the tipping moment (M2) produced on the periodontally compromised tooth will increase because the distance from the the point of force application to the center of resistance is greater (d2>d1).

We can consider the following situation: three first mandibular premolars with the same dental morphology but the first has an alveolar bone with normal height (the center of resistance will be at 12 mm from the bracket slot) and the last two have a reduced bone support with 50% (the center of resistance will be at 17 mm from the bracket slot) (Fig.2).

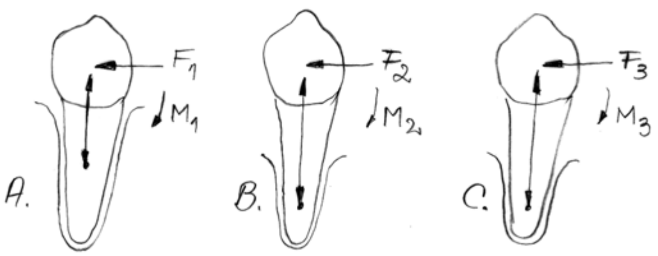

Fig.2 Three different clinical situations for the study of forces and moments

For optimal orthodontic movement of the first considered premolar it is sufficient a force (F1) of 100mg that will produce an moment (M1) of 1200mg/mm [2].

If we apply the same force F2=F1 to the second premolar it will produce a greater pressure (double) in the periodontal ligament of the periodontally compromised tooth. The countervailing moment that we apply to the tooth M1=1200mg/mm will be insufficient to prevent the greater tipping moment produced by this force (M2=1700mg/mm).

The ideal solution is ilustrated in the third situation by applying a smaller force F3=50mg and a countervailing moment of 850mg/mm that can neutralize the tipping moment (M3=850mg/mm) and produce bodily movement of the tooth. This is possible only by using fixed orthodontic appliances.

Also in periodontally compromised patients we must take into consideartion that intrusion has a very accentuated vestibular tipping side-effect (Fig.3).

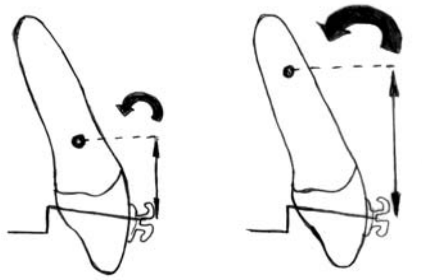

Fig.3 Intrusion has in cases with reduced periodontium a greater tipping effect than in teeth with normal alveolar bone height.

2.2 The analysis of tensions by means of the finite element method (FEM)

We constructed an model of a canine with normal and 4mm reduced periodontal support bone to wich we applied the same orthodontic force in the center of the vestibular clinical crown (the L.A. point) and 3 mm more gingivally. The constructed model had 2851 points and 1513 nodes.

Two-dimensional images in false colors with intensity of tensions and its areas of extension are generated.

The force was applied in mesio-distal direction (Fig.4).

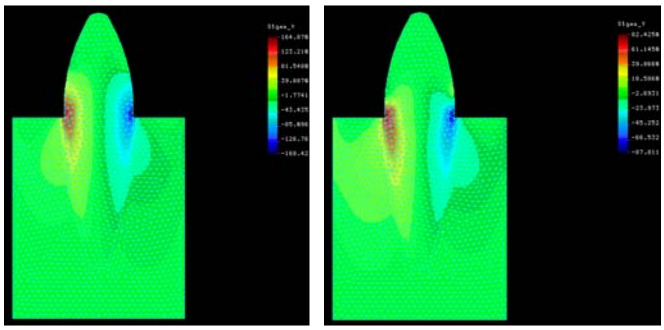

Fig.4 The generated tensions in the OY axis for a tooth with reduced periodontium and application of the force in the center of the clinical crown and 3 mm more gingivally

The analyze of the tensions with the FEM method shows advantage from applying the orthodontic force more gingivally in each tooth with reduced periodontal support.

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2.3 Orthodontic Tissue Regeneration (O.T.R.)

The actual trend in the treatment of patients with periodontal disease is to try to regenerate the lost periodontal structures.

The orthodontic movement has a very great osteogenic potential that can be used in the interdisciplinar treatment of this patients.

This clinical case of a 42 years lady with advanced periodontal disease and malocclusions was treated in an interdisciplinar team where we applied the above mentioned biomechanical considerations (Fig.5).

Fig.5 Initial clinical status with a heavily affected periodontium and a complicated class III malocclusion.

The final results of the orthodontic, periodontal and prosthodontic treatment shows a very good improvement of the oral health (Fig.6).

Fig.6 Final clinical situation with a good periodontal health

Fig.7 Panoramic radiograph of the patient at the beginning of the treatment showing a great resorbtion of the alveolar bone, especially around the right mandibular premolars

The important orthodontic tissue regeneration effect can be seen clinically by examining the periodontal status parameters but especially radiologically, to demonstrate the new periodontal bone formation (Fig.7,8).

Fig.8 Panoramic radiograph during the orthodontic treatment with extrusion of the right mandibular premolars and new bone formation. The brackets were palced more ginigvally.

3 Problem Solution

The advantages from placing the brackets more gingivally are very important especially in the orthodontic treatment of periodontally compromised patients because this allows a better control of the tooth movement. This is useful in a mutilated dentition where we have only a few anchorage units.

Because the base of a bracket is generally designed to be placed in the center of the vestibular crown the manufactures should design a new base more adapted to the gingival part of the crown in order to have a more stabile tooth/bracket interface and introduce new informations in the bracket (tip, torque, angulation).

4 Conclusion

A new bracket from the manufactures and the specific biomechanical considerations will help in improving the succes of the adult orthodontic treatment.

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