Microimplants, head gears and bracket systems in orthodontic tooth movement: a biomechanical study

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Bracket systems, head gears and microimplants are widely used for orthodontic tooth movement. The micro-implants are effective tools for the anchorage of orthodontic intrusion. Until now, various techniques to reinforce anchorage have been devised and used in orthodontic practice. Multi-bracket appliances have commonly been used in routine orthodontic treatment. When maximal anchorage is required, additional aids are often needed to support the anchoring teeth. Headgears were introduced more than a century ago and are used in some cases for orthodontic treatment. Its design, force balance, efficiencies and management have been explained in a series of papers. Outer bow asymmetries and their influence on the orthodontic effect have already been studied while the asymmetries in the inner bow have not been studied yet. Here some results of the biomechanical study of the force system in various asymmetric inner bow forms are presented. Different sort of rotation, extrusion/intrusion, tipping and translation movement can be obtained by different appliances, initial tooth position and state of the structural and metabolic bone fractions. The finite element method (FEM) is the most efficient tool for numerical computations of the strain-stress state and the tooth displacement/rotation in a given configuration.

Here a brief review of the appliances for the tooth movement, their efficiency and the corresponding biomechanical models is given. The results of FEM computations for a given teeth allocation in the tooth rows are presented. It is shown the preliminary quantitative biomechanical analysis is important for choosing the best orthodontic procedure and appliance. A theoretical evaluation of the axisymmetric and non-axisymmetric face-bows based on the canonical equations of the force method is done. It is shown a small displacement of one of the molars into the anterio-posterior direction may produce important differences in the force and moment of force applied by the face-bows to the both molars resulting in their different displacement and unfavourable rotation. The difference in the displacement will result into bigger differences in the positions of the molars in the anterio-posterior direction which will enhance the initial asymmetry providing the positive feedback relations in the system.

Three finite element models of cervical headgears with asymmetric inner bows have been designed in SolidWorks 2006 and meshed in ANSYS Workbench Ver. 11.0. A 150-gram force is applied at each side of the outer bow after model transfer to ANSYS Ver. 11.0. Inner bow ends are restrained and force results are derived. In the first model the inner bow ends is asymmetric due to a 2 mm difference in medio-lateral position of the right and left ends. In the second model the asymmetry is due to a 2 mm mesial shift in one molar. The third model is a combination of the two showing a 2-mm mesially and a 2-mm medially displaced molar in one side. FEM computations for the three models have revealed a difference between antero-posterior forces showing the larger one in the molar located anteriorly; a two times bigger force in the nearer molar to the midline than in the unaffected one. This difference for the distal driving forces was four times bigger on the molar shifted mesially and mediallty in comparison with unaffected one. In that way a larger distal driving force was shown in molars displaced mesially or medially in one side of the arch in relation to their opposite side. Different extrusive forces are shown to exist in molars with asymmetric position. A tendency to apply a palatally directed force vector in the normal side molar and a buccaly directed one in the affected side is shown. In that way upper dental arch should be assessed carefully before adjusting a headgear. A symmetroscope can be employed to assess the molars' position. All discrepancies should be corrected using a palatal bar with unilateral extensions to treat molars and reach a symmetric position. The symmetroscope is also suggested to be used in assessing the inner bow form at the end of adjustment.