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Adjustment of the Level of Vibrational Force on Targeted Teeth

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Abstract : The effect of vibrational force (VF) on accelerating orthodontic tooth movement depends on the level of delivered stimulation to the tooth in terms of peak load (PL), which requires contacts between the tooth and the VF device. A personalized device ensures the contacts, but the resulting PL distribution on the teeth is unknown. Furthermore, it is unclear whether the PL on particular teeth can be adjusted to the prescribed values. The objective of this study was to investigate the efficacy of apersonalized VF device in controlling the level of stimulation on two teeth, the mandibular canines and 2nd molars. A 3-D finite element (FE) model of human dentition, including teeth, PDL, and alveolar bone, was created from the cone beam computed tomography images of an anonymous subject. The VF was applied to the teeth through a VFdevice consisting of a mouthpiece with engraved tooth profile of the subject and a VF source that applied 0.3 N force with the frequency of 30 Hz. The dentition and mouthpiece were meshed using 10-node tetrahedral elements. Interface elements were created at the interfaces between the teeth and the mouthpiece. The upper and lower teeth bite on the mouthpiece to receive the vibration. The depth of engraved individual tooth profile could be adjusted, which was accomplished by adding a layer of material as an interference or removing a layer of material as a clearance to change the PL on the tooth. The interference increases the PL while the clearance decreases it. Fivemouthpiece design cases were simulated, which included a mouthpiece without interference/clearance; the mouthpieces with bilateral interferences on both mandibular canines and 2nd molars with magnitudes of 0.1, 0.15, and 0.2-mm, respectively; and mouthpiece with bilateral 0.3-mm clearances on the four teeth. Then, the force distributions on the entire dentition were compared corresponding to these adjustments. The PL distribution on the teeth is uneven when there is no interference or clearance. Among all teeth, the anterior segment receives the highest level of PL. Adding 0.1, 0.15, and 0.2-mm interferences to the canines and 2nd molars bilaterally leads to increase of the PL on the canines by 10, 62, and 73 percent and on the 2nd molar by 14, 55, and 87 percent, respectively. Adding clearances to the canines and 2nd molars by removing the contactsbetween these teeth and the mouthpiece results in zero PL on them. Moreover, introducing interference to mandibular canines and 2nd molarsredistributes the PL on the entireteeth. The share of the PL on the anterior teeth are reduced. The use of the personalized mouthpiece ensures contactsof the teeth to the mouthpiece so that all teeth can be stimulated. However, the PL distribution is uneven. Adding interference between a tooth and the mouthpiece increases the PL while introducing clearance decreases the PL. As a result, the PL is redistributed. This study confirms that the level of VF stimulation on the individual tooth can be adjusted to a prescribed value.

Keywords : finite element method, orthodontic treatment, stress analysis, tooth movement, vibrational force
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