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Effect of corticision and different force magnitudes on orthodontic tooth movement in a rat model

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Introduction: The aims of this study were to evaluate the effect of 2 distinct magnitudes of applied force with and without corticision (flapless corticotomy) on the rate of tooth movement and to examine the alveolar response in a rat model. **Methods:** A total of 44 male rats (6 weeks old) were equally divided into 4 experimental groups based on force level and surgical intervention: light force, light force with corticision, heavy force, and heavy force with corticision. The forces were delivered from the maxillary left first molar to the maxillary incisors using prefabricated 10-g (light force) or 100-g (heavy force) nickel-titanium springs. The corticision procedure was performed at appliance placement and repeated 1 week later on the mesiopalatal aspect of the maxillary left first molars, with the right sides serving as the untreated controls. Microcomputed tomography was used to evaluate tooth movement between the maxillary first and second molars, and the alveolar response in the region of the maxillary first molar on day 14. Osteoclasts and odontoclasts were quantified, and the expression of receptor activator of nuclear factor kappa ß ligand was examined. **Results:** Intragroup comparisons of bone volume fraction (BVF) and tissue density were found to be significantly less on the loaded sides, with the exception of BVF in the light force group. Intergroup comparisons evaluating magnitude of tooth movement, BVF, apparent density, and tissue density showed no significant differences. Histomorphometric analysis indicated that BVF was decreased in the light force group. No significant differences in the total numbers of osteoclasts and odontoclasts and the expression of receptor activator of nuclear factor kappa ß ligand were found between the groups. **Conclusions:** No differences in tooth movement or alveolar response were observed with microcomputed tomography based on force level or corticision procedure. A flapless surgical insult in the mesiopalatal aspect of the first molar with a single-site corticision was unable to induce clinical or histologic changes after 2 weeks of orthodontic tooth movement regardless of the force magnitude. Histologic analysis of the furcation area showed that light force significantly decreased BVF. (Am J Orthod Dentofacial Orthop 2014;146:55-66)

Although there are numerous benefits of orthodontic treatment, its prolonged duration is often seen as a drawback. The length of therapy is influenced by a number of factors, including the complexity of the malocclusion, the orthodontist's skill, the patient's cooperation, and the rate of tooth movement. Extended treatment times have been associated with negative outcomes, such as increased risk for caries,[1] periodontal disease,[2,3] root resorption,[4] and pulpal reactions.[5] Reducing the duration of orthodontic

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All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest, and none were reported.
Supported by a Biomedical Research Award 2012 from the American Association of Orthodontists Foundation.

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Submitted, October 2013; revised and accepted, March 2014.
0889-5406/$36.00

http://dx.doi.org/10.1016/j.ajodo.2014.03.024

treatment has the benefit of possibly minimizing these unwanted side effects and improving patient satisfaction and acceptance.

Orthodontic tooth movement is a dynamic process of bone modeling involving anabolic and catabolic responses to mechanical loading.[6] The strains generated by orthodontic forces are transmitted to the periodontal ligament (PDL) and supporting alveolar bone, producing areas of tension and pressure within the PDL, with bone resorption occurring at sites of compression, and bone formation occurring in regions of tension.[7] The velocity of tooth movement is regulated by bone turnover, bone density, and the degree of hyalinization of the PDL in response to the forces being applied. Continuous light forces are widely believed to be the most effective means of producing efficient tooth movement.[8,9] Ideally, a method to increase tooth movement should be directed by frontal resorption (tightly coupled osteoclast-driven resorption on the compression side) and also cause minimal patient discomfort.[7,10]

Efforts to enhance the rate of orthodontic tooth movement have targeted these factors and can be categorized as either pharmacological or physical. Pharmacologic agents have been shown to influence orthodontic tooth movement by altering bone metabolism. Despite augmenting tooth movement, these treatments have had limited clinical use because of many negative local and systemic side effects such as hyperalgesia,[11] bone loss and osteoporosis, delayed wound healing, and root resorption.[12,13] As a result, research has shifted toward physical methods aimed at enhancing tooth movement.

A number of physical methods to increase tooth movement have been examined previously. These have included the use of pulsed and static magnetic fields,[14,15] electrical currents,[16,17] lasers,[18] and surgical manipulation of the alveolar bone.[19] Surgical methods to enhance the rate of tooth movement have garnered considerable attention in recent years and include alveolar surgery to undermine interseptal bone,[19] corticotomies,[20-26] dentoalveolar distraction,[27-29] dental distraction,[21,30] and corticision.[31-33] By enhancing the local catabolic and anabolic processes of bone turnover, these surgical methods might have the potential to increase the rate of orthodontic tooth movement and reduce treatment times.[34,35]

The clinical applications of these surgical interventions have been hampered by a number of factors, including duration of the effect and poor patient acceptance because of the invasiveness of these procedures. Kim et al[32,33] introduced the corticision procedure in an effort to develop a minimally invasive approach to induce a regional acceleratory phenomenon effect without flap reflection that could be repeated with less patient discomfort. Unlike corticotomies, in which the surgical insult is obtained by reflecting a full flap to gain access to the cortical bone, with corticision, a reinforced scalpel is used as a thin chisel to separate the interproximal cortices transmucosally without reflecting a flap. These authors demonstrated that even minimally invasive insults to the alveolus with corticision can invoke a regional acceleratory phenomenon effect and stimulate orthodontic tooth movement. More evidence is needed that examines the biologic process involved to fully understand the mechanism by which orthodontic tooth movement can be modulated by these procedures. In addition, determining the effects of light and heavy forces on the overall rate of tooth movement is needed to better understand the optimal range required. The ideal force level for efficient tooth movement also requires further study. This study was designed to assess the rate of tooth movement and the biologic effects of corticision with 2 distinct force magnitudes on the remodeling of alveolar bone 14 days after the initiation of orthodontic tooth movement in a rat model.

MATERIAL AND METHODS

A total of 44 male Wistar rats (weight, 150-250 g; Charles River Laboratories, Wilmington, Mass) were used in this study after approval by the Animal Care Committee of the University of Connecticut (number 2010-668). The final sample size was determined by a power analysis performed with data from a pilot study. Based on the initial pilot data, it was determined that 11 rats would be required in each group to provide statistical power (1-ß) of 0.8 and type I error of 0.05.[36] The rats were randomly allocated to 1 of the 4 groups (11 per group) based on the surgical procedure and the application of light (10 g) or heavy (100 g) force: (1) no corticision and 10 g of force (LF), (2) no corticision and 100 g of force (HF), (3) corticision at appliance insertion and 1 week later with 10 g of force (LF+C), and (4) corticision at appliance insertion and 1 week later with 100 g of force (HF+C). The contralateral (right) side was used as the unloaded control for each animal.

The rats were subjected to orthodontic forces from the maxillary left first molar to the central incisors (Fig 1, *A*). Closed-coil nickel-titanium springs delivering 10 or 100 g of force were used for the application of the light and heavy orthodontic forces, respectively. The force/deflection rate for the spring was determined to calibrate the amount of force produced by activation of the spring.

The animals were placed under general anesthesia with xylazine (13 mg/kg) and ketamine (87 mg/kg).