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Elevation of a full-thickness mucoperiosteal flap alone accelerates orthodontic tooth movement

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Introduction: Our objective was to determine whether the elevation of a full-thickness mucoperiosteal flap alone, without cortical cuts, decreases the amount of bone around teeth and accelerates mesial tooth movements. **Methods:** The mandibular second premolars of 7 beagle dogs were extracted, and on a randomly selected side, a full-thickness mucoperiosteal buccal flap extending from the distal aspect of the third premolar to the mesial aspect of the first premolar was elevated. The other side did not receive flap surgery. The mandibular third premolars were protracted with orthodontic appliances. Tooth movements were analyzed biweekly over an 8-week period with calipers and radiographs. The amount and density of bone were analyzed using microcomputed tomography; bone remodeling was evaluated with histologic sections. **Results:** Experimental tooth movements measured intraorally between cusp tips were significantly greater (25.3%) than control tooth movements. The approximate center of resistance measured radiographically also moved significantly more (about 31%) on the experimental than on the control side. The experimental premolar tipped more than the control premolar (10.5° vs 8.7°), but the difference was not statistically significant. The medullary bone volume fraction mesial to the third premolar was significantly less (9.1%) and the bone was significantly less dense (9%) on the experimental side than on the control side. Histology showed no apparent side differences in the numbers of osteoclasts and osteoblasts evident in the medullary bone. **Conclusions:** Elevation of a full-thickness mucoperiosteal flap alone (ie, without injury to bone) decreases the amount and density of medullary bone surrounding the tooth and accelerates tooth movement. Due to its limited effects, elevation of a flap alone to increase tooth movements may not be justified. (Am J Orthod Dentofacial Orthop 2017;152:49-57)

Orthodontic treatment duration ranges from 21 to 27 months for nonextraction patients and from 25 to 35 months for extraction patients.[1-7] Treatment time is influenced by many factors, including type of malocclusion, amount of tooth movement required, mechanics used, and patient compliance.[2,8,9] Prolonged treatment times are problematic because they are associated with increased risks of root resorption,[10,11] decalcification,[12] and periodontal problems.[13] To minimize these risks, orthodontists are continually trying to reduce treatment time, while providing treatment results equal to or better than those currently being delivered.

The best way to reduce treatment time is to increase the rate of tooth movement. Corticotomy surgeries are currently the most popular means of facilitating tooth movement.[14-16] Experimental results show that corticotomies approximately double the rates of tooth movement.[17-19] Rates are increased by injuring the bone and inducing the regional acceleratory phenomenon (RAP).[20] Corticotomies injure the bone in 2 ways: by elevating a full-thickness mucoperiosteal flap and by cutting or perforating cortical bone. Unexpectedly, cortical bone damage to depths of 2 to 3 mm without mucoperiosteal flap elevation has no effect on tooth movements.[21,22] Even when the flapless procedures produced the same amount of cortical bone damage as traditional corticotomies, tooth movements were not accelerated because the RAP effects were restricted to the cortical bone.[22] This

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All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest, and none were reported.
Partially funded by the Robert E. Gaylord Endowed Chair in orthodontics at Texas A&M University College of Dentistry.
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Submitted, April 2016; revised and accepted, November 2016.
0889-5406/$36.00

http://dx.doi.org/10.1016/j.ajodo.2016.11.026

emphasizes the potential importance of flap elevation or the interaction of flap elevation and cortical damage.

In 1994, Yaffe et al[23] showed that the RAP can be induced in rats by the elevation of full-thickness mucoperiosteal flaps alone (ie, without cortical bone cuts). However, they readapted the flaps in place without sutures, which could have confounded the results. Moreover, rats are not good models for humans because of differences in bone composition, density, quality, and turnover rates. In addition, performing flap surgery in animals the size of rats probably produces a noxious stimulus greater than that produced in humans. Experiments evaluating the effects of mucoperiosteal flap surgery on bone should be performed using larger animal models, such as dogs, which are superior to rodents, and even many larger mammals for studying bone.[24,25] Because the effect of flap surgery alone on orthodontic tooth movement has not previously been evaluated, it remains unclear whether the effects extend to the bone surrounding teeth that need to be moved.

The null hypothesis of this study was that flap elevation alone has no effect on tooth movements or bone surrounding the tooth to be moved. Understanding the unique role that flap surgery plays in producing the RAP effect should provide important insights into the potential mechanisms responsible for accelerating tooth movements with corticotomies.

MATERIAL AND METHODS

Seven skeletally mature male beagle dogs, weighing between 20 and 25 pounds, were used in this experiment. All animals had fully erupted dentitions and were healthy. Housing, care, and experimental protocols were approved by the Institutional Animal Care and Use Committee at Texas A&M University, Baylor College of Dentistry in Dallas. During the experiment, the dogs were fed a soft diet to minimize damage to the orthodontic appliances.

After a 10-day quarantine, the animals fasted for 12 hours and then were sedated with an intramuscular injection of ketamine (8-24 mg/kg) mixed with xylazine (0.22 mg/kg). Dental prophylaxis using an ultrasonic scalar irrigated with 0.12% chlorhexidine gluconate was performed, and bone markers (6-mm long Imtec miniscrew implants; 3M Unitek, Monrovia, Calif) were placed for radiographic reference. Four markers were placed in the mandible, 2 on each side. The heads of the screws were removed to the level of the gingival tissue for animal comfort.

Right and left periapical radiographs were taken before and after bone marker placement using size 4 film. A custom holder was designed to standardize film and x- ray tube angulations and distances. To standardize intraoral measurements, notches were cut into the cusp tips of the canines and third premolars and at the most gingival aspect of the mesiobuccal groove of the first molars. Digital calipers were used to measure the distance between the canines and third premolars, as well as the distance between the third premolars and first molars. Three replicate caliper measurements were made for each distance and averaged. Triad custom tray material (Dentsply, York, Pa) was used to make mandibular impression trays, and alginate impressions of the mandibles were taken. The impressions were poured in die stone, and the models were used for appliance fabrication.

Appliances were designed based on an established protocol.[22] Orthodontic band material (Dentaurum, Ispringen, Germany) was custom pinched and welded to fit the mandibular canines and third premolars. Headgear tubes (diameter, 0.051 indiameter) (3M Unitek) were soldered to the orthodontic bands on the third premolars.

Orthodontic wire (diameter, 0.045 in) was soldered to the canine bands and inserted through the headgear tubes on the bands of the third premolars (Fig 1, *A*). The wire was designed to have a loop at the distolingual aspect of the canine band to attach a spring at the time of appliance delivery. The third premolars were able to move freely along the wire. The interior aspect of each band was microabraded before cementation. For animal comfort, a ball of solder was placed on the distal end of the wire.

After initial sedation with the ketamine and xylazine cocktail previously described, the dogs were intubated and administered 1% to 1.5% isoflurane in oxygen at a rate of 1 L per minute. Vital signs were monitored throughout. Local anesthetic (2% lidocaine with 1:100,000 epinephrine) was administered at the surgical sites via regional infiltration and an inferior alveolar block.

Both mandibular second premolars were sectioned, elevated, and extracted. On the experimental side, chosen using an electronically generated random number table, a full-thickness mucoperiosteal flap was elevated from the distal aspect of the third premolar to the mesial aspect of the first premolar. A vertical releasing incision was made at the mesial limit of the flap that went past the keratinized gingiva and into the level of the buccal mucosa (Fig 1, *B*). The tissue was reapproximated with simple interrupted 4-0 vicryl resorbable sutures.

A 12-fluted carbide bur was used to remove calculus and debris from the teeth and to cut retention grooves around the canines and third premolars. The teeth were etched with 37% phosphoric acid gel for