ORIGINAL ARTICLE

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Bony adaptation after expansion with light-to-moderate continuous forces

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Introduction: The purpose of this study was to evaluate the biologic response of dentoalveolar bone to archwire expansion with light-to-moderate continuous forces. **Methods:** With a split-mouth experimental design, the maxillary right second premolars of 7 adult male dogs were expanded for 9 weeks using passive self-ligating brackets (Damon Q; Ormco, Orange, Calif) and 2 sequential archwires (0.016 × 0.022-in copper-nickel-titanium alloy, followed by 0.019 × 0.025-in copper-nickel-titanium alloy). Intraoral and radiographic measurements were made to evaluate tooth movements and tipping associated with expansion; archwire forces were measured using a force gauge. Microcomputed tomography was used to compare buccal bone height, total tooth height, total root height, and buccal bone thickness. Bone formation was evaluated histologically using tetracycline and calcein fluorescent labels and hematoxylin and eosin stains. **Results:** Buccal expansion was produced by forces between 73 and 178 g. Compared with the control side, which showed no tooth movement, the experimental second premolars were expanded by 3.5 ± 0.9 mm and tipped by 15.8°. Buccal bone thickness was significantly thinner (about 0.2 mm) in the coronal aspects and significantly thicker (about 0.9 mm) in the apical aspects over the mesial roots. The tipping and expansion significantly (P <0.05) reduced buccal bone height (ie, caused dehiscences) at the mesial (about 2.9 mm) and distal (about 1.2 mm) roots. Bony apposition occurred on the trailing edges of tooth movement and on the leading edges of the second premolar apices. The axial microcomputed tomography slices indicated, and the bone histomorphometry and histology demonstrated, newly laid-down bone on the periosteal side of the buccal cortical surfaces. Ordered osteoblast aggregation was also evident on the periosteal surfaces of buccal bone, just cervical to the apparent center of rotation of the tooth. Tooth and root heights showed no significant differences between the experimental and control second premolars. **Conclusions:** Buccal expansion with light-to-moderate continuous forces produced 3.5 mm of tooth movement, uncontrolled tipping, and bone dehiscence, but no root resorption. Bone formation on the periosteal surfaces of cortical bone indicates that apposition is possible on the leading edge of tooth movements. (Am J Orthod Dentofacial Orthop 2014;145:655-66)

A tooth size-arch length deficiency is a common problem faced by clinical orthodontists.[1-6] This can be treated by reducing tooth size or by increasing space in the arch. To gain space and address transverse maxillary deficiencies, patients are often treated with archwire expansion.[7-9] Unfortunately, root resorption is associated with dental expansion.[10,11] Moreover, the palatal and buccal cortical plates can inhibit tooth movements before root resorption occurs.[12-14] Although expansion has been purported to be possible without causing excessive tipping,[7] most studies have reported tipping of posterior teeth from 7° to 13.5°.[15-17] Tipping has been shown to cause dehiscences of buccal bone[18,19] and root resorption.[11,12]

Although it has been claimed that improved alveolar bone formation occurs, the effects of archwire expansion on the alveolar bone surrounding the teeth remain largely unknown.[7] Can a tooth be expanded beyond the outer boundary of the buccal cortex? Does dental tipping cause significant dehiscence formation? Can dental expansion with light continuous forces create bone lateral to the tooth?

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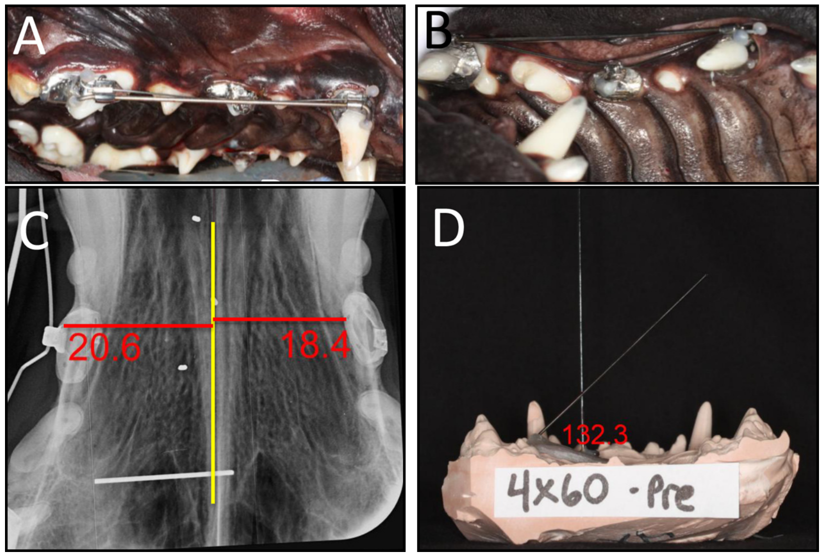

Fig 1. **A,** Lateral, and **B,** occlusal views of the appliances in place with bands cemented onto the maxillary right canines, second premolars, and fourth premolars. A protective wire (0.045-in stainless steel) was placed through the headgear tubes; **C,** radiograph showing width measurements from the midsagittal reference line to the second premolars; **D,** dental casts used to evaluate tipping, calculated from the angle created between wires extending from the experimental second premolar and from stable rugae and untouched adjacent teeth.

Table I. Timeline of the 12-week experiment with records taken every other week

	Week								
	0	*2*	*4*	*6*	*7*	*8*	*9*	*10*	*12*
Records	T0	T1	T2	T3		T4		T5	T6
Wires	.016 × .022-in CuNiTi	.016 × .022-in CuNiTi	.019 × .025-in CuNiTi	.019 × .025-in CuNiTi	.019 × .025-in CuNiTi	.019 × .025-in CuNiTi	Passive	Passive	Passive
Bone markers			Tetracycline		Calcein			Tetracycline	

The first archwire was active for 4 weeks, and the second archwire was active for 5 weeks before being made passive. Bone markers were placed at weeks 4, 7, and 10.
T, Measurement time; *CuNiTi*, copper-nickel-titanium alloy.

To address these questions, the aims of this project were to (1) evaluate the movements of the maxillary second premolars expanded with light-to-moderate continuous forces, (2) determine whether a multirooted premolar can be moved buccally through the maxillary cortex, and (3) evaluate the adaptation of bone when the teeth are expanded.

MATERIAL AND METHODS

Seven male, periodontally healthy, mixed-breed dogs, each weighing 55 to 65 lbs and between 1 and 2 years of age (skeletally young adults), were used in this experiment. Previous split-mouth designs have shown significant differences in tooth movement with similar numbers of animals.[20-23] The housing, care, and experimental protocol were approved by the Institutional Animal Care and Use Committee at Texas A&M University, Baylor College of Dentistry, Dallas, Tex.

The animals received a dental prophylaxis with an ultrasonic scaler with 0.2% chlorhexidine gluconate mouth rinse. Alginate impressions were made, and models were poured with dental stone. The maxillary right canines, second premolars, and fourth premolars, along with the control left second premolars, were banded. Orthodontic band material (Dentaurum, Ispringen, Germany) was custom formed, welded, and soldered to fit each tooth. Brackets (0.022 in) were welded to all 3 bands on the experimental right side; no brackets were welded to the control left second premolar bands. The canine bracket (3M Unitek, Monrovia, Calif) had 0° offset, 0° torque, and a 0.051-in headgear tube. The second premolar bracket (Damon Q; Ormco,