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Comparison between orthodontic micro-implants and dental units as anchorages for tooth retraction in dogs

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Abstract

Background and objective: Dental units, extra oral devices and mini-implants are the main types of anchorage that are used in orthodontic treatment. The aim of this study was to compare between mini-implants and dental unites as anchorage.

Methods: This study used seven dogs wearing orthodontic appliances in the right and left sides of the maxilla for 40 days to retract the 3rd incisors toward the canines. On right side, canine was used as dental anchorage to retract the 3rd incisor by nickel-titanium closed coil spring along a straight arch wire. On the left side, mini-implant between the roots of canine and 1st premolar was used as skeletal anchorage. Different clinical measurements were done on the stone casts and photographs of maxillary dental arch for each dog before and after tooth retraction to assess the effectiveness of each anchorage type on the same animal.

Results: Clinical measurements revealed a highly significant difference between dental and mini-implant sides. The mini-implant side showed less loss of anchorage than dental side, while the extrusion was higher in retracted tooth of mini-implant side than in dental side

Conclusion: This study showed that the mini-implants provide more stable anchorage units than the teeth but cause more extrusion in the moving tooth.

Keywords: Mini-implants, Dental anchorage, Tooth retraction, Dogs.

Introduction

A goal of any orthodontic treatment is to achieve desired tooth movement with a minimum number of undesirable side effects[1]. Strategies for anchorage control have been a major factor in achieving successful orthodontic treatment since the specialty begun. Edward Angle's writing in 1900 was one of the earliest to advocate the use of equal and opposite appliance forces to control anchorage[2]. Dental units are the main type of anchorage used in the practice. Ideal occlusion can be achieved in adults with severe malocclusion using dental anchorages3, however many problems related with it, mainly the movement of the anchoring tooth which is largely depends on the treatment mechanics and the anchoring tooth shape, size, length and the number of the roots[1,4]. Traditionally, anchorage is reinforced by increasing the number of teeth bilaterally or by using the musculature, extra oral devices, and the alveolar process[5]. Many patients reject headgear wear because of social and esthetic concerns, and the success of this treatment greatly depends on patient cooperation[6]. In most of the studies on Nance appliances, anchorage loss was unavoidable, and reduced hygiene under the acrylic resin button led to inflammation of soft tissues[7]. For this reason, other intraoral alternatives have been developed such as mini-implants and screws[8]. Orthodontic mini-implants can be easily inserted into various sites in oral cavity and can be loaded at a relatively early stage compared with prosthodontic implants and

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onplants[9,10]. The insertion site should be chosen in an area of good quality bone and if possible in an area where no tooth. Most often, the mini-implants are inserted between the roots of neighboring teeth[11,12]. The introduction of skeletal anchorage as a source of stationary anchorage to orthodontic forces has made most complex tooth movements simple. Because of their small dimensions, miniscrews offer the advantages of immediate loading, multiple placement sites, relatively simple placement and removal, placement in interdental areas where traditional implants cannot be placed, and minimal expenses for patients[13,14]. It has been shown that miniscrews can be loaded to forces up to 500 g and yet stay intact until the end of the treatment[15]. In a comparative study done by Park *et al*,[16] mini-implant anchorage provided better anchorage and less arch-dimension change in the maxillary posterior teeth than dental anchorage during en-masse retraction of the maxillary anterior teeth. In another comparative study done on 30 adult patients using cephalometric analysis, mini-implants served as absolute anchorage without any anchorage loss for the treatment of skeletal open bite compared with conventional dental anchorage[3]. Similar results obtained by the study done for the treatment of 34 adult class II female patients. Both mini-implants and fixed functional appliance provide adequate dental compensation for the class II malocclusion, but the mini-implant group offered better anchorage control[4]. This study aimed to compare between mini-implants and natural teeth as anchorage units in the same animal to evaluate the clinical outcomes of two different main types of anchorages.

Methods

In this study seven local dogs with age range (16-17 months) were used. They wore an orthodontic appliance to retract the maxillary 3rd incisor against the canine in order to close the space which already exists between these two teeth. On the right side, the appliance consisted of custom made edgewise bands on both the 3rd incisor and canine through which a piece of rectangular stainless steel wire (17*25 ml) pass to slide the 3rd incisor along this arch wire. The retraction force was applied by Ni -Titanium closed coil spring (6mm) which attached to the hooks of each band (Figure 1a). On the left side, AbsoAnchor self-drilling mini-implant of 1.8 mm diameter and 7 mm length[17] (Dentos Company, Korea) was inserted halfway between the roots of canine and 1st premolar using self drilling implant hand driver, 8 mm apical to the gingival margin with the same operator for all dogs in the early morning. The orthodontic appliance on this side differ in that the distal end of the Nickel-Titanium closed coil spring attached to the mini-implant head instead of the band hook on the canine (Figure 1b). On both sides 150 g of force was applied by nickel-titanium closed coil springs measured using orthodontic pressure-tension gauge.

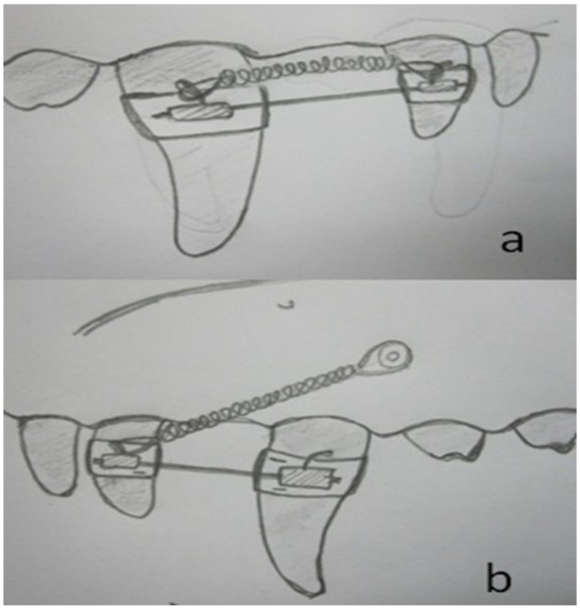

Figure 1: design of the orthodontic appliance on right and left side

The dogs were anesthetized with a mixture of 0.22 mg/kg Xylasine and 2.2 mg/kg Ketamine intramuscularly[18], in the beginning of the study for taking primary impression, appliance insertion and mini-implant

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placement. Another shot of anesthesia was given at the end of the study (40 days) for removing the appliance and the mini-implant and for taking the final impression. The impressions were poured with stone to form the stone casts which were used to record the clinical measurements and changes that took place during the studying period. Photographs for the casts and the left buccal side of the dog's mouth with the mini-implant were taken using a professional camera (Canon, power-shot, SX40) with fixed lens distance (20cm) from them. Calibration was done by calculating the magnification factor by measuring the canine crown length in the mouth and in the photograph. In order to provide a high degree of reliability, the measurements were done 2 times with a 2 week interval by single examiner. The measurements were done on photographs using the auto CAD software (2012, 64bit).

Clinical measurements:

*Loss of anchorage (L.O.A): On the right side, the loss of anchorage was estimated by measuring the distance between two fixed points (the midpoint between the 1st incisors, and the midpoint of the distal side of canine cervical area) (Figure 2a). On the left side, anchorage loss of the mini-implant was estimated by measuring the distance from a fixed point (tip of 1st premolar cusp) to the midpoint of the mini-implant head before the appliance placement and at the end of tooth retraction (Figure 3a').

*Space closure (S.C): Space from the cervical area of the 3rd incisor (midpoint of its distal side) to the cervical area of the canine (midpoint of its distal side) was measured on right and left side (Figure 2 b and b'). The absolute space closure was calculated by subtracting the loss of anchorage from the amount of closed space in order to get the pure space closure.

*Degree of rotation (D.O.R): From the occlusal view a straight line was drawn from the incisal tip through the cingulum of the 3rd incisor formed an angle with the inter-palatal line, the value of this angle indicating the degree of rotation on right and left side (Figure 2c and c').

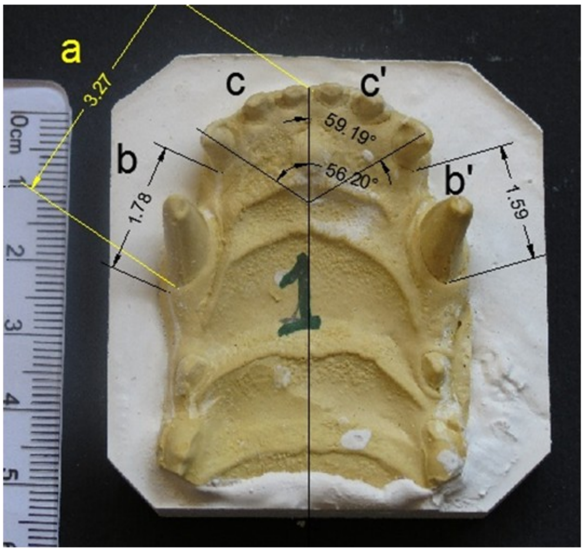

Figure 2: Oclussal view of the stone cast with clinical measurements

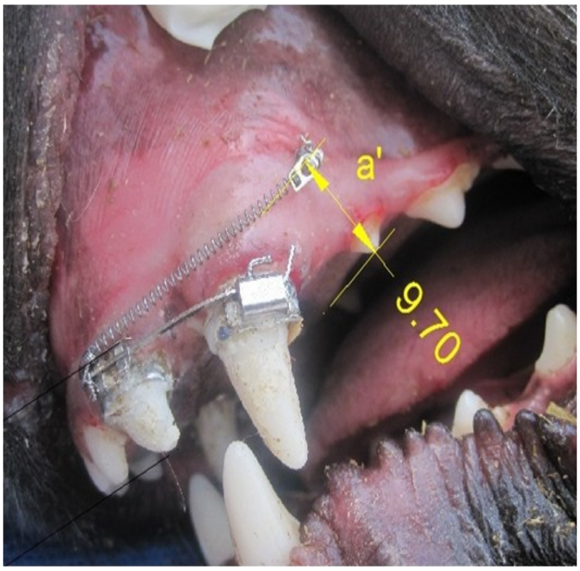

Figure 3: buccal photograph of the mini-implant side

*Degree of tipping (D.O.T): From the buccal view of the cast, a straight line was drawn from the incisal tip of the 3rd incisor to the midpoint of the labial gingival margin formed an angle with the horizontal line connecting the gingival margins of 1st premolar, 2nd premolar and 3rd premolar on both sides (Figure 4a). The angle was measured before and after tooth retraction to calculate the amount of tipping.

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* Extrusion: Extrusion was estimated by measuring the vertical distance of 3rd incisors tip in relation to a fixed line passing tangential to the tip of 2nd incisor and parallel to the previous gingival line before and after orthodontic treatment on both sides (Figure 4b).

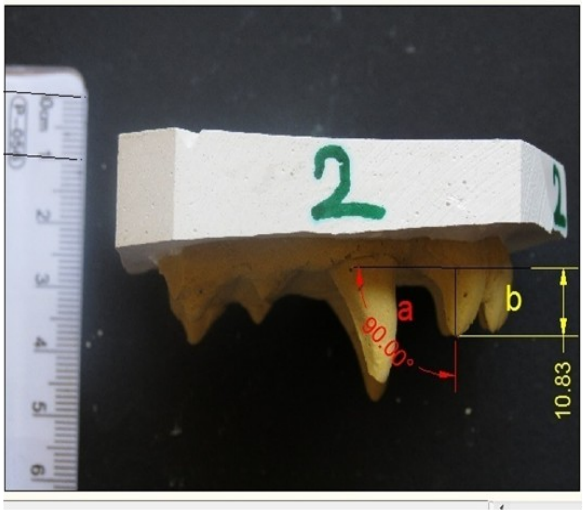

Figure 4: buccal view of the stone cast with clinical measurements

Statistical analysis of the collected clinical measurements were performed with software (version 17.0; SPSS) with a "P" value ≤ 0.05 was considered as statistically significant. The results of two sides of the same group were compared by using paired *t* test.

Results

The statistical analysis of the clinical measurements revealed obvious differences between dental anchorage and mini-implant sides. Regarding loss of anchorage, there was a highly significant difference between dental anchorage side and mini-implant side (P=0.001), where the mini-implant side demonstrated less loss of anchorage (0.683 mm) than the dental anchorage side (1.396 mm). Concerning space closure, although mini-implant side revealed higher rate of space closure (1.149 mm) compared with dental side (0.850 mm), but statistically this difference was non-significant (P=0.125). About the degree of rotation, the dental anchorage side revealed a higher degree of rotation of the 3rd incisor (2.013°) while the mini-implant side showed less D.O.R (1.903°) but the difference was non significant(P=0.819). On the other hand there was a highly significant difference between the two sides (P<0.001) in the degree of extrusion being higher at mini-implant side (1.874 mm) compared to dental side (0.599 mm). Regarding degree of tipping, there was no significant difference between the two groups (P=0.918) as shown in, Table 1.

Table 1: Paired t-test of the clinical measurements.

Variables	**Mean**	**± SD**	**P value**	
L.O.A.Dental mm	1.396	.241	**.001****	**N=7**
L.O.A.Microimplant mm	.683	.128		
S.C.Dental mm	.850	.212	.125	
S.C.Microimplant mm	1.149	.278		
D.O.R.Dental degree	2.013	.904	.819	
D.O.R.Microimplant degree	1.903	.953		
ExtrusionDental mm	.599	.437	**< 0.001****	
ExtrusionMicroimplant mm	1.874	.264		
D.O.T.Dental degree	4.900	1.704	.918	
D.O.TMicroimplant degree	4.989	1.649		

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Discussion

Many studies were preformed to compare different kinds of intra and extra-oral anchorage for orthodontic movement and most of these studies compared between human being who wears different orthodontic appliances. This study has compared between the conventional dental anchorage and mini-implant anchorage for the retraction of 3rd incisor toward the canine in the same dog providing same ambience and comparing different orthodontic treatment in the same biological circumstances. The movement is closely similar to the retraction of canines toward the 2nd premolars in human beings that is widely used in every day orthodontic practice. This study revealed that the loss of anchorage at mini-implant side was very much less than loss of anchorage that happen at dental anchorage side. In addition there was highly significant difference in the degree of extrusion in the retracted tooth between the two different types of anchorage. The use of min-implant increased the incidence of extrusion in the 3rd incisor which was retracted distally by the Nickel-Titanium closed coil spring. Similar results obtained by Koyama *et al*[19] in a prospective study who compared treatment outcome using mini-implants, high pull headgear and inter-maxillary elastics as anchorage in bi-maxillary protrusion patients using lateral cephalograms before and after treatment. Sliding mechanics with implant anchorage provided absolute anchorage and control of mandibular rotation more than the conventional techniques. Another agreement come from the results obtained by a comparative study between conventional anchorage and mini-implants as anchorage for the treatment of class II division 1 in 24 patients using pre- and post-treatment three-dimensional virtual maxillary cast superimposition. Linear, angular and arch-dimension variables of that study showed that mini-implants provided better anchorage and less arch-dimension change in the maxillary posterior teeth than the conventional anchorage during en-mass retraction of maxillary anterior teeth[16]. Upadhyay *et al*[4] study, compared between mini-implants and fixed functional appliance for the treatment of class II female patients. Half of the patients treated with fixed functional appliance, and the other 17 patients treated with upper 1st premolar extraction followed by space closure with mini -implants. The two treatment protocols provided adequate dental compensation but did not correct the skeletal discrepancy with a better anchorage control offered by the mini-implant group. The results of this study also similar to results obtained by Ohmae *et al*[20] who used mini-implant in beagle dogs for the intrusion of 3rd premolar by placing a mini-implant buccally and other one lingually connected by a closed coil spring running along the crown of 3rd premolar. All the mini-implants remain stable without displacement or mobility offering maximum anchorage after 12 weeks of orthodontic force application. On the other hand the results of this study disagree with Feldmann *et al*[21] who studied the anchorage capacity of osteo-integrated and conventional anchorage systems by taking cephalograms of 120 patients before and after orthodontic treatment using onplant, head gear, trans-palatal arch and orthosystem implant as anchorage units. The maxillary molars were stable during the leveling/ aligning in the Onplant, Orthosystem implant, and headgear groups, but the transpalatal bar group had some anchorage loss. Liou *et al*[22] studied the treatment outcome of 50 adult patients with maxillary protrusion who treated orthodontically by en-mass retraction with extraction of 1st premolar using mini-implants for 30 patients and transpalatal arch on 1st molars for other 20 patients as anchorage. The amount of maxillary en-masse anterior retraction was significantly greater in mini-implant group than in other group. Motoyoshi *et al*[23] studied the factors affecting the stability and success rate of mini-implants as anchorage units on 57 orthodontic patients (148 mini-implants). They proved that the success rate and stability of these mini-implants are highly technique sensitive and highly dependent on the placement period, quality of the bone, oral hygiene, and amount of force applied and not all the mini-implants placed was clinically successful as anchorage units.

Conclusion

According to these results, mini-implants provided more anchorage and support than dental anchorage but have the disadvantage of extrusion which may be avoided by changing appliance design to have intrusive vertical force, further studies required to confirm these results including longer treatment duration and further investigation on histological and ultra-structural levels.

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