Dual Force Magnitudes on Implant Supported Canine etraction: a Prospective Clincal Trial

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Abstract: *The aim of this clinical study was to compare the use of two different force magnitudes (100 gm and 200 gm) with indirect mini-screw implant anchorage, and evaluating the rate of canine movement, amount of molar anchorage loss, canine disto-buccal rotation and canine mesio-distal tipping. The sample consisted of 15 adult female patients (mean age, 19.4 years) requiring therapeutic extraction of the maxillary first premolars, with subsequent retraction of the maxillary canines. Nickel-titanium closing coil springs delivered a force of 100 g or 200 g were used to retract the canines after an alignment and stabilization period. The force delivered was measured using a push–pull force gauge. Maxillary cast measurements were made at the beginning of canine retraction (T0) and every 28 days for 84 days (T1, T2, T3) to assess canine retraction rates. Photocopies of pre-retraction and post-retraction maxillary casts were taken to measure molar anchorage loss and canine rotation. Pre-retraction and post-retraction panoramic radiographs were taken to measure canine tipping. The amount of initial tooth movement (T0-T1) was not related to force magnitude. However, during (T1-T2) and (T2-T3) periods, significant increase in the amount and rate of tooth movement were found with 200 gm group than 100 gm group. Canine rotation, tipping and anchorage loss were significantly higher in 200 gm group than 100 gm group.*
Keywords*: Force magnitude, Mini-screw, Rate of canine retraction, Anchorage loss.*

I. Introduction

Canine retraction after premolar extraction is a common orthodontic procedure. Usually, is used for treatment of patients with severe crowding of anterior teeth, or protrusion and less frequently to camouflage mild Class II or Class III skeletal discrepancies. Canine retraction depends on various factors: the appliance used, the force applied, the technique used, and the periodontal ligament area.

Several force magnitudes have been advocated for canine retraction. The use of "light" forces once became popular on the basis of the classic studies of Story and Smith[1] and Reitan[2] in the 1950s and 1960s, respectively. The assumption was that a so-called differential movement of teeth, at first proposed by Begg[3], could be generally achieved. Moreover, it was generally thought that light forces are more efficient and more "biologic" and, hence, less painful [1-4].

To use the entire extraction space for retraction of the canines, various anchorage techniques have been used. Traditionally, orthodontists have used teeth, intra oral appliances, and extra oral appliances to control anchorage-minimizing the movement of anchor teeth, while completing the canine retraction. The possibility of using different types of temporarily placed anchorage devices in approximation to bone with the intent of enhancing or overcoming the limitations of traditional anchorage is now available. Specifically designed orthodontic implants have been successfully used as a source for absolute anchorage [5-15].

Minimizing the orthodontic treatment time and controlling anchorage would raise two questions: First, does the rate of tooth movement increase as the force level increases? Second, does the change in force system associated with the use of orthodontic mini-implant anchorage affect the canine and anchor tooth position? The present clinical study was tried to answer the preceding questions.

II. Materials And Methods

The sample consisted of 15 female patients, their age range from 14 to 26 years (mean age 19.4 years). The subjects were selected from the outpatient clinic Department of Orthodontics and Dentofacial Orthopaedics, Faculty of Oral and Dental Medicine, Cairo University. All patients had to fulfill the following criteria: Angle Class I or Class II malocclusion and required bilateral extraction of maxillary first premolars with maximum anchorage, full permanent dentition without missing teeth, no previous orthodontic or orthopedic treatment, absence of any systemic diseases or chronic illness, no dental or skeletal anomalies, no history of trauma, bruxism, or para-functional habits, no past or present signs and symptoms of periodontal disease and balanced emotional or behavioral performance.

Ethical approval was obtained from the Ethics Review Committee of the dental school at Cairo University, Cairo, Egypt. Full fixed preadjusted edgewise appliance with slot size 22 x 28 "ROTH prescription" were bonded to teeth and the distal movement of the maxillary canine was performed by using a continuous 0.016 x 0.022-inch stainless steel archwire. After placement of maxillary fixed appliances and completion of the leveling and alignment phase of treatment, mini-screw implants (AbsoAnchor, Dentos, Daegu, Korea, diameter, 1.3 mm; length, 8 mm), used as skeletal anchor units. It was positioned at the maximum thickness of interdental bone between the roots of the second premolar and the   first molar as recommended by Fayed et a[16]. According to Cousley RR[7], stainless steel ligature wire (23, (0.010" diameter) was tied from the mini-implant to the posterior anchor teeth. Canine was retracted[24) directly to first molar and not to mini-implant to provide a horizontal vector of traction and eliminate the vertical component of traction. Orthodontic forces were applied 15 days after implant placement via 8-mm closed nickel-titanium coil springs (Dentos, India).

Force delivered was measured using a push–pull force gauge (ORG Ltd, China). On a random basis [8, 16], the maxillary canines were retracted using a light force (100 gm) nickel titanium closed-coil spring on one side and on the contra-oral side, a medium force (200 gm) nickel titanium   closed-coil spring stretched between the distal hook of canine bracket and the hook of the molar band[11, (Fig 1).

Patients were evaluated before (T0) and after 4 weeks (T1), 8[12) weeks (T2), and 12 weeks (T3) of canine retraction. At each appointment, impressions of the upper jaw were taken with alginate material to obtain the dental casts. The models were then scanned from an occlusal perspective; the resulting images were printed and linear and angular measurement was made as described by Machado[17] and Gulati et al[18]. Photocopies of the models were taken with the same machine (Xerox, X-C865 machine, Stanford, CT, USA) using 1:1 duplication. Measurements were made on the models photocopies using a digital caliper (Anyi Instrument Co. Ltd, China). Mid-palatal raphe was constructed by joining the anterior and posterior raphe points and used as a reference median line for measurements. Constructed mid palatal raphe as the reference plane and medial aspect of 3rd rugea as reference points were drawn (Van der Linden[19], Antonio Almeida[20]). Perpendiculars were dropped on this median line from the mesiobuccal cusp tips of the maxillary permanent first molar and the cusp tip of the maxillary permanent canine.

Rate of retraction was defined as the distance travelled, divided by time required to complete space closure. This was recorded in millimeters per interval. An interval was defined as a 28-day period. Quantification of antero-posterior movement of the canines was done with the method described by Ziegler and Ingervall[21].

This was done by projecting the canine cusp tip point on the median line and measuring the distance from this point to the projected position of the third medial rugea point. Change in sagittal position of the maxillary first molar was also assessed from the dental casts [21]. This was done by projecting the mesiobuccul cusp tip point on the median line and measuring the distance from this point to the projected position of the third medial rugea point.

Amount of antero-posterior movement of maxillary first molar was determined by calculating the difference in antero-posterior distance pre and post canine retraction.

Disto-buccal rotation of upper canines represented by the angle formed between the median palatine suture and a line passing through the mesial and distal contact points of the canines as described also by Ziegler and Ingervall[21]. Difference between pre and post retraction gives the actual amount of canine rotation.

Panoramic radiographs were taken before and after canine retraction for the determination of canine tipping. According to Almeida-Pedrin[22], Canine tipping was defined as the lateral angle formed by the intersection of the infraorbital line and a line represent the long axis of the canine. The difference between pre and post retraction gives the actual amount of canine tipping.

III. Statistical Analysis

One-way ANOVA was used to evaluate the effect of time on canine movement and canine movement rates in each group. The paired t-test was used to compare mean values before and after treatment of the canine rotation and tipping.

Independent student's t-test was used to compare the mean difference of canine rotation, tipping and molar loss of anchorage of both groups.

The data were tabulated by using the Excel software (Microsoft Office Excel 2007) and then analyzed with SPSS 16.0 statistical software package for Windows (SPSS Inc, Chicago, Illinois, USA).

IV. Results

In 100 gm group, there was statistically significant difference in the rate of canine movement between all intervals. In 200 gm group, there was statistically significant difference between (T1 - T2) and (T1 – T3); while there was no statistically significant difference between (T2 - T3). The Differences between both groups in each follow up interval was statistically significant at T2 & T3 and not significant at T1 (Fig.3).

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There was statistically significant difference in anchorage loss, canine rotation and tipping after treatment in both groups. Group II showed a statistically significantly higher difference than group I in canine rotation and tipping (Table 1&2).

V. Discussion

Optimal orthodontic force produces an excellent biological response with minimal tissue damage, resulting in rapid tooth movement with little discomfort, avoiding or minimizing hyalinized areas. [1] However, the magnitude and duration of the ideal force remain controversial.   The forces employed in the present study followed recommendations found in the literature to apply forces between 100 g and 200 g for canine retraction. [1, 5, 25-28].Anchorage loss often produces unsatisfactory treatment results, particularly in patients who require maximum anchorage, with a resultant increase in the treatment period. [9] Skeletal anchorage has evolved as a mainstream orthodontic technique with the introduction of temporary anchorage devices. [11] In this study, mini-screw implants were used as skeletal anchorage during canine retraction because of their simpler placement technique and the possibility of eliminating the reliance on patient compliance. Related to anchorage methods it was better to choose an indirect anchorage in order to minimize the risk of losing the mini-screw.

The present study was planned to use the recommended force magnitudes (100 and 200 gm) and the recommended anchorage type and evaluating the rate of canine movement, anchorage loss, canine rotation and tipping. The study started with 20 patients who required therapeutic extraction of maxillary first premolars, but five patients were excluded. Three patients were excluded because of mini-screw failure, one because multiple missed appointments and one for coil spring dislodgement. In order to eliminate the effect of gender, the selected subjects in present study were all females.

For each patient, one side was randomly allocated (coin toss) as described by Aboul-Ela et al[8] and Nightingale and Jone[16] to receive a 100 g of force, and the other side a 200 g of force. The placement site of the mini-screws was buccally between the maxillary second premolar and the first molar based on the recommendations of Fayed et al[6]. At every clinical appointment the mini-screws were assessed for mobility and inflammation of the gingival tissue around the mini-screw neck.

According to Cousley RR[7], indirect alveolar bone anchorage could be obtained by using mini-implant to stabilize the posterior teeth (the dental anchorage unit) by a stainless steel ligature from the mini-implant to anchor teeth.

In this study, a stainless steel ligature wire (0.010" diameter) was tied from the mini-implant to the posterior anchor teeth. Canine was retracted directly to first molar and not to mini-implant to provide a horizontal vector of traction and eliminate the vertical component of traction. This minimized the risk of canine intrusion as described by Park and Kwon[14].

Despite of using an indirect anchorage and there was no direct loading on the mini-screw, a mini-screw failure in three patients occurred. It might have occurred because of inflammation of the tissues around the mini-implant.

Van der Linden[19], Antonio Almeida[20] demonstrated that medial aspect of the third rugae point was a stable reference point for analysis of mesiodistal movement of canines and molars. Panoramic radiographs were used to determine the mesiodistal tipping of canine. Canine tipping was defined as the lateral angle formed by the intersection of the infraorbital line and a line represent the long axis of the canine as described by Almeida-Pedrin[22].

Almeida-Pedrin[22] reported that panoramic radiograph was an effective tool for evaluating the mesiodistal axial inclinations of maxillary anterior teeth. On the other hand, vertical and horizontal magnification and image distortion in panoramic radiographs have been reported by Larheim and Svanaes[30].

The results related to the rate of canine retraction showed that: there was no statistically significant difference between both groups at T1, while there was statistically significant difference between both groups at T2 and T3.These results confirmed that of Yee et al[28] and Gonzales et al[31] in comparing the rate of tooth movement between 200 g and 100 g forces, the amount of initial tooth movement till 28 days (T1) was not related to force magnitude. While after 56 & 84 days (T2-T3), a significantly more tooth movement occurred in with 200 gm.

In 100 gm group, there was a statistically significant difference between all intervals with a gradual increase in the rate of tooth movement, while in the 200 mg group, there was statistically significant difference between (T1-T2) and (T1-T3), while there was no statistically significant difference between (T2-T3) with an interrupted rate of tooth movement. These findings were similar to those of Yee et al[28]. Canine retraction with 100 gm group exhibited a gradual increase in the rate of tooth movement. On the other hand, 200 gm group exhibited an interrupted rate of tooth movement. In the present study, the amount and the rate of canine movement were significantly higher in the 200 gm group than on the 100 gm group. The findings in this study agreed with those of and Yee et al[28] and Gonzales et al[31].

Anchorage loss was significant in both groups. Molar anchorage loss was significantly higher in the 200 gm group than on the 100 gm group. Holberg et al[15] recommended the use of indirect anchorage. Despite their conclusions, the results of this study are in contradiction with them because there was a significant loss of anchorage in both groups.

Indirect implant anchorage in both groups caused significant molar anchorage loss and anchorage loss was significantly higher in the 200 gm group as compared with 100 gm group.

Canine rotation and tipping was significant in both groups. The use of 200 gm of force caused a higher canine rotation and tipping as compared with 100 gm of force. These findings agreed with those of Reitan[2], Iwasaki et a[15], Yee et al[28] and Gonzales et al[31] who reported that amount of canine rotation and tipping increased as the magnitude of force increased.

VI.   Figures And Tables

Fig. 1: Indirect anchorage reinforcement. Stainless steel ligature wire (0.010" diameter) was tied from the mini-implant to the posterior anchor teeth. Nickel titanium closed-coil spring stretched between the distal hook of canine bracket and the hook of the molar band.
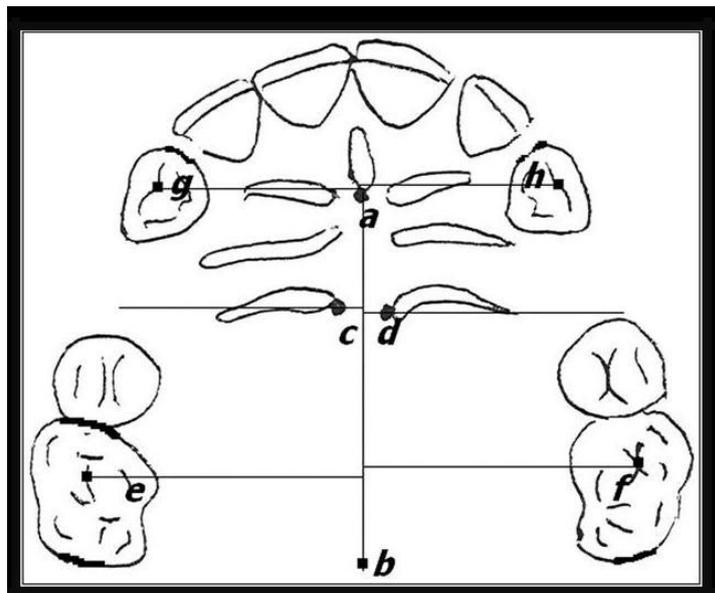

Fig.2: Measurement of tooth movement on the scanned image of a dental cast. (a-b): Mid palatal suture, (c): medial end of right third palatal rugea, (d): medial end of left third palatal rugea, (e): central fossa of maxillary right first permanent molar, (f): central fossa of maxillary left first permanent molar, (g): cusp tip of right canine, (h): cusp tip of left maxillary canine.
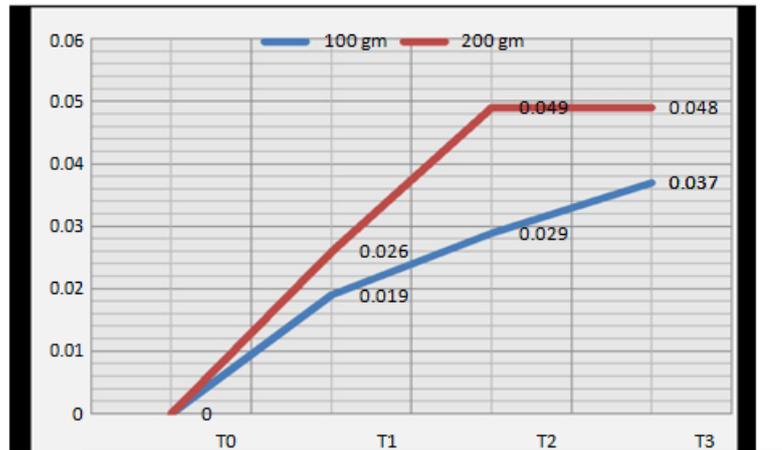
Fig. 3: Line chart showing the rate of canine movement in both groups throughout the study period.
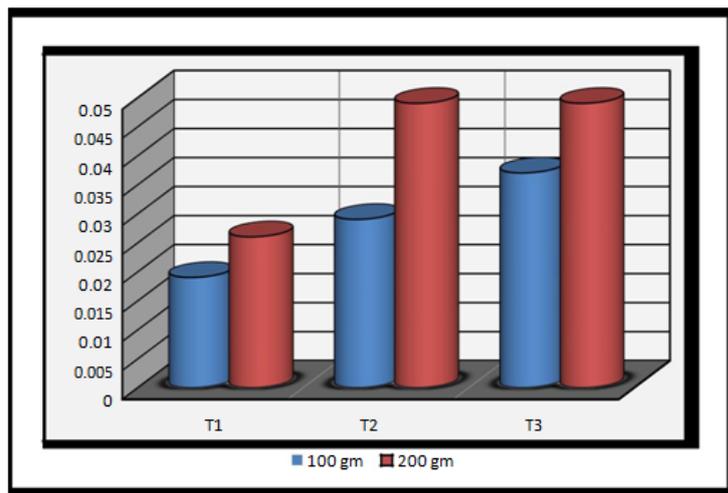

Fig. 4: A bar chart showing mean values of canine movement rate (mm/day) in both groups during the study period

Table 1: Rate of canine movement (mm/day)

Parameter	Group				"t"	Probability
	100 gm		200 gm			
Time	Mean	SD	Mean	SD		
T1	0.019	± 0.016	0.026	±0.024	0.904	0.187 NS
T2	0.029	± 0.012	0.049	±0.018	3.539	0.001 *
T3	0.037	± 0.012	0.048	±0.016	2.284	0.015 *
F value	6.469		6.838		3.26	0.002 *
Probability	0.004		0.003			
LSD	0.007		0.010			

Table 2: Anchorage loss, Canine rotation and tipping before and after retraction in both groups

		Before		After			
		Mean	SD	Mean	SD	"t"	Probability
Anchorage loss	100 gm group	7.36	±2.48	7.15	±2.48	3.401	0.002 *
	200 gm group	7.78	±2.67	6.91	±2.80	5.475	0.00004 *
Canine Rotation	100 gm group	30.47	±5.19	21.87	±7.11	5.056	0.00009 *
	200 gm group	31.47	±6.59	16.2	±7.31	13.391	0.000000001 *
Canine Tipping	100 gm group	86.33	±3.09	77.87	± 4.72	7.111	0.000001 *
	200 gm group	86.13	±4.61	71.87	± 3.00	13.785	0.0000000007 *

VII.   Conclusions

On the basis of the results obtained from this study, it could be concluded that:
1. For the given experimental treatment time, using 200 gm of retraction force increased the rate and the amount of canine retraction compared with 100 gm of force.
2. Amount of canine rotation, tipping and anchorage loss was higher in 200 gm of force than in 100 gm of force.
3. Indirect mini-screw anchorage obtained by stainless steel ligature wire (0.010" diameter) tied from the mini-implant to the second premolar was not effective in preventing anchorage loss because a significant loss of molar anchorage occurred with both 200 gm and 100 gm force magnitudes.

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