A CAD-CAM Evaluation of Maxillary Canine Retraction Using Two Different Modalities with MBT Prescription-An *In Vivo* Study

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Abstract: *Objective:* (1) To measure and compare the amount of maxillary canine retraction.

(2) To compare the rate of maxillary canine retraction.

Materials and Methods: This was a split mouth design study to compare the amount of maxillary canine retraction using two different modalities. The two modalities of maxillary canine retraction were conventional mechanics with E-chain extending from molar to maxillary canine on one side and the other modality was using orthodontic microimplants loaded with E-chain to the maxillary canine. The sample comprised 15 patients (9 male, 6 female, mean age 19.8 years; range 16-25 years) who were scheduled for extraction of all the upper first premolar. A brass wire guide and a peri-apical radiograph were used to determine the microimplant position. Titanium orthodontic microimplants 1.3 mm in diameter and 10 mm in length were placed between the roots of the second premolar and the first molar of the maxillary arch. After 15 days, the microimplants and the molars were loaded with continuous elastomeric chains expressing 150 grams for canine retraction. Pre-retraction and post-retraction study models were taken for measuring the amount of retraction. Study models were scanned and assessed using CAD-CAM.

Results: The total space closure on the molar anchor side was 4.62 mm (1.1 mm contributed by mesial molar movement) and microimplant anchor side was 4.12 mm. The rate of canine retraction on the molar anchor was 1.07 mm/month and 0.91 mm/month on the microimplant anchor side.

Conclusion: The amount and rate of canine retraction is similar when proceeded with a conventional or a microimplant supported canine retraction.

Keywords: CAD-CAM, Microimplants, Canine retraction.

1. INTRODUCTION

Reducing the duration of orthodontic treatment is of a great interest to the orthodontists in which space closure is one of the most important and crucial stages [1]. Premolar extraction is one of the most routinely carried out procedure. The most time consuming stage of premolar extraction based orthodontic treatment is the canine retraction. Any treatment procedure utilized in shortening the orthodontic treatment duration is at a great advantage for the clinician as well as the patient. In retracting the canines separately in the first step without adding the additional force that would be required to move the incisors at the same time as in the case of En-masse tooth movement, advocates of the 2-step procedure assume that the load on the posterior teeth is lower, thus reducing the susceptibility of the maxillary molars to displace forward. In the second step, the posterior segments, now buttressed by the incorporation of the canines, are pitted against the reduced resistance of the incisors alone. *Wick Alexander* advised retraction of canines, during the levelling phase with rectangular wire (016" x .022" stainless steel) with the aim of placing the tooth with the longest root in its final position at the very beginning of the orthodontic treatment [2]. Roth recommended individual canine retraction for maximum anchorage extraction cases [3]. Several bracket types and methods have previously been reported to sufficiently move the teeth [4]. Orthodontic tooth movement is greatly influenced by the characteristics of the applied force, including its magnitude, direction, moment force ratio and the physiological conditions of the periodontal tissues of the individual patients. In edgewise mechanics, orthodontic tooth movement during space closure can be achieved through two types of mechanics. The first is friction mechanics in which the canines slide distally, guided through a continuous wire. Friction mechanics gives superior rotation control as compared with a retraction spring [5]. The second method frictionless involves use of closing loops fabricated either on full or segmental archwires [6]. Space closure can be accomplished through various methods *via* elastomeric chains or Ni-Ti coil springs. Coil springs are increasingly onerous to keep clean. Forces delivered by Ni-Ti coil springs can differ and they are expensive whereas elastomeric chains are economical, easy to use, relatively hygienic and comfortable for the patient [7, 8, 9]. The development of microimplants in orthodontics has overcome the limitation of anchorage during orthodontic

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treatment. The characteristics of sliding mechanics with microimplant anchorage is independence of patient's compliance [10]. The vertical vector of force is also at a higher level which can cause both intrusion and retraction simultaneously rather than retraction alone as seen in the conventional method canine retraction. Technologic advances in three-dimensional (3D) imaging of the dentition, digital model technology, computer-aided designing, and robotics have catalysed newer approaches to the orthodontic treatment. The state of the art and the essence of modern era investigations have brought to light the new and the advanced system of education. In this study for the first time CAD-CAM has been used to assess the linear changes precisely before and after retraction of the maxillary canines.

The purpose of this study was to measure the amount of canine retraction and to compare the rates of canine retraction with microimplant anchorage and conventional molar anchorage with elastomeric chains using CAD-CAM.

2. MATERIALS AND METHODS

This study was approved by the Institutional Scientific Review Board and the Human Ethical Committee. 15 patients were selected for this study from the Department of Orthodontics, Saveetha university, Tamil Nadu, India under a split-mouth design and were chosen based on the following criteria 1) Adult Patients between 16-30 years of age 2) Patients who require the first premolar extraction 3) After the completion of levelling and aligning phase of treatment 4) Cooperative patients and those who are willing to undergo the procedure 5) Maximum anchorage cases. A consent form duly signed was obtained before initiating the individual canine retraction procedure. Routine protocol was followed for each patient which included - case history, extra oral and intraoral photographs, alginate impressions, lateral cephalogram, panaromic radiographs and study models.

The patients were strapped up with 0.022" slot MBT prescription and were subjected for individual canine retraction. As the orthodontic treatment progressed to the levelling and aligning phase, photographs and study models were prepared before and after individual canine retraction procedure.

The microimplant selected for anchorage was the Dentos Absoanchor (CH type), South korea, 1.3 X 10 mm. Peri-apical radiographs were taken prior and after the microimplant placement to estimate the root proximity and thickness of the bone. The stent was fabricated with the help of a 0.020" brass wire. The brass wire was inserted in the interdental region of the IInd premolar and molar and turned at 90 degree to the occlusal plane. A straight driver was utilized to carry the microimplant to the placement location. The driver was rotated clockwise with light pressure. The threaded portion of the microimplant was completely placed into the alveolus. The microimplant was placed precisely at the end of the twisted brass wire. The placement of microimplant was performed under local anesthesia (2% lignocaine) infiltrated slowly at the microimplant site for profound anesthesia (Figure **1a**). Stability was measured by using cotton forceps and forces were applied laterally to the microimplants (Approximately 100g). During the first 15 days after microimplant placement soft tissue health, pain in the surrounding region and mobility was evaluated. Patients were educated regarding oral hygiene and brushing techniques surrounding the microimplant region. Orthodontic forces were applied 15 days after microimplant placement in order to allow enough time

(**a**) (**b**)

Figure 1: (**a**) Implant anchor side. (**b**) Molar anchor side.

for the periodontal tissues to reorganize. Elastomeric chains (continuous type, Ormco) with a force of 150 grams were stretched between the microimplant and the canine bracket hook on the microimplant anchored side (Figure **2a**) and between the molar hook and the canine bracket hook on the molar anchored side (Figure **2b**). The amount of force application was measured with the help of the Dontrix gauge. The elastomeric chains (ORMCO) were replaced once in every 4 weeks to maintain optimum force of 150 grams for optimum orthodontic tooth movement. En-masse retraction was carried out in the lower arch using friction mechanics simultaneously. Patients were advised to use 0.12% chlorhexidine gluconate mouth rinse twice daily to maintain the oral hygiene in and around the orthodontic braces and the microimplant site.

Two sets of routine records were taken. The first was taken before microimplant placement and the other when the canine retraction was completed in accordance with which side closes first (Figure **3a** and **3b**). The method of investigation to measure the amount of canine retraction was assessed precisely on

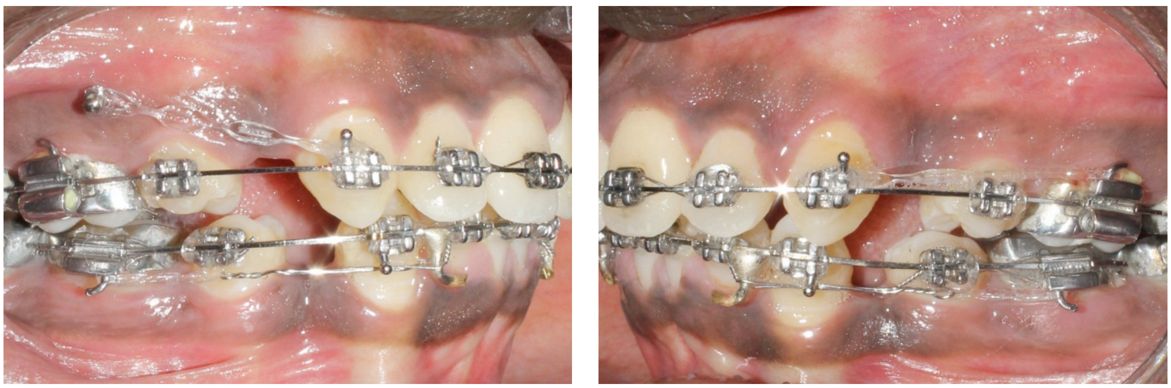
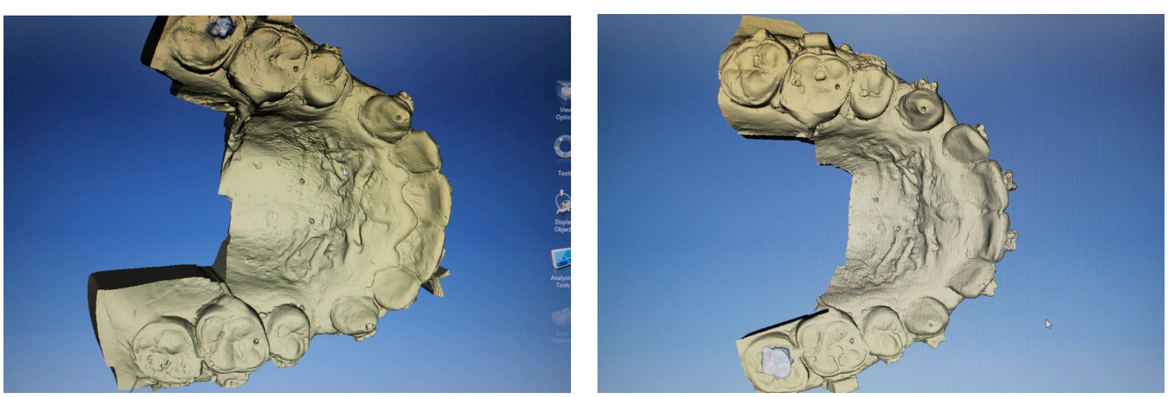
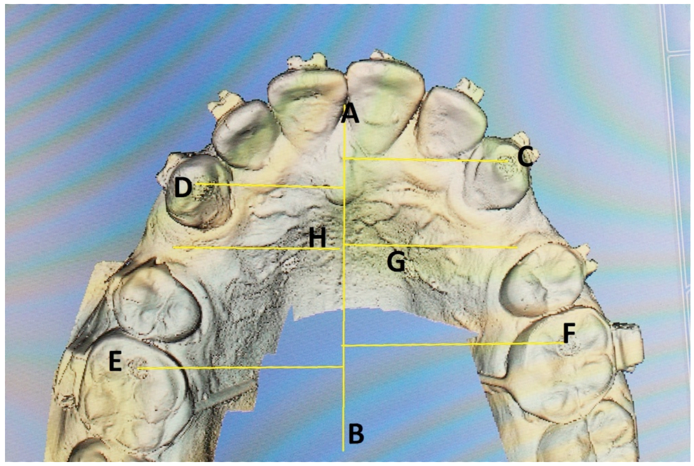


Figure 2: (**a**) Implant anchored with Elastomeric chains. (**b**) Molar anchored with Elastomeric chains.

Figure 3: (**a**) Canine retracted on implant anchor side. (**b**) Canine retracted on molar anchor side.



Figurer 4: (**a**) CAD-CAM assessed pre canine retraction models. (**b**) CAD-CAM assessed post canine retraction models.



A-B: Mid palatal suture.

C: Cusp tip of left maxillary canine.

D: Cusp tip of right maxillary canine.

E: Mesial pit of maxillary right first permanent molar.

F: Mesial pit of maxillary left first permanent molar.

H: medial end of right third palatal rugae.

G: medial end of left third palatal rugae.

Figure 5: Cast scanned using CAD-CAM.

the study models using CAD CAM software 4.2 (Figure **4a** and **4b**). Dental casts that were scanned using CAD-CAM were used for the quantification of the anteroposterior movement of the canines and the first molars (Figure **5**). The rate of canine retraction every month was calculated by dividing the mean amount by the total time taken for canine retraction. The data's obtained were subjected to statistical analysis. Means, standard errors and standard deviations were tabulated. The Student *t* test was used to determine the level of significance and the correlation coefficient of the rate of canine retraction between microimplant anchorage and conventional molar anchorage were also tabulated.

3. RESULTS

Routine records were taken based on, which group completed space closure first. Dahlberg's method of error determination did not show any intra operator error (correlation coefficient r <0.001). The duration of the study was 4-6 months. 16 microimplants were placed in this study and all remained stable until completion of the study. All sixteen patients completed the study. At the end of maxillary canine retraction, the microimplants were easily removed with a straight driver by the primary investigator without local anaesthesia. There was no microimplant osseointegration as no resistance was felt during removal. Two patients who had post-operative pain were prescribed medications. The mean distance between the cusp tip of canine and the mesial pit of the first molar was 20.17 ± 0.39 mm in the MAS group (Table **1**). The mean distance between the cusp tip of canine and the mesial pit of the first molar in the IAS group was 20.2 ± 0.46 mm (Table **1**). The difference in linear distance between the pre and post maxillary canine retraction, were 4.62 ± 0.42 mm in MAS group with t=10.92 ("p" value 0.00) which is with a confidence interval of 3.71 to 5.52 and 4.12 ± 0.34 mm with t=11.95 ("p" value 0.00) which is with a confidence interval of 3.38 to 4.8 in the IAS group (Table **2**). The rate of canine retraction was 1.07 ± 0.10 mm per month on molar anchor side and 0.91 ± 0.06 mm per month on the implant-anchored side (Table **3**). The results further revealed that the difference in the amount of canine retraction and the rate of canine retraction on comparing between MAS and IAS group was not statistically significant (Table **4**).

Table 1: Mean Distance between Molar and Canine in MAS and IAS Group

Group	Distance
MAS	20.17 ± 0.39 mm
IAS	20.2 ± 0.46 mm

MAS: Molar anchored side, IAS: Implant anchored side.

Table 2: Comparison of Treatment Changes (Pre and Post) in MAS and IAS Group

Parameter	Group	Pre	Post	N	Mean ± S.E	t value	P value
Amount of Canine Retraction	MAS	20.17 ± 0.39 mm	15.5 ± 0.56 mm	15	4.62 ±0.42mm	10.9	0.000*
	IAS	20.2 ± 0.46 mm	16.08 ± 0.46 mm	15	4.12 ±0.34mm	11.95	0.000*

P < .01.

Table 3: Rate of Canine Retraction in Both Groups

Group	N	Mean ± S.E
MAS	15	1.06 ± 0.10mm
IAS	15	0.93 ± 0.07mm

Table 4: Comparison of Treatment Changes between MAS and IAS Group Using CAD-CAM

Parameter	N	Group	Mean X +/- S.E	t value	P value
Amount of Canine Retraction	15 15	MAS IAS	4.62 ±0.42mm 4.12 ±0.34mm	0.72	0.47 NS
Rate Of Canine Retraction	15 15	MAS IAS	1.06 ±0.10mm 0.93 ±0.07mm	0.99	0.33 NS

NS Indicates nonsignificant.

4. DISCUSSION

Canine retraction in orthodontics can be brought about by two modalities through two types of mechanics - friction and frictionless mechanics. In friction mechanics the extraction space is closed with the help of elastic chain or NiTi coil spring which is attached to the tooth and the continuous archwire placed through application of a force, the canine is expected to slide distally along and is guided by a continuous arch wire. Friction mechanics are superior to frictionless mechanics for rotational control and arch dimensional maintenance [11, 12]. Friction between archwires and brackets varies according to ligation method which in turn can affect the rate of tooth movement during sliding mechanics [13, 15].

Frictionless mechanics, segmental or sectional mechanics, involves closing loops fabricated either in a full or sectional archwire [16, 19]. Factors that might affect friction in pre-adjusted edgewise appliance include the wire size and archwire stiffness which in turns not only depends on cross sectional size and Youngs modulus but also on interbracket distance [20, 21]. In this study, friction mechanics or sliding mechanics was used as the method of canine retraction which was proved to attain better treatment result as stated in the literature. Storey and Smith, reported the optimal force theory and documented that forces of 150-200 grams applied to maxillary canines would produce the maximum rate of tooth movement for distalization [22]. Quinn and yoshikawa suggested that 100-200 g of force is optimal for canine retraction [23]. Boester and Johnston used sectional closing loops to retract canines in extraction situations using force levels of 60, 150, 240 and 330 g. Their objective was to study the rate of tooth movement at various force levels. Maxillary canine retraction was 0.8 mm/month for 60 g, 1.3 mm/month for 150 g, 0.8 mm/month for 240 g and 1 mm/month for 330 g of force [24]. Iwasaki *et al.* reported that forces as low as 18 g could cause effective tooth movement and recommended that optimum pressure should be less than 100 g [25]. Ricketts advocated 75 grams [26] and Lee [27] recommended 150 to 200 g as the optimum force value for the canine retraction. Sonis *et al.* used elastomeric chains and latex thread to retract canines on 0.016 X 0.022 inch archwire with force values of 250-400 g. The mean velocity of tooth movement calculated over a 3week period was 1.28 mm for elastic threads and 1.51 mm for the elastic chains. This study was performed by using forces of 150 g delivered through an elastomeric continuous chain which was within the optimum orthodontic force level for canine retraction and a similar result of 1.1 mm/month was seen. Our study had a lesser rate compared to this study because of the force levels were comparatively lesser. The rate of tooth movement was not statistically significant between both the groups. Microimplant side did not reveal complete retraction of the canine as the methodology demanded post canine records to be taken depending on which side the canine retraction completed early. The amount of canine retraction on the implant anchor side (IAS) was 4.12 ± 0.34 mm ("p" value 0.00) as compared to the molar anchored side measured as 4.62 ± 0.42 mm ("p" value 0.00). The uniqueness of this study for assessing total space closure was done for the first time using CAD-CAM (version 4.2), as no literature revealed CAD-CAM application for assessing maxillary canine retraction in orthodontics. Microimplants has revolutionized the clinical orthodontic practice over the last few years. Park *et al.* retrospectively evaluated the success rate of 180 microscrew implants for orthodontic anchorage placed in 73 patients. He found an overall success rate of 93.3% and a mean usage period of 15.8 months, with an even higher success rate of 94.6% of implants placed in the maxillary buccal alveolar bone [28]. The ease of placing a microimplant has led many clinicians to apply it even in their clinical practice. Several factors should be considered before placing a microimplant. Microimplants should be of smaller dimensions to place anywhere in the oral cavity. A biocompatible material such as titanium microimplants should be preferred. It should be easy to place and remove. The microimplant used in this study was Dentos Absoanchor, which was found to meet most criteria for an ideal implant for orthodontic anchorage.

The rate of canine retraction was measured as a mean of the four months duration of canine retraction. It revealed that canine retraction on the microimplant side was (0.93 mm/month) as compared with the canine retraction on the conventional molar supported anchorage (1.1 mm/month). This study is on par with the literature quoted by thiruvenkatachari *et al.* [29]. It was noted that minor space existed distal to canine and there was no mesial movement of the molar on the microimplant anchor side conforming absolute anchorage. The percentage of space closure from exclusive canine retraction was statistically significant on the implant supported side with no anchorage loss. Subsequently canine retraction space on the microimplant side was made to close by burning anchorage (intentionally) by detaching the Transpalatal arch to finish with the same class I molar relation on the MAS. On the conventional canine retraction side canine got retracted completely adjacent to the IInd premolar with molar mesial movement as well. The lower arch space closure was completed with friction mechanics.

5. CONCLUSION

The rates of tooth movement are indirect indicators of bone turnover and remodeling. The differences in rate of tooth movement determine which mechanics is ideal for space closure in orthodontics. Tooth movement differs with various mechanics employed for space closure. A complete understanding of how teeth moves for any force applied is the basis for making treatment more efficient.

This study proves that the null hypothesis is justified with the results being not statistically significant as compared with both the modalities of the maxillary canine retractions in terms of amount and rate of canine tooth movement.

Extrapolating the findings from our study under ideal clinical conditions

- The rate of canine retraction was similar with both the modalities.
- The use of microimplants as anchorage for the retraction of canines is a viable alternative to conventional molar anchorage.

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