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Cone-beam computerized tomography evaluation of canine retraction using micro implant and conventional anchorage



Girish Chaudhary [a,*], *Maninder S. Sidhu* [b], *Seema Grover* [b], *Anshul Chaudhry* [c]

[a] *Department of Orthodontics, Baba Jaswant Singh Dental College, Hospital & Research Institute, Chandigarh Road, Ludhiana 141010, Punjab, India*

[b] *Department of Orthodontics, SGT Dental College, Hospital and Research Institute, Budhera, Gurgaon 122505, Haryana, India*

[c] *Department of Orthodontics, Christian Dental College, Hospital & Research Institute, Brown Road, Ludhiana 141010, Punjab, India*

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ABSTRACT

Objective: Various anchorage techniques have been designed for canine retraction. The aim was to measure and compare the rate of canine retraction with conventional method and micro implant using CBCT.

Materials and methods: Sample size comprising of 17 subjects were scheduled for extraction of all first premolars. After leveling and aligning, titanium micro implants were placed between the roots of the second premolar and the first molars on right side, in both the arches. Pre and post retraction CBCT scans were taken. Retraction was done using sliding mechanics using stainless steel arch wire.

Results: The maxillary right canine (micro implant) retracted by 6.75 mm and tipped distally by 9.51° at a rate of 1.05 mm/month while the mandibular right canine retracted by 4.83 mm and tipped distally by 7.88° at a rate of 1.13 mm/month. On the left side (conventional) with molar as a source of anchorage, maxillary canine retracted by 6.03 mm and tipped distally by 6.51° at a rate of 1.46 mm/month while the mandibular canine retracted by 5.03 mm and tipped distally by 4.34° at a rate of 1.15 mm/month.

Conclusion: Implants can serve as a source of anchorage.

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1. Introduction

Anchorage in orthodontics is the most important factor that determines the treatment and results. The intraoral anchorage techniques have not always been successful. Although Headgear has been proved to be the best source of anchorage; the problems related to patient co-operation,[1] undesirable side effects on the maxillary complex and the

* *Corresponding author.*
E-mail addresses: dr.girishchaudhary@gmail.com, dr.anshulchaudhry@gmail.com (G. Chaudhary).

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Fig. 1 – Surgical guide between the first molar and second premolar to assist the exact positioning of the micro screw at a specific height.

risk of injuries[2–4] have jeopardized the success. Since dental anchorage of any type to a certain degree would result in unwanted movement of the anchored teeth, devices have been developed that do not use teeth as the anchorage unit.

Introduction of the micro implant has provided an excellent alternative to conventional intraoral and extraoral anchorage devices.[5–8] Micro implants can help in achieving various corrections of sagittal and vertical discrepancies, closure of extraction spaces, en-masse retraction of anterior teeth, intermaxillary anchorage to correct sagittal discrepancies and correction of vertical skeletal discrepancies.

The degree of tooth movement can be studied with a conventional two-dimensional (2D)[9,10] cephalogram which has been used since long time to see the skeletal and dental changes during the course of orthodontic treatment but its major drawback is the superimposition which makes difficult to exactly assess the right and left side dental changes separately and accurately. With the advancement in the field of diagnostic radiology this problem has been overcome. CBCT specifically dedicated to imaging the maxillofacial region heralds a true paradigm shift[11] from 2D to a 3D approach to data acquisition and image reconstruction[12] and has a faster X-ray acquisition time, reduced image distortion due to patient movements, and increased X-ray efficiency. CBCT provides accurate assessment of the craniofacial structures in three dimensions with radiation exposure shorter than standard panoramic radiography.

CBCT derived images can give right and left side views separately which overcomes the problem of superimposition and provide accuracy in assessing the type and exact amount of tooth movement.

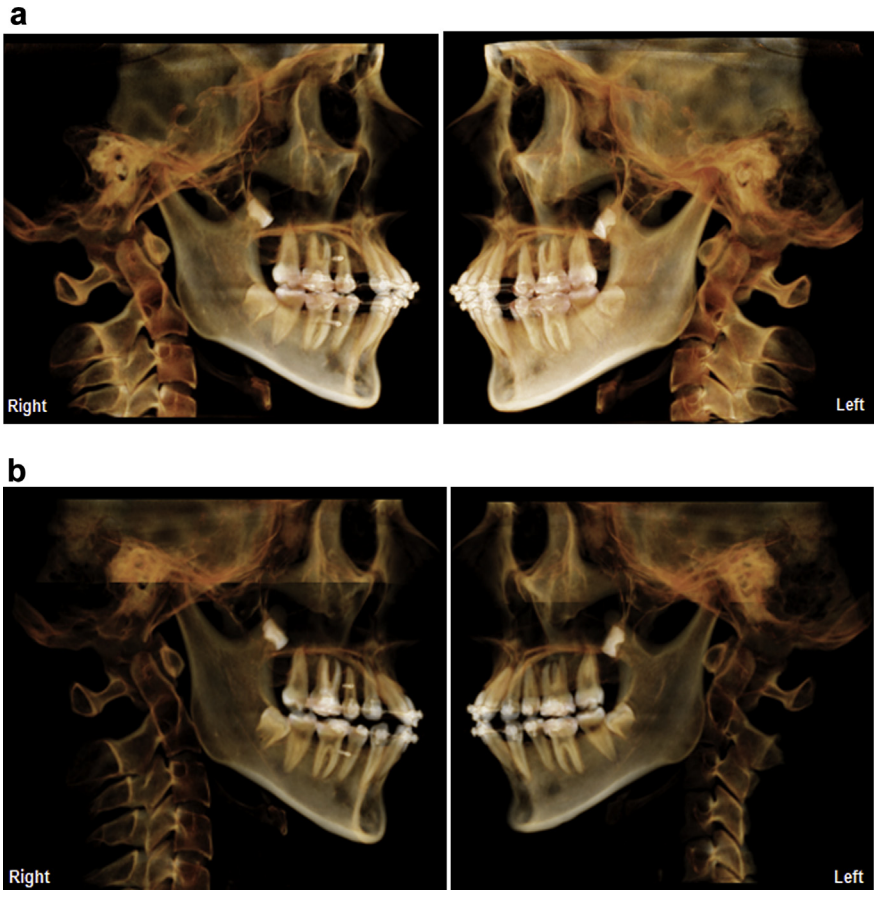


Fig. 2 – a. CBCT generated 2D cephalometric images showing right and left side before canine retraction. b. CBCT generated 2D cephalometric images showing Right and left side after canine retraction.

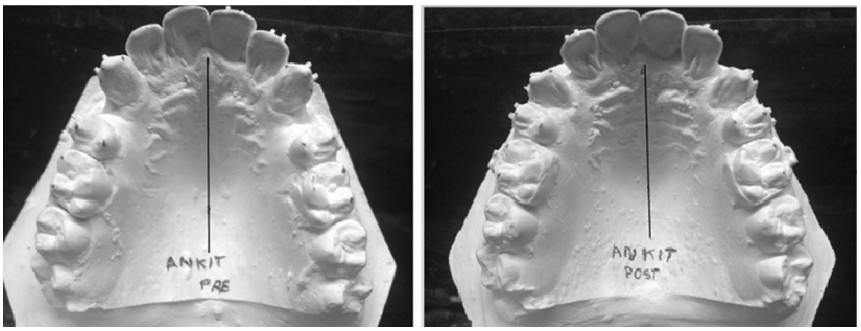


Fig. 3 – Pre and post canine retraction maxillary casts showing the marking for canine rotational measurements.

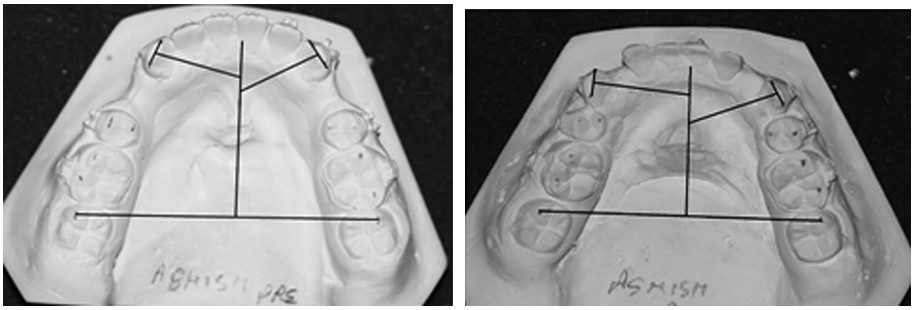


Fig. 4 – Pre and post canine retraction mandibular casts showing the marking for canine rotational measurements.

Hence the study was undertaken to understand the accurate evaluation of movement of canine using conventional method on one side and skeletal anchorage (micro implants) on the other side of the same patient.

2. Materials and methods

A sample size consisting of 17 subjects was selected from patients coming to the department of orthodontics in the SGT Dental College who were recommended for orthodontic treatment. The inclusion criteria was no comprehensive medical and dental history to rule out any systemic illness, all the cases were of maximum anchorage with discrepancy of more than 9 mm requiring extraction of first premolars in all quadrants, the age and sex of patient were not taken into account.

All the cases selected were undergoing fixed orthodontic treatment utilizing 0.022 slot MBT bracket systems. Informed consent was obtained for all patients before placement of the implants. The titanium micro implants AbsoAnchor® system

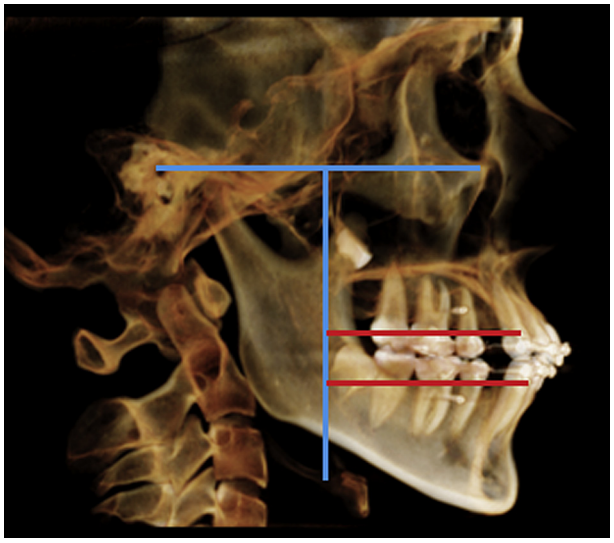


Fig. 5 – CBCT generated view showing the linear distance from pT line to the distal surface of maxillary and mandibular canine bracket.

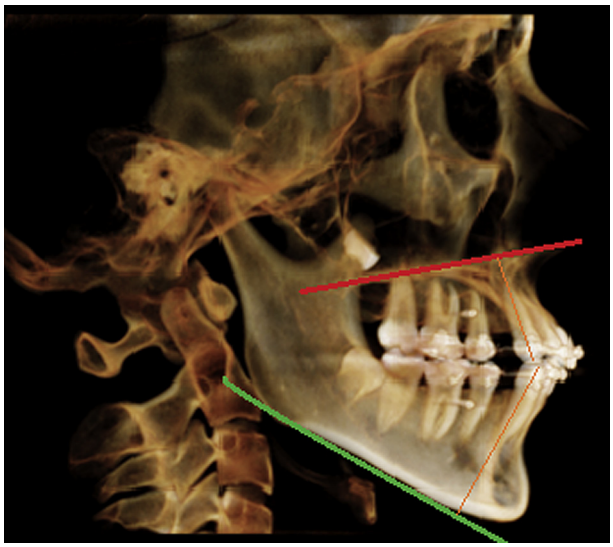


Fig. 6 – Angle formed by the long axis of teeth with the palatal plane and mandibular plane.



Fig. 7 – Intraoral photographs of a. Pre retraction and b. Post retraction of canine using mini implant on right side and molar anchorage on left side.

(Dentos, Inc. Daegu, Korea) of 1.2 × 8 mm in length were placed between the roots of second premolar and the first molar using a surgical guide (Fig. 1) in the right side of maxilla and the mandible. Retraction was done using sliding mechanics on 0.017 × 0.025 stainless steel coordinated arch wire, using NiTi closed coil spring giving a force, ranging from 120 to 150 g (measured with the Dontrix gage; American Orthodontics, Sheboygan, Wis). The conventional method of retraction was used on the left side. The period of the study was 6–8 months. Two sets of records were taken: one before starting the retraction, and the other after completion of retraction including CBCT scans, photographs and models. 3D cephalometric images of right and left side (Fig. 2a and b) were generated from CBCT using the IN VIVO DENT 5.0 software for the analysis.

The rotational change in the canine position was measured in the dental casts using the Ziegler and Ingervall[13] method. The photographs of the maxillary and mandibular cast were taken using a CANON EOS 400D DIGITAL SLR CAMERA with an installed macro lens of 1:1 ratio which was mounted over a stand from a fixed distance of 3 feet for all the casts so that all the photographs were of same size without any magnification. After transferring images to the computer, the rotational changes were measured by evaluating the angular changes using Digimizer software. Standardization of cast to exact 1:1 ratio was not necessary as the angular changes are independent of the linear measurements. The rotational changes in the canine, premolar and molar were measured for right and left side (Fig. 3) by marking the mid palatal raphe for the maxilla and lingual frenum, the mesiobuccal cusp tips of right and left second molar for mandible (Fig. 4).

For Linear measurements, right and left canines, were measured from fixed co-ordinates in x and y axis, using 3D CBCT generated views which can be rotated in any plane using the IN VIVO 5 software. Using this software, the 3D view was split from the mid sagittal plane and right and left sides were separated which eliminated all the superimpositions of right over the left side.

For the cephalometric linear measurements, the FH plane was drawn using the point Orbitale (O) and point Porion (Po). After the construction of FH plane, pT point was located which is the posterior superior point on the pterygopalatine fossa. Through this pT point a line perpendicular to FH plane was drawn as given by Ricketts[14,15] which creates the x-axis and y-axis which will be fixed in pre and post treatment 3D cephalometric view. Through this pT perpendicular, all the linear measurements for both maxillary and mandibular canine were made. A line perpendicular to the pT perpendicular was drawn to the assigned points to measure the horizontal distance from distal surface of canine bracket (Fig. 5).

For the angular changes in the maxillary teeth (Fig. 6), the palatal plane was drawn by joining the anterior nasal spine (ANS) and the posterior nasal spine (PNS). For the angular measurement of mandibular teeth (Fig. 6), the mandibular plane was constructed using the menton (me) and gonial (go) point. The long axis of the canine was drawn to measure the angular change before and after retraction. The mesiobuccal cusp tip and the mesial root tip were joined to make the long axis of the molar.

The data obtained were subjected to statistical analysis. Mean and standard deviations were tabulated, with the Student *t* test used to determine the level of significance and correlation of the rate of canine retraction between implant and conventional molar anchorage in the maxilla and the mandible.

3. Results

Canine retraction was completed successfully for all 17 patients (Fig. 7). It was considered complete when the extraction

Table 1 – Showing the linear, angular, rotational changes and rate of canine retraction for maxillary right and left canine.

CANINE	MAXILLARY				MANDIBULAR			
	Linear (mm)	Angular (degree)	Rotational (degree)	Rate of retraction (mm/month)	Linear (mm)	Angular (degree)	Rotational (degree)	Rate of retraction (mm/month)
RIGHT (mini implant used as a source of anchorage)	3.56	7.21	-5.43	1.61	6.78	10.61	-33.08	1.81
	8.02	11.49	-18.23	1.46	8.17	9.92	-39.65	1.81
	7.09	15.33	-20.67	1.49	5.79	14.27	6.28	1.18
	10.87	20.68	-23.27	0.81	3.78	7.42	-9.75	0.81
	6.21	1.4	3.19	0.64	2.91	2.16	-32.27	0.59
	5.95	22.42	5.05	0.84	3.52	9.76	17.56	0.88
	9.73	7.66	-34.8	1.12	8.46	12.02	-27.93	0.9
	8.7	3.53	-5.05	1.04	5.3	10.12	-23.66	1
	5.22	-0.4	-4.7	0.6	3.69	4.53	13.7	1.11
	7.11	9.8	25.46	0.66	3.21	11.79	12.85	0.58
	2.45	1.5	-22.26	0.63	4.48	6.64	-17.24	0.55
	6.28	4.88	-13.03	0.86	5.72	6.26	-20.61	0.72
	6.78	5.96	-3.98	1.17	4.48	-1.54	-12.82	2.4
	6.34	13.18	-12.89	0.88	3.56	3.91	-0.88	1.2
	5.97	14.57	-5.55	2.01	2.35	-2.04	7.6	1.26
	7.21	9.75	-0.27	0.78	4.05	10.64	-29.45	0.76
	7.2	12.68	-20.27	1.3	5.9	17.52	-14.04	1.67
Mean ± SD	6.75 ± 2.02	9.51 ± 6.54	-9.21 ±13.96	1.05 ± .41	4.83 ± 1.77	7.88 ± 5.27	-11.96 ± 18.40	1.13 ±.52
LEFT (molar used as a source of anchorage)	2.6	10.48	-20.6	1.75	3.51	10.74	-15.41	1.66
	6.33	11.04	-20.07	3.26	5.75	3.85	-15.93	1.67
	8.36	10.63	-21.31	1.83	6.72	6.59	-18.57	1.28
	11.22	15.06	-22.88	0.83	6.28	0.51	-12.73	0.83
	3.03	8.83	-12.9	0.78	1.68	-0.91	-14.67	0.72
	4.86	4.33	-9.49	0.91	4.9	8.02	-13.48	0.75
	6.79	7.31	4.94	0.85	7.14	-10.6	-10.63	0.78
	6.28	3.92	-3.82	1.24	3.89	3.2	-13.42	0.76
	5.82	2.15	-7.09	1.09	4.95	0.18	-11.76	1.57
	6.51	13.19	-6.51	0.86	7.73	16.06	-33.71	0.83
	3.24	3.75	-31.44	0.52	5.16	17.16	-5.27	0.54
	8.69	-1.28	-21.78	0.87	6.7	2.28	-14.65	0.98
	5.36	8.69	-4.29	1.66	4.12	0.44	-7.28	3
	5.68	-3.75	-8.4	2.2	3.37	2.35	-4.13	0.86
	5.56	5.07	-23.18	2.35	4.2	0.09	14.27	1.18
	8.01	8.2	-9.22	1.11	5.06	-0.49	-9.19	0.79
	4.18	3.02	-1.8	2.55	4.37	14.34	-11.98	1.47
Mean ± SD	6.03 ± 2.22	6.51 ± 5.02	-12.93 ± 9.77	1.46 ±.77	5.03 ± 1.56	4.341 ± 7.116	-11.68 ± 9.31	1.15 ±.59

space was closed on the molar-anchored side. Results show the changes in the amount and rate of canine retraction. Angular changes in the canine before and after the retraction were compared using the CBCT generated 3D views and the rotational changes were assessed by using dental cast.

The following were the results obtained from the linear measurements done on the 3D view generated from CBCT:

The mean linear distal movement of canine on implant side was by 6.75 mm in the maxilla and by 5.03 mm in the mandible. The distal movements of canine with conventional anchorage were 6.03 mm in the maxilla and 4.83 mm in the mandible (Table 1). The average differences were 0.72 mm in the maxilla and 0.199 mm in the .mandible (Table 2). These values were not statistically significant ($P > 0.01$).

The mean angular changes on the implant side were by 9.51° in the maxilla and by 7.88° in the mandible. On the conventional anchorage site, angular change in the maxilla was by 6.51° and in the mandible by 4.34° (Table 1). The average differences were 3° in the maxilla and 3.54° in the mandible (Table 2). These values were not statistically significant ($P > 0.01$).

The mean rotational changes, seen on cast, on implant side were by 9.21° in the maxilla and by 11.96° in the mandible. On the conventional anchorage side, the maxilla showed a change by 12.93° and mandible showed a change by 11.68° (Table 1). The average differences were 3.71° in the maxilla and −0.28° in the mandible (Table 2). These values were not statistically significant ($P > 0.01$).

The mean rate of canine retraction in maxilla on implant side was by 1.05 mm/month and by 1.13 mm/month in the mandible. The conventional anchorage side showed a rate by 1.46 mm/month in the maxilla and by 1.15 mm/month in the mandible (Table 1). The mean rate of retraction was 0.39 mm/month in the maxilla and 0.03 mm/month in the mandible (Table 2). These values were not statistically significant ($P > 0.001$).

Table 2 – Showing the results of the paired t test comparing maxillary right and left canine for linear, angular, rotational changes and rate of canine retraction.

Canine	Pair	Mean	Standard Deviation	Std. Error Mean	P Value
MAXILLARY	Linear	0.72	1.63	0.40	0.088*
	Angular	3	7.23	1.75	0.106*
	Rotational	3.71	15.79	3.83	0.347*
	Rate Of Retraction	-0.39	0.56	0.14	0.009**
MANDIBULAR	Linear	-0.199	1.95	0.47	0.679*
	Angular	3.54	7.12	1.73	0.057*
	Rotational	-0.28	20.42	4.95	0.955*
	Rate Of Retraction	-0.03	0.26	0.07	0.677*

*$P > 0.01$, **$P > 0.001$

But the fundamental difference was that the anchorage loss was observed in the study where molar was used as a source of anchorage by 1.31 mm in the maxilla and 1.03 mm in the mandibular molar. Where mini implants were used as a source of anchorage, small amounts of molar distalization (anchorage gain) were noted; in the maxillary molars by 0.41 mm and 0.05 mm in the mandibular molar (Table 3). These values were statistically significant (Table 4).

4. Discussion

The retraction of canines depends on various factors: the type of appliance used, the amount of force applied, the methodology, and the surface root area of the tooth. In this in vivo study, the movement of the canine against the skeletal anchorage unit was compared with the dental anchorage unit with the help of CBCT which is the first study of its kind to visualize the exact amount of movement of teeth in same patient.

CBCT generated two types of 3D dentofacial reconstruction images of right and left side for the same patient which provide accuracy in assessing the type and exact amount of tooth movement. The degree of tooth movement can be studied with a conventional two-dimensional (2D)[9,10] cephalogram which has been used since long time to see the skeletal and dental changes during the course of orthodontic treatment but its major drawback is the superimposition which makes difficult to exactly assess the right and left side dental changes separately and accurately.

In this in vivo study, the rate of canine retraction in maxilla on right side was 1.05 mm/month and on left side 1.46 mm/month. In the mandible, right side showed a rate of retraction by 1.13 mm/month and left side by 1.15 mm/month. Canines were retracted slowly with implant anchors and the differences in average amount of canine retraction were 0.39 mm/month in the maxilla and 0.03 mm/month in the mandible. The reported rates of canine retraction have varied from 0.35 to 1.55 mm per month. Paulsen et al[16] showed an average canine retraction rate of 1 mm per month which is comparable with the present study. In the study of Sonis et al,[17] the rates of canine retraction were 0.99–1.51 mm in 3 weeks. In a randomized clinical trial by Dixon et al,[18] the mean rate of canine retraction with nickel titanium coil springs was 0.81 mm per month. Darendelier et al[19] compared pull coil springs and drum springs in adults and reported an average rate of canine retraction of 0.87 mm per month with pull coil springs. The results were similar with the present study. Sleichter[20] showed a canine retraction rate of 1 mm per month; this is close to the value obtained during the present study. The difference in the rates of retraction between the molar anchorage and the implant anchorage might be because of the difference in the level of force. Implants are positioned much higher than the molar power arm because of which there is a horizontal and a vertical force component for the force applied where as in the molar anchorage only the horizontal force component was present which leads to a faster rate of retraction on molar anchorage side.

The cephalometric assessment is a two-dimensional (2D) modality to check anteroposterior movement. The use of a 3D digitizer has made possible a more comprehensive assessment of tooth position changes during treatment.[21] Cone-beam computed tomography is most recent comprehensive tool to generate 3D dentofacial reconstruction images, so that minute

Table 3 – Showing the linear changes for maxillary right and left molar.

Molar Linear (mm)	MAXILLARY	MANDIBULAR
RIGHT (mini implant used as a source of anchorage)	0.77	0.3
	0.2	0.14
	-0.08	-0.04
	0.77	-1.23
	0.24	0.29
	0.63	0.21
	1.56	1.01
	0.31	0.06
	0.14	0.14
	0.04	-1.85
	0.17	0.67
	0.27	0.12
	0.79	0.17
	0.71	0.9
	0.23	0.32
	0.13	-0.48
	0.12	0.16
Mean ± SD	.41 ± .41	.05 ± .69
LEFT (molar used as a source of anchorage)	-1.55	-0.33
	-1.43	-1.34
	-1.72	-1.87
	-1.96	-1.19
	-1.85	-1.66
	-1.09	-0.88
	-0.94	-1.35
	-1.25	-1.16
	-0.86	-1.3
	-1.51	-0.98
	-1.45	-0.29
	-1.43	-0.47
	-0.64	-0.1
	-1.24	-0.85
	-1.12	-0.97
	-0.97	-1.21
	-1.34	-1.54
Mean ± SD	-1.31 ± .35	-1.03± .49

linear and angular changes after orthodontic tooth movements can be studied. CBCT images are produced with lower radiation doses, similar to full-mouth periapical views. Compared with spiral CT, they provide higher resolutions in every axis.[22–24]

In the present study, the amount of canine retraction was comparable between two sides with no statistical significance. The retraction was primarily achieved by tipping and partly by translation. Mini implants used in the present study were similar to the mini implants used by Thiruvenkatachari[25] in their study. The amounts of distal movement of canines with implants as anchorage were 4.29 mm in the maxilla and 4.10 mm in the mandible and with conventional molar anchorage were 3.79 mm in the maxilla and 3.75 mm in mandible. The important finding of present study was the loss of anchorage where molar was used as a source of anchorage by 1.31 mm in the maxilla and 1.03 mm in the mandibular molar. A small amounts of anchorage gain in the form of molar distalization was noted where mini implants were used as a source of anchorage by 0.41 mm in the maxillary molars and 0.05 mm in the mandibular molar.

Table 4 – Showing the results of the paired t test showing the linear changes for maxillary and mandibular left molar.

Pair	Mean	Standard deviation	Std. Error mean	P value
Maxilla	1.40	0.57	0.14	0.000
Mandible	1.35	0.86	0.20	0.001

Daskalogiannakis and McLachlan[26] compared the effects of continuous and impulsive forces on tooth movement. Twice the amount of tooth movement was obtained with continuous force application after 3 months. Owmann-Moll et al[27] stated that continuous force was more efficient than interrupted force. Huffman and Way[28] investigated canine distalization with the Pletcher spring producing a force of 200 gm. Canine was retracted by 3.37 mm and tipping was 5.30° with the rate of 1.4 mm/month.

Canine distalization with nickel–-titanium coil springs producing a force of 150–200 gm, along a 0.016-inch arch wire was investigated by Rajcich and Sadowsky.[29] During a period of 7.1 months, right and left canine distalization was 5.6 mm and 5.8 mm, respectively. Average canine distalization was 3.9 mm, with latex elastics producing a force of 75–100 gm during a period of 4–8 months.[13] Canine distalization with chain elastics producing a force of 380 gm along 0.018-inch arch wire showed a rate of movement of 1.4 mm/month. The amount of distalization was 6 mm and the amount of tipping was 8.5^{0} [29].

Rotation of canines showed a statistically no significant difference between the two groups. In the implant side maxillary canine rotated distopalatally by 9.21° and mandibular canine distolingually by 11.96° whereas in the molar anchorage side maxillary canine rotated distopalatally by 12.93° and mandibular canine distolingually by 11.65°.

Ziegler and Ingervall[13] and Rajcich and Sadowsky[29] observed distopalatal rotation of the canine 24° and 15.3° respectively during retraction. Distopalatal rotation of the canines should be observed because of the relationship between the force application point and the center of resistance of the canine. In both groups, the line of action of force passed buccally and distally to the center of rotation. However, distopalatal rotation observed may be explained by force duration and by arch wire control and the way the teeth have been ligated.

5. Conclusion

1. Although the movement is equal on the both sides but anchorage loss is seen on the conventional side using molar as an anchorage unit.
2. The average treatment time for which the mini implants were used for canine retraction was 7.35 ± 2.23 months with an overall success rate of approximately 97%.
3. The retraction was primarily achieved by tipping and partly by translation. Maxillary canine retraction was more

on the implant side (6.51 mm). Distal tipping was also more on the implant side (9.51°)

Conflicts of interest

All authors have none to declare.

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