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ORIGINAL RESEARCH

Evaluation of Canine Retraction through Distraction of the Periodontal Ligament: A Clinical Study

KV Sujan Kumar, K Umashankar, D Pradeep Kumar, D Praveen Kumar

ABSTRACT

Aim: The aim of this study is to evaluate the efficiency of canine distraction and also to evaluate the position of canine in the arch after distraction.

Materials and methods: The study sample consisted of five patients, (4 males and 1 female), in the age group of 14 to 25 years who needed canine retraction (ten maxillary canines including both left and right) and first premolar extraction as their treatment protocol were included in the study. This study used a in-house manufactured periodontal ligament distractor.

Results: The maxillary canines were distracted distally by 6.42 mm in three and half weeks with a distal tipping of around 15.1° and the maxillary first molars tipped mesially by an average of 6.1°. The maxillary canines rotated mesiobucally by an average of 7.8° bilaterally.

Conclusion: Canines can be distracted rapidly with minimal effects on the vitality and the periodontal condition and almost all of extraction space can be used for anterior dental alignment or retraction. Maxillary canines can be rapidly retracted into the first premolar extraction space at the rate of about 2.43 mm per week.

Clinical significance: The overall treatment time is reduced as the time taken for retraction of canine is decreased considerably from 6 and 8 months to 3 weeks. Also there is no significant anchorage loss during this period and is well suitable for cases with group a anchorage where the whole extraction space is needed for retraction of anterior teeth.

Keywords: Distraction, Periodontal ligament, Canine.

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INTRODUCTION

Orthodontic tooth movement is a process in which a mechanical force is applied to induce bone resorption on the pressure side and deposition on the tension side. On the tension side, the periodontal ligament is stretched (distracted) followed by alveolar bone deposition (osteogenesis). The regular rate of osteogenesis is about 1mm per month.[1] Canine retraction is an integral part of both edgewise and preadjusted edgewise meachanics with lots of stress on anchorage considerations. Conventional treatment techniques can generally be grouped as either frictional or frictionless mechanics.[2]

In 'frictional' system, the canine is intended to slide distally, guided by a continuous archwire. The main advantage of this technique is the limited possibility of flaring and rotation. Disadvantages are lack of vertical incisor control and the need for anchorage control. In 'frictionless' or 'nonfrictional, segmented system the canine is moved by a buccal sectional closing loop or a retraction spring. This method avoids unwanted displacements of the incisors.

The fastest rate of canine retraction achieved by these methods as reported in the literature is about 2 mm/month. Thus, it takes a minimum time period of 4 to 6 months to retract the canines completely into the first premolar extraction space by conventional methods.[3-7]

Liou and Huang in 1998,[8] pointed out that after first premolar extraction, the interseptal bone distal to the canine is the only significant obstacle for canine retraction. They proposed that rapid canine retraction could be achieved through distraction of its periodontal ligament and surgically weakening and bending the interseptal bone distal to the canines into the first premolar space.

The aim of this study was to evaluate the dentoalveolar effects of canine distraction through which maxillary canines were distalized in 3 weeks time period with a custom-made intraoral distraction device.

MATERIALS AND METHODS

The patient sample was selected from subjects seeking treatment at the Department of Orthodontics, College of

Dental Surgery, Saveetha University, Chennai. The study sample consisted of five patients, (4 males and 1 female), in the age group of 14 to 25 years who needed canine retraction. A total of ten canine distractions inclusive of right and left side were carried out with custom made, in-house fabricated, tooth borne, intraoral periodontal ligament distraction device.

Clinical Procedure

The procedure of canine retraction through distraction of periodontal ligament was accomplished by bending the interseptal bone distal to the canines into the extraction socket. To keep bending the interseptal bone and carrying it with tooth movement, the light continuous force generated by conventional orthodontic appliances were not adequate enough. Thus, it was necessary to fabricate a rigid, segmental tooth bone intraoral periodontal ligament distraction device for performing canine distraction.

Distraction Device

The device was designed in-house in the Department of Orthodontics, College of Dental Surgery, Saveetha University, Chennai. It consists of two parts, an anterior and posterior part (Fig. 1). The device has two components, an active component or the screw and stainless steel stabilizing rod or guiding arm of 036" diameter. The pitch of the screw was 0.4 mm (Fig. 2).

Bands were fabricated on canines and first molars bilaterally in the maxillary arch using conventional band material of 0.180 × 0.005" and 0.125 × 0.003" thickness (Rocky Mountain Orthodontics, Denver, USA) respectively. To position the long axis of the screw parallel to the occlusal plane, the thickness of the band on the molar was added at the molar tube area to compensate the in-out discrepancy. Transpalatal arches were fabricated and were inserted in the lingual sheaths of the first molar bands to enhance anchorage.

Surgical Procedure

The patient was subjected to extraction of first premolars under local anesthesia. Immediately after the first premolar extraction, the interseptal bone distal to the canine was undermined with a straight fissure bone bur No.702 (Figs 3A to C). Vertical grooves were made inside the extraction socket, along the mesiobuccal and mesiolingual line angles which were connected at the base of the interseptal bone by an oblique groove to weaken its resistance. The interseptal bone was not cut through and through mesiodistally towards the canine. The surgical procedure used in this study was similar to the procedure described by Liou and Huang.[8] The custom-made intraoral distraction device was then inserted for canine retraction. The screw was positioned with its axis approximately parallel to the occlusal plane and placed as gingival as possible without causing excess irritation to the vestibular mucosa.

Fig. 1: Distraction device

Fig. 2: Magnified view

The device was cemented in place and transpalatal arch was inserted in the lingual sheaths of the molars. The lingual button welded on to the canine band serves for the attachment of the elastomeric chain, to counteract any rotation force that was encountered by the canine during the distraction process.

Activation Protocol

Activation of the screw was started on the day of insertion and consisted of one half turn each day (Fig. 4) in the morning and one half turn in the evening, thus a total activation of 0.4 mm/day.

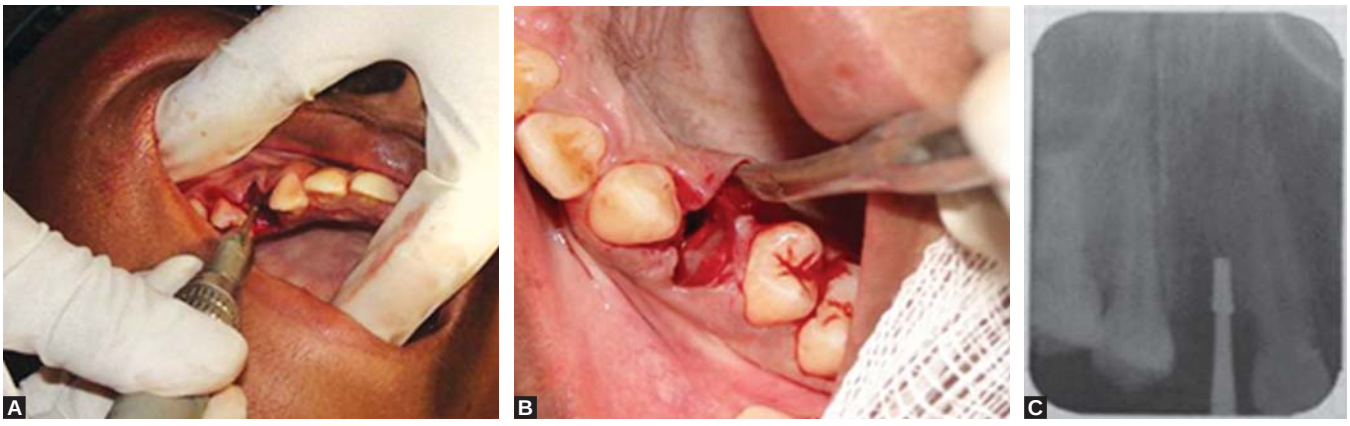
Record Analysis

The protocol for this study included clinical and radiographic review till complete retraction of canines.

DATA ANALYSIS

Amount and Rate of Canine Distraction

The distance between the contact points of the canine and lateral incisor (amount of distraction) was recorded to



Figs 3A to C: (A and B) Intraoral view of surgical technique, (C) position of bur

Fig. 4: Activation key

0.1 mm with a sliding caliper (Yamayo digital calipers) preoperatively, after 1 week of retraction, after 2 weeks of retraction and at the end of retraction respectively as mentioned by Liou and Huang.[8] The number of days taken to complete each canine retraction was recorded.

Pulp Vitality Testing

Pulp vitality tests of the distracted maxillary canines and first molars were recorded with an electronic pulp tester[9] before the placement of any appliance, and 1 month after the distraction.

Mobility

Tooth mobility was assessed by holding it firmly between the handles of two metallic instruments and making an effort to move it in all directions. It was assessed preoperatively and one month after distraction. Mobility was then graded according to the scale as mentioned by Carranza.[10]

Radiographic Analysis

Radiographs included sequential intraoral periapical radiographs and occlusal radiographs at weekly intervals, while lateral cephalogram and orthopantomogram were taken preoperatively and at the end of retraction.

The periapical radiographs were assessed for apical root resorption in each case as advocated by Sharpe et al.[11]

RESULTS

This study revealed that maxillary canines can be distracted rapidly with an intraoral distractor. Distraction maintained the vitality of the tooth and optimum force levels were delivered by the appliance. The maxillary canine was distracted in a span of 3 weeks with activation being done twice daily beginning immediately after the surgical procedure. Few patients reported of discomfort during the time of activation and sensitivity in relation to the canines. Patients complained of bulkiness of the appliance and difficulty was experienced during laterotrusive movements.

The data obtained from cephalograms, orthopantomograms and study model analysis of the ten distracted teeth were analyzed statistically. For paired data, Student's t-test for paired samples was performed.

The level of significance used was $p < 0.05$ (s), $p > 0.05$ was not considered significant (ns).

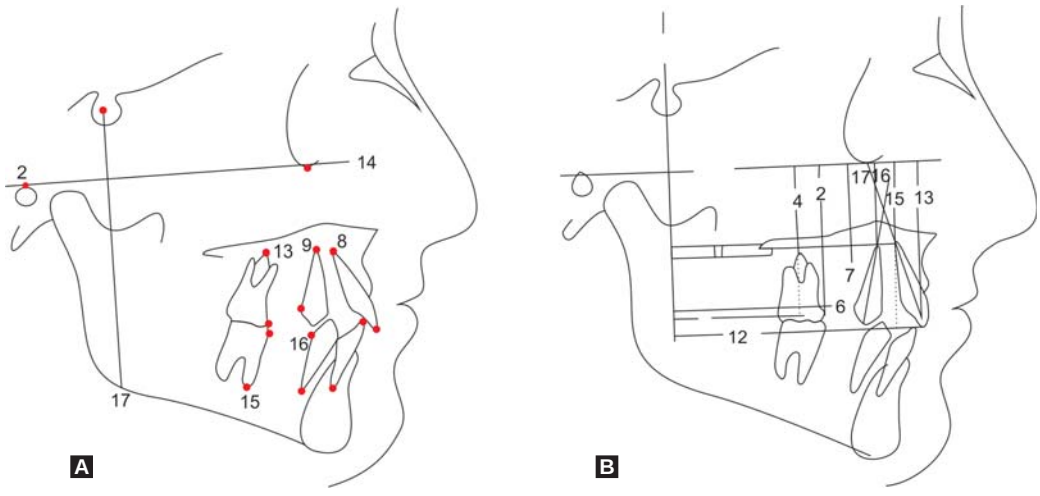
Cephalometric Analysis

Cephalometric radiographs were obtained on all patients before and after canine distalization. All cephalometric radiographs were exposed with standardized settings. Every parameter was measured twice by the same operator, and the mean values were used in the statistical analysis. Cephalometric points and planes were used in the study were advocated by Seher Sayin et al[12] (Figs 5A and B).

Panoramic Radiographic Analysis

Changes in the angulation of canine and first molar were assessed by examining the panoramic radiographs taken before and after distraction.

To analyze the panoramic radiographs, four reference points were determined as described by Ursi et al[13] and two reference planes were formed by using these points.



Figs 5A and B: (A) Cephalometric landmarks, (B) cephalometric planes

Additional planes were constructed by connecting the coronal and apical points of root canals of the canine as advocated by Yusuf Sukurica et al[14] (Fig. 6).

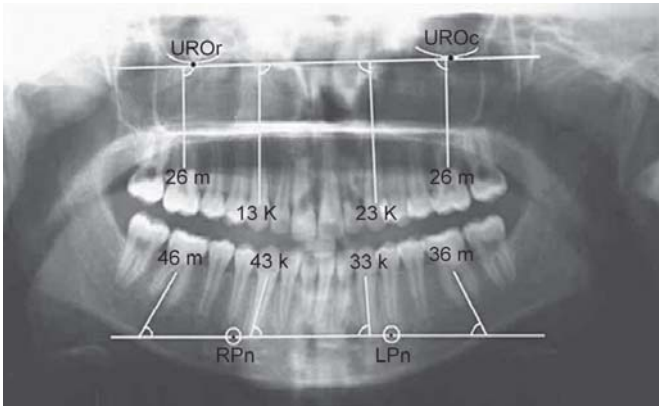


Fig. 6: Landmarks and planes for OPG analysis

Panoramic Radiographic Analysis

The above table depicts that the maxillary canines have tipped distally at an average of 15.1° bilaterally, and the maxillary first molars tipped mesially by an average of 6.1°.

Model Analysis

To evaluate the amount of canine movement and posterior anchorage loss model analysis was done. The movements of the teeth in the anteroposterior direction were assessed by determining the location of maxillary rugae in relation with midpalatine raphe by using two predetermined reference points on the rugae, (Fig. 7) as described by Haas and Cisneros[15] and Hoggan and Sadowsky.[16]

To assess magnification, a millimeter ruler was placed next to each dental cast on the flat bed scanner. This ruler

Cephalometric Evaluation

Table 1: Position of maxillary canine, first molar and central incisor cephalometrically pretreatment and postdistraction

Variable	*Predistraction*		*Postdistraction*		*p-value**
	Mean (mm)	*SD*	*Mean (mm)*	*SD*	
U6M-y	44.60	4.08	45.30	3.78	0.027
U6M-x	42.70	2.10	44.10	2.01	0.013
U6A-y	43.70	3.62	43.20	3.64	0.011
U6A-x	26.20	2.65	27.30	2.30	0.035
U6M-y-U6A-y	0.9	1.38	4.10	1.78	0.004
U3D-y	59.00	5.61	53.40	4.17	0.004
U3D-x	46.40	4.43	47.00	3.90	0.020
U3A-y	61.70	4.32	60.90	4.76	0.001
U3A-x	27.90	4.76	28.80	4.92	0.003
U3D-y- U3A-y	-2.70	3.38	7.50	1.94	0.003
U3/FH	95.60°	8.64	85.40°	5.02	0.025
U1I-y	79.90	4.46	79.30	4.44	0.578
U1I-x	54.90	5.98	55.60	5.22	0.173
U1A-y	63.30	3.64	63.60	4.22	0.324
U1A-x	33.10	3.13	33.40	3.30	0.003
U1I-y-U1A-y	16.80	3.11	15.50	4.02	0.330
U1/FH	129.00°	7.66	126.80°	7.38	0.004

*p < 0.05 significant

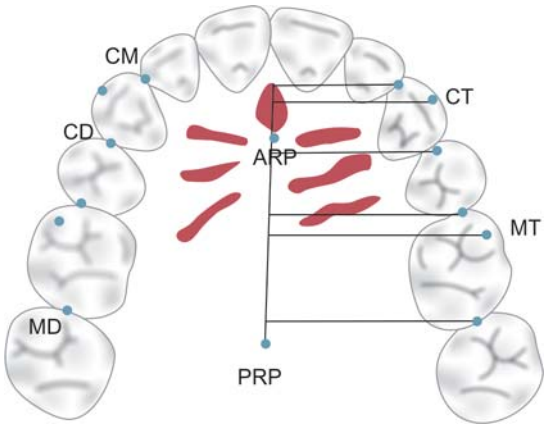


Fig. 7: Landmarks and planes used for model analysis

was scanned and printed with each study cast, compared with the original ruler and magnification was checked.

The above table reveals the position of the canines transversely in relation to the raphal plane. The maxillary canines rotated mesiobucally by an average of 7.8° bilaterally which was statistically significant.

Intraoral Clinical Photographs

Photos were taken before treatment, at weekly intervals during the distraction process, at the end of distraction and 1 month after distraction (Figs 8 to 13).

DISCUSSION

Canine retraction is an integral part of both edgewise and preadjusted edgewise mechanics with lots of stress on anchorage considerations. As these techniques tax the anchorage to the core, its a great disadvantage during the various phases of treatment. The procedure of canine retraction takes about 6 to 8 months and hence any procedure which shortens the overall treatment time is a boon to any orthodontic patient. Therefore, it was decided to shorten the treatment span by 'dental distraction' using the periodontal ligament after minor oral surgical procedure in the extracted premolar socket.

The outcome of this study has been confirmed by the various records of study models, clinical assessment and radiological investigations.

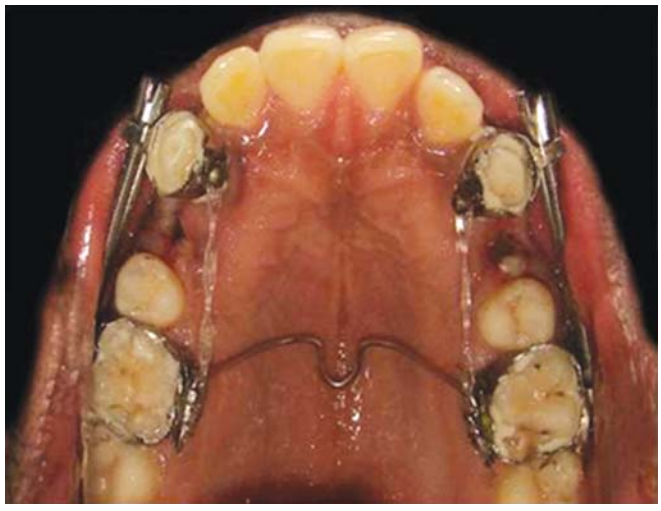


Fig. 9: Pretreatment intraoral—maxillary occlusal

Fig. 10: Pretreatment intraoral—left molar

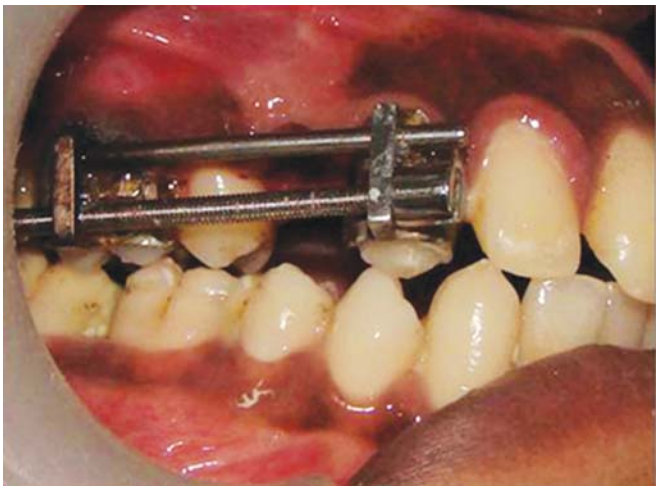


Fig. 8: Pretreatment intraoral—right molar

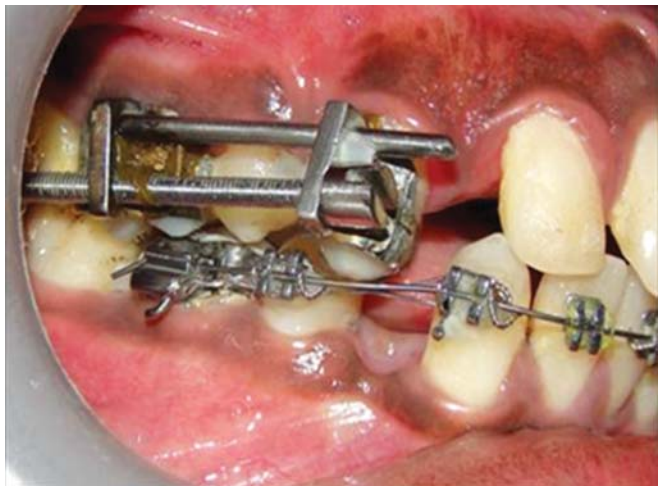


Fig. 11: Post-treatment intraoral—right molar

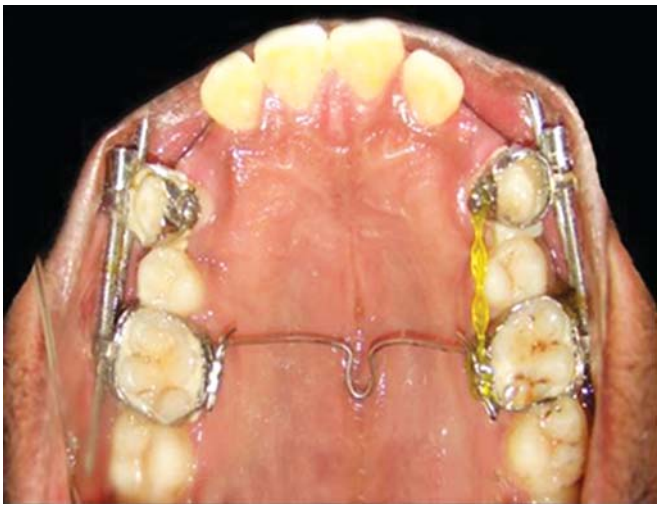


Fig. 12: Post-treatment intraoral—maxillary occlusal

Fig. 13: Post-treatment intraoral—left molar

The maxillary canines were distracted distally by 6.42 mm (p = 0.004) in three and half weeks in our study compared to Liou and Huang[8] maxillary canine distraction of 6.5 mm in 3 weeks time. Seher Sayin[12] found out that the maxillary canines distalized at an average of 5.76 mm in 3 weeks time. Uniformly the distractors were activated 0.2 mm twice daily over a period of 3 weeks.

The maxillary right canine was found to be tipped into the premolar extraction socket by 15.2° (p = 0.001) and maxillary left canine by 15° (p = 0.000) (Table 2). Liou and Huang[8] reported a distal tipping of canines by 17° and Seher Sayin[12] reported it to be 11.4° after a 3 week distraction period. The distance between the distal points and the apex of the canine teeth were increased 4.4 mm (p = 0.009) and 2.6 mm (p = 0.001) respectively (Table 1). In Seher Sayin's[12] investigation the distance was increased by 4.64 mm (p = 0.000) and was found to be statistically significant. Anchorage loss was very negligible and was not statistically significant to warrant discussion.

Table 2: The amount of tipping of the canines and first molars bilaterally

Tooth assessed	*Predistraction*		*Postdistraction*		*p-value**
	Mean	*SD*	*Mean*	*SD*	
13	88.8°	5.93	73.6°	5.17	0.001
23	88.0°	6.364	73.0°	7.93	0.000
16	103.8°	6.261	109.6°	5.85	0.022
26	101.4°	6.835	107.8°	5.97	0.051

*p-value <0.05 significant

Study model analysis revealed that the maxillary canines moved buccally for a short period during the activation and reverted back into the path of distraction and moved distally by 6.2° as measured from the anterior raphe point and the molar inclined mesially by 2.8° (Table 3) The mean distalizing value of the maxillary canines decreased when compared with the Seher Sayin[12] perhaps because of the design of the intraoral distractor, placement of the distractor, time of activation, status of bone remodeling and gingival adaptation tendency.

Liou and Huang[8] stated that 73% of the maxillary molars did not move mesially and the anchorage loss was only 0.1mm in the remaining 27%. Seher Sayin[12] found that the maxillary molars exhibited very minimal mesial molar movement. The extrusion of the maxillary canines and molars were not very statistically significant (p = 0.035) in our study. Liou and Huang[8] did not investigate on the vertical position of the maxillary canines and molars. Seher Sayin[12] found them to be statistically significant (p = 0.04).

The rate of canine distraction whether in the maxilla or in the mandible corresponds to the thickness of the interseptal bone distal to the canine which can be reduced to 1.0 to 1.5 mm without jeopardizing the vitality of the periodontal ligament and the root of the tooth. Our hypothesis was that periodontal ligament is a suture like tissue located between the tooth and the alveolar bone, and therefore can be rapidly stretched in a manner similar to midpalatal suture stretching during rapid palatal expansion (Hass).[17]

Table 3: Evaluation of canine position as assessed on the study models

	Pretreatment	*SD*	*Post-treatment*	*SD*	*p-value**
13MPR	18 mm	1.36	19.9 mm	0.96	0.001
13TPR	20.1 mm	1.08	22.4 mm	1.08	0.009
13DPR	20.3 mm	1.15	21.2 mm	2.28	0.266
13Ip	70.2°	9.01	63.2°	7.12	0.054
23MPR	17.5 mm	1.00	21.2 mm	0.57	0.001
23TPR	19.1 mm	0.41	22.1 mm	1.43	0.017
23DPR	19.8 mm	0.90	21.7 mm	1.52	0.012
23Ip	72°	3.60	63.4°	3.84	0.012

*p-value <0.05 significant

CONCLUSION

The results of this study indicate that the periodontal ligament can be distracted to elicit rapid orthodontic tooth movement. By using this concept, maxillary canines can be rapidly retracted into the first premolar extraction space at the rate of about 2.43 mm per week.

This technique has the potential to significantly reduce orthodontic treatment time. But it is use may be limited to those cases in which canines are reasonably well-positioned within the alveolar ridge, as distraction of labially positioned canines may compromise their thin labial cortical plate and soft tissue attachment. The canines can be distracted rapidly and almost all of extraction space can be used for anterior dental alignment or retraction. After distraction, the anterior tooth retraction can be rapid as well, while the new bone tissues distal to the lateral incisors are still fibrous.

However, the long-term effects of canine distraction are not well known and should be closely monitored. The periodontal health and pulpal status of the distracted teeth and mineralization and maturation of the newly formed bone needs to be assessed on a long-term basis.

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ABOUT THE AUTHORS

KV Sujan Kumar (Corresponding Author)

Senior Lecturer, Department of Orthodontics and Dentofacial Orthopedics, MNR Dental College, Sangareddy, Hyderabad, Andhra Pradesh, India, Phone: +919000539459, e-mail: drsujank@yahoo.co.in, drsujank@gmail.com

K Umashankar

Professor and Postgraduate Guide, Department of Orthodontics and Dentofacial Orthopedics, Saveetha Dental College, Chennai, Tamil Nadu, India

D Pradeep Kumar

Reader, Department of Orthodontics and Dentofacial Orthopedics RVS Dental College, Coimbatore, Tamil Nadu, India

D Praveen Kumar

Associate Professor, Department of Orthodontics and Dentofacial Orthopedics, Vishnu Dental College, Bhimavaram, Andhra Pradesh India