Evaluation of Root Resorption, Pulp Vitality, Canine Retraction and Anchorage loss after Dentoalveolar Distraction: A Radiographic and Model Study

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ABSTRACT

Introduction : Canine retraction through dentoalveolar distraction osteogenesis was introduced to reduce the overall orthodontic treatment period. The amount of canine retraction, root resorption, pulp vitality and anchorage loss after dentoalveolar distraction were evaluated.

Material: The study sample consisted of 20 maxillary canines in 10 adult patients with mean age, 19.53 years. First bicuspids were extracted, the distraction surgical procedure was performed, and a rigid, custom made , intraoral distractor was placed. The cuspids were moved into the extraction sites in 7 to 13 days, at a rate of 1.0 mm per day.

Results :Complete retraction of canines was achieved in a mean time of 9.23 days with minimal anchorage loss. There was insignificant molar intrusion or extrusion with decreased overjet. No radiographic and clinical evidence of complications such as mucosal lacerations, dehiscence of soft tissues, root resorption and periodontal problems were encountered.

Conclusion: There was minimal root resorption , anchorage loss and the distracted canines preserved their pulp vitality at the end of dentoalveolar distraction.

Key words: Dentoalveolar distraction , Canine retraction , Rigid distraction device.

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INTRODUCTION

Distraction osteogenesis [DO] is a process of growing new bone by mechanical stretching of the pre existing bone tissue[1]. It has gained its wide spread recognition in orthopedic surgery as an effective means of bone lengthening, deformity correction and filling large diaphyseal defects.

Most orthodontic patients have some crowding. Although non-extraction treatment has become very popular during the last decade, many patients do need extractions[2]. The first phase of treatment for premolar extraction patients is the distal movement of the canine with conventional orthodontic treatment techniques. Biologic tooth movement can be achieved but the canine retraction phase usually lasts 6 to 8 months. Extraoral or Intraoral anchorage mechanics are required to maintain the extraction space obtained during canine distalization particularly when maximum anchorage is required.

With the present technique of rapid orthodontic canine retraction through distraction osteogenesis by Reha-Kisnisci and Halukiseri[2], the dentoalveolus is itself is designed as a bone transport segment for posterior movement. Vertical osteotomies are performed around the root of the canine teeth followed by splitting of spongy bone around it. Therefore the design of surgical technique itself does not rely on the periodontal stretching which obviates overloading and stress accumulation in this tissue, which was the drawback of the previous attempts of canine distraction through periodontal ligament described by Eric JW Liou, C. Shing Huang[3]. This procedure does not require any extraoral force and has significant clinical application[4,5] . Thus, using distraction osteogenesis technique rapid tooth movement can be achieved[6]. The purpose of the study was to evaluate the amount of canine retraction, root resorption, pulp vitality and anchorage loss after dentoalveolar distraction.

MATERIALS AND METHODS

Twenty maxillary canine distractions of patients were done with a custom made intraoral distractor on the basis of the following selection criteria:

INCLUSION CRITERIA

1. Patients in the age range of 14-23years.
2. Cases which require extraction of the maxillary 1st premolars.
3. Cases that require maximal anchorage .
4. Maximal canine teeth that were reasonably placed within the arch without rotation and without considerable tipping.
5. Patients with periodontally healthy teeth.

EXCLUSION CRITERIA

1. Canines placed in excessive palatoversion and excessive labioversion.
2. Canines with severe rotation and or tipping.
3. Non-vital teeth.
4. Abnormal curvature of the canine roots.
5. Poor oral hygiene and periodontally weak teeth.
6. Any systemic illnessess contradicting local anaesthesia and treatment.
7. Poor internal motivation.

Ten adult patients, 5 females and 5 males in the age range 14-23 years(mean age,19.53years) scheduled for orthodontic treatment with first bicuspid extractions and subsequent canine distalization were selected for the study and they underwent distraction osteogenesis procedure.

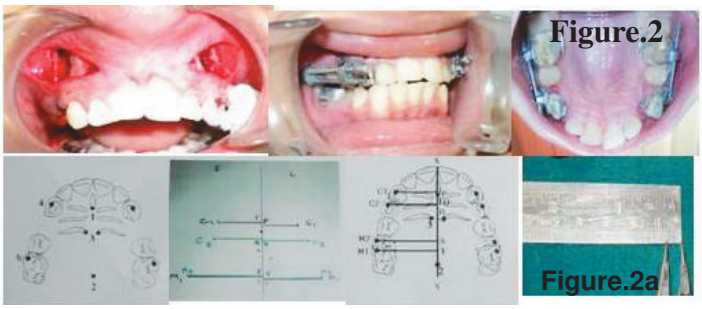
The canine distractor used in the study was a custom made, rigid, intraoral, tooth borne device. The bands were first fabricated for the canine and 1st molar . Then impression was taken with

Alginate. The bands were transferred into the impression and models of die stone were made. The distractor with appropriate length was soldered to the bands directly. (Fig.1)

Since the distractor was unilateral, a 360 degree activation of the screw in a clockwise direction with the screw wrench produced 1.0mm of distal movement of canine tooth.

SURGICAL PROCEDURE

The transport dentoalveolar segment includes the buccal cortex and the underlying spongy bone that envelopes the canine root, leaving an intact apical, palatal cortical plate.The wound was

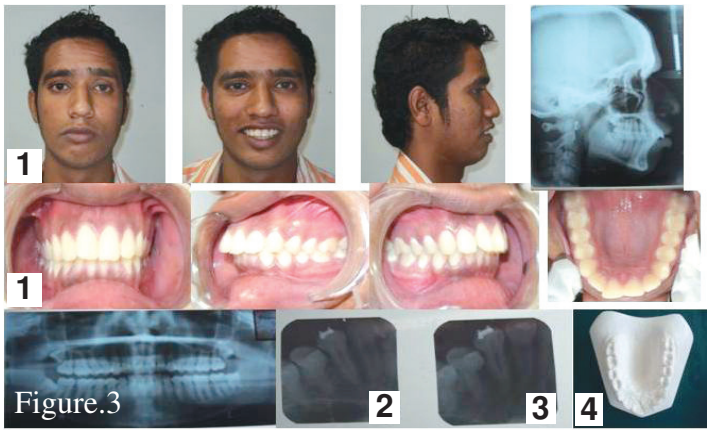


irrigated with saline and closed in a single mucosal layer with 3-0 catgut suture. The distraction device was fitted and cemented to the first molar and canine teeth at the end of the surgical procedure. (Fig.2)

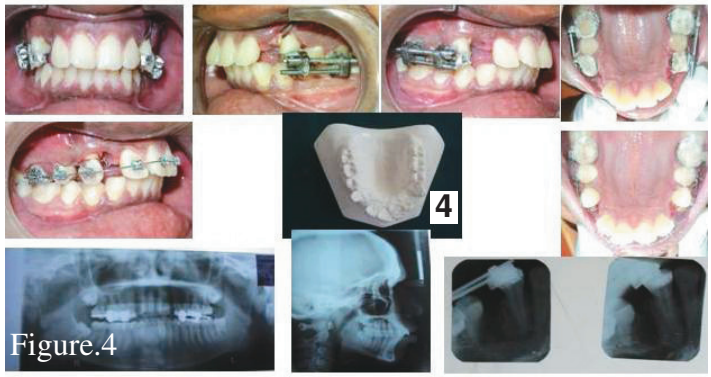
The patient was prescribed antibodies and non-steroidal anti-inflammatory drugs for 5 days. Dentoalveolar distraction was started on the day of surgery and continued at a rate of 0.5mm twice a day. It was discontinued when the canine tooth moved posteriorly into the desired position.

DISTRACTION PROTOCOL

1. Corticotomy cuts done
2. No latency period
3. Rate of distraction- 1.0mm a day
4. Rhythm of distraction- twice a day
5. Distraction period was discontinued when canine tooth moved posteriorly into the desired position.The distracted dentoalveolar segment after distraction was kept for 3 months of consolidation period till the radiographic evidence of bony regenerate was confirmed. Later orthodontic therapy was carried out with the fixed appliances. During activation phase and after the completion of activation phase, as well as during early consolidation period and late consolidation periods, the following records were obtained for each patient:



1. *Standard photographs [extraoral and intraoral]*
2. *Periapical radiographs of the maxillary canines.*
3. *Periapical radiographs of the maxillary first molars.*
4. *Study models were made only during pre and post distraction periods. (Fig. 3 and Fig.4)*



The time taken for space closure i.e retraction of canines into the extraction socket were calculated. (Fig. 2a, Table 1).Patients were assessed periodically during and after distraction phase for bone changes [radiographically]. [Table 2]. After the removal of the distraction appliance the patients were assessed radiologically for root resorption [using IOPAs](Fig.4,Table 3) and for pulp vitality with an Electronic pulp vitality tester.(Table 6).

STUDY MODEL ANALYSIS

Pre-distraction and post-distraction study models were analysed and compared to evaluate the following

1. Amount of canine retraction
2. Amount of anchorage loss

Landmarks on the study casts:

The following landmarks were identified and marked in the pre-distraction and post-distraction maxillary dental casts.(Fig. 2a)

TABLE -1

TIME TAKEN FOR SPACE CLOSURE

PATIENT NO.	TOOTH	POST-OP DAY	ACTIVATION DAY	CLOSURE OF SPACE
1	13	10	9	COMPLETE
	23	10	10	COMPLETE
2	13	11	11	COMPLETE
	23	14	13	COMPLETE
3	13	9	9	COMPLETE
	23	9	9	COMPLETE
4	13	10	10	COMPLETE
	23	10	10	COMPLETE
5	13	9	9	COMPLETE
	23	9	9	COMPLETE

TABLE 2

BONE FORMATION PATTERNS

PATIENT NO.	TOOTH	FIRST EVIDENCE OF TRABECULAR BONE FORMATION					COMPLETION OF BONE FORMATION	
		2WKS	4WKS	6WKS	8WKS	12WKS	2MON	3MON
1	13	_	✓					✓
	23	_	✓					✓
2	13	_	✓					✓
	23	_	✓					✓
3	13	_	✓					✓
	23	_	✓					✓
4	13	_	✓					✓
	23	_	✓					✓
5	13	_	✓					✓
	23	_	✓					✓

TABLE 3

ASSESSMENT FOR EXTERNAL ROOT RESORPTION

(3 MONTHS POST DISTRACTION PERIOD)

Patient No.	Tooth	Apical resorption				Lateral resorption				Other Periapical Abnormalities
		0	1	2	3	0	1	2	3	
1	13	✓				✓				_
	23	✓				✓				_
2	13	✓				✓				_
	23	✓				✓				_
3	13	✓				✓				_
	23	✓				✓				_
4	13	✓				✓				_
	23	✓				✓				_
5	13	✓				✓				_
	23	✓				✓				_

1. ANTERIOR RAPHE POINT- The most discernable anterior point on the midpalatal raphe.
2. POSTERIOR RAPHE POINT- The most discernable posterior point on the midpalatal raphe.
3. RUGAE POINT - The most medial point of the most distinct right on the left rugae.
4. CANINE CUSP TIP- Tip of the maxillary right/left permanent canine.
5. MOLAR MESIOBUCCAL CUSP TIP - Tip of mesiobuccal cusp of the maxillary right or left permanent 1st molar.

MEASURING PROCEDURE

1. Photocopies of the predistraction and post distraction study models for all the patients were done on the same standard machine with 1-1 duplication by the same investigator.
2. The photocopies of the pre-distraction and post-distraction study casts were superimposed on OHP sheet.
3. The mid-palatal raphe was constructed by joining the anterior and posterior raphe points and used as reference line for measurement.
4. Using the constructed mid-palatal raphe as the reference plane and the rugae points as reference points proper superimposition was made.
5. Then Perpendiculars were dropped on the median line [MIDPALATAL RAPHE PLANE] from the cusp tip of the maxillary permanent canine(C1-Pre-distraction, C2-Post-Distraction) and the rugae point (R), the mesiobuccal cusp tips of the maxillary 1st molar (M1-Pre-distraction, M2-Post-distraction) (Fig.2a)

DETERMINATION OF THE AMOUNT OF CANINE RETRACTION (Fig. 2a)

1. Canine retraction= Amount of movement of Canine from C1(Pre-distraction) to C2 (Post-distraction)
2. Distance measured between P and Q on the mid-palatal raphe plane.
3. Canine retraction = the linear distance PQ
4. This difference was evaluated as the amount of space closure or the amount of canine retraction.
5. Each measurement was done twice and the mean of the two

TABLE 4

AMOUNT OF CANINE RETRACTION

PATIENT NO.	TOOTH	AMOUNT OF RETRACTION IN MM
1	13	7
	23	8
2	13	7
	23	8
3	13	7
	23	7
4	13	7
	23	7
5	13	8
	23	7

values was recorded (Table 4)

DETERMINATION OF LOSS OF ANCHORAGE

1. The change in the anteroposterior positions of the maxillary permanent 1st molar (Anchor loss) were measured from the study cast analysis.
2. The linear distance moved by the mesiodistal cusp tip of the maxillary 1st molar from M1 (Pre-distraction) position to M2(Post-distraction) will give the amount of anchorage loss.(Fig. 2a)
3. Each measurement was made twice and the mean of the values were recorded.(Table 5)

TABLE 5

AMOUNT OF ANCHORAGE LOSS

Patient no.	Tooth	Anchorage loss in mm
1	16	0.3
	26	0.2
2	16	0.1
	26	0.1
3	16	0.3
	26	0.1
4	16	0.3
	26	0.1
5	16	0.1
	26	0.2

ANCHORAGE LOSS[AL]

AL= Amount of movement of tooth from MI (Pre-distraction) to M2(Post-distraction).Distance is measured between S and T on the midpalatal raphe plane.AL= the linear distance ST is the formula which gives the amount of anchorage loss in the 1st molars.(Fig.2a)and (Table 5)

RESULTS

The results were evaluated based upon clinical, radiographic, and study model analysis findings.

IMMEDIATE POST OPERATIVE COMPLICATIONS

1. All patients reported no pain, but some reported slight discomfort when the distraction device was activated. The discomfort lasted for few seconds only.
2. Till third post-operative day there was pain and swelling over the surgical site in all the patients which were treated by medications that subsequently resolved by one week post-operatively.
3. During early post-operative period there was tenderness over the premolar -molar regions.
4. All patients experienced injury in the cheek due to impingement of distal end of distractor's screw which was resolved by cutting the appropriate length of the screw end.

ROOT RESORPTION

1. Bone formation was assessed radiographically, IOPA was considered to be the golden standard and thus bone formation was assessed by means of IOPA alone.
2. All patients showed first evidence of trabecular bone formation during 4th week of consolidation period and the completion of normal mature radio-opaque bone formation occurred by about 3 months of post-activation period.(Table 3).
3. There was no evidence of external root resorption or tooth ankylosis formation after distraction device removal and alveolar bone levels around the canine root were normal.
4. There was no loss of lamina dura and the periodontal ligament space was maintained in all patients at the end of 3 months post-activation period when the distraction device was removed.
5. No other periapical abnormalities were present.
6. Apical and lateral root resorption were assessed by the root resorption scale modified from Sharpe et al, as follows.

APICAL ROOT RESORPTION

0= no apical root resorption.
1=widening of the periodontal ligament (PDL) space at the root apex.
2=moderate blunting of the root apex (upto one third of the root length).
4=severe blunting of the root apex.(beyond one third of the root length),(Table 3).

LATERAL ROOT RESORPTION

0= smooth lateral root surface and periodontal ligament
1=slightly irregular lateral root surface, not beyond one third of the dentine width between the distal side periodontal ligament and pulp chamber
2=moderate irregular lateral roots surface beyond one third and up to two thirds of the dentine width between the dis tal side periodontal ligament and pulp chamber.
3=excessive irregularity of the lateral root surface beyond two thirds of the dentine width between the distal side peri odonatal ligament and pulp chamber.(Table 3)

AMOUNT OF CANINE RETRACTION

Canines were retracted with a minimum of 7mm and maximum of 8mm (average =7.29mm) range.(Table 4).

ANCHORAGE LOSS

Anchorage loss was very minimal with maximum of 0.3mm and minimum of 0.1mm(average =0.14mm)(Table 5).

PULP VITALITY

Pulp vitality test of those distracted canines and the lateral incisors and second premolars beside the distracted canines were recorded with an electronic pulp tester. They were tested before treatment and they proved to be vital after the removal of the distractor by the end of 3 month post distraction period. (Table 6)

DISCUSSION

Orthodontic tooth movement is a process whereby the application of a force induces bone resorption on the pressure side and bone apposition on the tension side. Classically, the rate of orthodontic tooth movement depends on the magnitude and dura-

TABLE 6

PULP VITALITY

Patient no.	Tooth no.	Pulp vitality pre-distraction	Pulp vitality 3 months post-distraction
1	13	✓	✓
	23	✓	✓
2	13	✓	✓
	23	✓	✓
3	13	✓	✓
	23	✓	✓
4	13	✓	✓
	23	✓	✓
5	13	✓	✓
	23	✓	✓

tion of the force, the number and shape of the roots, the quality of the bony trabecula, the patient's response and compliance. The rate of biologic tooth movement with optimum mechanical force is approximately 1 to 1.5 mm in 4 to 5 weeks. Therefore, in maximum anchorage premolar extraction cases, canine distalization usually takes 6 to 9 months, contributing to an overall treatment time of 1.5 to 2 years. The duration of orthodontic treatment is one of the issues patients complain about most, especially adult patients[7].

MINIMAL ANCHORAGE LOSS

The amount of anchorage loss in 1st molars was 0.16 mm on an average. So this technique of dentoalveolar distraction osteogenesis can be a breakthrough for orthodontic treatment in adults where anchorage requirements are critical. Angle stated "the resistance of the anchorage must be greater than that offered by the teeth to be moved; otherwise, there will be a displacement of the anchorage and failure in the movement of teeth in the desired direction." Liou and Huang et. al in their study found 0.5mm or less than 0.5mm of anchorage loss during rapid canine retraction.

After the initial tooth movement by a light or heavy orthodontic force, a lag period of minimal tooth movement persists for approximately 2 to 3 weeks before tooth movement again proceeds. In this study, the canine distraction was completed while the first molar was still in its lag period or just initiating its mesial movement[8].

The initial obstacle to orthodontic tooth movement is the necessary elimination of the necrotic (hyalinizing) tissues by the undermining resorption. The elimination of the hyalinizing tissues takes 2 to 3 weeks, which is the lag period[8].

Any technique that takes longer than 3 weeks to retract a canine will result in loss of anchorage. Because not only the canine but also anchor unit will move to each other after the lag period. The average time of a canine retraction takes 4 to 6 months according to the anchorage needs. However, the anchor, unit also will move forward accordingly (loss of anchorage). The best way to avoid losing anchorage is to move the canine before the anchor unit moves[3,4].

MINIMAL ROOT RESORPTION

There was no external root resorption or tooth ankylosis occurrence in our study. External root resorption is initiated 2 to 3 weeks after the orthodontic force is applied and may continue for the duration of force application. In this study, the canine distraction was completed within 3 weeks while the root resorption was just initiating.

It is generally accepted that a certain degree of root resorption will occur in patients undergoing orthodontic treatment and a variety of conditions may be related to the root resorption. An association between the increased root resorption and the duration of the applied forces has been reported. The duration of the applied force is an aggravating factor for the root resorption and it is regarded as a more critical factor than the magnitude of force ,especially in connection with long treatment periods. The best way to minimize the root resolution induced by orthodontic tooth movement is to complete the tooth movement in a short duration or even before initiation of root resorption[9].

RAPID CANINE DISTRACTION

The orthodontic tooth movement is faster and root surface resorption is less in an alveolar bone with loose bone trabeculae and less bone resistance. In this study, the canine was distracted into an extraction socket that has not been refilled by solid bone tissue.

After tooth extraction, regenerative bone tissue will refill the extraction socket in 3 weeks and become resistant and solid in 3 months. If the canine is not retracted across the first premolar extraction socket in the first 3 weeks, the rate of tooth movement will slow down, root surface resorption will increase, and the anchor unit will start to move forward.Before the extraction socket becomes resistant and solid, especially in the first 3 weeks after the first premolar tooth extraction, the canine tooth should be distracted[7,8].

The mean distraction time was 7.4 days and the distraction procedure was completed in 9 to 14 days. This is the most rapid movement of a tooth demonstrated in the literature.

PULP VITALITY

Although no meaningful findings were achieved with the electronic pulp tester, we will think that the distracted canines preserved their pulp vitality at the end of dentoalveolar distraction. Moreover, no color change was observed in any teeth during the observation period of the study. Block et al demonstrated that the blood vessels regenerate a short time after distraction. Findings of our study indicate that the distal movement of the canines is a combination of tipping and translation. This means that the crown moves more than the root apex, and similar to the neurovascular bundle in distraction, the pulp tissues of the teeth will remain vital under controlled rapid stretching. Therefore, observed tipping of the canines might be an advantage with regard to pulp vitality during rapid tooth movement with DAD.

CONCLUSION

Distraction osteogenesis for rapid orthodontic tooth move-

ment is a promising technique. With DAD, canines can be retracted in 9 to 14 days. Canines were retracted 7-8 mm (7.4 mm on an average) over a period of 9 - 14 days with an anchorage loss of 0.1 - 0.3 mm (0.16 mm on an average) in first molars.

1. The following older adolescent and adult patients could benefit from the technique: those with compliance problems, those with moderate or severe crowding; those with Class 2 malocclusions with increased overjet; those with bimaxillary dental protrusion; orthognathic surgery patients who need dental decompensation; and those with small root shape malformations, short roots, periodontal problems, or ankylosed teeth[2,3].
2. With the DAD technique, anchorage teeth can withstand the retraction forces with no anchorage loss and without clinical or radiographic evidence of complications, such as root fracture, root resorption, ankylosis, periodontal problems, and soft tissue dehiscence[3-5] .
3. The DAD technique reduces orthodontic treatment duration by 6 to 9 months in patients who need extraction, with no need for extraoral or intraoral anchorage devices and with not unfavorable short - term effects in the periodontal tissues and surrounding structures[3-5].
4. Properly designed custom made intraoral tooth borne distraction device can be very useful for achieving rapid retraction of the canines by means of the distraction osteogenesis technique [transport disc phenomenon] as described in this technique.

REFERENCES

1. Seher Sayn, Osman Bengi, Umit Gurton, Kerim Ortakolu. Rapid canine distalization using distraction of the periodontal ligament. A preliminary clinical validation of the original tec hnique. The Angle Orthodontist. 2004; 74(3): 304-315.

2. Haluk iseri, Reha kisnisci, Nurettin Bzizi, and Hakan Tuz Rapid canine retraction and orthodontic treatment with den toaiveolar distraction osteogenesis. Am J Orthod Dentofacial Orthop 2005; 127: 533-541.

3. Liou JW Eric, Shing Huang. Rapid canine retraction through distraction of the periodontal ligament. American Journal of orthod and Dentofacial Orthop 1998.

4. John E-BHodeau. Dental Distraction for an adult patient- case report. American Journal Orthod Dentofacial Orthop 2003.

5. John E-Bilodeau Non surgical treatment with Rapid mandibular canine retraction through periodontal ligament distraction in an adult patient with a class III malocclusion. American Journal Orthod Dentofaciai Orthop. 2005;128:388- 396.

6. Eric Jein - Wein Liou, Alvaro Figueroa, John Policy. Rapid orthodontic tooth movement into newly distracted bone after mandibular distraction osteogenesis in a canine modei. Araerican Journal Orthod Dentofacial Orthop. 2000;117:391-398.

7. Jason B. Cope, Mikhail L. Samchukov Regenerate Bone Formation and Remodeling During Mandibular Osteodistraction Angle Orthod 2000; 70:99-111.

8. Keles A, Sayinsu K A new approach in maxillary molar distal ization: Intraoral bodily molar distalizer Am J Orthod Dentofacial Orthop 2000; 117: 39- 48.

9. Seher Sayn, Osman Bengi, Umit Gurton, Kerim Ortakolu. Rapid canine distalization using distraction of the periodontal ligament. A preliminary clinical validation of the original tech nique. The Angle Orthodontist. 2004; 74(3): 304-315.

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