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Original Research

Dento-Alveolar distraction osteogenesis using rigid intra-oral tooth borne distraction device

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Abstract:

Background: The aim of this clinical prospective study is to apply and evaluate an approach to reduce the overall orthodontic treatment time, by means of dentoalveolar distraction osteogenesis to achieve rapid canine retraction using an indigenously developed intra-oral tooth-borne distraction device.

Materials & Methods: This study was carried out in the Department of Orthodontics and Dentofacial Orthopedics. Four patients selected for the purpose of Maxillary and/or Mandibular canine distraction with a rigid custom-made, intra-oral distraction device made of stainless steel and were scheduled for orthodontic treatment with bilateral first premolar extraction and then subsequent bilateral canine teeth distalization.

Results: In all the patients the canine teeth moved distally and made contact with the second premolars within 14-16 days range after which they were kept passive, with the appliance for a week of consolidation. The amount of canine retraction was in 7-7.5mms range, in all the patients, in each of the four quadrants studied. Bodily movement, tipping and buccal flaring of the canine teeth were noticed in all the cases.

Conclusion: Combination of newer orthodontic appliances and the principles of biomechanics to maintain the control over rapid tooth movement, rapid canine distalization using distraction osteogenesis awaits further development before routine application, of this innovative and exciting approach.

Key Words: Corticotomy, distraction osteogenesis, orthodontic appliances, premolar extraction distalization

Introduction

Distraction osteogenesis has gained widespread recognition in orthopedic surgery as an effective means of bone lengthening, deformity correction and filling large diaphyseal defects. Recently distraction osteogenesis has been extensively applied to the craniofacial complex and is becoming a viable treatment option in the correction of craniofacial deformities.[1]

Initially external devices were used for distraction osteogenesis. Later intra-oral appliances came into existence and has been used for lengthening, widening and augmentation to correct several skeletal problems.[2,3] These intra-oral devices can be tooth-borne, bone-borne or both and has gained popularity as it is much simpler and more patient acceptable.[4] Osteodistraction of the mandibular symphysisusin uses principles of rapid palatal expansion by a custom-made intraoral Hyrax appliance. This lengthening of the human mandible by distraction was successful using a miniaturized Hoffman device.[5,6] Ever since distraction osteogenesis has undergone various metamorphosis in its design and it indicates to an extent where it can replace other modalities of reconstruction techniques.

A recent innovative use of distraction osteogenesis technique in the field of orthodontic tooth movement is the application of the principle of distraction to move individual tooth segments rapidly thus reducing orthodontic treatment time. The rate of osteogenesis during tooth retraction, limits the tooth movement to a maximum of 1mm to 1.5mm per month. Conventional orthodontic mechanics achieve space closure at the rate of 1mm per month. Canine retraction is a slow process and is heavy on anchorage requirement. It takes 6 to 8 months just to retract the canine into the premolar extraction site. A novel method of reducing the time and the anchorage demands during canine movement is employing the principles of distraction osteogenesis. With the present technique of rapid orthodontic canine retraction through distraction osteogenesis by Reha-Kisnici and Haluk-Iseri,[7] the dentoalveolus itself is designed as a bone transport segment for posterior movement. Vertical osteotomies were performed around the root of the canine teeth, followed by splitting of the bone around it. Therefore the design of surgical technique itself does not rely on periodontal stretching, which obviates overloading and stress accumulation in this tissue, which was the drawback of the previous attempts of canine distraction through the periodontal ligament.

Figure 1: Pre-Fabricated Components of Distraction Device.

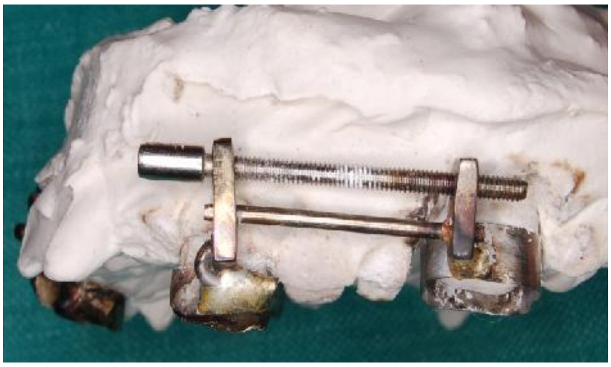


Figure 2: Soldered Distraction Device.

The study objectives included evaluation of

1. Amount of canine retraction.
2. Time taken for canine distraction.
3. Vitality of canine after distraction.
4. Any adverse effect on the roots of the lateral incisor, canine, second premolar and first molar.
5. Bone changes in relation to roots of lateral incisor, canine, second premolar and first molar.
6. Gingival changes in relation to lateral incisor, canine, second premolar and first molar.

Materials and Methods

This study was carried out in the Department of Orthodontics and Dentofacial Orthopedics. Four patients in the age group of 20-29 years who required bilateral extraction of the Maxillary and/or Mandibular 1st premolars wherein the canine teeth were reasonably placed within the arch without rotation and without considerable tipping were selected. Prior to surgery, the entire procedure was explained to all the patients and a written consent was taken.

Evaluation of the Patients

All patients had routine case history work-ups, clinical examination based on a standard proforma. Routine pre-treatment records including standard photographs(extra oral and intra oral), study models, panoramic radiograph (Figure 1) and lateral cephalogram were obtained from each of the patients. The following pre-distraction records were also obtained from each patient:

1. Intra-oral Periapical radiographs of the Maxillary and/or Mandibular lateral incisors, canines, second premolars and first molars.
2. Maxillary and/or Mandibular occlusal view radiographs prior to distraction.

The patients were admitted as in-patients prior to surgery. Routine blood investigations, chest X-Ray were done. They were also examined foranesthetic fitness. In the patients, the surgical procedure was done bilaterally at the same time under sedation.

An intra oral custom made tooth borne distraction device was used for each of the patients.

Design of the distraction device

The individual canine distractor used in this study was a custom made, rigid, stainless steel, tooth borne device. (Figure 2) The bands were first fabricated for the canine and first molar. An impression was made with an irreversible hydrocolloid (alginate). The bands were transferred into the impression and working models were made. The distraction device was soldered on to the buccal surfaces of the canine and molar bands. The distraction device, made of stainless steel, consisted of an anterior segment, which consisted of a retention arm for the canine tube, with two non grooved slots, the larger one for the screw and the smaller one for the sliding (balancing) rod.

A posterior segment included a retention arm for the molar tube and a similar larger non-grooved slot for the distal part of the screw and the smaller slot to which the sliding rod is soldered. The length of the screw was adjusted according to the distance between the two retention arms soldered to the canine and the molar tube. The anterior segment of the sliding rod slides through the anterior retention arm during the activation of the screw. (Figure 3) An activation of 360 degree of the screw in the clockwise direction, with the screw wrench produced a 0.4mm of distal movement of the canine tooth.

Figure 3: Incision.

The distraction devices provide access for device placement, and ease of device activation. It caused minimum discomfort to the patient and thereby having the patients co-operation during each stage of the treatment.

Surgical Procedure

All patients underwent the same surgical procedures and were operated under local anesthesia. A horizontal mucosal incision 3cm long was made parallel to the gingival margin of the canine and bicuspid teeth well above the depth of the vestibule. (Figure 4) Subperiosteal elevation was done around the canine. The 1st premolar teeth were extracted along with the buccal cortex attached to it using forceps. All around the canine teeth multiple cortical holes were made using a tungsten carbide bur. Fine osteotomes in appropriate sizes were used along the anterior aspect of the dentoalveolar segment that includes the canine tooth to split the surrounding bone around its root off the lingual cortex and the neighboring teeth. (Figure 5a, 5b) Minimal force was necessary for full mobilization of the transport bone disc. The distraction device was inserted and it's engagement was checked, then the appliance was activated and the movement of the transport disc segment was noticed. (Figure 6) The transport disc segment consisted of the canine buccal cortex, and the underlying spongy bone, that envelops the canine root, leaving intact, the lingual or palatal cortical plate, and the bone around the apex of the canine. Wound was closed with a single mucosal layer using absorbable sutures.

Figure 5a: Corticotomy.

Figure 5b: Mandibular Corticotomy.

Figure 6: Device Fit Checked.

Distraction Protocol

Distraction started within three days and the rate of distraction was 0.8mm per day, and the screw was turned 360° clockwise twice a day. Distraction period was discontinued once the canine tooth moved posteriorly into the desired position. The distracted dento alveolar segment with the distraction device was kept passive after distraction stage for 1 week of consolidation period, and the orthodontic therapy was carried out using the fixed appliances. (Figure 7, 8 & 9)

Patients were evaluated clinically for immediate post-operative complications, the time taken for space closure, time taken for the retraction of canines into the extraction socket was calculated.


Figure 7: During Distraction.


Figure 8: Fixed Appliance.

Patients were assessed periodically during and after distraction phase for gingival changes (clinically) and for bone changes (radiographically). The problems encountered, due to the distraction device were assessed during various periods of the distraction phase.

Results

One of the patients reported pain, and two patients reported some discomfort due to the bulkiness of the distraction device. Buccal mucosal ulceration was seen in one of the patients.

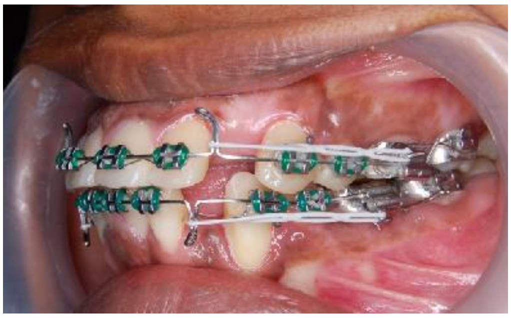


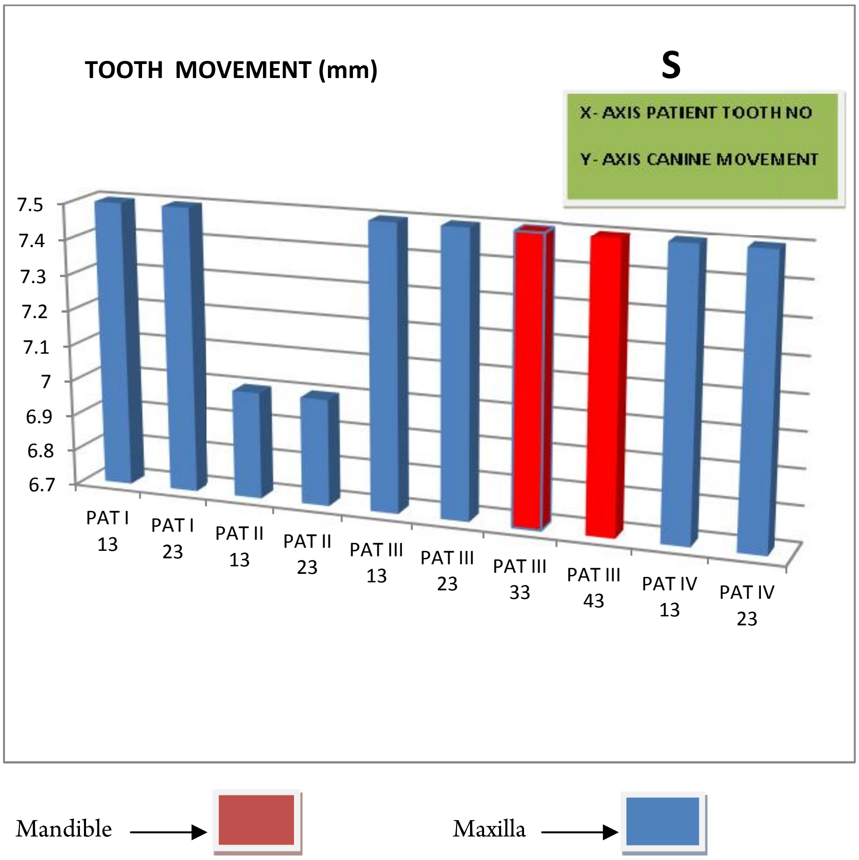
Figure 9: Retraction.

The results were evaluated based on clinical and radiographic findings. (Table 1, Graph 1, Graph 2)

- In all the patients the canine teeth moved distally and made contact with the second premolars within 14-16 days range after which they were kept passive, with the appliance for a week of consolidation. The amount of canine retraction was in the range of 7-7.5mm in all the patients in each of the four quadrants studied. Bodily movement, tipping and buccal flaring of the canine teeth were noticed in all the cases.
- Pain and swelling was present over the surgical site in all the patients, which subsided within the third post operative day, and resolved completely, within one week of surgery and were treated only with routine medication (antibiotics and analgesics). No other post operative complications were seen with respect to the surgical procedure.
- During latency and activation periods, some pain was experienced as the cheeks were stretched by the appliance, but they recovered from pain, as the soft

Table 1: Amount of Canine Retraction and Time Taken for Space Closure.

Patient No.	Tooth	Movement (mm)	Time Duration for Canine Distraction	
			Activation (Days)	Post-Operative Day
1	13	7.5	15	19
	23	7.5	15	19
2	13	7	15	19
	23	7	15	19
3	13	7.5	14	18
	23	7.5	14	18
	33	7.5	15	19
	43	7.5	15	19
4	13	7.5	14	18
	23	7.5	14	18



Graph 1: Amount of Tooth Movement (in mm).

tissues got accustomed during the consolidation period.

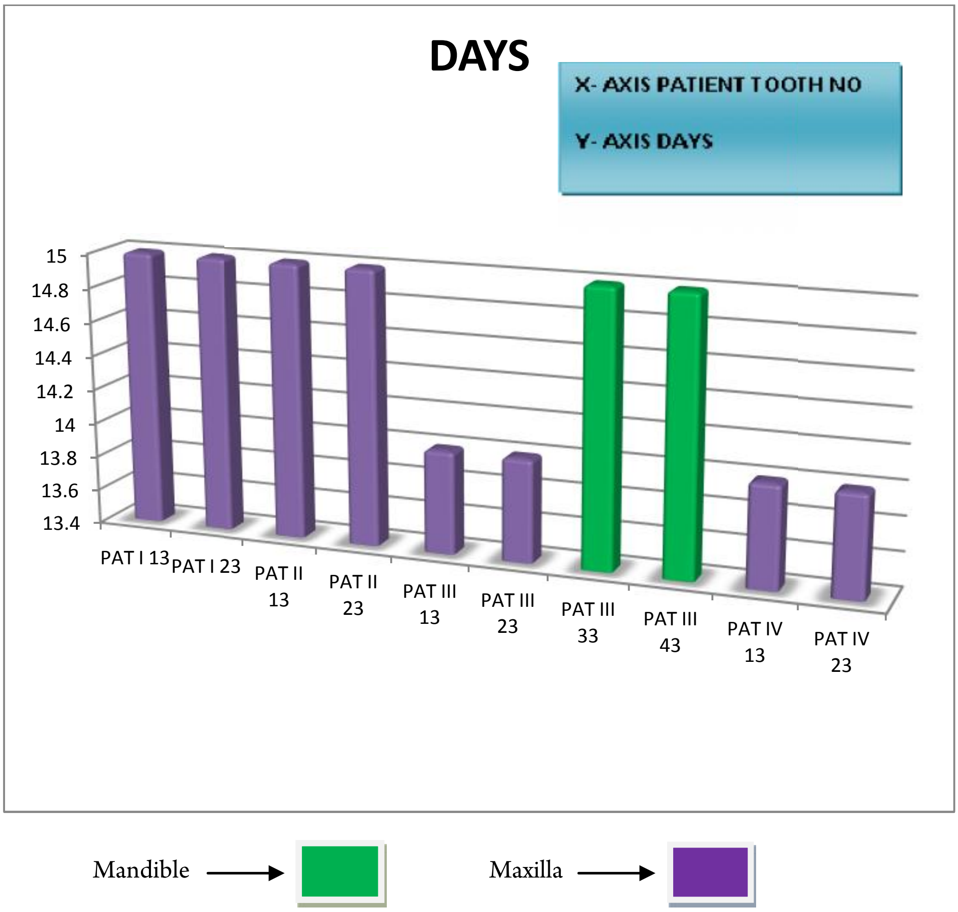
- Minor complaints of unaesthetic appearance and speech alterations during latency and activation period, got resolved during consolidation.
- Patients did not have any difficulty in mastication, swallowing and maintaining oral hygiene. There was normal healthy gingiva around all the teeth, after rapid canine distalization and the removal of the distraction device.
- No periodontal pockets were seen in relation to the teeth before and after the conclusion of distraction and the removal of the distraction device.
- There was no evidence of external bone resorption and, alveolar bone levels around the teeth were, normal. There was no loss of lamina dura and, the periodontal ligament space was maintained, in all the patients. No other periapical abnormalities were noticed after, removal of the distractors.

Discussion

Orthodontic tooth movement is a process in which a mechanical force is applied to induce alveolar bone resorption on the pressure side and alveolar bone deposition on the tension side.[1] Using conventional techniques biological tooth movement can be achieved at a limited rate.[8] During conventional orthodontic tooth movement, hyalinization as a result of pressure, results in permanent damage and plays a major role as a rate limiting factor, in the treatment. Also during retraction of canines, the maintenance of posterior tooth position has always been a major concern for the orthodontist, mainly in those cases, in which maximum anchorage is needed. In our clinical study the aim was to, reduce the overall orthodontic treatment time using, transport distraction osteogenesis, and also to avoid the limitations of conventional orthodontic treatment.[9]

The Dento-alveolus canine tooth with surrounding buccal cortex, and the spongy bone was designed as a bone transport segment for posterior movement. Only corticotomy of the buccal cortex was performed, keeping the lingual cortical shelves intact, which acted as a guide for the movement of the dentoalveolar segment.[10]

Various designs of intra-oral distraction devices, have been used by many researchers. In our study we used a rigid



Graph 2: taken for Canine Retraction.

intra-oral, tooth borne, custom made, distraction device made of stainless steel.[11-13] The theoretical foundation of our study was laid by Lioui and Huang[13] who presented a new method of rapid canine retraction after extraction of the first premolar through weakening of the interseptal bone distal to canine, and distracting the periodontal ligament, using a custom made intra-oral distraction device.[14-16]

Although introduced by Liou and Huang[1], rapid canine distalization was tried out by other researchers. Reha Kisnisci[17] used a custom made intra-oral distraction device for rapid canine retraction, a similar surgical concept was followed in our study. Vertical corticotomies were performed, all around the root and crown of the canine teeth, followed by splitting of the spongy bone around it. Therefore the surgical technique design does not rely on periodontal stretching which obviates overloading and stress, accumulation in these tissues.

The technique of distraction through the periodontal ligament, as described by Liou and Huang[1] had some shortcomings like the decreased vascular blood supply, which occurred, when the magnitude of tensile force is extended, resulting in cell death within the vicinity of the stretched periodontal fibers. Thus the technique followed by us overcomes the limitations of the periodontal ligament distraction technique.

In this study, clinically adequate retraction of canines, posteriorly to contact the second pre-molars was achieved in 14-16 days. Teeth moved along the arch, and it's alignment with other teeth were maintained. The buccal cortical plate and interseptal bone distal to canine was brought into the extraction socket, closely followed by canine retraction which eventually contacted the interseptal bone mesial to the second premolar.

Distalized canines upto 6.5mm over 3 weeks. In the present study, we have achieved canine retraction of around (7mm- 7.5 mm) in all the cases, in a period ranging from 14-16 days. We have achieved adequate retraction of canines compared to the earlier technique in a shorter period of time, as the surgical technique, does not rely on periodontal stretching, as described by Reha S. Kisnisci.17

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 the tooth movement proceeds again. Any technique that takes longer than 3 weeks to retract a canine, would result in loss of anchorage as not only the canine, but also the anchor unit will more towards each other after the lag period.[1]

Bodily movements of canines were noticed in all the cases, with a minimal amount of tipping. Less amount of tipping indicates that more amount of bodily movement has occurred. The probable reason for tipping could be the osteotomy cut around the canine root, relieving, bony inferences at the apical region of the socket that can be encountered during tooth movement.

There was no external root resorption seen around the concerned teeth roots. External root resorption is initiated 2-3 weeks after the orthodontic force is applied, and may continue for the duration of force application. The duration of the applied forces is an aggravating factor for the root resorption and it is a more critical factor than the magnitude of forces.[1] Also the periodontal ligament space was patent after the removal of the distraction device. Thus the widespread application of this approach, awaits further follow up, in issues regarding, teeth vitality, periodontal attachment levels and, periodontal health of the rapidly moved teeth, and has to be studied further clinically.

Conclusion

Combination of newer orthodontic appliances and the principles of biomechanics to maintain the control over rapid tooth movement, rapid canine distalization using distraction osteogenesis await further development before routine application, of this innovative and exciting approach. As this was a short term study, further research is required on a long term basis on a larger group of patients, to be clinically relevant. The widespread application of this technique awaits follow up in issues regarding teeth vitality, periodontal attachment levels and periodontal health of the rapidly moved teeth and has to be studied in detail.

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