Rapid Canine Retraction and Orthodontic Treatment with Dentoalveolar Distraction Osteogenesis

PANKAJ J. AKHARE, AKSHAY M. DAGA, SHILPA PHARANDE

ABSTRACT

Duration of treatment is one of the things that orthodontic patients complain about most. To shorten the treatment time, a new technique of rapid canine retraction through distraction osteogenesis was introduced. The effects of dentoalveolar distraction on the dentofacial structures are presented in this article.

Material: The study sample consisted of 20 maxillary canines in 10 growing or adult subjects (mean age, 16.53 years; range, 13.08-25.67 years). First premolars were extracted, the dentoalveolar distraction surgical procedure performed, and a custom-made intraoral, rigid, tooth-borne distraction device was placed. The canines were moved rapidly into the extraction sites in 8 to 14 days, at a rate of 0.8 mm per day.

Results: Full retraction of the canines was achieved in a mean time of 10.05 (–2.01) days. The anchorage teeth were able to withstand the retraction forces with minimal anchorage loss. The mean change in canine inclination was 13.15° – 4.65°, anterior face height and mandibular plane angle increased. No clinical and radiographic evidence of complications, such as root fracture, root resorption, ankylosis, periodontal problems, and soft tissue dehiscence, was observed. Patients had minimal to moderate discomfort after the surgery.

Conclusions: The dentoalveolar distraction technique is an innovative method that reduces overall orthodontic treatment time by nearly 50%, with no unfavorable effects on surrounding structures.

Key Words: Rapid Canine Distraction, Dentoalveolar distraction device, Canine Retraction

INTRODUCTION

Distraction osteogenesis was used as early as 1905 by Codivilla [1] and was later popularized by the clinical and research studies of Ilizarov in Russia. Distraction osteogenesis was performed in the human mandible by Guerrero [3] in 1990 and by McCarthy et al [4] in 1992. Since then, it has been applied to various bones of the craniofacial skeleton.

Most of the orthodontic patients have some crowding. Although non-extraction treatment has become popular during the last decade, many patients do need extractions [5]. The first phase of the treatment for the premolar extraction patients is the distal movement of the canines. With the conventional orthodontic treatment techniques, biological tooth movement can be achieved [6,7], but the canine retraction phase usually lasts for 6 to 8 months.

Therefore, under normal circumstances, a conventional treatment with fixed appliances is likely to last for 20 to 24 months. The duration of the orthodontic treatment is one of the major concerns that orthodontic patients complain about the most – especially the adult patients. To address this problem, a technique of rapid canine retraction in which the concepts of distraction osteogenesis are used, has been developed: dentoalveolar distraction (DAD). In this technique, which has been described and used by I'şeri et al [8] and Kişnişci et al [9], osteotomies surrounding the canines are made to achieve the rapid movement of the canines in the dentoalveolar segment, in compliance with the principles of distraction osteogenesis.

The purpose of this study was to examine the effect of the DAD technique on the dentofacial structures.

MATERIAL AND METHODS

Class I or II patients who needed orthodontic treatment with fixed appliances and tooth extractions were selected for this study. All the patients were in the permanent dentition and had moderate to severe crowding or an increased overjet at the start of the treatment (6 females and 4 males). Because the treatment involved surgery, only subjects who were aged 13 years or older were included. The initial mean age was 16.53 years (range-13.08–25.67 years). A custom-made, rigid, tooth-borne intraoral distraction device was designed for DAD and rapid tooth movement [Table/Fig-1]. Ethical clearance was obtained from the local ethical committee for the surgical procedure.

The device is made of stainless steel and has a distraction screw and 2 guidance bars. The patient or his/her parent turns the screw clockwise with a special apparatus, and this moves the canine distally.

The device is placed after a surgical procedure, which has been described below, which includes the extraction of the first premolars. No other appliances are placed on the second premolars or the incisors during the distraction procedure. The treatment procedure was explained in detail to all the patients and their parents, and their informed consent was obtained before surgery.

SURGICAL PROCEDURE

The surgery was performed on an outpatient basis, with the patient under local anaesthesia, sometimes being supplemented with sedation. The procedure was described previously by Kişnişci et al [9]. Briefly, a horizontal mucosal incision was made parallel to the gingival margin of the canine and the premolar beyond the depth of the vestibule.

Cortical holes were made in the alveolar bone with a small, round, carbide bur [Table/Fig-2] from the canine to the second premolar, curving apically to pass 3 to 5 mm from the apex. A thin, tapered, fissure bur was used to connect the holes around the root. Fine osteotomes were advanced in the coronal direction.

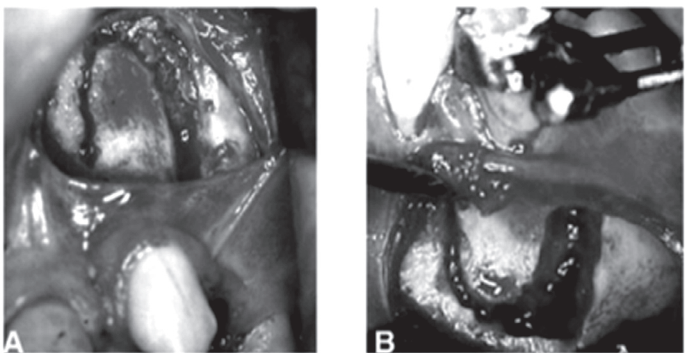
The first premolar was extracted and the buccal bone was removed between the outlined bone cut at the distal canine region anteriorly and the second premolar posteriorly [Table/Fig-2]. The buccal and apical bone through the extraction socket and the possible bony interferences at the buccal aspect that could be encountered during the distraction process were eliminated or smoothed between the canine and the second premolar, thus preserving the palatal or the lingual cortical shelves. The palatal shelf was preserved, but the apical bone near the sinus wall was removed, leaving the sinus membrane intact to avoid interferences during the active distraction process.

The incision was closed with absorbable sutures, and an antibiotic and a non-steroidal anti-inflammatory drug were prescribed for 5 days. The surgical procedure lasted for approximately 30 minutes for each canine [9].

THE DISTRACTION PROTOCOL AND DENTOALVEOLAR DISTRACTION

The distractor was cemented on the canine and on the first molar immediately after the surgery. To ensure that the alveolar segment which was carrying the canine was fully mobilized intra-operatively, the device was activated for several millimeters and set back to its original position.

[Table/Fig-1]: Dentoalveolar distraction device in place. Canine and molar bands are fabricated and distractor is soldered to bands on cast



[Table/Fig-2]: Intraoral view of surgical site (A) Corticotomy; (B) Extraction socket of first premolar.
Dentoalveolar segment will be used as transport unit to carry maxillary canine posterioorly.

[Table/Fig-3]: Dentoalveolar distraction of maxillary canines from start to end of distraction, occlusal views.

[Table/Fig-4]: Dentoalveolar distraction of maxillary canines from start to end of distraction, occlusal views.
Full distraction of Canines completed in 11days

The distraction was initiated within 3 days after the surgery. The distractor was activated twice per day, in the morning and in the evening, for a total of 0.8 mm per day. Immediately after the canine retraction was completed, fixed orthodontic appliance treatment was initiated, and the leveling stage was started in both the dental arches. Ligatures were placed under the archwire between the distracted canine and the first molar and they were kept at least 3 months after the DAD procedure. Periapical radiographs of the canines and the first molars and panoramic films were taken at the start and at the end of the distraction procedure to evaluate the root structures. The root resorption was evaluated with a root resorption scale, which was a modified form of Sharpe et al's procedure [10], which was as follows:

S0: no apical root resorption;

S1: widening of the periodontal ligament (PDL) space at the root apex;

S2: moderate blunting of the root apex (up to one third of the root length);

S3: severe blunting of the root apex (beyond one third of the root length).

The pulp vitality was evaluated and recorded with an electronic digital pulp tester. All teeth which were subjected to the pulp vitality test (canines, incisors, second premolars and first molars) were cleaned and tested on the buccal surfaces.

RESULTS

Tables I and II show the mean rate and the duration of the distraction, the mean posterior anchorage loss (NSLv-ms), and the mean change in the canine inclination (NSL/can). The canines were moved into the socket of the extracted first premolars, in compliance with the distraction osteogenesis principles. The distraction procedure was completed in 8 to 14 days (mean- 10.05 –2.01 days) at a rate of 0.8 mm per day [Table/Fig-4]. The canines were fully retracted, and the anchorage teeth (first molars and second premolars) were able to withstand the retraction forces, with minimal anchorage loss [Table/Fig-5]. The mean sagittal (NSLv-ms) and vertical (NSL-ms) anchorage loss was 0.19 mm and 0.51 mm, respectively, during the rapid distraction of the canines, and these were statistically insignificant. The distal displacement of the canines was mainly a combination of tipping and translation, with a mean change in the canine inclination of 13.15° (–4.65°) at the end of the distraction period [Table/Fig-6].

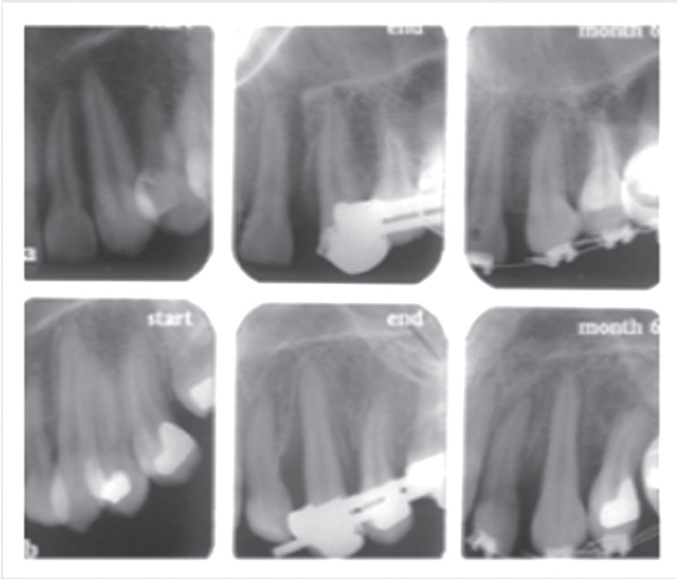
In addition, the anterior face height (n me) and the mandibular plane angle (NSL/ML) were increased and the overjet was decreased significantly during the distraction period (*P*–.05, *P*–.01). No significant changes were observed in the other measurements. The clinical and radiographical examination showed no evidence of complications such as root fracture, root resorption, ankylosis, and soft tissue dehiscence, in any patient. No apical root resorption (S0) was detected in any subject, at the start or at the end of the dentoalveolar distraction (Table/Fig-7). The patients reported minimal to moderate discomfort, especially during the first 2 days after the surgery, and oedema was observed in some patients (Table/Fig-8).

Before the start of the treatment, the pulp vitality was tested with an electronic pulp tester. All the teeth reacted positively, with the exception of a right maxillary central incisor in a patient who had previously had root canal therapy. At the end of the dentoalveolar distraction procedure and during the fixed appliance orthodontic treatment, it was found that the pulps of all the concerned teeth remained vital, as was confirmed by the pulp vitality tests.

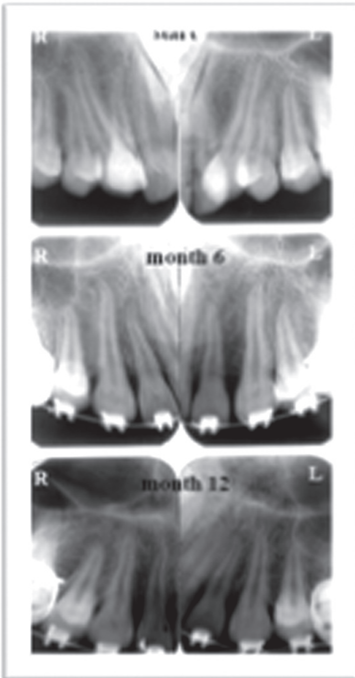
DISCUSSION

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 [6,7]. Classically, the rate of the orthodontic tooth movement depends on the magnitude and the duration of the force [6], the number and the shape of the roots, the quality of the bony trabecula, the patient's response, and the patient's compliance. The rate of the biological tooth movement with the optimum mechanical force was approximately 1 to 1.5 mm in 4 to 5 weeks [13]. Therefore, in the 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 which patients complain about the most, especially the adult patients. Many attempts have been made to shorten the orthodontic tooth movement [14-16]. Liou and Huang [16] reported a rapid canine retraction technique which involved the distraction of the PDL after the extraction of the first premolars.

[Table/Fig-5]: Dentoalveolar distraction of maxillary canines, from start (before surgery) to end lateral views. Anchorage teeth (first molars and second premolars) withstood reaction forces almost without anchorage losss



[Table/Fig-6]: Radiographic appearance of maxillary canines before and after dentoalveolar distraction. Canines were retracted with combination of tipping and translation. New bone formation in distraction sites was achieved after dentoalveolar distraction during fixed appliance orthodontic treatment



[Table/Fig-7]: Radiographic appearance of maxillary canines before and 12 months after dentoalveolar distraction. No radiographic evidence of complications, such as root fracture, root resorption, or anklylasis.

The method was described as an innovative approach; however, refinements in the surgical technique, such as the use of corticotomies versus full osteotomies and the applicability of the technique to the teeth, close to the mandibular dental nerve, were suggested [17]. I'şeri et al [8] and Kişnişci et al [9] described and clinically used a new technique for the rapid retraction of the canines, the DAD.

With this technique, the horizontal and the vertical osteotomies surrounding the canines are made to achieve the rapid movement of the canines in the dentoalveolar segment, in compliance with the principles of distraction osteogenesis.

Ten patients with Class I or II malocclusion, with moderate to severe crowding, were selected for this study. Two patients had Class II Division 1 malocclusions, and 1 had an open bite. The maxillary and the mandibular canines were moved rapidly into the cavity of the extracted first premolars, following a surgical procedure that lasted about 30 minutes for each canine.

Nine vertical corticotomies were performed around the root of the canine, and the spongy bone around it was split. With this surgical technique, the dentoalveolus could be used as a bone transport segment for the rapid posterior movement of the canines. This surgical technique does not rely on the stretching and the widening of the PDL, which prevents overloading and stress accumulation in the periodontal tissues. The buccal bone, the apical bone through the extraction site and the palatal cortical plate did not interfere with the movement of the canine-dentoalveolar segment during the distraction procedure.

All the patients tolerated the surgery and the device after the surgery. Fixed appliance orthodontic treatment was started immediately after the termination of the canine distraction in all the patients [18].

The term *physiological tooth movement* designates, primarily, the slight tipping of the tooth in its socket and, secondarily, the changes in tooth position that occur during and after tooth eruption [19]. In fact, there is basically no great difference between the tissue reactions which are observed in the physiological tooth movement and those which are observed in the orthodontic tooth movement.

However, because the teeth are moved more rapidly during (Table/Fig-3) the treatment, the tissue changes which are elicited by the orthodontic forces are more marked and extensive. It has been assumed that the application of force will result in hyalinization, which is caused partly by anatomical and partly by mechanical factors [20]. The hyalinization period usually lasts for 2 or 3 weeks [19], and the tooth movement continues at a rate of 1 to 1.5 mm in 4 to 5 weeks [13]. On the other hand, with the custom-made, rigid, tooth-borne distraction device, the canines were retracted at a rate of 0.8 mm per day and they were moved into the socket of the extracted first premolars in compliance with the distraction osteogenesis principles. The mean distraction time was 10 days (the canines were retracted until they came into contact with the second premolars), and the distraction procedure was completed in 8 to 14 days. This was the most rapid movement of a tooth which was demonstrated in the literature [13,16].

Although every attempt was made to achieve the bodily movement of the canines with distraction osteogenesis (the distractor was designed with 2 guidance bars and was placed as high as possible on the buccal side of the teeth), a significant amount of tipping of the canines was observed [Table/Fig-2]. Therefore, the distal displacement of the canines was mainly a combination of tipping and translation.

The full retraction of the canines was achieved, and the anchorage teeth (first molars and second premolars) were able to withstand the retraction forces, with minimal anchorage loss. The mean sagittal and vertical anchorage losses were 0.19 mm and 0.51 mm, respectively, during the rapid distraction of the canines.

In fact, the mandibular plane angle (NSL/ML) and the anterior face height (n me) were increased slightly (0.67°–0.80° and 0.99–0.57 mm, respectively), which may be related to the insignificant amount of extrusion of the maxillary first molars (0.51–0.93 mm). Therefore, one should consider the vertical anchorage loss of the maxillary first molars, especially in patients with an open bite or with a tendency to open bite, who were treated with DAD. In a previously published study [16] which demonstrated rapid canine retraction with the PDL distraction technique, the average mesial movement of the first molars was less than 0.5 mm in 3 weeks; however, no data regarding the vertical posterior anchorage loss were presented.

After the extraction of the first premolars and the rapid retraction of the canines into the socket, a significant spontaneous decrease in the overjet was observed. This may be expected by taking into account the recently distracted fibrous new bone tissue, just behind the incisors. Another observation of this study was the rapid movement of the lateral incisors into the newly generated fibrous bone tissue after DAD.

Liou et al [18] demonstrated in mature beagles, that the best time to initiate the tooth movement was immediately after the distraction, when the edentulous space was still fibrous and the bone formation was just starting; they suggested that the tooth movement should be initiated when the osteogenic activity which was brought about by the distraction process was active, the new bone was still fibrous, and the trabeculae were not well developed.

Our clinical observations support the findings of that experimental study and may provide an example to relieve severe dental crowding and overjet in an extremely short time. However, systematic clinical and experimental research studies are still needed. No clinical and radiographical evidence of the complications, such as root fracture, root resorption, ankylosis, and soft tissue dehiscence, was observed in any of the patients. Although the fundamental causes of the treatment-associated root resorption are still poorly understood, and the magnitude of resorption is almost unpredictable, an association between the duration of the applied force and increased root resorption has been reported [21]. It has generally been accepted that the best way to minimize root resorption was to complete the tooth movement in a short time. Root resorption begins 2 to 3 weeks after the orthodontic force is applied and can continue for the duration of the force application [21-23].

The full retraction of the canines with DAD occurred in 8 to 14 days in our study, an extremely short time for root resorption to begin. Although no meaningful findings were achieved with the electronic pulp tester, we still think that the distracted canines preserved their pulp vitality at the end of the dentoalveolar distraction. The pulp-vitality test is not a reliable technique when it is performed during the orthodontic tooth movement [16]. Moreover, no colour change was observed in any teeth during the observation period of this study. Block et al [24] demonstrated that the inferior alveolar nerve and the blood vessels regenerate a in short time after the mandibular distraction.

The 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 mandibular distraction, the pulp tissues of the teeth will remain vital under controlled rapid stretching.

Therefore, the observed tipping of the canines might be an advantage with regards to the pulp vitality during the rapid tooth movement with DAD. However, further investigation of the pulp vitality is needed in patients who are subjected to rapid tooth movement with dentoalveolar distraction.

CONCLUSIONS

Distraction osteogenesis for rapid orthodontic tooth movement is a promising technique. With DAD, canines can be fully retracted in 8 to 14 days. 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 II malocclusions with 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. With the DAD technique, the anchorage teeth can withstand the retraction forces with no anchorage loss and without any clinical or radiographical evidence of the complications, such as root fracture, root resorption, ankylosis, periodontal problems, and soft tissue dehiscence.

The DAD technique reduces the orthodontic treatment duration by 6 to 9 months in the patients who need extraction, with no need for extraoral or intraoral anchorage devices and with no unfavourable short-term effects in the periodontal tissues and in the surrounding structures.

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