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Research Article

Canine Distraction: Periodontium Integrity Evaluation

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Abstract

Background: Underscoring the importance of maintaining periodontal tissue health in ensuring high-quality orthodontic treatment outcomes remains highly significant. The present study aimed to evaluate the effect of dental distraction (DD) for rapid canine distalization on the periodontium integrity of the distracted maxillary canines.

Materials and Methods: The study sample comprised 14 maxillary canines of 7 adult female patients aged between 19 and 24 years. A ready-made distraction device was used for all patients. Plaque index (PI), gingival index (GI), pocket depth (PD) and width of the keratinized gingiva were measured pre-DD, post-DD and 6-months post-distraction procedure (6-m post-DD). Data were analysed using repeated measure ANOVA and Friedman's tests.

Results: There was a statistically significant increase in PI, GI and PD measurements of buccal and distal sites during the post-distraction evaluation period. In contrast, all parameters were significantly decreased at 6-m post-DD. The width of keratinized gingiva showed no significant changes at any time point.

Conclusion: It could be concluded that dental distraction is an efficient technique with no unfavourable long-term effects on the periodontal tissues of rapidly distalized canine teeth.

Keywords: Dental Distraction; Canine Distalization; Periodontium; Plaque Index; Gingival Index; Pocket Depth

Abbreviations

DD: Dental Distraction; GI: Gingival Index; PD: Pocket Depth; PI: Plaque Index

Introduction

Orthodontic treatment is a multifaceted endeavour aimed at improving dental aesthetics as well as optimising oral function. A persistent challenge in orthodontic practice revolves around the intricate balance between tooth movement and maintaining anchorage since most patients experience a shortage of space and crowding of teeth [1-4]. The extraction of premolars has been a contentious topic in orthodontics, with a divide between extraction and non-extraction modalities of treatment [1-4]. For patients requiring premolar extraction, canine distalization emerges as an essential phase of treatment. However, conventional orthodontic approaches are often limited by the rate of tooth movement and the associated extended duration of treatment [5,6]. The canine retraction phase, in particular, can span almost 6-8 months and presents a significant hurdle for orthodontists in terms of anchorage control [5,6]. Consequently, reducing the length of orthodontic treatment and managing anchoring loss became a common aim of research. Pioneered by Liou and Huang in 1998, rapid canine distraction emerged as a ground-breaking technique [7]. Termed 'dental distraction (DD)', this technique enables significant canine retraction of 6.5 mm within 3 weeks, minimising anchorage loss and subsequently reducing the overall treatment time [7]. It is important to recognise the significance of preserving periodontal tissue integrity within the domain of orthodontic treatment quality. The primary objective of this prospective clinical study was to examine the changes in the periodontal parameters of the distracted canine teeth for 6 months following the DD procedure.

Materials and Methods

Seven adult female patients (a total of 14 maxillary canines) aged between 19 and 24 years, who were planned for orthodon-

tic treatment with extraction of bilateral maxillary first premolars were considered for this study. All patients displayed moderate-to-severe dental protrusion and/or crowding. Both the alternate conventional therapy option and the proposed surgical treatment plan were explained to the patients and their parents. Before starting the DD procedure, each patient gave their informed consent. The Research Ethics Committee approved the study.

Distraction device adaptation

The study used readymade 'PiTractor', a tooth-borne semi-rigid canine distraction tool made of stainless steel, with two guidance attachments consisting of rectangular tubes and screw retaining clips measuring 0.022 x 0.028 inches. First, the canines and first molars were banded, and impressions were taken with these bands in position on the teeth. Subsequently, the distractor was fixed onto dental casts on the buccal side of the canine and first molar bands. The device's orientation ensured that the vector of distraction force remained parallel to the occlusal plane when viewed laterally and aligned with the alveolar trough from the occlusal perspective (Figure 1).

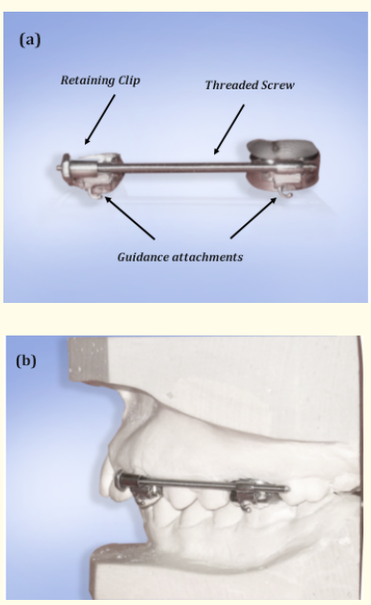

Figure 1: PiTractor' distraction device. (a) Buccal view, (b) Device on the cast.

Surgical procedure

The surgical procedure closely adhered to the method originally described by Liou and Huang (1998) [7]. After extracting the maxillary first premolars, the surgeon deepened the first premolar socket to match the estimated length of the maxillary canine root from CBCT images. Then, they reduced the interseptal bone distal to the canine to a thickness of 1-1.5mm (Figure 2). Finally, to weaken the interseptal bone distal to the canine, two vertical grooves were created with a 1-mm fissure carbide bur. The grooves were interconnected at the base of the interseptal bone forming a U-shape. This eliminated the need for any mucoperiosteal flaps or osteotomies on the buccal or palatal alveolar plate of the canine since the surgical procedure occurred exclusively within the extraction socket (Figure 3).

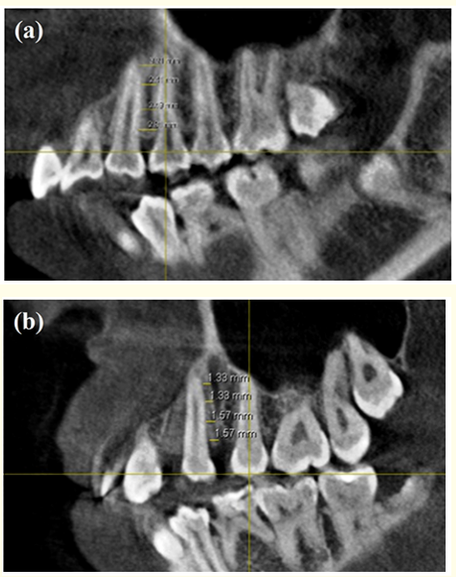

Figure 2: Sagittal multiplanar view showing the width of the interseptal bone distal to maxillary canine. (a) Before, (b) After surgical preparation.

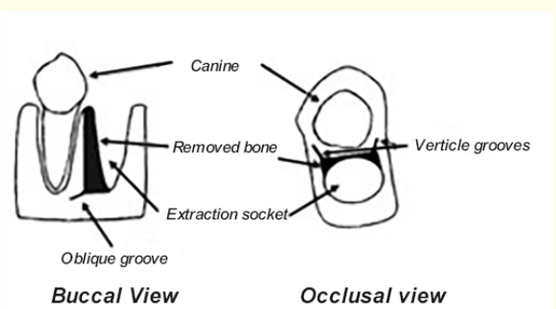

Figure 3: Diagrammatic presentation of the surgical technique for undermining the interseptal bone distal to canine.

Distrction protocol

After the placement of the distraction devices, the patients were educated about the process of activating the device and were instructed to turn it once every 12 hours, generating an overall activation of approximately 0.72 mm per day. Subsequently, the patient's adherence to the distractor activation plan and oral hygiene guidance was monitored at intervals of 3 days. The distraction phase was concluded once the canines had been distalized to the extent required by the proposed treatment plan (Figure 4).

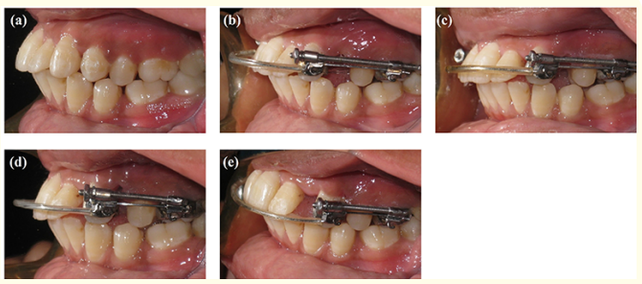

Figure 4: Intra-oral photographs showing the sequence of canine dental distraction (Right side occlusion). (a) Before canine DD, (b) Day 2 of canine DD, (c) Day 6 of canine DD, (d) Day 10 of canine DD, (e) Day 16 of canine DD.

Clinical evaluation

Regarding the assessment of clinical periodontal parameters, all patients were provided with identical oral hygiene instructions, which encompassed routine brushing and flossing practices. No patients in the study had received antibiotics or extra topical chemical plaque inhibitors.

The examiner evaluated patients' clinical periodontal conditions using these parameters

- **Plaque measurement (Plaque Index or PI):** The identification of plaque presence or absence at the gingival margin was conducted for all areas of the maxillary canine teeth (mesial, mid-buccal, distal and mid-palatal) using the subsequent scale in accordance with an established methodology [8]

0 = Absence of plaque in the gingival region.

1 = Detection of a thin layer of plaque by gently sliding a probe along the free gingival margin and adjacent tooth area.

2 = Noticeable accumulation of soft deposits within gingival pockets, margins, or on neighboring teeth, visible without magnification.

3 = Excessive soft tissue accumulation between gums and teeth, as well as on gums contiguous to teeth.

- **Gingival assessment (Gingival Index or GI):** Inflammation status (presence or absence) at the gingival border was evaluated for all areas encompassing the canine teeth (mesial, mid-buccal, distal and mid-palatal) following the guidelines outlined by the World Health Organization (1978) [9], using the subsequent criteria

0 = Healthy gingiva.

1 = Mild inflammation-slight alteration in colour, minor swelling and no bleeding upon probing.

2 = Moderate inflammation-redness, swelling, shininess and bleeding upon probing.

3 = Severe inflammation-pronounced redness, swelling, ulcers and a tendency to spontaneous bleeding.

- **Pocket depth (PD) measurement:** The measurement of the distance from the gum line to the lowest point of the gum pocket was performed for all canine tooth locations (mesial, mid-buccal, distal, and mid-palatal) using a periodontal probe with precision up to 0.5 mm (Figure 5). Measurements were taken at the most profound proximal site between the buccal and palatal surfaces.
- **Width of keratinized gingiva:** The digital caliper was used to measure the distance from the mid-buccal surface of the canine to the mucogingival junction, with a precision of 0.1 mm (Figure 6). Visual assessment of the mucogingival junction was performed following a well-established approach [10].

Figure 5: (a) A periodontal probe, (b) Measuring the post-DD pocket depth from the mid-buccal site of the maxillary canine.

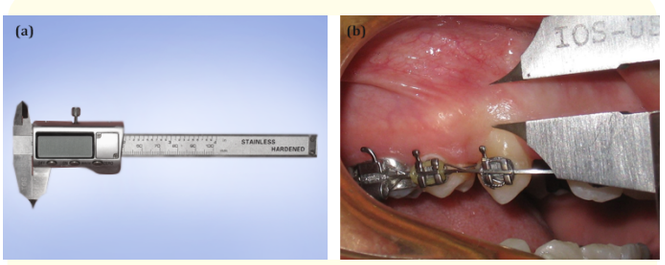

Figure 6: (a) A digital caliper, (b) Measuring the distance from the gingival margin to the mucogingival junction from the mid-buccal surface of the maxillary canine.

The clinical measurements were taken before surgery (pre-DD), after removing the distraction device (post-DD), and 6 months after the DD period (6-m post-DD).

Statistical analyses

The data was analysed using the SPSS package for Windows, version 16.0, by IBM. Descriptive statistics, including mean, standard deviation (SD) and standard error (SE), were computed for all variables at each evaluation period.

- Repeated measures ANOVA test was performed to analyse changes in PD and width of keratinized gingiva over time.
- Tukey's test was used for pairwise comparison of means after significant ANOVA.
- Friedman's test was used to analyze changes over time in gingival and plaque indices.
- The Wilcoxon signed-rank test was used for pairwise mean comparisons when Friedman's test was significant.

- Intra-observer reliability was assessed using Cronbach's alpha test. Seven canines were randomly selected for clinical measurements, which were re-measured after two weeks. The differences were tested for intra-observer reliability. A value of Cronbach's alpha closer to 1 indicated greater reliability.

Results and Discussion

Results

The 14 maxillary canines were distalized into the sockets of extracted first premolars using the DD principle. The entire procedure took 12-19 days (mean 14.5 [1.9] days) with 0.36 mm/day and a total distalization of 5.2 [0.6] mm. The maxillary first molars were able to withstand the retraction forces with insignificant horizontal (0.5 [0.4] mm) and vertical (0.2 [0.3] mm) anchorage loss during canine distalization (Table 1). The DD procedure was well tolerated by the patients, and no one reported swelling or severe pain. Some patients experienced minimal discomfort following the surgery that improved spontaneously without the need for analgesics.

Table 1: Descriptive statistics of the amount, duration and rate of canine distraction and anchorage loss.

Variables	Mean	SD
Canine distalization	5.2	0.6
Horizontal anchorage loss (mm)	0.5	0.4
Vertical anchorage loss (mm)	0.2	0.3
Distalization duration (days)	14.5	1.9
Distalization rate (days/mm)	0.36	0.05

SD: Standard deviation

During the post-DD evaluation period, there was a significant increase in the mean GI and PI (Table 2). On the other hand, through the period (post-DD to 6-m post-DD), a statistically significant decrease in mean GI and PI was observed. However, throughout the whole study period (pre-DD to 6-m post-DD), there was a statistically significant increase in the mean GI and PI.

Table 2: The mean values and significance of changes in gingival and plaque indices using Friedman's test.

Variables	Gingival Index		Plaque Index	
Time	Mean	SD	Mean	SD
Pre-DD	1.40	0.37	1.06	0.39
Post-DD	2.08	0.49	1.83	0.45
6-m post-DD	1.65	0.24	1.31	0.36
p-value	0.006**		0.003**	

** Significant ($p \leq 0.01$)

NB: Means with different letters are statistically significantly different according to Wilcoxon signed rank test.

SD: Standard deviation

The study found statistically significant changes in mean PD for buccal and distal sides during post-DD evaluation period, but a decrease in mean PD during the period from post-DD to 6-m post-DD (Table 3). However, there was an overall increase in mean PD throughout the entire study period. No significant changes were observed in mean PD for mesial and lingual sides or in mean width of keratinized gingiva. All measurements showed very good intra-observer reliability (Cronbach's alpha ranged from 0.990 to 0.992).

Table 3: The mean values and significance of changes in pocket depths and widths of keratinized gingiva using repeated measures ANOVA test.

Variables	Pocket Depth (mm)								Width of Keratinized Gingiva (mm)	
Time	Buccal		Lingual		Mesial		Distal			
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Pre-DD	1.21	0.26	1.63	0.53	1.79	0.72	2.21	0.58	4.99	0.68
Post-DD	1.54	0.33	1.67	0.65	2.00	0.52	3.13	0.64	4.88	0.54
6-m post-DD	1.38	0.31	1.58	0.51	2.00	0.30	2.75	0.54	4.93	0.64
p-value	0.028*		NS		NS		0.003**		NS	

* Probably significant ($p \leq 0.05$)

** Significant ($p \leq 0.01$)

NB: Means with different letters are statistically significantly different according to Tukey's test

NS: Not significant

SD: Standard deviation

Discussion

Although tooth extraction has become a routine aspect of orthodontic treatment, it brings forth concerns about the duration of the treatment and the use of extra-oral anchorage, which causes dissatisfaction among orthodontic patients [1-4]. Finding ways to provide effective and quicker treatment is particularly important for adult patients. The present study utilised the periodontal ligament distraction technique to rapidly distalize the maxillary canines in 7 adult female patients with the necessity that the canines be fully erupted and well aligned in the alveolar trough.

Rapid canine distalization through the distraction of the periodontal ligament reportedly results in minimal and clinically insignificant loss of anchorage [7,11,12]. Consequently, the patients were selected with moderate to maximum anchorage requirements, and no attempt was made to reinforce the anchorage by using adjunctive intra- or extra-oral appliances. Clinical periodontal selected parameters (PI, GI, PD and width of keratinized gingiva) were measured at three evaluation periods to investigate the alterations that occurred over time in the periodontium of maxillary canines. The reliability, accuracy and validity of these periodontal parameters were substantiated by established studies [10,13].

This study demonstrated that it is possible to quickly move the upper canines 5.2 mm in 12 to 19 days, at a rate of 0.36 mm per day. These findings are similar to previous studies on canine distalization [7,11,12]. The rapid rate of canine movement could likely be attributed to two factors: first, the interseptal surgery reduced the osteal resistance distal to the canines followed by bending and/or fracture of the interseptal bone, allowing for easier movement; and second, the immediate repositioning of the canines into the sockets after extraction, which had not been refilled by solid bone tissue. Importantly, the horizontal and vertical anchorage losses observed were minimal, with only a slight movement of the first molars.

The study implemented the 'lag period' strategy to control the anchorage of posterior teeth. This period is a short interval where tooth movement is minimal, lasting a few weeks after treatment initiation, which eliminates the hyalinizing tissues by undermining resorption [14]. This facilitates specific tissue changes, aiding controlled tooth movement. Consequently, canine distraction focuses on rapidly distalizing canines through the extraction socket, coinciding with posterior teeth still in their lag period or initiating mesial movement. This strategy thus controlled the posterior teeth anchorage.

The present study showed a statistically significant increase in the mean GI and PI during the post-DD evaluation period. This may be related to the lack of accessibility for effective cleaning due to the presence of the distraction device. However, the post-DD to 6-m post-DD period demonstrated a statistically significant decrease in the mean GI and PI possibly due to meticulous oral hygiene and surgical site healing. Nonetheless, throughout the whole study period (pre-DD to 6-m post-DD), mean GI and PI showed a statistically significant increase. The PD analysis revealed a post-DD increase at distal and buccal sites due to impaired cleaning from the distraction device, canine bands or bone reduction. The 6-m post-DD period showed improved periodontal support tissue around canines, aligning with established histological findings, indicating collagen-cementum restoration post-DD [15]. Almost normal dental features were reflected 8 weeks after the distraction of the periodontal ligament.

However, comparing pre-DD and 6-m post-DD, the mean PD showed a significant increase at the buccal and distal sites. Keratinized gingiva width remained unchanged across evaluation periods. This study has a few limitations. The limited number of participants within the patient sample and the absence of a comparative group are significant constraints requiring consideration: small patient sample and lack of a comparative group. Comparative cohort studies with larger participant groups become imperative for the validation of these findings.

Conclusion

The DD technique emerges as a clinically efficient method for achieving rapid canine distalization while minimising potential posterior anchorage loss. Moreover, the canine distraction procedure led to minimal changes in its clinical periodontal parameters. Although there was a temporary increase in PI, GI and PD on the buccal and distal sides, these effects gradually improved over time. Notably, no adverse events were observed regarding the width of keratinized gingiva throughout the entire duration of the study.

Conflict of Interest

The authors report no conflict of interest.

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