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Original Article

Evaluation of canine retraction following periodontal distraction using NiTi coil spring and implants – A clinical study

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ABSTRACT

Objective: To evaluate the amount of canine retraction with periodontal distraction using miniscrew implants and NiTi coil spring.

Material and method: Sample comprised of 25 patients who were scheduled for all 1st premolar extraction (13 males and 12 females), in the age range of 16–22 years with mean age 18.8 ± 2.7 years. For each patient left side served as control side (Group I) and right side as experimental side (Group II). At the time of first premolar extraction, periodontal distraction was performed only on the experimental side, followed by retraction of canine from mini-implant by closed NiTi coil spring on both the sides. “Nemotech” software was used to evaluate the amount of canine retraction for a period of 3 months.

Results: Significantly higher amount of tooth movement was seen from T0–T1 and from T1–T2 in Group II for the maxillary parameters 3C–5C, 6CF–3C, 3C–I/3C–J and for the mandibular parameter 6CF–3C. Whereas no significant amount of tooth movement was observed for maxillary and mandibular parameters between T2–T3 except for 6CF–3C ($p \leq 0.01$) which was significantly higher for the Group II.

Conclusion: There was accelerated canine retraction on the periodontal distraction side as compared to the control side, with negligible anchorage loss.

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1. Introduction

Orthodontic tooth movement is a process by which a mechanical force is applied to induce bone resorption on the pressure side and deposition on tension side.¹ Canine retraction following the 1st premolar extraction is common orthodontic procedure which is followed by retraction of incisors. In maximum anchorage cases, anchorage conservation is of utmost importance, for these various intraoral and extraoral mechanics are employed. Among the intraoral mechanics, miniscrew is served as one of the best method to conserve anchorage.

Using conventional methods the teeth move at slow rate (about 1 mm/month) and it takes about 6–8 months to retract the canine. With distraction osteogenesis the upper canine can be retracted into premolar extraction spaces in about 3 weeks with minimal loss of anchorage. Periodontal ligament distraction is based on the similar principle as distraction osteogenesis that is a process of growing new bone by mechanical stretching of the pre-existing vascularized bone tissue.^{2,3} With this technique, new bone is generated in the gap of osteotomy or corticotomy at the approximate rate of 1 mm per day, in contrast to 1 mm/month by traditional sliding mechanics.³ In previous studies on periodontal distraction, the tooth borne intraoral distraction device had been used, which were bulky, unidirectional, had to be activated daily and were inconvenient to the patient with adverse effect on canine root resorption and vitality.⁴ To overcome the limitation of intraoral distractors, canine was retracted with the use of NiTi coil spring in the present study. Thus the aim of the present study was to compare and evaluate the amount of canine retraction with and without periodontal distraction using NiTi coil spring and miniscrew at monthly intervals for three months.

2. Materials and method

The present study was conducted on 25 orthodontic patients (13 males and 12 females), with the age range of 16–22 years (mean age of 18.8 ± 2.7 years), in the Department of Orthodontics and Dentofacial Orthopaedics, BBDCODS; Lucknow who required extraction of all 1st premolars for fixed orthodontic treatment. The left sides of the patients were served as Group I (Control side) and the right sides of the same patients as Group II (Experimental side) so as to avoid errors due to type of bone and individual response. Prior to conduction of the study the approval was taken from ethical committee and written informed consent was obtained from all the subjects participating in the study.

Patients with bi-maxillary protrusion needing extraction of all 1st premolars for fixed orthodontic treatment, crowding less than 5 mm (not confined to one side) and no loss of periodontal attachment with any radiographic evidence of bone loss were included in the study. Missing, impacted or significant morphological anomalies in canine, or a history of previous orthodontic treatment, or presence of any systemic illness and pathological diseases e.g., cyst, tumor, bony lesion etc. were reasons to exclude the patients.

2.1. Clinical procedure

The case history and records were taken before starting the treatment. During the alignment and leveling phase Mini-implants (S.K Surgical Pvt. Ltd.) 1.3×9 mm in dimensions were placed between the roots of first molar and 2nd premolar in both arches.^{5–10} At the time of premolar extraction interseptal bone distal to maxillary and mandibular canine was undermined with a tapered tungsten carbide bur on right side. Vertical grooving was done along the buccal and lingual sides of the extraction socket up to the depth of premolar roots. Another oblique groove was also done toward the base of the interseptal bone to weaken its resistance (Fig. 1a and b (I)). The depth of the grooves was depending on the thickness of the interseptal bone.^{3,4,11,12}

After the extraction of all 1st premolars, impressions were taken for baseline records and $0.019'' \times 0.02''$ S.S. wire was ligated. Closed NiTi coil spring of 6 mm length is placed from canine bracket to mini-implant on both the sides. 150 gm force was applied for the retraction of canine,^{5,8,13–16} Dontrix gauge⁷ was used to measure the force. Force was maintained throughout the period of retraction. Patients were recalled every month for the period of 3 months. At each recall visit, impressions and intraoral photographs of the patients were taken (Fig. 1).

Measurements taken at different intervals were T0 – Commencement of canine retraction after extraction, T1 – Amount of canine retraction after 1st month, T2 – Amount of canine retraction after 2nd month and T3 – Amount of canine retraction after 3rd month.

Digital photograph of maxillary and mandibular model were taken with central projection perpendicular to the occlusal plane, together with millimeter scale mounted in this plane. Millimeter scale was used to calibrate and standardize the model being photographed. The landmarks were identified on digitized model; the pre-treatment and mid-treatment models were evaluated at the same time. Points, landmarks and parameters used in the study on maxillary and mandibular model are shown in Figs. 2–5. Measurements on mandibular model and on maxillary model with help of Nemoceph software are shown in Figs. 6 and 7.

3. Statistical analysis

The data obtained was analyzed using Statistical Package for Social Sciences (SPSS) version 20. Descriptive data that include mean and standard deviation were calculated for both the groups. As the sample size was small (<30), hence a normality test (Kolmogorov–Smirnov test) was also carried out for different parameters. All the parameters showed normal distribution in both the groups; hence parametric tests were used to evaluate the statistical significance. p -value <0.05 was considered statistically significant.

3.1. Reliability test

Reliability of measurement was tested by doing double determinations of 7 models randomly selected at 7 days interval from the collected sample by the same operator. The

Fig. 1 – a. Schematic diagram showing surgical technique for undermining interseptal bone distal to canine. **b.** Mechanics and surgical technique involved in canine retraction. (A–D) Mechanics involved in canine retraction without periodontal distraction for Group I at time T0–T3; (E–H) Mechanics involved in canine retraction with periodontal distraction for Group II at time T0–T3; (I) Surgical technique for undermining interseptal bone distal to canine.

comparison was drawn between 1st and 2nd determinations by Student's *t*-test. There was insignificant difference between 1st and 2nd measurements (Table 1).

4. Results

Significantly higher amount of tooth movement was seen from T0–T1 in Group II for the maxillary parameters 3C–5C, 6CF–3C, 3C–I/3C–J and for the mandibular parameter 6CF''–3C'' (Table 2). Significantly higher amount of tooth movement was also seen from T1–T2 in Group II for the maxillary parameters 3C–5C, 6CF–3C, 3C–I/3C–J and for the mandibular parameter 6CF''–3C'' (Table 3).

Whereas no significant amount of tooth movement was observed for maxillary and mandibular parameters between

T2 and T3 except for 6CF''–3C'' which was significantly higher for the Group II (Table 4). For the parameter (6CF–I/6CF–J), depicting the mean mesial movement of the maxillary first molars, the difference was found to be statistically non-significant (Tables 2–4).

5. Discussion

Minimizing the orthodontic treatment time and controlling the anchorage loss are the basic goals of fixed orthodontic treatment.⁴ Thus, in present study canine retraction was done from miniscrew to prevent anchorage loss and periodontal distraction was done to minimize treatment time. Periodontal distraction was introduced by Liou and Huang,³ based on the principle that canine should be retracted soon after premolar

Fig. 2 – The points and the landmarks used in the study on maxillary model: Mesio-incisal angle of maxillary lateral incisors (2MI) – Point A (right) and Point B (left), Cusp tip of maxillary canine (3C) – Point C (right) and Point D (left), Buccal cusp tip of maxillary 2nd premolar (5C) – Point E (right) and Point F (left), Central fossa of permanent 1st molar (6CF) – Point G (right) and Point H (left), Medial end of 3rd palatal rugae – Point I (right) and Point J (left) and Midpoint of incisive papilla – Point K.

Fig. 4 – Parameters used in the study on maxillary model: 1 – Distance from Central fossa of maxillary 1st molar to Mesio-incisal angle of lateral incisor (6CF-2MI), 2 – Distance from Cusp tip of maxillary canine to Cusp tip of maxillary 2nd premolar (3C-5C), 3 – Distance from Central fossa of maxillary 1st molar to Cusp tip of maxillary canine (6CF-3C), 4 – Distance from central fossa of maxillary 1st molar to Medial end of 3rd palatal rugae (6CF-I and 6CF-J), 5 – Distance from cusp tip of maxillary canine to Medial end of 3rd palatal rugae (3C-I and 3C-J), 6 – Distance from midpoint of incisive papilla to medial end of 3rd palatal rugae (K-I and K-J), 7 – Distance from midpoint of incisive papilla to central fossa of maxillary 1st molar (K-6CF).

extraction before the regenerative bone tissue refills the extraction socket. Considering this, it was decided to compare the amount of canine retraction with and without periodontal distraction.

To measure the amount of canine retraction and anchorage loss, medial point of 3rd rugae was used as

reference point, since it is a stable point as shown in studies by Van der Linden,¹⁷ Almeida et al,¹⁸ Hoggan et al¹⁹ and Jang et al.²⁰ The results of the present study showed that retraction of maxillary and mandibular canine was faster in Group II as

Fig. 3 – The points and the landmarks used in the study on mandibular model: Cusp tip of mandibular canine (3C') – Point L (left) and Point M (right) and Central fossa of permanent 1st molar (6CF'') – Point L (left) and Point M (right).

Fig. 5 – Parameters used in the study on mandibular model: 8 – Distance from Central fossa of mandibular 1st molar to Cusp tip of mandibular canine (6CF''-3C').

Fig. 6 – Measurements on maxillary model with help of Nemoceph software.

compared to Group I. Amount of maxillary canine retraction in Group II was 6.9 mm and in Group I was 5.31 mm after three months. The mean difference between amount of canine retraction from T0–T1 and T1–T2 for the parameters 3C–5C, 6CF–3C and 3C–J was statistically highly significant. In a study by Aboul–Ela et al⁸ mean retraction of canine was 4.79 mm in 3 months on the operated side, which was less as compared to present study (6.9 mm), though the technique used for canine retraction and method of measurement was same in both the studies, but the difference observed could be due to the difference in the surgical approach used in the present study. In the present study interseptal bone was grooved distal to the canine, and this would elicit a regional noxious stimuli thereby accelerating RAP which is characterized by increase in bone turnover and decrease in mineralized content, thereby permitting faster orthodontic tooth movement, while study by Aboul–Ela et al⁸ the perforations were made only in the buccal

cortical plate after raising the periosteal flap. Similarly faster canine retraction of 5.25–6.5 mm in 3 weeks was observed in the studies conducted by Liou and Huang,³ Sayin et al⁴ and Kumar et al¹¹ in comparison to 6.9 mm in 3 months in the present study. The reason for faster canine retraction in their studies in 3 weeks could be due to use of intraoral distractors that were activated on daily basis as compared to use of NiTi coil spring with periodontal distraction in the present study. The forces applied were more physiological, practically feasible and more comfortable to patients in the present study. Method of assessment of canine retraction from 3rd palatal rugae is more accurate and realistic than measurement made in the above mentioned studies^{3,4,11} from lateral incisors or 2nd premolars or 1st molars that can vary because of tooth movements.

On the contrary, no significant difference was found for above parameters between Group I and Group II from T2 to T3.

Fig. 7 – Measurements on mandibular model with help of Nemoceph software.

Table 1 – Intra examiner reliability for the maxillary and mandibular parameters.

S. no.	Parameters	1st set of observations (mm) (n = 7)	2nd set of observations (mm) (n = 7)	Mean difference	t-value	p-value
Maxillary parameters						
1.	6CF-2MI	34.32	34.29	0.028	0.017	0.987
2.	3C-5C	20.10	20.096	0.008	0.007	0.995
3.	6CF-3C	29.97	29.95	0.02	0.014	0.989
4.	6CF-J/6CF-I	11.438	11.44	-0.006	-0.005	0.996
5.	3C-J/3C-I	18.056	18.088	-0.032	-0.031	0.976
6.	K-J/K-I	13.792	13.808	-0.016	-0.016	0.987
7.	K-H/K-J	24.528	24.494	-0.034	0.018	0.986
Mandibular parameters						
8.	6CF''-3C''	21.02	21.01	0.008	0.014	0.989
Not significant ($p \geq 0.05$), *Just significant ($p < 0.05$), **Significant ($p \leq 0.01$), ***Highly significant ($p \leq 0.001$).						

Hence it was interpreted that the rate of movement of canine slows down from T2 to T3 due to healing and organization of extraction socket which was depicted with no statistically significant difference in the rate of canine retraction between 2nd and 3rd month of the study.

In the present study the amount of canine retraction on the side without periodontal distraction was 5.31 mm in 3 months, but in other studies amount of canine retraction without the support of mini-implant was, 1.91 mm/month with PG retraction spring and 1.41 mm/month with the sliding mechanics,¹⁷ 5.69 mm (over 10.7 weeks) with tip-edge bracket and 5.58 mm (11.8 weeks) in straight wire brackets.²¹ In studies where implant supported canine retraction was done, mean value were 4.29 mm in maxilla in 4–6 months⁷ and 3.2 mm over 8 week.²² The result of the present study was higher compared to the above mentioned studies; the reason for above finding can be explained by the fact that the force level was maintained in our study by monthly activation.

In the present study, it was found that the mandibular canines were retracted 5.37 mm in the Group II and 3.96 mm in the Group I over the period of 3 months. The difference between Group I and Group II was statistically significant for the parameter 6CF''-3C'' from T0 to T1, T1 to T2 and T2 to T3. In studies^{3,4} where intraoral distractors were used, amount of canine retraction was much higher compared to the present study. In a study by Thiruvengkatachari et al⁷ mean distal movement of canine was found to be 4.10 mm in 4–6 months, and in a study by Martins et al,²² the mandibular canine cusp

tip was retracted 3.8 mm over 8 week from miniscrew placed for anchorage. These values are similar to the Group I of our study, where periodontal distraction was not done.

The rate of canine retraction in Maxillary arch was observed to be more in comparison to the Mandibular arch at 1st, 2nd and 3rd month of the canine retraction. These findings could be attributed to the fact that the mandible had more dense cortical bone whereas maxilla had more cancellous bone.

No significant molar anchorage loss (6CF-I/6CF-J) was found during canine retraction in both the groups. This showed that miniscrews can function as simple and efficient anchors for canine retraction, this result was supported by the study conducted by Aboula et al.⁸

The major advantages of distraction were shortening of the treatment time and rapid retraction of canines. As intraoral distractors were not used for canine retraction in present study, the periodontal distraction would be more comfortable and convenient for the patients. The average treatment time would also reduce by three to four months. However, the clinical techniques and procedures in canine distraction still need to be refined. The long term effects on root resorption, subsequent development of a developing root, pulp vitality, periodontal tissues, and possible root ankylosis of the canine should be closely monitored.

In future, histologic studies to evaluate underlying biological background of this surgical approach must be carried out. Further research should aim at validating the results of

Table 2 – Comparison of mean and S.D. values of various parameters between Group I and Group II from T0–T1.

S. No.	Parameters	Tooth movement (mm) (T0–T1)		Mean difference	t-value	p-value
		Group I (Mean ± S.D.)	Group II (Mean ± S.D.)			
Maxillary parameters						
1.	6CF-2MI	0.06 ± 0.03	0.104 ± 0.05	0.044	1.126	0.273
2.	3C-5C	2.7 ± 0.52	3.6 ± 0.77	0.90	3.066	0.007**
3.	6CF-3C	2.7 ± 0.49	3.58 ± 0.68	0.88	2.91	0.008**
4.	6CF-J/6CF-I	0.01 ± 0.011	0.01 ± 0.012	—	0.876	0.392
5.	3C-J/3C-I	2.69 ± 0.48	3.57 ± 0.76	0.88	2.89	0.008**
6.	K-J/K-I	0.06 ± 0.04	0.06 ± 0.089	—	0.263	0.793
7.	K-6CF	0.08 ± 0.03	0.08 ± 0.088	—	0.072	0.926
Mandibular parameters						
8	6CF''-3C''	1.96 ± 0.38	2.65 ± 0.39	0.69	4	0.001***
Not significant ($p \geq 0.05$), *Just significant ($p < 0.05$), **Significant ($p \leq 0.01$), ***Highly significant ($p \leq 0.001$).						

Table 3 – Comparison of mean and S.D values of various parameters between Group I and Group II from T1–T2.

S. No.	Parameters	Tooth movement (mm) (T1–T2)		Mean difference	t-value	p-value
		Group I (Mean ± S.D.)	Group II (Mean ± S.D.)			
Maxillary parameters						
1.	6CF-2MI	0.16 ± 0.8	0.134 ± 0.136	0.026	0.45	0.631
2.	3C-5C	1.75 ± 0.2	2.21 ± 0.42	0.46	3.02	0.008**
3.	6CF-3C	1.74 ± 0.27	2.19 ± 0.40	0.45	2.72	0.015*
4.	6CF-J/6CF-I	0.02 ± 0.021	0.01 ± 0.016	0.01	0.698	0.489
5.	3C-J/3C-I	1.72 ± 0.254	2.18 ± 0.424	0.46	2.782	0.013*
6.	K-J/K-I	0.11 ± 0.1	0.09 ± 0.12	0.02	0.31	0.760
7.	K-6CF	0.13 ± 0.1	0.12 ± 0.12	0.01	0.432	0.67
Mandibular parameters						
8.	6CF''-3C''	1.11 ± 0.12	1.53 ± 0.35	0.42	3.716	0.002**
Not significant ($p \geq 0.05$), *Just significant ($p < 0.05$), **Significant ($p \leq 0.01$), ***Highly significant ($p \leq 0.001$).						

Table 4 – Comparison of mean and S.D values of various parameters between Group I and Group II from T2–T3.

S. No.	Parameters	Tooth movement (mm) (T2–T3)		Mean difference	t-value	p-value
		Group I (Mean ± S.D.)	Group II (Mean ± S.D.)			
Maxillary parameters						
1.	6CF-2MI	0.06 ± 0.041	0.114 ± 0.13	0.054	1.341	0.188
2.	3C-5C	0.91 ± 0.269	1.17 ± 0.209	0.26	2.12	0.057
3.	6CF-3C	0.91 ± 0.271	1.16 ± 0.22	0.25	2.04	0.055
4.	6CF-J/6CF-I	0.01 ± 0.01	0.01 ± 0.018	—	0.304	0.765
5.	3C-J/3C-I	0.9 ± 0.266	1.15 ± 0.234	0.25	1.938	0.069
6.	K-J/K-I	0.03 ± 0.019	0.06 ± 0.05	0.06	1.133	0.266
7.	K-6CF	0.04 ± 0.027	0.1 ± 0.132	0.06	1.221	0.236
Mandibular parameters						
8.	6CF''-3C''	0.89 ± 0.082	1.19 ± 0.335	0.3	2.86	0.01**
Not significant ($p \geq 0.05$), * = just significant ($p < 0.05$), ** = significant ($p \leq 0.01$), *** = highly significant ($p \leq 0.001$).						

the present study on larger sample size and to compare the rate of en masse retraction with and without periodontal distraction.

6. Conclusion

We conclude that periodontal distraction during canine retraction reduces the total duration of orthodontic treatment by 3–4 months as there was accelerated canine retraction on the periodontal distraction side as compared to the control side, with negligible anchorage loss and without any unfavorable short term effects in the PDL tissue or surrounding structures.

Conflicts of interest

All authors have none to declare.

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