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Effect of flapless micro-osteoperforations on maxillary canine retraction rate and anchorage loss; a CBCT comparative study

Ahmed A. El Awady, bKalied F. A.abdu allah** and Al-Dany A.Mohammed****

ABSTRACT

Objectives: The purpose of this study to evaluate the effect of micro-osteoperforations on maxillary canine root length changes and anchorage loss . Materials and Methods: Twelve subjects (4 males, 8 females; mean age, 16.17 ± 2.29 years) who required therapeutic extraction of maxillary 1st premolars. Both maxillary canines, in each patient, were randomly assigned to either an experimental or control side in a split-mouth design. In the experimental side, MOPs were performed distal to the canine before starting retraction, while the other side served as a control. Patients were followed up every 28 days until complete canine retraction. A CBCT scans were used to assess the amount of canine root length changes. Also molar anchorage loss was assessed .Results: There were also no significant differences in canine root length changes between both groups. Also no significant difference was found regarding molar anchorage loss between both groups ($P > 0.05$). Conclusions: Micro-osteoperforations doesn't affect the root length of maxillary canine and also have no role in augmentation of maxillary 1st molar anchorage.

KEY WORDS: Root resorption, Micro-osteoperforation, Canine retraction, Anchorage loss.

* Asistant lecturer, Department of Orthodontics, Faculty of Dental Medicine (Boys), Al-Azhar University, Cairo, Egypt.

** Lecturer, Department of Orthodontics, Faculty of Dental Medicine (Boys), Al-Azhar University, Cairo, Egypt.

*** Professor, Department of Orthodontics, Faculty of Dental Medicine (Boys), Al-Azhar University, Cairo, Egypt.

Introduction

One main issues in orthodontics is the prolonged treatment time which can last up to 2 to 3 years, leading patients, especially adults, to avoid treatment or seek alternative options such as implants or veneers with less than optimal results.[1] Increased orthodontic treatment duration has several adverse effects, like pain, discomfort, caries, periodontal problems, gingival recession and apical root resorption. Therefore, both orthodontists and patients are interested in procedures that can speed up the orthodontic tooth movement to minimize the potential treatment risks .[2-5]

Several approaches have been studied in an attempt to accelerate orthodontic tooth movement, including pharmacological approaches , surgical, and physical methods.[3,6-8] The treatment designs which have recently received most attention involve the surgical manipulation.[9] Researchers have attempted to identify minimally invasive surgical procedures for inducing RAP, and it could be induced by micro-osteoperforations and corticision.

Therefore, the study of less invasive dentoalveolar surgical approaches combined with the use of conventional orthodontic appliances with optimum force to accelerate the rate of tooth movement is currently of significant interest. Micro-osteoperforations consists of small and shallow osteoperforations that can safely be placed on the surface of the buccal or lingual cortical plates by the treating orthodontist, with minor side effects and limited pain or discomfort.

This procedure does not require a soft tissue flap or any additional incision. In both animal and human studies, application of few shallow osteoperforations in the proximity of the moving tooth resulted in a significant increase in inflammation, osteoclast activation, bone remodeling, and tooth movement.[5] It can be incorporated into routine orthodontic mechanics and at different stages of treatment, facilitating alignment and root movement, reducing the possibility of root resorption, stimulating bone remodeling in areas of deficient alveolar bone, and reducing the stress on anchor units. [4]

Materials and methods

This was a split mouth randomized clinical trial. Ethical approval was obtained from the ethical committee, faculty of dental medicine (boys), AL-Azhar University, Cairo, Egypt. Patients were selected from the outpatient clinic of the Department of Orthodontics at the faculty. The patients selected for this study had met the following criteria: An age between 14 to 18 years with Class II division 1 malocclusion or Class I bimaxillary protrusion with no or mild symmetrical crowding on both sides. Patients who diagnosed to require extraction of at least maxillary first premolars bilaterally as a part of their treatment plan.

Sample size calculation was based on a previous study, for an alpha error of 0.05 and power of 80 %, the minimum sample size required was estimated to be 12 patients.[8] The randomization was performed with coin tosses to prevent selection bias. Both maxillary canines, in each patient, were randomly assigned to either an experimental or control side.

Interventions

All patients fitted with directly bonded 0.022×0.028-inch slot Roth preadjusted edgewise metallic brackets (Ormco Corporation, Orange, CA). Prior to undergoing dental extractions bilateral 1st and 2nd molars were banded and connected with a transpalatal arch and connected together with a 0.9 mm stainless steel wire soldered palatally for anchorage reinforcement. Extraction was done at the start of treatment, before bonding of the fixed orthodontic appliance. Upper arches were leveled and aligned using conventional sequences of NiTi archwires (Ortho Organizer Super Elastic Nitanium® Archwiress, USA). A final working wire 0.016 × 0.022-inch SS archwires (Ortho Organizer Stainless Steel® Archwiress, USA) were placed for at least 3 weeks to ensure that the archwires were passive by sliding the archwire through the bracket slots.

Micro-osteoperforation Procedure: [8,12-14]

After the leveling and alignment phase and before canine retraction, MOPs were performed in the experimental side according to randomization. Under local anesthesia three MOPs of 1.6 mm width and 4 mm depth inside the bone was made by using miniscrews (HUBIT, Korea) of 1.6 mm diameter and 8 mm length at 3 points distal to the canine midway in the extraction space. First insertion point was 6 mm from the free gingival margin then second insertion point was marked 5 mm from the first one and third point was marked 5 mm from the second point.

Canine retraction and follow up

After application of the MOPs on the experimental side canines were retracted using a NiTi closed coil springs (Modern Orthodontics, India) deliver 150 gm force, stretched between the hooks on the buccal surface of the 1st molar bands and the canine brackets. The applied force was checked by force gauge at each visit (4 weeks) and the appliances were examined for any distortion or change in position and the amount of retraction was measured at each appointment during space closure. Canine retraction was considered completed when Class I canine relationships were established. Post retraction records (CBCT, intra-oral photographs, and study models) were taken.

Patients were evaluated every 28 days to assess the rate of canine retraction.[15] It was based on measuring the bilateral distance between the distal contact points of the canines and the mesial contact points of the second premolars. [16]Each measurement was done twice and the mean of the two values was recorded in the data recording sheet to be used for statistical analysis.[17]

The CBCT scans were taken before orthodontic treatment (T_1) and after canine retraction (T_2) to be analyzed for the following measurements:

1. Root length changes of maxillary canines as was measured along the axis of the root, perpendicular to a line connecting the buccal and palatal CEJ in sagittal view (Fig 1).

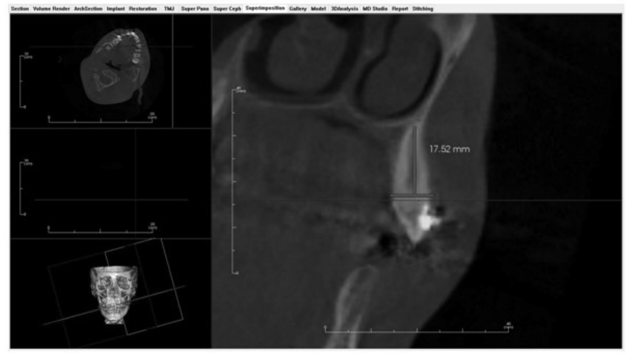

Fig 1 :CBCT sagittal section showing maxillary canine root length

2. Anchorage loss of maxillary 1st permanent molars as the distance measured along perpendicular from distal surface of 1st permanent molar to Ptv plane (Fig 2).

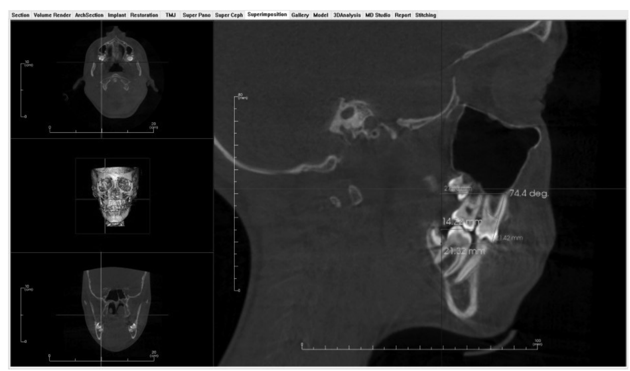

Fig 2: CBCT sagittal section showing 1st molar anchorage loss

Statistical analysis

Statistical analysis was accomplished using the SPSS software (version 20.0; IBM, Armonk, NY). Probability values equal or less than 0.05 were considered significant. Independent sample-t tests were calculated to compare the difference between the MOP and control sides.

Results

All 12 patients had successfully completed the canine retraction phase. The age range of patients was 13-19 years with a mean age was (16.17 ± 2.29) years, the sample was consisted of 8 females and 4 males.

To determine the intra-examiner error of measurements 2nd set of measurements were performed on the records of 4 patients and compared to the first measurements taken from the total sample using Independent sample t-test. The statistical results have demonstrated that no significant difference between 1st and 2nd measurements ($P < 0.05$).

Rate of canine retraction

The results have showed non-statistically significant differences between the two groups in the monthly rate, during 1st month, after 3 months and after total duration of maxillary canine retraction (Table 1).

Comparison of the treatment effects between the two groups:

The result showed non-statistically significant differences ($P > 0.05$) between the two groups for all CBCT measurements.(Table 2)

Table (1): Descriptive statistics and test of significance (independent sample t-test) for the mean differences of total duration ,extraction space, rates of movement at the end of 1st month ,3rd month and total monthly rate of canine retraction between the two groups.

	Control group			MOPs group			Test value	P-value	Sig.
	Mean	SD	SE	Mean	SD	SE			
Duration (days)	110.42	33.15	9.57	105.67	39.91	11.52	-0.317	0.754	NS
Duration (months)	3.68	1.11	0.32	3.52	1.33	0.38	-0.319	0.753	NS
3-5 distance (extraction space)	5.12	0.97	0.28	5.13	1.29	0.37	0.023	0.982	NS
Rate of 1st months (mm/month)	1.10	0.51	0.15	1.51	0.50	0.14	1.991	0.059	NS
Rate of 3 months (mm/month)	1.21	0.32	0.09	1.42	0.45	0.13	1.336	0.195	NS
Rate of total retraction (mm/ month)	1.50	0.42	0.12	1.59	0.49	0.14	0.502	0.621	NS

SD= standard deviation, SE= standard error, P = Probability value, NS.= non significant at P > 0.05

Table (2): Descriptive statistics and test of significance (independent sample t-test) for the mean differences of CBCT variables between the two groups

	Control			MOPs			Test value	P-value	Sig.
	Mean	SD	SE	Mean	SD	SE			
Root Length	-0.25	0.13	0.04	-0.18	0.13	0.04	1.319	0.201	NS
Anchorage Loss (mm)	1.48	1.15	0.33	1.21	0.92	0.27	0.635	0.532	NS

P = Probability level, SD = Standard Deviation, SE = Standard Error, NS - Non-Significant at P > 0.05, PTV = Pterygoid vertical, mm = millimeter.

Discussion

The split-mouth design was selected to reduce the inter-subject biologic variability and each patient acts as his/her own control, thus decreasing the number of participant required. [13] The sample of the current study has included 24 maxillary canines of 12 patients (8 females and 4 males) with an age ranged between 13 and 19 years (16.17 ± 2.29). Narrow age range was selected to obtain as much as possible the same biological response in all subjects. Maxillary canines were selected as they are frequently free from occlusal interferences. During canine retraction occlusal interferences were checked, but none was found that required occlusal adjustment.[8]

To minimize this possibility in the current study, extraction was done at the start of the treatment, and before fitting of the orthodontic appliance. This may facilitate the assessment of the pure impact of MOPs when done after leveling and alignment stage instead of being done in conjunction with extractions.[8,13] Double transpalatal arches on both maxillary 1st and 2nd molars were used in order to control the posterior segment and reduce the torsion of molars.

NiTi closed coil springs were used to retract canines since they generate a continuous light force of 150 g during the whole treatment period, as they do not exhibit rapid force decay such as seen with elastomeric chains or elastic modules.[13,16]

In this study CBCT, which is a 3-dimensional (3D) tool, its images allow accurate 1:1 linear measurements to be made along any plane. So minute linear and angular changes after OTMs can be evaluated with a relatively low dose of radiation and higher resolutions.[18-20]

Regarding the reliability of CBCT measurements in the present study, all measurements were repeated for randomly selected 4 patients. The 1st and 2nd sets of measurements were compared using independent sample t-test. The results have demonstrated that no significant difference between 1st and 2nd measurements ($P < 0.05$) that could indicate a low error of CBCT measurements.

The utilization of conventional orthodontic mini-screw for creation of MOPs offers great potential because they are readily available in some orthodontic offices, and most orthodontists are already trained in their use for multiple orthodontic cases.

In the present study, the possibility of increasing the rate of maxillary canine retraction by using MOPs has been positively demonstrated only during the 1st month of retraction. The average amount of distal canine movement achieved on the MOPs side as measured clinically was 1.51 ± 0.50 mm, while the average amount of canine movement on the control side was 1.10 ± 0.51mm (Table.1). Although there was an increase in the rate of canine retraction on the MOPs side more than on the control side, this increase was very close but didn't reach a statistically significant level ($p=0.059$).

In spite of the rate of canine movement acceleration in the present work didn't reach a statistically significant level, This result is generally agreed with the results of most previous studies tested the effects of MOPs during the first month of retraction.[8,14,21-23] The lack of a significant increase in OTM on the MOPs side in this study can be a result of the minimal surgical insult of MOPs that may not be able to trigger an adequate inflammatory response to activate an ideal RAP effect.[13]

In the present study, most of acceleration had occurred during the 1st month only, and then the rate of canine retraction gradually decreased thereafter. This phenomenon could be attributed to the transient nature of the RAP, as it was reported by Wilcko et al. that RAP had a specific pattern in its emergence and quantity since it begins within few days following injury reaching its peak after 4 to 8 weeks and lasting for 2 to 4 months.[24]

Regarding the total rate of canine movement all over the retraction period (3.52 ± 1.33 month MOPs, 3.68 ± 1.11 month conventional) showed no statistically significant difference between MOPs and control sides (1.59 ± 0.49 versus 1.50 ± 0.42 mm/month) ($p=0.621$). (Table.1) This result is in agreement with the results of Aboalnaga et al and Alkebsi et al. [13,25]

An external RR is a known adverse effect that commonly seen with orthodontic treatment. In the present study, the root length was significantly reduced in both MOPs and control sides after retraction (-0.25 ± 0.13

mm in control and -0.18± 0.13 mm in MOPs side). On comparing both sides, although RR was greater in the control side, the difference was not significantly differs from MOPs side (p= 0.201) (Table.2). The less RR observed in the MOPs side may be due to the increased osteoclastic activity and decreased bone density that were associated with the RAP. It may also due to the decrease of the likelihood of hyalinization necrosis and subsequent RR. This finding is supported by previous studies [13, 25]

Mild anchorage loss of 1st molar occurred in both sides(control 1.48 ± 1.15 mm and MOPs sides 1.21 ± 0.92 mm), the mean difference was greater in the control than the MOPs side by 0.27mm, with no significant difference (P = 0.532) (Table.2). This anchorage loss is less than 1.5 mm and is not considered clinically significant which is concomitant with the results of previous studies.[13]

Conclusions

1. Micro-osteoperforations increases the rate of maxillary canine retraction during the 1st month, this increase seems clinically significant, although it was not statistically significant. This gives clue about the ineffectiveness of the technique unless become repeated on monthly basis.

2. Anchorage loss was similar in both groups.

3. Minimal and clinically insignificant amount of RR was observed in both groups.

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