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Comparative study of root resorption between two methods for accelerated orthodontic tooth movement.

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Abstract: Objective: The aim of this study was to assess apical root resorption (RR) following the application of micro-osteoperforation (MOP) and piezocision (PzC) assisted orthodontics for the acceleration of tooth movement (TM). Materials and Methods: A total number of 16 patients seeking orthodontic therapy were included in this study. All patients had undergone 1st premolars extraction and were indicated for canine retraction. These patients were divided into two groups; one was treated using MOP in one side while the other side served as control. In the other group PzC was performed in one side with no intervention done on the other side. Cone-beam Computed Tomography (CBCT) scans were obtained for every patient before and after canine retraction in order to evaluate amount of RR. Results: In the MOP group, there was no significant difference in canine root length between experimental and control sides. Whereas, in the PzC group, there was a statistically significant decrease in root length in the experimental side compared with the control side. When comparing both groups, the experimental PzC side showed a statistically significant decrease in root length compared to experimental MOP side postoperatively. Conclusion: Experimental PzC showed statistically significant decreases in canine root length compared to both experimental MOP and control side after canine retraction.

Keywords: Root resorption; micro-osteoperforation; piezocision; canine retraction; Cone-beam Computed Tomography.

INTRODUCTION.

Orthodontic treatment related risk factors include treatment duration, TM direction, force magnitude and method of applied force.[1-3] The way orthodontic treatment stimulates RR is unknown. Killiany showed in an evidence-based review that patients undergoing orthodontic treatment are more prone to RR.[1,4]

Apical RR is an undesirable sequela of orthodontic therapy that may affect the result of treatment in some cases.[5] Orthodontic treatment may be continued, modified or discontinued when RR is detected during treatment. Early detection of RR during orthodontic treatment is important for identifying teeth at risk of severe resorption.[6]

During the last decade, many adult patients have been seeking orthodontic treatment. Prolonged treatment times may lead to an increased risk of several undesirable outcomes such as caries, periodontal disease and RR, which is why many adult patients refuse orthodontic treatment.[7]

Keser and Dibart,[8] introduced in 2013 the PzC technique, a novel minimally invasive accelerated orthodontic for TM. This procedure combines micro incisions and local piezoelectric surgery to achieve similar results as decortication, but with minimal trauma.

Alikhani *et al.,*[9] tried also in 2013, MOP clinically for the retraction of canines after first premolar extraction in twenty Class II divison 1 patients, and found that MOP increases rate of TM 2.3 fold in the experimental group compared to the control group.[9]

Hoogeveen *et al.,*[10] in 2014 conducted a systemic review to evaluate the effectiveness of proposed surgically facilitated orthodontic technique on orthodontic TM, including periodontal distraction, dentoalveolar distraction, and corticotomy in addition to minimally invasive methods, which included PzC and MOP. They concluded that there was a low to moderate quality evidence that surgically facilitated orthodontics seemed to be safer for oral tissues and was characterized by a temporary phase of accelerated TM.

Many studies have documented the incidence of RR following orthodontic treatment. This is considered a drawback of orthodontic therapy that can negatively affect the treatment outcome.

The extended treatment time needed in orthodontic therapy is one of the major causes of the increase in the risk of RR. As such, many techniques were introduced in order to accelerate TM thus reducing treatment time. Hence, the aim of this study was to compare the susceptibility of external apical RR in two methods for acceleration of orthodontic TM: MOP and PzC assisted orthodontics.

MATERIALS AND METHODS.

This study was carried out at the Faculty of Dentistry, Alexandria University, Egypt. This study was approved by the Research and Ethics Committee of the Alexandria University, Egypt, ethical approval number IRB: 0001986; IORG: 0009974.

Sixteen patients, aged between 16 and 25 years, seeking orthodontic treatment and indicated for maxillary 1st premolars extraction followed by canine retraction, were equally and randomly divided into two groups. Patients who were taking regular prescription drugs, had parafunctional habits, temporomandibular joint dysfunction, impacted teeth (except third molars), or were periodontally compromised were excluded from the study. The patients were randomly allocated by a sequence generated in SPSS and the allocation was centrally concealed. The sample size was calculated using G*Power software, version 3.1.9. The power of the study was set at 0.80 with a 95% confidence interval, and the effect size was set at 0.6. Hence, the total sample size intended for this research was 16 subjects.

The principal investigator assessed the patients for eligibility and discussed the nature of the trial with patients. After obtaining informed consent, the allocation to experimental or control group was carried out when canine retraction was ready to be started.

Banding and bonding of the maxillary arch using a fixed orthodontic appliance was performed in both groups using a self-ligating straight wire Roth appliance bracket (0.022x0.028 inch slot). This followed patient referral for extraction of the maxillary first premolars. Levelling and alignment was then started until a 0.016x0.022 inch stainless steel arch-wire could be placed passively before the onset of canine retraction.

Maximum anchorage was ensured by placing mini-screws, 10mm in length and 1.6mm in diameter (HUBIT, Korea), bilaterally between the maxillary second premolars and first molars. The mini-screws were placed under local anaesthesia and self-drilled into the bone using a screw driver.

In group A, three MOPs were performed distal to the maxillary canine on the experimental side, while the control side received no intervention prior to the onset of canine retraction. The location of MOPs was initially identified using a periodontal probe punched through the attached gingiva. MOPs were performed using a handheld disposable device especially designed for this purpose (Propel Orthodontics, Ossining, NY, USA) under local infiltration anaesthesia. The device has an adjustable length and a light signal that turns on upon achieving the desired depth during the procedure. Each perforation was 1.5mm wide, and 2 to 3mm deep.

In group B, the surgical procedure was performed under local infiltrative anaesthesia to the mesial and distal sides of the canine on the experimental side. Vertical interproximal incisions were made, 5mm apical to the mesial and distal interdental papilla of the canine, on the buccal aspect using a surgical blade No. 15. Incisions were performed extending 10mm in length apically through the periosteum, allowing the blade to reach the alveolar bone. A piezo surgical knife (Piezomed, tip B1) was used to create the cortical bone incisions through the gingival opening to a depth of 3mm approximately. The canine on the opposite side served as control.

Canine retraction was then started in both groups with the same arch wire (0.016x0.022inch stainless steel), using nickel-titanium closed coil springs placed bilaterally, delivering a force of 150g per side. The closed coil springs were stretched from the miniscrew to the canine hooks.

Before and after canine retraction, CBCT scans were taken for each patient to evaluate external apical RR. CBCT scans were acquired using the Sirona Galileos CBCT system (Sirona Dental System, Bensheim, Germany), at 82 KV, 32mA, scanning time of 2.6sec, voxel size of 0.35mm amorphous silicon flat panel and 13cmx15cm FOV. The scans were saved as DICOM 3D multi-files and imported into a computer software program (Galileos implant version 1.9 SICAT, Bensheim, Germany).

The coronal, sagittal and axial plans were adjusted to intersect in the pulp chamber of the tooth in question at the level of cemento-enamel junction (CEJ). The root length was measured from the most apical point of the root to the cusp tip for the maxillary canines on both sides in both groups, along the long axis in the sagittal view. The measurements were obtained using the software tools, including the linear measurement tool and a digital magnification lens.

Statistical analysis

Analysis was performed using Statistical Package for Social Sciences (SPSS version 20, Chicago, IL, USA) software. Paired t-test was used to compare between the same group (pre and post-operative), while unpaired t-test was used to compare between the two different studied groups. The level of significant considered was $p<0.05$. Inter class correlation (ICC) was performed for intra examiner reliability on 20% repeated measurement after 2 weeks.

Table 1. Evaluation of apical root resorption in the micro-osteoperforation group pre- and post-operative.

N=8	Experimental (mm)		Control (mm)	
	Preoperative	Postoperative	Preoperative	Postoperative
Range	24.33 - 30.39	24.19 - 29.29	24.28 - 31.38	24.1 - 29.6
Mean	27.69	27.24	27.95	27.26
S.D.	2.09	1.76	2.50	1.94
p 1	0.458		0.625	
p 2			0.106	0.422

p1: Pre- and post-operative comparison within group. **p2:** Comparison between the two groups at the same period.

Table 2. Evaluation of apical root resorption in the piezocision group pre- and post-operative.

N=8	Experimental (mm)		Control (mm)	
	Preoperative	Postoperative	Preoperative	Postoperative
Range	24.27 - 31.23	23.7 - 29.6	24.45 - 31.03	23.5 - 29.94
Mean	26.86	24.68	27.05	25.87
S.D.	2.78	2.00	2.70	2.56
p1	0.032*		0.041*	
p2			0.108	0.033*

p1: Pre- and post-operative comparison within group. **p2:** Comparison between the two groups at the same period.
***:** Statistical significant.

Table 3. Comparison between the two groups studied regarding apical root resorption at different subgroups and different period of measurements.

Cases		Experimental (mm)		Control (mm)	
		Preoperative	Postoperative	Preoperative	Postoperative
Micro-osteoperforation group	Range	24.33-30.39	24.19 -29.29	24.28 - 31.38	24.1-29.6
	Mean	27.69	27.24	27.95	27.26
	S.D.	2.09	1.76	2.50	1.94
Piezocision group	Range	24.27-31.23	23.7-29.6	24.45-31.03	23.5-29.94
	Mean	26.86	24.68	27.05	25.87
	S.D.	2.78	2.00	2.70	2.56
	p-value	0.069	0.001*	0.311	0.007*

***p*-value:** Comparison between the two groups at the same time. ***:** Statistical significant.

RESULTS.

The ICC reliability coefficient value ranged from 0.921 to 0.945.

Table 1 shows measured values of canine root length before and after retraction in each side in the MOP group. There was no significant difference on the experimental side before and after retraction. Likewise there was no significant difference in the control side. On comparing both sides after canine retraction, no significant differences were observed ($p>0.05$).

Table 2 shows measured values of canine root length before and after retraction in each side in the PzC group. On comparing the experimental side before and after retraction, there was a statistically significant decrease in root length ($p<0.05$). Also, there was a statistically significant decrease in root length on the control side before and after retraction ($p<0.05$). Comparing canine root length between experimental and control group after retraction a statistically significant decrease in root length in the experimental side compared to the control side was noted ($p<0.05$).

Table 3 shows the comparison between experimental sides regarding canine root length in both groups post-retraction. The experimental PzC side showed a statistically significant decrease in root length compared to experimental MOP side postoperatively ($p<0.05$).

DISCUSSION.

Orthodontic TM is influenced by the applied mechanical force that leads to tissue remodelling within the periodontium. One of the iatrogenic outcomes of orthodontic TM is induced inflammatory RR. Alikhani *et al.*,[11] stated in 2015 that shortening the orthodontic treatment time offers significant value to both orthodontist and patient. Less treatment time with fixed orthodontics reduces the risk for external apical RR.

In various fields within dentistry, we often perform basic imaging methods like intraoral and panoramic radiographs, which usually meet the requirements for dental imaging. However, due to their two-dimensional nature, these imaging methods have some limitations in the evaluation of three-dimensional (3D) structures. In recent years, the advancement of radiography had led to the use of new techniques such as multislice computed tomography (MSCT) and CBCT, which are now uses widely in dentistry due to their reliable and accurate 3D imaging.[12]

RR is a 3D phenomenon, and its extent must be accurately measured. Despite their limitations, radiographic methods were the only available tool to evaluate and measure apical RR. CBCT imaging has shown high sensitivity and excellent specificity. John *et al.*,[12] in 2010 concluded that CBCT is the most reliable method to measure and evaluate external apical RR compared to periapical radiographs which have magnification errors and lack accurate landmark identification.

Jiang *et al.*,[13] in 2017 studied external apical RR using CBCT because it is an accurate imaging technique and provides reliable results. There are many factors that cause RR, such as the magnitude of orthodontic force applied, treatment technique and method of measuring RR. Controlling these factors was difficult in previous studies because data based on 2D radiographs was used, which can result in errors. Using CBCT to measure external apical RR eliminates the errors produced when 2D radiographs are used. In this study, tooth length was used instead of root length to determine external apical RR and this eliminates the effect of different methods to define the root, as it is generally accepted that crown length does not change during orthodontic treatment.[14,15]

Limited clinical knowledge is available on the effect of patient age in inducing external apical RR. The present study has not investigated age and sex related differences. Jiang et al investigated multiple factors that may cause apical RR during canine retraction treatment and reported that older patients tend to have a higher tendency to external apical RR after canine retraction.[13] It is also not clear whether the gender of the patient is a factor increasing the liability of external apical RR. However results reported by Jiang et al showed that female patients tend to be more likely to experience apical RR, but was not statistically significant.[13]

Alikhani *et al.,*[9] in 2013 studied the effect of MOP on the rate of TM after canine retraction and found that no patient in their clinical study showed any signs of RR in routine panoramic radiograph taken at the end of treatment. However, panoramic or periapical radiographs are not accurate for measuring RR and they recommended further studies to investigate the effect of accelerated orthodontic TM on apical RR using more accurate radiographic methods.

In 2015, Alikhani *et al.,*[11] studied MOPs as a minimally invasive accelerated TM technique and found that external apical RR did not increase following MOP treatment. One of the main reasons for external apical RR is the high stresses that produce a cell free zone when a tooth is pushed towards dense bone. In these areas, osteoclasts are recruited from the surrounding periodontal ligament and endosteal surface. The prolonged presence of osteoclasts rather than number of osteoclasts causes external apical RR. With MOP, the number of osteoclasts increases and since MOP decreases the density of adjacent alveolar bone, the cell free zone is smaller and is cleared faster, which prevents prolonged osteoclastic activity adjacent to the tooth root. External apical RR decreases significantly in MOP treatment during TM over long distances. We found insignificant differences between experimental (MOP) and control group.

Darendeliler et al studied the effect of PzC on RR associated with an orthodontic force of 150g using computed tomography, and found that the PzC procedure resulted in an increase in RR on all surfaces and vertical thirds when compared with control sides after application of orthodontic force for 28 days. However, only total RR values reached statistical significance.

It was found that the PzC procedure resulted in 44% average increase in RR compared with the control side.[16] Similarly, the current study also found significant differences among experimental PzC *versus* control and MOP group. Makedonas *et al.,*[17] did not find a relation between treatment duration and RR, where PzC decreased treatment duration by accelerating TM; theoretically this should decrease total RR, but on the contrary the PzC procedure resulted in more apical RR when compared to the control side, which coincides with the results of this study.

CONCLUSION.

No significant differences regarding apical RR were observed between the MOP group and the control group after canine retraction. Significant differences in apical RR were observed between the the PzC group and the control group after canine retraction. Significant apical RR were observed in the experimental PzC side compared to experimental MOP side postoperatively after canine retraction.

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