Original Article

Effect of piezocision-assisted lower second molar protraction on periodontal tissues, alveolar bone height, and lower second molar root resorption

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ABSTRACT

Objectives: To assess the effect of piezocision on periodontal tissues and alveolar bone height and to detect lower second molar root resorption in piezocision-assisted mandibular second molar protraction compared to no-piezocision molar protraction.

Materials and Methods: Twenty-one subjects (four males, 17 females, aged 22.43 ± 2.83 years) who presented with bilateral extraction of lower first molars were included. The patients were divided into two groups; Group 1: Piezocision-assisted molar protraction (right or left side of subjects) in which piezocision was performed immediately before lower second molar protraction and, Group 2: No-piezocision molar protraction in which lower second molar protraction was not surgically assisted. Plaque index (PI), gingival index (GI), periodontal pocket depth (PPD), width of keratinized gingiva (WKG), gingival recession (GR), lower second molar mesial root resorption, alveolar bone height, and mandibular bone height were recorded at T1 (immediately before molar protraction) and at T2 (after second molar space closure).

Results: In the piezocision-assisted molar protraction group, significant changes were detected in the WKG ($P < .001$), GR ($P < .05$), and the mandibular bone height ($P < .001$). Compared to the no-piezocision group, piezocision-assisted molar protraction resulted in an increased WKG ($P < .001$) and less second molar mesial root resorption ($P < .01$).

Conclusions: Piezocision does not have any detrimental effect on the periodontium and produces less root resorption. (*Angle Orthod.* 2023;93:306–312.)

KEY WORDS: Piezocision; Molar protraction; Root resorption; Periodontal tissues

INTRODUCTION

Orthodontic treatment duration varies depending on the type of malocclusion, extraction or nonextraction treatment plan, and patient compliance.[1] Generally, treatment involving closing extraction spaces may prolong treatment duration.[2,3] Conventional treatments using fixed appliances require 18–24 months, where one-third to one-half of this duration is consumed by closure of the extraction space.[4]

Many techniques have been suggested to accelerate orthodontic tooth movement and, hence, shorten treatment time; these include surgical and nonsurgical approaches.[5] Surgical techniques rely on the concept of the regional acceleratory phenomenon (RAP).[6] When a surgical wound is created, it induces the healing process and increases the number of inflammatory mediators around injured tissue. Consequently, bone cells (osteoclasts and osteoblasts) are stimulated to start bone turnover. Additionally, surgical cuts

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around teeth to be moved orthodontically will lead to a decrease in bone density, which will enhance tooth movement.[7] In 2009, Dibart et al.[8] introduced piezocision as a minimally invasive technique to accelerate tooth movement. Piezocision is a flapless surgical technique that involves microsurgical cuts through gingiva to allow the piezoelectric knife to reach the cortical bone in the interproximal area.[9]

In the last few years, many clinical trials have been conducted to evaluate the effects of piezocision on the rate of orthodontic tooth movement,[4,7,9,10] and few studies have explained the possible outcome of piezocision on periodontal tissues and root resorption.[4,11–16] In a systematic review, Figueiredo et al.[7] found no evidence of adverse effects of piezocision on periodontal parameters or root resorption. Raj et al.[11] reported that piezocision-assisted canine retraction was associated with an increase in alveolar bone level on the mesial and buccal aspects.

It has been suggested that the increased osteoclastic activity and decreased bone density that are associated with piezocision decrease the likelihood of root resorption.[12] Abbas et al.[4] evaluated root resorption, plaque index, gingival index, probing depth, attachment level, and gingival recession in piezocision-assisted upper canine retraction. They reported that canine root resorption was greater on the control side and periodontal variables exhibited no differences between the control and the experimental sides over a 3-month follow-up period. However, different findings were reported by others.[13–15] On one hand, Patterson et al.[13] reported that piezocision increased iatrogenic root resorption when used in conjunction with orthodontic forces and Strippoli et al.[15] showed that piezocision-assisted orthodontic treatment resulted in significant anterior tooth root resorption and reduction of alveolar bone height. On the other hand, Charavet et al.[14] found that root length remained unchanged between the two groups (piezocision and no-piezocision) in the pre- to posttreatment interval.

Although the impact of piezocision on periodontal tissues and root resorption has been studied during upper canine retraction,[4,16] buccal tipping of premolars[13] and nonextraction orthodontic treatment,[14,17] no study reported the impact of piezocision on periodontal tissues and root resorption of the lower second molar after protraction to close old first molar extraction space. It has been shown that cortical bone density is greater in the mandible than in the maxilla and in the molar area compared to the canine region.[18] The increased bone turnover and decreased regional bone densities that accompany piezocision may affect alveolar bone height and second molar root resorption. Therefore, this study was conducted to assess the effect of piezocision on periodontal tissues and alveolar bone height and to detect lower second molar mesial root resorption in piezocision-assisted lower second molar protraction compared to no-piezocision molar protraction.

Table 1. Inclusion and Exclusion Criteria

Inclusion criteria
1. Class I malocclusion
2. Bilaterally extracted mandibular first molars
3. First molars extracted more than 1 year ago and with a residual extraction space of more than 5 mm
4. Lower second molar protraction was indicated to close first molar extraction space
5. No history of periodontal surgery in the lower molar area
6. No history of antibiotics use in the last 6 months prior to the study
7. All permanent teeth are present except for the extracted mandibular first molar/molars
Exclusion criteria
1. Poor oral hygiene
2. History of previous orthodontic treatment
3. Smoking habits
4. Presence of any systemic disease

MATERIALS AND METHODS

Ethical approval for conducting this prospective clinical trial was obtained from the Institutional Review Board at Jordan University of Science and Technology (approval number 28/98/2016). Included subjects were participants of a previously published investigation conducted by the same research team.[10,19] All surgical procedures and orthodontic treatments were carried out at the Postgraduate Dental Clinics Jordan University of Science and Technology. The inclusion and exclusion criteria for this study are shown in Table 1. Before orthodontic treatment, periodontal health was assessed by the periodontal department and patients received regular oral healthcare thereafter. Pre- and post-molar protraction radiographs (orthopantomogram [OPG] and periapicals [PA]) were available for all participants.

The G*Power 3.1.9 program was used to calculate the sample size. Assuming a large effect size difference (0.6) at a conventional alpha level (0.05) and a power ($1 - \beta$) of 0.90, a total sample estimate of 33 molars was determined. An overall attrition rate of 10% was assumed; therefore, initial recruitment targeted a total of 37 molars with 19 molars per group.

Intervention

A split-mouth trial design was used. All subjects were treated by the same orthodontic resident (MA) using fixed pre-adjusted edgewise-orthodontic appliances. Tooth alignment started with nickel-titanium (NiTi) archwires before a 0.019×0.025-inch stainless steel (SS) rectangular archwire was tied into the

Table 2. Definition of Clinically Measured Periodontal Parameters

Variable	Definition
Plaque index (PI)[20]	Each of the four surfaces of the lower second molar (buccal, lingual, mesial, and distal) were scored (0 to 3) and averaged to produce a mean value for plaque index. Score 0 No plaque 1 A film of plaque, inside the sulcus and/or the adjacent area of the tooth surface. The plaque can be seen only after passing the probe through the gingival sulcus or by application of disclosing solution on the tooth surface 2 Moderate accumulation of soft deposits within the gingival sulcus and up to the gingival third of the tooth surface, which can be seen with the naked eyes 3 Abundance of soft debris within the gingival sulcus and covering more than one-third of the tooth surface
Gingival index (GI)[21]	Four sites were scored for lower second molar and averaged to produce a mean value for the individual tooth. A probe is inserted in the gingival sulcus to assess the gingival tendency to bleed. 0 No inflammation (normal gingiva) 1 Mild inflammation (slight changes in the gingival color, slight edema with no bleeding on probing 2 Moderate inflammation (increased redness and edema with bleeding on probing) 3 Severe inflammation (marked redness and edema, with ulceration and tendency for spontaneous bleeding)
Periodontal probing depth (PPD)	Measured from the free gingival margin to the base of the sulcus, expressed in mm. PPD was assessed by inserting the probe at six points of tooth surfaces, (mesiobuccal, midbuccal, distobuccal, mesiolingual, midlingual, and distolingual), and the mean was calculated for the indicated tooth.
Width of keratinized gingiva (WKG)[22]	Measured from the free gingival margin to the mucogingival junction, were expressed in mm and assessed at the midbuccal aspect of lower second molars
Gingival recession (GR)[22]	Measured as the distance from the cemento-enamel junction to the free gingival margin

bracket slots. A miniscrew (3M Unitek, Monrovia, CA, USA) temporary anchorage device (TAD), with a 1.8-mm diameter and 8mm length, was inserted on the buccal side of the mandibular alveolar ridge between the roots of the lower first premolar and lower canine to provide anterior anchorage in all patients.

A NiTi coil spring (3M) for space closure (150 g) on a 0.019×0.025-inch SS archwire was applied from the head of the miniscrew to the lower second molar hook.

All the piezocision procedures were performed by the same resident in the periodontal clinic (RA). After rinsing with chlorhexidine gluconate 0.2% for 1 minute, 2% lidocaine anesthetic agent was infiltrated mesial and distal to the lower first molar extraction space. Two incisions were made mesial and distal to the extraction space and a Piezotome was then inserted and bone cuts were done at a depth of 3 mm up to the mucogingival line. Piezocision was performed using a Mectron piezosurgery device (Mectron, Genoa, Italy) without any surgical dressings or sutures placed afterward.

Twenty-one patients (four males, 17 females aged 22.43 ± 2.83 years) who fulfilled the inclusion criteria were selected and divided into two groups:

Group 1: Piezocision-assisted Molar Protraction

Right or left side of the participants. First molar extraction space in this group averaged 8.3 ± 0.7 mm. Pre- and posttreatment second molar angulations averaged $80.4 \pm 3.2°$ and $89.2 \pm 1.3°$, respectively. The piezocision was performed immediately before second molar protraction.

Group 2: Molar Protraction with No Piezocision

Right or left side of participants. First molar extraction space in this group averaged 8.1 ± 0.9 mm. Pre- and posttreatment second molar angulations averaged $81.9 \pm 2.6°$ and $88.7 \pm 1.2°$, respectively. Lower second molar protraction on this side was not surgically assisted.

Measurements

Periodontal parameters (clinical). Periodontal parameters were measured manually using a periodontal probe (Dental probe, University of North Carolina, CP15, PCPUNC156, Hu Friedy, USA) around each lower second molar by a calibrated periodontist (RA). Plaque index (PI), gingival index (GI), periodontal probing depth (PPD), width of keratinized gingiva (WKG), and gingival recession (GR) were recorded. The definitions of the clinically measured periodontal parameters are shown in Table 2.[20–22]

Second molar mesial root resorption (PA). The cementoenamel junction (CEJ) was the line between the mesial CEJ and distal CEJ points. It was called the cervical line where enamel meets cementum to form

Table 3. Means, Standard Deviations (SD) and Wilcoxon Rank-Test Statistics To Detect Within-Group Differences[a]

	No-Piezocision Group		Wilcoxon Rank-Test Statistics		Piezocision Group		Wilcoxon Rank-Test Statistics	
	Before MP	After MP			Before MP	After MP		
	Mean (SD)	Mean (SD)	(Z)	*P* Value	Mean (SD)	Mean (SD)	(Z)	*P* Value
PPD	2.38 (0.50)	3.17 (0.62)	−3.62	<.001***	2.95 (0.38)	3.71 (0.56)	−3.56	<.001***
PI	1.83 (0.29)	1.86 (0.35)	−1.67	.095	2.21 (0.39)	2.15 (0.51)	−0.09	.931
GI	1.68 (0.47)	1.74 (0.48)	−1.48	.138	1.78 (0.27)	1.89 (0.58)	−0.96	.339
WKG	3.87 (0.20)	3.88 (0.18)	−0.71	.476	3.91 (0.22)	4.23 (0.27)	−4.02	<.001***
GR	0.00 (0.00)	0.14 (0.36)	−1.73	.083	0.10 (0.30)	0.33 (0.58)	−2.24	.025*
Distance from CEJ-AC	2.23 (0.27)	2.11 (0.24)	−2.02	.044*	2.15 (0.25)	2.02 (0.22)	−1.95	.052
Distance from LM-AC	28.48 (1.86)	32.05 (1.43)	−4.04	<.001***	29.57 (1.47)	32.76 (1.45)	−4.04	<.001***
Root resorption	1.64 (0.36)				0.94 (0.26)			

[a] AC indicates alveolar crest; CEJ, cementoenamel junction; GI, gingival index; GR, gingival recession; MP indicates molar protraction; PI, plaque index; PPD, periodontal probing depth; WKG, width of keratinized gingiva; LM, lower border of the mandible; * $P < .05$, *** $P < .001$.

the CEJ. The crown length (C) was measured as the length of the line from the highest point on the incisal edge to CEJ line. The root length (R) was measured as the length of the line from CEJ line to the root apex. Crown and root lengths at T1 and T2 (C1 and C2) and (R1 and R2) were measured from the periapical radiograph. The amount of root resorption was calculated as described by Linge and Linge.[23] It was assumed that the crown length does not change during orthodontic treatment; therefore, the ratio between C1 and C2 determined the enlargement factor. If the root was shortened during treatment, the amount of orthodontically induced root resorption (OIRR) was calculated as: R1-R2 (C1/C2). This method of root resorption measurement was reported as being the most accurate.[24]

Alveolar bone height (OPG). After locating the CEJ and AC on the radiographs, the perpendicular distance between them was measured using a digital caliper (sensitivity: 0.01 mm).

Mandibular bone height (OPG). The distance from the upper edge of the alveolar crest (AC) to the inferior border of the mandible (LM) was measured using a digital caliper (sensitivity: 0.01 mm).

The timepoints for periodontal and radiographic measurements were: T1, baseline measurement immediately before molar protraction with or without piezocision; and T2, after second molar space closure (<0.5 mm of space) approximately 10 months after T1 (before debond).

Method Error

Five randomly selected patient records were remeasured after a 2-week interval by the same investigator (MA) to determine the measurement error in this study. Dahlberg's formula ($ME = \sqrt{\sum d2/2N}$) for double measurements was used. The Dahlberg error ranged from 0.05 mm for alveolar bone height, 0.12 mm for mandibular bone height, and 0.05 mm for root resorption.

Statistical Analysis

Statistical Package for the Social Sciences computer software (SPSS 28.0, SPSS Inc., IL, USA) was used. Means and standard deviations (SD) were calculated for all included variables. The Shapiro-Wilk test to assess normality of the data revealed that the data was not normally distributed. The nonparametric Wilcoxon signed-rank test was used to detect within-group differences at the different time intervals. Mann-Whitney *U*-tests were conducted to examine and define the differences between the two studied groups. The level of significance was set at ($P \leq .05$).

RESULTS

Means, standard deviations (SDs), Wilcoxon rank statistics, and *P* values for the periodontal tissue variables, lower second molar mesial root length, and alveolar bone height in the studied groups at the two time points are shown in Table 3.

In the no-piezocision assisted lower molar protraction group, significant changes were detected in alveolar bone height ($P < .05$), PPD ($P < .001$), and the distance from the lower border of the mandible to AC ($P < .001$). In the piezocision-assisted second molar protraction group, significant changes were detected in PPD ($P < .001$), WKG ($P < .001$), GR ($P < .05$), and the distance from lower border of the mandible to AC ($P < .001$).

The results of the Mann-Whitney *U*-test to detect differences between piezocision assisted and no-piezocision molar protraction is shown in Table 4. The piezocision-assisted molar protraction resulted in increased WKG ($P < .001$) and less second molar mesial root resorption ($P < .01$) compared to the no-piezocision molar protraction group.

DISCUSSION

Piezocision has been introduced as a minimally invasive technique to accelerate tooth movement.

Table 4. Mean Rank and Mann-Whitney *U*-Test Statistics of the Change in the Studied Variables Between Piezocision-Assisted and No-Piezocision Molar Protraction[a]

	No-Piezocision Group	Piezocision Group	Mann-Whitney *U*-Test Statistics	
	Mean Rank	Mean Rank	Z	*P* Value
Change in PPD	21.67	21.33	−0.10	.921
Change in PI	20.10	22.90	−0.74	.457
Change in GI	20.50	22.50	−0.53	.597
Change in WKG	11.76	31.24	−5.21	<.001***
Change in GR	20.50	22.50	−0.78	.437
Change in distance from CEJ-AC	21.60	21.40	−0.05	.960
Change in distance from LM-AC	23.12	19.88	−0.88	.379
Root resorption	26.81	16.19	−2.81	.005**

[a] AC indicates alveolar crest; CEJ, cementoenamel junction; GI, gingival index; GR, gingival recession; PI, plaque index; PPD, periodontal probing depth; WKG, width of keratinized gingiva; LM, lower border of the mandible; * <.05, *** $P < .001$.

However, it involves microsurgical cuts through gingiva, which might affect the periodontal tissues. Controversy exists regarding the effect of piezocision on root resorption. Though some studies suggested that periodontal inflammation caused by piezocision resulted in more root resorption,[25] others reported that the reduced bone density as a result of piezocision would reduce force pressure on the tooth roots and, hence, reduce root resorption.[12] Also, it has been shown that cortical bone density is greater in the mandible than in the maxilla and in the molar area than the anterior region.[18] Therefore, this clinical investigation was conducted to assess the effect of piezocision on periodontal tissues, lower second molar mesial root resorption, and alveolar bone height in piezocision-assisted mandibular second molar protraction compared to no-piezocision molar protraction. This was the first clinical trial that compared the periodontal tissues (PI, GI, PPD, WKG, GR) and lower molar root resorption during protraction of mandibular second molars with and without piezocision.

The first molars were extracted at least 1 year before treatment to ensure similar bone structure and dimensions in the extraction socket. It has been reported that complete cortication of the extraction socket was evident in more than 80% of the sockets after only 9–12 months.[26] In a systematic review to analyze dimensional changes of the alveolar ridge after tooth extraction, it was shown that socket height loss was on average 2.5 mm and that loss of socket width was greater than the loss in height.[27]

A mesially tipped mandibular second molar is a frequent finding in subjects with a previously extracted mandibular first molar.[28] In the current study, all subjects presented with their lower second molars tipped mesially before orthodontic treatment. This was associated with reduced alveolar bone level mesial to the lower second molar, which was in agreement with others who suggested that alveolar bone support is usually reduced in tipped molars.[29,30]

Molar uprighting was accompanied by an increase in alveolar bone height in both groups.

The increase in the alveolar bone height was significant in the no-piezocision group and close to the level of significance in the piezocision group when the height was measured to the CEJ. However, alveolar bone height increased significantly in both groups when the height was measured to the lower border of the mandible. The increase in alveolar bone height in both groups suggested that this increase was related to second molar movement into the edentulous space and not to the increased cellular activity when piezocision was done. This was in agreement with others who reported improved alveolar bone dimensions in the area to which a tooth had been moved.[31]

In the current study, no detrimental effects on the periodontium were observed due to the piezocision procedure. Plaque and gingival indices were comparable before and after the molar protraction procedure. This was in agreement with previous studies that suggested similar GI and PI in piezocision and no-piezocision groups during canine retraction[4,16] and complete orthodontic treatment.[14] Maintenance of good oral hygiene during the study due to close supervision of the included subjects may have affected these readings.

Although molar uprighting is usually associated with a reduction of PPD, in the current study, PPD increased after second molar protraction in both groups. In the presence of improved alveolar bone height, this may be explained by the accumulation of gingival overgrowth during space closure, giving rise to a pseudo pocket mesial to the second molar.[32]

In the current study, the WKG was increased in piezocision-assisted molar protraction, while no change was observed in the no-piezocision group. This may be explained by the lingual crown movement of lower second molars, which has been demonstrated after piezocision-assisted molar protraction. The increased osteoclastic activity and decreased bone density that are associated with the osteopenia created by piezocision[6] produce a pliable environment,[8,33] which may lead to lingual torque of second molars.

In the current study, piezocision-assisted molar protraction resulted in more gingival recession after treatment. However, the difference between the two groups was not significant. This was in agreement with Charavet et al.,[14] who demonstrated no change in gingival recession after treatment and periodontal parameters that were similar in the piezocision and control groups.

More second molar mesial root resorption was found in the no-piezocision assisted molar protraction group compared to the piezocision group. This can be explained by the fact that less bone resistance and more osteoclastic activity associated with piezocision can reduce the likelihood of hyalinization necrosis and, hence, root resorption.[12] These findings were in agreement with Abbas et al.[4] and Charavet et al.[14] who reported no increase in root resorption detected in both groups posttreatment, and in contrast with Patterson et al.,[13] who found that the piezocision procedure resulted in a 44% average increase in root resorption. However, none of the above studies investigated root resorption after lower molar protraction. Abbas et al.[4] compared before and after canine retraction, and Charavet et al.[14] compared before and after orthodontic treatment.

Limitations of this study included: greater female-to-male ratio, two-dimensional records were used to record root resorption, and root resorption was measured only on the mesial root of the second molar. The mesial root of the second molar was assessed because of its proximity to the piezocision cut and, also, it was protracted against the more dense, old, first molar extraction space.

CONCLUSIONS

- Piezocision does not produce any detrimental effect on periodontal tissues and was associated with increased WKG and less second molar mesial root resorption.

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