

Effect of piezocision on mandibular second molar protraction

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ABSTRACT

Objectives: To assess the effects of piezocision on the rate of mandibular second molar protraction.

Materials and Methods: Thirty-one subjects (average age: 22.26 ± 5.63 years) who presented with at least one extracted mandibular first molar were selected to participate in the study. The subjects were subdivided into one of two groups, 22 molars each: group 1, where piezocision was performed immediately before molar protraction and group 2, where molar protraction was performed with no piezocision. Piezocision was performed by making two vertical incisions mesial and distal to the extraction space, and bone cuts were done with a length up to the mucogingival line at a depth of 3 mm. The rate of second molar protraction, duration of space closure, and level of interleukin-1- β (IL-1 β) in gingival crevicular fluid (GCF) during the first month of space closure were recorded.

Results: During the first 2 months after surgery, the rates of second molar protraction were 1.26 ± 0.12 mm/month and 0.68 ± 0.19 mm/month in the piezocision and no piezocision groups, respectively ($P < .001$). Duration of lower first molar space closure was 9.61 ± 0.98 months in the piezocision group and 10.87 ± 1.52 months in the no piezocision group ($P < .01$). The level of IL-1 β in GCF was higher in the piezocision group compared to the no piezocision group, up to 1 week after surgery ($P = .02$).

Conclusions: Although piezocision doubled the rate of second molar protraction during the first 2 months after surgery, overall second molar protraction was increased by only 1 month. (*Angle Orthod.* 2020;90:347–353.)

KEY WORDS: Piezocision; Molar; Protraction; Accelerated

INTRODUCTION

Traditional treatment options in Class I malocclusion patients with missing mandibular first molars are either a fixed three-unit bridge or an endosseous dental implant. However, orthodontic space closure of a

remodeled edentulous space by second molar protraction is another treatment that is less invasive.¹ Protraction of a second molar into the space of a missing first molar is a viable alternative when a sound third molar is present, but the thick cortical bone makes it difficult to maintain root parallelism during mesial movement, especially in the mandible.²

The main problem with orthodontic treatment is the long treatment duration which, on average, takes 2 years.^{3,4} This length of time may discourage adult patients to seek orthodontic treatment, encouraging them to accept prosthodontic treatment even if it is dentally invasive.⁵ Many methods to accelerate tooth movement have been reported in the literature to shorten treatment duration and make orthodontic treatment more acceptable to adults.^{5,6} Techniques to accelerate tooth movement can be divided into surgical and nonsurgical. All surgical-orthodontic techniques are based on a biological mechanism called the regional acceleratory phenomenon (RAP) first reported by Frost.⁷ In RAP, the cortical and medullary alveolar bone surrounding the teeth is demineralized (reversible

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Table 1. Baseline Characteristics and Inclusion Criteria of Subjects

	Group 1 (n = 22)	Group 2 (n = 22)
Age (y)	22.25 ± 5.70	22.19 ± 5.60
SNA°	80.89 ± 3.27	81.97 ± 5.91
SNB°	78.87 ± 4.58	78.08 ± 5.28
ANB°	2.68 ± 2.81	3.13 ± 2.18
Maxillary/Mandibular planes angle°	26.73 ± 3.04	27.39 ± 2.64
Lower molar space width (mm)	8.76 ± 0.86	8.43 ± 1.16
Inclusion criteria		
Age range: 20–27 years (averaged 22.26 ± 5.63 years)		
At least one extracted mandibular first molar (first molar extracted more than 1 year ago and with a residual extraction space of >6 mm)		
Class 1 malocclusion where molar protraction is indicated		
All permanent teeth are present except for the extracted mandibular first molar/molars		
Healthy periodontium (gingival index score ≤2, plaque index score ≤2 and probing depth <4 mm)		
No previous orthodontic treatment		
No systemic disease		
Nonsmoker		

osteopenia), which leads to a significant increase in the rate of tooth movement.⁸

Piezocision is one of the latest surgical methods used to accelerate tooth movement.⁹ Dibart et al.¹⁰ were the first to describe this minimally invasive procedure that combined microincisions limited to the buccal side creating small cuts into the bone using a piezotome. The RAP begins a few days after surgery reaching its peak at 1 to 2 months, at which time the RAP begins to decline and disappear, and mineralization of the bone is reestablished again. Many clinical trials were conducted to evaluate the effect of piezocision on the rate of tooth movement.^{6,11,12} Aksakalli et al.¹¹ concluded that piezocision produced a higher rate of canine retraction and decreased the overall duration of the treatment. Uribe et al.⁶ reported that anterior tooth alignment was enhanced 1.6 times in the first 4 to 5 weeks after piezocision but resulted in no significant reduction of overall treatment duration. Charavet et al.¹² reported that the acceleratory effect of piezocision decreased with time.

It was reported that IL-1 β was significantly elevated during orthodontic tooth movement in experimental groups compared with control group.^{13,14} Vujačić et al.¹⁴ reported that both IL-1 β and IL-6 were elevated in juvenile and adult groups after 24 and 168 hours of orthodontic tooth movement. No study has been done as yet to investigate the effect of piezocision on the rate of mandibular second molar protraction. This study was the first clinical trial to investigate the rate of mandibular second molar protraction associated with piezocision. The aim of this study was to assess the effect of piezocision on the rate of mandibular second

molar protraction compared with a no piezocision group (control group).

MATERIALS AND METHODS

The study was reviewed and approved by the Institutional Review Board at King Abdullah University Hospital (KAUH). The participants for this study were recruited from patients attending orthodontic clinics at the postgraduate dental clinics/Jordan University of Science and Technology (JUST). Subjects were selected based on inclusion criteria shown in Table 1. Subsequently, they were asked to sign a consent form to participate in this study after clarifying the purpose of the intervention.

Sample size was calculated using the G*Power 3.1.9 program. According to the power analysis, assuming a large effect size difference (0.6) between groups, it yielded a total sample size estimate of 32 molars at a conventional alpha level (0.05) and desired power (1 – β) of 0.90. Assuming an overall attrition rate of 15%, initial recruitment targeted a total of 37 molars with 19 molars per group.

After recruiting patients who met the inclusion criteria, the intervention (piezocision) was randomly allocated using the permuted random block size of 2 with a 1:1 allocation ratio. The allocation sequence was concealed from the researcher (M.A.) by sequentially numbered, opaque, sealed, and stapled envelopes before the intervention. In subjects with bilaterally extracted first molars, piezocision was randomly assigned to the left or right sides with the contralateral side allocated to serve in the other group (no piezocision). Patients were asked to pick at random a sealed envelope that assigned the method/pattern of intervention.

Subjects were referred to the periodontal department for evaluation of their periodontal health, and to have regular oral care thereafter. The selected patients had their orthodontic treatment performed by the same orthodontic resident (M. A.) using fixed preadjusted edgewise-orthodontic appliances (3M Gemini Unitek brackets, 3M, St. Paul, Minn; 0.022-in. Roth prescription). Patients were followed with monthly appointments. Tooth alignment started with an 0.014-in. nickel-titanium (NiTi) archwire followed by a sequence of NiTi 0.016-in., 0.018-in., 0.016 × 0.022-in. and 0.019 × 0.025-in. archwires before an 0.019 × 0.025-in. stainless steel (SS) rectangular archwire was tied into the slots.

Thirty-one patients who presented with at least one extracted mandibular first molar were selected to participate in the study. The patients (four males and 27 females) were divided into two groups:

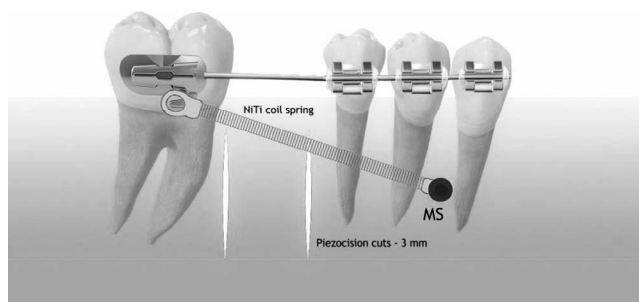


Figure 1. Illustration of molar protraction technique with piezocision.

Group 1: Piezocision / Molar Protraction

This group consisted of 22 molars (13 patients/bilateral and nine patients/unilateral first molar extraction spaces; average age: 22.25 ± 5.70 years). Piezocision was performed immediately before molar protraction.

Group 2: No Piezocision / Molar Protraction (Control Group)

This group consisted of 22 molars (13 patients/bilateral and nine patients/unilateral first molar extraction spaces; average age: 22.19 ± 5.60 years). Molar protraction was performed without piezocision.

After tying in a 0.019×0.025 -in. SS archwire, the miniscrew (3M Unitek) temporary anchorage device (TAD) with a 1.8 mm diameter and 8 mm length was screwed into the bone on the labial surface of the mandibular alveolar ridge between the roots of the mandibular canine and lower first premolar on all patients. A NiTi coil spring (3M) was used for space closure attached from the lower second molar hook to the head of the miniscrew (Figure 1). The protraction force delivered by the coil spring was 150 g. The force was measured using a strain gauge (Dentaurum, Ispringen, Germany) to the nearest gram.

Labial movement of lower incisors during molar protraction was prevented by lingual incisor crown torque and cinch back of the archwire. Occlusal interferences were checked. If present, glass ionomer cement was used on the maxillary incisors to raise the bite (applied in 10 patients with bilateral first molar extraction). Patients were followed up monthly, during which alginate impressions were obtained of all patients at each visit. After removal of the lower archwire, study models were fabricated. These were then scanned with a Ceramill Map 400+ scanner (Amann Girrbach, Koblach, Austria) to obtain a 3D model for accurate measurement. By using Ceramill Mind design (computer-aided design or CAD), 3D model measurements were obtained.

The four gingival crevicular fluid (GFC) samples were obtained from the mesio gingival side of the lower

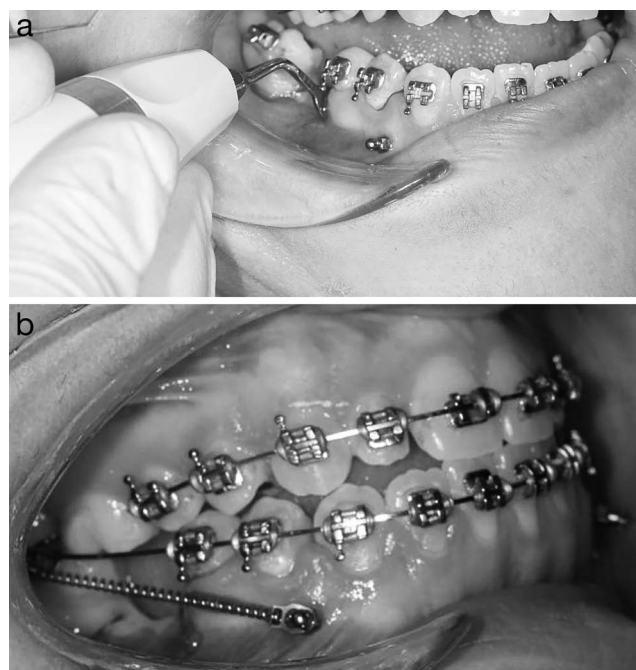


Figure 2. (a, b) Clinical photographs showing piezotome/piezocision.

second permanent molar with use of PerioPaper (Oraflow, Hewlett, NY, USA). The PerioPaper was placed for 60 seconds in the mesio gingival sulcus of the lower second permanent molar. After 60 seconds, the PerioPaper was transferred to an Eppendorf tube (ExtraGene, Taiwan) containing phosphate-buffered saline. The tube was kept for 24 hours at room temperature and then stored at -80°C until the analysis step was carried out. Patients of both groups were asked to come back to the orthodontic clinic 1 day, 1 week, and 4 weeks after molar protraction to take another GFC sample from the same site using the previously described procedure.

All the piezocisions were performed by a single resident in the periodontal clinic (R. A.). The patients were asked to rinse with chlorhexidine gluconate 0.2% for 1 minute before being given local anesthesia. An anesthetic agent (2% lidocaine) was used to perform an infiltration technique mesial and distal to the extraction space. Two incisions were then made using a No. 15 blade, mesial and distal to the extraction space. A Piezotome (Mectron, Genoa, Italy) was then inserted into the previously made incisions and bone cuts were done up to the mucogingival line and at a depth of 3 mm (Figure 2a-b). Piezocision was performed using a Mectron piezosurgery device (Mectron, Genoa, Italy). No sutures or any surgical dressings were placed.

In group 1, patients were asked to return to the orthodontic clinic immediately after the piezocision procedure to attach the NiTi coil spring from the hook of

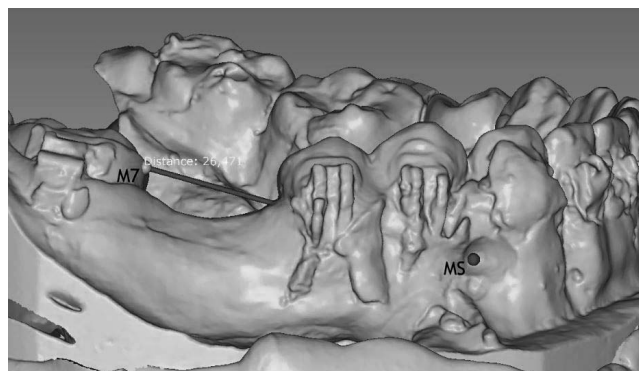


Figure 3. Dental cast measurement of the rate of molar protraction (MS-M7).

the mandibular second permanent molar to the miniscrew. In group 2, a NiTi coil spring was attached from the hook of the mandibular second permanent molar to the miniscrew once the 0.019×0.025 -in. SS archwire was tied in, with no surgical intervention.

Outcomes

- The rate of second molar protraction was determined by indirect measurement of the on-screen study casts. It was measured as the distance from a point representing the maximum convexity of the mesial surface of the lower second molar (M7) to a point representing the miniscrew head (MS) constructed on the lower occlusal plane (Figure 3). The measurements were repeated three times, and the average reading was used.
- The level of interleukin 1 beta (IL-1 β) in GCF were determined according to the manufacturer's instructions using enzyme-linked immunosorbent assay (ELISA) Platinum ELISA (eBioscience Inc, San Diego, CA, USA). GCF level was measured before (baseline), 1 day, 1 week, and 4 weeks after molar protraction.

Method Error

Ten subjects were selected randomly and measurements were done twice with 2-week intervals. The reliability coefficient (Cronbach's alpha) was used to measure the reliability of the first and the second measurement. The Dahlberg formula was used to calculate the standard error of the method. Dahlberg errors were 0.17 mm for the rate of molar protraction. Coefficients of reliability were above 88%.

Statistical Analysis

Statistical analysis was performed using the Statistical Package for the Social Sciences computer software (SPSS 22.0, SPSS Inc., IL, USA). Descriptive statistics

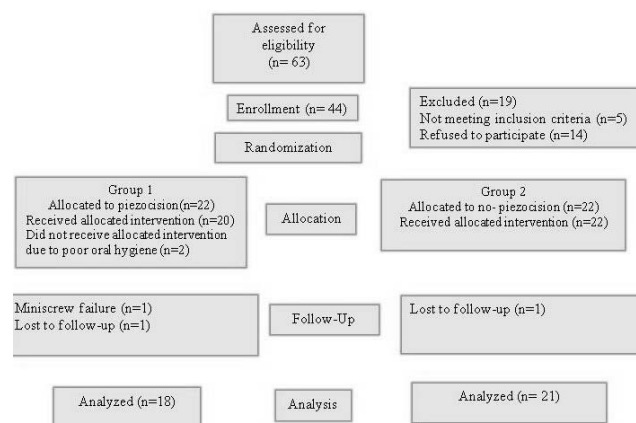


Figure 4. Flowchart showing patient flow during the trial.

for the variables in this study were calculated. Intention-to-treat (ITT) analysis was performed. A repeated-measures analysis of variance (within-subject ANOVA) and independent *t*-tests were conducted to examine and define the differences between the studied groups. The level of significance was set at $P \leq .05$.

RESULTS

Data regarding age, mandibular molar space width and cephalometric analysis of the subjects in each group are listed in Table 1.

Participant Flow (Figure 4)

In group 1, 20 molars received piezocision intervention. Two patients were excluded (one due to miniscrew failure and the other missed one appointment). In group 2, one patient was excluded due to missing appointments. During the analysis stage, there were 26 patients (four males and 22 females) with 39 first molar extraction spaces (18 molars that received piezocision intervention and 21 molars that did not and acted as the comparison group). No bracket or molar tube failure was identified during molar protraction in any subject.

Mean differences, standard deviations (SDs), differences between the means, standard error (SE), 95% confidence interval (CI) of the mean differences and *P* values for the rate of second molar protraction, and interleukin-1- β level in the studied groups are shown in Tables 2–4. The rate of molar protraction was doubled in the first 2 months after performing piezocision ($P < .001$) and slowed down afterward ($P > .05$). The total amount of molar protraction was 1.26 mm/month and 1.21 mm/month more on the piezocision side ($P < .001$) after 3 months and 5 months of the surgical procedure, respectively. Duration of complete lower first molar space closure by second molar protraction was 9.61 ± 0.98 months and 10.87 ± 1.52 months in

Table 2. Mean Differences, Standard Deviations (SD), Differences Between Mean, Standard Error (SE), 95% Confidence Interval (C.I.) of the Mean Differences and *P* Values for the Rate of Second Molar Protraction per Month in Studied Groups

Molar Protraction	Piezocision Group Mean \pm SD	No Piezocision (Control Group) Mean \pm SD	Mean Diff \pm SE	95% CI of the Mean Diff
Diff T1-T0	1.26 \pm 0.12	0.68 \pm 0.19	0.57 \pm 0.05***	0.46–0.68
Diff T2-T1	1.23 \pm 0.13	0.61 \pm 0.20	0.61 \pm 0.05***	0.50–0.73
Diff T3-T2	0.73 \pm 0.24	0.67 \pm 0.34	0.06 \pm 0.10	0.03–0.21
Diff T4-T3	0.65 \pm 0.12	0.68 \pm 0.20	–0.03 \pm 0.08	–0.05–0.12
Diff T5-T4	0.66 \pm 0.16	0.68 \pm 0.21	0.01 \pm 0.10	0.00–0.13
Diff T3-T0	3.22 \pm 0.32	1.97 \pm 0.48	1.26 \pm 0.13***	0.64–1.12
Diff T5-T0	4.53 \pm 0.40	3.32 \pm 0.36	1.21 \pm 0.16***	0.12–0.54
Space closure duration (mo)	9.61 \pm 0.98	10.87 \pm 1.52	1.26 \pm 0.41**	–2.09 to –0.42

^a T0: Baseline, T1: after 1 mo, T2: after 2 mo, T3: after 3 mo, T4: after 4 mo, T5: after 5 mo.

** *P* < .01, *** *P* < .001.

piezocision and non piezocision groups, respectively (*P* < .01).

The piezocision side showed significant elevation of interleukin-1- β level in the piezocision group for up to 4 weeks (*P* < .01), compared to the baseline reading, while the no piezocision side showed a significant elevation in interleukin-1- β level up to 1 week (*P* < .001) compared to the baseline reading.

DISCUSSION

The aim of this clinical study was to compare the rate of molar protraction, with and without piezocision, during lower first molar extraction space closure. The rate of tooth movement depends on bone density, turnover rate, and hyalinization of the periodontal ligament.¹⁵ In adult patients, there is a reduced cellular activity and an increased bone density. Hyalinized zones are formed more readily on the pressure side, thereby reducing the rate of tooth movement and increasing treatment duration.¹⁶ This was the first clinical trial that compared the rate of tooth movement of protraction of mandibular second molars with and without piezocision.

Although the effects of age on OTM was mostly concluded using animal model studies, the effect of age on OTM clearly exists and is likely due in part to a

decreased biologic response. Misawa-Kageyama et al.¹⁷ reported that a significantly greater amount and rate of tooth movement occurred in younger rats compared with their older counterparts. In the current study, all selected patients were older than 18 years of age, since a higher rate of tooth movement has been reported in patients younger than 16 years of age.¹⁸

Patients with an extraction space of at least 1 year old were included to ensure complete extraction socket cortication. Bertl et al.¹⁹ suggested that 60% of extraction sockets were not completely corticated 6–9 months after tooth loss, and that complete cortication was present in more than 80% of the sockets only after 9–12 months.

Molar protraction was achieved using NiTi coil spring and a 0.019 \times 0.025-in. SS arch wire to achieve maximum amount of bodily movement. Any occlusal interferences from opposing first molars were eliminated before starting molar protraction by intrusion of upper molars using TADs or raising the bite with glass ionomer cement because occlusal interferences might have had a negative effect on the rate of tooth movement.²⁰ Although some mesial tipping of the second molar may have occurred during protraction, second molar and second premolar roots were parallel after space closure.

Table 3. Means and Standard Deviations (SD) for the Interleukin-1- β Level, Differences Between the Means, Standard Error (SE), 95% Confidence Interval (CI) of the Mean Differences and *P* Values for Interleukin-1- β Level in GCF Within Each Group at the Different Time Points

Interleukin-1- β Level in GCF (Pg/mL)	Piezocision Mean \pm SD	No Piezocision Mean \pm SD				
T0 (baseline level)	169.94 \pm 81.33	189.93 \pm 76.12				
T1 (after 1day)	384.13 \pm 118.18	301.60 \pm 82.42				
T2 (after 1week)	301.32 \pm 103.43	248.92 \pm 75.93				
T3 (after 4 weeks)	234.54 \pm 103.43	209.69 \pm 69.36				
	Mean Diff \pm SE	CI of the Mean Diff	<i>P</i> Value	Mean Diff \pm SE	CI of the Mean Diff	<i>P</i> Value
T1-T0	214.20 \pm 24.07	142.36–286.03	.001***	111.68 \pm 16.14	64.43–158.93	.001***
T2-T0	131.39 \pm 20.95	68.86–193.91	.001***	58.99 \pm 8.39	34.45–83.54	.001***
T3-T0	64.60 \pm 18.53	9.13–119.89	.01*	19.76 \pm 7.48	2.12–41.64	.09

* Significant at *P* < .05, *** Significant at *P* < .001.

Table 4. Mean Differences, Standard Deviations (SD), Differences Between the Means, Standard Error (SE), 95% Confidence Interval (CI) of the Mean Differences and *P* Values for Interleukin-1- β Level in GCF in Studied Groups

Interleukin 1- β Level (Pg/mL)	Piezocision Mean \pm SD	No Piezocision (Control Group) Mean \pm SD	Mean Diff \pm SE	8CI of the Mean Diff
Diff T1-T0	214.20 \pm 102.13	111.68 \pm 73.97	102.52 \pm 28.28***	45.22–159.82
Diff T2-T1	82.81 \pm 46.20	52.68 \pm 52.79	30.13 \pm 16.02	2.33–62.86
Diff T2-T0	66.79 \pm 43.0	39.23 \pm 37.33	27.55 \pm 12.86*	1.50–53.61
Diff T3-T0	64.60 \pm 78.61	19.76 \pm 43.25	44.84 \pm 18.93*	6.48–83.20

^a T0: baseline, T1: after 1 day, T2: after 1 week, T3: after 4 weeks.

* *P* < .05, *** *P* < .001.

Piezocision was carried out just before space closure by second molar protraction according to the technique described by Dibart et al.²¹ On the experimental side, two vertical incisions on the buccal side of the alveolar ridge were performed. A 3-mm deep piezoelectric corticotomy was done.²¹ The cuts in this study were deeper than the traditional circumscribed corticotomy, which involve 2 mm vertical and horizontal cuts in the cortical bone circumscribing the teeth to be moved.

The current clinical trial demonstrated that there was a significant increase in the rate of tooth movement in patients who received piezocision compared to the patients who did not. The duration of this increased rate was for 2 months and the magnitude was 1.3 mm/month. The increased rate of tooth movement observed in this trial was in agreement with Alikhani et al.,⁵ who reported that canine retraction was doubled when the piezocision technique was performed before retraction. Also, Abbas et al.²² reported that piezocision increased the rate of upper canine retraction by 1.5 times compared to controls. The increased rate of tooth movement was evidenced only for a period of 2 months after performing the surgical procedure before declining toward the normal value at the end of 3 months. This was in agreement with Abbas et al.²² reported faster tooth movement, which lasted for 10 to 12 weeks after piezocision.

Although the rate of molar protraction was doubled during the first 2 months after piezocision, the net reduction in space closure duration was only 1.26 months. As the acceleratory effect of piezocision was transient, the possibility of needing to repeat the procedure to continue the space closure at the same rate would be needed. However, the 1-month gain of time during treatment does not justify such a procedure even if it is minimally invasive. This was in agreement with Liu et al.,²³ who found only low-quality evidence to support that flapless corticotomy could accelerate tooth movement.

The results of the current study showed that the level of IL-1 β in GCF was elevated in the first 24 hours after application of orthodontic force. This was in agreement

with Tzannetou et al.,¹³ who reported that the level of IL-1 β significantly increased after application of orthodontic force. The resulting increased rate of molar protraction in the piezocision group can be explained by the elevation of IL-1 β , which would have a positive effect on osteoclast function.

Limitations of the current study included a greater female-to-male ratio, the short duration of this clinical study and the use of alginate impressions to fabricate dental casts that were then further scanned to 3D digital models on which measurements were taken. Also, the use of TADs as a stable reference point for evaluating the rate of OTM was another added limitation. Liou et al.²⁴ suggested that miniscrews did not remain absolutely stationary during orthodontic loading and may move according to the orthodontic loading.

Clinically, piezocision reduced orthodontic treatment time by only 1 month, which does not justify such an added procedure even if it was minimally invasive. More evidence to justify the use of surgically-assisted orthodontics as an additional procedure is needed.

CONCLUSIONS

- Although piezocision doubled the rate of second molar protraction for the first 2 months after surgery, first molar space closure overall was reduced by 1 month only. The level of interleukin-1- β in GCF was elevated up to the first 28 days after piezocision and up to 1 week after orthodontic force application.

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