Evaluation of patient-centered outcomes associated with the acceleration of canine retraction by using minimally invasive surgical procedures: A randomized clinical controlled trial

Ocena korzyści pacjenta związanych z akceleracją cofania kłów po zastosowaniu minimalnie inwazyjnych technik chirurgicznych – randomizowane badanie kliniczne z grupą kontrolną

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Conflict of interest

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Abstract

Background. Only a few studies in the literature have reported patient-centered outcomes associated with minimally invasive corticotomy, and thus, related scientific evidence is limited.

Objectives. The objective of this study was to evaluate patient-centered outcomes associated with upper canine retraction assisted with piezocision or laser-assisted flapless corticotomy (LAFc).

Material and methods. Thirty-two patients (19 females, 13 males) at a mean age of 18.25 ± 3.05 years were randomly divided into 2 equal groups: the LAFc group (LG; $n = 16$) and the piezocision group (PG; $n = 16$). In each group, the surgical procedure was randomly assigned to one side of the maxillary arch, and the other side served as the control. Standardized questionnaires using the numerical rating scale (NRS) were distributed to all patients during the 1st month after the surgical procedure at 4 time points: 24 h (T1); 3 days (T2); 7 days (T3); and 14 days (T4). The patients' responses were obtained, regarding their feelings of pain, discomfort, swelling, eating difficulty, jaw movement restriction, analgesic consumption, and satisfaction.

Results. The levels of pain, discomfort, swelling, and difficulty in chewing were significantly greater at the experimental sides as compared to the control sides only at T1 in both groups ($p < 0.05$). The levels of pain and discomfort in LG were significantly lower than those in PG only at T1 ($p = 0.013$ and $p = 0.009$, respectively) whereas there were no significant differences between the groups regarding swelling, eating difficulty, jaw movement restriction, and analgesic consumption. The patients in both groups reported high levels of satisfaction, with no significant differences. The levels of pain, discomfort, swelling, eating difficulty, and jaw movement restriction were dramatically decreased 1 day after flapless corticotomy treatment in both groups ($p < 0.05$).

Conclusions. Both LAFc and piezocision were associated with high levels of pain, discomfort, swelling, and difficulty in chewing at T1. Laser-assisted flapless corticotomy caused less pain and discomfort than piezocision.

Key words: piezosurgery, orthodontic tooth movement, minimally invasive surgical procedures, patient-centered care

Słowa kluczowe: piezochirurgia, ortodontyczny ruch zębów, minimalnie inwazyjne techniki chirurgiczne, opieka skoncentrowana na pacjencie

Introduction

Due to esthetic concerns, the reduction of orthodontic treatment time is considered one of the most important needs of both patients and orthodontists.¹ Corticotomy-assisted orthodontic treatment (CAOT) has been recently introduced as an effective solution for adults who seek accelerated orthodontic tooth movement,^{2,3} but it has not met with general approval from patients because of the aggressive nature of corticotomy, and the attendant anxiety and fear of pain.⁴ Therefore, several forms of minimally invasive corticotomy have been developed as alternative procedures to traditional corticotomy; these procedures do not need the extensive removal of the cortical bone or full mucoperiosteal flaps, and use innovative tools which cause less trauma. One example is piezocision – a minimally invasive procedure introduced in 2009 by Dibart et al. to overcome the disadvantages of corticotomy.⁵ This technique involves performing vertical cuts in the attached gingiva and the alveolar cortical bone without flap elevation using a piezosurgery knife.⁵ It has also been suggested that laser-assisted flapless corticotomy (LAFC) might cause less trauma to hard and soft tissues, and result in fewer complications.^{6,7}

One of the most important disadvantages of surgical techniques used to accelerate tooth movement is the patient's pain and discomfort.⁸ Furthermore, studies have shown that pain is considered a deterrent for orthodontic treatment and an important reason to stop it.⁹ It has been claimed that minimally invasive surgical procedures could accelerate orthodontic tooth movement with minimal levels of pain and discomfort, but only a few studies in the literature have reported patient-centered outcomes associated with minimally invasive corticotomy,¹⁰ and related scientific evidence is limited.^{11–13} Therefore, the aim of the current trial was to evaluate and compare patient-centered outcomes associated with canine retraction accelerated by using piezocision or LAFC.

Material and methods

Subjects and study design

The local ethics committee of the Dental School at the University of Damascus in Syria approved the protocol of the current trial (UDDS-372-07042015/SRC-2744). The trial was conducted between February 2017 and December 2018. This study was a compound parallel-group randomized controlled trial. Thirty-two patients were allocated randomly to the LAFC group (LG; $n = 16$) and the

piezocision group (PG; $n = 16$); then, a split-mouth design was applied in each group so that patients could receive canine retraction facilitated with either LAFC or piezocision at the experimental side, with the contralateral side serving as the control (without any intervention). Computer-generated randomization lists with an allocation ratio 1:1 were created by one of the co-authors (O.H.) using Minitab®, v. 17 (Minitab Inc., State College, USA). Allocation was concealed by using a sequentially numbered, opaque, sealed envelope. Blinding was applied only for the outcome assessor, as blinding of the principal researcher and the patients was not possible.

Thirty-two adult patients (19 females, 13 males) at a mean age of 18.25 ± 3.05 years who visited the Department of Orthodontics of the Dental School at the University of Damascus, Syria, were recruited into this study. All the patients met the following inclusion criteria: class II division I malocclusion with an indication for the extraction of the upper first premolars (an overjet of 5–10 mm, normal or long face growth patterns); age range between 16 and 29 years; healthy patients with no prior orthodontic treatment; and good oral hygiene (probing depth ≤ 3 mm, no alveolar bone loss assessed radiographically).

The teeth were leveled and aligned using MBT™ prescription brackets with 0.022-inch slots (JISCOP Co., Ltd., Gunpo-si, South Korea). The upper first premolars were extracted before the fixed appliances were applied and moderate anchorage (soldered transpalatal arch) was used. After the completion of leveling and alignment, and before canine distalization, flapless corticotomy was performed at the experimental side. Once local anesthesia had taken effect, in PG, 2 vertical incisions, each of a length of 10 mm, were made using a No. 15 blade in the attached gingiva distal to the upper canines; then, cortical incisions were made using a piezosurgery knife (BS1, Piezotome®, Implant Center™ 2; Satelec, Mérignac, France) in the alveolar cortical bone with a depth of 3 mm. In LG, an erbium-doped yttrium aluminum garnet (Er:YAG) laser (LightWalker® ST-E; Fotona, Ljubljana, Slovenia) with a R14C handpiece and the Cylindrical Sapphire Tip (diameter: 1.3 mm, length: 8 mm) in the non-contact mode was used to perform both gingival and cortical perforations. Five perforations were conducted distal to the upper canines; each perforation was 1.3 mm wide and away from the other perforation at least 1.5 mm, with a depth of 3 mm. The device settings were as follows: 100 mJ, 10 Hz and 2 W for soft tissue perforations, and then the settings were changed to 200 mJ, 12 Hz and 3 W for cortical perforations. No sutures were applied and antibiotics (Augmentin®, 625-milligram tablets) were prescribed for 5 days in both groups,^{14,15} although recent guidelines of the American Dental Association (ADA) indicate that it is not necessary

to administer a prophylactic antibiotic cover following minor surgery in patients with good health and immunity.¹⁶ The patients were instructed to take analgesics (paracetamol, 500-milligram tablets) only when necessary and at least 6 h before filling out the questionnaire. The patients were also asked to record and inform the researcher about the number of paracetamol tablets they took.

Canine retraction was initiated immediately on 0.019 × 0.025-inch stainless steel (SS) wires using 150-gram NiTi closed-coil springs and continued until class I relationship was achieved as shown in Fig. 1. The same researcher (A.M.H.A.) treated all patients in both groups.

Questionnaires

Standardized questionnaires were answered by the patients at chairside as shown in Table 1. The researcher was present to answer any questions raised by the patients while filling out the questionnaire without affecting their responses. The patients' responses were obtained, regarding their perception of pain, discomfort, swelling, eating difficulty, jaw movement restriction, and analgesic consumption at 4 assessment time points: 24 h (T1), 3 days (T2), 7 days (T3), and 14 days (T4) after the onset of canine retraction. The patients were also asked about their levels of satisfaction, whether they would advise a friend to undergo the same surgical intervention, and whether the extraction of the premolars or the surgical intervention was the most annoying experience at the end of the canine retraction stage (T5).

The first 10 questions were related to the perception of pain, discomfort, swelling, difficulty in chewing, difficulty in swallowing, and restriction in jaw movement. The patients recorded their responses using the numerical rating scale (NRS), with 0 and 10 placed at the opposite ends of this scale. With regard to pain assessment, the patients were instructed that 0 would mean 'no pain' and 10 would mean 'the worst pain imaginable'.

Table 1. Questions given to the patients at 5 assessment time points

No.	Question
1	Do you have pain in your mouth or teeth at the surgical intervention side?
2	Do you have pain in your mouth or teeth at the non-operated side?
3	Do you experience discomfort in your mouth or teeth at the surgical intervention side?
4	Do you experience discomfort in your mouth or teeth at the non-operated side?
5	Do you experience swelling in your mouth at the surgical intervention side?
6	Do you experience swelling in your mouth at the non-operated side?
7	Do you experience difficulty in chewing food at the surgical intervention side?
8	Do you experience difficulty in chewing food at the non-operated side?
9	Do you experience difficulty in swallowing?
10	Do you experience restriction in jaw movement?
11	Have you used analgesics for pain from your teeth or jaws? If yes, what dosage did you use?
12	Are you satisfied with your treatment?
13	Would you advise a friend to undergo the same treatment?
14	What was more disturbing to you – the extraction of the premolars or the surgical intervention?

Questions 1–11 were asked at 1 day (T1), 3 days (T2), 7 days (T3), and 14 days (T4) after the onset of canine retraction whereas questions 12–14 were asked at the end of canine retraction (T5).

The same method of recording the patients' experiences on this scale was explained for the rest of the questions. Question 11 was answered with 'yes/no' and a space was provided for writing the amount of consumption in grams. Question 12 was also answered using NRS, but 0 meant 'no satisfaction' and 10 meant 'the best satisfaction'. The questionnaires were analyzed by one of the co-authors (M.A.A.), who was blinded to treatment allocation.

Fig. 1. Canine retraction using NiTi closed-coil springs, facilitated by laser-assisted flapless corticotomy (LAFC) (A) or piezocision (B)

Statistical analysis

The Minitab software, v. 17 was used to calculate the sample size and conduct all statistical analyses by one of the co-authors (M.Y.H.), who was blinded to the data collected in the questionnaires.

The non-parametric Wilcoxon signed-rank tests were used to assess differences within each group between the control and experimental sides. The Mann–Whitney *U* tests were used to detect differences between the 2 groups regarding pain, discomfort, swelling, difficulty in chewing, difficulty in swallowing, restriction in jaw movement, and satisfaction. The χ^2 tests were used to assess differences between the groups concerning the consumption of analgesics, the recommendation of the procedure to a friend, and whether the extraction of the premolars or the surgical intervention was the most disturbing experience. To evaluate changes in the studied variables over time, Friedman's test was used. When a result was significant, the post-hoc Wilcoxon matched-pairs signed-rank tests were employed. Statistical significance was considered when a *p*-value was found less than 5%. For the multiplicity of tests, the Bonferroni correction was employed.

Results

All patients completed their questionnaires and no patient was lost to follow-up. Consequently, LG involved 16 patients (10 females, 6 males) at a mean age of 18.44 ± 3.38 years whereas PG involved 16 patients (9 females, 7 males) at a mean age of 18.06 ± 2.79 years. There were no significant differences between both group regarding age ($p = 0.711$) and gender ($p = 0.719$). Patient allocation and follow-up are presented in Fig. 2.

Pain and discomfort

The levels of experienced pain and discomfort were significantly greater at the experimental sides as compared to the control sides at T1 in LG ($p = 0.005$ and $p < 0.001$, respectively) and also PG ($p = 0.001$ and $p < 0.001$, respectively) as shown in Table 2 and Fig. 3.

Then, the levels of pain and discomfort perception greatly decreased at the experimental sides to the extent that the differences between the 2 sides were not significant at T2, T3 and T4 in both groups. The levels

Fig. 2. CONSORT (Consolidated Standards of Reporting Trials) participants' flow diagram

PG – piezocision group; LG – LAFC group.

of pain and discomfort perception in LG were significantly lower than those in PG only at T1 ($p = 0.013$ and $p = 0.009$, respectively) whereas there were no significant differences between both groups at the subsequent assessment time points.

Swelling and difficulty in chewing

The levels of swelling and difficulty in chewing were significantly higher at the experimental sides than in the control sides only at T1 in both groups ($p < 0.001$).

Table 2. Descriptive statistics of the levels of pain, discomfort, swelling, and difficulty in chewing perceived by the patients as well as the p -values of significance tests

Time point	Variable	LG (<i>n</i> = 16)					PG (<i>n</i> = 16)					LG vs PG	
		experimental side		control side		<i>p</i> -value [†]	experimental side		control side		<i>p</i> -value [†]		<i>p</i> -value ^{††}
		<i>Me</i>	<i>IQR</i>	<i>Me</i>	<i>IQR</i>		<i>Me</i>	<i>IQR</i>	<i>Me</i>	<i>IQR</i>			
T1	pain	4	2–5	2	1–2.75	0.005*	5.5	4–7	1.5	0.25–2.75	0.001**	0.013*	
	discomfort	5.5	5–7	3	2–4	<0.001***	8	6–9	4	3–5	<0.001***	0.009**	
	swelling	2	1.25–3	1	0–1	<0.001***	3	2–4	1	0.25–2	<0.001***	0.118	
	difficulty in chewing	4	3–5	1	1–2	<0.001***	4.5	4–6	2	1–3	<0.001***	0.082	
T2	pain	1	0–2	1	0–1	0.106	1.5	1–2.75	1	0.25–1.75	0.100	0.338	
	discomfort	3	1.25–4	2	1–2.75	0.096	3	2–4.75	2	1–3	0.065	0.528	
	swelling	1	0–2	0.5	0–1	0.070	2	1–2	1	0–2	0.078	0.109	
	difficulty in chewing	1	0–2	0.5	0–1	0.073	2	0.25–3	1.5	0–2	0.119	0.194	
T3	pain	0	0–1	0	0–1	0.157	1	0–1	0	0–1	0.157	0.695	
	discomfort	0	0–1.75	0	0–0.75	0.167	0	0–2	0	0–1	0.121	0.983	
	swelling	0	0–0	0	0–0	0.480	0	0–1	0	0–0.75	0.405	0.281	
	difficulty in chewing	0	0–1	0	0–0.75	0.272	0.5	0–2	0	0–1	0.155	0.415	
T4	pain	0	0–0	0	0–0	0.157	0	0–0	0	0–0	0.317	0.632	
	discomfort	0	0–0.75	0	0–0.75	1.000	0	0–0.75	0	0–0	0.317	0.920	
	swelling	0	0–0	0	0–0	0.317	0	0–0	0	0–0	0.157	0.551	
	difficulty in chewing	0	0–0.5	0	0–0	0.414	0	0–1	0	0–0	0.102	0.544	

Me – median; IQR – interquartile range; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; † Wilcoxon signed-rank test; †† Mann–Whitney U test.

Fig. 3. Box plot showing the levels of pain (A) and discomfort (B) assessed on the numerical rating scale (NRS) in both groups. The asterisks indicate extreme outliers whereas dots indicate outliers.

There were no significant differences between both sides at T2, T3 and T4. There were no significant differences between both groups at all evaluated time points as shown in Table 2 and Fig. 4.

Difficulty in swallowing and jaw movement restriction

There were no significant differences between LG and PG at all evaluated time points (Table 3 and Fig. 5).

Fig. 4. Box plot showing the levels of swelling (A) and difficulty in chewing (B) assessed on NRS in both groups. The asterisks indicate extreme outliers whereas dots indicate outliers.

Fig. 5. Box plot showing the levels of difficulty in swallowing (A) and restriction in jaw movements assessed on NRS in both groups. The asterisks indicate extreme outliers whereas dots indicate outliers.

Table 3. Descriptive statistics of the difficulty in swallowing and restriction in jaw movement perceived by the patients as well as the *p*-values of significance tests

Time point	Variable	LG (n = 16)		PG (n = 16)		LG vs PG
		Me	IQR	Me	IQR	<i>p</i> -value [†]
T1	difficulty in swallowing	2	1–2	2	1–3.75	0.236
	restriction in jaw movement	2	1–3	2	1–3	0.877
T2	difficulty in swallowing	0	0–1	0	0–1	0.687
	restriction in jaw movement	0	0–2	1	0–1.5	0.427
T3	difficulty in swallowing	0	0–0	0	0–1	0.422
	restriction in jaw movement	0	0–0.5	0	0–1	0.630
T4	difficulty in swallowing	0	0–0	0	0–0	0.551
	restriction in jaw movement	0	0–0	0	0–0	0.632

[†] Mann–Whitney *U* test.

Analgesic consumption

The amount of paracetamol consumption was low in both groups, with a maximum of 1g at T1, and did not differ significantly between both groups (Table 4).

Satisfaction and acceptance

The patients reported high levels of satisfaction in both groups; the median value for LG was 10 (interquartile range (IQR): 8.25–10) and it was 9 (IQR: 7–10) for PG, with no significant differences between the 2 groups. A great proportion of patients in both groups (i.e., 87.5% in LG and 81.3% in PG) reported that they would advise a friend to undergo the same treatment and the difference in proportions between both groups was insignificant (*p* = 0.626). Additionally, the majority of patients in both groups (i.e., 75% in LG and 68.8% in PG)

found that the extraction of premolars was more disturbing than flapless corticotomy and the difference in proportions between both groups was insignificant (*p* = 0.828).

Changes within groups

The results of Friedman's test showed that there were significant differences between the 4 evaluated time points regarding the levels of pain (*p* < 0.001, *p* < 0.001), discomfort (*p* < 0.001, *p* < 0.001), swelling (*p* < 0.001, *p* < 0.001), difficulty in chewing (*p* = 0.001, *p* = 0.001), difficulty in swallowing (*p* < 0.001, *p* < 0.001), and restriction in jaw movement (*p* = 0.001, *p* = 0.001) for LG and PG, respectively. There were no significant differences in analgesic consumption between the 4 evaluated time points within LG (*p* = 0.164) whereas the differences were significant within PG (*p* = 0.002). Post-hoc pairwise comparisons are demonstrated in Tables 5 and 6.

Table 4. Descriptive statistics of analgesic consumption as well as the *p*-values of significance tests

Time point	Amount of paracetamol [g]					Patients taking/not taking analgesics n (%)				
	LG (n = 16)		PG (n = 16)		<i>p</i> -value [†]	LG (n = 16)		PG (n = 16)		<i>p</i> -value ^{††}
	Me	IQR	Me	IQR		yes	no	yes	no	
T1	0	0–0.5	0.5	0–1	0.137	5 (31.3)	11 (68.8)	9 (56.3)	7 (43.8)	0.154
T2	0	0–0	0	0–0.37	0.695	3 (18.8)	13 (81.3)	4 (25.0)	12 (75.0)	0.669
T3	0	0–0	0	0–0	0.551	1 (6.3)	15 (93.8)	2 (12.5)	14 (87.5)	0.544
T4	0	0–0	0	0–0	0.317	1 (6.3)	15 (93.8)	0 (0)	16 (100)	0.310

[†] Mann–Whitney *U* test; ^{††} χ^2 test. Question 11: Have you used analgesics for pain from your teeth or jaws? If yes, what dosage did you use?

Table 5. Results of the significance tests of pairwise comparisons between the 4 evaluated time points for patient-centered outcomes in the laser-assisted flapless corticotomy group (LG)

Time points	Pain	Discomfort	Swelling	Difficulty in chewing	Difficulty in swallowing	Restriction in jaw movement	Analgesic consumption
T1–T2	0.003*	0.001*	0.017	0.001*	0.033	0.051	0.319
T1–T3	0.001*	<0.001*	0.001*	<0.001*	0.003*	0.003*	0.071
T1–T4	0.001*	<0.001*	0.001*	<0.001*	0.002*	0.002*	0.071
T2–T3	0.097	0.006*	0.018	0.133*	0.129	0.068	0.257
T2–T4	0.006*	0.001*	0.007*	0.019	0.066	0.040	0.083
T3–T4	0.038	0.103	0.257	0.059	0.317	0.414	1.000

The Wilcoxon signed-ranks tests were employed for pairwise comparisons, with the Bonferroni adjustment of alpha level (i.e., 0.05 / 6 = 0.008).

* *p* < 0.008 (significant difference).

Table 6. Results of the significance tests of pairwise comparisons between the 4 evaluated time points for patient-centered outcomes in the piezocision group (PG)

Time points	Pain	Discomfort	Swelling	Difficulty in chewing	Difficulty in swallowing	Restriction in jaw movement	Analgesic consumption
T1–T2	<0.001*	0.001*	0.004*	0.001*	0.003*	0.026	0.041
T1–T3	<0.001*	<0.001*	0.001*	0.001*	0.002*	0.005*	0.008
T1–T4	<0.001*	<0.001*	0.000*	<0.001*	0.001*	0.001*	0.007*
T2–T3	0.015	0.001*	0.003*	0.039	0.236	0.038	0.180
T2–T4	0.003*	0.001*	0.001*	0.003*	0.039	0.018	0.059
T3–T4	0.046	0.130	0.096	0.101	0.180	0.366	0.157

The Wilcoxon signed-ranks tests were employed for pairwise comparisons, with the Bonferroni adjustment of alpha level (i.e., $0.05 / 6 = 0.008$).

* $p < 0.008$ (significant difference).

Discussion

According to our knowledge, this is the first trial in the literature comparing patient-centered outcomes during upper canine retraction associated with piezocision vs LAFC. There were no significant differences between both groups regarding age and gender. Therefore, both groups were homogeneous and comparable. The numerical rating scale was used to answer most of the questions, since this scale has been shown to possess high reliability in comparison with the visual analog scale (VAS).^{17–19} The patients' responses were first taken 1 day after flapless corticotomy treatment in both groups. Immediate recording of pain following the intervention was deemed unsuitable due to the possible interference of pain relief resulting from the use of local anesthesia. The main finding was that patients in LG experienced significantly less pain and discomfort at T1 as compared to PG.

The levels of pain and discomfort at the experimental sides were significantly higher than those at the control sides in both groups at T1. These slightly higher levels can be explained by the trauma of the gingiva and the alveolar bone during the implementation of LAFC and piezocision. The levels of pain and discomfort were significantly lower in LG as compared to PG and this could be attributed to the fact that soft tissue incisions in PG were performed with a blade whereas in LG, an Er:YAG laser was used to perform both soft tissue and alveolar bone perforations, which is characterized by less painful cuts in addition to little postoperative pain.^{20,21} One of the theories that explains this is that protein coagulation caused by laser cutting seals the sensory nerve endings, and thus relieves the sensation of pain.²² Furthermore, the fiber tip used in LG was in the non-contact mode; thus, no mechanical pressure was applied to the gingival tissue, as opposed to the traditional blade used in PG.

A significant reduction in pain and discomfort levels was observed after 1 day following the surgical intervention in both groups. Therefore, the differences between the experimental and the control sides were no longer significant. This could be explained by rapid recovery

associated with the use of a piezosurgery knife²³ and an Er:YAG laser.²⁴ Consequently, analgesic consumption was low in both groups. There are no trials in the literature evaluating pain and discomfort while accelerating canine retraction in conjunction with piezocision or LAFC; therefore, a direct comparison with other trials is not straightforward. The levels of pain and discomfort associated with micro-osteoperforations accomplished with the Propel[®] device were not significant 1 day after canine retraction in Alikhani et al.'s trial,²⁵ but in the present trial, they were significant. This difference between the 2 studies could be explained by different designs of the surgical intervention as well as different devices employed.

High levels of swelling perception were observed at the experimental sides at T1 for both techniques, which could be attributed to edema resulting from surgical trauma that is associated with such procedures. Additionally, difficulty in chewing was significantly higher at the experimental sides than at the control sides in both groups at T1, and this could be correlated with the encountered pain and discomfort following the surgical intervention. The levels of difficulty in swallowing and restriction in jaw movement were low in both groups, with no significant differences. This can be explained by the conservative nature of the surgical intervention in both groups.

Patients reported high levels of satisfaction and acceptance of the surgical intervention, with negligible differences between both groups. This might be due to the minimally invasive nature of piezocision and LAFC, as they did not require flap raising or suturing like conventional corticotomy. Another factor could be related to the use of innovated tools, which resulted in less trauma and morbidity as compared to the traditional use of surgical burs. These findings are in line with those of Uribe et al.²⁶ and Charavet et al.,²⁷ who found that high levels of satisfaction were achieved in patients subjected to piezocision during the leveling and alignment of their teeth. In the present study, the majority of patients in both groups indicated that the extraction of the upper premolars was a more disturbing experience than flapless corticotomy. This could have resulted from the fact that the extraction

of the premolars was performed bilaterally whereas piezocision/LAFC was conducted only at one side of the upper arch. Another factor is the conservative nature of flapless corticotomy employed in this trial.

One of the limitations of this study is its split-mouth design. The patients experienced oral pain or discomfort only from one side of the mouth, which would not reflect the actual picture if the surgical intervention had been carried out at both sides. Therefore, the results of this study cannot be generalized unless a complete procedure mimicking the actual scenario in the daily practice is carried out for patients undergoing canine retraction in the context of orthodontic treatment.

Conclusions

Both piezocision and LAFC were associated with significantly high levels of pain, discomfort, swelling, and difficulty in chewing at 1 day following the intervention. Laser-assisted flapless corticotomy was associated with significantly lower levels of pain and discomfort than piezocision. The levels of pain, discomfort, swelling, eating difficulty, and jaw movement restriction dramatically decreased 24 h after LAFC and piezocision. Both piezocision and LAFC were associated with high levels of satisfaction and acceptance.

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