

Techniques to accelerate dental movement in orthodontics: Piezocision and Corticotomy: A review of the literature

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Abstract

Aim: The objective of this review of the literature is oriented towards an analysis of the current available evidence on the efficacy of corticotomy and piezocision procedures in the acceleration of orthodontic dental movement.

Methodology: It has been made an electronic search in 3 databases with the following selection criteria; randomized controlled trials (RCTs) of the last 10 years, in which apply orthodontic treatments combined with corticotomy or piezocision in front of the conventional orthodontic treatment.

Results: Eleven randomized controlled trials were included in this review of the literature, where all demonstrated a greater acceleration of tooth movement compared to conventional orthodontics, observed that with both techniques the retraction time decreased significantly on the experimental side than on the control side with a variation between 25% - 53%.

Conclusion: The application of techniques such as corticotomy and piezocision show best results; that is, a greater acceleration of the movement of dental pieces during orthodontic treatment compared to conventional techniques.

Keywords: Orthodontics; Accelerated movement; Stimulation; Corticotomy; Piezocision.

1. Introduction

The tooth is a solid anatomical element connected to the alveolar bone by the ligament periodontal, being this an elastic tissue, constituted by bundles of collagen I fibers, capable of absorbing mechanical stresses, and providing cellular and vascular elements, involved during tooth movement. The periodontal ligament is anchored to the alveolar bone through a compact bone called hard layer. During the movement, the “pressure/tension theory” describes that the surface of the hard layer is compressed specifically, the surface on which the tooth is applying pressure is resorbed by osteoclasts associated with compression, while bone apposition is produced by tension-associated osteoblasts along the surface subjected to tension [1].

The duration of orthodontic treatment has been the reason for the emergence, study and application of state-of-the-art techniques, which aim to reduce the time that each patient must remain with fixed orthodontic appliances in the mouth to get their esthetic and functional expectations. Each technique offered for this purpose must achieve not only with the reduction of time, but also with the functional achievement and with the protection of the supporting biological tissue.

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It is estimated that approximately 12 to 24 months is the time needed for integral orthodontic treatment, it also depends on the severity, planning and the individual characteristics of patients [2].

Thus, various methods that help speed up tooth movement such as low-level laser therapy, pulsed electromagnetic field, electric currents, osteogenesis, corticotomy, mechanical vibration and biological approach therapies. Helping with this to prevent certain disadvantages that occur when the treatment is very prolonged [3] as problems related to the oral hygiene, gingival recession and root resorption. Therefore, many researchers have focused on new approaches to accelerate orthodontic tooth movement [4]. Despite the multiple methods of accelerating orthodontic movement that are presented in the literature, we will focus our discussion on two techniques: corticotomy and Piezocision.

Corticotomy is a surgical process where cuts are made in the cortical bone down to reach the cancellous bone. These cuts can be made by manual instruments or low or high speed rotary, and can also be performed with piezoelectric instruments. The corticotomies over time have been proposed as a therapeutic, safe and effective option, to help potentiate dental movement during orthodontic treatment. It is pointed out that the acceleration of the movement is due to a phase of demineralization that allows displacement of the collagenase bone matrix with the surfaces root. When an alveolar corticotomy is performed near the tooth to be moved, the histological results prove that the phenomenon of regional acceleration activates the appearance of macrophages that eliminate hyaline in a short term, about 1 week after starting orthodontic force. This early removal allows bone resorption to occur in a more anticipated way, this helps with faster tooth movement compared to treatments that do not perform corticotomies [3].

On the other hand, piezocision is a new minimally invasive surgical approach without flap elevation. Described for the first time in 2009 by Dibart, it combined the approach of flapless corticision with the advantage offered by PAOO. This technique combines buccal gingival microincisions that allow the use of the piezoelectric scalpel to peel the alveolar bone and thus initiate the regional acceleratory phenomenon. The technique is minimally invasive, but allows hard tissue and/or soft tissue grafting through selective tunneling, in order to correct gingival recessions or bone deficiencies. Due to the absence of the need for flap elevation, surgical time is reduced and postoperative discomfort is minimal. The drawback of this technique is that there is no reflection of the flap, the cuts are made blindly. It is considered beneficial to use navigational or surgical stents to avoid root injury [5].

The objective of this literature review is to comprehensively evaluate and compare the conventional orthodontic techniques with those of corticotomy and piezocision, in order to determine which of the three alternatives provides better clinical results and is considered the most effective and efficient for orthodontic treatment today.

2. Material and methods

2.1. Search strategies

Searches were made for articles published in the last 10 years in databases of electronic sources such as PubMed, Scopus and Web of Science.

The search terms used were designed according to the PICO principle. (Patient/Problem/Population; Intervention/Exposure; Comparison and Results). Q: Patients undergoing orthodontic treatment, I: Techniques to accelerate tooth movement, C: Corticotomy and Piezocision, R: Tooth movement and rate of tooth movement to apply both techniques.

The search used a combination of the following keywords: "orthodontic movement" AND "piezocision" AND "corticotomy" AND "orthodontics".

2.2. Eligibility criteria

The articles were selected according to the following inclusion criteria and exclusion.

2.2.1. Inclusion criteria

- Randomized controlled clinical trials.
- Healthy participants needing orthodontic treatment.
- Orthodontic treatment combined with corticotomy or piezocision in front of the conventional orthodontic treatment.
- Cumulative distance traveled, rate and velocity of tooth movement, or duration of treatment.

- Full text articles, published in the last 10 years.

2.2.2. Exclusion criteria

- Non-randomized studies, case-control studies, cohort studies, studies observational as transversal and descriptive.
- Non-clinical studies, animal study
- Systematic reviews, descriptive studies, opinion articles, abstracts only.
- Case reports/case series/opinions/letters.
- Systemic disease or dental, pulp and periodontal problems, including participants under medical treatment that could interfere with bone metabolism or orthodontic tooth movement.
- Animal studies and studies using drugs.

3. Results

3.1. Selection of studies

The studies selected were those that had a similar design. All of them were randomized and non-randomized controlled trials. Those studies investigated the effectiveness of corticotomy or piezocision in relation to conventional orthodontic treatment.

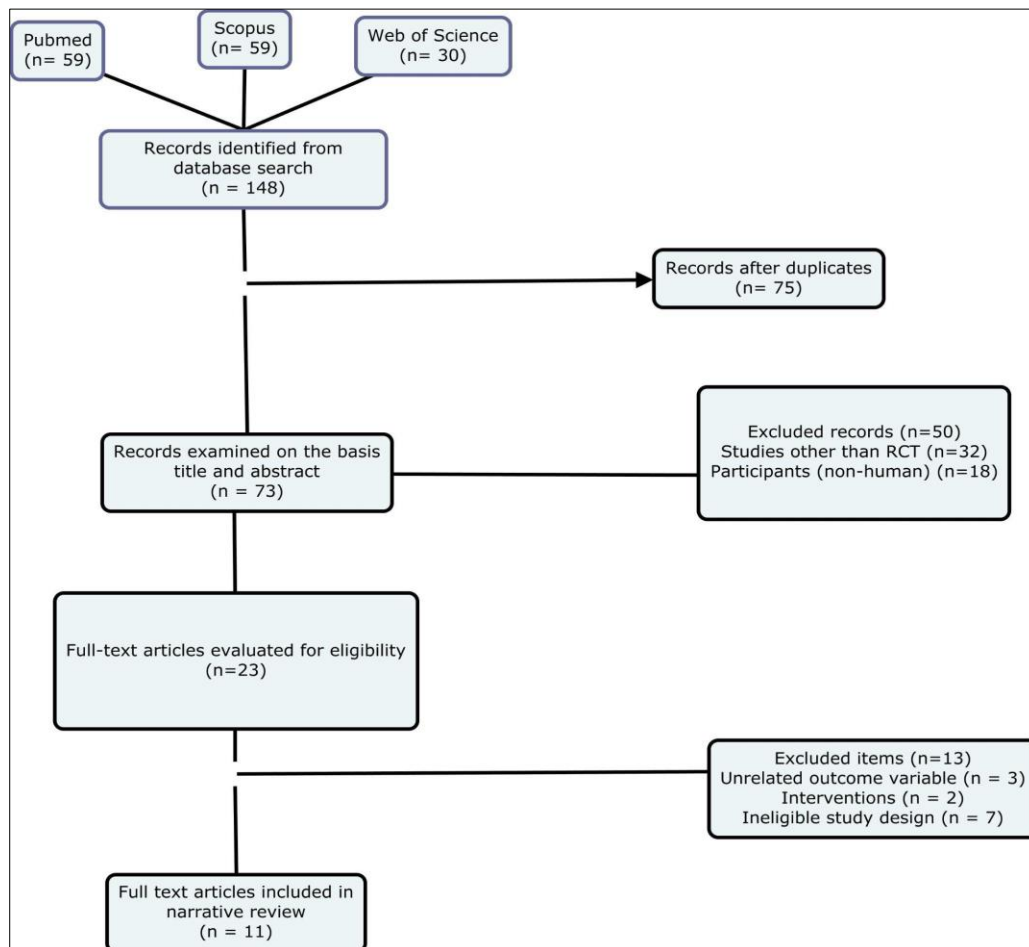


Figure 1 Details about the number of articles and the reasons for the exclusion

As shown in Figure 1, the database search retrieved 148 abstracts: 59 from PubMed, 59 from Scopus, 30 from Web of Science. After reviewing the abstracts, 125 records were removed according to the inclusion and exclusion criteria, leaving 23 full-text articles for review.

Details about the number of articles and the reasons for exclusion at each step are shown in Figure 1. Ultimately, 11 full-text articles were included and assessed in this review.

3.2. Characteristics of the studies

All studies were RCTs. The included studies measured the effectiveness of corticotomy or piezocision compared with conventional orthodontic treatment. The outcome of interest was the speed of tooth movement (detailed in Table 1).

3.3. Surgical intervention

The surgical details of corticotomy or piezocision are described in Table 1. Of the 11 articles analyzed, 4 performed the corticotomy surgical procedure, 4 piezocision, and 3 performed both procedures.

3.4. Orthodontic interventions

Orthodontic interventions (fixed or removable appliances), as well as their duration, are detailed in Table 1.

3.5. Rate of tooth movement

Table 1 shows the results of the eleven studies. The results are briefly listed below:

3.6. Corticotomy vs. Conventional Orthodontics

Three studies using corticotomy procedures demonstrated a statistically significant improvement in the rate of orthodontic tooth movement compared with the conventional technique. Arango and Burgos [6] mention that the linear movement during the first month for the experimental group in the maxilla was 3.56 ± 1.90 mm vs. 1.20 ± 0.85 mm in the control group, and in the mandible was 3.78 ± 1.72 mm for the experimental group vs. 1.35 ± 0.88 mm for the control group.

Likewise, Al-naoum and Hajeer [7] found that the speed of tooth movement was approximately 4 times faster on the experimental side than on the control side. Similarly, Cassetta and Giansanti [8] demonstrated that it was possible to complete the orthodontic treatment in approximately one third of the time required for conventional orthodontic treatment.

3.7. Piezocision vs. Conventional Orthodontics

Charavet and Lecloux [9] show that orthodontic treatment was 1.6 times (36%) faster in the piezocision group compared to the control group. Likewise, Hatrom and Zawawib [10] in their study mention that the amount of mass retraction was significantly higher in the experimental group (mean 2.4 ± 0.57 mm) than in the control group (mean: 2.4 ± 0.33 mm, $p < 0.001$). There was also more extraction space closure (rate of 1.2 mm per month) than in the experimental group (rate of 0.6 mm per month).

In the same way, Gibreal and Hajeer [11] mention that the movement rate presented a difference of 4.38 in the first month between the experimental group and the control group, of 2.80 at two months and of 0.08 at the end of treatment. In turn, Raj and Praharaj [12] indicate that the canine retraction rate was consistently higher on the experimental side than on the control side at all time intervals, and the difference was statistically significant ($P < 0.001$). Finally, Al-Imam and Ajaj [13] in their study show that the retraction rate increased significantly in the experimental group by 53%, with a significant reduction in the retraction time in the experimental group by 27% ($P < 0.001$).

3.8. Corticotomy vs. piezocision

Abbas and Sabet [14] show that orthodontics facilitated by corticotomy is 1.5 to 2 times faster than conventional orthodontics and piezocision was 1.5 times faster than conventional orthodontics. Finally, Alfawal and Hajeer [15] mention that the canine retraction rate was significantly higher on the experimental side than on the control side in both groups 2 times in the first month and 1.5 times in the second month. Furthermore, the overall duration of canine retraction was significantly reduced on the experimental side compared to the control side in both groups.

Both techniques decreased retraction time significantly on the experimental side than on the control side with a variance of 25% - 53%.

Table 1 Summary of the interventions carried out in the selected articles

Study	Participants	Age of participants	Intervention	Rate/speed motion	Duration of force applied	Orthodontics apparatus	Surgical method	Result
Arango et al. 2015 [6]	10 patients	20- 40 years	Corticotomy	Linear motion during the first month for the experimental group in the maxilla of 3.56 ± 1.90 mm vs. 1.20 ± 0.85 mm in the group control, and in the jaw for the experimental group 3.78 ± 1.72 mm vs. 1.35 ± 0.88 mm for the control group.	The measures about periodontal changes, bone lamina, linear and angular movement, were measured at the beginning, 30, 90 and 210 days after the procedures.	Brackets slot 0,018 x 0,025 prescription Roth 1	Intrasulcular incision from mesial of first molars (upper and lower) to first molars contralaterals; A fullthickness buccal flap was raised, allowing access to the most apical area of the teeth (minimum 8 mm). After this, the perforation of the buccal bone cortex was started interproximal from 1.5 to 2.5 and from 3.5 to 4.5, Taking care not to make cuts in the interproximal bone crest, respecting 2 mm of it. Cuts were made in the apical areas at an angle of 4.5 degrees. It was washed with abundant saline solution and the flaps were positioned and sutured.	The Teeth undergoing orthodontics and corticotomy showed a higher speed of movement compared to the control group during the first 30 days of examination.
Al-naoum et al. 2014 [7]	30 patients	15 - 24 years	Corticotomy	There was a significant difference ($P < 0.001$) between experimental and control side. The speed motion of tooth movement was approximately 4 times faster on the experimental side.	3 months	Applications fixed presets and brackets slot 0.022x0.08 and transpalatines arches.	The horizontal cut line of the corticotomy was made 2-3 mm above the canine apices on the buccal side and at the level of the palatal groove on the palatal side. The vertical cut lines were made 1-2 mm apical to the alveolar ridges of the canine to the horizontal cut. Small corticotomy perforations were made in the buccal and palatal cortical bone. The corticotomy cuts were made with a depth of 2 mm. The mucoperiosteal flaps were sutured.	The speed of orthodontic movement showed significantly faster in the corticotomy group than in the control group

Charavet et al. 2016 [9]	24 patients	N/E	Piezocision	In this trial, the overall treatment was 1.6 times (36%) faster in the group of piezocision in comparison with the control group	3 months	Self-ligating Damon systems	Vertical microincisions were made under each interdental papilla. A vertical device made corticotomies 5 mm long and 3 mm deep, and the use of suture was not required.	The piezocision technique appeared to be effective in accelerating orthodontic tooth movement. No gingival recession, bone dehiscence, or increased root resorption was observed in any of the groups.
Hatrom et al. 2020 [10]	26 patients	16-26 years	Piezocision	Presented significantly more retraction in the experimental group than in the control group ($p < 0,001$). The amount of retraction in mass was significantly higher in the experimental group ($2,4 \pm 0,57$ mm) than in the control group ($2,4 \pm 0,33$ mm; $p < 0,001$). There was also more closure of the extraction space in the experimental group compared with the control group, the space closure rate per month was 1.2 mm in the PCG and 0.6 mm in the CG.	1 year- 4 months.	System multi-bracket two-dimensional modified.	Vertical interproximal microincisions were made below the interdental papilla on the buccal aspect of each mandible. A surgical scalpel was used to create the cortical alveolar incision to a depth of about 3mm.	Mass retraction combined with corticotomy is an effective treatment technique to accelerate tooth movement, showing a better result compared to the control group.

<p>Fernandes et al. 2021 [16]</p>	<p>51 patients</p>	<p>15 a 38 years.</p>	<p>Corticotomy, Piezocision</p>	<p>No isolated and time-dependent significant differences were observed in bone biomarker levels between the experimental and control sides. (P>0.05)</p>	<p>6 meses</p>	<p>6 mm mini screws.</p>	<p>Corticotomy. Mucoperiosteal flap. Incisions without papillae. Vertical corticotomies in the mesial and distal root of the canine, which is joined with a horizontal on apex of the canine. Additional spherical bone lesions from the alveolar surface of the canine to the mesial surface of the second premolar. They were accompanied with abundant saline irrigation. Replacement flap and sutured. Piezocision. Vertical linear incisions with scalpel on the mesial and distal face of the canine root, as well as mesially in the second premolar. Beginning of the incisions began 5 mm on the papilla to preserve it and extended parallel to the roots. Vertical bone lesions with a depth of 3 mm and a height of 5 mm. The incisions were not sutured.</p>	<p>Corticotomy and piezocision appeared to be ineffective in accelerating canine retraction. However, these findings cannot be generalized to other types of orthodontic movements, since only canine distalization movement was investigated in the present study.</p>
<p>Abbas et al. 2016 [14]</p>	<p>20 patients</p>	<p>15-25 years</p>	<p>Corticotomy, Piezocision</p>	<p>Orthodontics facilitated by corticotomy is 1.5 to 2 times faster than conventional orthodontics. Piezocision was 1.5 times faster than conventional orthodontics</p>	<p>3 months</p>	<p>In both groups, a wire was used Immediately after surgery, a stainless steel wire of 0.022 inches was tied and closed nickel-titanium</p>	<p>A submarginal flap was used, the incision was made 4 mm apical to the gingival margin, extending from the mesial surface of the upper lateral incisor to the mesial surface of the upper second premolar incisor. Then a vertical release incision was made and a full-thickness mucoperiosteal flap was raised through a mucoperiosteal elevator; this flap</p>	<p>Corticotomy-facilitated orthodontics and piezocision are effective treatment alternatives that decrease the time required for canine retraction and decrease</p>

						spiral springs that applied 150 g	extended beyond the apex of the canine. Bone activation was achieved with vertical cuts and perforations. Vertical cuts were made along the mesial and distal sides of the canine root starting 2 to 3 mm below the alveolar crest to protect the crestal bone, and perforations were performed vestibulately along the canine root. The flap was then repositioned and stitched.	root resorption in adults.
Alfawal et al. 2018 [15]	36 patients	15 - 27 years	Corticotomy, Piezocision	The canine retraction rate was significantly greater on the experimental side than on the control side in both groups 2 times in the first month and 1.5 times in the second month (P < .). In addition, the overall duration of canine retraction was significantly reduced in the experimental side compared to the control side in both groups around 25% (p 0.001).	4 months	Transpalatal arches were placed from the beginning of treatment as moderate anchorage	Piezocision Two incisions were made in the oral gum at an equal distance from the upper canine and the second premolar. These incisions began 3-4 mm apical to the interdental papilla and were 10 mm long, then alveolar cortical incisions were made 3 mm deep. Corticotomy Five small perforations were made in the oral gum at the same distance from the upper canine and the second premolar. Each hole was 1.3 mm wide and was separated from the other hole at a distance of 1.5-2 mm. Alveolar cortical perforations with 3 mm depth.	Teeth undergoing piezocision and corticotomy appeared to be effective treatment methods to accelerate canine retraction without any significant adverse effect on canine anchoring or rotation during rapid retraction.
Gibreal et al. 2019 [11]	34 patients	17 - 24 years	Piezocision	The movement rate showed a difference of 4.38 in the first month between the experimental group	28 days	Devices with prescription MBT and slot 0.022 inches. Then, a 0.014 inch NiTi arc	Incisions began 4 mm below the papilla avoiding further gingival recessions. Vertical incisions 5 to 8 mm long and 3 mm deep.	Teeth subjected to the flap-free piezocision technique were very effective in accelerating

				and the control group, 2.80 at two months and 0.08 at the end of treatment.		was inserted and tied to each bracket with steel tie wires 0.010 inch stainless steel.		orthodontic dental movement.
Cassetta, et al. 2016 [8]	10 patients	17-28 years	Corticotomy	It was possible to complete orthodontic treatment in approximately one third of the time required for conventional orthodontic treatment with transparent aligners in all cases.	1 year	Transparent aligners	The minimally invasive and flap-free corticotomy procedure was performed by combining piezoelectric surgery cortical microincisions with the use of a 3D printed CAD/CAM surgical guide.	Despite the different techniques described in the literature, corticotomy appears to be the only effective and safe method for accelerating orthodontic dental movement, although there are currently few reports of it. All corticotomy techniques described so far are characterized by high morbidity and possible damage to periodontal tissues.
Raj, et al. 2020 [12]	20 patients	20-25 years	Piezocision	The canine retraction rate was consistently higher on the experimental side	6- 7 months	conventional orthodontics	Alveolar cortical incisions with a depth of 3 mm. The penetration depths in the cortical bone were verified by the use of a Goldman-Fox probe. After careful	Piezocision-assisted orthodontics reduces treatment time

				than on the control side at all time intervals, and the difference was statistically significant ($P < 0.001$).			inspection, interrupted sutures were placed using vicryl 5-0.	by increasing the rate of canine retraction. In addition, it ensures a better periodontal result and less harmful side effects on the alveolar support.
Al-Imam, et al. 2019 [13]	42 patients	15 - 26 años	Piezocision	The retraction rate of the incisors increased significantly in the experimental group by 53%, with a significant reduction of the retraction time in the experimental group by 27% ($P < 0.001$).	15 months.	-Transpalatal arch. -Brackets	Vertical interproximal microincisions were made through the periosteum between the particular teeth, 4 mm above the interdental papillae, and extended along the middle third of the root. Oral and palatal cortical alveolar incisions were created at a depth of approx. 3 mm	Significant change was shown in the type of retraction movement of the incisors, which was predominantly a translation movement in the experimental group and a controlled inclination movement in the control group.

4. Discussion

The present review of the literature shows that both techniques, piezocision and corticotomy increase the retraction rate significantly higher on the experimental side than on the control side compared to the conventional retraction rate according to the surgical methods used in all cases. Likewise, it was observed that with both techniques the retraction time decreased significantly on the experimental side than on the control side with a variation of 25% - 53%. These results show the great effectiveness of both piezocision and corticotomy to accelerate tooth movement and reduce the time needed for this purpose.

Similar results were obtained with the study by Viwattanatipaa and Charnchairerk [17] who carried out a systematic review on the effectiveness of corticotomy and piezocision in canine retraction, in which only 5 randomized clinical trials (RCTs) were included, with a split-mouth design and all of them used canine retraction. Alfawal and Hajeer [15] conducted a split-mouth randomized controlled clinical trial in which they found that the canine retraction rate was significantly higher on the experimental side (piezocision and corticotomy), it was 2 times faster in the first month and 1.5 times in the first month. the second month.

In addition, it was observed that the retraction time was decreased by 25% compared to the control side. Likewise, Gibreal and Hajeer [11] and Al-Imam and Ajaj [13] who evaluated the efficacy of piezocision-based flapless corticotomy for orthodontic correction of anterior teeth reported that the time to retraction was significantly reduced by 59 % and 27 % respectively compared to the control group. Patterson and Dalci [18], in their systematic review on the efficacy of corticotomy in orthodontic movement, included randomized clinical trials (RCTs) as well as controlled clinical trials (CCTs), finding evidence supporting that corticotomy can produce significant increases in rate of orthodontic tooth movement producing minimal side effects in patients. However, their study has many limitations compared to Viwattanatipaa and Charnchairerk [17] who included only randomized clinical trials. The quality of the body of evidence was judged low due to the presence of multiple methodological problems, high risk of bias and heterogeneity in the included articles Viwattanatipaa and Charnchairerk [17] and Mheissen and KhanI [19] conducted a systematic review and meta-analysis, analyzed a total of 14 articles and included controlled clinical trials (CCTs) and randomized clinical trials (RCTs) to assess the effectiveness of piezocision in accelerating orthodontic tooth movement.

The results of the meta-analysis showed that the mean difference in canine retraction rate in the first and second month after piezocision was 0.66 mm/month and 0.48 mm/month, respectively. Showing that the total canine retraction rate in the first 2 months was statistically significant at 0.57 mm/month. It was also observed that there was a decrease in treatment time after piezocision. However, the article by Sonone and Nawab [20] concluded that piezocision and corticotomy are not effective in accelerating canine retraction as there was no statistically significant difference from the control group.

5. Conclusion

Surgical techniques aimed at accelerating tooth movement are not new, these techniques began in 1983 and are constantly evolving. There is little evidence reported from studies conducted in patients but the information acquired demonstrates the possibility of performing an orthodontic treatment for a short period of time and at the same time demonstrate good preservation of supporting tissues. Upon analysis of the different sources, it was determined that using techniques such as corticotomy and piezocision show better results; that is, a greater acceleration of the movement of teeth during orthodontic treatment compared to conventional techniques.

In addition to the above, it is essential to consider other key aspects, such as minimizing patient trauma during orthodontic treatment, as well as reducing the time they spend in the dental chair, since this can significantly improve the overall patient experience. It is recommended to follow proper protocols and conduct a thorough patient evaluation to achieve the best possible results.

Compliance with ethical standards

Disclosure of conflict of interest

The authors declare no conflicts of interest.

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