The Impact of Piezocision on the Rate of Orthodontic Tooth Movement

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Abstract

AIM: To assess the efficacy of piezocision in increasing the rate of orthodontic tooth movement compared with conventional orthodontic methods.
METHODS: PubMed and ScienceDirect were searched to April 2024 for randomised controlled trials (RCTs) and controlled clinical trials (CCTs) evaluating piezocision adjunctive to orthodontic treatment; a manual search was also performed. Included studies reporting clinical outcomes of tooth movement were analysed.
RESULTS: Seventeen publications met the inclusion criteria: four CCTs and thirteen RCTs, comprising 550 participants. Investigated movements included lower anterior alignment, en masse retraction, canine distalisation, overall orthodontic treatment and second molar mesialisation. Across studies ages ranged from 13 to 38 years (mean 20 years). Observation periods varied from 4 to 24 months (mean 4–6 months). Higher rates for all tooth movements were found for piezocision versus conventional treatment. The accelerating effect was most pronounced in the first month and, in some studies, at three months, but the effect was not consistently maintained over longer follow-up and generally diminished with time. The intervention was safe for periodontal tissues and teeth. Effective pain relief for piezocision was generally achieved with a single dose of paracetamol.
CONCLUSION: Piezocision corticotomy accelerates orthodontic tooth movement in the early phase. Different piezocision techniques produced variable outcomes, but the number of incisions did not correlate with the rate of tooth movement.

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1 Introduction

Extended periods of fixed orthodontic treatment can lead to various adverse effects, including pain, discomfort, heightened susceptibility to caries, gingival recession, external root resorption, pulpal damage, temporomandibular joint disorders, speech difficulties and enamel deterioration. Multiple factors influence these risks, including the type of orthodontic appliance used, the direction of the applied force and the duration of treatment (Wishney, 2017).

Orthodontic treatment acceleration has become increasingly popular, particularly among adult patients who are looking for quicker completion of their treatment (Alhaija et al., 2022). Piezocision, a minimally invasive surgical technique that involves creating small perforations in the cortical bone, has emerged as a promising approach to expedite orthodontic tooth movement. Research indicates that the use of Piezocision can notably increase the rate of tooth movement compared with conventional orthodontic procedures (Dibart & Keser, 2014). Despite numerous clinical trials, debate remains concerning the efficacy of Piezocision in accelerating orthodontic tooth movement (Alhaija et al., 2022).

Several studies have reported that Piezocision produces a short-term increase in the rate of tooth movement. The technique, which entails targeted piezoelectric alveolar decortication, is minimally invasive and aims to accelerate tooth displacement. However, the effectiveness of Piezocision remains contested, with conflicting results across studies. Although initial findings suggest a prompt effect on tooth movement, patient comfort and willingness to undergo the procedure are important determinants of its clinical uptake. These considerations underscore the need for acceleration methods that are better tolerated by patients.

The aim of this review is to compare the rate of tooth movement, adverse effects (root resorption and anchorage loss), patient pain and satisfaction, and periodontal outcomes in patients undergoing Piezocision-assisted versus conventional orthodontic space-closing techniques.

2 Methods

The research question was formulated using PICO elements. Population: healthy patients aged > 13 years requiring orthodontic treatment. Intervention: Piezocision performed at the start of treatment to accelerate the rate of tooth movement. Comparator: no Piezocision (conventional fixed mechanotherapy). Outcomes: primary outcome was the rate of tooth movement (moved distance, mm per observation time); secondary outcomes included adverse effects, patient satisfaction and pain, and periodontal status.

Electronic searches were conducted in PubMed and ScienceDirect for published articles that evaluated and compared the impact of Piezocision on the speed of orthodontic tooth movement (**Figure 1**). The searches were limited to publications from 2009 to 2024. The search strategy used the following terms and Boolean operators: ("Piezocision" OR "Piezosurgery") AND ("orthodontics" OR "orthodontic" OR "orthodontic tooth movement"), which returned 699 results. Reference lists of the selected studies and pertinent reviews were also searched manually to identify additional relevant studies.

The inclusion criteria were defined as follows: (1) human randomised controlled trials (RCTs) or controlled clinical trials (CCTs); (2) research studies comparing Piezocision-accelerated orthodontic treatment with conventional orthodontic treatment in patients aged 13 years or older and including at least 10 subjects; (3) studies reporting clinical outcomes and parameters, such as treatment duration and tooth movement; and (4) studies published in English with full-text accessibility.

The exclusion criteria were as follows: (1) preclinical or in vitro studies; (2) studies including fewer than 10 subjects; (3) non-comparative studies; (4) studies lacking sufficient information or data that could not be fully extracted; and (5) review articles, case reports and other non-research publications.

From each study that remained after application of the exclusion criteria, data were extracted on the title, study type, number of individuals or sites per experimental condition, age of the experimental subjects, periodontal and bone injury (Piezocision procedure), tooth movement measurements, mean rate of tooth movement over the experimental period in mm/wk, and observation time.

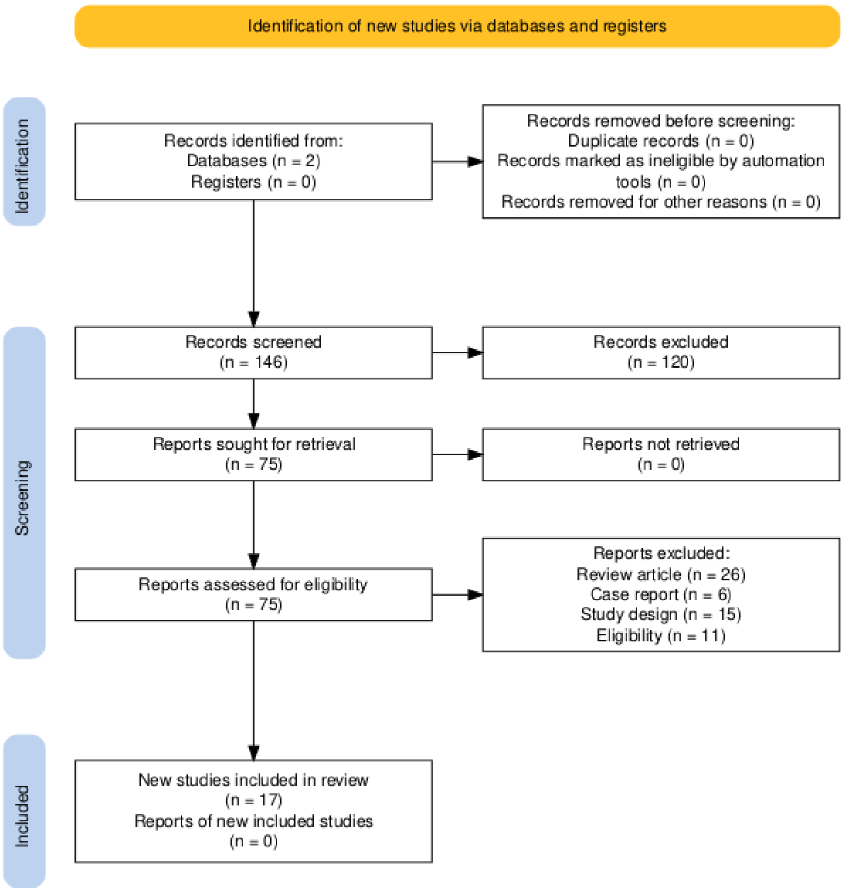

Figure 1. Prisma flow diagram of article selection.

2.1 Statistics

Descriptive statistics, frequency analysis, and content analysis were employed as part of the qualitative methodology to systematically analyze the textual content of the included studies. It is important to note that, given the narrative nature of this study, regression analysis and meta-analysis techniques were not deemed suitable for the analytical framework.

3 Results

3.1 Study characteristics

The analysis encompassed 17 studies, comprising eight randomised controlled clinical trials with a parallel-group or split-mouth design, six randomised controlled clinical trials, and three controlled clinical trials with a parallel-group or split-mouth design (Supplementary **Table S1**). Participants' ages ranged from 15 to 38 years, with observation periods ranging from 3 to 24 months. Key tooth movements documented included maxillary canine retraction, anterior teeth retraction, protraction of the second mandibular molar, and decrowding of the anterior teeth.

In canine retraction, seven split-mouth randomised controlled trials, one parallel-group randomised controlled trial, and one controlled clinical trial investigated the acceleration of canine retraction. The majority of participants were around 20 years old, with ages ranging from 15 to 38 years. Observation periods varied from 4 to 6 months. One trial utilised 0.019 x 0.025-inch slot brackets with 0.019 x 0.025-inch steel wires for canine retraction (Alfawal et al., 2018), while two trials employed 0.022 x 0.02-inch brackets and 0.019 x 0.025-inch stainless steel archwires for the same purpose (Al-A'athal et al., 2022; Alqadasi et al., 2020). Additionally, one trial used self-ligating 0.022-inch slot brackets, 0.020-inch stainless steel main archwires with prebent 0.016 x 0.016-inch stainless steel power arms, and applied 150 g of force (Hawkin et al., 2022), with observation periods ranging from 1 to 4 months.

In en-mass retraction, one randomised controlled trial investigated acceleration of canine retraction using a modified bidimensional 0.019 x 0.025-inch slot bracket system to improve anterior torque control and a 0.018 x 0.022-inch stainless steel archwire for optimal torque control (Hatrom et al., 2020). The participants' ages ranged from 16 to 24 years, with an observation period of 4 months.

In mandibular molar protraction, two controlled trials employed a 0.022-inch Roth prescription with a 0.019 x 0.025-inch stainless steel archwire. A mini-screw, serving as a temporary anchorage device (TAD), was used with a diameter of 1.8 mm and a length of 8 mm. In these trials, a NiTi coil spring (3M) applying 150 g of force was attached from the mandibular second molar hook to the head of the mini-screw located between the roots of the mandibular canine and first premolar for space closure (Al-Areqi et al., 2020).

In a split-mouth randomised controlled trial, 0.022 x 0.028-inch brackets and molar tubes were used along with 8-mm-long, 1.5-mm-diameter mini-screws employed as temporary anchorage devices positioned between the roots of the mandibular premolars. A mesial force of 150 g was applied to the second molars using 9-mm nickel titanium closed coil springs (Ogrenim et al., 2023). The age of participants ranged from 15 to 38 years, with observation periods ranging from 4 to 12 months.

In anterior teeth leveling and alignment, one randomised controlled trial reported fixed orthodontic appliances using brackets with a 0.022-inch slot (Sultana et al., 2022). Another randomised controlled trial with parallel groups employed brackets featuring the Damon self-ligating system (Charavet et al., 2016). Additionally, in a controlled clinical trial with parallel groups, brackets with a 0.022-inch slot were used for fixed orthodontic appliances (Yavuz et al., 2018). The age range of participants spanned from 13 to 30 years, and observation periods ranged from 4 to 24 months.

3.1.1 Piezocision groups

The piezocision procedure in the studies generally followed the protocol described by Dibart et al. (2014). Prior to commencing the surgical procedure, patients rinsed their mouths with 0.2% chlorhexidine for one minute. Using the panoramic radiograph as a guide, the proximity of the roots and the long axis of the teeth were identified, and corticotomy lines were marked on the mucogingival tissue with a marker pen after administering local anaesthesia. An anaesthetic solution (2% lidocaine) was administered by infiltration both mesial and distal to the extraction site.

Two incisions were then made using a No. 15 blade, situated 3–4 mm apical to the interdental papilla to preserve the papillary gingival margin and the alveolar crest, on both the mesial and distal aspects of the extraction space. A Piezotome was inserted into these incisions for bone cutting. The gingiva was slightly elevated laterally to visualise the alveolar cortical bone and root. Piezocision was not performed in cases involving root proximity. The piezosurgery procedures were conducted up to the mucogingival line, to a depth of 3 mm and extending a length of 5–10 mm.

Exceptions were noted in the studies evaluating the duration of levelling and alignment of anterior teeth. In these cases, the piezocision procedure was carried out with each incision starting 3 mm away from the interdental papilla and extending vertically to approximately 4–5 mm in length. Following the administration of anaesthesia, incisions were made through the gingiva on the marked lines using a 15C surgical scalpel blade at an angle of 45°–60° to the long axis of the teeth.

Cortical alveolar bone incisions were performed with a piezosurgery blade (BS1 insert, Satelec Acteon Group) oriented in alignment with the scalpel blade to create a 3 mm-deep cut into the medullary bone. The depth of the corticotomy cut was regulated by the markings on the BS1 blade and maintained consistently along the corticotomy line. The Piezotome device was set at a low frequency of ultrasonic waves (28–36 kHz) for cutting the cortical bone with a continuous 60% saline irrigation. Excess fluid in the surgical area was removed using high-speed suction. Haemostasis was achieved using cotton gauze and thumb pressure, without the need for sutures or bone grafting.

Postoperatively, patients were advised to take analgesics (paracetamol) as needed, practise careful tooth brushing, and use 0.2% chlorhexidine mouthwash twice daily for one week.

3.1.2 Conventional orthodontic techniques

The controls used were conventional orthodontic appliances only. Photobiomodulation methods, such as low-level laser therapy (LLLT) or photobiomodulation therapy (PBMT), have emerged as non-invasive approaches with the potential to accelerate tooth movement. A total of ten treatments—five administered on the buccal aspect and five on the palatal aspect—were conducted. Two treatment doses were applied to the mesial and distal aspects of the cervical third of the root, and the same was done for the apical third. Additionally, one treatment dose was delivered to the middle third of the canine, lateral incisor and central incisor on the experimental side, while another dose was administered between the contact points of the maxillary canine and second premolar (Jayavarma et al., 2023).

Laser-assisted flapless corticotomy (LAFC) utilising a YAG laser involved creating five small perforations in the buccal gingiva equidistant from the upper canine and second premolar. A fibre tip was used and the laser settings were adjusted to 100 mJ, 10 Hz, 2 W for each perforation; each perforation was 1.3 mm wide and positioned 1.5–2 mm apart from the adjacent perforation (**Figure 2**). Subsequently, the parameters were modified to 200 mJ, 12 Hz, 3 W to execute alveolar cortical perforations at a depth of 3 mm (Alfawal et al., 2018).

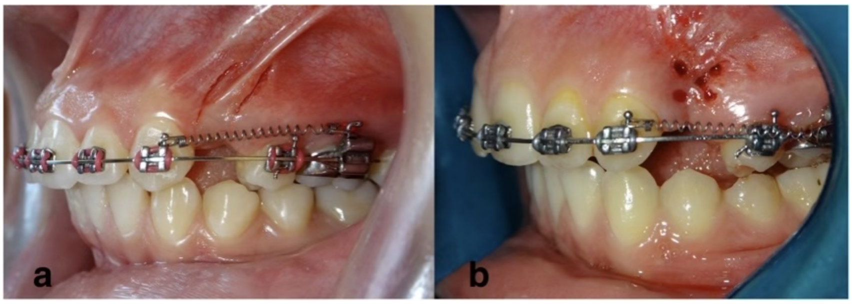

Figure 2. The retraction phase were use NiTi closed coil springs directly after flapless corticotomy, distinguished between the following groups: a) Piezocision group, and b) Laser-assisted flapless corticotomy group. Image source: Alfawal et al. (2018).

The micro-osteoperforations (MOPs) group underwent three flapless perforations on the designated experimental side within the extraction space, utilising an automated mini-implant driver. Each perforation measured approximately 1.5–2 mm in diameter and 5–7 mm in depth (Alqadasi et al., 2020).

For corticotomy using a conventional bur in rapid orthodontic tooth movement, vertical guideline holes were drilled and connected on the buccal cortex with a No. 8 tungsten carbide round bur mounted on a straight handpiece, operated at 30,000 rpm (**Figure 3**). The groove extended through the cortical bone, minimally penetrating the spongiosa to a depth of 2 mm (Simre et al., 2022).

Figure 3. Corticotomy using bur over buccal cortex. Image source: Simre et al. (2022).

The decision technique involves utilising a disc-saw bur connected to a micromotor device typically employed for shaping or cutting the crest of the ridge during dental implant surgery. Vertical micro-incisions were made to align with the midpoint of each interdental papilla, starting 1 mm below the free gingival groove and extending beyond the mucogingival line (**Figure 4**). Following this, vertical corticotomies were carried out using a 7 mm-long, 3 mm-deep disc saw (Yavuz et al., 2018).

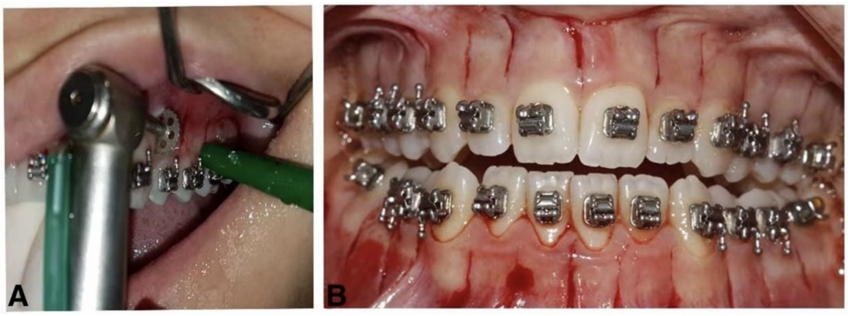

Figure 4. Intraoral discision application (a). Discision post-operative view (b). Image source: Yavuz et al. (2018).

3.2 Tooth movement rate

Several studies have shown a statistically significant increase in the rate of anterior teeth decrowding with the use of piezocision in orthodontic treatment when compared to conventional orthodontic treatment (Charavet et al., 2016; Yavuz et al., 2018; Sultana et al., 2022; Gibrel et al., 2023). The outcomes of all studies are summarized in **Table S2**.

The treatment time for levelling and alignment was significantly reduced by 43% in one study (Charavet et al., 2016) and by 53% in another (Gibrel et al., 2023) for the piezocision group compared to the control group. In addition, orthodontic treatment time was reduced by 23% in both the Piezocision and Dicision groups compared to the orthodontic group. Yavuz et al. (2018) did not find any statistical difference between the two experimental groups. Sultana et al. observed a greater reduction in crowding and a higher tooth-levelling rate during the first two months in the piezocision group compared to the control group.

Five studies (Alfawal et al., 2018; Al-Imam et al., 2019; Alqadasi et al., 2020; Simre et al., 2022; Sonone et al., 2022) reported statistically higher rates of upper canine retraction. The rates of canine movement were significantly greater on the piezocision side than on the control side (conventional orthodontic treatment) during the 10-week period ($p < 0.05$), as reported by Sonone et al. (2022).

In a study comparing corticotomy using a bur and the piezocision technique for retraction of upper and lower canines, the mean rate of tooth movement was significantly faster in the piezo group than in the bur group. Specifically, the mean rate of tooth movement in the piezo group was 1.41 ± 0.08 mm per month, which was significantly greater than the bur group's rate of 1.00 ± 0.07 mm per month ($p = 0.0001$).

Alqadasi et al. (2020) reported that both the micro-osteoperforation and piezocision groups exhibited a significantly higher rate of tooth movement on the cortectomy-accelerating sides compared to the conventional orthodontic sides after three months. This suggests that both MOPs and piezocision techniques can effectively accelerate tooth movement relative to conventional orthodontic methods. The amount of tooth movement at different time intervals also favoured the piezo group over the bur group.

In contrast, three studies (Fernandes et al., 2021; Al-A'athal et al., 2022; Jayavarma et al., 2023) reported no statistically significant increase in the rate of maxillary canine retraction.

Hatrom et al. (2020) found that the rate of tooth movement during en-masse retraction per month differed significantly between groups: the rate of space closure was 1.2 mm per month in the Piezocision group and 0.6 mm per month in the control group.

According to Al-Areqi et al. (2020), Alhaija et al. (2022) and Orgrenim et al. (2023), there is statistical evidence that the rate of second molar movement was significantly increased on the piezocision corticotomy side compared to the control side that received conventional orthodontic treatment. This indicates that piezocision may lead to a higher rate of second molar protraction than traditional orthodontic methods.

Al-Areqi et al. (2020) reported that following piezocision the rate of molar protraction doubled during the first two months; despite this acceleration, the net reduction in space closure duration was only 1.26 months. Patients who received piezocision experienced a marked increase in the rate of tooth movement compared to those who did not receive piezocision corticotomy. This increased rate lasted for two months, with a magnitude of 1.3 mm per month in the piezocision group and 0.68 mm per month in the non-piezocision group. The difference was statistically significant (p < 0.01).

3.3 Adverse effects

Root resorption. In the study assessing molar protraction, both groups experienced a reduction in root length, with a more pronounced decrease observed in the experimental group ($p < 0.001$). However, there was no significant change in Panoramic X-ray values over time within the experimental group ($p = 0.148$) (Ogrenim et al., 2023).

In the investigation focusing on en masse retraction, the ProPulse Carriere Mechanotherapy Group (PCG) exhibited significantly less tipping and root resorption of incisors compared with the control group ($p < 0.05$) (Hatrom et al., 2020).

Anchorage loss. Six studies that evaluated anchorage loss during maxillary canine retraction reported no statistically significant differences in anchorage loss (Alfawal et al., 2018; Al-Imam et al., 2019; Hawkins et al., 2022; Al-A'athal et al., 2022), and no statistically significant differences in maxillary canine rotation (Alfawal et al., 2018; Al-Imam et al., 2019; Hawkins et al., 2022).

However, one trial demonstrated that anchorage loss was significantly lower in the experimental group, while incisor tipping was higher in the control group ($p < 0.001$) (Al-Imam et al., 2019).

In a study examining anchorage loss and the extent of second molar protraction, anchorage loss—characterised by mandibular incisor proclination and distal movement of mandibular second premolars—was similar across all three groups under investigation (Alhaija et al., 2022).

Pain. Reported pain levels were significantly elevated on the initial day following piezocision treatment compared with the control group; however, pain levels were comparable between the two groups after 24 hours ($p < 0.001$) (Hatrom et al., 2020).

Patients who underwent piezocision surgery on their maxillary anterior teeth reported either no pain or mild discomfort and expressed satisfaction with the treatment. Specifically, in the piezocision group, 75% experienced mild pain while 25% reported no pain (Sultana et al., 2022).

Regarding the subjective assessment of pain during maxillary canine retraction, 13 of the 20 patients completed the questionnaire. Findings suggested variation in perceived pain levels among patients. Significant pain was reported by four patients (scoring 60 out of 100 on the VAS) on the day of the procedure; this subsequently reduced at D7 and D14. Only two patients experienced a significant restriction in function on the day of the procedure (scoring 70 out of 100 on the VAS), which improved on D7 and D14. Piezocision received low acceptance and recommendation scores: one patient reported finding the procedure increasingly uncomfortable on the day of surgery and thereafter (both D7 and D14, 93 out of 100). Eight patients consumed analgesics on the first day after the procedure and reported paracetamol as the compound of choice; seven received one dose (one or two paracetamol 500 mg tablets) and one received three doses (Hawkins et al., 2022).

There was no statistically significant difference observed between the two experimental groups regarding the VAS for the alignment of anterior teeth ($p > 0.05$) (Yavuz et al., 2018).

Satisfaction. Following piezocision surgery on their maxillary anterior teeth, 62.5% of patients in the piezocision group reported being satisfied, while 37.5% reported being most satisfied with the procedure (Sultana et al., 2022).

Periodontal status. During the trial, baseline alignment of maxillary and mandibular anterior crowding showed no increase in overall recession scores post-treatment in either the piezocision or control groups (Yavuz et al., 2018; Charavet et al., 2016), with $p > 0.05$.

In the anterior teeth alignment trial, there were no changes in gingival condition, periodontal pocket depth, or pulp status in either group (Sultana et al., 2022).

In maxillary canine retraction, postoperative complications (periodontal pocket depth greater than 5 mm, fenestration/dehiscence) in both piezocision and bur groups showed no statistically significant difference ($p > 0.05$) (Simre et al., 2022). However, one trial (Alqadasi et al., 2020) reported a reduction in canine palatal bone height on the experimental side of the piezocision group; overall changes were deemed insignificant.

Two studies evaluated biomarkers in gingival crevicular fluid. In all groups, biomarker expression occurred at specific time points but no consistent pattern was observed; some changes were reported as statistically significant ($p < 0.05$) (Sonone et al., 2022; Fernandes et al., 2021).

4 Discussion

The aim of this review was to compare the rate of tooth movement in patients undergoing piezocision and conventional orthodontic treatment techniques when closing spaces between teeth.

In a synthesis of seventeen studies evaluating the impact of piezocision on accelerating orthodontic tooth movement, thirteen studies reported an apparent increase in the rate of tooth movement in experimental groups. Studies addressing anterior teeth alignment, maxillary canine retraction and mandibular molar protraction demonstrated statistically significant acceleration. Several trials that employed buccal surgical interventions reported a twofold acceleration in the first month and a 1.5-fold increase in the second month.

Four studies assessing maxillary canine retraction found no statistically significant difference in rate of movement. Taken together, these studies suggest that piezocision may produce an immediate effect on tooth movement during the first month, but this effect is not consistently maintained in subsequent months. Some studies reported significantly faster tooth movement on the piezocision side after three months compared with conventional treatment, although the accelerating effect of piezocision generally diminished over time.

Across the seventeen studies, piezocision procedures comprised either a single incision or multiple incisions (3–6) of varying lengths (4–10 mm) and depths (3–5 mm) in the labial and palatal mucogingival tissues. In two studies a single incision was placed at the centre of the first premolar extraction site, which appeared to confer potential advantages for increasing the speed of tooth movement. Thirteen studies reported effects on orthodontic outcomes, but no consistent correlation was observed between the number of incisions and the rate of tooth movement. Direct comparisons between studies were limited by heterogeneity in evaluation methods.

Conventional orthodontic treatment, which typically lasts about two years for moderate to severe malocclusion, can be associated with side effects such as decalcification, dental caries, gingival inflammation or recession, pain, discomfort and apical root resorption.

Root resorption is a common consequence of orthodontic treatment and is influenced by multiple factors. Two studies that assessed root resorption reported reductions in root length in both piezocision and control groups; these reductions did not reach statistical significance. Five studies on anterior alignment and canine retraction found no increase in gingival recession scores or probing pocket depth post-treatment in either group. Six studies evaluating anchorage loss during maxillary canine retraction reported no statistically significant differences between groups.

Overall, the evidence indicated that piezocision used to accelerate orthodontic treatment was safe for periodontal tissues and teeth. Patient-centred outcomes demonstrated substantial acceptance and satisfaction with the minimally invasive approach. Four studies assessing pain reported that patients in the piezocision group experienced minimal or no pain, although discomfort was slightly greater on the first day after the procedure compared with controls. Patients typically used analgesics on the first day, with paracetamol preferred; effective pain relief was generally achieved after a single dose, commonly 1–2 tablets of 500 mg.

In conclusion, piezocision has been shown to accelerate the rate of tooth displacement. The absence of major complications and the reduction in treatment duration reported in the studies suggest that piezocision can be considered a safe and effective adjunct in orthodontic practice.

Conclusions

The analysis of seventeen studies revealed diverse piezocision techniques with varying impacts on orthodontic outcomes. Notably, the number of incisions did not correlate directly with the rate of orthodontic tooth movement. Moreover, no notable differences were observed between groups in gingival recession or pocket formation.

Patients who underwent piezocision reported either no pain or only mild discomfort and expressed satisfaction with treatment outcomes. These findings support the conclusion that piezocision can be considered a safe and effective method in orthodontic treatment.

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Ethical approval

No ethical approval was required for this study as it did not involve human participants, animal subjects, or sensitive data. This study falls under the category of data collection without participant identification.

Consent for publication

Not applicable.

Authors' contributions

The author(s) declare that all the criteria for authorship designated by the International Committee of Medical Journal Editors have been met. More specifically, these are: (a) Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; AND (b) Drafting the work or revising it critically for important intellectual content; AND (c) Final approval of the version to be published; AND (d) Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Competing interests

The author(s) declare that there are no competing interests related to this work.

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