Corticotomy, Piezocision, and Micro-Osteoperforation versus No Adjunct for Canine Retraction Acceleration – A Systematic Review and Meta-Analysis

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Abstract

AIM: The objective of this study was to evaluate the efficacy and benefit-to-harm relation of conventional corticotomy, piezocision, and micro-osteoperforation in accelerating canine retraction.

METHODS: A systematic search was conducted across PubMed, Cochrane Library, Embase, CT.gov, WHO ICTRP, Scopus, Google Scholar, with additional screening using NCT and study identification number. Randomized studies published between 2023 and the 20^{th} February 2025 (last date searched) evaluating surgical interventions for canine retraction acceleration were included.

RESULTS: Twenty-eight randomized clinical trials, in qualitative review, reported mild to moderate pain and discomfort, moderate root resorption, and acceptable anchorage loss. Ten randomized clinical trials in meta-analysis showed short term acceleration with piezocision yielding higher first month mean acceleration (0.81 mm, 95% CI 0.65 to 0.96) than micro-osteoperforation (0.48 mm, 95% CI 0.32 to 0,65).

CONCLUSION: All three interventions resulted in a short-term acceleration of canine retraction, accompanied by mild-to-moderate adverse effects. The acceleration was statistically significant during the first month and provided the greatest clinical benefit when closing canine gaps of 5 mm or less, with only transient effects and minimal anchorage loss.

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1 Introduction

Orthodontic treatment acceleration has been of interest to both patients and providers over the last decade (Uribe et al., 2014). Orthodontic treatments typically take around 2 years (Fink & Smith, 1957), with extraction treatments lasting 21–27 months and non-extraction treatments lasting 25–35 months (Buschang et al., 2012). Shorter treatment times appeal strongly to patients (Uribe et al., 2014) and offer potential to minimise adverse effects such as root resorption (Pandis et al., 2008), decreased compliance (Roykó et al., 1999), and carious lesions (Bishara & Ostby, 2008) from prolonged orthodontic tooth movement.

Both non-surgical and surgical interventions have been developed in attempts to accelerate orthodontic treatment. Non-surgical interventions include low-level laser, low-frequency vibration, photobiomodulation, and platelet-rich plasma injection (El-Angbawi et al., 2015). Surgical interventions include conventional corticotomy, flapless corticotomy, piezocision, and micro-osteoperforations (Fleming et al., 2015). Among these interventions, surgical procedures, consisting of various forms of corticotomies, have the most available supporting evidence (MacDonald et al., 2021).

Surgical interventions were first described by Dr. LC Bryan, who used osteotomy to accelerate orthodontic tooth movement (Guilford, 1898). In 1959, Kole attempted to create separated bone blocks, believing bone continuity to be the main impediment to tooth movement (Kole, 1959). Frost later observed a direct correlation between the severity of insult and the speed and magnitude of bone turnover rate (Frost, 1989). Based on Frost's observations, Wilcko et al. (2001) suggested that, rather than bone blocking, the acceleration is in fact caused by a series of physiological bone healing responses called the regional acceleratory phenomenon (RAP).

RAP is a physiological bone healing and remodelling process. After local injury to the bone structure, osteoclasts and osteoblasts recruited to the site initiate a series of remodelling cascades, leading to lower density and higher plasticity of the resulting bone structure. These bone properties, providing a less resistant environment for tooth movement, are the foundation of orthodontic treatment acceleration. The RAP is transient with a peak at 1–2 months, a general duration of 4 months, and subsidence within 6–24 months (Wilcko et al., 2001). Surgical interventions based on RAP have been the main focus of interest for accelerating orthodontic tooth movement.

Aggressive attempts have been succeeded by minimally invasive techniques with the progressive discovery of underlying mechanisms and the development of modern instruments. Conventional corticotomy, involving the raising of a flap, bears the greatest acceleration (Yi et al., 2017) but also the most invasiveness.

Low patient acceptance of conventional corticotomy, owing to the discomfort and complications from the procedure (Charavet et al., 2019), motivated the development of less invasive, flapless procedures. Park et al. first attempted corticision, using a scalpel and mallet (Park et al., 2006). In 2009, Dibart et al. modified corticision into piezocision, using a piezotome for healing enhancement, minimal osteonecrotic damage, higher precision, and preservation of root integrity and blood supply (Dibart et al., 2009; Vercellotti et al., 2005). The newest development is micro-osteoperforation, first proposed by Teixeira et al., with minimal flapless bone puncturing (Teixeira et al., 2010). However, the efficacy of this procedure remains controversial (Alikhani et al., 2013; Alkebsi et al., 2018).

A large number of clinical trials have emerged along with the evolving progress of surgical intervention procedures. The wide variety of research designs contributes to high heterogeneity and limits inter-study comparison, rendering a reliable assessment of the true benefit

versus harm relationship complex and difficult.

The aim of this review is to provide an update on the effectiveness and adverse effects of corticotomy, piezocision, and micro-osteoperforation versus no adjunct for canine retraction acceleration.

2 Methods

2.1 Eligibility criteria

This review applied separate screenings for meta-analysis of canine retraction acceleration and for the qualitative synthesis of surgical adverse effects.

The meta-analysis inclusion criteria, based on the PICOS framework, were defined as follows. Participants were patients receiving fixed conventional orthodontic treatment involving bilateral extraction of the maxillary first premolars, with subsequent retraction of the maxillary canines that was not undertaken as part of preparation for orthognathic surgery. The intervention consisted of a single surgical procedure confined to the buccal side, either mesial or distal to the canine, with no additional procedures. The comparison group received no intervention. The quantitative outcome was the rate of canine retraction measured at monthly intervals. For studies reporting canine retraction rates at weekly intervals, values were converted to monthly rates by multiplying the weekly rate by four.

Only first-month data were eligible for pooling because this was the only interval consistently reported across all three interventions with comparable measurements.

The qualitative review inclusion criteria applied the same population, intervention, and comparison elements. Although the PIC elements were identical, the outcomes were reported descriptively because they were not standardized measured in a standardized manner and were reported with various follow-up periods across studies, precluding quantitative pooling. The descriptive qualitative outcomes are: pain and discomfort with supplementary swelling information, root resorption, and anchorage loss in the surgical group or on the surgical side. We included randomised parallel-group clinical trials and randomised split-mouth clinical trials published between 1 January 2013 and 20 February 2025. No articles were excluded on the basis of language.

The studies excluded were those that used non-randomised experimental groups or sides, involved orthodontic treatments that were not fixed, or focused on non-surgical interventions. Also excluded were studies combining surgical procedures with additional interventions, those with multiple surgical interventions, and studies where the surgical site was not the canine (for example, between the incisors). Control sides or groups receiving any intervention, as well as studies of tooth movement other than canine retraction, were omitted. In addition, animal studies, in vitro studies, retrospective studies, case reports, surveys, reviews, and study protocols were not considered.

2.2 Search strategy and selection process

MeSH terms and keywords, including word variations, were used to search PubMed, the Cochrane Library, Scopus and Google Scholar up to 20 February 2025. General terms relating to the study fields and aims were combined into one keyword pattern, while each specific intervention was included in a separate keyword pattern (**Table 1**). Published and unpublished trials registered on ClinicalTrials.gov (CT.gov) and the WHO International Clinical Trials Registry Platform (WHO ICTRP) were reviewed. For each ClinicalTrials.gov

registry entry, if a publication was not automatically linked to the NCT number, the NCT number, the principal investigator's name, other study identification (ID) numbers and the official title were searched to identify corresponding publications. Additional publications listed under "other information" on each ClinicalTrials.gov registry page were also screened.

Table 1. Databases used and search strategy.

DATABASE	SEARCH KEYWORDS
PubMed	(((Surgery) OR (Surgical)) AND (orthodontic)) AND (Acceleration) Filters: Randomized Controlled Trial, from 2013 - 2025
PubMed	((accelerat*) AND (orthodont*)) AND ((tooth) OR (teeth)) Filters: Randomized Controlled Trial, from 2013 - 2025
PubMed	((accelerat*) AND (orthodont*)) AND ((tooth) OR (teeth)) AND ((surgery) OR (surgical)) Filters: Randomized Controlled Trial, from 2013 - 2025
PubMed	((distract*) OR (PAOO) OR (piezocision) OR (MOP) OR (PDLD) OR (DAD) OR (corticotomy)) AND (accelerat*) AND (orthodont*) Filters: Randomized Controlled Trial, from 2013 - 2025
PubMed MESH	((distract*) OR (PAOO) OR (piezocision) OR (MOP) OR (PDLD) OR (DAD) OR (corticotomy)) AND (Tooth Movement Techniques[MeSH Terms]) Filters: Randomized Controlled Trial, from 2013 - 2025
Cochrane Library	orthodontic in Title Abstract Keyword AND acceleration in Title Abstract Keyword - with Cochrane Library publication date from 2013 to present, in Trials (Word variations have been searched)
Scopus	(distract* OR paoo OR aoo OR piezocision OR mop OR pdld OR dad OR corticotomy) AND (accelerat*) AND (orthodont*) AND PUBYEAR > 2012 AND PUBYEAR < 2026 AND (LIMIT-TO (SUBJAREA , "DENT")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (EXACTKEYWORD , "Orthodontic Tooth Movement") OR LIMIT-TO (EXACTKEYWORD , "Tooth Movement Techniques"))
GoogleScholar	"acceleration" "orthodontic" ("corticotomy" | "piezocision" | "MOP") -systematic -review -"case report" -mandibular

2.3 Risk of bias and effect measures

The Cochrane Handbook version 6.4 and RevMan Web version 7.10.1 were used to assess selection bias, performance bias, attrition bias, detection bias, and reporting bias. Seven categories of risk of bias, including random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and gap period after extraction, were evaluated. Risk of bias is marked as high, unclear, or low.

Canine retraction acceleration was computed as the difference between canine retraction rate in the surgical intervention group and the control group. Canine retraction rates in both groups were extracted as canine movement on a monthly interval.

The following scales are used to evaluate in qualitative analysis. Root resorption levels were classified as: no resorption (normal root length), mild (irregular root contour), moderate ($<$ 2 mm loss), severe (2 mm–$\frac{1}{3}$ root length loss); and extreme ($>$ $\frac{1}{3}$ root length loss). Acceptable, mild, moderate, and severe molar anchorage loss were implemented according to the following ranges: (0–1.5 mm); (1.5–3 mm); (3–4.5 mm); (4.5–6 mm). Pain, discomfort, and supplementary swelling scales were divided into thirds, representing mild (lower third), moderate (middle third), and severe (upper third), with the initiating value in each scale indicating none (e.g. 0 for VAS and NRS; 1 for Likert's scale). For studies reporting pain and discomfort without percentage-based incidence data, severity was categorized based on the highest reported level.

2.4 Statistics

Certainty of evidence is evaluated based on the following categories: risk of bias, inconsistency, indirectness, imprecision, and publication bias. GRADEpro GDT is used to compute and form the summary of findings tables.

Funnel plots were generated to assess publication bias if 10 or more studies were included in each intervention group in the quantitative analysis.

3 Results

The initial search yielded 905 records. After removing 331 duplicates, 32 records fulfilled the PIC inclusion criteria and were retrieved for detailed evaluation. Two studies with no adverse effects and canine retraction rates not in monthly intervals (accumulative data) were further removed (Fernandes et al., 2021; Golshah et al., 2021). The selection process is shown in **Figure 1**.

Twenty-eight studies assessing adverse effects were included in the qualitative analysis. Ten studies evaluating canine retraction rates at monthly intervals following a single surgical intervention were included in the quantitative analysis.

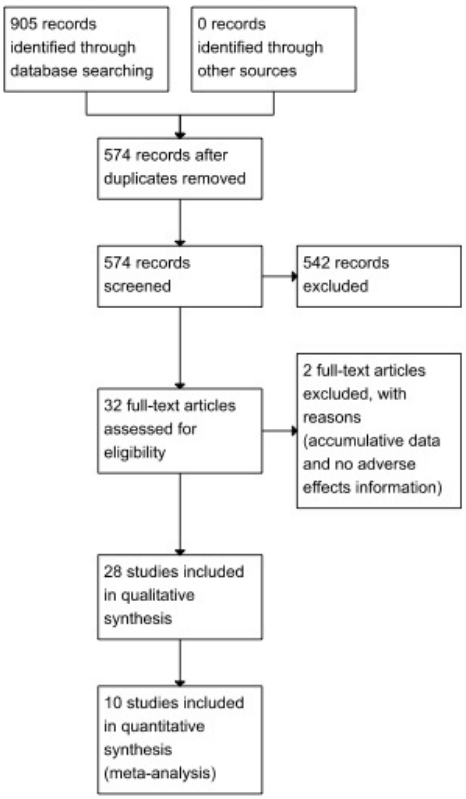

Figure 1. Flow diagram of study selection.

This review included randomized clinical trials, the majority of which employed a split-mouth design; three studies used a parallel-group control design. Across the included studies, participant characteristics varied in gender and age, most commonly involving adolescents and young adults. Follow-up durations ranged from one to six months, with most studies reporting follow-up periods of three months or less. Detailed characteristics of each study are presented in supplementary **Table S1**.

3.1 Risk of bias

Most of the studies described randomization processes, including random sequence generation or allocation concealment, except for a few that lacked detailed descriptions of these methods.

Due to the nature of the intervention, blinding of participants and operators was considered unfeasible. Most studies reported single blinding (outcome assessor blinding), although some did not specify the blinding procedures employed.

Several studies demonstrated exclusion and attrition with documented reasons. Contributing factors included irregular attendance, poor oral hygiene, flap involvement during premolar extraction, presence of bone defects, and broken dental casts.

A considerable proportion of studies had follow-up periods of three months or less. This suggests potential reporting bias, given that the regional acceleratory phenomenon (RAP) peaks at 1–2 months and generally lasts approximately 4 months (Wilcko et al., 2001).

Several studies did not incorporate a gap period between the completion of extraction and the initiation of intentional tooth movement, rendering the extraction a confounding factor accelerating tooth movement and thus exposing the study to *other bias* (**Figure 2**). Funnel plots were not generated to assess publication bias since no more than 10 studies were included in each intervention group in the quantitative analysis.

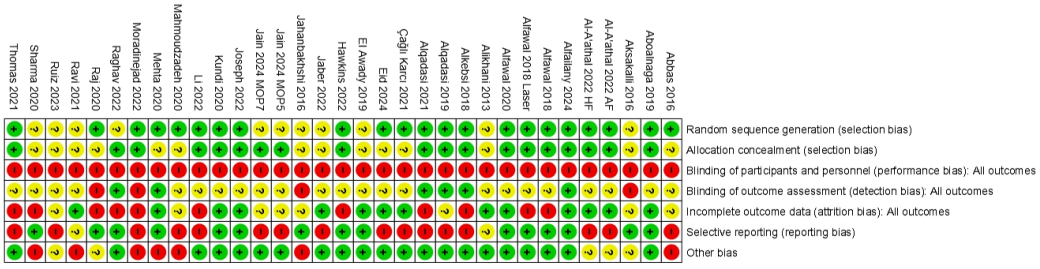

Figure 2. Risk of bias summary.

3.2 Quantitative analysis

Canine retraction acceleration rates comparing all three interventions to control groups were available for 1–6 months. The majority of the studies, however, had data only for the 1–3 month period.

Conventional corticotomy. One study (Jahanbakhshi et al., 2016) fulfilled the inclusion criteria and analyzed canine retraction acceleration by conventional corticotomy compared to no surgical intervention between 1–4 months. Meta-analysis was not feasible since only one study was available. The mean data from the single study showed that conventional corticotomy accelerated the rate of canine movement by 1.2 mm compared to the control group in the first month. The acceleration then rapidly decreased to 0.9 mm (second month), 0.6 mm (third month), and 0.3 mm (fourth month). In this study, extraction procedure was completed within three months from starting canine retraction and may serve as a confounding surgical insult to the RAP effect.

Piezocision. Two studies (Alfawal et al., 2018; Raj et al., 2020) evaluated the acceleration of canine retraction due to piezocision compared to no intervention in the first month. The

average mean differences of tooth movement rate between piezocision group and control group started at 0.81 (95% CI 0.65 to 0.96) at 0–1 month. In the following months, data from only one study (Alfawal et al., 2018) was available, and thus was not included in meta-analysis. The heterogeneity among studies was low (I2=0). The two studies implement the same piezocision depth (3 mm) and piezocision amount (two vertical incisions) on patients with similar ages and dental malocclusions. Raj et al. (2020) applied piezocision on buccal alveolar bone mesial and distal to canine with suture afterwards while Alfawal et al. (2018) had both incisions at middle distance between canine and second premolar without sutures.

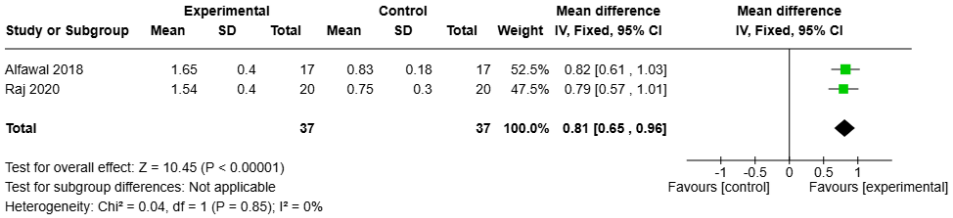

Figure 3. Piezocision: Difference in canine retraction rates compared to controls for of the first month.

Micro-osteoperforation. Six studies (Alfawal et al., 2018; El-Awady et al.,2019; Jain et al., 2024; Li et al., 2022; Raghav et al., 2022; Thomas et al., 2021) were analyzed in the meta-analysis with regard to the acceleration of orthodontic movement using micro-osteoperforation during 1 to 4 months. Meta-analysis was conducted focusing on the first month due to limited available study in the comparable interventions (conventional corticotomy and piezocision). The tooth acceleration rate started high (0.48 mm, 95% CI 0.32 to 0,65) at 0–1 month and quickly diminished the following two months. After the third month, the acceleration effect decreased to negative value (-0.01 mm). The canine retraction rate acceleration was statistically significant in the first and second month.

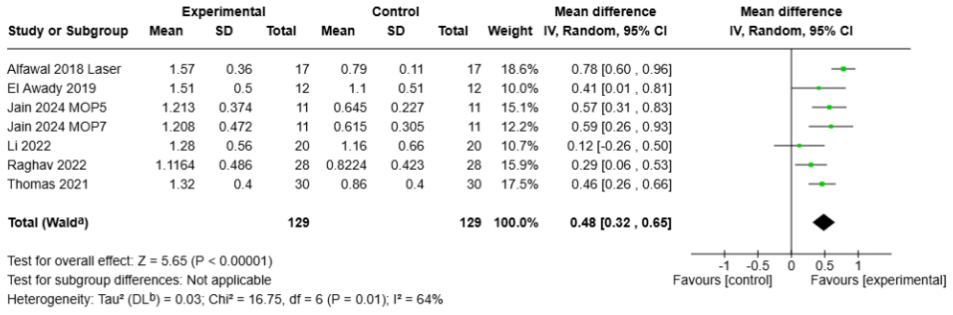

Figure 4. Micro-osteoperforation: Difference in canine retraction rates compared to controls for of the first month.

Long-term effects across all interventions. Overall, the data indicate that conventional corticotomy, piezocision, and micro-osteoperforation commonly produce a short-term acceleration of canine retraction during the first two months, but this effect markedly diminishes thereafter and is often no longer detectable by months 3–4; results are highly

heterogeneous and many confidence intervals include zero, so relatively few effects are robustly significant and only one study reports outcomes to six months (**Table 2**). Specifically, CC shows a strong early effect that wanes yet remains positive through month 4; PC yields a moderate early benefit that typically disappears or slightly reverses by months 3–4; MOP presents an inconsistent picture, with some studies reporting an early advantage and others showing no benefit or even reduced retraction later, likely reflecting variability in technique, perforation depth and measurement timing. Given the paucity of long-term data, substantial heterogeneity and frequent lack of statistical significance, any clinical gain appears confined to short-term acceleration.

Table 2. Change in the canine retraction rate in mm [95% CI] after two months concerning different interventions.

AUTHOR (YEAR)	INTV.	2nd MONTH	3rd MONTH	4th MONTH	5th MONTH	6th MONTH
Jahanbakhshi (2016)	CC	0.90 [0.76, 1.04]	0.60 [0.43, 0.77]	0.30 [0.19, 0.41]		
Alfawal (2018)	PC	0.50 [0.33, 0.67]	0.12 [-0.05, 0.29]	-0.07 [-0.14, -0.00]		
Alfawal (2018)	MOP	0.40 [0.24, 0.56]	0.10 [-0.08, 0.28]	-0.01 [-0.12, 0.10]		
EI Awady (2019)	MOP	-0.01 [-0.43,0.41]	0.18 [-0.17, 0.53]	-0.14 [-0.42, 0.14]	-0.32 [-0.48, -0.16]	-0.37 [-0.77, 0.03]
Jaber (2022)	MOP	0.72 [0.36, 1.08]	-0.12 [-0.38, 0.14]			
Jain (2024)	MOP5*	0.32 [0.08,0.56]				
Jain (2024)	MOP7*	0.27 [-0.03, 0.56]				
Li (2022)	MOP	0.11 [-0.21, 0.43]	0.29 [-0.05,0.63]			
Raghav (2022)	MOP	-0.15 [-0.44, 0.15]	-0.05 [-0.37, 0.27]	0.07 [-0.19,0.32]		

*CC = conventional corticotomy; PC = piezocision; MOP = micro-osteoperforation; *five or seven millimetre depth*

3.3 Qualitative analysis - adverse effects from surgical interventions

Among the 31 included studies, adverse effects reporting was inconsistent with heterogeneous protocols (**Table 3**). Eleven (35.5%) studies reported RR. Around half of the studies reported AL and P/D (51.6% and 45.2%).

Moderate root resorption was reported across all three interventions. Most trials reported none or minimal anchorage loss less than the control groups. Pain and discomfort occurred with a consistent pattern of mild to moderate extent with peak on the first day and a marked reduction on the third day.

Across all three interventions, adverse effects were predominantly mild to moderate. CC has the fewest available outcomes. MOP demonstrated general mild symptoms profiles with comparatively more reported studies. However, the lack of comparable and consistently reported data deem the recommendation in favour of a particular technique not definable.

4 Discussion

Accelerating orthodontic treatment offers the potential benefit of reducing treatment duration and the associated risk of adverse effects. The objective of this review was to provide a quantitative overview and analysis of the efficiency in reducing treatment time, as well as a qualitative review of the incidence of adverse effects.

Canine retraction acceleration rates diminished rapidly after the first month, with statistically significant differences observed in the first month across all three interventions: conventional corticotomy, piezocision, and micro-osteoperforation groups. This trend aligns with Wilcko et al.'s (2001) theory, in which the regional acceleratory phenomenon (RAP) peaks within the first 1–2 months and lasts for approximately four months.

Table 3. Severity and reporting frequency of adverse effects by intervention: root resorption (RR), anchorage loss (AL), and pain/discomfort (P/D) indicated on a visual analogue scale of $0 - 10$.

AUTHOR (YEAR)	RR (mm)	AL (mm)	P/D
CONVENTIONAL CORTICOTOMY			
Abbas (2016)	< 2	1.5 - 3.0	
Sharma (2020)		3.0 - 4.5	0.0 - 3.9 (0*)
PIEZOCISION			
Abbas (2016)	< 2	3.0 - 4.5	
Aksakalli (2016)		1.5 - 3.0	
Al-A'athal (2022) AF		< 1.5	
Al-A'athal (2022) HF		< 1.5	
Alfailany (2024)			0.0 - 3.9 (+*)
Alfawal (2018)		1.5 - 3.0	
Alfawal (2020)			7.0 - 10.0 (+*)
Alqadasi (2021)	< 2		
Çağlı Karcı (2021)		< 1.5	
Eid (2024)	< 2		
Hawkins (2022)		< 1.5	4.0 - 6.9
Mahmoudzadeh (2020)		< 1.5	
Moradinejad (2022)		< 1.5	
Raj (2020)	< 2		
Ravi (2021)	< 2		
Ruiz (2023)		< 1.5	
MICRO-OSTEOPERFORATION			
Aboalnaga (2019)	irregular	< 1.5	4.0 - 6.9
Alfawal (2018)		1.5 - 3.0	
Alfawal (2020)			4.0 - 6.9 (+*)
Alikhani (2013)			0.0 - 3.9
Alkebsi (2017)	< 2	< 1.5	0.0 - 3.9
Alqadasi (2019)	< 2		0.0 - 3.9
Alqadasi (2021)	< 2		
Jaber (2021)			0.0 - 3.9 (0*)
Jain (2024) MOP5			0.0 - 3.9
Jain (2024) MOP7			0.0 - 3.9
Joseph (2022)	< 2		
Kundi (2020)		< 1.5	4.0 - 6.9
Li (2022)			0.0 - 3.9
Mehta (2020)		0	0.0 - 3.9
Thomas (2021)	< 2		

**Swelling outcomes, when available, are provided as supplementary data in the P/D dataset.*
RL = root length

Among individual studies, acceleration values became negative during the later months, suggesting a possible catch-up of the tooth movement rate in the control group as the acceleration effect diminishes in the intervention groups.

Based on the inclusion criteria, piezocision and micro-osteoperforation were the only interventions with comparable outcomes for meta-analysis. In the first month, piezocision showed an average acceleration of 0.81 mm (95% CI 0.65 to 0.96) while micro-osteoperforation exhibited an average acceleration of 0.48 mm (95% CI 0.32 to 0,65). The lower acceleration value from micro-osteoperforation could be explained by the less extent of insult, resulting in weaker RAP (Frost, 1989). In addition, the use of laser (Alfawal et al., 2018) may promote healing and further attenuate the magnitude of RAP.

After the first month, a rapid decline of the transient RAP effect is observed in individual available studies. Considering the average canine retraction duration of four to six months (Koteswara Prasad et al., 2014), the acceleration effect is diluted corresponding to the total treatment time.

First premolar extraction produces a gap of approximately 7.16–7.39 mm (Fuentes et al., 2011). The mean unaccelerated monthly movement of a canine (controls) is 0.93 mm (Thiruvenkatachari et al., 2008). The space would therefore require roughly eight months to close. Calculating mean acceleration values for PC and MOP for months 2–6 (**Table 2**) shows that, from month 4, the acceleration rate falls below that of the controls (**Figure 5, left**). If the same acceleration values are then assumed for months 6, 7 and 8, after eight months PC achieves a distance of 7.35 mm, corresponding to an extension of treatment time of 4.8 days; with MOP, after eight months a distance of 7.02 mm is achieved, corresponding to an extension of 22.5 days. It can be concluded that the RAP effect offers the most clinical benefit (1.1-1.4 month) when closing extraction spaces of 5 mm or less and where anchorage loss is absent (**Figure 5, right**).

Most canine retraction clinical trials quantify only the early phase of canine retraction. This early improvement is influenced by tipping, friction, and anchorage interactions, and reflects only a portion of the total 7-8 mm extraction space (Ribeiro and Jacob et al., 2016). Consequently, the seemingly prominent first month treatment time reduction may be further diluted using full-phase canine retraction reference rate.

Discrepancies in study designs contribute to potential confounding and biased results. For example, Jahanbakhshi et al. (2016) evaluated the space closure rate instead of the canine movement rate. The experimental and control sides may exhibit different bone metabolism rates and consequently different amounts of anchorage loss. Therefore, the space closure rate can assume considerably higher values than the canine movement rate (Fernandes et al., 2021).

Various biological and non-biological factors may impede the clinical relevance of the acceleration effect induced by surgical interventions. For example, male patients with high facial height and younger age exhibit higher rates of tooth movement (Al-A'athal et al., 2022). Patient compliance and treatment complexity also influence total treatment duration (Uribe et al., 2017).

In qualitative analysis, mild to moderate symptoms were observed with high patient acceptance (Alfawal et al., 2020). In piezocision and micro-osteoperforation groups, patients reported extraction procedure as the more unpleasant procedure (Alfawal et al., 2020). In contrast, none reported extraction being more disturbing in conventional corticotomy (Sharma et al., 2020). The elevation of flaps in conventional corticotomy may contribute to the increased pain and discomfort reported (Charavet et al., 2019).

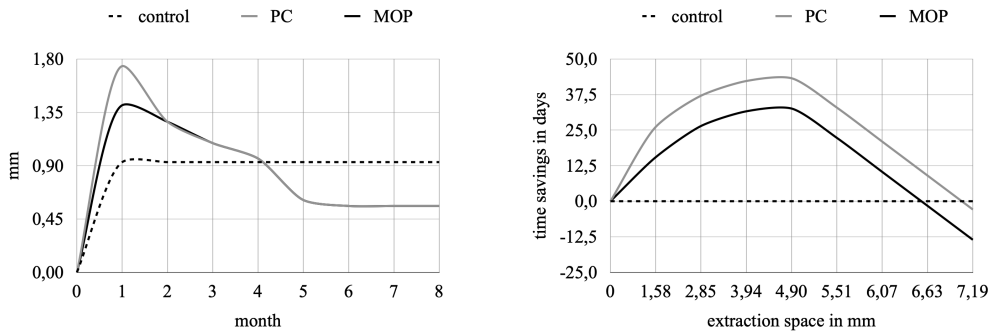

Figure 5. Left: Calculated canine retraction rates following piezocision and micro-osteoperforation. Assuming an average tooth movement of 0.93 mm per month (control), a 7.4 mm premolar extraction space would be closed in approximately eight months. Acceleration values were obtained from Figures 3 and 4 and from Table 2 (assuming the same rate for month 6, 7 and 8). From month 4 onwards, the acceleration declines to below that observed in the control group. **Right**: Time savings in days in relation to the extraction space. The largest values for both interventions are observed in month 4 for distances smaller than 5 mm.

A general pattern of moderate root resorption and acceptable anchorage loss less than the control group was observed with the exception of Al-A'athal et al.'s (2022) HF group. The reduction of resistance opposing tooth movement by the surgical intervention may result in less hyalinisation and facilitate tooth movement, which explains the observed pattern.

Overall, micro-osteoperforation delivers moderate acceleration effect in the first month with mild to moderate adverse symptoms. These findings suggest short-term advantages in initial phase of canine retraction with confined clinical impact.

The majority of studies include follow-up periods of no longer than three months across all interventions. Therefore, the acceleration effect of surgical interventions over the entire two-year duration of orthodontic treatment remains uncertain.

Conclusions

All three interventions resulted in a short-term acceleration of canine retraction, accompanied by mild-to-moderate adverse effects. Among the techniques included into the meta-analysis, piezocision achieved a greater initial acceleration than micro-osteoperforation. The results are in line with the theory of the regional acceleratory phenomenon. This acceleration is transient, with rapid deterioration, offering the greatest clinical benefit when closing canine gaps of 5 mm or less, with only transient effects and minimal anchorage loss.

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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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