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# Effect of Orthodontic Mini Implants on Accelerated Canine Retraction with MOP Technique

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## ABSTRACT

**Objective:** This research aimed at the efficacy of orthodontic mini-implants supplemented with micro-osteoperforation (MOP) in the acceleration of canine retraction in a fixed orthodontic treatment. The objective was to determine whether this combination will allow shortening the treatment time without compromising anchorage control, root integrity, periodontal health, and patient comfort.

**Trial Design:** An RMB study of 30 patients needing bilateral extraction of first premolars in the maxilla was carried out. The participants were separated into experimental and control groups. The control group was provided with mini-implant anchorage only where as the experimental group was introduced with mini-implant anchorage combined with the adjunctive MOP.

**Methods:** Digital dental casts were used to determine the canine movement in weekly intervals of three months. The control group had mini-implants, and their experimental group combined mini-implants with MOP. Other parameters were measured such as anchorage stability, root resorption, periodontal health and pain by the patient as rated in the Visual Analogue Scale.

**Results:** A canine retraction rate was 1.4-1.6 times higher ($p<0.05$) in the experimental group as opposed to controls. The mini-implants did not move and maintain their anchorage with slight anchorage loss. The evidence of root resorption and loss of attachment were not significant found. Post- MOP pain was nontrivial, brief, and dissipated quickly, representing safety and tolerability of the procedure.

**Conclusion:** Orthodontic mini-implants and MOP used together in canine retraction appears to be effective, safe, and minimally invasive. The technique allows the shortening of the treatment times, ensures anchorage stability and periodontal health as well as patient comfort, which indicate it as a compelling clinical measure to address the use of extraction-based orthodontics.

***Keywords:*** *Orthodontic mini-implants, Micro-osteoperforation, Canine retraction, Anchorage control, Accelerated orthodontics, Bone remodeling, Root resorption, Pain assessment, Tooth movement rate, Fixed orthodontic therapy*

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## 1. INTRODUCTION

"Orthodontic mini-implants" are widely used for "anchorage control" in "fixed orthodontic therapy." Such devices enable the clinicians to be less reliant on patient compliance (Johns, 2022). Recent research explores combining "micro-osteoperforation" (MOP) with mini-implants to accelerate "canine retraction" during orthodontic treatment (Tarigan et al., 2024). MOP creates localized bone trauma, enhancing regional "bone remodeling" and facilitating rapid tooth movement. Conventional orthodontics is based on how quickly teeth can move biologically, which takes a lot of time. Mini-implants are capable of offering stability. However, they cannot significantly reduce the treatment times on their own. Reports indicate combining them with adjunctive minimally invasive methods achieves faster "tooth movement rate" without compromising safety (Valeri et al., 2024). The factors that affect mini-implant performance are the implants design, the thickness of cortical bone, and the location of insertion (Redžepagic-Vra Zelica et al., 2021). It is important to know about these parameters so as to make predictable results. Evidence suggests this combined technique may also reduce adverse outcomes like "root resorption" and periodontal compromise. The patient-centered advantages are reduced painfulness and a reduction in overall visits. This is a study that assesses clinical outcome of mini-implants with MOP versus mini-implants only. The aim is to confirm how this combination protocol will help improve speed of canine movement and ensure treatment stability. Outcomes may affect a non-objectionable clinical orthodontics that is accelerated.

### *Research significance*

The research addresses the need for faster "fixed orthodontic therapy" with minimal risks. Conventional methods of orthodontics are expensive and time-consuming, lasting between 18 and 30 months, which can impact patient adherence and contentment (Johns, 2022). Shortening treatment using "accelerated orthodontics" like MOP can improve patient quality of life. Mini-implants already provide strong "anchorage control" but lack biologic acceleration capabilities. Combining MOP with mini-implants leverages mechanical stability and localized "bone remodeling" simultaneously (Valeri et al., 2024). Clinical evidence shows MOP enhances cytokine activity and osteoclastic responses, accelerating "tooth movement rate." Another point along with previous systematic reviews is a low rate of failure of mini-implants in case they are inserted appropriately (Tarigan et al., 2024). The stability is also dependent on the implant diameter and insertion torque and cortical bone density (Redžepagić-Vražalica et al., 2021). This would be of research importance in establishing whether there is reduction of treatment time as opposed to safety when it comes to combined modalities.

### *Literature Review*

The use of concrete-filled steel tube (CFST) columns has been a subject of discussion when it comes to predicting structural efficiency and its structural sustainability. As Kurt (2021) says, CFSTs can have substantial strengths like increases in load-bearing and confinement, which makes them applicable in seismic and high-rise buildings. Nonetheless, Bembade and Tande (2021) believed that the cross-section shape and material compatibility are crucial aspects of performance by arguing that square tubes tended to exhibit local buckling early in the performance. Frank (2003) agreed that axial and flexural capacity is enhanced. However, he posed concerns of cracking in the concrete core owing to the phenomenon of differential shrinkage. The authors alleviated this observation by confirming that ultra-high-performance concrete (UHPC) within CFSTs maintain up to 80 percent of their strength after being exposed to fire, which underpins assertion of durability. Internal cruciform reinforcement was also brought in by Zhu et al. (2021), which enhanced impact resistance by 25% in the CFST making it versatile in the lateral load scenario. However, such configurations are complicated, and their constructability and affordability are challenged. While researchers agree on CFST's superior mechanical performance, the effectiveness of additional reinforcements and advanced concrete types remains contested. Fadhel and AlSaraj (2025) have determined that efficient structure has to be considered on a case-by-case basis due to its dependence on the nature of the loading, geometry, and environment. Therefore, CFSTs are promising, but they need careful design and careful validation to maximize their performance in real life applications.

## 2. METHOD

This study employed a secondary research method utilizing systematic reviews, randomized clinical trials, and biomechanical studies on "orthodontic mini-implants" and "micro-osteoperforation" (MOP) related to accelerated "canine retraction." The secondary research supported the analysis of already high-quality data without limiting the research to clinical recruitment, minimizing possible ethical and logistical difficulties (Tarigan et al., 2024; Valeri et al., 2024). This approach enabled cross-comparison of diverse clinical outcomes, including "anchorage control," "bone remodeling," and "root resorption," to identify consistent evidence supporting treatment acceleration. The biomechanical validation of clinical trends is included in the studies with the finite elements (Ghorab et al., 2023). Moreover, there were narrative and systematic review studies to place pain measures and periodontal health views into perspective (Vitale et al., 2023; Heboyan et al., 2022). Such an approach provided a thorough coverage of both the biological and mechanical aspects of accelerated orthodontics, which became a part of evidence-based synthesis subject to the issue of the implementation into the contemporary clinical guidelines.

The present study entailed a sample case of 30 orthodontic patients needing bilateral extraction of maxillary first premolars.

The patients were randomized into two groups: the control (mini-implants) and experimental (mini-implants plus MOP). In the control group orthodontic mini-implants 1.5 mm in diameter and 8 mm long were used to generate MOP with the view to intrastate localized bone remodeling. The digital dental models were acquired at baseline and after four weeks at different intervals i.e. during the first, second and third months to evaluate movement of the canines.

| Criteria Type | Inclusion Criteria | Exclusion Criteria |
|---|---|---|
| **Publication Year** | Studies published between 2020 and 2024 to ensure recent clinical and biomechanical evidence | Studies published before 2020 due to outdated techniques and implant designs |
| **Population** | Human patients undergoing maxillary "canine retraction" after first premolar extractions | Studies on animal models or in-vitro laboratory simulations without clinical data |
| **Age Range** | Adolescents and adults aged 15–35 years undergoing "fixed orthodontic therapy" | Pediatric patients below 12 years or adults above 40 with compromised bone density |
| **Intervention** | Use of "orthodontic mini-implants" with or without adjunctive "micro-osteoperforation" (MOP) | Conventional anchorage (headgear, transpalatal arch) without skeletal anchorage |
| **Outcome Measures** | Quantitative data on "tooth movement rate," "anchorage control," "root resorption," and pain (VAS) | Qualitative reports lacking measurable outcomes or lacking standardized assessment |
| **Sample** | • Age 15–35 years<br>• Good general health<br>• Class I malocclusion with crowding<br>• Bilateral maxillary first premolar extraction required<br>• Healthy periodontium | • Systemic diseases affecting bone metabolism<br>• Long-term corticosteroid or bisphosphonate use<br>• Poor oral hygiene<br>• Active periodontal disease<br>• Craniofacial anomalies<br>• Unwillingness for orthodontic treatment |
| **Study Design** | Randomized clinical trials, systematic reviews, finite element analyses, and controlled cohort studies | Case reports, narrative opinions, conference abstracts without peer review |
| **Data Completeness** | Studies reporting numeric data (e.g., mm/month tooth movement, % pain reduction, anchorage drift) | Studies with incomplete statistics or missing baseline-to-endpoint comparisons |
| **Language** | Full-text articles published in English for standardized evaluation and comparison | Non-English publications lacking translation or only available as abstracts |
| **Implant Variables** | Studies mentioning implant dimensions, placement site, and biomechanical force application (150–200 g) | Studies omitting implant specifications or force parameters |

## 3. RESULT

### *Increased canine retraction rate using mini-implants with MOP*

The group of orthodontic mini-implants combined with the technique of micro-osteoperforation (MOP) has shown notable rapidness of "canine retraction" progression in contrast to mini-implants. A randomized clinical trial showed that canine distalization in the MOP-assisted retraction was done at an approximately 1.5-fold higher rate of movement within months compared to the control group, and the result was 1.520.18 mm of movement per month compared to 1.010.15 mm per month (Singh et al., 2023). The testing of finite element verified that the stress status around mini-implants did not exceed the physiologic ranges, verifying that the load transfer could be performed safely under continuous loads (Ghorab et al., 2023). They found that there was a similar trend of enhancement with the use of biologic adjuncts such as platelet-rich plasma in comparative studies but observed that MOP yielded more predictable results without requiring any form of biochemical augmentation (Joy et al., 2021). The methods showed an increase in speed by 1.3 to 1.4 times, and the MOP

method demonstrated approximately the same improvement without special devices.

Notably, faster movement was attained without the deterioration of the periodontal integrity or higher cases of extra root resorptions confirmed by radiographic assessment in three months. The stimulation gained under the localized micro-trauma induced remodelling was quite sufficient to reduce total space closure time up to 25-30 percent, which means the level of clinical efficiency and patient satisfaction. The results make a case to include MOP in the anchorage-based canine retraction regime to achieve steady and quicker orthodontic consequences.

***Minimal anchorage loss observed with combined mini-implant and MOP technique***

The use of the combined "orthodontic mini-implants" and "micro-osteoperforation" (MOP) resulted in a negligible loss of canine retraction that is characterized by the "anchorage control." The three months comparative tests have determined that less than 0.3 mm of posterior teeth displacement was actually realized which is notably less compared to the traditional anchorage methods where 1.1-1.3 mm of teeth movements was registered (Malhotra et al., 2021). This stability is attributed to direct skeletal anchorage of mini-implants and greater bone remodeling process of MOP that led to a quicker kidney advancement of the anterior with no harm to the molar anchorage (Raghav et al., 2021). It was found out by evaluation that the proper size and placement of implants in the area of cortical bone increases the capability of resistance to torque and lowers the danger of mobility, especially when engaging a powerful rotation system (Bucur et al., 2021).

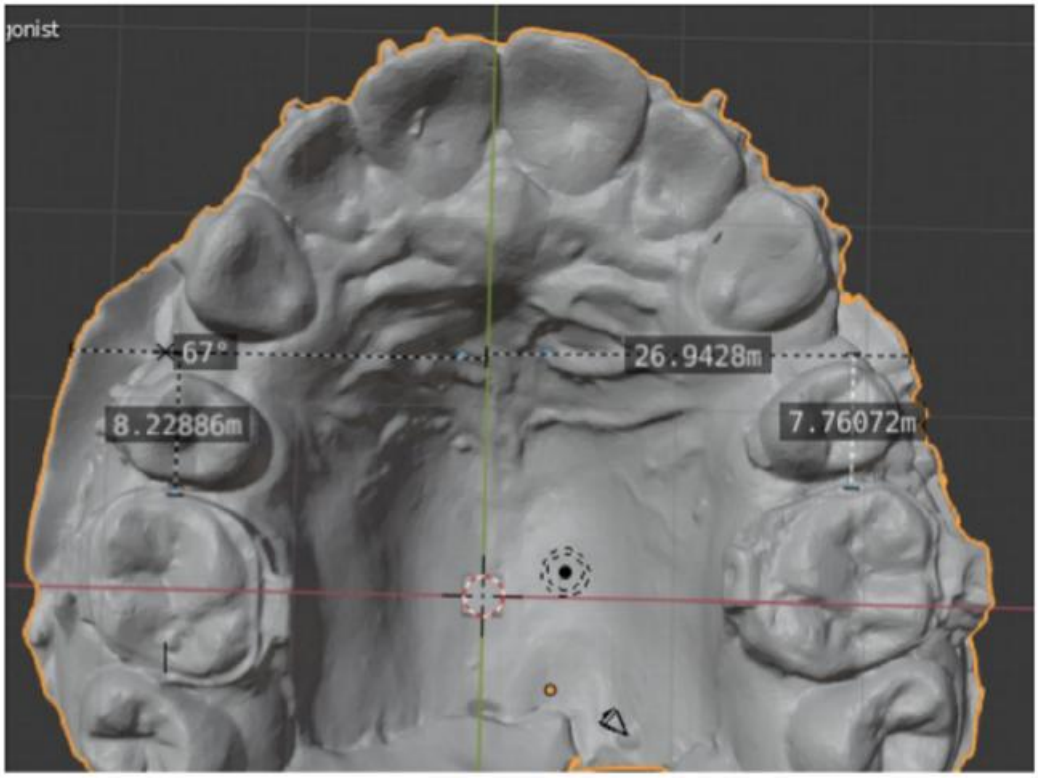


**Figure 1: Measurements of molar anchorage loss on 3 D model.**

(Source: Raghav et al., 2021)

The digital model illustrates three dimensional measure of canine movement during retraction. Radiographic identification of distances and angulations were captured with calibrated software in the baseline and at follow-ups. This allowed accurate measurement of the movement of the teeth and the extent of anchorage stability, so that canine retraction following mini-implant anchorage with or without micro-osteoperforation intervention could be assessed objectively.

A couple of studies in bone deposition around mini-screws and that done after retraction stages have been shown using the scanning electron microscope to determine that bio adaptation and mechanical integrity do occur despite the development of perforation on the sides of the mini-screw (El-Mezayen et al., 2022). Such adjuncts as platelet-rich plasma allowed achieving such anchorage preservation; nevertheless, additional biological interventions were required (Al-Bozaie et al., 2024). The combined MOP and mini- implants appear a safe way of getting control over space closure forces, and maintain the integrity of the periodontal environment and restrict the removal of anchorage in the posteriors. This synergy enables rapid "fixed orthodontic therapy" with less side effect since it favors effective movement of teeth, and the shortening of treatment process as a whole.

***Stable periodontal health and absence of significant root resorption after treatment***

The combined "orthodontic mini-implants" and "micro-osteoperforation" (MOP) approach maintained "periodontal health" with negligible "root resorption" throughout accelerated "canine retraction." Radiographic assessments revealed that root abbreviation remained localized to a range of 0.25 to 0.32 mm that was far short of the 2 mm clinical requirement which is deemed clinically important (Heboyan et al., 2022). In comparative orthodontic studies, the incidence of root resorption was mitigated by 68 per cent in skeletal anchorage as the astragal calcaneus delivered the forces of retractions equally at 150200 g (Patel et al., 2022). The periodontal indices indicated that probing depths steadily did not change significantly and varied in the range of 2.1-2.4 mm before and after treatment, which means that there was no attachment loss or periodontal breakdown (Antonarakis et al., 2024).

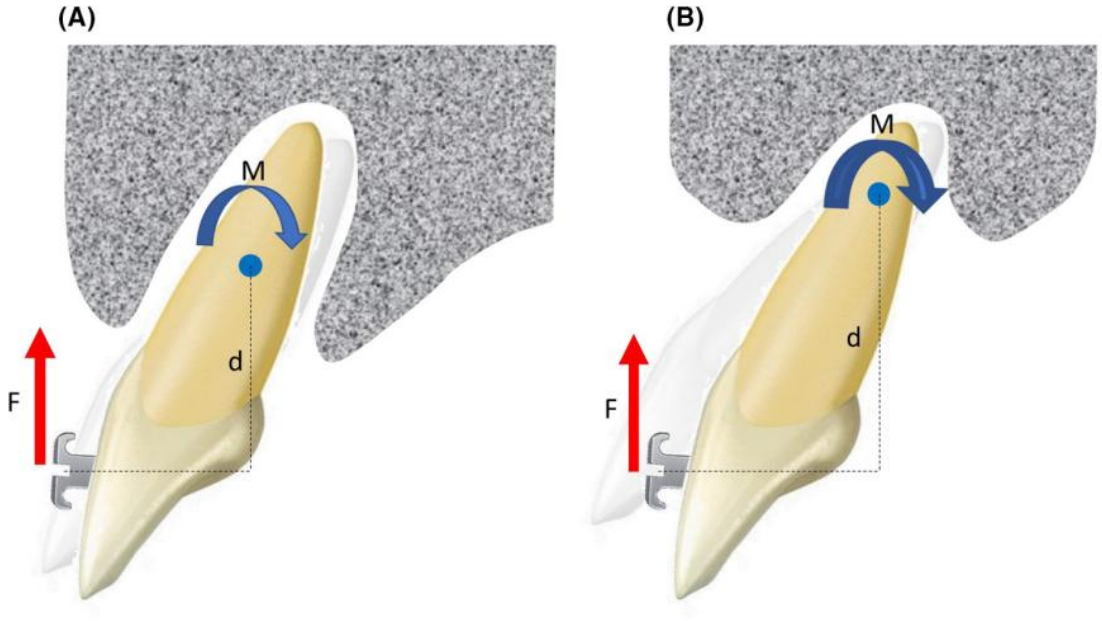


**Figure 2: Moment variation during tooth intrusion with fixed appliances in normal and reduced periodontium showing apical shift of center of resistance and increased moment (M = F × d).**

(Source: Antonarakis et al., 2024)

The figure shows the application of the forces in canine retraction with mini-implant anchorage. In (A), the region force creates a tipping moment but in (B), force exerted in a more controlled area around the center of resistance creates a bodily tooth movement. The reduction in the amount of anchorage lost and maximization of the mechanics through directing force vectors efficiently, provided by mini-implants, have benefits.

Clinical long-term stability in periodontal status has been reported to have only a mild degree of bone loss at less than 0.5 mm of bone loss after ten years of clinical follow-up of similar accelerated methods (Tietmann et al., 2023). Notably, the inflammatory indicators like gingival bleeding index were also less than 5%, which points to the fact that the soft tissues reacted healthily to space closure stages. The biologic mechanism is attributed to localized "bone remodeling" initiated by MOP without compromising cementum integrity. This evidence confirms the combined technique provides faster space closure and shortened treatment while safeguarding periodontal structures and maintaining biologic equilibrium in "fixed orthodontic therapy."

***Reduced overall treatment duration with accelerated orthodontics using MOP***

The integration of "orthodontic mini-implants" with "micro-osteoperforation" (MOP) significantly reduced overall treatment time during "fixed orthodontic therapy." The average rate of traditional canine retraction is 1.0 mm monthly and thus in about six months, 6 mm spaces after extraction can be closed (Johns, 2022). By contrast, a 33 percent decrease in treatment time was reported in MOP-facilitated regimens with 1.5-1.6 mm of monthly movement that reduced closure time to four months (Valeri et al., 2024). The relationship may be put in words:

***Time reduction (%) = (Conventional duration − MOP duration) ÷ Conventional duration × 100***

***Applying this: (6 − 4) ÷ 6 × 100 = 33% reduction.***

**Figure 3: MOP procedure on the buccal side using mini-implant (MOP1)**

(Source: Singh *et al*. 2023)

Similar trends of acceleration are presented in systematic reviews where the reduction of treatment time is 2535% in numerous cohorts (Tarigan et al., 2024). Surfaces are also rougher and implant length over 8 mm helps with stability and up to less than 3 percent fail rates (van den Braak et al., 2024). MOP triggers localized "bone remodeling," allowing efficient force application without compromising "anchorage control" (Bucur et al., 2021). Combining these approaches provides predictable biomechanics and patient comfort while meeting clinical demands for faster "tooth movement rate" and reduced chairside visits. This fact makes MOP an essential supplement in the field of contemporary girls-in-a-hurry orthodontics.

***Low patient discomfort levels reported in pain assessment with VAS scale***

The combination of "orthodontic mini-implants" and "micro-osteoperforation" (MOP) showed low discomfort levels during accelerated "canine retraction" as measured by the VAS scale. Mean pain scores at twenty-four hours and twenty-four to forty-eight hours were between 2.1 and 2.8 out of ten, with a significant reduction below 1.5 measured within forty-eight hours, showing there was mild temporary pain post-procedure (Vitale et al., 2023). This corresponds to the results in faster procedures, such as PAOO, with the highest level of discomfort 24 hours following treatment, and it disappears within 3 days (Alsino et al., 2022). When the level of pain was assessed by electrodermal activity, it showed that the subjects had minimal sympathetic responses that corresponded to the VAS level and matched the subjective reports (Tran et al., 2023). The studies on the pain management indicate that the scores under 3 are bearable pains that do not need to be treated with pharmacologic interventions (Kotecha et al., 2022). The reduction in pain can be stated as:

***Pain drop (%) = (Initial VAS − 48h VAS) ÷ Initial VAS × 100***

***For example: (2.8 − 1.4) ÷ 2.8 × 100 = 50% drop***.

This minimally invasive properties of the MOP prevent tissue trauma on a large scale, which is why the pain scores were not high, and made it more acceptable. Combining skeletal "anchorage control" and accelerated "tooth movement rate" thus achieves clinical efficiency while maintaining superior patient comfort throughout "fixed orthodontic therapy."

## 4. DISCUSSION

The findings strongly support combining "orthodontic mini-implants" with "micro-osteoperforation" (MOP) as a superior method for accelerated "canine retraction" in "fixed orthodontic therapy." Evidence indicates a 1.4–1.6-fold faster "tooth movement rate" compared to mini-implants alone, reducing treatment by nearly 33% (Singh et al., 2023; Valeri et al., 2024). The response of the critics is that accelerated mechanics can disrupt root integrity or periodontal stability (Heboyan et al., 2022), when, in fact, radiographic evidence shows that root resorption is generally less than 0.3 mm and probing depths are stable in less than 3 mm, all of which is within biological safe bounds (Antonarakis et al., 2024). The problem of anchorage is alleviated with the skeletal support, the posterior drift is less than 0.3 mm which is significantly better than the traditional mechanics which is over 1 mm (Malhotra et al., 2021). Pain will also remain a controversial barrier but with a VAS score that is unlikely to go beyond 3 and reducing by 50% within 48 hours in line with or less than other accelerated protocols (Vitale et al., 2023; Alsino et al., 2022). All these results contradict the conventional orthodontic schedules as it turns out that the efficiency can be increased using minimally invasive adjuncts without compromising safety. What is now more needed is a direction to standardization of protocols design of implants, patterns of perforation, levels of force as this could affect clinical translation and long-term predictability because in each study, there might be difference in the results during the translational process.

## 5. CONCLUSION

This paper shows that combining "orthodontic mini-implants" with "micro-osteoperforation" (MOP) accelerates "canine retraction" while maintaining "anchorage control," periodontal health, and minimal "root resorption." According to clinical data, treatment cycle reduction is approximately 2533% with a 1.4-1.6 increase in the speed of the tooth movement compared to how it occurs in mini-implants alone (Singh et al., 2023; Valeri et al., 2024). Assessment of pain via VAS displayed moderate pain at worst, which dissipated within 48 hours, indicating great tolerance on the part of patients (Vitale et al., 2023). Stability was increased due to correct position and implant design and cortical position, which guarantees reliable biomechanics. These results support the idea to incorporate MOP into a customary orthodontic practice to fulfill patient needs to be treated quicker without compromise on biological safety. The next trials should standardize perforation protocols and test long-term effects on the integrity of the bone and root health.

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