Evaluation and Comparison of the Rate of Canine Retraction Using Two Accelerated Orthodontic Treatment Techniques: An *In Vivo* Study

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ABSTRACT

Aim: The study was aimed at evaluating and comparing the rate of canine retraction using piezocision (PZ) and micro-osteoperforation (MOP).

Materials and methods: A split-mouth study design was used in which the canine of each side of the arch of each subject was divided into the PZ side and the MOP side. After first premolar extraction, PZ was performed on one side and MOP was performed on the contralateral side. Canine retraction on both sides was performed using NiTi closed coil springs. All the measurements were performed by a direct technique with the help of a digital Vernier caliper on stone casts obtained before canine retraction (T0) and after the completion (T1) of retraction. This data of the rate of individual canine retraction in the PZ and MOP groups obtained were subjected to the statistical analysis.

Results: The mean rate of canine retraction was 1.64 ± 0.43 mm/month for the PZ group and 1.34 ± 0.51 mm/month for the MOP group. The paired difference in the rates of the canine retraction was 0.39 ± 0.26 mm/month, which was statistically significant ($p < 0.05$). Canine retraction on the PZ was seen to be 1.22 folds faster than the MOP side.

Conclusion: Piezocision showed a significant increase in the rate of canine retraction whereas MOP showed a nominal increase in the rate of canine retraction. Piezocision increased the rate of canine retraction by 1.2 folds compared to MOP.

Clinical significance: The need to reduce the duration of treatment and the associated factors is the need of the hour. There is therefore a need to find the best and most feasible approach to accelerate tooth movement with existing biomechanical systems.

Keywords: Accelerated orthodontics, Canine retraction, Micro-osteoperforation, Piezocision, Regional acceleratory phenomenon.

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INTRODUCTION

Fixed orthodontic treatment involves various types of tooth movement leading to achievement of ideal occlusion. The tissue response that takes place during orthodontic treatment happens on a chemical, cellular, and mechanical level around the tissues involved. The time required for achieving treatment goals is usually 18–24 months.

The number of adult patients seeking orthodontic therapy has increased considerably over the last few years. The demand for shorter treatment duration has set precedent for researchers to look at newer paths to shorten treatment duration without compromising on the efficiency of the treatment.

Prolonged orthodontic therapy causes increased vulnerability to dental caries, gingival recession, root resorption, and also leads to decreased patient cooperation.

The introduction of accelerated orthodontic tooth movement (AOTM) with minimally invasive techniques has decreased treatment duration and increased patient acceptance toward treatment over the past decade.

The regional acceleratory phenomenon (RAP) is a local response to a deleterious stimulus. It is a process by which the tissue forms faster than the normal local regeneration by intensifying the various healing stages. This phenomenon makes healing 2–10 times faster than normal physiologic healing.¹

There are several methods used for accelerating tooth movement such as corticotomies, periodontal distraction, use of low-level lasers, mucoperiosteal flap surgery, piezocision (PZ), and micro-osteoperforation (MOP).

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Piezocision, introduced by Dibart in 2009, is a flapless alveolar decortication procedure, where labial vertical incisions are made through the soft tissue between all teeth, not including the papilla.² This technique uses microincisions limited to the buccal gingiva that allow the use of a piezoelectric knife to give osseous cuts to the buccal cortex and to initiate the RAP.²

The piezoelectric knife works only on mineralized tissues; it does not harm soft tissues and their blood supply. Hard tissue or soft tissue grafting can be combined with PZ through selective tunneling, which allows for gingival correction.

Micro-osteoperforation is one of the least invasive surgical techniques described for use in conjunction with orthodontic therapy. This involves the production of multiple transmucosal

perforations within the alveolar bone, situated in close proximity to the region of the desired tooth movement and in specific configurations, depending on the movement of the tooth required.

Thus, this study was aimed at evaluating and comparing the rate of canine retraction using PZ and MOP.

MATERIALS AND METHODS

The study sample comprised of patients reporting to the Department of Orthodontics and Dentofacial Orthopedics, JSS Dental College and Hospital, requiring fixed orthodontic treatment and who fulfilled the inclusion criteria.

Inclusion Criteria

- Patients requiring fixed orthodontic treatment with first premolar extraction followed by canine retraction.
- Patients aged between 16 years and 25 years of age.
- Healthy gingival and periodontal condition.
- All teeth mesial to second molar were erupted.
- Patients giving an informed consent to participate in the study.

Exclusion Criteria

- Patients with history of long-term use of antibiotics, systemic corticosteroids, and calcium channel blockers.
- Patients with history of previous orthodontic treatment.
- Patients with history of systemic diseases that are contradicted for orthodontic treatment.
- Periodontally compromised patients.

Collection of Data

The estimated sample size was 15 sites per group. The sample consisted of eight patients. Patients fulfilling the inclusion criteria and accepting to participate in the study were requested to sign an informed consent form.

A split-mouth study design was used where one side of the arch was designated as the PZ side and the contralateral as the MOP

side. Ethical clearance was obtained from the institutional ethical committee of JSS Dental College and Hospital, Mysuru.

Methodology

- Prior to the start of the treatment, patient was advised first premolar extraction under local anesthesia.
- Before PZ and MOP were performed, initial leveling and aligning was done.
- Before the start of canine retraction (T0), impressions were taken and study models were made using a dental stone.

Piezocision Technique

- After the induction of local anesthesia, one vertical interproximal incision was placed through the periosteum and below the interdental papilla not including the free gingiva on the mesiobuccal and distobuccal sides of the canines using a no. 15 blade with a Bard and Parker (BP) handle (Fig. 1).
- The grooves between the roots of the neighboring teeth were used as reference for the cuts.
- Vertical interproximal incisions were performed approximately 5 mm apical to the mesial and distal interdental papilla of the canine.
- Incision lengths of approximately 10 mm were placed apically.
- A piezo surgery knife using a BS-1 insert (Fig. 2) was used to create cortical alveolar incisions of approximately 3–4 mm in depth (VarioSurg3; NSK, Tokyo, Japan).
- The depth was measured using a periodontal probe.
- The incisions were sutured with nonresorbable 4-0 silk with an interrupted technique.

Micro-osteoperforation Technique

- On the contralateral side, three to five MOPs were performed distal to the canine before retraction (T0).
- Post induction of local anesthesia, no flap was raised.

Fig. 1: Armamentarium for piezocision

- Three to five MOPs were placed 1–3 mm apart distal to the canine in the extraction space using the roots of the adjacent teeth as reference.
- The MOPs were created using 1.2-mm commercially available orthodontic mini- implant drill bits to a depth of 5 mm using a hand driver. The mini-implant drill bits were graduated using a file stop to ensure consistent depth of the MOP (Fig. 3).
- The arch wire was ligated back and a NiTi closed coil spring was engaged from the canine to the first molar to retract the canine. A force of 150 g per side was given and checked using a Dontrix gauge.
- Patients were seen at every 1-month interval until retraction was completed. Alginate impression was taken post canine retraction (T1) and the impression was poured with a dental stone.
- The maximum distance between the cusp tip of the canine to the central fossa of the permanent molar at T0 and T1 was measured (Fig. 5).
- All cast measurements were made using a digital caliper with an accuracy of 0.01 mm.
- The difference in measurement was calculated to give the distance of retraction and divided by the number of intervals to give the rate of retraction in millimeters per interval (Fig. 6).
- Each interval was defined as 1 month.
- The total duration was from the beginning of canine retraction till the canine was completely retracted into the extraction site, which was between 2 months and 4 months.
- This measurement was done by one investigator and repeated three times and the mean value was taken.

Measurement of Canine Retraction

- Measurements were performed from stone casts, using a digital Vernier caliper. The measurements were done prior to retraction (T0) and post retraction (T1) (Fig. 4).

Statistical Analysis

All data were analyzed using the SPSS version 22.0 for Windows. Descriptive Statistics were employed in the present study—mean and standard deviation.

Fig. 2: BS-1 insert

Fig. 3: Mini-implant standardized for micro-osteoperforation

Fig. 4: Measurements performed by direct technique from stone casts, prior to retraction (T0) and post-retraction

Fig. 5: Acrylic plug corresponding to the F point and the C point on the pre-retraction cast

The independent samples *t* tests were done to compare the means of two groups of cases. The subjects were randomly assigned to two groups so that any difference in response was due to the treatment (or lack of treatment) and not due to other factors.

RESULTS

The sample consisted of 15 sites for PZ and 15 sites for MOP, respectively.

The sample consisted of two male and six female patients with mean age 19.6 ± 3.3 years. In this split-mouth study, the sites were randomized and PZ was performed on one side and on the contralateral side, MOP was performed.

The maximum time taken for canine retraction in the PZ group was 3.5 months and 3.75 months for the MOP group. The minimum time taken for canine retraction was 2 months for the PZ group and 2.25 months for the MOP group. The mean time taken was 2.66 ± 0.42 months for the PZ group and 3.18 ± 0.47 months for the MOP group, respectively (Table 1 and Fig. 7).

The mean rate of canine retraction was 1.64 ± 0.43 mm/month for the PZ group and 1.34 ± 0.51 mm/month for the MOP group. The paired difference in the rates of the canine retraction was

0.39 ± 0.26 mm/month, which was statistically significant ($p < 0.05$) (Tables 2 and 3 and Fig. 8).

Piezocision was seen to be 1.22 folds faster than MOP.

DISCUSSION

The goals of orthodontic therapy lie in achieving a pleasing and esthetic face along with stable occlusion. An esthetic smile goes a long way in improving the self-esteem of a person and also helps in building confidence. Orthodontic correction helps in also correcting jaw deformities, which improves the quality of life of the person.

The rate of biologic tooth movement in response to the application of optimum mechanical force is approximately 1–1.5 mm over 4–5 weeks. Therefore, in cases of maximum anchorage cases with premolar extraction, canine retraction usually takes 6–9 months, leading to an overall treatment time of 1½ to 2 years. The orthodontic biomechanics used applies mechanical force to bring about tooth movement by remodeling the periodontal tissues surrounding the teeth.

Table 1: Time taken for canine retraction

Group	<i>n</i>	Maximum time (months)	Minimum time (months)	Mean (months)	SD
PZ	15	3.5	2	2.66	0.42
MOP	15	3.75	2.25	3.18	0.47

Table 2: Rate of canine retraction

Group	<i>n</i>	Maximum (mm/month)	Minimum (mm/month)	Mean (mm/month)	SD
PZ	15	2.78	0.98	1.64	0.43
MOP	15	2.36	0.46	1.34	0.51

Table 3: Comparison of rate of retraction between piezocision and micro-osteoperforation

<i>T</i>	<i>df</i>	Paired difference	Significance
5.756	14	0.39 ± 0.26	$p < 0.05$

Fig. 6: Acrylic plug transferred to the post-retraction cast

Fig. 7: Time taken for canine retraction

Fig. 8: Rate of canine retraction

Various techniques using the RAP phenomenon have been investigated, which includes corticotomies, periodontal distraction, PZ, MOP, and biomodulation using lasers. The RAP is a local response of tissues to noxious stimuli by which tissue regenerates faster than normal in a regional regenerative/remodeling process. This is an increased bone response in the form of increased osteoclastic and osteoblastic activity, and increased levels of local and systemic inflammatory markers in areas around the cuts that extend up to the marrow. This response varies in duration, size, and intensity with the magnitude of the stimulus, and it is considered a physiological “emergency” mechanism, which accelerates the healing of injuries that could affect survival. The duration of RAP depends on the type of tissue, and usually lasts for about 4 months in the human bone. This phenomenon causes bone healing to occur 10–50 times faster than normal bone turnover.¹

Piezocision and use of a piezotome at specific vibration frequency settings has shown to cause a more widespread and diffuse demineralization accompanied by an increased remineralization effect on the bone in contrast to the bur used in corticotomies. This could be due to the additive effect of osteocytes in response to microvibrations produced by the ultrasonic handpiece at specific settings.

Cheung et al.³ advocated the use of mini-implant-facilitated MOPs to accelerate tooth movement. Commercially available 1.2-mm mini-implants were used to make the perforations. Thus, the use of commercially available mini-implants also is an option for creating perforations for accelerating tooth movement.

The primary treatment objective in most cases including those with severe skeletal disharmonies is improvement of function as well as achievement of a pleasing profile. Premolar extraction is a relatively common treatment protocol, especially in patients with dental protrusion and dental crowding.

The retraction of anterior teeth is a critical part of bicuspid extraction treatment and should be precisely controlled. The rate of tooth movement gives an idea to the orthodontist about the importance of physiological and clinical changes.

Physiologically, the rate of tooth movement is an indirect indicator of bone turnover and remodeling. The tooth movement occurs followed by a lag phase associated with hyalinization, a third

phase with accelerated rates of tooth movement, and a fourth phase of constant tooth movement.

Proffit and Fields recommended the sequential canine retraction for maximum anchorage, stating that this approach would allow the reaction force to be constantly dissipated over the large periodontal ligament area in the anchor unit.

The mode of canine retraction in both the groups was using NiTi closed coil springs, extending from the first permanent molar to the canine bracket to avoid any kind of difference in the rate of retraction due to unequal retraction forces. The force value for canine retraction was 150 g on both the sides as it has been found to be the optimum value for bodily movement of the canine.⁴

The findings of the present study are discussed below.

To Evaluate the Rate of Canine Retraction by PZ

The rate of retraction in the present study was 1.64 ± 0.34 mm/month on the PZ side.

A study conducted by Aksakalli showed that PZ accelerated canine retraction by 1.53 mm in the PZ group. The rate of retraction was constant over the time period evaluated. This is in agreement with the present study.⁵

In a study conducted by Abbas to evaluate the efficiency of corticotomy-facilitated orthodontics and PZ in rapid canine retraction, they concluded that PZ was 1.5 times faster than conventional orthodontics; the results of this study showed that PZ is 1.22 times faster than MOP, which is in agreement with the above study.⁶

A systematic review conducted by Yi et al. evaluated the efficacy of PZ on accelerating tooth movement. All studies reported accelerated tooth movement after PZ, and three reported a significant reduction of treatment duration post PZ. The results of the present study show that PZ accelerates canine retraction by 1.22 times, which is in agreement with the above study.⁷

In a study to evaluate the efficacy of PZ and laser-assisted flapless corticotomy in the acceleration of canine retraction conducted by Alfawal et al., they found that PZ accelerated the rate of canine retraction by 1.19 ± 0.61 mm/month. In the present study, the rate of canine retraction in the PZ group was 1.64 ± 0.43 mm/month, which is in close conformity with the above study.⁸

Tunçer evaluated the efficiency of PZ in en-masse retraction of canines anchored to mini-screws and concluded that the piezosurgery technique was found to be ineffective in accelerating en-masse retraction. This is in variance with the present study as the present study involves single canine retraction and PZ is shown to accelerate tooth movement by 1.22 times in comparison to MOP.⁹

To Evaluate the Rate of Canine Retraction by MOP

The present study showed that the rate of canine retraction on the MOP side was 1.34 ± 0.51 mm/month.

A clinical trial conducted by Feizbakhsh et al. to evaluate the effect of MOP in accelerating tooth movement concluded that MOPs significantly increased the rate of tooth movement by more than twofold in comparison to a control group. The average rate of tooth movement in the interventional side was 1.3 mm/month, which is agreement with the present study.¹⁰

A study performed by Abdelhameed to evaluate the effect of combined low-energy laser application and MOPs vs the effect of application of each technique separately on the rate of orthodontic tooth movement found the rate of tooth movement on the MOP side was 1.8 mm/month that MOP increased the rate of tooth movement by 1.6 times in comparison to the control group. The rate of canine retraction on the MOP side was 1.34 ± 0.51 mm/month. These results are in close agreement with the above study.¹¹

A randomized clinical trial to compare the rate of tooth movement associated with MOP using fixed appliance therapy by Attri et al. found the mean rate of canine retraction on the MOP side was 0.89 ± 0.17 mm/month in comparison to the control side being 0.63 ± 0.11 mm/month. The results of the present trial indicate that the acceleration of orthodontic tooth movement was seen with MOPs. The present study showed the rate of canine retraction was 1.34 ± 0.51 mm/month on the MOP side. This is in agreement with the above study.¹²

In a split-mouth trial by Aboalnaga to investigate the effects of MOPs on the rate of orthodontic tooth movement, they found the mean rate of canine retraction to be 0.99 ± 0.3 mm/month for both the MOP and the control side. They concluded that MOPs were not able to accelerate the rate of canine retraction; however, it seemed to facilitate root movement. In the present study, the rate of canine retraction on the MOP side was 1.34 ± 0.51 mm/month, which was higher than the previous study but was lesser than the rate of canine retraction on the PZ side. The results are congruent with above study in terms of MOPs facilitating tooth movement.¹³

To Compare the Rate of Canine Retraction between PZ and MOP

The results of the present study show that the mean rates of canine retraction on the PZ and MOP sides were 1.64 ± 0.43 and 1.34 ± 0.51 mm/month, respectively. Piezocision increases the rate of canine retraction by 1.22 times when compared to micro-osteoperforation.

Studies conducted by Alkebsi et al. showed that three MOPs were ineffective in accelerating the rate of tooth movement in comparison to a control group. The average rate of tooth movement is said to be 1–1.5 mm per month. Micro-osteoperforation increases the rate of tooth movement in comparison to the biologic rate of tooth movement. The difference in the rate of retraction between the two methods can be attributed to the increased RAP phenomenon in the piezocision group.¹⁴

In a clinical trial conducted by Norman to compare the rate of canine retraction using two springs, they found the average rate of retraction using NiTi coil springs was 0.58 ± 0.24 mm/4 weeks. The results of the present study show that both PZ and MOP accelerate tooth movement when compared to conventional orthodontics, but PZ shows a higher rate of retraction in comparison to MOP by 1.22 times.¹⁵

Limitation of the Study

The sample size in the present study was 15 sites; further studies with larger sample size are required to validate the results of this study.

CONCLUSION

Within the limitations of the present study, it can be concluded that PZ showed a significant increase in the rate of canine retraction while MOP showed a marginal increase in the rate of canine retraction. Piezocision increases the rate of canine retraction by 1.2 folds compared to MOP. Both the techniques may be used as a safe adjunct during routine orthodontic therapy for accelerating tooth movement.

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