Comparison of Mesial Molar Migration Associated with Different Depths of Micro-Osteoperforation Assisted Canine Retraction

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ABSTRACT

Objectives: Micro-osteoperforation is a minimally invasive procedure to accelerate orthodontic tooth movement. Accelerated orthodontics can sometimes lead to migration of the anchor teeth. The objective of this randomised control study was to compare the amount of mesial molar migration between different depths (3 millimetre and 6 millimetre) of micro-osteoperforation assisted canine retraction.

Methods: Ten adult patients requiring extraction of maxillary first premolar for orthodontic treatment were enrolled for this split mouth study. The micro-osteoperforation of varying depth (3 millimetre and 6 millimetre) were made using a mini implant. Direct anchorage was taken with the help of a mini implant to retract the canine teeth. The patients were divided into two groups - 3 millimetre depth and 6 millimetre depth of micro-osteoperforation. The primary outcome was to compare the mean mesial molar migration between the two groups for three months.

Results: The mean mesial molar migration with 3 millimetre depth of micro osteoperforation was 0.49 ± 0.20 millimetre and with 6 millimetre depth it was 0.39 ± 0.18 millimetre, which was statistically insignificant (P >0.350).

Conclusion: Micro-osteoperforations of different depths do not cause a significant difference in mesial molar migration and are not clinically significant. When it comes to clinical situations even a slight mesial movement of molar can have high significance in the treatment outcome.

Keywords: Micro-osteoperforations, molar mesial migration, canine retraction, mini-implant, MOPs

INTRODUCTION

Longer treatment duration time in orthodontics is undesirable for both the patient and clinician (Moresca, 2018). Usually, an average course of orthodontic treatment with fixed appliances requires less than 2 years to complete (Tischlaki et al., 2016). So, to accelerate tooth movement, there are various surgical and non-surgical procedures in orthodontics. Surgically assisted accelerated orthodontic procedures produce better results than non-surgical accelerated orthodontics procedures however procedures like corticotomies are invasive, traumatic, and require skill of clinician as well as increased cost makes them a little less viable option for the patients (Shirude et al., 2018). So, to overcome the shortcomings of corticotomies, non-invasive surgical methods like micro-osteoperforation have come into existence (Clinical Guide to Accelerated Orthodontics - With a Focus on Micro-Osteoperforations | Mani Alkhanai | Springer, n.d.; Uribe et al., 2014). Micro-osteoperforation (MOP) is a minimally-invasive option able to accelerate tooth movement and it yields very little or minimal discomfort to the patient (Alkhanai et al., 2013; Alkebsi et al., 2018; Chou and Alkhanai, 2017; Zamora Escobar and Murillo Samper, 2017).

Controlling anchorage has been one of the challenges when it comes to orthodontics (Kuroda and Tanaka, 2014). Anchorage control is very essential to achieve a desired treatment outcome especially in severe proclination cases where losing anchorage can have detrimental effects on treatment outcome (Zhang et al., 2019). The molars are considered to be the most important teeth when it comes to anchorage during retraction of the anterior teeth and any mesial migration of these anchor teeth can lead to anchorage loss (Teng et al., 2019). With the advent of mini implants the term absolute anchorage has now become possible as it can provide resistance to unwanted tooth movements (Jain et al., 2014; Sivamurthy and Sundari, 2016; Vikram, 2017). Also it has provided a paradigm shift in the envelope of discrepancy in terms of different orthodontic treatment mechanics (Sumathi Felicita, 2018). The mini implants can be used as direct anchorage or indirect anchorage (Cozzani et al., 2016). However a previous study has suggested that indirect mini-implant anchorage provided better sliding mechanics compared to direct anchorage (Zhang et al., 2019). In direct anchorage the force vector is upward and backward as a result it can produce more friction which can have an effect on the posterior anchor teeth as well (Zhang et al., 2019). So this has
to be taken into consideration while retracting the anterior teeth. MOP facilitates faster tooth movement by inducing Regional Acceleratory Phenomenon (RAP). Another clinical advantage of micro-osteoperforation is the ability to titrate the rate of tooth movement by establishing "Biological Anchorage" while accelerating the movement of target teeth (Chou and Alikhani, 2017). Application of micro-osteoperforation on particular locations can selectively decrease the bone density around the target tooth while the bone density around the anchor unit remains unchanged. Since micro-osteoperforation works on the RAP phenomenon its effect on other teeth and anchorage devices also need to be studied.

Previously our team had conducted numerous clinical trials, animal studies, and in-vitro studies (Dinesh et al., 2013; Felicita et al., 2012; Felicita and Sumathi Felicita, 2017a, 2017b, 2018; Jain et al., 2014; Kamesetty et al., 2015; Krishnan and Saravana Pandian, 2015; Kumar et al., 2011; Rubika et al., 2015; Samantha, 2017; Saravana Pandian et al., 2018; Svmurthy and Sundari, 2018; Vikram et al., 2017; Viswanath et al., 2015). Since there is no literature available about the effect of different depths of micro-osteoperforations on the amount of mesial molar migration during canine retraction, the idea for this randomised control trial was procured from the trending demand for accelerated orthodontics nowadays and its growing interest among the orthodontists. The aim of this split-mouth study was to assess the amount of mesial molar migration associated with different depths (3 millimetre and 6 millimetre) of micro-osteoperforation assisted canine retraction.

MATERIALS AND METHODS

The study design was a split-mouth randomized controlled trial with one observation subsequent to the initial baseline observation. The study procedures and ethical approval were approved by the Scientific Research Board of Saveetha Dental College of Hospitals, Chennai,Tamil Nadu,India. The subjects were selected from the outpatient clinic of the Department of Orthodontics,Saveetha Dental College and Hospitals, Chennai, Tamil Nadu, India. The sample size was calculated from the previous study based on the mesial movement of molar (0.48 ± 0.11), 5% probability of error and 80% statistical power (Kundi et al., 2020). The sample consisted of 10 adult patients (6 females and 4 males) between the age of 18-35 years requiring therapeutic extraction of the first maxillary premolars. The subjects with missing teeth, periodontally compromised condition, systemic conditions were excluded from the study. Before the start of the treatment informed consent was obtained from all patients. The numbers of the subjects were kept in opaque sealed envelopes until the commencement of canine retraction. All subjects received a straight wire appliance (McLaughlin Bennett Trevis prescription 0.022* slot bracket system, 3M victory series brackets) on their upper and lower arches. After initial leveling and alignment, self-drilling temporary anchorage devices of size 1.4 x 6 millimetre were placed buccally between upper 2nd premolar and first molar bilaterally to be used as direct anchorage. Alginate (Tropicalgin, Zhermack) impressions before micro-osteoperforation (T0) were taken.

After disinfecting the area with betadine, local anaesthesia was administered using 2% Lidocaine with 1:100,000 Epinephrine. Two mini implants (Favanchor, 1.6 millimetre diameter x 8 millimetre length) were added with composite stops to differentiate between different depths and this was used to make the perforations through the gingiva 3 millimetre away from the disto labial aspect of canine(Figure 1) (Figure 2). Three perforations were placed on each side based on the varying depth. The 0.017 X 0.025 stainless steel wire was placed and canine retraction was commenced immediately after micro-osteoperforation using 9 millimetre nickel-titanium closed-coil springs (3M Unitek; 9 millimetre) connecting the miniscrews between the maxillary second premolar and first molar to the power arm bonded to the maxillary canine tooth around the bracket to the mini implant using direct anchorage (Figure 3). A force of 150 gram was given and it was measured by using a Dontrix gauge (Correx; Dentaurum, Ispringen, Germany) on the day of application to ensure a constant and equal force in all subjects. Post operatively subjects were advised to rinse with chlorhexidine mouthwash twice a day daily. The patients were recalled once every month post the procedure was completed with a follow up period of three months. At each followup period the force levels were measured and the mesial migration of the molar was measured. Alginate impressions were taken at T0 (initial) and T1 (after 3 months of retraction) for superimposition to assess the mesial molar migration.

Outcome assessment

The maxillary stone model (T0 and T1) was scanned using Medit i500 (South Korea) to obtain the stl format of the digital maxillary model (Figure 4). The digital model taken before initial stage (T0) was superimposed on to the digital model obtained after three months of retraction(T1) using 3-point superimposition taking three common reference points selected on the third rugae (Ziegler and Ingerval, 1989) (Figure 5). The distance between mesiobuccal cusp tip of the molar of the initial model (T0) to the mesiobuccal cusp of the molar of the final model (T1) is superimposed and measured to obtain the mesial molar migration using 3 shape software (3-Shape Ortho Analyzer) (Figure 6).

STATISTICAL ANALYSIS

The statistical analysis was done using SPSS (version 17) software. The variables were described by the mean, range (minimum–maximum), standard deviation (SD) and 95% confidence interval of the mean values. Independent sample t-test was done to compare the amount of anchorage loss between different depths of MOP.

RESULTS

All 10 patients had successfully completed the 3 months duration of the study without any dropouts. The mean anchorage loss of the upper first molars in the 3 millimetre micro-osteoperforation side and 6 millimetre micro-osteoperforation side were 0.49 ± 0.20 millimetre and 0.39 ±
0.18 millimetre respectively (Table 1) (Figure 7). Independent sample t test showed that there was no statistically significant difference in the mean molar mesial migration between 3 millimetre and 6 millimetre depth of micro-osteoperforation (p = 0.350).

Test/ retest reliability
A high degree of reliability was found between the measurements. The average measure intra class correlation coefficient was 0.997 with a 95% confidence interval from 0.994 to 0.999 (F (19,19) = 379.57, P < 0.001) (Table 2) (Figure 8).

DISCUSSION
This study evaluated the amount of molar mesial migration associated with different depths of micro-osteoperforation during individual canine retraction. The mean molar mesial migration with 3 millimetre depth of micro osteoperforation was found to be 0.49 ± 0.20 millimetre and with 6 millimetre depth it was found to be 0.39 ± 0.18 millimetre, which was statistically insignificant (P > 0.350). The different depths of micro-osteoperforation did not seem to produce significant molar mesial migration during canine retraction. Frost et al. have mentioned the amount of severity of the bone injury and accelerated bone turnover at the surgical site (Frost, 1989). The micro-osteoperforation facilitates tooth movement in a similar way by activating the osteoclasts through regional acceleratory phenomenon thereby decreasing the bone density. So, the various depths of micro-osteoperforation can also have an effect on regional acceleratory phenomenon based on the severity of perforations. The theory behind micro-osteoperforation is explained by the biphasic theory where the activation of osteoclasts by osteoclasts is observed during tooth movement and the bone resorption phase of tooth movement (catabolic phase) is followed by a bone formation phase (anabolic phase) to prevent bone loss during tooth movement. It is said that deeper micro-osteoperforations cause more catabolic activity and shallow micro-osteoperforations cause more anabolic activity (Alkhami, 2017).

The findings from previous studies have shown that anchorage loss or the mesial molar migration with micro-osteoperforation was insignificant (Alkhami et al., 2018; Alqadasi et al., 2019; Ibrahim, 2015; Kundi et al., 2020). Lee et al. & Sebaoun et al. have reported the systemic and histological evidence supporting the theory that the alveolar responses to corticotomy is localized in the injury site and doesn’t extend to further teeth (Lee et al., 2008; Sebaoun et al., 2008). In our study there was no mini implant failure during the time this trial was conducted. Therefore, direct anchorage from mini implants can be safely done along with accelerated orthodontics procedures like micro-osteoperforation. When retraction is being done the elimination of undesired mesial molar movement is the key issue in preserving the anchorage. Even with the usage of mini implants there can be minor anchorage loss (El-Bealy et al., 2009). The success of mini implants also depends on their primary stability and loading quality and quantity (Ren, 2009). A study comparing conventional and mini implant aided retraction has shown that the mini implant aided retraction had no mesial molar migration seen. However, the superimposition of the results was based on lateral cephalograms which won’t give accurate results like digital model superimposition does. In our study we measured the molar mesial migration using digital models and we found there was mesial molar migration despite the use of direct anchorage. Even though the results were statistically insignificant, the molar mesial migration should be taken into consideration whenever faster tooth movement is achieved through accelerated orthodontics. A primary concern in orthodontics is to adequately preserve anchorage by preventing the migration of the anchor teeth. In a study on corticotomy in conjunction with mini-screws it was found that corticotomy can dramatically augment posterior anchorage, which is of prime importance since effective anchorage would greatly improve orthodontic treatment results (Thiruvenkatachali et al., 2006). Accelerating tooth movement by micro-osteoperforation procedure causes potential decrease in the anchorage value of the target teeth, which will be helpful in the cases requiring differential expansion or intrusion (Babanouri et al., 2020).

There are a few limitations in the present study, first was that our study had a short evaluation period and there was no conventional control group. Secondly, the sample size was smaller and also we feel that this study should be more standardised based on various kinds of malocclusion, growth pattern being treated. Since most of the movements take place after micro-osteoperforation during the first three months, the study duration was limited to 3 months. However, a long-term study needs to be performed. Micro-osteoperforation reduces cortical resistance and increases bone remodeling of the target teeth alone which allow safer and stable retraction of the anterior segment without overloading the posterior segment (Bolan, 2019). Hence, we can infer from our study that varying the depths of micro-osteoperforations does not tax the anchorage and there was no clinically significant molar mesial migration.

CONCLUSION
The mean mesial molar migration was minimal and there was no statistically significant difference between mesial molar migration with different depths of micro-osteoperforations.

CONFLICT OF INTEREST
The authors declare no conflict of interest.

FUNDING
This was a self-funded project.

ACKNOWLEDGMENTS
The authors would like to thank the Department of Orthodontics and Maxillofacial Orthopaedics, Saveetha Dental College, Chennai, Tamil Nadu for this project.

SOURCES OF SUPPORT
Equipment support from Saveetha Dental College and Hospitals.
REFERENCES

Table 1: Mean distribution and comparison of molar mesial migration. This table represents the mean molar mesial migration between two groups. Independent t test was done to determine the mean mesial migration of the molar between different depths of micro-osteoperforation # P value >0.05; hence statistically not significant.

<table>
<thead>
<tr>
<th>Molar Mesial Migration</th>
<th>N</th>
<th>Mean ± Standard deviation</th>
<th>p Value</th>
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<tbody>
<tr>
<td>3 millimetre</td>
<td>10</td>
<td>0.49 ± 0.20</td>
<td></td>
</tr>
<tr>
<td>6 millimetre</td>
<td>10</td>
<td>0.39 ± 0.18</td>
<td>0.350*</td>
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Table 2: Intraclass correlation coefficient. This table represents the reliability test between mean molar mesial migration measurements done at two sessions between two groups. A high degree of reliability was found between the measurements. The average measure intraclass correlation coefficient was 0.997 with a 95% confidence interval from 0.994 to 0.999 ($F_{(19,19)} = 379.57, P < .001$).

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<tr>
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<th>Intraclass Correlationb</th>
<th>95% Confidence Interval</th>
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<td>Single Measures</td>
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<td>Value</td>
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Figure 1: Image represents micro-osteoperforation being done using mini implant.

Figure 2: Composite stop added to the mini implant to differentiate the different depths.
Figure 3: Canine retraction done using NiTi coil spring after micro-osteoperforation

Figure 4: Pre and post digital models being superimposed using 3shape Ortho Analyzer software

Figure 5: Pre and Post digital models after superimposition to measure the mean molar mesial migration
Figure 6: Measuring mean molar mesial migration from digital model superimposition

Figure 7: Bar graph depicting mean molar mesial migration between 3mm (red) and 6mm (blue) depths of micro-osteoperforation. X axis depicts the groups 3mm and 6mm depth of micro-osteoperforation and y axis depicts mean anchor loss in millimetre. The mean values of the mesial molar migration are statistically insignificant with \( p = 0.350 \) (\( p < 0.05 \) statistically significant). Different depths of micro-osteoperforation does not have a significant effect on mean mesial molar migration.
Figure 8: Scatter plot depicting the molar mesial migration measurements during first session plotted against molar mesial migration measurements during second session showing a positive correlation.