Three-dimensional assessment of the effect of micro-osteoperforations on the rate of tooth movement during canine retraction in adults with Class II malocclusion: A randomized controlled clinical trial

Amal Alkebsi, Emad Al-Maaitah, Hisham Al-Shorman, and Elham Abu Alhaija
Irbid, Jordan

Introduction: The purpose of this split-mouth trial was to investigate the effect of micro-osteoperforations (MOPs) on the rate of tooth movement. **Methods:** Thirty-two patients (24 female, 8 male; mean age, 19.26 ± 2.48 years) who required fixed orthodontic treatment and maxillary first premolar extractions participated in this trial with MOPs randomly allocated to either the right or left sides distal to the maxillary canines. Eligibility criteria included Class II Division 1 malocclusion, healthy periodontal condition, no smoking, and no systemic disease. Miniscrews were used to support anchorage and retract the canines with the aid of closed-coil nickel-titanium springs with 150 g of force. Randomization was accomplished with block randomization with a permuted block size of 2 with a 1:1 allocation ratio to either right or left with allocations concealed in opaque, sealed envelopes. Blinding was used at the data collection and analysis stages. Three MOPs were performed using miniscrews (5 mm depth, 1.5 mm width) on the buccal bone distal to the canines on the randomly selected side. The primary outcome was the rate of canine retraction measured from 3-dimensional digital models superimposed at the rugae area from the baseline to the first, second, and third months. The following secondary outcomes were examined: anchorage loss, canine tipping, canine rotation, root resorption, plaque index, and gingival index. Pain level, pain interference with the patients' daily life, patients' satisfaction with the procedure and degree of ease, willingness to repeat the procedure, and recommendation to others were also evaluated. **Results:** There was no statistically significant difference in the rates of tooth movement between the MOP and the control sides at all time points (first month: $P = 0.77$; mean difference, 0.2 mm; 95% CI, −0.13, 0.18 mm; second month: $P = 0.50$; mean difference, −0.08 mm; 95% CI, −0.33, 0.16 mm; third month: $P = 0.76$; mean difference, −0.05 mm; 95% CI, −0.40, 0.29 mm). There were also no differences in anchorage loss, rotation, tipping, root resorption, plaque index, periodontal index, and pain perception between the MOP and control sides at any time point ($P > 0.05$). MOPs had no effect on the patients' daily life except for a feeling of swelling on the first day ($P = 0.05$). Level of satisfaction and degree of easiness of the procedure were high. A significant percentage of patients were willing to repeat the procedure and recommend it to others. No serious harm was observed. **Conclusions:** Three MOPs were not effective in accelerating tooth movement at any time point. Other secondary parameters evaluated were not different between the MOP and control sides except for the feeling of swelling on day 1 on the MOP side. Patients were highly satisfied with the MOP procedure, and many considered MOPs an easy procedure and were willing to repeat and recommend it to friends. **Registration:** This trial was registered at Clinicaltrials.gov with identifier number NCT02473471.

From the Department of Preventive Dentistry, Faculty of Dentistry, Jordanian University of Science and Technology, Irbid, Jordan.
Address correspondence to: Amal Abdullah Alkebsi, Department of Preventive Dentistry, Faculty of Dentistry, Jordanian University of Science and Technology, PO Box (3030), Irbid 22110, Jordan; e-mail, aaalkebsi13@den.just.edu.jo; amalkibsi@gmail.com.

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Lengthy treatment is 1 challenge in orthodontic treatment that makes it unfavorable for both patients and orthodontists.[1] The average treatment duration of fixed orthodontic treatment ranges from 19.9 months[2] to 2 years.[3,4] The estimated amount of tooth movement is 0.35 to 2.04 mm per month.[5]

Prolonged treatment duration usually is associated with other negative sequelae such as discomfort, pain, and bacterial time-load factors,[6] like white spot lesions and dental caries.[7] Also, it has been confirmed that the longer the duration of tooth movement, the greater the chance of root resorption.[8-12] In addition, long treatment duration adversely affects patients' satisfaction with the orthodontic outcome[13,14] and their compliance during treatment.[15] Hence, methods to accelerate tooth movement not only to shorten the treatment time, but also to reduce or eliminate its associated risks are the prime interest of both orthodontists and patients.[1]

Micro-osteoperforations (MOPs) are a new, simple, and minimally invasive technique to accelerate tooth movement. The biologic mechanism behind MOPs is to increase the cytokine expression that leads to increased bone resorption, the catabolic phase of tooth movement, in the direction of tooth movement. Transmucosal holes in cortical bone are made to trigger bone remodeling changes for faster tooth movement.[16]

Although there is much literature on the effects of selective decortication on tooth movement, only 2 animal studies[17,18] and 1 clinical study[16] have investigated the effects of MOPs on accelerating tooth movement. Alikhani et al[16] conducted the first human clinical trial based on the positive results of the animal study by Teixeira et al.[17] Promising results had shown a 2.3-fold increase in the rate of tooth movement with no side effects. However, a high-quality clinical trial is still needed to draw a final conclusion of its clinical benefit.

A recent Cochrane review[19] selected only 4 randomized clinical trials based on the Cochrane strict inclusion criteria including the study of Alikhani et al.[16] Nevertheless, the authors concluded that each included study had a small sample size and an unclear risk of bias. These drawbacks signify the need for conducting high-quality randomized clinical trials.

Therefore, this study is the first to investigate the effect of MOPs on the rate of tooth movement during a 3-month period and to record the changes in tooth position using 3-dimensional (3D) superimposition models.

Specific objectives or hypotheses

The primary purpose of this study was to assess the effect of MOPs on the rate of tooth movement during canine retraction for 3 months compared with the control sides. The secondary outcomes were anchorage loss, canine tipping, rotation, root resorption, and periodontal condition in both the MOP and control sides before and after the 3-month period. Pain level, pain interference with daily life, level of satisfaction, degree of ease, willingness to repeat, and willingness to recommend the MOP procedure to others were also assessed as secondary outcomes. The null hypothesis was that MOPs do not accelerate tooth movement by 2.3 fold compared with traditional orthodontic treatment.

MATERIAL AND METHODS

Trial design and any changes after trial

This study was a split-mouth randomized clinical trial with a 1:1 allocation. The methods were not changed after trial initiation.

Participants, eligibility criteria, and settings

Ethical approval was obtained from institutional review board at King Abdullah University Hospital, Jordanian University of Science and Technology in Irbid, Jordan, with approval number 20150263. This trial was also registered at ClinicalTrials.gov with identifier number NCT02473471. Participants were recruited from new patients attending the orthodontic department at the Postgraduate Dental Clinics at Jordanian University of Science and Technology. The following inclusion criteria were applied: (1) both male and female subjects, (2) 16 or more years old, (3) Class II Division 1 malocclusion, (4) Class II canine relationship, and (5) average lower facial height and maxillomandibular plane angle. Patients with lower facial height from 53% to 57% (55% ± 2%) and with maxillomandibular plane angles from 23° to 31° (27° ± 4°) were only considered based on Eastman cephalometric standards.[20] The exclusion criteria were (1) diseases and medications that were likely to affect bone biology, (2) poor oral hygiene, (3) low or high angle, (4) previous orthodontic treatment, (5) evidence of bone loss, (6) active periodontal disease, and (7) smoking. Patients were selected according to the inclusion and exclusion criteria during the recruitment time. Subsequently, they