Original article

Orthodontic Extraction of Impacted Mandibular Third Molar Using the Minimally Invasive Bracket System

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Abstract

The purpose of this study was to introduce the application of an orthodontic extraction (OE) with a reinforced dental device, called "minimally invasive bracket (MIB)", to an upright impacted mandibular third molar (MI8) before extraction. The performance of the MIB for OE of an MI8 was investigated. Twenty-four MI8s, planned for OE, were divided into two groups. In the MIB group (n= 12), the MI8s were uprighted with anchorage reinforcement of posterior teeth provided by the MIB. In the control group (n= 12), the MI8s were uprighted without any anchorage reinforcement. All MI8s were removed by simple extraction after the uprighting process. Lateral cephalograms and panoramic radiographs were taken at the beginning (T0) and by the end (T1) of the uprighting process. Using T0 and T1 radiographs, altered movement and angulation of the MI8 (moving unit) and adjacent second molars (anchorage unit) were monitored and compared between the two groups. For the moving unit, the amount and rate of MI8 distalization between the MIB (1.8±1.0 mm, 0.9±0.5 mm/month) and control (1.3±0.7 mm, 0.6±0.3 mm/month) groups were significantly different (*p*=0.117, 0.041). For the anchorage unit, the amount and rate of second molar mesial tipping between the MIB (1.8±0.9°, 0.8±0.2°/month) and control (4.2±2.5°, 1.8±0.9°/month) groups were significantly different (*p*=0.008, 0.004). The amount and rate of second molar mesialization between the MIB (0.6±0.3 mm, 0.3±0.1 mm/month) and control (2.1±0.9 mm, 1.0±0.2 mm/month) groups were significantly different (*p*=0.000, 0.000). The amount and rate of second molar intrusion between the MIB (0.7±0.3 mm, 0.3±0.2 mm/month) and control (1.8±0.9 mm, 0.8±0.3 mm/month) groups were significantly different (*p*=0.002, 0.000). OE with the MIB efficiently uprights the MI8s and reinforces dental anchorage, thus avoiding undesirable dental movement.

Keywords: Dental anchorage, Orthodontic extraction, Third molar, Uprighting

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Introduction

The surgical removal of impacted mandibular third molars (MI8s) is a very common surgical procedure.[1-3] Patients are often referred for the surgical removal of MI8s for several orthodontic reasons, such as preparation for molar distalization,[4] preparation for bilateral sagittal split osteotomy[5], and the prevention of late mandibular incisor crowding.[6] However, the risks and complications involved in this procedure cannot be completely avoided.[7]

Inferior alveolar nerve (IAN) injury is the most serious complication resulting from an MI8 removal. It can affect a patient's quality of life by causing speech and mastication problems.[8] Therefore, several surgical approaches have been proposed to facilitate the removal of the MI8, thus decreasing or eliminating the risk of IAN injury. These include the use of the coronectomy[9] and orthodontic extraction approaches.[10]

Coronectomy was initially proposed by Ecuyer and Debien in 1984 to avoid the risk of IAN injury.[11] This approach was introduced as an alternative method to the extraction of MI8s in proximity to the IAN by removing the crown portion and allowing spontaneous migration of the root.[12-14] Although this technique has been shown to prevent nerve injury, various complications, such as alveolitis, swelling, pain, pulpits, pulp necrosis, and apical periodontitis, may occur.[15,16] Moreover, a second surgery may be necessary for the removal of the retained roots when they migrate into the oral cavity.[16]

A relatively more sophisticated approach to facilitate the surgical removal of risky MI8s, the so-called "orthodontic extraction" (OE), uses the principles of orthodontics to upright the MI8s before their extraction. Therefore, the orthodontic extraction has been defined as the application of orthodontic forces to decrease the risk of IAN injury and facilitate the extraction of MI8s that are in close anatomical relationship to the mandibular canal.[10] This approach was initially applied by Checchi *et al.* in 1996, to move a deep MI8 away from the IAN canal.[17] Since then, several techniques with dental and skeletal anchorage have been used for the OE of MI8s.[17-29] With skeletal anchorage from the miniscrew implants, there is no risk of undesired tooth movement or anchorage loss.[29] However, miniscrew implant placement has contraindications, complications, and a risk of root damage.[30,31] Another option, the OE with tooth-borne anchorage is simpler, less invasive, and cheaper than the skeletal anchorage. However, adequate case selection is mandatory to avoid undesirable anchor tooth movement.

Partially erupted MI8s are reported to be 51 % of the post-orthodontic patients and 35 % of untreated individuals.[32] Mesio-angulation is the most common type that occurs in 43 % of the MI8s.[33] Mesially and partially erupted MI8s have a higher risk of pericoronitis and incidence of caries on the adjacent second molars compared to unerupted third molars.[34,35] For these reasons, the MI8s are often referred to be removed before, during, or at the end of orthodontic treatment.

Complications associated with the surgical removal of MI8s, such as bleeding, pain, swelling, hematoma, alveolitis, delayed healing, post-operative infection, risk of TMD, and IAN damage has been reported in about 4.6 % of extraction sites.[36,37] However, complications are more likely to occur in mesioangular impaction cases.[38] Moreover, bone defects at the distal aspect of adjacent second molars (M7s) also are likely to occur after the surgical removal of mesioangular MI8s.[10] Therefore, the OE using dental anchorage would be an alternative to facilitate mesioangular and partially erupted MI8s extraction without using invasive procedure and risk of complications. However, the movement of MI8s and anchorage teeth have never been investigated.

Therefore, the purpose of this study was to introduce the application of OE using a reinforced dental device, called "minimally invasive bracket" (MIB), to upright mesio-angular MI8s before extraction. The performance of the MIB for MI8 uprighting and anchorage reinforcement was also investigated.

Participants and Methods

In this prospective clinical study, all participants, at the Graduate Clinic, Department of Orthodontics, Faculty of Dentistry, Bangkokthonburi University, consisted of both genders (age 18-29 years), whose MI8s were referred for removal as part of their orthodontic treatment plan, were recruited from April to December 2018, during the period of their orthodontic treatment plan. Twenty-four MI8s were included in this study as the participants were chosen based on the following inclusion criteria: 1) good general health; 2) good oral hygiene and healthy periodontium; 3) no use of medications affecting tooth movement or contraindicated for surgery; 4) non-smoking habit; 5) non-carious mandibular third molars and adjacent second molars; 6) no opposing tooth obstructing the path of the third molar uprighting; 7) anchorage teeth (mandibular first molars, second molars and second premolars) present with good contacts and with no spacing or crowding; 8) having enough surface area for orthodontic devices to be attached to MI8 without using invasive methods, such as flap opening or bone removal; and 9) mesio-angulated and partially erupted third molars with Class I or II impaction and depth A or B according to the Pell & Gregory classification[39] and the Winter classification.[40] Approval for the use of the MIB for research activities was granted by the Human Ethics Committee, Faculty of Dentistry, Bangkok Thonburi University (approval number: 15/2018). Informed consent was obtained from all participants.

Methods

Twenty-four MI8s, planned for OE, were divided into two groups: MIB and control groups. In the MIB group, 12 mesio-angulated and partially erupted MI8s were uprighted using the Smart Springs connected to the posterior teeth with anchorage reinforcement provided by the MIB. Another 12 mesio-angulated and partially erupted MI8s, served as controls, were uprighted using the Smart Springs with no anchorage reinforcement of posterior teeth. All MI8s in both groups were removed by simple extraction after the uprighting process.

MIB and Smart Spring

The MIB consisted of 0.019” x 0.025” stainless steel wire welded to the metal brackets of posterior teeth for reinforced anchorage (Figure 1A) and the Smart Spring consisted of a 0.017” x 0.025” stainless steel wire, bent to form a hook and a helical loop at the mesial and the distal ends, surrounded by a closed coil spring, a 150 gram-open NiTi coil spring and a movable hook at the mesial end (Fig. 1B).

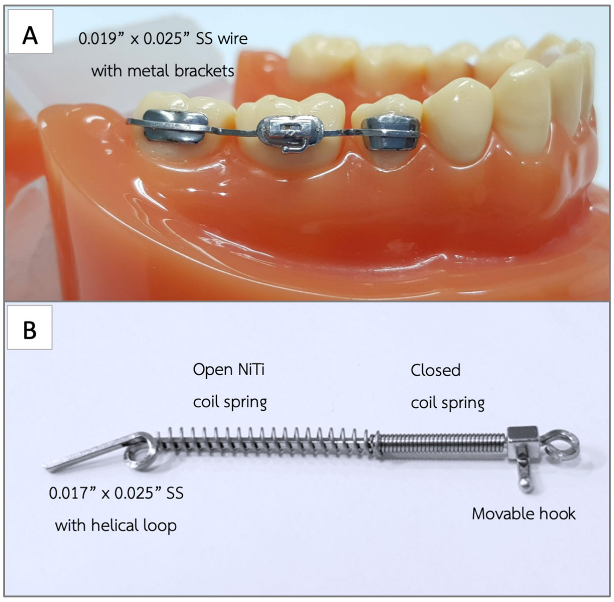

Figure 1 *A) Composition of the MIB for reinforced dental an chorage. B) Composition of the Smart Spring*

Activation of the Smart Spring

The helical loop at the distal end was adjusted and inserted into a buccal tube on the MI8, while the movable hook at the mesial end was activated and connected to the posterior teeth with the MIB reinforcement in the MIB group (Fig. 2).

Or without the MIB in the control group, the movable hook at the mesial end of the Smart Spring was activated and connected to the individual first molar (Fig. 3).

Activation of the Smart Spring generates a total of 200 g of force (50 g controlled tip-back force from tip-back bending at the distal end and 150 g distalizing force from the open NiTi coil spring application) to upright the MI8. The passive and activated stages of the Smart Spring are illustrated in Figure 4.

Monthly re-activation of the Smart Spring was performed by re-adjusting the tip-back bending at the distal end providing 50 g controlled tip-back force to gain adequate tooth movement of uprighting for removal by simple extraction, based on the clinical judgment of an experienced oral surgeon.

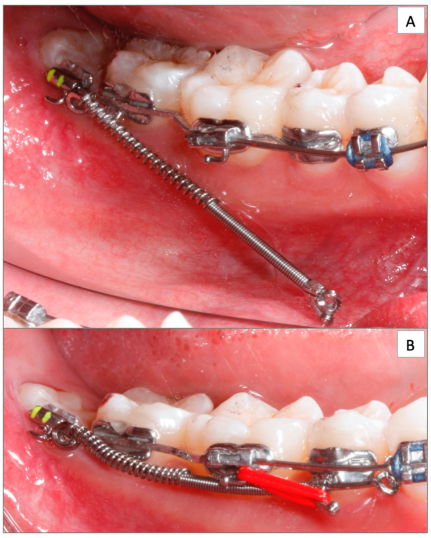

Figure 2 Activation of the Smart Spring in the MIB group. A) the helical loop was adjusted and inserted into a buccal tube on the MI8. B) the movable hook was pushed back and connected to the MIB, generating the force

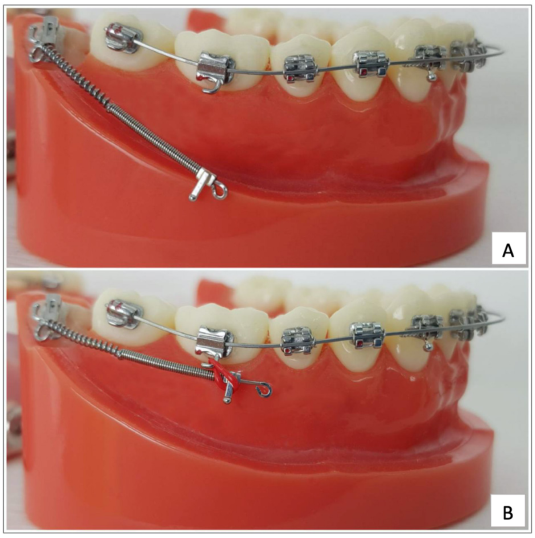

Figure 3 Activation of the Smart Spring in the control group. A) the helical loop was adjusted and inserted into a buccal tube on the MI8. B) without the MIB, the movable hook was pushed back and connected to a bracket on the individual first molar, generating the force

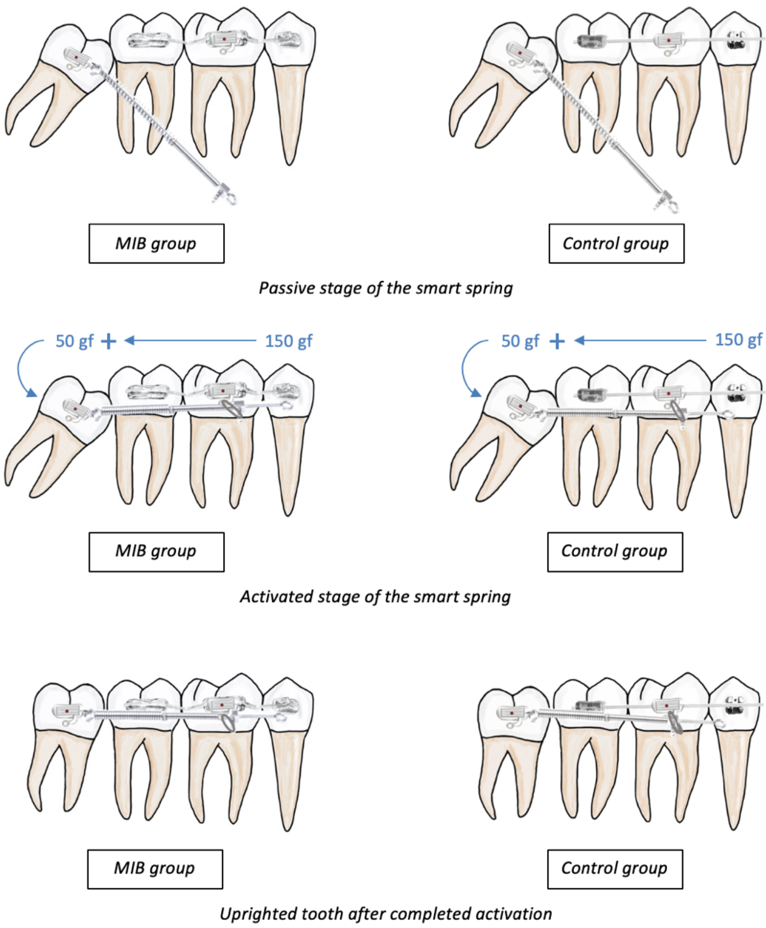

Figure 4 When the Smart Spring is activated, 200 grams of force (50 g controlled tip-back force from tip-back bending at the distal end and 150 g distalizing force from the open NiTi coil spring application) is generated to upright mandibular third molars, resulting in transforming the MI8 removal procedure from surgical removal to simple extraction

Assessment of the Movement of Moving Unit and Anchorage Unit

Lateral cephalograms and panoramic radiographs were taken at the initial (T0) and by the end of the MI8 uprighting (T1). Altered movement and angulation of 24 MI8s (moving unit) and adjacent M7s (anchorage unit) in both groups were monitored and assessed using T0 and T1 radiographs, and Smart'n Ceph MIB v1.1 software (Y&B Products, Chiangmai, Thailand), to evaluate the movement f the moving unit and the anchorage unit (Fig. 5).

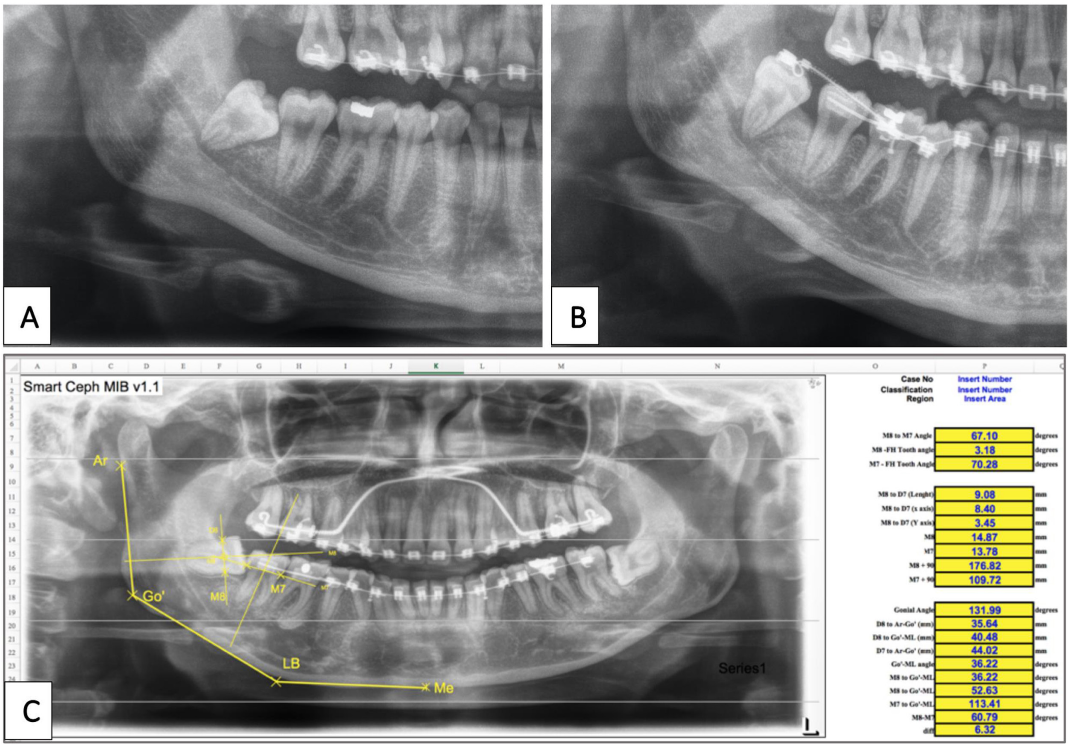

Figure 5 *The assessment of changes in position and angulation of the MI8s and M7s using pre- and post-operative panoramic radiographs. A) before MI8 uprighting, B) uprighted tooth after completed activation, and C) Smart'n Ceph MIB v1.1 software*

The position of the patients was adjusted and verified to decrease positioning errors in panoramic radio graphy, as previously described.[41] Using the mandibular plane as a reference line,[42] the angulation changes in M7s were obtained from the altered M7 tooth axis, and the position changes in the MI8s and M7s were measured from the tooth displacement.

Statistical Analysis

SPSS 23.0 software (SPSS Inc., Chicago, IL, USA) was used for all statistical analyses. The average age of participants and the MI8 initial impaction angulation were compared between the MIB and control groups using the independent *t*-test. The proportion of gender in both groups was compared using the Chi-square test. The average movement of the moving unit and the anchorage unit were comparedbetween the two groups. Significance was established at $P < 0.05$.

Five randomly selected panoramic radiographs (20 % of the participants) were remeasured one month later by the same examiner to assess reliability. The intraclass correlation coefficients showed high interobserver reliability ranging from 0.916-0.998 for linear measurement and 0.999 for angular measurements.

Results

The age of patients between the MIB and control groups was not significantly different (p=0.336). The duration of OE between both groups was not significantly different (p=0.832). There was also no significant difference (p=0.613) between the initial impaction angulation of the MI8s in the MIB and control groups (Table 1).

Table 1 Demographic data of control and experimental groups

Variable	MIB group (n=12)	Control group (n=12)	Statistical difference
Age (years)	22.5 ± 1.6	23.2 ± 1.7	N.S.
Duration of orthodontic extraction (months)	2.2 ± 1.1	2.3 ± 0.8	N.S.
MI8 initial impaction angulation (degrees)	44.9 ± 22.2	48.8 ± 14.3	N.S.

N.S. = Not significant

The proportion of gender between the MIB (M=4, F=8) and control (M=6, F=6) groups was not significantly different (*p*=0.408).

Comparison of the Movement of Moving Unit (MI8s) Between Groups

The amount and rate of MI8 distal tipping between the MIB (26.8±12.9°, 12.8±3.0°/month) and control (26.9±8.7°, 12.3±2.7° /month) groups were not significantly different (*p*=0.962, 0.703). The amount and rate of MI8 distalization between the MIB (1.8±0.9 mm, 1.0±0.5 mm/month) and control (1.3±0.5 mm, 0.6±0.2 mm/month) groups were significantly different (*p*=0.043, 0.008). The amount and rate of MI8 extrusion between the MIB (0.9±0.6 mm, 0.5±0.3 mm/month) and control (0.9±0.6 mm, 0.4±0.2 mm/month) groups were not significantly different (*p*=1.000, 0.445). The amount and rate of the MI8 movement in both groups are illustrated in Figure 6.

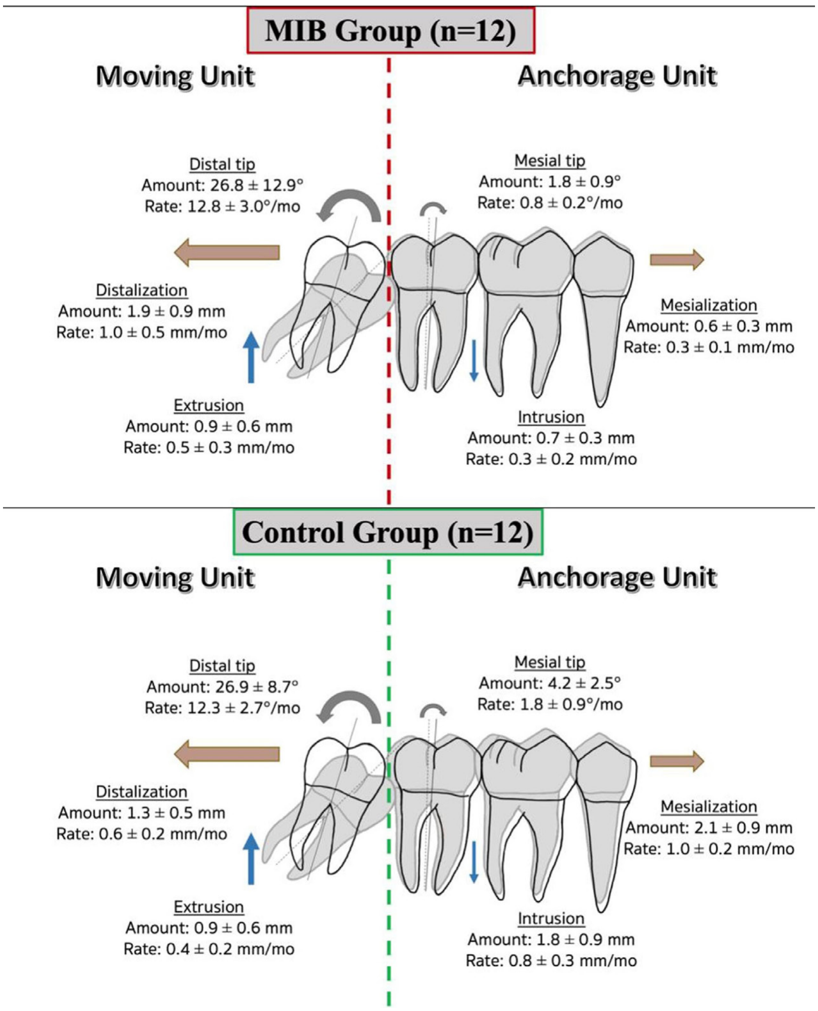

Figure 6 *The dental changes following the orthodontic extraction in MIB and control groups*

Comparison of the Movement of Anchorage Unit (M7s) Between Groups

The amount and rate of M7 mesial tipping between the MIB (1.8±0.9°, 0.8±0.2°/month) and control (4.2±2.5°, 1.8±0.9°/month) groups were significantly different (p=0.008, 0.004). The amount and rate of M7 mesialization between the MIB (0.6±0.3 mm, 0.3±0.1 mm/month) and control (2.1±0.9 mm, 1.0±0.2 mm/month) groups were significantly different (p=0.000, 0.000). The amount and rate of M7 intrusion between the MIB (0.7±0.3 mm, 0.3±0.2 mm/month) and control (1.8±0.9 mm, 0.8±0.3 mm/month) groups were significantly different (p=0.002, 0.000). The amount and rate of M7 movement in both groups are illustrated in Figure 6.

Discussion

This study provided a minimally invasive technique: the OE of mesio-angulated and partially erupted third molars using the dental anchorage device. With the dental anchorage, there are no complications and risk of root damage from the miniscrew implant placement procedure. OE with dental anchorage also is simpler, less invasive, and cheaper than with skeletal anchorage. All participants with mesio-angulated and partially erupted third molars with Class I or II impaction and depth A or B according to the Pell & Gregory classification[39] and the Winter classification[40] were included to perform the OE without surgical operation or any invasive procedure. The mesio-angulated and partially erupted third molar is the most common tooth impaction and is often referred for removal due to the increased risk of pericoronitis and the increased incidence of caries on the adjacent second molars.[32-35] Moreover, bone defects at the distal aspect of adjacent second molars and other complications are more likely to occur after the surgical removal of mesioangular MI8s.[10,38] For these reasons, mesio-angulated and partially erupted third molars were selected to be the participants in this study.

Previous studies have offered many techniques and devices to perform the OE of MI8s.[17-29] Most of them were case reports and showed successful results of OE to avoid the complications of the surgery, especially IAN injury.[17,18,20-26,43] Moreover, OE also decreases the risk of post-surgical periodontal defects by promoting periodontal healing and bone formation at the distal aspect of the second molar.[20,25] However, the performance of uprighting devices and the dental anchorage situation, which are important for orthodontic treatment planning, have never been investigated. Thus, this study examined the performance of the MIB and evaluated the dental anchorage loss.

Although the successful OE of MI8s in the present study was similar to Bonetti[20] and Wang,[22] the results also demonstrated that the dental anchorage loss in the control group was significantly greater than in the MIB group.In the control group, since the uprighting forces were delivered directly to the mandibular first molars through the conventional orthodontic appliances, an undesirable dental mesial drift, and intrusion, with consequent anchorage loss was observed. Such problems might be minimized by anchoring all posterior teeth as a large and single dental unit to resist the uprighting forces.

On the other hand, in the MIB group, the anchorage reinforcement was obtained by connecting the posterior teeth with the aid of the MIB, thus creating a single and large dental unit.[44] Moreover, the rigidity of MIB increased the total posterior unit resistance against the uprighting force application in all three planes.

Moreover, the mesial movement of M7s was significantly greater in the control group than in the MIB group, whereas less distal movement of MI8s was observed in the control group. This finding implies that the greater the mesial movement of M7s in the control group, there was less need for distal movement of MI8s to gain space for MI8 uprighting.

In this study, the amount and rate of the MI8 movement indicate that there was tooth displacement in an upright direction using the MIB device. The orthodontic force was applied to MI8s until the MI8s could be atraumatically removed by simple extraction. The average duration of uprighting being approximately two months which was shorter than previous studies.[17-29] The Smart

Springs provides both tip-back and light continuous distalizing forces, resulting in the ideal combination for an optimum MI8 uprighting.

Conclusion

Orthodontic extraction, using dental anchorage with MIB, efficiently uprights MI8s and reinforces anchorage teeth, thus avoiding undesirable dental movement.

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