Posterior Available Space for Uprighting Horizontally Impacted Mandibular Second Molars Using Orthodontic Microimplant Anchorage

Ki-Jun Kim* / Jae Hyun Park** / Mi-Jung Kim*** / Hong-Ik Jang **** / Jong-Moon Chae *****

Treatment of horizontally and deeply impacted mandibular molars is challenging for both orthodontists and oral surgeons because of the limited access and anchorage control. We report on two patients who had horizontally and mesially impacted mandibular second molars (MM2s). Both patients were treated by a surgical orthodontic approach, and the crowns of the impacted teeth were brought into the arches by closed forced eruption. Mesially impacted MM2s were uprighted with orthodontic microimplants, inserted in the retromolar area, and then moved into their ideal position. The first patient was in an active growing stage, while the second patient was beyond the active growing stage. Therefore posterior available space (PAS) should be analyzed before treatment of impacted MM2s to prevent periodontal problems after uprighting of impacted teeth. If PAS is not enough for uprighting impacted MM2s, alternative treatment should be considered based on the stage of growth.

Keywords; *Posterior available space, Impaction, Molar uprighting, Orthodontic microimplant anchorage*

INTRODUCTION

Impaction of the mandibular second molars (MM2s), although a relatively rare occurrence (reported prevalence of 0.06 to 1.36%), has recently become more prevalent with an autosomal genetic trait.[1-7] Shapira *et al*[5] reported that impacted MM2s were more unilateral than bilateral and mesially inclined impacted MM2s were more common. There are many etiologic factors that impede the eruption of the MM2: a lack of arch length, abnormal erupting angulation, premature eruption of the mandibular third molar (MM3), deviations in the dentition, abnormal craniofacial morphology, vertical condylar growth pattern, arrested development of its mesial root, and lack of space between the mandibular first molar (MM1) and the anterior margin of mandibular ascending ramus.[2,5,7-9]

Impacted MM2s can cause many problems such as extrusion of opposing teeth, caries, periodontitis and root resorption of the adjacent MM1s, cystic development, midline deviation toward the impacted tooth, and continued root development in close proximity to the inferior dental alveolar nerve,[10,11] so early diagnosis of the impacted MM2s is imperative in order to start treatment at the optimal time to reduce the need for complicated orthodontic treatment. This means that a thorough and regular examination of a child's developing dentition is recommended to diagnose dental impaction promptly.[1-6,12]

Various treatment modalities for uprighting mesially impacted MM2s have been suggested including surgical repositioning and orthodontically-assisted eruption with surgical uncovering of the

*Ki-Jun Kim, Graduate student, Department of Orthodontics, School of Dentistry, University of Wonkwang, Iksan, Korea.
**Jae Hyun Park, Professor and chair, Postgraduate Orthodontic Program, Arizona School of Dentistry & Oral Health, A.T. Still University, Mesa, Ariz; Adjunct Professor, Graduate School of Dentistry, Kyung Hee University, Seoul, Korea.
***Mi-Jung Kim, Graduate student, Department of Orthodontics, School of Dentistry, University of Wonkwang, Iksan, Korea.
****Hong-Ik Jang, Graduate student, Department of Orthodontics, School of Dentistry, University of Wonkwang, Iksan, Korea.
*****Jong-Moon Chae, Professor, Department of Orthodontics, School of Dentistry, University of Wonkwang, Wonkwang Dental Research Institute, Iksan, Korea; Visiting Scholar, Postgraduate Orthodontic Program, Arizona School of Dentistry and Oral Health, A.T. Still University, Mesa, Ariz.

Send all correspondence to
Jong-Moon Chae, Department of Orthodontics, School of Dentistry, Wonkwang University, Daejeon Dental Hospital, 77 Doonsan–ro, Seo-Gu, Daejeon, 35253, Korea Phone:+82-42-366-1103
E-mail ; jongmoon@wku.ac.kr

MM2s or removal of the MM3s.[10,12-20] Although surgical uprighting of impacted MM2s appears to be a quick and easy procedure, orthodontic uprighting technique is more advantageous and offer a better long term prognosis with no adverse pulpal or periodontal risks to the tooth or supporting structures.[12,21,22]

Recently, skeletal anchorages[13-17,19,20] such as mini-implants and mini-plates have been used for uprighting of impacted MM2s. They have some advantages in that they reduce the side effects formerly associated with dental anchorage and they simplify the design of orthodontic devices. Direct application of an appropriate force system using skeletal anchorage in the retromolar area is a simple and effective way to upright an impacted MM2, while avoiding the loss of posterior anchorage and improving treatment predictability.[15-17,22] It is also beneficial for obtaining vertical and distal traction forces simultaneously with proper line of action and moment.

Available space in the posterior retromolar area should be analyzed before uprighting impacted MM2s to prevent periodontal problems after the impacted teeth have been uprighted. An analysis of anatomic location, desired eruption path and available space of the MM2s should proceed the uprighting process for a favorable outcome.[23-26] Space availability is related to presently existing space, developmental formation of the MM3s, later resorption of the anterior ramus with growth, and actual size of the mandible.[23-26] Posterior available space (PAS) for eruption of impacted MM2s can be calculated from the distal surface of the MM1s to external oblique line of the ramus along the occlusal plane.[24,26] On average, the PAS increases by 1.5 mm on each side per year until age 14 for girls and 16 for boys.[26,27] Therefore, the prediction of available space in the posterior mandibular arch should be based on age and sex.[24,26]

The posterior limit is recognized as being 2-7 mm distal to the anterior border of the ramus because of the lingual shelf that exists to accommodate the mandibular molars.[27,28] However, teeth on the lingual shelf are not generally in good functional occlusion and pericoronitis can occur by an accumulation of soft tissue over the MM2,[28,29] so mesial movement of MM2s by premolar extraction or interproximal reduction[30,31] and operculectomy may be necessary to increase PAS and prevent pericoronitis.[29,32-35]

We present two cases with unilateral and bilateral impacted MM2s considering posterior available space. In these two cases, mesially displaced MM3s blocked the uprighting of the MM2s.[23,32] Therefore, extraction of the MM3s, surgical exposure of the MM2s and insertion of orthodontic microimplants (OMIs) were performed simultaneously for efficient uprighting of the MM2s.

CASE REPORTS

Patient 1

Patient 1 was a 14-year-old boy with the chief complaint of bilaterally impacted MM2s. He was in good health with no history of dental trauma. He had an ectopically erupted and mesially angulated maxillary right canine along with small maxillary lateral incisors, and the dental midline of his maxillary arch was deviated by 1.0 mm to the right. Radiographs confirmed severely mesioangulated and impacted MM2s blocked by the MM3s on both sides in a very similar pattern and he was in skeletal maturation index (SMI) stage 4 (Figure 1). Cone-beam computed tomography (CBCT) images showed that the long axes of the horizontally and deeply impacted MM2s were located distally perpendicular to the MM1s without bucco-lingual angulations. The PAS distal to the MM1 was 6.8 mm in the pre-treatment CBCT image. If the mandible continues to grow normally until the patient is 16, the PAS will be 9.8 mm.[26,28] The posterior limit at the occlusal level will be 2-3 mm or 7 mm distal to the anterior border of the ramus,[27,28] so the total expected PAS should be at least 11.8 mm. The actual mesiodistal width of the impacted MM2 was approximately 10.9 mm, so considering the expected PAS and the size of the tooth, molar uprighting should be possible. In fact, the PAS after 29 months of treatment was 9.5 mm. It was very similar to the average increase (Figure 2).

Two treatment options were considered. The first was to extract the impacted MM2s and MM3s to prevent root resorption of the MM1s, then place implants and fixed prosthetics later after the patient is fully grown. The second was to upright the impacted MM2s following extraction of the MM3s. The second option was selected because the parents wished to bring the impacted teeth up rather than extracting them.

The impacted MM2s were exposed under local anesthesia, and buttons were bonded on the distal surface of the crowns and OMIs (1.3-1.2 mm in diameter, 8 mm in length; Absoanchor SH1312-08; Dentos, Taegu, South Korea) were inserted in the retromolar area following extraction of the MM3s. Traction of the MM2s was initiated on the day of surgery with elastic threads that were replaced every 4 weeks. Three months into treatment, an OMI was installed in the buccal alveolar bone between the maxillary right first and second premolars to distalize the ectopically erupted canine using indirect skeletal anchorage. After 7 months of treatment, the MM2s emerged into the oral cavity, making it possible to bond buttons on the occlusal surface of the MM2s and the maxillary right canine moved distally. Ten months into treatment, orthodontic treatment using a fixed appliance was initiated to level the maxillary arch. Eighteen months into treatment, full fixed orthodontic treatment begun in the mandibular arch for uprighting and mesial root movement of the MM2s. When uprighting and alignment of the MM2s was completed, debonding was done. Fixed lingual retainers were bonded on the maxillary and mandibular anterior teeth. Wraparound removable retainers were also delivered to secure the stability of both arches (Figure 3).

The impacted MM2s and ectopically erupted maxillary right canine were well aligned, but there was an operculum that partially covered the disto-occlusal surface of the MM2s without any discomfort. Operculectomy might be necessary if pericoronitis persists. Class I molar relationship was achieved on both sides. However, as the patient did not want to restore the small maxillary lateral incisors, forcing us to finish the treatment with a shallow overjet and overbite. The total treatment period including full fixed treatment was 29 months, and he was in SMI stage 10 after treatment. The results were acceptable 7 months after retention (Figure 4).

Figure 1. Patient 1: pretreatment intraoral photographs and, hand-wrist and panoramic radiographs.

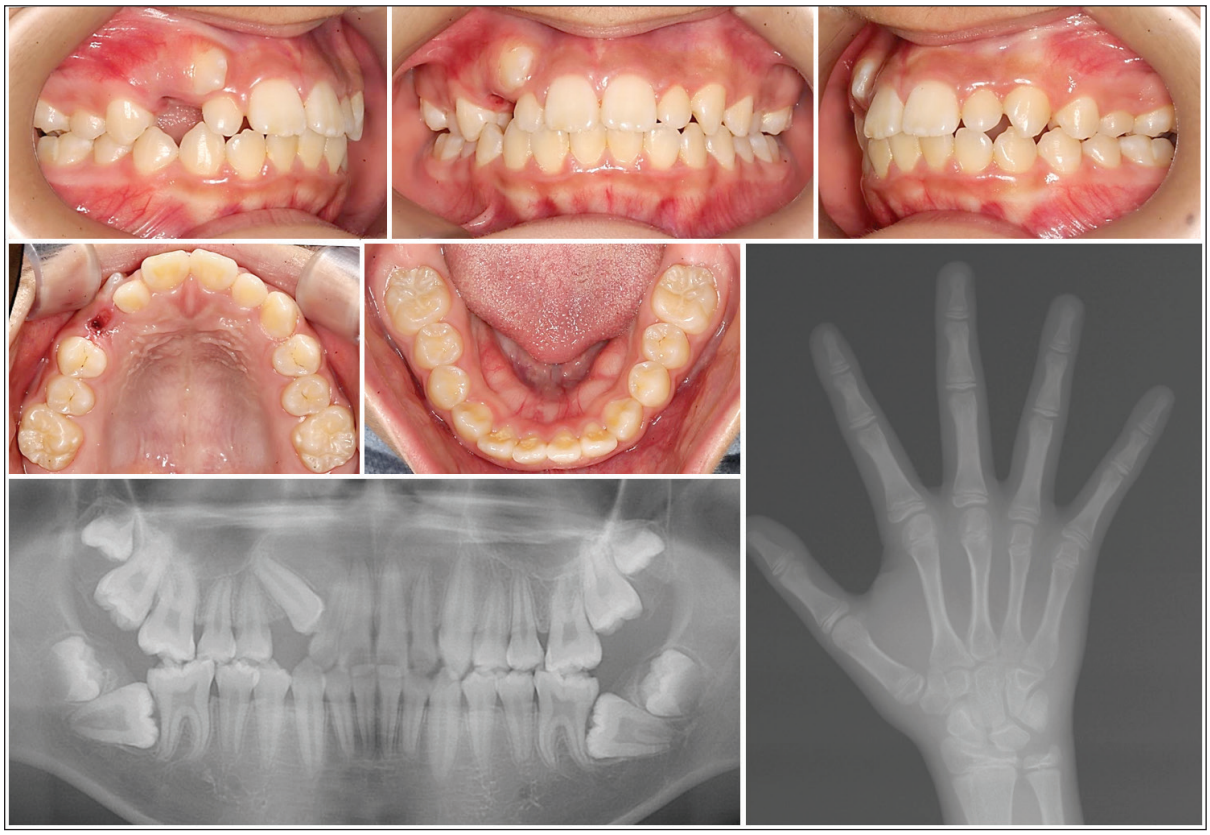


Figure 2. CBCT images of Patient 1: A. Pretreatment; a, lingual view; b, occlusal view; c, mesiodistal width of mandibular second molar: B, posterior available space: a, pretreatment; b, 29-month posttreatment.

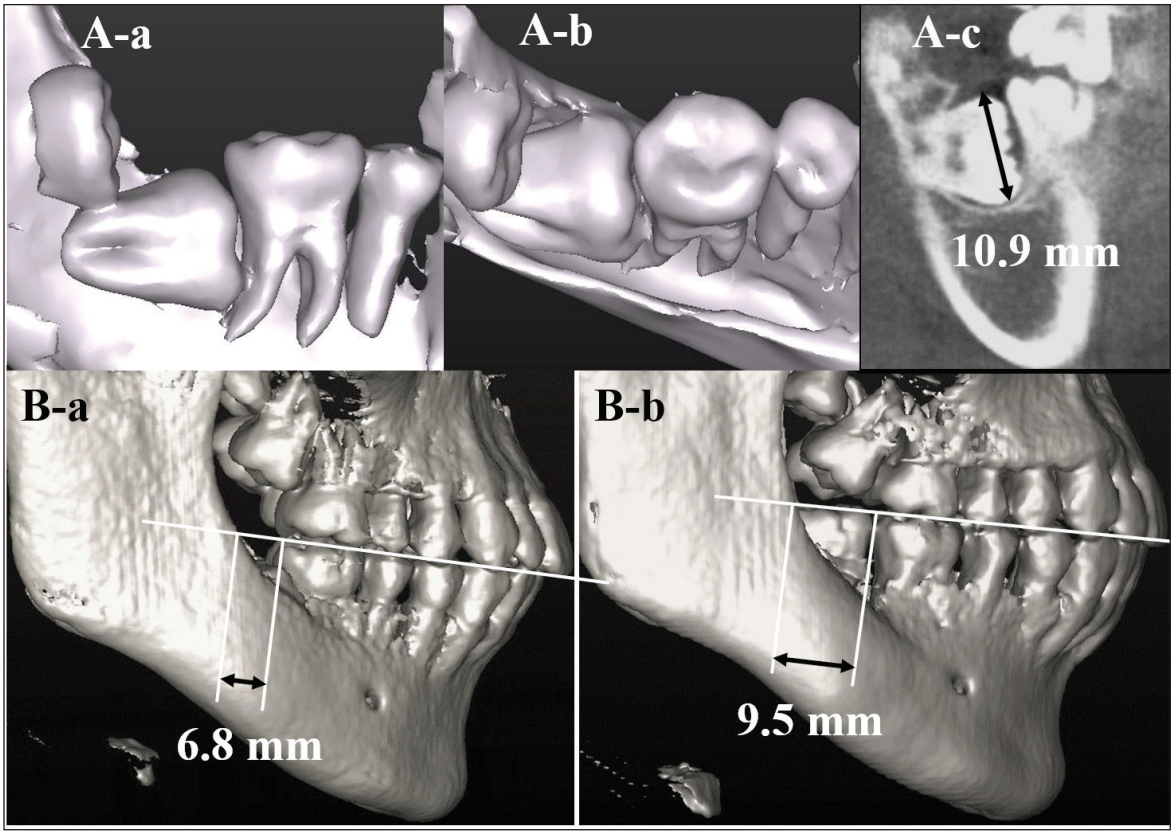


Figure 3. Panoramic radiographs of Patient 1: A, insertion of retromolar orthodontic microimplants on both sides; B, 3 months; C, 7 months; D, 10 months; E, 26 months; F, posttreatment.

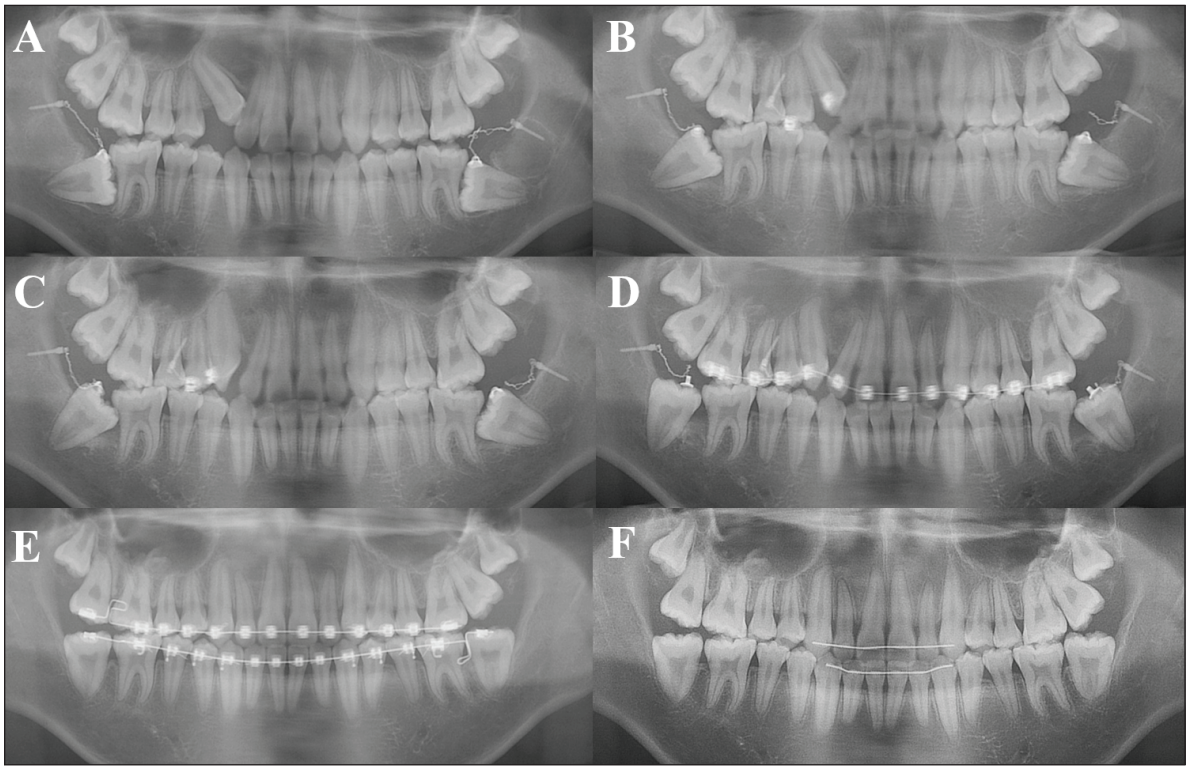
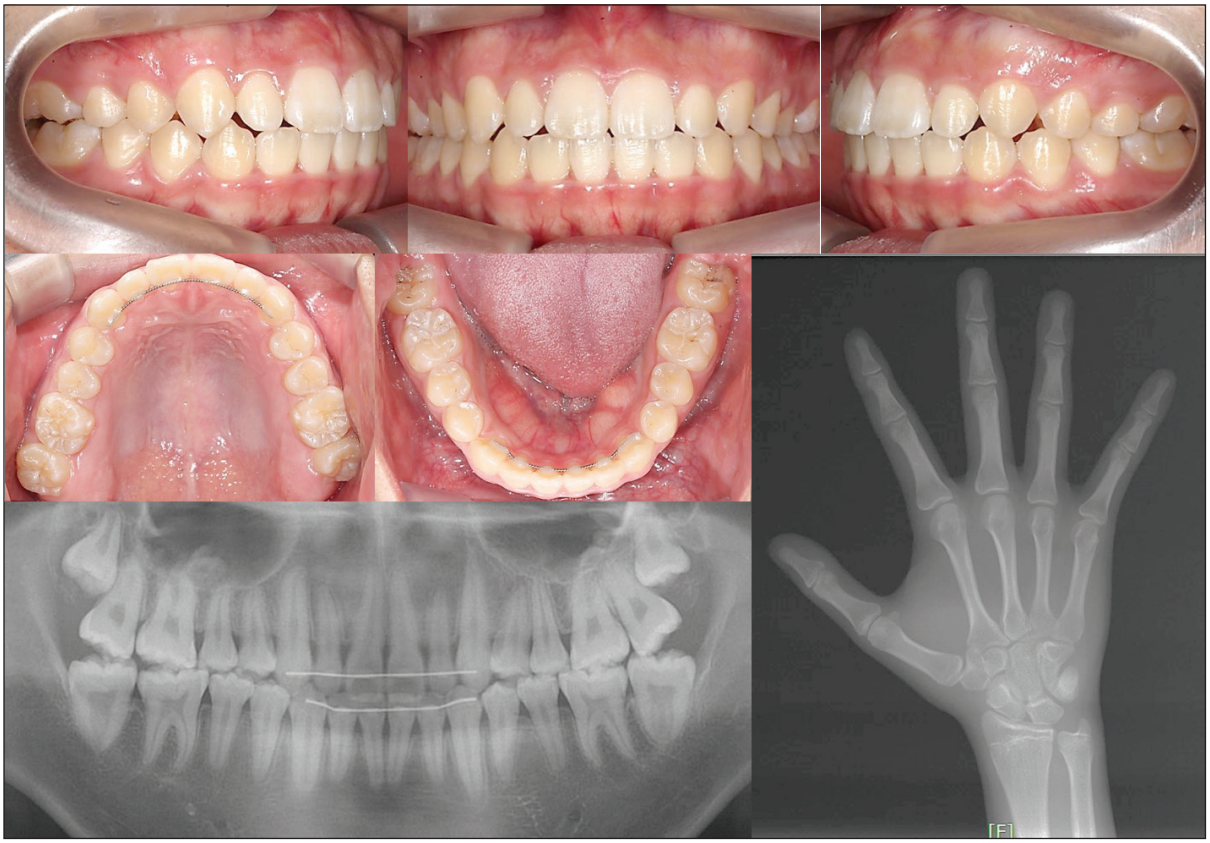


Figure 4. Patient 1: posttreatment intraoral photographs and hand-wrist radiograph, and 7-month retention panoramic radiograph.



Patient 2

Patient 2 was a 17-year-old boy with the chief complaint of unilaterally impacted MM2s. He was in good health with no history of dental trauma. His left MM2 was horizontally impacted and blocked by the MM3. There was 14.2 mm of PAS and the mesiodistal width of the impacted MM2 was about 13.5 mm, so the expected total PAS was at least 16.2 mm even though there would be no further increase of PAS because he was almost past the growing stage. Orthodontic traction of his impacted left MM2 was made possible with an OMI inserted in the retromolar area. After uprighting of MM2, full fixed treatment was done to correct crowding to satisfy patient's demands (Figures 5 and 6).

Figure 5. Patient 2: A, pretreatment CBCT images: a, lingual view; b, occlusal view; c, mesiodistal width of mandibular second molar; B, posterior available space on lateral cephalograms: a, pretreatment; b, 12-month treatment; c, posttreatment.

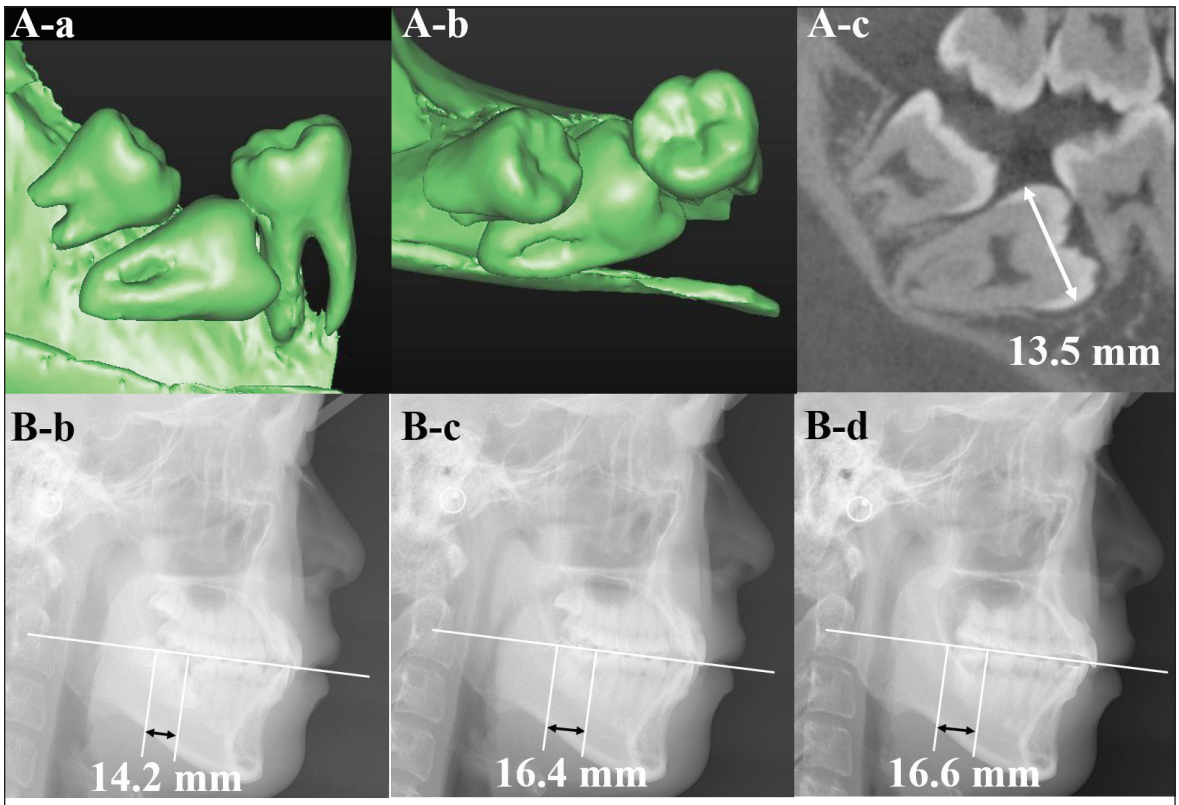
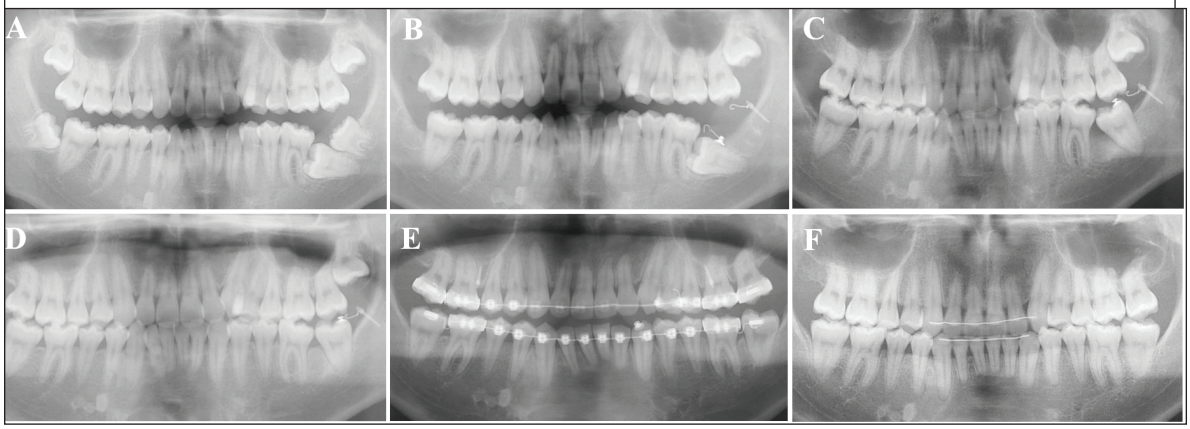


Figure 6. Panoramic radiographs of Patient 2: A, pretreatment; B, insertion of retromolar orthodontic microimplant on the left side; C, 6 months; D, 12 months; E, 19 months; F, posttreatment.

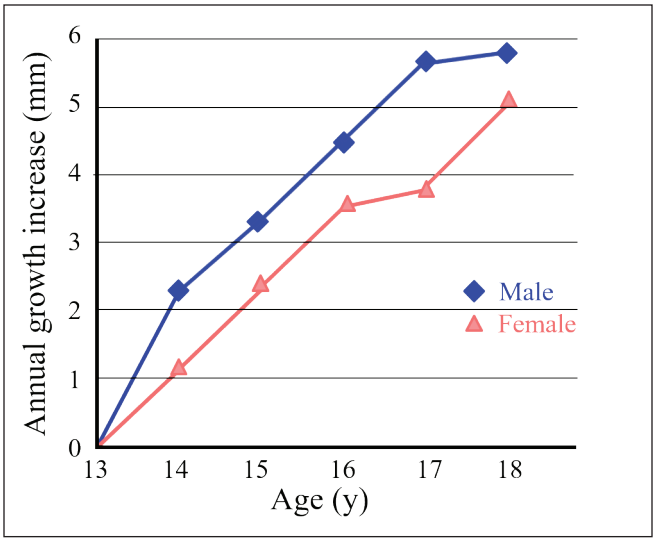


DISCUSSION

The main reason for the impaction of the MM2s is a reduced distance between MM1 and the anterior margin of mandibular ramus.[7-9] In adolescents, the posterior space of the mandible increases as the anterior border of the ramus resorbs.[23-26] According to a longitudinal study,[24] on average, the PAS increased 1.22 mm a side per year in girls under 16 and 1.45 mm a side per year in boys under17 (Figure 7). Previous studies[26,28] also suggested that 3 mm of increase per year occurs in the posterior dentition area until age 14 for girls and age 16 for boys with an increase of 1.5 mm per year on each side of the arch after the complete eruption of the MM1s. And the posterior limit was recognized as being 2-3 mm or 7 mm distal to the anterior border of the ramus because of the lingual shelf that exists to accommodate the MM2s.[27,28] Thus, in adolescent patients, the growth of the mandible causes an increase in the available space of the posterior teeth. Therefore, even if the space in which the MM2s is arranged is not immediately available, it may be possible to arrange the MM2s without premolar extraction[31] or interproximal reduction[32] if the space of the posterior area is secured as the mandible grows as in Patient 1. However, if no more available space can be obtained in the posterior area in adult patients, posterior space analysis is more critical for success of uprighting MM2s as in Patient 2. The MM3 is not a risk factor for MM2 impaction,[8] but the developmental formation of the MM3s is associated with the available retromolar space,[23] so predicting the eruption stage of MM3 might be helpful for estimating PAS.[24]

On the other hand, teeth on the lingual shelf are not generally in good functional occlusion.[28] And even if impacted MM2s were successfully uprighted, adequate retromolar space for uprighting should be ensured to prevent pericoronitis by an accumulation of soft tissue over the MM2.[29] Treatment of pericoronitis involves debridement of the periodontal pocket, and disinfection with an irrigation solution such as chlorhexidine or hydrogen peroxide. Only in severe cases is antibiotic therapy warranted. Operculectomy has been recommended as a prevention tool. However, soft tissue regrowth is a frequent occurrence due to insufficient available space making this an incomplete prevention technique.[32-35] In many cases, the MM2's uprighting is blocked by a mesially displaced MM3. In our cases, the MM3s were impacted or incapable of ever erupting into a useful position, therefore, extraction of MM3s and inserting OMIs in the retromolar area were performed simultaneously with bonding buttons on the MM2s when the oral surgeon exposed the distal aspect of the MM2.[32] After uprighting MM2s, removal of OMIs in the retromolar area and buttons on the MM2s was performed simultaneously with periodontal surgery to reduce soft tissue inflammation.

Figure 7. An increased curve of posterior available space (the distance between the intersection of the occlusal plane with the anterior border of the ramus and the distal contact point of the mandibular permanent first molar) from 13 to 18 years of age in boys and girls.[24]



There are some disadvantages with retromolar OMI. Impacted MM2s can be pulled out in only one direction when using retromolar OMI. Single force or the moment is not enough to upright and align an impacted MM2 which is tilted and rotated. Also, surgical procedures are needed when placing and removing OMIs. But these surgical procedures are well tolerated by patients and have little risk of infection.[14] The retromolar area is highly risky for inserting OMIs because it is covered with thick and mobile soft tissue,[15] so a closed method with surgical flap[16,22] has to be used when inserting OMIs in the retromolar area. Recently, the open method[14,15,17] has been reported to reduce the need for a surgical procedure and it is easy to load traction force.

Retromolar skeletal anchorage[14-17,22] is effective in treating deeply and horizontally impacted MM2s. The retromolar area is advantageous for securing initial stability of the skeletal anchorage because of its high bone density. Moreover, the retromolar placement of the OMIs has relevant biomechanical advantages, permitting the application of force distal to the center of resistance of the MM2 and facilitating vertical control during the extrusion phase of treatment.[14] Tip back moment and extrusive force are applied to the impacted MM2s due to their positional relationship. The orthodontic buttons bonded to the crown are replaced occlusally and mesially. In addition, a full fixed orthodontic treatment can be achieved with alignment of roots during mesial movement of MM2s. In order to upright one molar efficiently, it is necessary to produce a moment with a magnitude of about 900g-mm.[36] In Patient 1, the distance between the line of action and center of resistance was about 9.0 mm, so 100g of force was necessary to upright his MM2s (Figure 8).

Impacted MM2s were too deep and close to the adjacent MM1 to move upward in our cases. Therefore, upward and backward force and moment were needed to prevent interference with the distal surface of MM1 during uprighting. The mechanics using OMIs inserted in the retromolar area were highly efficient in uprighting deeply and horizontally impacted MM2s.

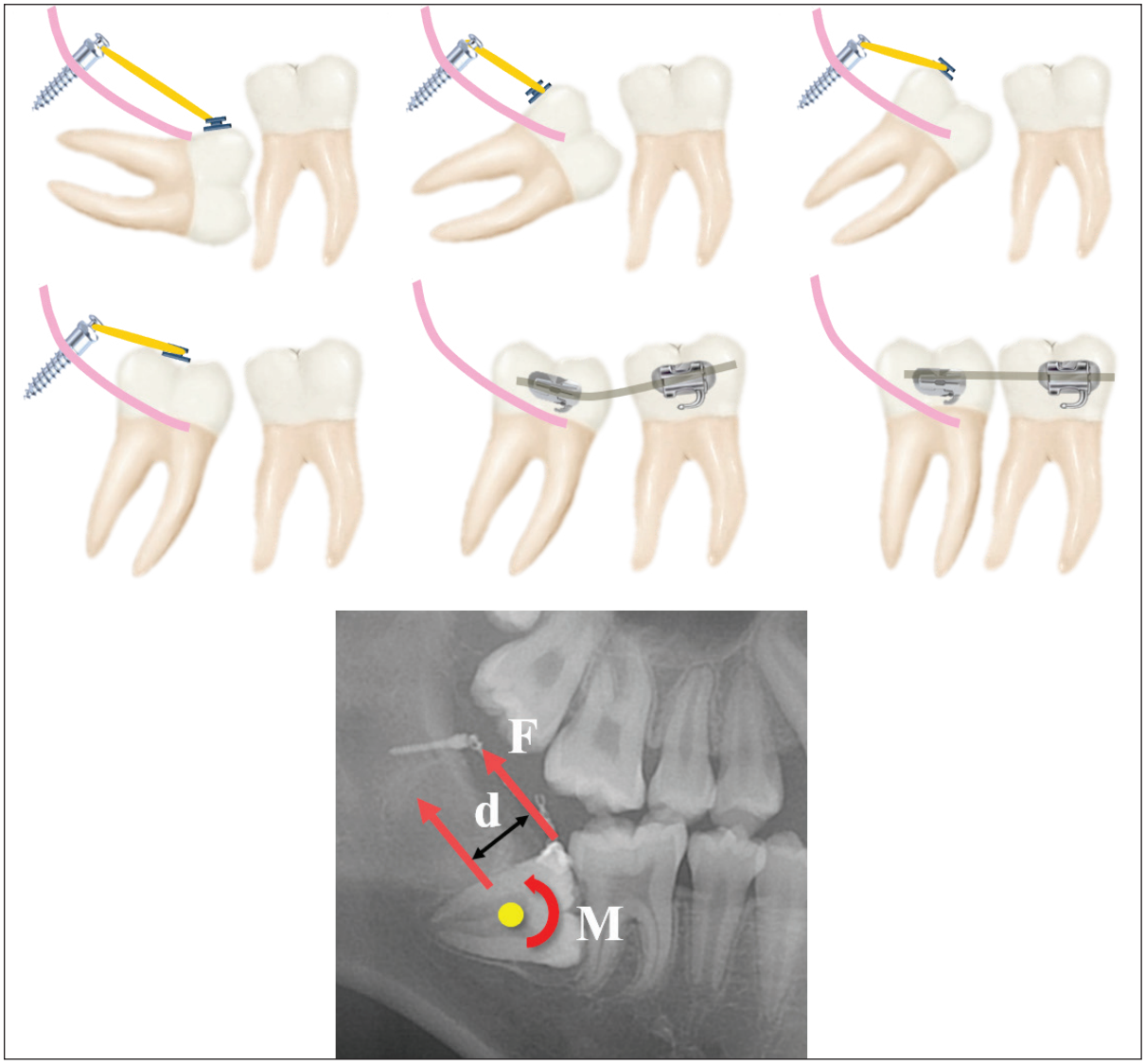
CONCLUSIONS

Clinicians should consider the location and desired movement of the impacted MM2 to upright them. Also, PAS should be analyzed before uprighting of impacted MM2s to prevent periodontal problems after treatment. Orthodontic microimplants (OMIs) in the retromolar area were very efficient in uprighting horizontally and deeply impacted MM2s.

ACKNOWLEDGMENT

This paper was supported by Wonkwang University in 2018.

Figure 8. The biomechanical procedure for uprighting horizontally and deeply impacted mandibular second molars with retromolar orthodontic microimplants. F, force; d, distance; M, moment.



REFERENCES

1. Grover PS, Lorton L. The incidence of unerupted permanent teeth and related clinical cases. Oral Surg Oral Med Oral Pathol, 59: 420-425, 1985.
2. Vedtofte H, Andreasen JO, Kjaer I. Arrested eruption of the permanent lower second molar. Eur J Orthod, 21: 31-40, 1999.
3. Bondemark L, Tsiopa J. Prevalence of ectopic eruption, impaction, retention and agenesis of the permanent second molar. Angle Orthod, 77: 773–778, 2007.
4. Cho SY, Ki Y, Chu V, Chan J. Impaction of permanent mandibular second molars in ethnic Chinese schoolchildren. J Can Dent Assoc, 74: 521a-e, 2008.
5. Shapira Y, Finkelstein T, Shpack N, Lai YH, Kuftinec MM, Vardimon A. Mandibular second molar impaction. Part I: Genetic traits and characteristics. Am J Orthod Dentofacial Orthop, 140: 32-37, 2011.
6. Fu PS, Wang JC, Wu YM, Huang TK, Chen WC, Tseng YC, Tseng CH, Hung CC. Impacted mandibular second molars. Angle Orthod, 82: 670-675, 2012.
7. Cassetta M, Altieri F, Di Mambro A, Galluccio G, Barbato E. Impaction of permanent mandibular second molar: a retrospective study. Med Oral Patol Oral Cir Bucal, 18: e564-568, 2013.
8. Cassetta M, Altieri F, Calasso S. Etiological factors in second mandibular molar impaction. J Clin Exp Dent, 6: e150-154, 2014.
9. Padwa BL, Dang RR, Resnick CM. Surgical Uprighting Is a Successful Procedure for Management of Impacted Mandibular Second Molars. J Oral Maxillofac Surg, 75: 1581-1590, 2017.
10. Mah SJ, Won PJ, Nam JH, Kim EC, Kang YG. Uprighting mesially impacted mandibular molars with 2 miniscrews. Am J Orthod Dentofacial Orthop, 148: 849-861, 2015.
11. Mah M, Takada K. Orthodontic management of the impacted mandibular second molar tooth. Orthod Fr, 87: 301-308, 2016.
12. Shapira Y, Borell G, Nahlieli O, Kuftinec MM. Uprighting mesially impacted mandibular permanent second molars. Angle Orthod, 68: 173-178, 1998.
13. Lee KJ, Joo E, Yu HS, Park YC. Restoration of an alveolar bone defect caused by an ankylosed mandibular molar by root movement of the adjacent tooth with miniscrew implants. Am J Orthod Dentofacial Orthop, 136: 440-449, 2009.
14. Giacontti A, Arcuri C, Barlattani A. Treatment of ectopic mandibular second molar with titanium miniscrews. Am J Orthod Dentofacial Orthop, 126: 113-117, 2004.
15. Lin SY, Chang CH, Roberts WE. Forty Consecutive Ramus Bone Screws Used to Correct Horizontally Impacted Mandibular Molars. Int J Orthod Implantol, 41: 60-72, 2016.
16. Lee KJ, Park YC, Hwang WS, Seong EH. Uprighting mandibular second molars with direct miniscrew anchorage. J Clin Orthod, 41: 627-635, 2007.
17. Giancotti A, Muzzi F, Santini F, Arcuri C. Miniscrew treatment of ectopic mandibular molars. J Clin Orthod, 37: 380–383, 2003.
18. Lau CK, Whang CZ, Bister D. Orthodontic uprighting of severely impacted mandibular second molars. Am J Orthod Dentofacial Orthop, 143: 116-124, 2013.
19. Yun SW, Lim WH, Chun YS. Molar control using indirect miniscrew anchorage. J Clin Orthod, 39: 661-664, 2005.
20. Kravitz ND, Yanosky M, Cope JB, Silloway K, Favagehi M. Surgical Uprighting of Lower Second Molars. J Clin Orthod, 50: 33-40, 2016.
21. Gazit E, Lieberman M. A mesially impacted mandibular second molar. Treatment considerations and outcome: a case report. Am J Orthod Dentofacial Orthop, 103: 374-376, 1993.
22. Choi YJ, Huh JK, Chung CJ, Kim KH. Rescue therapy with orthodontic traction to manage severely impacted mandibular second molars and to restore an alveolar bone defect. Am J Orthod Dentofacial Orthop, 150: 352-363, 2016.
23. Ghougassian SS, Ghafari JG. Association between mandibular third molar formation and retromolar space. Angle Orthod, 84: 946-950, 2014.
24. Chen LL, Xu TM, Jiang JH, Zhang XZ, Lin JX. Longitudinal changes in mandibular arch posterior space in adolescents with normal occlusion. Am J Orthod Dentofacial Orthop, 137: 187-193, 2010.
25. Lee NB, Kim KW. A study on the change of posterior available space and the relationship between posterior available space and crowding. Korean J Orthod, 24: 535-546, 1994.
26. Merrifield LL. Dimensions of the denture: back to basics. Am J Orthod Dentofacial Orthop, 106: 535-542, 1994.
27. Kim SJ, Choi TH, Baik HS, Park YC, Lee KJ. Mandibular posterior anatomic limit for molar distalization. Am J Orthod Dentofacial Orthop, 146: 190-197, 2014.
28. Vaden J, Klontz H, Dale J. Standard edgewise: Tweed-Merrifield philosophy, diagnosis, treatment planning, and force systems. In: Graber L, Vanarsdall R, Vig K, editors. Orthodontics: current principles and techniques. Philadelphia: Mosby, 2012.
29. Nakamura M, Kawanabe N, Kataoka T, Murakami T, Yamashiro T, Kamioka H. Comparative evaluation of treatment outcomes between temporary anchorage devices and Class III elastics in Class III malocclusions. Am J Orthod Dentofacial Orthop, 151: 1116-1124, 2017.
30. Sarig R, Vardimon AD, Sussan C, Benny L, Sarne O, Hershkovitz I, Shpack N. Pattern of maxillary and mandibular proximal enamel thickness at the contact area of the permanent dentition from first molar to first molar. Am J Orthod Dentofacial Orthop, 147: 435-444, 2015.
31. Mendoza-García LV, Vaillard-Jiménez E, García-Rocha A, Bellot-Arcís C, Paredes-Gallardo V. Effect of orthodontic treatment involving first premolar extractions on mandibular third molar angulation and retromolar space. J Clin Exp Dent, 9: e333-337, 2017.
32. Johnson E. Managing second molars. Am J Orthod Dentofacial Orthop, 140: 269-273, 2011.
33. Kravitz ND, Kusnoto B. Soft-tissue lasers in orthodontics: an overview. Am J Orthod Dentofacial Orthop, 133: S110-114, 2008.
34. Oh YH, Park HS, Kwon TG. Treatment effects of microimplant-aided sliding mechanics on distal retraction of posterior teeth. Am J Orthod Dentofacial Orthop, 139: 470-481, 2011.
35. Folayan MO, Ozeigbe EO, Onyejaeka N, Chukwumah NM, Oyedele T. Non-third molar related pericoronitis in a sub-urban Nigeria population of children. Niger J Clin Pract, 17: 18-22, 2014.
36. Romeo DA, Burstone CJ. Tip-back mechanics. Am J Orthod, 72: 414-421, 1977.