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Review in the Treatment Decision of Modalities for Impacted Second Molar

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Abstract

Impacted permanent tooth can occur on any tooth in the dental arch. The incidence of retention and impaction of the second molar lies between 0 and 2.3%. It is infrequently found in normal dental patients because most of the second molar impactions are asymptomatic. However, it is a common occurrence in orthodontic practice. The impacted second molar may provoke many pathologic disorders to the adjacent and opposite teeth, eventually malocclusions. There are many treatment modalities in facilitating the eruption of the second molar impaction. Early diagnosis and early treatment are crucial for the successful treatment of mandibular second molar impaction. This article presents an overview of various treatment modalities for an impacted second molar.

Keywords: Second molar, Treatment modality, Unerupted tooth, Impacted tooth, Diagnosis, Surgery

1. Introduction

Unerupted or impacted permanent tooth can involve any tooth in the dental arch. According to many authors, the teeth that are usually involved are the maxillary and mandibular third molars, the maxillary canines, and the mandibular second premolars, respectively. The delayed eruption of second permanent molars is an infrequent occurrence; however, it has clinical impacts when it occurs.

The frequency of occurrence in the impacted second molars is rare and can vary within 0% to 2.3% [1–3]. Permanent molars are exceptionally crucial for the dentition to develop normally and for the facial growth synchronization, along with providing occlusal support for masticatory functions. Any disturbance in the eruption path of permanent molars can lead in a short lower facial height [4].

Most of the time, the pathology from the impacted second molar may provoke many pathologic disorders to the adjacent and opposite teeth. Caries, periodontitis, roots resorption, or pericoronitis may occurred to those neighboring teeth. Other results may form the follicular cyst, tilting of neighboring teeth, and eventually malocclusions [5, 6].

The treatment modalities for unerupted second molars depend on the impaction's severity and the stage of development of the patient [5], which often requires a multidisciplinary approach. The treatment options include surgical procedures [7, 8], orthodontic methods [9, 10], and combined surgical and orthodontic [11]. Some authors suggested extracting the unerupted molar and following orthodontic approaches [10, 12, 13]. Each method has its advantages and disadvantages.

Timely early diagnosis and treatment of permanent second molars' impaction contribute to the most satisfactory consequences with promising and lasting prognosis [14]. Later treatment will be more problematic because not only will the clinical divergence increase with time, but also, the ability to adjust the existing dentition is less.

There are various treatment modalities of the second molar impactions. However, there are no clear guidelines for the clinician to follow when dealt with such cases. Therefore, this review will explain the etiology and incidence of impacted second permanent molars, emphasize the need for earlier diagnosis, and focus on treatment options that can guide the decision-making process.

2. The eruption of permanent molar

The eruption of permanent molars diverges on or after the eruption of other permanent teeth because the former primary teeth are absent. The formation of permanent molars is consecutively originated in the maxillary tuberosity and at the connection of the mandibular ramus and body of the mandible. The jaws' development results in the respective position of the first permanent molar to shift forward at the time of the development of the second molar. The occlusal surface of the mandibular molars is mesially inclined while the occlusal surface of maxillary molars is distally inclined during the beginning of the formation. The crowns then slowly shift to a more vertical position. Notably, there is an inherent close association between the eruption of a tooth and the stage of root development. Moreover, three-quarters of the roots of the tooth will be formed right after emergence. Remarkably, half of the roots of central incisors and lower first permanent molars have been developed by this time [5].

The concept of eruption failure is different from the delayed eruption. It is reflected as the incapacity of the tooth to erupt in the oral cavity [15]. This may occur in one or more teeth, with primary or the permanent dentition, and could possibly be incomplete and complete eruption failure. Bone or soft tissue may cover the teeth. In more ways, the failure is reliant on the pre-existing etiology [16].

3. Eruption disturbances and ectopic eruption

A disruption in the eruption path means the second molar erupts into contact apical to the eminence on the first permanent molar's distal surface, and from this occurrence, the second molar can be locked [17] (**Figure 1**). Impaction, by definition, is tooth retention owing to an obstruction in the tooth germ's eruption path or ectopic position in the dentition [11]. Impaction is deemed to be the termination of the eruption of a tooth. The obstruction can be detected clinically or radiographically in the route of eruption or due to the tooth's malposition. Primary retention stops the eruption of a customarily situated and developed tooth before the emergence, without a visible obstruction in the eruption path. Secondary retention is the ending of the tooth eruption after the emergence devoid of a physical barrier [2, 5, 18]. There are distinct treatment approaches for the eruption disturbances [5].



Figure 1.
The impacted second molar that occur (arrow) A: a part of panoramic radiograph on the left side B: in the oral cavity C: the occlusion of the lower impacted second molar and upper second molar.

4. Discussion

4.1 Incidence

The diagnosis of impacted second molars has been made typically between 10 and 14 years of age. Helm and Seidler defined ordinary emergence for the second molar at 12.4 and 11.9 years in the maxilla and 11.9 and 11.4 years in the mandible for boys and girls, respectively [19]. The late emergence of the second molars is seldom the primary reason for an orthodontic recommendation [20].

4.2 Prevalence of impacted second molars

The frequency of impacted second molars is only minimal and it varies from 0% to 2.3% [2]. Brondemark and Tsiopa found 2.3% of the wide-ranging prevalence of eruption disturbances of the permanent second molar. Cho et al. reported that the impaction mandibular second molars in Chinese children was only 1% [21]. The impacted second molars are usually overlooked whenever there is clinical examination, and radiographs might not be routinely taken for all cases. Furthermore, these impacted the second molar teeth are ignored by asymptomatic patients [22].

However, a greater incidence of second molar impaction is more common in orthodontic patients [23]. The prevalence of impacted second mandibular molar from orthodontic records of young caucasian was relatively high (1.36%) as the study was conducted on the orthodontic population [24]. The age of the individuals with impacted second molar varies from 9 to 26 years [1, 2]. Second molar impaction often ensues much more in the mandible than in the maxilla, which may arise for the reason that there is a later development of the upper third molar [25]. These impactions tend to be more unilateral than bilateral [2, 25]. Second molar impaction and retention are habitually detected during orthodontic treatment as a supplemental finding and are infrequently the main reason for referral to an orthodontic clinic [26].

4.3 Etiology

Many factors are elaborated with the failure of eruption, affecting prognosis and treatment [20]. The impacted second molar is an asymptomatic pathology. Failure of eruption is also more likely to be a secondary finding during orthodontic treatment [27]. Andreasen et al. [4] concluded that three leading factors are drawn in the eruption interference. These causes incorporate position of the ectopic tooth, barriers in the eruption path, and failures in mechanism of the eruption [17, 28]. Posterior crowding is thought to be the most common cause of mesially angulated lower-second-molar impactions [11].

Heredity is also brought up as a secondary etiological factor [29]. Patients with specific syndromes may involve some systemic factors [16]. In the patients with a disturbance of local eruption, only one or a few teeth may be affected. The early diagnosis of eruption disturbances is crucial. It is essential to provide treatment at a suitable time and minimize complications [5, 25, 30].

An ectopic eruption of the maxillary first molars impaction is often related to a mesial angle path to the expected direction of eruption. It may also affect the second molar's failure to upright from its mesial inclination during the emergence. Supernumerary teeth and odontogenic tumors or cysts can be the major physical barriers of the eruption path [5].

The eruption of mandibular second premolar and second molar usually in competition for space of the dental arch. When this posterior space in the arch is inadequate, the earlier emergence second premolar may cause the failure of eruption of the second molar [31].

4.4 Diagnostic approach and treatment time

The impacted second molars are diagnosed between 10 and 14 years of age [32]. Rapid diagnosis is crucial in improving prognosis and alleviating the effect of the failure of eruption. It requires a full clinical and radiographic examinations including previous medical record, which are enough to differentiate between impaction, primary, and secondary retention [5, 15].

As the time of eruption may differ among each child, follow-up at six-month intervals of children with mixed dentition is recommended to guide the pattern of eruption and the development of the teeth. The posterior crowding cases and the uncertain of the molar retention should be more concerned [21]. The orthodontist should be alerted if one erupted lower second molar without the contralateral molar is observed in the clinic. The number of teeth with delayed eruption compared to the contralateral teeth should be one of the cautions.

In a preadolescent patient, a panoramic radiograph showing a lower-third-molar follicle positioned on top of the developing second molar crown may give early warning of future impaction [32].

If the eruption of a permanent mandibular second molar is six-month delayed compared with its contralateral molar or both molars show a year delay in eruption, the dubitation of molar retention must necessitate further radiographic investigation [21]. The cone-beam computed tomography is a tool that can be employed to identify ankylosis [28].

Unerupted molar may be found in a panoramic radiograph thru a regular dental check-up or orthodontic assessment and treatment planning [20]. The radiological examination must focus on the follicles of unerupted molars, dental abnormalities, root abnormalities, dilacerations, taurodontism, invagination, resorption, or dental caries in both neighboring primary molar and first permanent molar [30].

The treatment option depends on the mandibular second molar impaction dictated by the degree of mesial angulation and its vertical depth, which could be seen in a panoramic radiograph. The inclination of impacted teeth is calculated from the angle between the first and second lower molars' long axis. The impacted second molar is in mesial inclination if the angle between their long axis is more than 40° . If the angle of the long axis of both molars is between 40° and -20° , the impacted second molar is in a vertical position, and if the angle is less than -20° means the impacted second molar is in distal inclination [20]. The vertical depth of impacted teeth will determine by the distance between the distal marginal ridge of the first molar to the mesial marginal ridge of the impacted second molar [22].

4.5 Treatment modalities

The treatment modalities for the second molar impaction depend on the variety of abnormalities of the eruption and the patient's age. Treatment options may incorporate observation, repositioning or surgical exposure, orthodontic uprighting, and the extraction of unerupted molar. Each modality has its indications, contraindications, advantages, and disadvantages [20].

The orthodontic or surgical approach is indicated only when the etiologies are from impacted ectopic erupting teeth and primary retention [17]. However, a prior observation time is essential to confirm the diagnosis through a radiographic follow-up before any intervention. The natural eruption may occur in normal occlusion in a few cases [11].

The intervention should be deliberated after an observation period of 12 months when the possibility of self-correction is ruled out [21]. Abnormally positioned tooth germ of the third molar may create a physical barrier that causes the second molar impaction. The suggested treatment is removing the third molar at the 11–14 years age old together with a in-depth follow-up for the second molar [5].

Once there is no chance for self-correction, the parents and patients should be informed about the treatment option for the impacted molars. The treatment options may include orthodontic uprighting, surgical repositioning, the impacted second molar extraction and letting the third molar drift into the second molar position, and transplanting the third molar into the extraction site of the impacted second molar [21].

4.6 Orthodontic treatment

Diagnosis made early on and prompt treatment are vital to an effective treatment of mandibular second molar impaction. The orthodontic treatment is recommended for impacted or ectopically erupted teeth and in cases of primary retention [17]. Although orthodontic treatment is usually given in the mandibular arch the success rate is the same for both the arches [11].

The individuals between 11 and 14 years in which the roots of second molars are still incomplete are suggested to treat the impaction. The poor prognosis is the impacted molars with fully formed roots [5]. The success of orthodontic treatment relates to numerous local considerations such as the impacted tooth's angulation, the third molar position, and the severity of crowding or follicle collision [11]. There are several methods to treat the second molar impaction. However, there are some limitations, specifically in the treatment of severely deep impacted teeth.

4.6.1 Conventional appliance

At the first stage of conventional orthodontic treatment, during the alignment and leveling, a tube is bonded to the molar's buccal surface. It will be engaged with a continuous archwire. Super-elastic archwire and a push coil spring will ensure the alignment and distalization. The super-elastic archwire used for alignment and leveling of the teeth is curved distally of the impacted second molar. It is inserted in the tube to help uprighting the impacted second molar [31].

4.6.2 Orthodontic uprighting cantilever spring

The techniques of uprighting the impacted mandibular second molar with a cantilever spring are optional treatments besides extraction or surgical repositioning of

the tooth. The treatment can be directed with or without the removal of the adjacent third molar. It needs surgical exposure of the crown of the impacted second molar, followed by bonding an orthodontic attachment for uprighting the impacted tooth [33].

It is a straight forward way to upright the angulated and impacted second molar using an uprighting cantilever spring attached to a bonded tube on the distobuccal cusps of the affected tooth [31].

The cantilever mechanics designed was useful for the correction of an extremely tipped and deeply impacted molar. When the cantilever mechanics is used, the tipped molar will have an uprighting moment and an extrusive force.

Thus, an occlusal interference with the opposing tooth may occur. Morita et al. suggested utilizing a compression force with a two-step bend incorporated into a NiTi archwire for cases in which the molar was slightly tipped and extruded [34].

4.6.3 Orthodontic uprighting and distalized segmented wire

Several orthodontic techniques utilize the distalized segmented archwire to upright the impacted molar. Before the bonding of fixed orthodontic appliances, a segmented wire is engaged between the impacted second molar and the adjacent first molar. The segmented archwire for the technique must have super elasticity characteristics. The wire will be bent and bonded to the occlusal surface of the first permanent molar [35].

Bach technique is one of the non-surgical technique for uprighting mesially impacted mandibular molars. The technique used an .014" x .025" Copper NiTi wire. Whereas other developed a technique using .016" x .016" NiTi wire [36]. Fu et al. developed a polearm using 0.016" x 0.022" titanium molybdenum alloy wire [22]. A major advantage of these techniques was that they could be utilized on both bonded and unbonded mandibular arch.

4.6.4 Temporary anchorage devices

Temporary skeletal anchorages devices have some superior advantages. They could provide vertical and distal traction forces at the same time with a good moment and line of action. They could also diminish the side effects related with dental anchorage. There are two methods of utilizing a temporary anchorage device for uprighting molar impaction, direct and indirect anchorage.

Direct anchorage is when the teeth moved directly towards or against the mini-screw. Chang et al., reported the use of a ramus screw to upright the complex impacted second molar [37]. An indirect anchorage refers to stabilizing certain teeth via a rigid connection with the mini-screw and subsequent use of these stabilized anchors to move other teeth in the dental arch [38].

4.7 Surgical approach

Because these impacted teeth have limited access, surgical approaches should be considered to help with their necessary uprighting. Techniques are as follows:

4.7.1 Surgical exposure without orthodontic traction

Surgical exposure of the buccal surface bonded with a bracket has been done by Going and Reyes- Louise in 1999 for an impacted second molar. The exposure

resulted in the successful positioning of the second molar of 40 patients. They applied this technique for seven years with an acceptable prognosis [39].

Usually, the buccal surface will be exposed via soft tissue removal or drilling into the bone covering the tooth. Care must be given to drilling into the bone to not traverse through the second molar's cemento-enamel junction and root areas [39]. This method was discussed as the most successful treatment by Magnusson and Kjellberg. These researchers conducted a clinical trial involving 87 patients ranging from 11 to 19 years old. The study gained 70% favorable results, making it a recommended modality [11].

4.7.2 Surgical exposure and luxation

As mentioned above, the procedure to expose the second molar is to remove the buccal bone to gain the tooth's surface visibility. In patients where, orthodontic treatment is not an option or contraindicated, luxation is the next step. Using a straight elevator, the second molar is gently and slightly manipulated to the tooth's position, luxating occlusally and distally, reaching the approximate level of the occlusal plane.

Kravitz et al. claimed that this technique is suitable for conserving the apical blood supply since the tooth will remain within the socket [32]. Hence, the tooth can have a favorable prognosis, especially when there is still incomplete root formation [32, 40]. Disadvantages would be fractures and pulp necrosis due to the manipulation employed in this method [20].

4.7.3 Surgical uprighting

To achieve the upright position of the impacted second molar, the extraction of the third molar might be necessary. The removal of the third molar can be done with a standard approach in these cases [41–43]. According to McAboy et al., a trough is made on the second molar's distal to compensate for the distal movement. Two hands are recommended in doing this procedure: one hand on the elevator to change the position of the tooth occlusal and distally, less than 75 degrees, five while the other hand will be for the cortical plate and alveolar ridge support [41].

The surgeon was said to feel a “snap” into the trough provided in the distal area, possibly indicating a stable position [44]. However, the tooth was advised to be placed off-occlusion slightly to avoid trauma on the site, and necessary stabilizing techniques can be performed if there is mobility [41]. This technique was widely evidenced to have a good prognosis and claimed to have no unfavorable sequelae in long-term follow-ups [43, 44]. Furthermore, other authors supported that removing the third molar might not be required in these cases [24, 40].

Autogenous bone grafting or any bone substitutes can be applied in this technique for stabilization in some cases where there are areas devoid of bone [41, 44]. On the other hand, Boynton and Lieblich suggested that bone grafts are not necessary for the stabilization process [45].

4.7.4 Extraction

Subsequently, suppose all other minimally to moderately invasive surgical modalities fail. In that case, the prognosis is poor, and pathology has commenced— then

extraction can be an option [33]. This method was said to be the most unsuccessful among all the modalities tested by Magnusson and Kjellberg since it was reported that the third molars that replaced these teeth resulted in a mispositioned state. Once this treatment is indicated, proper patient education on untoward outcomes is suggested [11].

4.7.5 Autotransplantation

Immediate transplantation of the third molar into the intentionally extracted second molar site is also an indicated management. Still, it possesses immense risk as there will be periodontal and pulpal complications after the procedure [32, 41]. Successful outcomes depend on the generation of new periodontal ligament and cellular structures, suggesting that the tooth should be transplanted right away to make way for a better prognosis.

According to Tsukiboshi, this treatment's indications include the donor and recipient teeth should be morphologically analogous to each other; both teeth should be prepared with less invasive procedures; if endodontic treatment is deemed necessary, the therapy completion should be completed after two weeks [46]. In this procedure, failure happens when there is a pulpal infection, ankylosis, and resorption on the transplanted tooth [47]. The use of a piezosurgery machine in autotransplantation has been developed and resulted in an effective modality in harvesting the third molar to replace a second molar [48].

4.8 Timing of uprighting

Preferably, the literature suggests that surgical repositioning approaches should be made in a second molar with half or two-thirds of root formation. Dessner [49] described that there is minimal root fracture that can happen in this development stage. Intervention in the earlier stages of root formation rather than the recommended one results in a displaced, unstable, and less than the second molar's desired position.

5. Conclusion

Second molar impaction and retention are infrequently the initial reason for orthodontic treatment recommendation because they are rare and asymptomatic. It may be discovered in a regular panoramic radiograph during routine orthodontic evaluation. The diagnosis and treatment planning, which should consider the patient's age is crucial. The treatment options include observation, surgical extraction of unerupted permanent molars, and a number of orthodontic and surgical methodologies for purposely uprighting the impacted molars. Though there are no definite guidelines for managing the second molar impaction, this literature can assist in the decision-making process and treatment planning of such clinical cases.

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References

- [1] Farman AG, Eloff J, Nortje CJ, Joubert JJ. Clinical absence of the first and second permanent molars. *Br J Orthod.* 1978;5(2):93-97.
- [2] Bondemark L, Tsiopa J. Prevalence of ectopic eruption, impaction, retention and agenesis of the permanent second molar. *Angle Orthod.* 2007;77(5):773-778.
- [3] Grover PS, Lorton L. The incidence of unerupted permanent teeth and related clinical cases. *Oral Surg Oral Med Oral Pathol.* 1985;59(4):420-425.
- [4] Proffit WR. Equilibrium theory revisited: factors influencing position of the teeth. *Angle Orthod.* 1978;48(3):175-186.
- [5] Raghoobar GM, Boering G, Vissink A, Stegenga B. Eruption disturbances of permanent molars: a review. *J Oral Pathol Med.* 1991;20(4):159-166.
- [6] Albert H B Schuurs AHB. Pathology of the dental hard tissues. 2012:225-55.
- [7] Haralabakis NB, Tsianou A, Nicolopoulos C. Surgical correction of mesially impacted mandibular second molars. *J Clin Orthod.* 2003;37(4):209-212; quiz 4.
- [8] Johnson JV, Quirk GP. Surgical repositioning of impacted mandibular second molar teeth. *Am J Orthod Dentofacial Orthop.* 1987;91(3):242-251.
- [9] Miao YQ, Zhong H. An uprighting appliance for impacted mandibular second and third molars. *J Clin Orthod.* 2006;40(2):110-116.
- [10] Johnson E. Managing second molars. *Am J Orthod Dentofacial Orthop.* 2011;140(2):269-273.
- [11] Magnusson C, Kjellberg H. Impaction and retention of second molars: diagnosis, treatment and outcome. A retrospective follow-up study. *Angle Orthod.* 2009;79(3):422-427.
- [12] Bach RM. Non-surgical uprighting of exposed, mesially impacted lower molars. *J Clin Orthod.* 2012;46(8):480-485; quiz 91-2.
- [13] Alessandri Bonetti G, Pelliccioni GA, Checchi L. Management of bilaterally impacted mandibular second and third molars. *J Am Dent Assoc.* 1999;130(8):1190-1194.
- [14] Salentijn EG, Ras F, G Mensink G, van Merkesteyn JPR. The unerupted maxillary second molar, due to an overlying and malformed upper third molar: Treatment and follow-up. *J Orthod.* 2008 Mar;35(1):20-24
- [15] Palma C, Coelho A, Gonzalez Y, Cahuana A. Failure of eruption of first and second permanent molars. *J Clin Pediatr Dent.* 2003;27(3):239-245.
- [16] Ahmad S, Bister D, Cobourne MT. The clinical features and aetiological basis of primary eruption failure. *Eur J Orthod.* 2006;28(6):535-540.
- [17] Andreasen JO PJ, Laskin DM. Textbook and colour atlas of tooth impactions. 1997.
- [18] Raghoobar GM, Boering G, Jansen HW, Vissink A. Secondary retention of permanent molars: a histologic study. *J Oral Pathol Med.* 1989;18(8):427-431.
- [19] Helm S, Seidler B. Timing of permanent tooth emergence in Danish children. *Community Dent Oral Epidemiol.* 1974;2(3):122-129.
- [20] Sanaa Alami HA, Bellamine M, Quars FE. Impacted First and Second Permanent Molars: Overview. *IntechOpen.* 2019:1-25.

- [21] Cho SY, Ki Y, Chu V, Chan J. Impaction of permanent mandibular second molars in ethnic Chinese schoolchildren. *J Can Dent Assoc.* 2008;74(6):521.
- [22] Fu PS, Wang JC, Wu YM, Huang TK, Chen WC, Tseng YC, et al. Impacted mandibular second molars. *Angle Orthod.* 2012;82(4):670-675.
- [23] Owen AHI. Early surgical management of impacted mandibular second molars. *J Clin Orthod.* 1998;32::446-50.
- [24] 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.* 2013;18(4):e564-e568.
- [25] Varpio M, Wellfelt B. Disturbed eruption of the lower second molar: clinical appearance, prevalence, and etiology. *ASDC J Dent Child.* 1988;55(2):114-118.
- [26] Evans R. Incidence of lower second permanent molar impaction. *Br J Orthod.* 1988;15(3):199-203.
- [27] Srinivasan MR, Poorni S, Venkatesh A, Vasanthi B. Prevalence of impacted permanent mandibular second molars in South Indian population: A cross-sectional study. *Indian J Dent Res.* 2016;27(5):540-543.
- [28] Proffit WR, Fields HW, Larson B, Sarver DM *Contemporary Orthodontics.* 6 ed., St. Louis, Mosby, 2018.
- [29] Fu PS, Wang JC, Chen CH, Huang TK, Tseng CH, Hung CC. Management of unilaterally deep impacted first, second, and third mandibular molars. *Angle Orthod.* 2012;82(3):565-571.
- [30] Suri L, Gagari E, Vastardis H. Delayed tooth eruption: pathogenesis, diagnosis, and treatment. A literature review. *Am J Orthod Dentofacial Orthop.* 2004;126(4):432-445.
- [31] Vedtofte H, Andreasen JO, Kjaer I. Arrested eruption of the permanent lower second molar. *Eur J Orthod.* 1999;21(1):31-40.
- [32] Kravitz ND, Yanosky M, Cope JB, Silloway K, Favagehi M. Surgical Uprighting of Lower Second Molars. *J Clin Orthod.* 2016;50(1):33-40.
- [33] Shpack N FT, Lai YH, Kuftinec MM VA, Shapira Y. Mandibular permanent second molar impaction treatment options and outcome *Open J Dent Oral Med.* 2013;1:9-14.
- [34] Morita Y, Koga Y, Nguyen TA, Yoshida N. Biomechanical considerations for uprighting impacted mandibular molars. *Korean J Orthod.* 2020;50(4):268-277.
- [35] DiBagno D BL, Rinchuse DJ. Uprighting impacted mandibular second molars using NiTi wire. *Orthod Practice.* 2015; 6:40-44.
- [36] Bach RM. Non-surgical uprighting of mesially impacted lower molars. *J Clin Orthod.* 2011;45(12): 679-681.
- [37] Chang CH, Lin JS, Roberts WE. Ramus screws: the ultimate solution for lower impacted molars. *Semin Orthod.* 2018;24:135-154.
- [38] Magkavali-Trikka P, Emmanouilidis G, Papadopoulos MA. Mandibular molar uprighting using orthodontic miniscrew implants: a systematic review. *Prog Orthod.* 2018;19(1):1.
- [39] Going RE, Jr., Reyes-Lois DB. Surgical exposure and bracketing technique for uprighting impacted mandibular second molars. *J Oral Maxillofac Surg.* 1999;57(2):209-212.

- [40] Padwa BL, Dang RR, Resnick CM. Surgical Uprighting Is a Successful Procedure for Management of Impacted Mandibular Second Molars. *J Oral Maxillofac Surg.* 2017;75(8):1581-1590.
- [41] McAboy CP, Grumet JT, Siegel EB, Iacopino AM. Surgical uprighting and repositioning of severely impacted mandibular second molars. *J Am Dent Assoc.* 2003;134(11):1459-1462.
- [42] la Monaca G, Cristalli MP, Pranno N, Galluccio G, Annibali S, Pippi R. First and second permanent molars with failed or delayed eruption: Clinical and statistical analyses. *Am J Orthod Dentofac Orthop.* 2019;156(3): 355-364.
- [43] Pogrel MA. The surgical uprighting of mandibular second molars. *Am J Orthod Dentofacial Orthop.* 1995; 108(2):180-183.
- [44] Shipper G, Thomadakis G. Bone regeneration after surgical repositioning of impacted mandibular second molars: a case report. *Dent Traumatol.* 2003;19(2):109-114.
- [45] Boynton T, Lieblich SE. Surgical uprighting of second molars. *Atlas Oral Maxillofac Surg Clin North Am.* 2013;21(2):235-237.
- [46] Tsukiboshi M. Autotransplantation of teeth: requirements for predictable success. *Dent Traumatol.* 2002;18(4): 157-180.
- [47] Rohof ECM, Kerdijk W, Jansma J, Livas C, Ren Y. Autotransplantation of teeth with incomplete root formation: a systematic review and meta-analysis. *Clin Oral Investig.* 2018; 22(4): 1613-1624.
- [48] Zufia J, Abella F, Trebol I, Gomez-Meda R. Autotransplantation of Mandibular Third Molar with Buccal Cortical Plate to Replace Vertically Fractured Mandibular Second Molar: A Novel Technique. *J Endod.* 2017;43(9): 1574-1578.
- [49] Dessner S. Surgical uprighting of second molars: rationale and technique. *Oral Maxillofac Surg Clin North Am.* 2002;14(2):201-212.