Original Article

E-space preservation
Is there a relationship to mandibular second molar impaction?

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ABSTRACT
Objective: To determine the relationship of E-space preservation with lingual holding arches to mandibular permanent second molar impaction.
Methods: Two hundred consecutively treated patients undergoing nonextraction treatment for incisor crowding were entered into the study. Lower incisor crowding was assessed by the Little Irregularity Index. Treatment involved E-space preservation via a passive lingual arch placed prior to exfoliation of the second primary molar. Panoramic and cephalometric radiographs were analyzed for any significant relationship of mandibular permanent second molar impaction relative to molar angulation, spacing, growth pattern, and skeletal relationships.
Results: Twenty-nine patients had at least one impacted second molar (14.5%). Of a possible 400 mandibular second molars, 34 were determined to be impacted (8.5%). Only the mandibular first molar–second molar angulation was found to be significant ($P < .001$). Pretreatment intermolar angulation of 24 degrees had a positive predictive value of 1.
Conclusion: Impaction of permanent second mandibular molars in patients undergoing nonextraction via E-space preservation with a passive lingual arch is 10 to 20 times more prevalent than that observed in the general population. Risk of impaction is best predicted by the pretreatment intermolar angulation between first and second permanent mandibular molars. (*Angle Orthod.* 2011;81:1045–1049.)

KEY WORDS: E-space; Lower lingual holding arch; Second molar impaction

INTRODUCTION

Rebellato et al.[1] demonstrated the effectiveness of a lingual arch in preventing mesial migration of the first permanent molars, thus maintaining arch length through the transition from late mixed dentition to permanent dentition. Brennan and Gianelly[2] showed that significant crowding of mandibular incisors of up to almost 5 mm could be resolved through placement of a passive lower lingual holding arch. Debaets and Chiarini,[3] Dugoni et al.,[4] and Villalobos et al.[5] in separate studies all showed lower incisor crowding relief on the order of 2 to 4 mm with timely placement of a lower lingual holding arch in the transitional dentition. This technique of preservation of mandibular E-space to resolve mild to moderate crowding has gained popularity and has likely contributed to the decrease in the number of extraction cases over the past several decades. Surveys of orthodontic practitioners indicate that percentages of extraction cases have shown a steady decline from 35% in 1986 to 18% in 2008.[6] However, prevention of the so-called late mesial shift, as described by Baum, interferes with conversion of a flush terminal plane occlusion-to-Class I molar relationship and decreases the amount of posterior arch length available for the erupting second molar that is potentially contributing to its impaction.[7]

Several studies report that the prevalence of impacted second molars in the general population ranges from 0.2% to 2.3%.[8–12] Studies examining the impact of available space for mandibular third molar eruption have revealed a direct relationship between available space and likelihood of impaction.[13–16] The study of Årtun et al.[14] reported that maxillary third molar impaction could be predicted according to the size of the retromolar space and the amount of mesial molar movement that occurred following premolar extraction therapy. Investigators observed a 34% reduction in impaction for every millimeter of space

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created through mesialization of the molars. They also found a relationship between angulation of the third molar and likelihood of impaction. Mesial angulation of the third molar of 30 degrees relative to the occlusal plane resulted in a fivefold increase in impactions when compared with molars angulated 30 degrees distally. A similar study by Kim et al.[16] yielded similar results, namely, that premolar extractions resulting in mesialization of molars resulted in fewer cases of impacted third molars when compared with treatment through a nonextraction approach.

The aim of the present study was to examine the effect of mandibular E-space preservation on mandibular second molar impaction. The null hypothesis was that there is no difference in the prevalence of second molar impaction between patients treated with E-space preservation and historic controls of untreated patients. Additionally, we hypothesized that several variables, including second molar angulation, spacing, and third molar presence, may contribute to these eruption problems.

MATERIALS AND METHODS

Two hundred consecutively treated patients (121 females and 79 males) were entered into the study. Inclusion criteria included (1) a nonextraction treatment approach with E-space preservation utilizing passive lingual holding arches, (2) nonsyndromic, medically well children with no dental or craniofacial developmental anomalies, and (3) position of the occlusal plane of the mandibular second permanent molar below the cementoenamel junction of the adjacent mandibular first permanent molar. Mean age of subjects was 11.2 years, with a range of 9.9 to 11.9 years. All patients were in late mixed dentition with intact second primary mandibular molars and had a score of 6 or less on a computer-measured Little Incisor Irregularity Index.[17,18] All patients underwent nonextraction therapy, which included placement of a 0.036 stainless steel passive lingual arch prior to exfoliation of the second primary molars. Upon eruption of the second mandibular premolars, the lingual arch was removed and conventional fixed appliance therapy was initiated.

Digital panoramic and cephalometric radiographs (Orthophos XG, Sirona Dental Systems Inc, Long Island, NY) and digital study models were obtained before insertion of the passive lower lingual arch (T1). A second digital panoramic radiograph was obtained following completed passive eruption of any of the second permanent molars, or when an impacted second molar was observed clinically (T2).

Mandibular second molar impaction was defined as incomplete eruption when the distal cusps of the

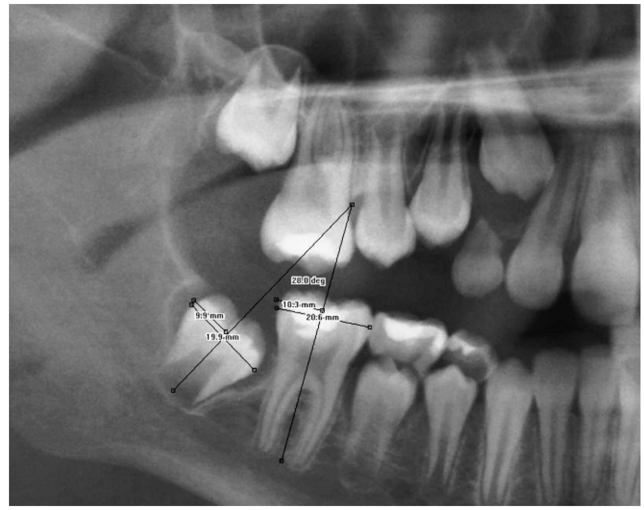

Figure 1. Construction of intermolar angle.

second molar were clinically visible and the mesial cusps were radiographically confirmed below the height of contour of the distal surface of the mandibular first molar.

Panoramic images were magnified 200% to facilitate analysis using diagnostic software. The angulation of all second mandibular molars was evaluated by constructing a computer-generated intermolar angle between the first and second molars using the long axis of each tooth by creating a right-angle line bisecting the mesial-distal dimension of the crown at its widest point (Figure 1) (Dolphin Imaging Version 11.0, Dolphin Imaging and Management Solutions, Chatsworth, Calif). The presence or absence of third molars and the amount of space between the mesial of the second molar and the distal of the first molar were recorded. Spacing was measured to the nearest 0.1 mm along a perpendicular line to the occlusal plane and tangent to the most mesial point on the second molar and the most distal point on the first molar (Figure 2). Subjects' growth patterns and skeletal relationships were determined by the pretreatment cephalogram and were classified as hypodivergent, normodivergent, or hyperdivergent based on the Frankfort horizontal-to-mandibular plane. Hypodivergent was defined as less than 22 degrees; normodivergert as $\geq$22 degrees and $\leq$28 degrees; and hyperdivergent as $>$28 degrees. Subjects' ANB angles were used to categorize their skeletal relationships as Class I (ANB $\geq$ 2 degrees but $<$ 4 degrees), Class II (ANB $\geq$ 4 degrees), or Class III (ANB $<$ 2 degrees).

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) for Windows, release 12.0.0 (SPSS Inc, Chicago, Ill). Logistic regression analyses were used to identify predictors of impaction. Initially, univariate logistic regression was used to test

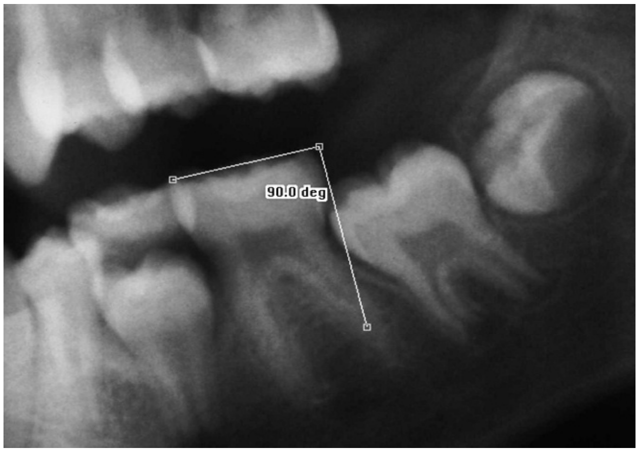

Figure 2. Example of negative space measurement.

for any associations between individual variables estimated at T1 and impaction (Table 1). This was followed by a stepwise multiple logistic regression to develop a prediction model for second molar impaction. Variables were successively entered into the model if their effects were significant at $P < .05$. At each step, the variable with the lowest P value was included, and previously entered variables with $P > .05$ were excluded. A single investigator made all measurements, and the reproducibility of the method was verified. To determine intraobserver concordance, 20 subjects were randomly selected from the sample and the measurements repeated after 2 weeks. Correlation analysis showed a mean r value of 0.99 ($P < .001$) for the intermolar angle measurement and a mean r value of 0.87 ($P < .001$) for space measurement between first and second molars.

RESULTS

Two hundred consecutively treated patients undergoing nonextraction therapy via E-space utilization for mild to moderate crowding were entered into the study (second molar, n = 400). Patients were evaluated for the prevalence of mandibular second molar impactions. Twenty-nine patients had at least one impacted second molar (14.5%). Twenty-four patients had unilateral impactions, and five were bilateral. Of a possible 400 teeth, 34 were classified as impacted (8.5%).

Table 1. Variables Used in Logistic Regression Analyses at T1 and T2 in 68 Subjects Treated With E-Space Preservation to Test Association With Impacted Mandibular Second Molars

Independent Variables	Time	Unit
Age	T1, T2	Years, months
Gender	T1, T2	Male/Female
Little Irregularity Index	T1, T2	Minimal (1–3), Moderate (4–6)
Angle SNA	T1	Degrees
Angle SNB	T1	Degrees
Angle ANB	T1	Degrees
Angle SN/MP	T1	Degrees
Intermolar angulation	T1, T2	Degrees
First molar/second molar spacing	T1, T2	Millimeters
Third molar	T!	Yes/No

Table 2. Relationship of Pretreatment Intermolar Angulation, Second Molar Spacing, Third Molar Presence, Facial Pattern, Skeletal Relationship, and Gender and Age to Second Molar Impaction[a]

Variable	
Intermolar angulation ($P < .001$)	Mean: 24.6 degrees Median: 22 degrees Range: 19 to 33 degrees
1st molar/2nd molar spacing*	Mean: 0.57 mm Median: 0.5 mm Range: −0.5 to 0.9 mm
Third molar presence*	Bilateral: 51% (n = 102), NS Unilateral: 15.5% (n = 31), NS
Facial pattern*	Normodivergent: 61% (n = 122) Hypodivergent: 29.5% (n = 59) Hyperdivergent: 9.5% (n = 19)
Skeletal relationship*	Class I: 68.5% (n = 137) Class II: 29.5% (n = 59) Class III: 2% (n = 4)
Gender*	Males: 79 Females: 121
Age*	Mean: 11.2 years Range: 9.9 to 11.9 years

[a] NS indicates not significant.
* Not statistically significant at $P \leq .05$.

Mandibular First Molar/Second Molar Angulation

Overall pretreatment intermolar angulation ranged from −4 degrees to 33 degrees with a mean of 14.5 degrees and a median of 10.5 degrees. Pretreatment intermolar angulation of impacted second molars ranged from 19 degrees to 33 degrees with a mean of 24.6 degrees and a median of 26 degrees (Table 2). A statistically significant relationship was found between pretreatment intermolar angulation and mandibular second molar impaction ($P < .001$). An intermolar angulation of 24 degrees resulted in a positive predictive value of 1.0 and a negative predictive value of 0.92. An intermolar angulation of 20 degrees resulted in the best sensitivity (94.12) and specificity (91.57).

Second Mandibular Molar Impaction and First Molar/Second Molar Spacing

Pretreatment spacing ranged from a minimum of −0.5 mm to a maximum of 0.9 mm with a mean of 0.57 mm and a median of 0.5 mm. No statistical significance was found between spacing and second molar impaction.

Third Molar Presence/Absence and Second Molar Impaction

One hundred two subjects had both mandibular third molars, and 31 had a single third molar. No statistical significance was found between third molar presence and second molar impaction.

Facial Pattern, Skeletal Relationship, and Second Molar Impaction

One-hundred twenty-two subjects were classified as normodivergent, 59 as hypodivergent, and 19 as hyperdivergent. No statistical significance was found between facial pattern and second molar impaction. One hundred thirty-seven patients were categorized as Class I, 59 as Class II, and 4 as Class III. No statistical difference was found between skeletal relationship and second molar impaction.

Age and Gender

No statistically significant differences were noted between ages or genders for all variables measured and second molar impaction.

DISCUSSION

Placement of a lingual arch has been demonstrated to be very effective in maintaining arch length through the transition from late mixed dentition to permanent dentition.[1–5] By preventing the so-called late mesial shift through preservation of the E-space, several millimeters of arch length can be gained to alleviate incisor irregularity and to potentially eliminate the need for premolar extractions. Although the popularity of this treatment approach is unreported, practice data would suggest that this treatment method should be adopted, as demonstrated by a downward trend in the percentage of extraction cases from 1986 to 2008, going from 35% to 18%.[6] Results of our study indicate that this treatment approach may adversely affect eruption of the mandibular second molar. Although not explored as part of this study, it is likely that any biomechanical approach that prevents mesialization of the first mandibular molar will produce similar results.

Patients in our study undergoing E-space preservation experienced a mandibular second molar impaction prevalence of 14.5% (29/200), with 34 out of a total of 400 mandibular second molars (8.5%) recorded as impacted. These findings suggest that this intervention significantly increases the chance of impaction of mandibular second molars compared with the reported prevalence of impacted second molars in the general population, which ranged from 0.2% to 2.3%.[8–12] Although we considered several variables, including facial pattern, skeletal relationship, spacing, and presence of third molars, as possibly contributing to impaction of the mandibular second molar, only the pretreatment intermolar angle was found to be a significant predictor of impaction.

Pretreatment intermolar angulation of 24 degrees proved to be a reliable predictor of impending impaction as demonstrated by a positive prediction value of 1; 20 degrees provided the best sensitivity and specificity. This slight discrepancy is likely the result of the relatively low prevalence of impaction.[19] The contribution of mesial inclination or angulation to mandibular second molar impaction has been examined by other authors in untreated subjects.[20] Evans,[20] besides noting this effect, cited crowding in the mandibular molar region as a contributing variable to impaction of the second molar. In a more contemporary study, Cho and Chu[21] found mesial angulations ranging from 14 degrees to 75 degrees in 31 of 32 impacted mandibular second permanent molars in an untreated Chinese sample population. The study by Tsai[22] would suggest that this angulation remains constant from crown calcification to root formation. Haavikko et al.[23] observed a similar relationship of angulation and impaction in studying mandibular third molars. An inverse relationship of the possibility of eruption of the mandibular third molar was observed as angulation increased beyond 20 degrees.

Although space between the first and second molars was found to have no significant contribution to impaction, studies examining mandibular third molar impactions suggest that anterior drift of the molars in premolar extraction cases creates space for the erupting third molar and improves its angulation.[24] Studies conducted by Kaplan[25] and Kim et al.[16] showed the occurrence of third molar impaction in nonextraction cases to be double that observed in extraction cases. Likewise, Behbehani et al.[15] reported premolar extractions resulting in a 63% reduction in third molar impaction. Although not specifically examined, several authors have suggested that impaction of second molars is usually associated with an arch length deficiency.[26,27] Placement of a passive lingual arch would negate any posterior space that would normally be available for the erupting second molar by blocking the mesial drift of the first permanent molar into the E-place.

The growth pattern and skeletal relationship findings are inconsistent with those of several previous studies. Although Brin et al.[28] found no association between skeletal relationship and the eruptive position of the second molar, Behbehani et al.[15] suggested that vertical condylar growth resulting in autorotation of the mandible contributes to a smaller gonial angle, leading to increased risk of third molar impaction.[28]

Magnusson and Kjellberg[12] reported on a patient series in which 166 second molars were impacted.

Seventy-eight teeth were associated with the presence of third molars, although it is not reported which arch was affected, or if there was any statistically significant relationship. However, the authors did note that crowding was associated with impaction of the second molars in 70% of patients. The authors did not report the location or the severity of the crowding. The results of our study show no relationship between the presence of third molars and impaction of the second molar.

The clinical implications of the findings of this study are significant. Simple placement of a passive appliance that interferes with the normal dentitional development process of mesialization of the mandibular first permanent molar is not done without risk. It is incumbent upon the clinician to inform the parent and the patient of the risks of what outwardly would appear to be a rather benign therapy. In terms of risk/benefit considerations related to nonextraction treatment, passive lingual arch therapy for space gain should be critically re-evaluated against alternative modalities of orthodontic treatment such as anterior arch expansion. This is particularly applicable if pretreatment angulations of the first and second molars approach higher levels of 24 degrees or more.

CONCLUSIONS

- Preservation of E-space with a passive lingual arch results in a significant increase in mandibular second permanent molar impaction when compared with historic controls.
- A mandibular first permanent mandibular molar–second permanent molar angulation of 24 degrees has a positive predictive value of 1, indicating that patients with this intermolar angulation or greater are at high risk of second molar impaction.

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