Surgical Uprighting Is a Successful Procedure for Management of Impacted Mandibular Second Molars

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Purpose: Impacted mandibular second molars can cause caries and root resorption on adjacent molars and can lengthen orthodontic treatment. Surgical uprighting is one management option. The purposes of this study were to *1)* evaluate radiographic outcomes for surgical uprighting of impacted mandibular second molars and *2)* propose an etiology for impaction.

Materials and Methods: This was a retrospective cohort study of patients who had surgical uprighting of mandibular second molars and had preoperative and at least 12-month postoperative panoramic images and an age- and gender-matched control group of patients undergoing routine orthodontic treatment. Predictor variables included age, gender, impaction type, preoperative angle of impaction, preoperative periodontal bone level distal to an adjacent first molar, posterior eruption space, pathology, and concomitant extraction of the adjacent third molar. Outcome variables were change in impaction type, postoperative periodontal bone levels around the first and second molars, postoperative tooth angle and posterior eruption space, periapical radiolucency, pulpal obliteration, root resorption, and need for extraction. Descriptive statistics were calculated.

Results: The sample and control groups each had 16 patients. The mean ages at the first radiographs were 13 $\pm$ 1.1 and 13.19 $\pm$ 0.61 years for the treatment and control groups, respectively, and the mean follow-up radiographs were obtained 2.4 $\pm$ 1.4 and 2.3 $\pm$ 0.82 years later. No preoperative images showed pathologic lesions obstructing eruption. Postoperatively, all uprighted molars were Pell and Gregory type IA. The mean change in the angles of the uprighted teeth was 23.5 $\pm$ 16.1° ($P < .001$). The mean distal bone levels of the adjacent first molar were 3.41 $\pm$ 1.52 mm preoperatively and 1.45 $\pm$ 0.54 mm postoperatively (improvement, 42.5%; $P < .001$). The preoperative posterior eruption space was 53.6% longer in the control than in the treatment group ($P < .001$), and the increase in this distance postoperatively was greater for the treatment group than for the control group ($P < .001$). Pulpal obliteration (n = 6; 31.5%), periapical radiolucency (n = 2; 10.5%), and root resorption (n = 1; 5.3%) were seen on postoperative radiographs. There were 2 failures (10.5%).

Conclusions: Surgical uprighting of mandibular second molars is a useful procedure with a low failure rate. Insufficient space for eruption is the likely primary etiology for impaction.

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Mandibular second molars become impacted in 0.03 to 0.65% of adolescents[1,2] and are usually detected at 11 to 13 years of age.[3] Second molar impactions occur most frequently in the mandible and tend to be unilateral, and the impacted teeth are typically mesially inclined.[4] Impacted second molars can cause caries and root resorption on adjacent molars and can be associated with prolonged orthodontic treatment.[1,2,5]

Proposed etiologies for these impactions include *1)* inadequate space for eruption; *2)* lack of guidance by the distal root of the first molar because of excessive distance between the first and second molars, possibly as a result of premature loss of a primary molar; *3)* lack of mesial movement of the permanent first molar because of ankylosis of a primary molar; and *4)* obstructed eruption because of pathology (eg, dentigerous cyst).[4-7]

Techniques for managing impacted second molars include orthodontic repositioning, surgical uprighting, and extraction with or without transplantation of the third molar into the extraction site.[3,7-9] Surgical uprighting has the advantage of immediate repositioning. Because of local trauma to the second molar that occurs during the procedure, there is a risk for loss of pulpal vitality and other complications. The current literature regarding outcomes of surgical uprighting is limited and consists mostly of case reports.

The purposes of this study were to *1)* evaluate radiographic outcomes for surgical uprighting of impacted mandibular second molars and *2)* to propose an etiology for second molar impaction. The authors hypothesized that surgical uprighting of mandibular second molars would be a successful technique with a low failure rate and that the most likely etiology of impaction is inadequate space for eruption. The specific aims were to document change in position and angulation of uprighted molars, to compare available space for second molar eruption between a series of patients with uprighted second molars and control patients with erupted second molars, and to assess the health of the repositioned teeth.

Materials and Methods

STUDY DESIGN AND SAMPLE

To address the research question, the authors implemented a retrospective cohort study of patients who had surgical uprighting of mandibular second molars and matched controls who had erupted mandibular second molars. This study was approved by the institutional review board of the committee on clinical investigation at Boston Children's Hospital (Boston, MA; protocol number P00007281).

The treatment group was composed of patients who had at least 1 impacted mandibular second molar surgically uprighted from 2003 through 2015 at the Department of Plastic and Oral Surgery at Boston Children's Hospital. To be included in the study sample, patients had to have preoperative (T0) and at least 12-month postoperative (T1) panoramic radiographs. The T1 radiographs were taken at the end of orthodontic treatment or for evaluation of third molars. Patients were excluded if they did not have adequate radiographs. An age- and gender-matched control group included patients from the Department of Dentistry at Boston Children's Hospital with erupted and normally positioned mandibular second molars who had panoramic radiographs at the same ages as the treatment group (T0 and T1) as part of routine clinical care, such as for the evaluation of dental eruption and timing for orthodontic treatment.

SURGICAL TECHNIQUE

After adequate anesthesia, a mucoperiosteal flap was elevated distal to the first molar. Ostectomy was performed as necessary with a surgical drill to expose the second molar, and soft tissue around the crown was debrided. A dental elevator was used to apply distal and occlusal pressure to the tooth until the mesial marginal ridge of the second molar was at the same level as the distal marginal ridge of the adjacent first molar. If the second molar could not be adequately uprighted to this position, then the third molar was removed using a standard technique and the second molar uprighting procedure was reattempted. If the second molar was successfully uprighted without removal of the third molar, then the third molar was left in place. The wound was irrigated and closed with 3-0 chromic gut suture. If necessary for added stability, then an orthodontic attachment was bonded to the facial surfaces of the uprighted second molar and the adjacent first molar (if the patient had no orthodontic appliances), and a 28-gauge ligature wire was tied in a figure-of-8 around the 2 attachments. The patient was instructed to avoid bite forces to the uprighted tooth for 2 weeks.

VARIABLES

Predictor variables included age, gender, type of impaction (as defined by the classification of Pell and Gregory[10]), preoperative angle of the long axis of the impacted tooth, preoperative periodontal bone level distal to the adjacent first molar, preoperative "posterior eruption space" defined as the horizontal distance from the distal contact point of the first molar to the most inferior point on the ascending ramus, presence of pathology in the path of eruption, and

concomitant extraction of the adjacent third molar. The primary outcome variable was success or failure of the procedure, with failure defined as need for extraction of the repositioned tooth during the follow-up period. Secondary outcome variables included change in the Pell and Gregory classification, postoperative long axis angle, postoperative periodontal bone levels on the distal aspect of the adjacent first molar and on the mesial and distal aspects of the second molar, postoperative posterior eruption space, presence of periapical radiolucency, pulpal obliteration, or root resorption.

DATA COLLECTION METHODS

Radiographic evaluation was performed using Dolphin Imaging 11.8 (Dolphin Imaging and Management solutions, Chatsworth, CA). The ruler tool was calibrated between images from the same patient using the unchanged landmark of distance between the distal contact points of the maxillary first molar tooth on each side. The 3-point angle tool was used to determine the angle formed by the long axis of the impacted second molar and the mandibular occlusal plane. The distance from the distal contact point of the mandibular first molar to the most inferior point on the ascending ramus (posterior eruption space) was calculated on each radiograph (Fig 1). To minimize error from panoramic image distortion, relative rather than absolute distance measurements were used for evaluation of posterior eruption space. For periodontal bone height measurements, an average mandibular first molar mesiodistal width of 11 mm was used for the ruler calibration,[11] and this calibration was performed on each image before measurement. The distance from the cementoenamel junction of the tooth to the crest of the alveolar bone ("periodontal bone height") was measured on the distal aspect of the first molar on the side of the uprighting procedure on all pre- and postoperative radiographs and on the mesial and distal aspects of the uprighted second molar on postoperative images[12] (Fig 2).

The preoperative images were assessed for pathology coronal to the impacted second molar teeth. The postoperative images were evaluated for periapical radiolucency that was not present preoperatively, internal or external root resorption, and a decrease in size of the pulp chamber ("pulpal obliteration").

DATA ANALYSIS

Descriptive statistics were computed. The Wilcoxon signed rank test was used to test differences between preoperative and postoperative values and groups. An independent-sample t test was used to compare the effect of concomitant mandibular third molar extraction on the change in the posterior eruption space. The χ^2 test of independence was used to test the association between success versus failure and the categorical predictor variables and logistic regression was used to test this association with continuous predictor variables. All analyses were performed using SPSS Statistics 23.0. (IBM Corp, Armonk, NY) and significance was set at a P value less than .05.

Results

STUDY SAMPLE

Ninety-seven patients underwent surgical uprighting of impacted mandibular second molars during the study period. Most were excluded because they did not have T0 and T1 panoramic radiographs. The final treatment group included 16 patients (68.7% female) with 19 uprighted second molars. The mean age at the time of the procedure (T0) was 13 ± 1.1 years (range, 11 to 15.2 yr) and the average follow-up radiograph (T1) was obtained

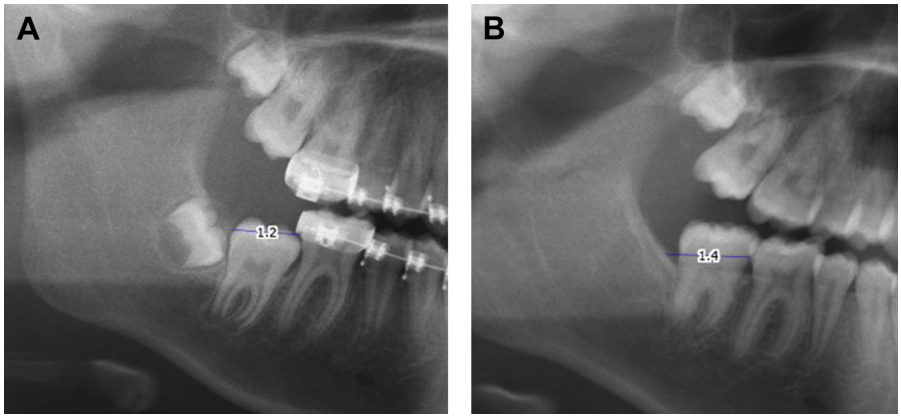

FIGURE 1. *A*, Posterior eruption space, measured from the distal contact point of the first molar to the most inferior point on the ascending ramus, on a preoperative image. *B*, Postoperative radiograph of the same patient.

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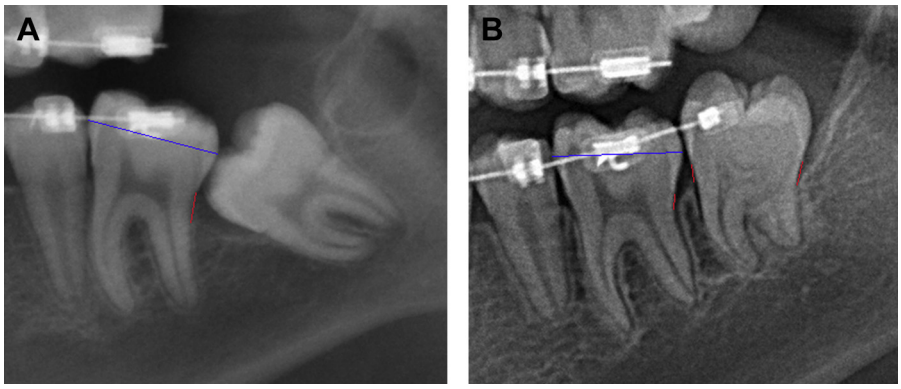

FIGURE 2. Ruler calibration (*blue lines*) and periodontal bone level measurements (*red lines*) on *A*, preoperative and *B*, postoperative radiographs from the same patient.

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2.4 ± 1.4 years later (range, 12 months to 5 yr). The adjacent third molar was removed in 50% of cases. No preoperative images showed pathologic lesions in the path of eruption of the second molar, and no lesions were identified intraoperatively.

The control group included 16 patients (75% female) with a mean age at the time of the first radiograph (T0) of 13.2 ± 0.6 years (range, 12 to 14.5 yr). The subsequent radiograph (T1) obtained was at an average follow-up of 2.3 ± 0.8 years (range, 1.1 to 3.7 yr). There were no statistically relevant differences in gender, age, or follow-up time between the 2 groups.

TYPE AND ANGLE OF IMPACTION

For the treatment group, the distribution of impactions at T0, based on the Pell and Gregory classification, was type IA (n = 5; 26.4%), type IB (n = 9; 47.3%), type IC (n = 1; 5.3%), type IIB (n = 3; 15.7%), and type IIC (n = 1; 5.3%). At T1, all uprighted molars were type IA. The mean angle of the long axis of the impacted tooth to the occlusal plane was 122.6 ± 34.9° at T0 and 100.3 ± 20.1 at T1 (mean change, 22.3 ± 16.1°; $P < .001$; Fig 3).

PERIODONTAL BONE HEIGHT

For the treatment group, the mean distal periodontal bone height on the adjacent first molar was 3.41 ± 1.52 mm at T0 and 1.45 ± 0.54 mm at T1 (improvement, 42.5%; $P = .001$). The mean T1 mesial and distal bone levels on the uprighted second molar were 1.32 ± 0.54 mm and 1.21 ± 0.40 mm, respectively. Before uprighting, 11 (57.9%) adjacent first molars had periodontal bone levels more than 3 mm inferior to the cementoenamel junction. At latest follow-up, none of the periodontal bone levels on the first or second molar were greater than 3 mm.

POSTERIOR ERUPTION SPACE

The distance from the distal contact point of the first molar to the ascending ramus was 53.6% longer in the control group than in the treatment group at T0 ($P < .001$). From T0 to T1, this distance increased by 27.7% in the treatment group ($P < .001$) and by 11.9% in the control group ($P = .03$), and these changes were significantly different between groups ($P < .001$). There was no significant difference in this distance between those who did and those did not have simultaneous extraction of the adjacent third molar ($P = .497$).

POSTOPERATIVE FINDINGS

Pulpal obliteration, periapical radiolucency, and root resorption were seen in 31.6% (n = 6; Fig 4), 10.5% (n = 2; Fig 5), and 5.3% (n = 1; Fig 6) of repositioned teeth, respectively. Two teeth (10.5%) required extraction during the follow-up period, one because the uprighted tooth subsequently became submerged and the other because of asymptomatic internal root resorption with periapical pathology noted radiographically (Fig 7). No patients presented with pain or infection during the follow-up period.

ASSOCIATIONS BETWEEN VARIABLES

There were no statistically relevant associations between the predictor variables and the primary outcome variable (success vs failure; Table 1).

Discussion

The purpose of this study was to present a series of patients who underwent surgical uprighting of an impacted mandibular second molar to evaluate treatment outcomes and propose an etiologic mechanism for failure of eruption. The authors hypothesized that surgical uprighting would be a successful technique with a low failure rate, and that patients with impacted

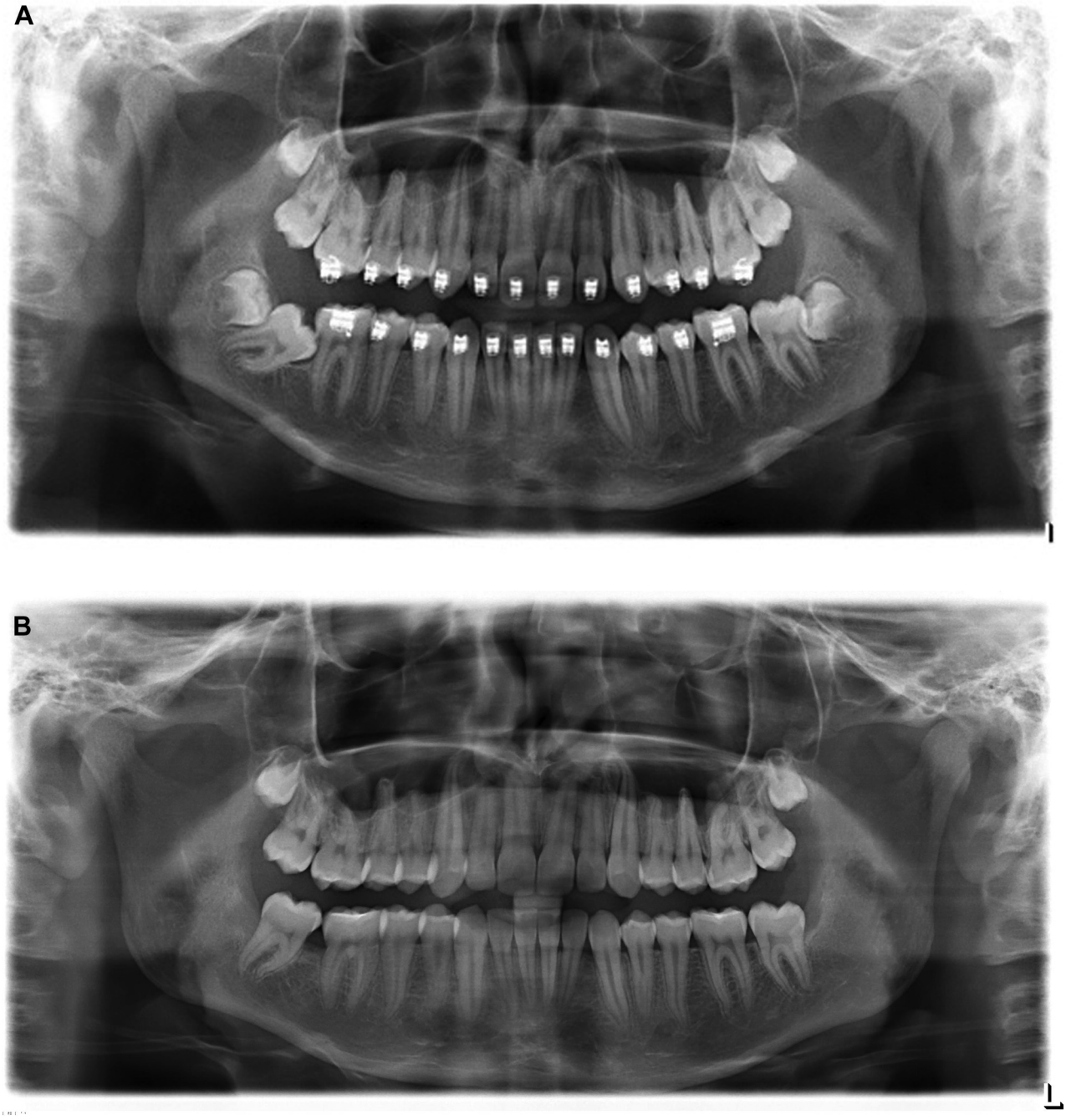

FIGURE 3. *A*, Preoperative and *B*, postoperative panoramic radiographs of a successfully uprighted mandibular right second molar.

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second molars would have less available posterior eruption space compared with patients with erupted second molars. The specific aims were to document radiographic outcomes of uprighted second molars and to compare the posterior eruption space between the treatment and control groups.

In this series, all surgically uprighted second molars were successfully moved to a vertical position. All periodontal defects on the distal aspect of the first molar that were present before uprighting of the adjacent second molar resolved after the procedure, and no new periodontal defects developed. The rate of abnormal postoperative radiographic findings was 47.3%, but no patient developed pain, swelling, or other symptoms during the mean follow-up period of 2.4 years. Two (10.5%) uprighted teeth, which were asymptomatic, were ultimately extracted because of malposition or radiographic abnormalities.

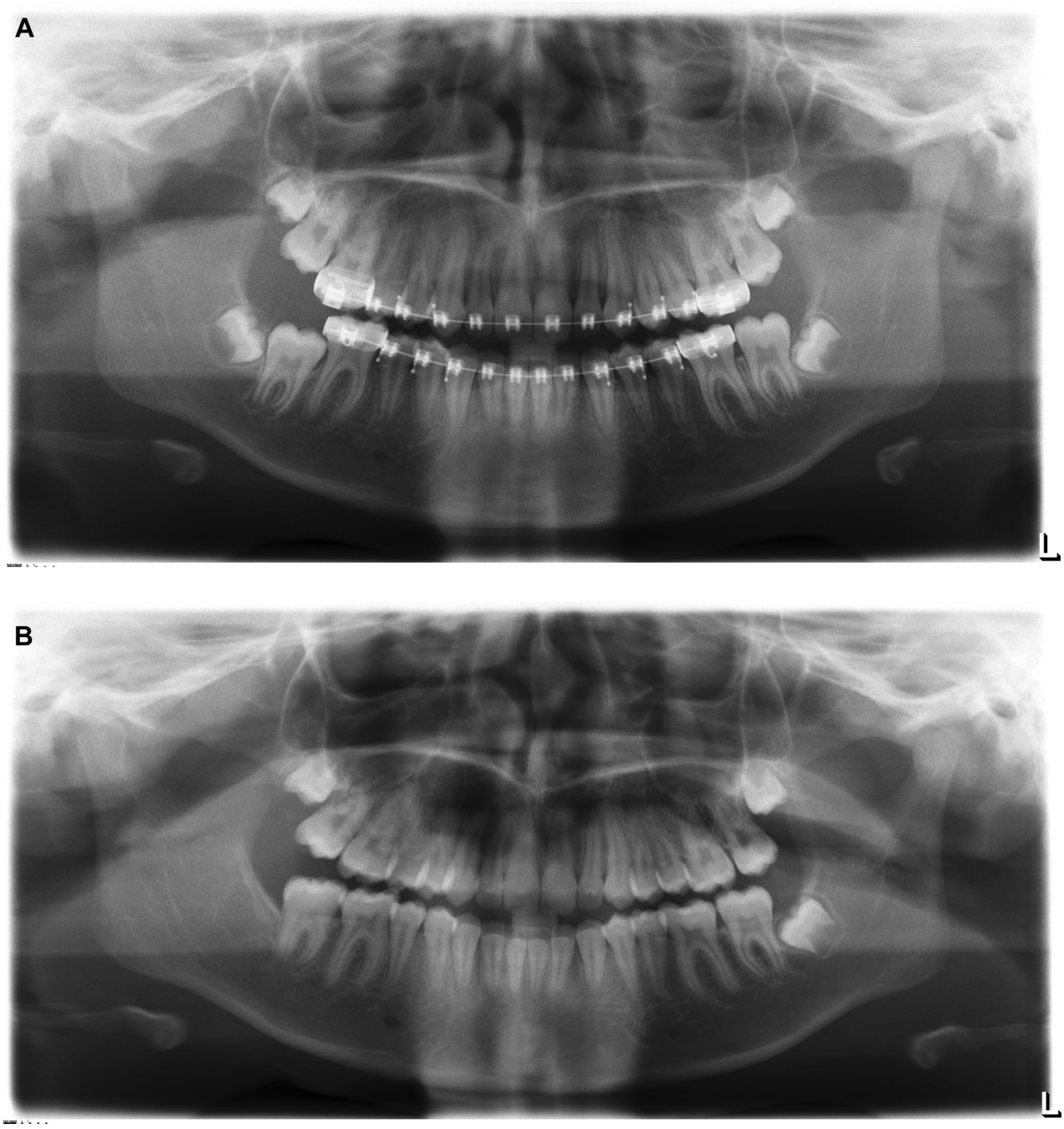

FIGURE 4. *A*, The impacted right mandibular second molar showed *B*, asymptomatic pulpal obliteration after surgical uprighting.

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These results are consistent with published failure rates ranging from 0 to 4.5%.[3,5,7,8,13] In a series of 22 surgically uprighted second molars by Pogrel,[3] 36.4% developed pulpal calcification and were nonvital on electric pulp testing postoperatively. None of these teeth were symptomatic. These and the present findings suggest that radiographic pulpal changes are not predictive of clinical failure.[3,9,14-16]

The available posterior eruption space at T0 was considerably smaller in the treatment group than in the control group in this series. This suggests lack of space for the second molar in the dental arch as an etiology for failed eruption. Although pathology in the path of eruption is another likely etiology for some cases, this was not seen in the present series.

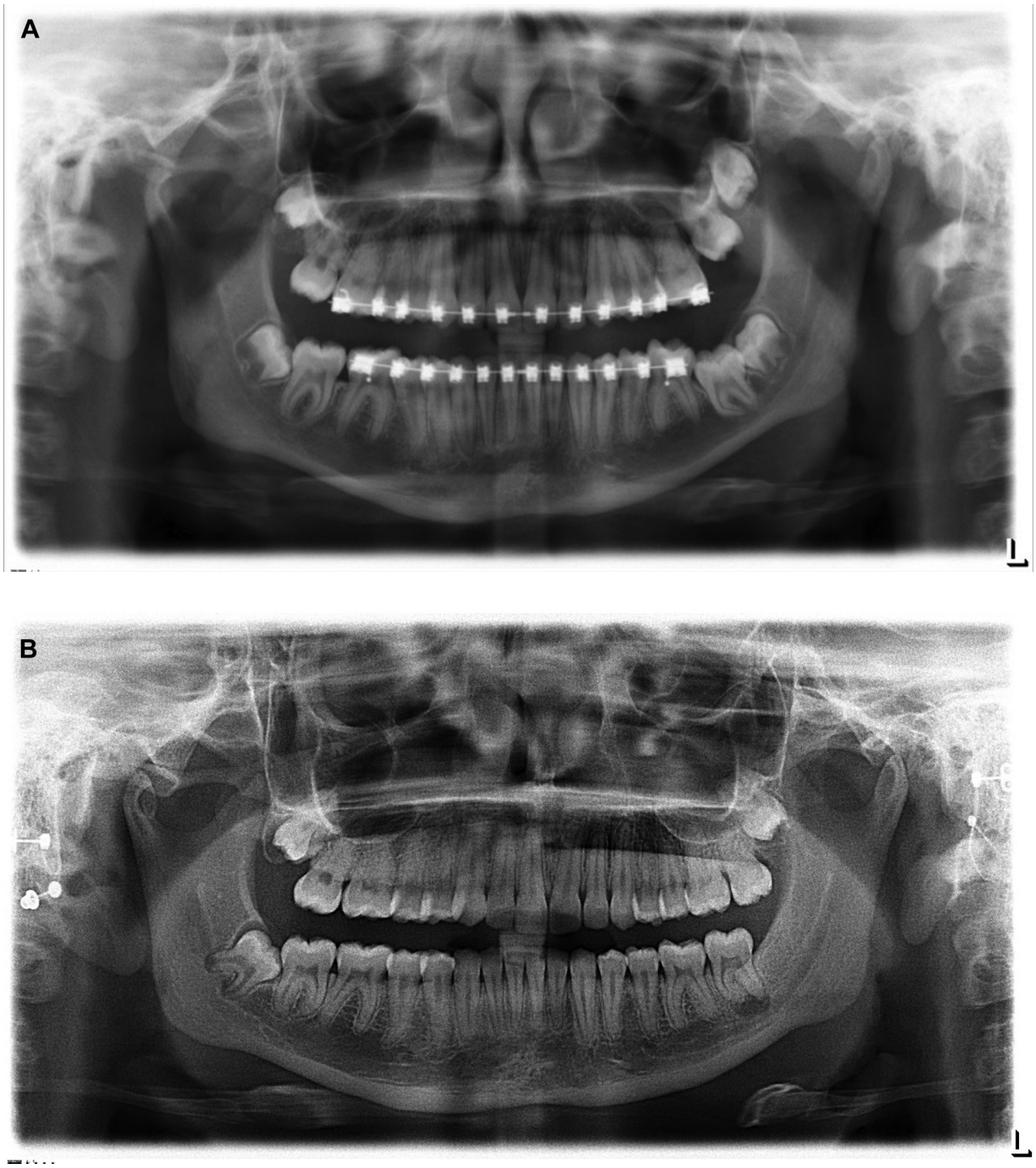

FIGURE 5. *A*, The impacted left mandibular second molar showed *B*, asymptomatic periapical radiolucency after surgical uprighting.

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The posterior eruption space increased from T0 to T1 in the 2 groups. Some of this change could be attributed to normal growth, and average increases in posterior mandibular space because of growth from 13 to 18 years of age have been reported to range from 4 to 5.79 mm.[17,18] However, the increase in posterior eruption space in the present sample was considerably greater in the treatment group than in the control group. Although the surgical procedure might have had some immeasurable influence on mandibular growth, the most likely explanation for this difference is the remodeling

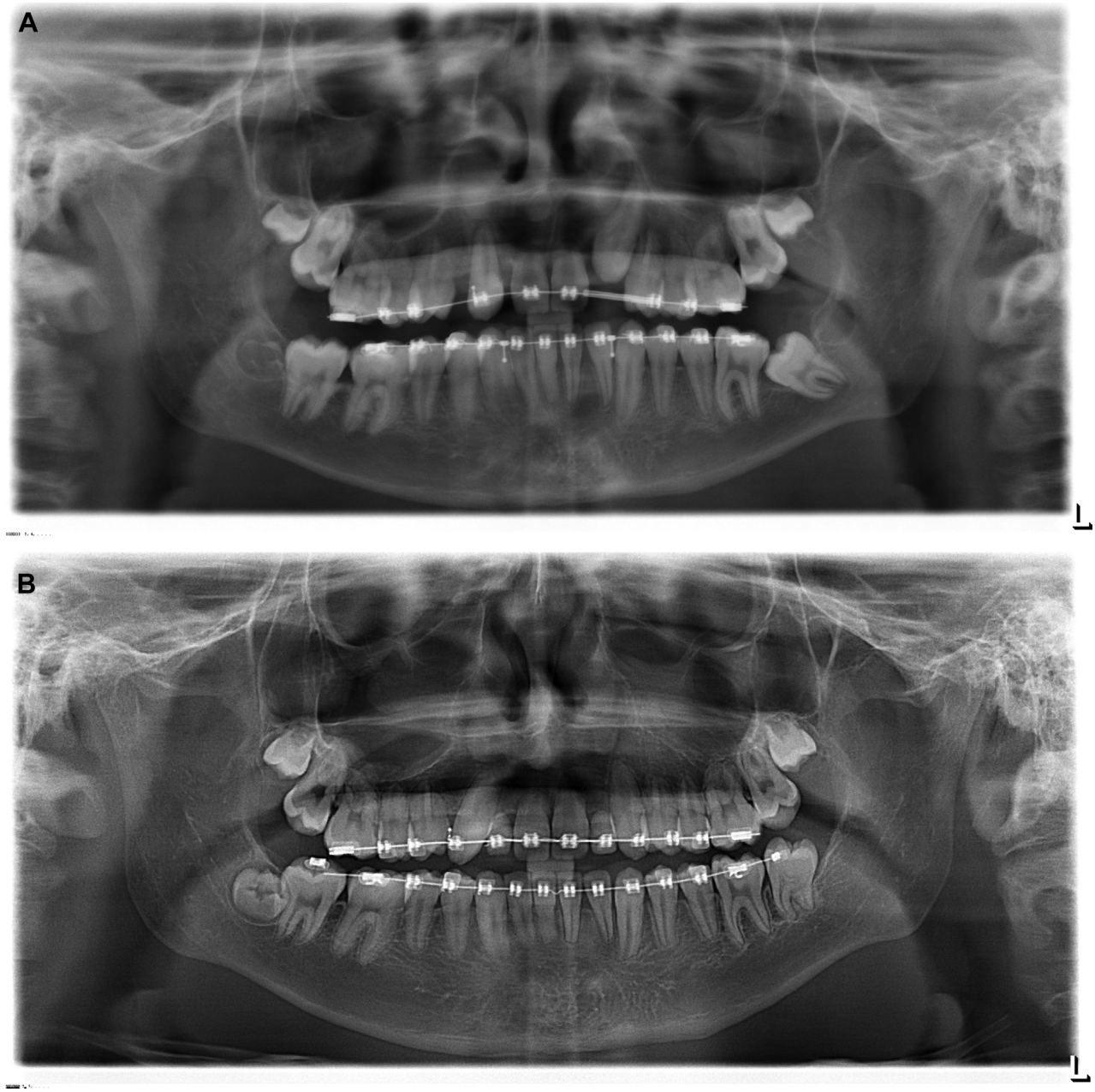

FIGURE 6. *A*, The impacted left mandibular second molar showed *B*, asymptomatic root resorption after surgical uprighting.

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associated with the uprighting procedure rather than growth.

Several investigators have advocated for removal of the adjacent third molar at the time of second molar uprighting.[3,5,13] In the present series, the third molar was removed only if it was an impediment to uprighting of the second molar, and this happened in 50% of cases. The authors prefer to maintain the third molar when possible because the presence of this tooth often creates a wedge effect against the second molar to improve the immediate postoperative stability of the uprighted position, and the third molar can be used as a future replacement if the second molar ultimately requires extraction. The maintenance or removal of the third molar had no relevant impact on the posterior eruption space in this sample.

This study has several limitations. First, the retrospective study design and small sample limit the conclusions that can be drawn. Second, all measurements were made on panoramic radiographs, which are prone to image distortions and magnification. These inaccuracies were minimized by using relative rather than absolute measurements and by calibrating

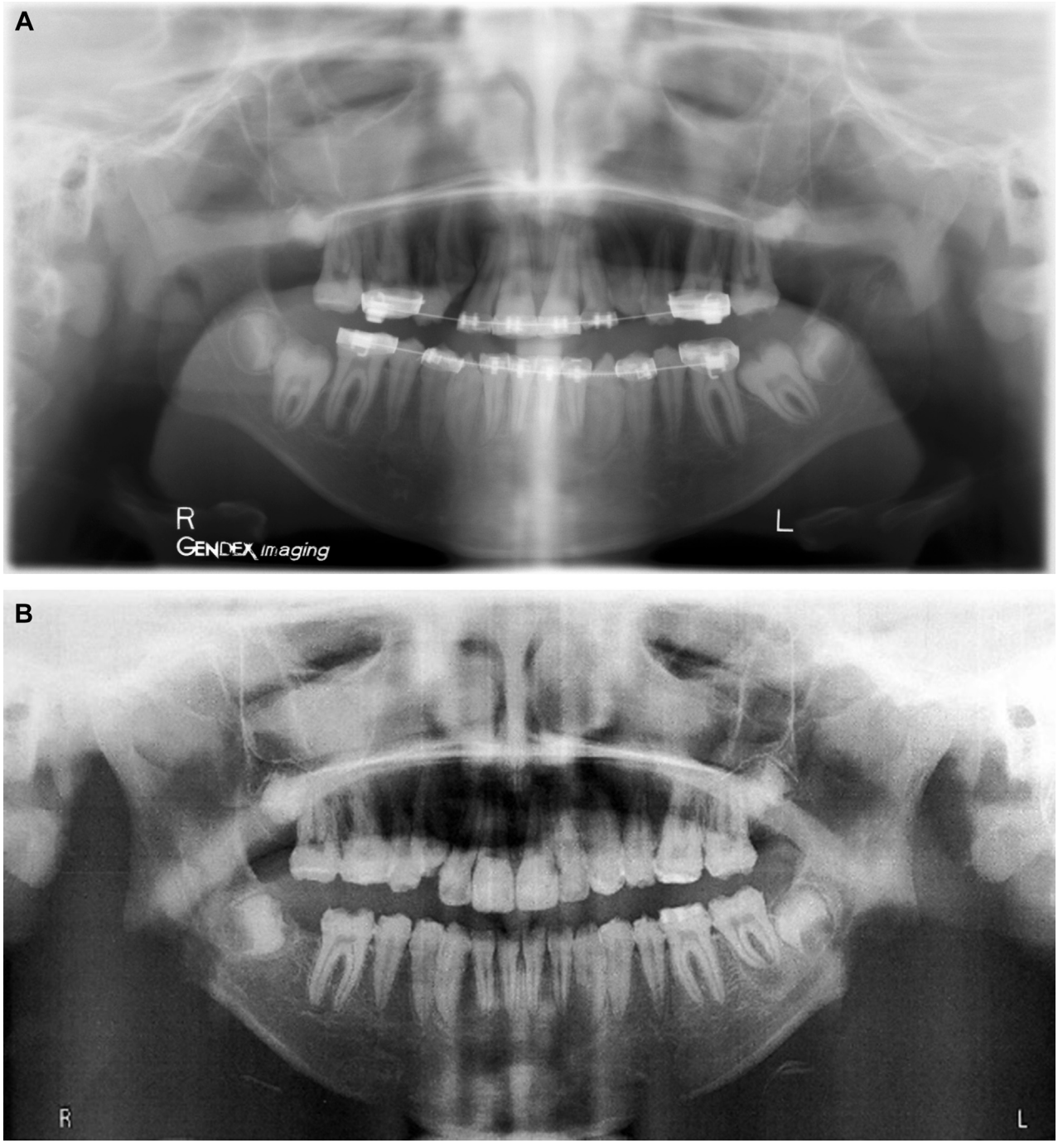

FIGURE 7. *A,* Preoperative and *B,* postoperative radiographs of a surgically uprighted left mandibular second molar that was ultimately extracted because of asymptomatic internal root resorption with periapical radiolucency.

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measurement tools for each patient using unchanged landmarks. Because of a lack of postoperative clinical evaluation, pulpal and oral health could be evaluated only radiographically.

In conclusion, surgical uprighting of mandibular second molars is a useful procedure that, despite a high rate of postoperative radiographic abnormalities, has a low failure rate. Insufficient space for eruption is likely the primary etiology for impaction. The authors will continue to follow these patients to monitor for additional complications in the longer term.

Table 1. EVALUATION OF THE ASSOCIATIONS OF PREDICTOR VARIABLES AND THE PRIMARY OUTCOME VARIABLE (SUCCESS VS FAILURE) IN THE TREATMENT GROUP

Variable	*P* Value
Age	.787
Gender	.371
Impaction type	1.000
Preoperative angle of impaction	.725
Preoperative bone level distal to first molar	.794
Posterior eruption space	.662
Concomitant extraction of adjacent third molar	.175

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