The Root Length Changes after Protraction of Mandibular Molars Combined with Corticotomy Assisted by Bone Grafting: 5 Year CBCT Follow-Up

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Abstract

The aim of this study was to determine root length changes following mandibular second molar protraction into a first molar space after corticotomy and bone grafting. The protraction of mandibular second molars into atrophic edentulous spaces were conducted in 16 patients with a mean age at initial treatment of 25.69 years old. The corticotomy and bone grafting were completed before second molar tooth movement. The root length changes of the mesial root of the mandibular second molar were measured by cone beam computed tomography (CBCT) at initial treatment (T0), 3 months after space closure (T1), and 5 years post-treatment (T2). The paired t-test was used to analyze the mean difference between time points. The root length significantly decreased at all time points. Average root resorption at T0 to T1, T1 to T2, and T0 to T2 were 0.16, 0.67 and 0.84 mm, respectively. In conclusion, there was minor root length loss after molar protraction into an atrophic edentulous space after a corticotomy and bone grafting. Root resorption after the 5 years follow-up period was statistically higher than the protraction period.

Keywords: *Molar protraction/ Root resorption/ Corticotomy/ CBCT*

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Introduction

Mandibular first molars are the first permanent teeth that erupt into the oral cavity when a child is six years of age. These molars are most frequently lost.[1-5] Edentulous areas of missing permanent molars can cause tipping or migration of adjacent teeth, and supra-eruption of opposing teeth, which bring about malocclusion and considerable periodontal problems.[6,7] After extraction, bucco-lingual narrowing of the alveolar bone is normally noticed.[8]

Aside from regular prosthesis treatment, the closure of the edentulous space by a second molar protraction is an alternative treatment option, which eliminates prosthetic restoration and can preserve alveolar bone. Closing edentulous spaces in the mandibular posterior region is a major challenge. Successful outcomes are difficult to achieve. Early removal of the mandibular first molar results in both vertical and horizontal changes of alveolar bone ridge dimension, so protracting the second molar is hardly possible because of complications. The possibility of complications such as root resorption and periodontal defects also increases with the age of the patient and the amount of space to be closed. Some investigators have even asserted that such spaces should not be closed.[9,10] A longer treatment time is another weak point of this method. Treatment duration for closing the first molar space by protracted second molars ranges from 2 to 4 years depending on bone density, bone turnover rate, and hyalinization of the periodontal ligament (PDL).[10-12] The longer the treatment duration, the more molar protraction leads to periodontal problems and high risk of root resorption.

Apical root resorption is a common unpredictable problem associated with orthodontic treatment. Root resorption induced by orthodontic tooth movement is part of the hyaline zone removal process.[13] Duration of orthodontic treatment is considered an aggravating factor that induces

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root resorption. The longer the treatment duration, the greater chances of root resorption.[14,15] Root resorption is considered as clinically important when 1-2 mm (1/4) of the root length is lost.[16]

Corticotomy with bone augmentation is the method provided for accelerating tooth movement. [17-19] Bone grafting has been offered to increase alveolar bone volume, prevent dehiscence and fenestration, and increase the metabolic response during tooth movement.[18,20] The injury from bone decortication decreases alveolar bone density (osteopenia) and thereby reduces the resistance of tooth movement.[21] Moreover, corticotomy can enhance the remodeling of hard and soft tissue to help fasten tooth movement via the regional acceleratory phenomenon (RAP).[22] No excessive pressure in the PDL occurs due to lower cortical resistance, transient osteopenia, increased local tissue turnover, and increased angiogenesis resulting in less hyalinization of the PDL.[21,23] When the hyalinization decreases, the root resorption decreases as well.[11]

As mentioned above, a corticotomy with bone grafting results in an increase in alveolar bone width, reduces treatment time, and decreases risk of root resorption.[17-23] This method is useful for patients with mandibular first molar loss as they have bone deficiency and a longer space for second molar movement. Therefore, the purpose of this study was to evaluate long-term root length changes from cone beam computed tomography (CBCT) images after a corticotomy with bone grafting for second molar protraction to close the edentulous space left by first molar extraction cases.

Materials and Methods

This retrospective study was approved by the Prince of Songkla University Faculty of Dentistry, Ethics committee (EC6107-XX-P-LR). Sixteen patients had their permanent mandibular first molar extracted, of whom fourteen were females and two were males (the mean age at initial treatment was 25.69±5.49 years). From CBCT, the bucco-lingual width of medullary bone in that area was less than the bucco-lingual width of the cervical one-third of the mesial root of the mandibular second molar at the same site. In all samples, the mandibular first molar spaces were closed by second molar protraction every 2 weeks after a corticotomy and bone grafting (the allograft was mixed with a cortical autograft). The molar protraction was performed by a segmented loop mechanic with 200 grams of force (Figure 1). Mean mandibular second molar movement was 5.09±1.76 mm with a range of 3-7.5 mm. The protraction period was 7.69±5.02 months. A CBCT (80 kV, 5 mA, 0.125 mm voxel resolution, and 60 x 60 mm field of view; J Morita MPG, Kyoto, Japan) was taken at initial treatment (T0), 3 months after space closure (T1), and 5 years post-treatment (T2).

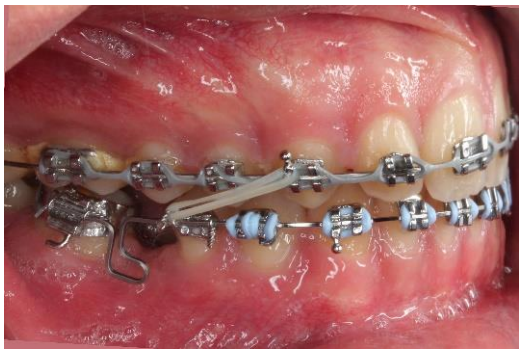

Figure 1 A segmented loop mechanic was used by the 0.017"x0.025" TMA to the mandibular second molar protraction.

Each CBCT was converted into (DICOM) Digital Imaging and Communications in Medicine files and processed by One Volume Viewer Imaging software. The three-dimensional position of the tooth was modified following Feiner's technique.[24] The axial slice was constructed in coordination within the dental arch. The other planes were automatically reconstructed. For accurate positioning, the buccal and lingual points of the cementoenamel junction (CEJ) of the mesial root of the second molar in the coronal plane, and the mesial and distal points of the CEJ in the sagittal plane were connected. The root length was measured at the mesial root of the second molar along the axis of the root, perpendicular to an imaginary line between the buccal and lingual of the CEJ to the apex of the tooth roots in the coronal view (Figure 2).

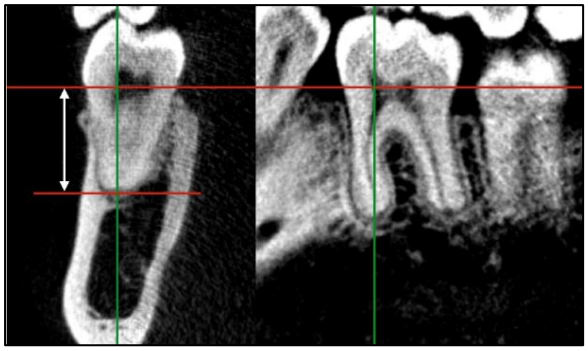

Figure 2 The root length was measured in the coronal view of the mesial root of the mandibular second molar from the CEJ to the apex of the tooth root (white arrow line).

CBCT measurements were measured twice by the same investigator after 4 weeks. Intraclass correlation coefficients were reconducted for repeated assessment to examine intraexaminer reliability. Method errors were calculated by using the Dahlberg formula. The paired t-test was used to analyzed the root length data at T1-T0, T2-T1, and T2-T0 of CBCT data at an alpha significance level of 0.05.

Results

The sixteen CBCT records were remeasured by the same investigator. The intraclass correlation coefficient was greater than 0.9. Consequently, the method was found to have excellent reliability. Dahlberg's formula was 0.05 mm for the distance.

The root length significantly decreased after protraction and after 5 years post-treatment, with an average of 0.16 mm (1.29%) and 0.67 mm (5.08%), respectively. The overall root length loss was an average of 0.84 mm (6.31%) from T0 to T2 (Table 1). From T0 to T1, all molars had a root resorption of less than 1 mm. From T1 to T2, 75% of molars had root resorption of less than 1 mm. From the total of T0 to T2, 68.75% had less than 1 mm root resorption and none of the molars had more than 2 mm resorption.

Table 1 The root length changes from CBCT data at initial treatment (T0), 3 months after space closure (T1), and 5 years post-treatment (T2).

	T0	T1	T2	T1-T0	p-value	T2-T1	p-value	T2-T0	p-value
				Root length mm (%)					
Mean	13.36	13.20	12.52	-0.16 (-1.29)		-0.67 (-5.08)		-0.84 (-6.31)	
SD	1.33	1.43	1.43	0.22 (1.83)	0.00**	0.55 (4)	0.00**	0.60 (4.53)	0.00**

** indicates statistical significance at $p<0.01$

Discussion

Long and atrophic edentulous spaces at the mandibular first molar pose a challenge for orthodontists as to whether or not to move the second molar tooth into the limited bone condition space. Some orthodontists believe that space closure of the edentulous molar area is impossible or undesirable with limited orthodontic movement. For instance, Graber stated that movement of posterior teeth is often difficult because of the large root surface area, the high tissue resistance, and the anchorage needs involved.[25] Other studies found that the mandibular first molar space cannot be completely closed by protraction of the mandibular second molar. Stepovich attempted to close first molar edentulous spaces in 8 adult patients but completed only 3, while all 8 spaces in the young adult group were closed.[9] Hom's study reported that only 5 from 19 quadrant molar spaces were completely closed.[10] Goldberge and Turley reported that from 20 quadrants, there was averaged 1 mm left in 9 quadrants.[26] In this study, all spaces in 16 quadrants were completely closed when applying corticotomy and bone grafting before protraction, and by using a segmented loop mechanic to move the second molar in adult patients. The corticotomy creates an osteoporosis stage in the alveolar bone and stimulates the

RAP process.[18] During the RAP, alveolar bone in that area is softened by a burst of cell activity and so then moving a large anatomical tooth through the softened area is not complicated.

Previous studies evaluated the root length changes from periapical radiographs, while this study measured it from a more precise CBCT procedure.[27,28] From systematic reviews, the CBCT is a more reliable tool to detect external root resorption than periapical radiographs.[28]

Root resorption is a condition occurring after the hyalinization phase of orthodontic tooth movement because hyalinization causes osteoclast activity in order to eradicate the necrotic tissue and also the normal root structure nearby the hyalinization zone.[29,30] It is considered as clinically important when 1-2 mm (1/4) of the root length is lost.[31] The posterior teeth present a low incidence of root resorption because of the small movement distance during regular orthodontic treatment.[32] However, protraction of the molar is different because the large distance required of molar tooth movement means there is a chance of losing the root structure.[33] Injury to the cortical bone by corticotomy induced the RAP response, which enhanced bone turnover and reduced bone density (transient osteopenia).[22] The resistance of bone is reduced during tooth movement. When there is tooth movement through the corticotomy area, the occurrence of hyalinization decreases, leading to less root resorption.[11,34] After corticotomy and bone grafting, an immediate heavy orthodontic force can be applied to take full advantage from the RAP effect.[35] In contrast to conventional treatment, the heavy force with corticotomy increased tooth movement without increasing the amount of root resorption.[36] In this study, using 200 grams of force following the previous study,[37] the mean root length significantly decreased by 0.16±0.22 mm at 3 months after the protraction was completed. However, this result was less than that reported by Stepovich,[9] Hom,[10] and Kim,[38] which presented that the average root resorption of mandibular molars after protraction without corticotomy was 0.38, 1.3, and 0.8 mm, respectively.

Minor apical root resorption is a common consequence of orthodontic tooth movement.[39] The data from Sameshima and Sinclair's study was supported this claim reporting that the root resorption of lower molars during regular orthodontic treatment was an average 0.42±1.22 mm.[32] In this study, the root length at T1 and T2, which was measured between 3 months after space closure and 5 years post-treatment, was reduced by 0.67 mm. Accordingly, root resorption possibly occurred due to common orthodontic tooth movement since there was orthodontic adjustment in the finishing phase after molar space closure. The effect of RAP begins within 1-3 days after injury and rises to peak at 1-2 months, and it can persist up to 6 to 24 months.[22] This result may indicate that during protraction with the RAP effect from corticotomy, the resorption of the root length was slowed down. In the author's opinion, after the effect of RAP gradually decreased, the root length can be lost following orthodontic tooth movement.

The amount of tooth movement is the one of many factors that related to root resorption.[40,41] Long distance of tooth movement causes more hyalinized tissue to be removed.[38] Kim stated that the small amount of root resorption in the mandibular molar protraction resulted from tooth movement through the trabecular bone during protraction.[38] Hence, local osteopenia situation within trabecular bone created by RAP response after corticotomy was occurred and promoted the soften trabecular bone, resulting in the fasten tooth movement. This situation also reduced hyalinization process leading to root resorption reduction.

The longer treatment time was significantly associated with increased root resorption.[14-15] A previous study reported the rate of molar movement using skeletal anchorage was 0.33 mm/months.[42] In this study, protraction period was 7.69±5.02 months (average 0.67 mm/months). Reducing treatment duration by corticotomy may be advantageous to reduce the risk of root resorption.[43] However, molar protraction increased the total treatment time than conventional treatment. Therefore, orthodontic treatment with selective decortication and alveolar augmentation has been proposed, in order to enhance speed of tooth movement and hyalinization reduction by decreasing the bone density and increasing tissue turnover.[18,44]

The clinical usefulness of a corticotomy has a clear effect on fastening tooth movement.[17-19] However, the studies on a corticotomy to reduce root resorption are still rare.[11,34] Some studies shown that a corticotomy can reduce root resorption in orthodontic treatment.[34,45,46] Moreover, the root length loss does not affect the longevity or the functional efficacy of the tooth.[47] Closing the space by molar protraction benefits patients by replacing lost teeth without prosthesis. However, age, size of the edentulous area, periodontal status, and patient compliance are factors that should be considered before deciding whether to close a molar space or not.[12,38,48]

Conclusion

This study was conducted to evaluate the root length of molars after protraction assisted with corticotomy and bone grafting. There was minor apical root length loss after protraction of the molar into the atrophic edentulous space after a corticotomy and bone grafting. After long-term follow-up, root shortening was apparent. However, none of the molars had more than 2 mm resorption. The mandibular second molar protraction assisted with corticotomy combined with bone grafting to close the mandibular first molar edentulous space has the benefit of accelerating tooth movement with minor root resorption.

Acknowledgement

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การเปลี่ยนแปลงของความยาวรากฟันภายหลังเคลื่อนฟันกรามล่างร่วมกับการทำคอร์ติโคโตมี และปลูกกระดูก: ติดตามผลด้วยภาพถ่ายรังสีโคนบีมคอมพิวเตดโทโมกราฟฟี 5 ปี ภายหลังการรักษา

พนิตนาฏ คงกระพันธ์ บัญชา สำรวจเบญจกุล***

บทคัดย่อ

การศึกษานี้มีวัตถุประสงค์เพื่อประเมินการเปลี่ยนแปลงของความยาวรากฟันภายหลังเคลื่อนฟันกรามล่างแท้ซี่ที่ 2 เพื่อแทนที่ตำแหน่งฟันกรามล่างแท้ซี่ที่ 1 ที่สูญเสียไป จากผู้ป่วยจำนวน 16 คน อายุเฉลี่ย 25.69 ปี ที่ได้รับการทำคอร์ติโคโตมีและปลูกกระดูกก่อนเคลื่อนฟันกรามล่างแท้ซี่ที่ 2 โดยศึกษาข้อมูลความยาวรากฟันด้านใกล้กลางของฟันกรามล่างแท้ซี่ที่ 2 จากภาพถ่ายรังสีโคนบีมคอมพิวเตดโทโมกราฟฟีก่อนการรักษา 3 เดือนภายหลังช่องว่างปิด และ 5 ปีภายหลังการรักษา ใช้การทดสอบความแตกต่างของค่ากลางของสองประชากรไม่อิสระในการวิเคราะห์ความแตกต่างของความยาวรากฟันในระหว่างช่วงเวลา ผลการศึกษาพบว่าความยาวรากฟันลดลงในแต่ละช่วงเวลา โดยพบมีการละลายของรากฟันภายหลังเคลื่อนฟันสำเร็จ การละลายของรากฟันเพิ่มขึ้นภายหลังติดตามผล 5 ปีภายหลังการรักษา และมีการละลายของรากฟันทั้งหมดตั้งแต่เริ่มต้นการรักษาจนถึง 5 ปีภายหลังการรักษา เฉลี่ย 0.16 0.67 และ 0.84 มิลลิเมตรตามลำดับ จากการศึกษานี้สรุปได้ว่าสามารถพบการละลายของรากฟันกรามล่างแท้ซี่ที่ 2 ภายหลังเคลื่อนฟันเพื่อปิดช่องว่างฟันกรามล่างแท้ซี่ที่ 1 ที่สูญเสียไปร่วมกับการทำคอร์ติโคโตมีและปลูกกระดูก และเมื่อติดตามการเปลี่ยนแปลงของความยาวรากฟัน 5 ปีภายหลังการรักษา พบว่ามีการละลายของรากฟันในช่วงหลังจากการเคลื่อนฟันเพื่อปิดช่องว่างและติดตามผลอย่างมีนัยสำคัญทางสถิติมากกว่าการละลายของรากฟันในช่วงที่ทำการเคลื่อนฟันภายใต้การทำคอร์ติโคโตมีและปลูกกระดูก

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