Prevalence of Dehiscence and Fenestration on Incisors after Orthodontic Treatment in High-Angle Patients using Cone Beam Computed Tomography

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Abstract

To assess the prevalence of dehiscence and fenestration based on alveolar bone height (ABH) and alveolar bone thickness (ABT) on upper and lower incisors in malocclusions with high-angle after orthodontic treatment using Cone Beam Computed Tomography (CBCT).

CBCT examinations were performed on twenty-seven skeletal malocclusion high-angle patients at RSKGM Faculty of Dentistry, Universitas Indonesia, for post orthodontic evaluation. The subjects were divided into 3 groups based on their malocclusions. ABH and ABT were measured on CBCT cross-sectional images of the upper and lower incisors to determine the presence of dehiscence and fenestration at labial and lingual aspects.

Dehiscence was associated the most in class II malocclusion (24.8%) and fenestration in class I (3.7%) and class II (3.7%) malocclusion. The prevalence of dehiscence that occurred in lower incisors was higher (39.2%) compared to upper incisors (23.5%). The prevalence of fenestration occurred in upper incisors was higher (5.7%) compared to lower incisors (3.4%).

The prevalence of dehiscence was highest in lower incisors of class II malocclusion, whereas fenestration in upper incisors of class I and II malocclusion, with labial, was the most frequently affected side.

Clinical article (J Int Dent Med Res 2021; 14(4): 1561-1568)

Keywords: CBCT, Dehiscence, Fenestration, High-Angle.

Received date: 05 October 2021 **Accept date:** 01 November 2021

Introduction

Alveolar bone condition as the primary support of teeth before and after orthodontic treatment is often forgotten. This is related to the limitation of tooth movement inside its alveolar bone housing.[1] Finding reveals that malocclusion with a high-angle patient has the thinnest alveolar bone compared to others.[2–4] It needs to be considered by orthodontists because thin alveolar bone limits the desired tooth movement. Inappropriate mechanotherapy may cause thinning of the alveolar bone and increase the distance of the alveolar bone to Cemento Enamel Junction (CEJ) (Dehiscence) and penetration of root out of the alveolar bone (Fenestration).[5]

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Previous studies reported prevalence of dehiscence and fenestration in malocclusion before orthodontic treatment were 36,51% and 51,09%, respectively.[6] These alveolar defects were more common in the mandible for class II and III malocclusion. Further dehiscence and fenestration may cause a gingival recession, pocket deepening, tooth mobility, and loss of stability in the post orthodontic retention phase.[5]

Generally, a panoramic radiograph that has a broad image coverage of the jaw is used to evaluate the condition of the alveolar bone before and after orthodontic treatment. The information obtained from this conventional radiograph is only a general description of the alveolar bone and does not convey in detail the condition of the alveolar bone because of its two-dimensional images that affect magnification, geometric distortion, and superimposition of anatomical structures.[5] Cone Beam Computed Tomography (CBCT) or CT Scan has advantages to determine the thickness of alveolar bone. CT Scan has some disadvantages because of its high radiation and is expensive for the patient, making it impractical in dentistry.[7]

Pratiwi et al. (2012) reported better reproducibility of CBCT compared to conventional radiographic by orthodontists on few landmarks such as S, N, A, B, Pog, and ANS. Moreover, CBCT has the same accuracy as CT scan in distance measurement for examination.[8] Until now, the use of CBCT in dentistry is still the most accurate tool to evaluate the result of fixed orthodontic treatment, especially in difficult cases such as malocclusion with high-angle patients.[7]

Lateral cephalometric radiograph and clinical examination may show dehiscence and fenestration. However, it is difficult to see details of its location and how much alveolar bone defect has occurred in the area. Therefore, it is necessary to evaluate alveolar bone utilizing CBCT by applying several parameters, such as the vertical distance between the alveolar crest to CEJ, which is known as Alveolar Bone Height (ABH), and the horizontal distance between the most outer aspect of cementum to the most outer aspect of alveolar bone which known as Alveolar Bone Thickness (ABT).[9,10]

The success of orthodontic treatment is often questioned especially in cases of severe malocclusion with camouflage treatment which would otherwise require orthognathic surgery. The initial dimensions of alveolar bone housing limit the orthodontic movement. Mechanotherapy may decentralize the tooth from its alveolar bone, over retraction or protraction of the anterior teeth may cause root resorption, alveolar bone loss, and gingival recession.[11] Hoang et al. (2016) reported that alveolar bone in high-angle patients after orthodontic treatment become more susceptible to dehiscence and fenestration.[9] After leveling and aligning, there was a generalized reduction in bone density. Patients with thinner alveolar bone may need a longer period of retention phase and have a higher risk for relapse.[1213] Therefore, it is vital to know ABH and ABT in expressing the occurrence of dehiscence and fenestration. In the case of a decreased alveolar bone crest or an increase of the distance between the alveolar crest and CEJ more than 2 mm, dehiscence has occurred on that tooth. This dehiscence may be followed by a recession of the gingiva. Whereas in cases with no ABT in the root area without the involvement of the alveolar crest, fenestration has occurred.[5,11] The occurrence of dehiscence and fenestration during orthodontic treatment depends on several factors such as tooth movement direction such as proclination and transverse expansion, frequency and magnitude of orthodontic forces, periodontal tissue condition, oral hygiene, restoration, and overhanging crown.[5,14]

Materials and methods

This research was a descriptive cross-sectional study, carried out at the department of orthodontics and oral and maxillofacial radiology department at the Dental and Oral Hospital (RSKGM) of the Faculty of Dentistry, Universitas Indonesia. This study was carried out by measuring several parameters on CBCT data evaluation from post-orthodontic treatment. This study was approved by the Research Ethics Committee of Faculty of Dentistry, Universitas Indonesia (No. 46/Ethical Approval/FKG UI/X/2020), RSKGM Faculty of Dentistry, Universitas Indonesia (No. 14/UN2.F2.RSGKM/PPM.00/2020), and written consent to perform CBCT radiographic examinations and to participate in this research was obtained from all patients.

Patients

A total of 27 high-angle patients were divided into three groups based on their sagittal jaw relationship. The sampling frame included was patients who fulfilled the following inclusion criteria: (1) Adult male and female, aged between 18 - 40 years old (2) Complete anterior teeth (3) High-angle (SN-GoGn > 37^{o}) (5) Class I (ANB 1-4^{o}), class II (ANB > 4^{o}), or class III malocclusion (<1 ^{o}) (6) Post orthodontic treatment with pre-adjusted edgewise MBT prescription. The exclusion criteria were (1) pregnant women (during orthodontic treatment and CBCT examination is performed), (2) dental caries/fracture/abfraction of incisors, (3) orthognathic surgery case, (4) history of root canal treatment, (5) history of previous orthodontic treatment (6) jaw bone disease (7) bone-related drug and systemic disease. Each type of malocclusion consisted of 5 non-extraction cases and 4 extraction cases where extraction in class I and II malocclusion was carried out only on the maxilla or both arches. As for class III malocclusion, the extraction was carried out on the lower arch only or both jaws. Extractions were carried out symmetrically on the left and right of the posterior teeth with the extracted elements were first premolar/second premolar/first molar. The required sample size was estimated using G*Power 3.1.9.6 Software, the estimation of sample size, effect size 0.637 using statistically significant difference means according to the results of a preliminary experiment by Ma et al. (2019) with alpha 0.05, beta 0.8, to detect a significant difference in ABH or ABT between the three groups, 9 patients were found to be required for each group.

CBCT Evaluation

For each patient, CBCT was taken for post orthodontic treatment evaluation in natural head position with maximum intercuspation using Carestream CS 9300 Premium (Carestream Dental LLC, USA). The scans were taken in a single 360-rotation at a scan time of 20 seconds, exposures 8.0 mA, 88 kV, voxel 90 micrometer, and FoV 5x5. Files were saved as Digital Imaging and Communications in Medicine (DICOM) format and the images were viewed and measured via CS 3D Imaging Version 3.8.7. software to orient images in cross-sectional slices through all three dimensions of each incisor. The slices were projected at the midline of the long axis labio-lingually on each tooth and reconstructed with 0.27-mm slice thickness. The cross-sections were generated passing through the apex and crossing the center of the root perpendicular to the alveolar contour at the level of the cervical third (Fig. 1). Variables are being measured: Alveolar Bone Height (ABH) and Alveolar Bone Thickness (ABT) at 2 mm, 4 mm, 6 mm, and apex on both side labial and lingual/palatal (Fig. 2).

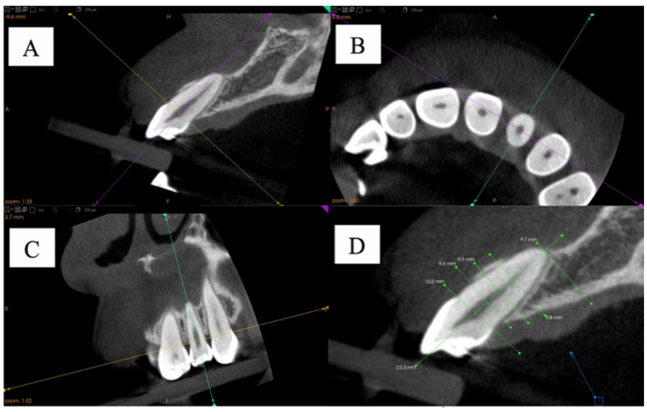

Figure 1. The oriented slice of CBCT images.

Statistical Analyses

To evaluate the reliability of the measurements, 3 patients were randomly selected from the total sample for intra-operator reliability at an interval of 1 month, and all patients were measured for inter-operator reliability between author and CBCT expert in the radiology department. The reliability of the measurements was calculated by Intraclass Correlation Coefficient (ICC) and also compared visually with the 95% confidence Bland Altman Plot. Univariate analyses were performed with SPSS Version 24.0 (IBM Statistics, USA) and Microsoft Excel Version 16.20 (Microsoft, USA) to assess descriptive statistics on each group of malocclusions.

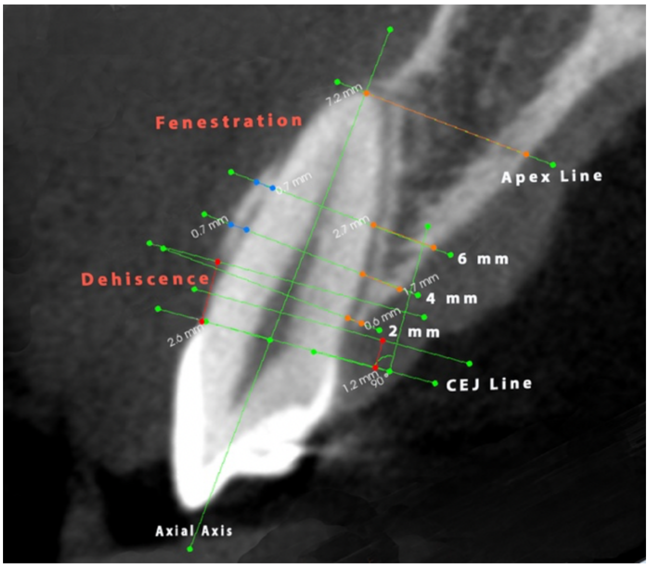

Figure 2. The measurement guide of alveolar bone height and thickness.

Results

For inter-operator reliability, ICC measurements were done for ABT and ABH, between and within operators. Intra-observer and inter-observer excellent consistency and agreement were demonstrated with ICC 0.98-0.99. All measurements were within the limits of agreement based on the Bland-Altman plots with >95% data between upper and lower limits (Fig.3-5). Mean bias between operators was -0.04±0.43, meanwhile within operator was -0.06±0.31 (CBCT expert) and -0.02±0.27 (researcher). Results of the regression test of the Bland-Altman diagrams (between operators, within researcher, and expert) showed that there was no significant proportional bias ($p > 0.05$). The high correlation of intra- and inter-observer either from ICC and Bland-Altman plots suggested that these measurements were replicable and robust.

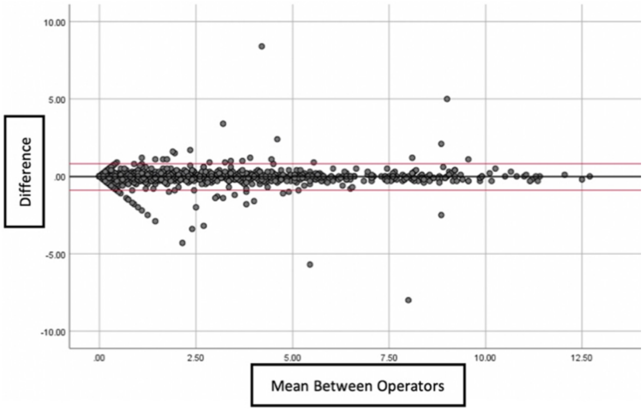

Figure 3. Bland altman between operators.

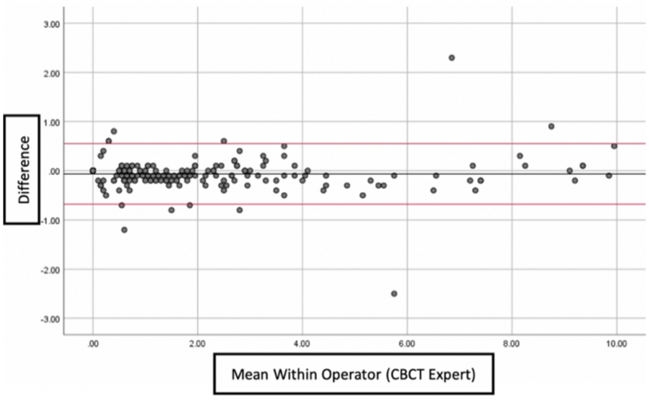

Figure 4. Bland altman within operator (expert).

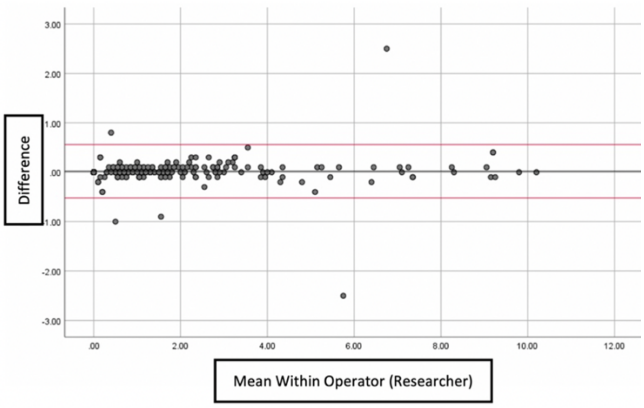

Figure 5. Bland altman within operator (researcher).

On the labial side of upper lateral incisors, the mean value of ABH is more than 2 mm, the same result on the lingual side in class I and II malocclusion (Fig. 6A, 6B). The ABH of lower central incisors had a higher mean value (>3 mm). This mean value resulted on both labial and lingual sides in lower central incisors of all malocclusions (Fig. 6C). Lower lateral incisors had > 2 mm of ABH on labial and lingual sides of all malocclusion, with class II had the highest mean value (>4 mm), followed by class III (≥ 3 mm) and class I (> 3 mm) on labial side, and class III had the highest mean value (>6 mm), followed by class I and II (>4 mm) on lingual side (Fig. 6D).

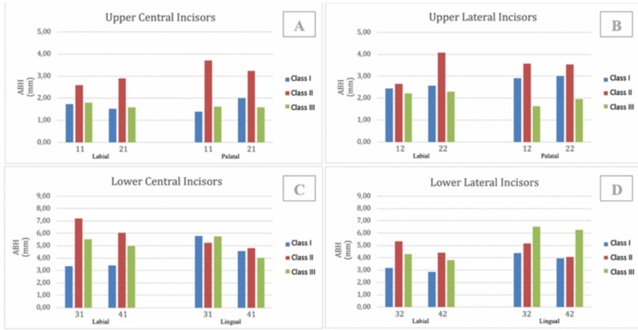

Figure 6. Alveolar bone height of (A) upper central incisors (B) upper lateral incisors (B) lower central incisors (C) lower lateral incisors (D).

Malocclusion	Tooth	Dehiscence (%) Upper Labial	Upper Palatal	Lower Labial	Lower Lingual	Σ Class
Class I (n=144)	Central Incisor	0.7	0.9	2.3	3.9	19.4
	Lateral Incisor	3.0	3.0	2.3	3.2	
Class II (n=144)	Central Incisor	2.5	3.2	4.2	3.7	24.8
	Lateral Incisor	2.8	2.3	3.2	2.8	
Class III (n=144)	Central Incisor	0.5	1.4	3.7	3.9	18.8
	Lateral Incisor	2.5	0.7	2.8	3.2	
					Σ Total	63.0

Table 1. Prevalence of dehiscence in upper and lower incisors.

All ABT mean values had the same pattern on the labial side of upper incisors that are thickening from 2 mm to 4 mm from CEJ, thinning on 6 mm from CEJ, then thickening back until apex (Fig. 7A, 7B). Meanwhile, ABT means value on the labial side of lower incisors increased from 2 mm below CEJ to apex. The thinnest ABT means value occurred in class II malocclusion on every level (2 mm, 4 mm, 6 mm below CEJ, and apex), followed by class III and class I malocclusion respectively (Fig. 7C, 7D). All ABT mean values on the palatal side of upper incisors showed a different pattern from the labial side that is increasing in thickness from 2 mm below CEJ to apex (Fig. 7E, 7F). Meanwhile, on the lingual side of lower incisors, the thinnest ABT means value occurred in class III malocclusion on every level, followed by class I and class II malocclusion (Fig. 7G, 7H).

Malocclusion	Tooth	Fenestration (%) Upper Labial	Upper Palatal	Lower Labial	Lower Lingual	Σ Class
Class I (n=144)	Central Incisor	0.9	0.2	0.2	0.0	3.7
	Lateral Incisor	1.2	0.0	0.9	0.2	
Class II (n=144)	Central Incisor	0.7	0.0	0.5	0.0	3.7
	Lateral Incisor	1.6	0.0	0.9	0.0	
Class III (n=144)	Central Incisor	0.2	0.0	0.2	0.0	1.9
	Lateral Incisor	0.9	0.0	0.5	0.0	
				Σ Total		9.3

Table 2 Prevalence of fenestration in upper and lower incisors.

Malocclusion	Alveolar Bone Height 0.1-2 mm	2.1-4 mm	4.1-6 mm	> 6 mm
Class I	13.89	12.27	3.47	3.70
Class II	8.56	10.88	5.56	8.33
Class III	14.58	9.49	3.01	6.25

Table 3. Prevalence of alveolar bone height in class I II and III malocclusions.

Table 1 showed the highest prevalence of dehiscence on class II malocclusion (24,8%) and Table 3 showed fenestration on class I (3,7%) and class II (3,7%) malocclusion. In this study, measurements of each malocclusion were carried out on 9 study subjects, each with 8 incisors (upper and lower, center and lateral incisors), and 2 sides (labial and palatal/lingual), so that the total sides measured on each group in this study were 144 (432 in total) as described in the prevalence Table 1 & 2. Table 3 showed the prevalence of alveolar bone height.

Discussion

Orthodontists should take alveolar bone support into account when considering the feasibility of the treatment plan. Alveolar bone limitation in orthodontic treatment is fully dependent on alveolar bone quality and quantity.[13] In this study, malocclusion with high-angle patients was chosen because they generally have the least alveolar bone compared to others, especially in the lower anterior region. Findings reveal that thin alveolar bone conditions cause dehiscence and fenestration.[2–4] Class II and III malocclusions with moderate difficulty are often ended with compromised treatment as a result of skeletal camouflage. Sheibani et al. (2010) reported prevalence of relapse after orthodontic treatment was quite high, 61,5%.[15] Orthodontic treatment relapse describes the lack of stability and can be caused by various factors such as number and distance of tooth movement, occlusion, age, etiology of malocclusion, bad habits, periodontal health, root position in the alveolar bone, etc.[16] Good treatment plan will position the root inside its alveolar bone housing so that alveolar defects such as dehiscence fenestration are hindered and stability of the orthodontic treatment is maintained.[13]

The number of female subjects in this study was more than men with male to female ratio of 1:5.75. However, for gender, there was no significant difference in alveolar bone thickness, except on the buccal side of the upper molar and lingual side of the retromolar region.[17] The mean age of the subjects in this study was 23.83 ± 5.13 years old with the youngest subject at 16 years old and the oldest at 37 years old. Sathapana et al. (2013) reported alveolar bone thickness on labial upper incisors was the most positively correlated region with the decrease in cortical bone thickness ($p < 0.001$) compared to other groups. However, the standard deviation between groups was small and did not differ much, with the largest difference between age groups of 0.22 mm, so that this difference did not have much effect clinically.[17] Another study by Deguchi et al. (2006) using CT scan and Ono et al. (2008) proved that there was no correlation between age or gender on cortical alveolar bone thickness.[18,19]

The mean duration of treatment in this study was 29 ± 7 months. The mean of class I malocclusion required 26.7 months, class II required 37.35 months, and class III malocclusion required 27.25 months. One of the reasons for the increased length of treatment was due to pandemic conditions, so there were at least 6 months of patients who did not come for routine control. Another cause was the cooperative problem of the patient.[20]

The purpose of this study was to determine and evaluate alveolar bone condition resulting from orthodontic treatment at the

Orthodontic Specialist Clinic of RSKGM Faculty of Dentistry, UI, especially malocclusions with high-angle skeletal that are most at risk of alveolar bone loss and thinning in the form of dehiscence and fenestration. This research showed how much dehiscence occurred. Another research objective is to determine alveolar bone thickness (ABT) that is the horizontal distance from the cementum at 2 mm, 4 mm, and 6 mm below the CEJ and the apex to the most outer aspect of the alveolar bone. The incidence of fenestration is expressed when the thickness of the alveolar bone is 0 mm.[5,11]

Overall ABT pattern in this research (Fig. 7A, 7B) the mean value of ABT on the labial upper incisors at 2 mm to 4 mm from the CEJ was thickened, thinned at 6 mm from the CEJ, then thickened again at the apex, following the anatomy of the tooth root. While on palatal of upper incisors and labial lingual of lower incisors, ABT means value increased from 2 mm below CEJ to apex. This could be due to the anatomy of the incisors' root and palatal roof support.[10]

Findings revealed that before orthodontic treatment, dehiscence mainly occurred in class III malocclusion (42,64%), which was more significant than class I (24,02%) and class II (22,77%).[5,6] In contrast to previous research, the results of this study found that the highest prevalence of post orthodontic dehiscence occurred in class II malocclusion (24.8%), followed by class I and III (19.4% and 18.8%), respectively. It was influenced by several things such as the initial condition before treatment which is a thinner cervical alveolar bone in class II malocclusion compared to class I and III malocclusions on both labial and palatal sides.[3,10]

In addition, when performing retractions, a bodily movement to the palate is sought rather than controlled tipping because the palatal thickness of the maxilla supports the movement.[21,22] The use of full slot as the main archwire when performing retraction is highly recommended for maximum bodily movement, especially in the case of class II malocclusion.[22] More complex mechanotherapy was also seen in the length of treatment because the length of treatment for class 2 malocclusion in this study was the longest with an average of 38 months compared to class I (23 months) and class III (28 months) malocclusion.[20] In addition, bimaxillary protrusion which requires reduced prominence of the dentoalveolar is an example of root dehiscence following incisor retraction.[11] On the lower arch, dental compensation of lower incisors in class II patients might increase the risk of dehiscence, therefore tipping mandibular movement is preferable to bodily in class II patients. It was due to correction of class II malocclusion followed by proclination of the mandibular incisors (either from leveling and aligning phase, correction of the Curve of Spee, or excessive use of class II elastics to reduce overjet) which causes stress on the periodontal support of the mandibular incisors.[5,6] In addition, research by Yagci et al. (2012) reported that treatment in class II malocclusion, both growth modification and camouflage, poses risks to the lower incisors if they want to pursue normal overjet and overbite.[3,5]

However, even though the dehiscence rate was higher in class II malocclusions if viewed from the level of severity, mild dehiscence (2.1-4 mm) mostly occurred in class I (12.27%) compared to class II (10,88%) and class III (9.49%). This mild dehiscence might occur to all malocclusions. A more detailed analysis of the previous study revealed that the orthodontic group had a greater prevalence of mild to moderate periodontal disease in the maxillary posterior and mandibular anterior regions.[23] Meanwhile, moderate (4.1-6 mm) and severe (>6 mm) dehiscence were highest at class II malocclusion at 5.56% and 8.3%, respectively. This can be caused by mechanotherapy of class II malocclusion that is more complex than other malocclusions.[20]

In line with previous studies, the highest prevalence of fenestration occurred in class I and II malocclusion (3.7%) compared to class III (1.9%). The prevalence of dehiscence was greatest in the lower incisors (Upper: 23.5% and Lower: 39.2%) and fenestrations in the upper incisors (Upper: 5.7% and Lower: 3.4%). It showed that both jaws (upper and lower incisors) had different risks of alveolar bone defects in both dehiscence and fenestration, depending on the initial position and the type of mechanotherapy given on each tooth.[5,11]

The prevalence of dehiscence of the lateral incisor (31.8%) was greater than that of the central incisor (30.9%) and the prevalence of fenestration of the lateral incisor (6.2%) was greater than that of the central incisor (2.9%). The maxillary prevalence could be caused by the difference bracket torque which was smaller on the lateral incisor, while the mandibular could be caused by the anatomy of the lateral incisor being larger in all dimensions than the central incisor which was accompanied by a disto-lingual twist of the lateral incisor.[10,24]

The prevalence of dehiscence on the palatal/lingual side (32.2%) was greater than on the labial side (30.5%) and fenestration on the labial side (8.7%) was greater than palatal/lingual (0.4%). These occurred due to retraction mechanotherapy, especially tipping movements that cause dehiscence on the palatal/lingual side and fenestration on the labial side.[5,6]

The limitations of this study were that it was a descriptive study therefore we were not able to compare ABH and ABT before and after orthodontic treatment. In addition, it could not prove the alveolar defects in this study were caused by orthodontic treatment, so in this study orthodontic treatment could only be a risk factor. Further cohort research is needed to see definite alveolar bone changes. Moreover, a prospective study should also be done to see a causal relationship between residual alveolar bone after orthodontic treatment and stability of treatment. Tooth position and root morphology contour the alveolar bone shape, especially when there is tooth movement. For that reason, orthodontists should evaluate bone limitations carefully in treating patients.

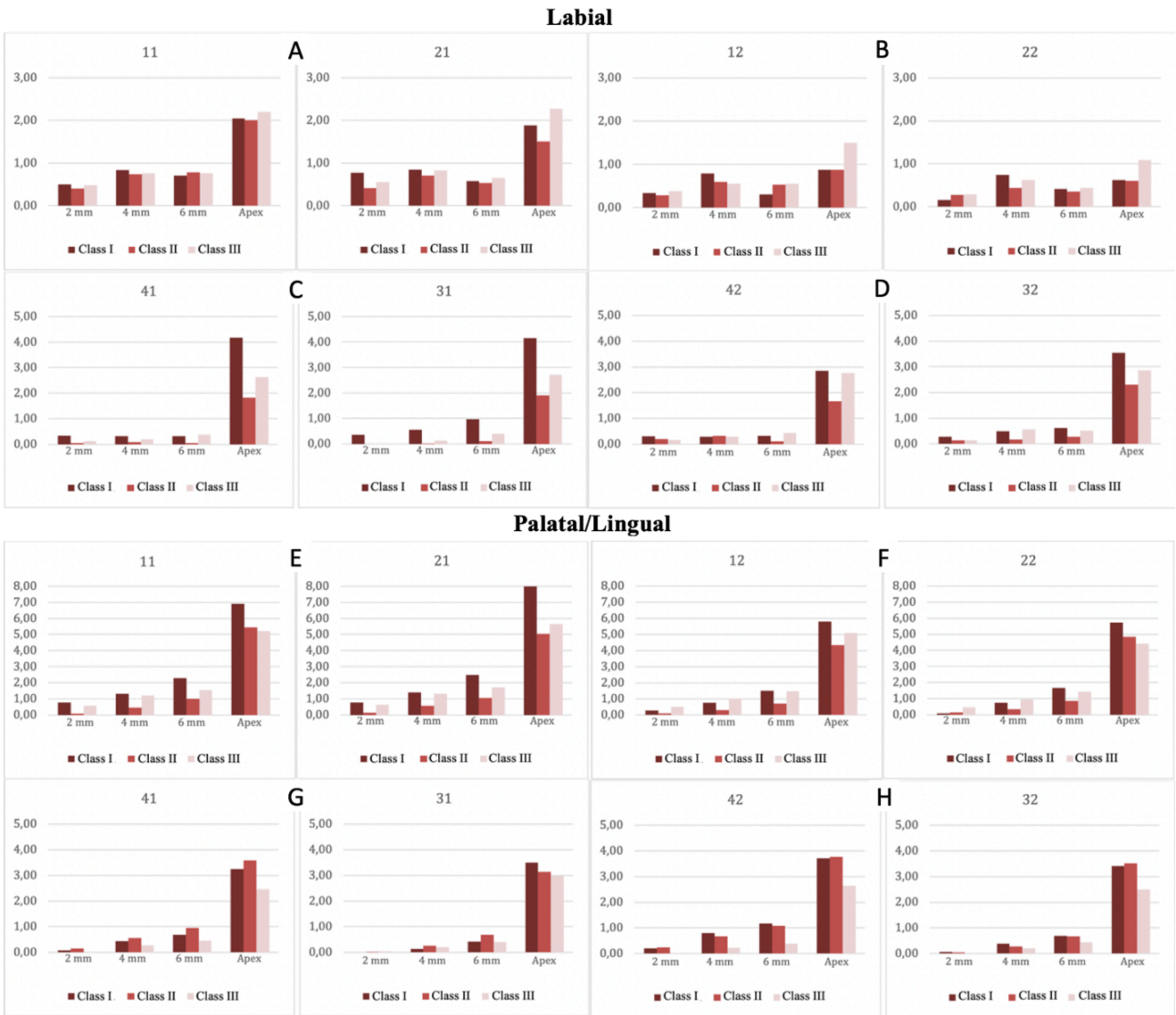

Figure 7. Alveolar bone thickness of labial (A) upper central incisors, (B) upper lateral incisors, (C) lower central incisors, (D) lower lateral incisors; palatal/lingual (E) upper central incisors, (F) upper lateral incisors, (G) lower central incisors, and (H) lower lateral incisors.

Conclusions

The highest prevalence of dehiscence occurred in class II malocclusion at 24.8% and fenestration in class I (3.7%) and class II (3.7%) malocclusion. Based on the level of severity, mild dehiscence (2.1-4 mm) mostly occurred in class I malocclusion at 12.27%, moderate (4.1-6 mm), and severe (>6 mm) dehiscence in class II malocclusion at 5.56% and 8.3%, respectively.

Acknowledgments

The authors report no conflict of interest and this study was supported by a grant from Publikasi Terindeks Internasional (PUTI) Saintekes 2020 Universitas Indonesia with contract number: NKB-2330/UN2.RST/HKP.05.00/2020.

Declaration of Interest

The authors report no conflict of interest.

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