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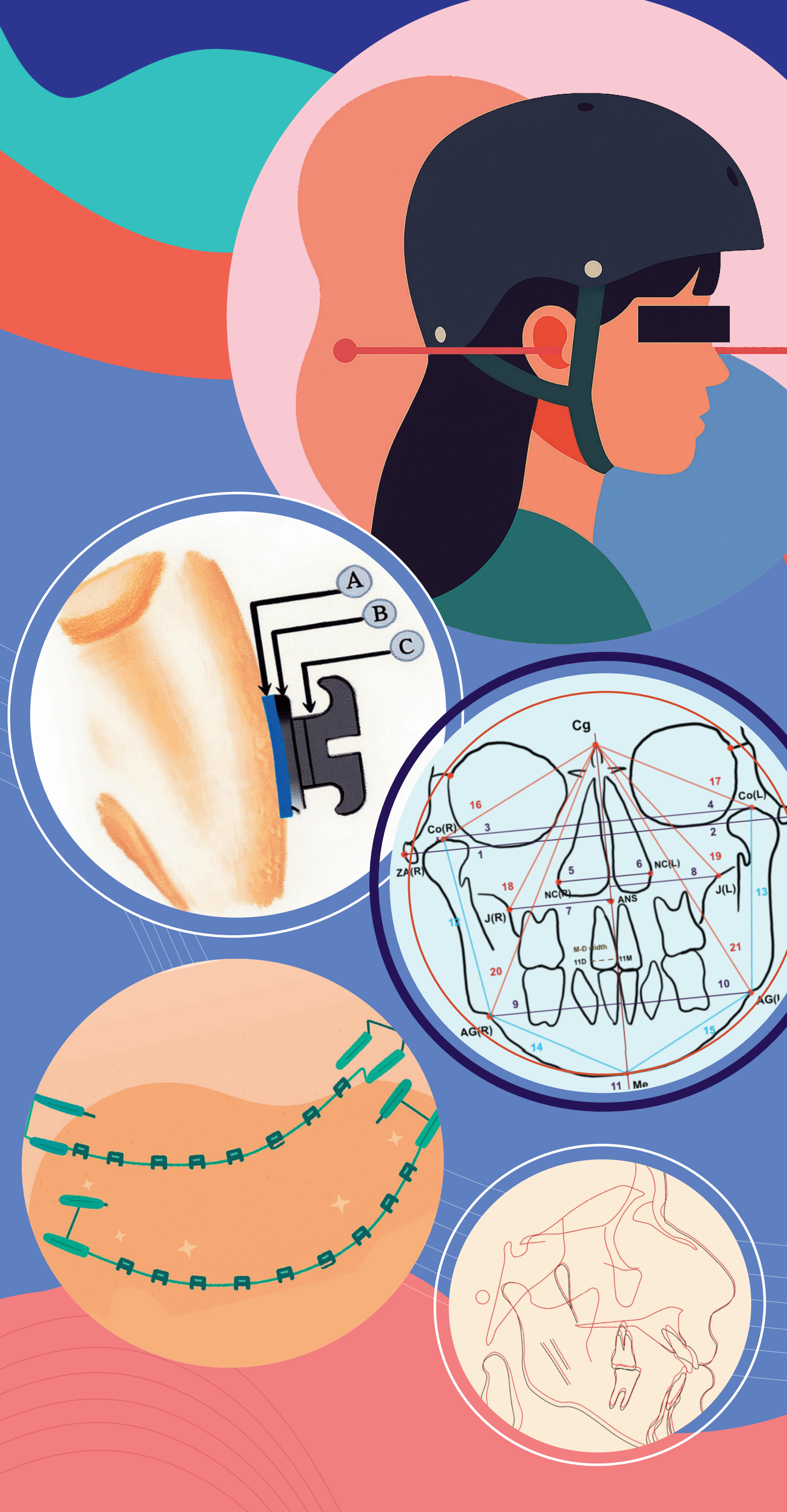

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Original Article

The Relationship between Skeletal Configuration and Soft Tissue Changes after Bracket Debonding using Repeatable Photographic Tool

Khitparat Kamoltham* Suchada Limsiriwong* Hataichanok Charoenpong** Rutapakon Insawak* Apichart Veerawattanatigul*

Abstract

Background: The presence of labial orthodontic appliances may impact final esthetic change after debonding. The skeletal configurations that support the soft tissue profile have not been examined their impact on the lip profile after debonding. **Objective:** To evaluate the effect of bonded orthodontic brackets on the lip change after the debonding and determine the correlation between the change in the lip profile and skeletal configuration. **Materials and methods:** Photographs were taken with a head fixer in thirty-three patients who had completed fixed orthodontic treatment before and immediately after bracket debonding to investigate the results of the change in the nasolabial and mentolabial angles using the Paired *t* test ($\propto$ = 0.05). The posttreatment lateral cephalometric measurements were used to find the correlation of skeletal configuration to the change in soft tissue profile using Pearson's correlation and one-way ANOVA. Results: Mentolabial angle significantly increased after debonding (P = 0.04). However, the Pearson correlation between soft tissue changes and underlying skeletal configurations was insignificant. (SNA with nasolabial angle: r = 0.13, P = 0.46; SNB with mentolabial angle: r = - 0.00, P = 0.98). Using one-way ANOVA, skeletal configurations demonstrated no significant difference compared with the mean difference in nasolabial angle (P = 0.69) and mean difference in mentolabial angle (P = 0.15). **Conclusion:** After debonding, the lower lip profile was flattened, however, the upper lip profile was maintained compared with the nose. There was no significant correlation between the change of nasolabial/mentolabial angles and the skeletal configurations.

Keywords: Fixed orthodontic appliance, Lateral cephalogram, Lip profile, Skeletal configuration

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Introduction

Currently, orthodontic treatment seeks to restore occlusal function and esthetics by improving the facial appearance. The major concept in orthodontic treatment has changed to a soft tissue paradigm[1] over the underlying hard tissue to optimize patient's satisfaction, who notice slight soft tissue lip changes. Therefore, treatment based on the correct orthodontic diagnosis and planning is necessary to achieve function and facial esthetics, including the change in the lip position and perioral soft tissue after bracket debonding.

There are various methods to perform the soft tissue facial profile analysis, such as two-dimensional (2D) evaluation (photographs),[2-4] three-dimensional (3D) evaluation,[5-9] lateral cephalograms[10] and cone beam computed tomography (CBCT) scans.[11] The measurement of the lip position after debonding the orthodontic appliances evaluated with a 3D system demonstrated that the lip commissures and the lower lip move significantly posteriorly after debonding.[6] However, the results of this study indicated a wide range of individual variation for all landmarks. 3D facial scans used to measure the lip and perioral soft tissue changes immediately before, immediately after and 3 months after bracket debonding showed that there were clinically significant lip and perioral soft tissue changes, in which the soft tissue retrusion was unrelated to gender, bracket type and lip thickness.[8] Another study using 3D stereophotogrammetry also found retrusion of the oral commissure and lower lip after debonding without a change in the upper lip.[9] A simple and costless method, conventional profile photographs, used to evaluate the prominence of the lips demonstrated that labial appliances bonded on the upper anterior teeth did not affect the lip prominence and no differences were found between the angular measurements before and after debonding.[2] The soft tissue profile can also be evaluated using standardized photographs with the advantages of low cost, versatility, no radiation and are routinely taken by orthodontists. However, this requires the correct standardization of the image setup to make the soft tissue profile analysis repeatable. Labial orthodontic appliances impact the lip profile and have shown variation between individuals. Various factors have been previously evaluated, such as gender and lip thickness. Skeletal relationships significantly influence soft tissue profiles, with variations in maxillary and mandibular positions directly affecting lip posture and facial esthetics [12-13] Understanding these complex interactions is crucial for orthodontists to develop treatment plans that optimize both occlusion and facial harmony, ultimately enhancing patient satisfaction.[14-15] However, the skeletal configurations that directly support the soft tissue profile have not been examined as to whether they have different impacts on the change in the lip profile before and after debonding labial orthodontic appliances. Therefore, the purpose of this study was to develop a repeatable photographic tool for evaluating the effect of bonded orthodontic brackets on the lip change at the debonding stage and determine the correlation between the change in the lip profile and skeletal configuration.

Materials and methods

This prospective study was approved by the Ethics Committee on Human Research at College of Dental Medicine, Rangsit University (COA. No.RSUERB2023-086). All participants provided informed consent before participating in this study.

Subjects

The sample size was calculated using the PS: Power and Sample Size Calculation software, version 3.1.2 (Vanderbilt University, Nashville, TN). The significant values of the distance change in the lower lip were taken from Eidson et al.[6] The level of significance of the change was established at 95 % (α = 0.05). The power of the test in this study was established at 80 % (β = 0.20). The sample size after adjusting for a dropout rate of 10 % was approximately 27 patients. The patients were recruited from the Orthodontic clinic, College of Dental Medicine, Rangsit University. The inclusion criteria were: 1) 18-45-year-old non-growing patients 2) Orthodontic bracket placement on all anterior teeth and at least one premolar present in every quadrant. 3) Completed the finishing phase of orthodontic treatment and ready for debonding. Patients with any craniofacial deformity or neuromuscular problem were excluded

Methods

Patients who were treated with fixed orthodontic appliances (Preadjusted edgewise fixed appliances, 0.022-in slot MBT system; 3M, Monrovia, CA, USA) The bucco-lingual thickness of the brackets used in this study was 2 mm to ensure standardization of the labial projection. and had completed the finishing phase of treatment were included. At the debonding visit, photographs were taken immediately before debonding (T1) with the head fixer (Figure 1 and 2). The brackets and remnants of the orthodontic `adhesive were removed. Postdebonding photographs (T2) were taken at the same setting as the predebonding photograph and a posttreatment lateral cephalogram was taken for analysis of the final skeletal configuration.

Photographs were taken with the head fixer in the same position in a fixed chair at a distance of 1.50 meters from the camera that was set in the same position with the camera tripod's height according to the patient's head (Figure 1). The patient was in a natural head position, horizontal lines were placed using a laser pointer at the level of the Frankfort horizontal plane (Figure 2). A lateral cephalogram was taken with a Planmeca machine (Planmeca ProMax® cephalostat, Helsinki, Finland) after appliance debonding at the same visit. The patient was positioned with the ear rods in place, the Frankfort horizontal plane was located, and nasion was fixed with a forehead clamp. They were then asked to place

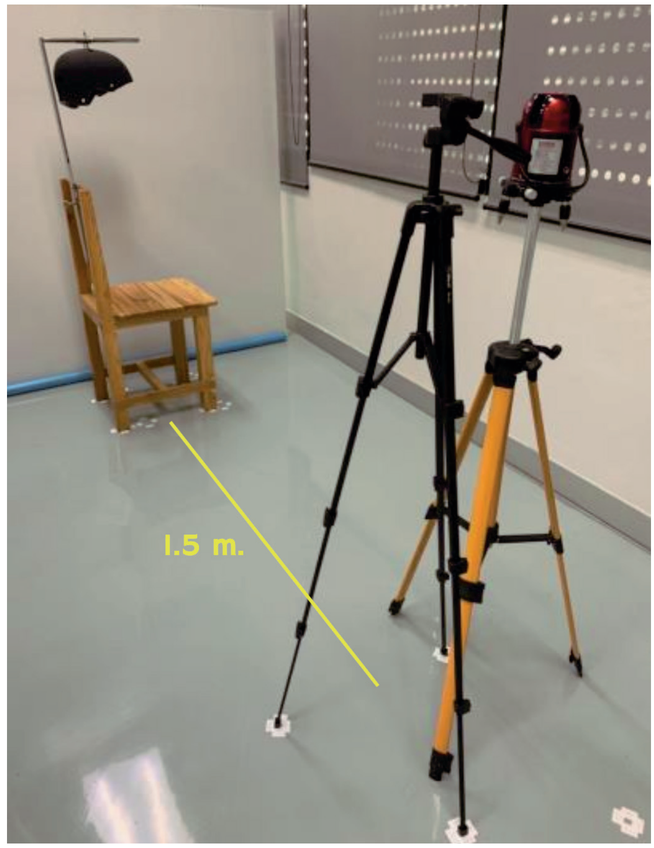

Figure 1 The settling of the head fixer

Figure 2 The head fixer and laser pointer referenced at the Frankfort horizontal plane

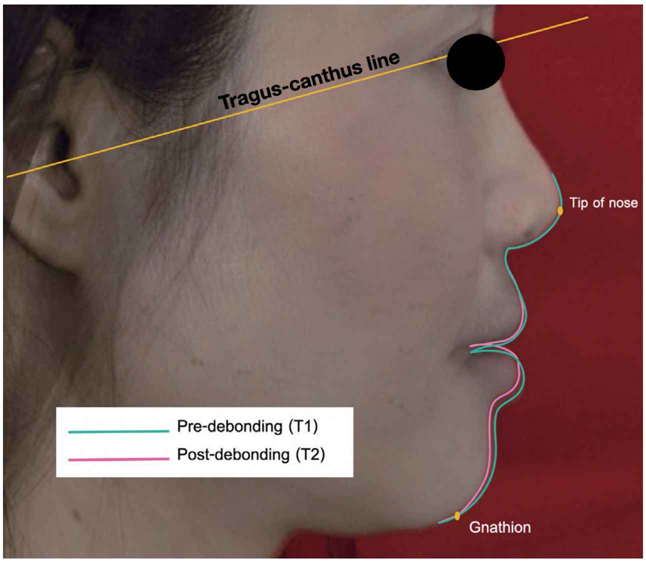

Figure 3 Pre and Posttreatment photographs were superimposed by digitalizing in the Adobe Photoshop computer program

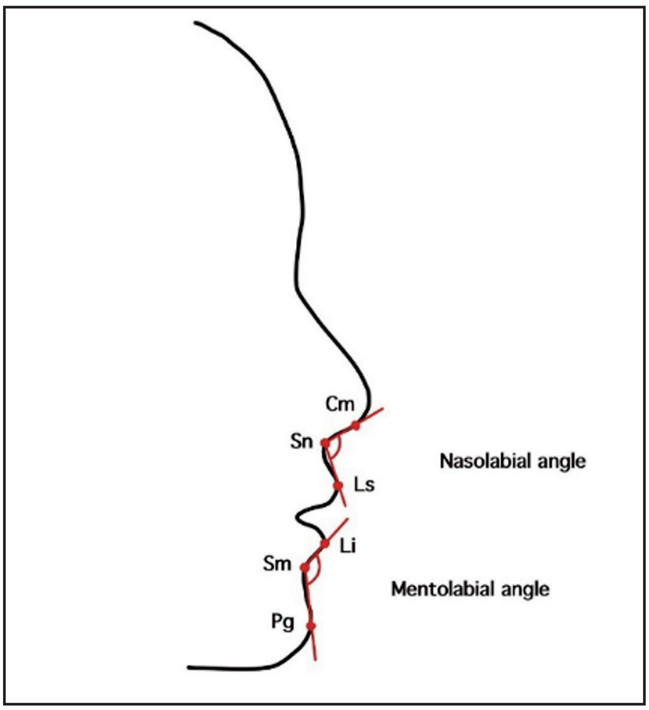

Figure 4 Nasolabial and mentolabial angle measurement

their teeth in maximum cuspation, with their mouth closed in a relaxed position, and remain still during exposure.

The photographs were digitalized and superimposed at one reference plane (Tragus-canthus line) and two reference points (tip of the nose and gnathion) (Figure 3).

The soft tissue change analysis was performed using measurements of the photographs with the profile of the soft tissues landmarks and the reference lines were defined as follows (Figure 4);

1) Nasolabial angle (Cm-Sn-Ls): The Columella-Subnasal-Labrale Superius angle formed by the intersection of the upper lip anterior and columella at subnasale. This angle should range from 90-120°.

2) Mentolabial angle (Li-Sm-Pg): The Labrale inferius-Supramental-Pogonion angle formed between the line joining the labrale inferius and the depth of the sulcus to the pogonion point.

The analysis of the patient's skeletal configuration comprised the following variables:

1) SNA: angle formed by the SN line and the NA line
2) SNB: angle formed by the SN line and the NB line
3) ANB: angle formed by the NA line and the NB line

Statistical analysis

Descriptive statistics, standard deviation, mean, median, maximum, and minimum were reported. The normality of the data was assessed using the Shapiro-Wilk test. ($P > 0.05$ indicates that the data is normally distributed). The paired *t* test ($\alpha = 0.05$) was used in inferential statistics to determine a significant difference between the means of all soft tissue lip measurements before and after debonding. A correlation analysis was used to determine the relationship between the changes in the lip profile and skeletal configuration. Pearson correlation was used to determine the relationship of the change in the nasolabial angle, mentolabial angle SNA, SNB, and ANB.[16] The skeletal cephalometric values of SNA SNB and ANB were classified into 3 types for each parameter, i.e., mandibular and maxillary position (retrognathic, orthognathic and prognathic) and skeletal configuration (Class I, II, III). These parameters were used to identify the relationship with the mean difference in the nasolabial angle and the mentolabial angle using one-way ANOVA. The SPSS statistical program (SPSS, An IBM Company, New York, USA) was used to perform the data analysis.

Method error

The reproducibility of the measurements for the photograph and lateral cephalogram was evaluated by statistically analyzing the difference between 10 randomly selected photographs and lateral cephalometric radiographs after an interval of 2 weeks. The calibration was done between 5 undergraduate dental students in the research group and a board-certified orthodontist to ensure that everyone in group had same ability. The error of the method was calculated with Dahlberg's formula

$$ME = \sqrt{\Sigma d^2 / 2n}$$

Where:

ME = Method Error

Σd^2 = The sum of the squared differences between the repeated measurements

n = The number of double measurements made

The flowchart was shown in figure 5 for better visualizing of the method.

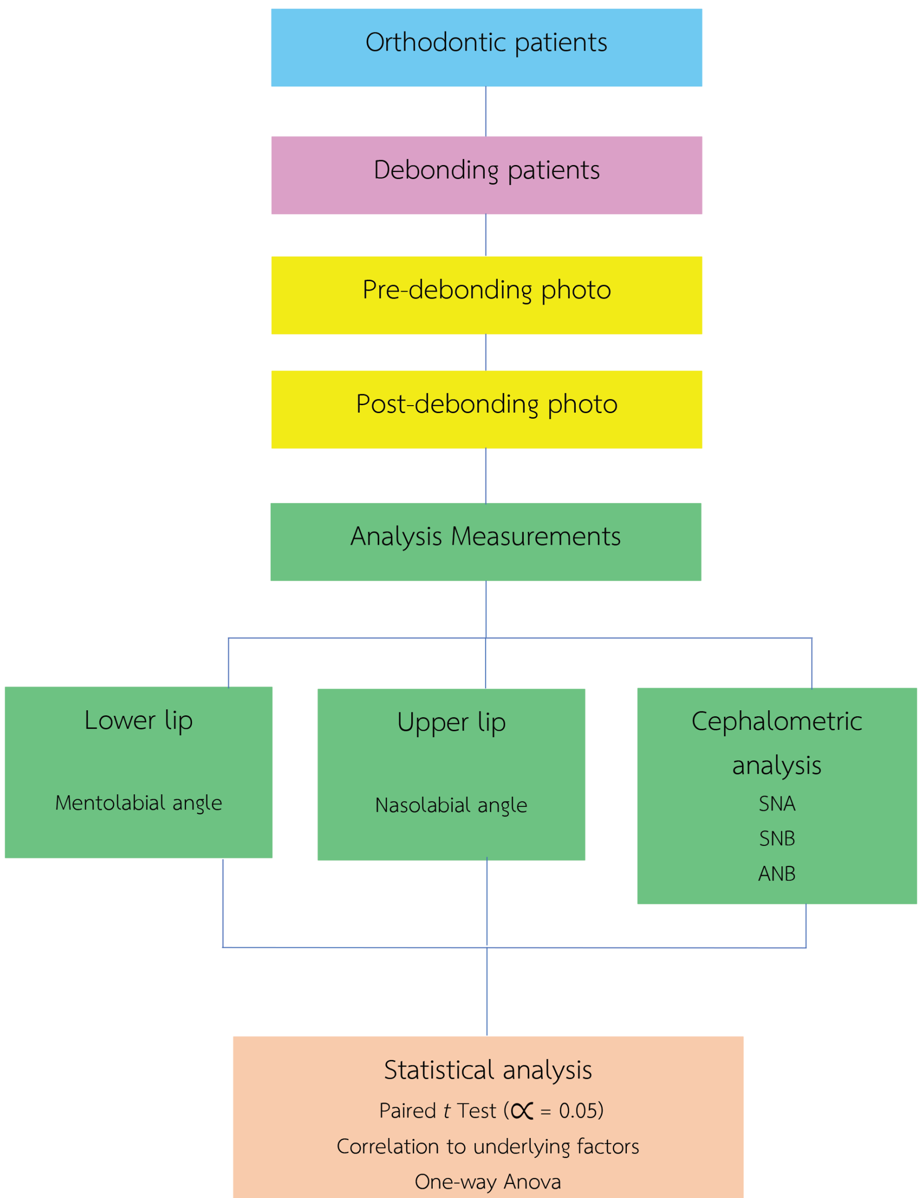

Figure 5 The flowchart

Results

The sample comprised 33 individuals (11 males, 33.33 %, and 22 females, 66.66 %). The orthodontic treatment was completed in all subjects. A predebonding photograph was taken at the same setting as the postdebonding photograph. The posttreatment lateral cephalogram was taken for analysis of the final skeletal configuration.

For the maxilla configuration, 4 subjects (12.10 %) had a retrognathic maxilla, 23 subjects (69.70 %) had an orthognathic maxilla and 6 subjects (18.20 %) had a prognathic maxilla. For the mandible configuration, 6 subjects (18.20 %) had a retrognathic mandible, 15 subjects (45.50 %) had an orthognathic mandible and 12 subjects (36.40 %) had a prognathic mandible. The skeletal relationship of the sample included 14 subjects (42.40 %) who had a Class I, 8 subjects (24.20 %) who had a Class II, and 11 subjects (33.30 %) who had a Class III relationship.

Sixty-six photographs from 33 patients (before and after they had the fixed orthodontic appliances debonded) were digitized and traced. The nasolabial angle (Cm-Sn-Ls) and mentolabial angle (Li-Sm-Pg) were assessed in this study.

The mean difference in the nasolabial angle and standard deviation was - 0.33 ± 4.83° (P = 0.69). The mean increase in the nasolabial angle from the predebonding angle was 0.33°, which meant that the upper lip profile flattened compared with the nose.

The mean difference in mentolabial angle and standard deviation was - 2.09 ± 5.79° (P = 0.04). The mentolabial angle was increased by 2.09° from the predebonding angle, indicating that the lower lip profile flattened compared with the nose.

The paired *t* test showed significant differences in the mentolabial angle change (P = 0.04), however, the change in the nasolabial angle (P = 0.69) showed no significant differences (Table 1).

The relationship between the mean difference in the nasolabial angle and mean difference in the mentolabial angle compared with skeletal configuration was determined using Pearson Correlation. The results are shown in Table 2.

Table 1 Soft tissue values between the predebonding and postdebonding photographs

Variables	Predebonding photograph (T1)		Postdebonding photograph (T2)		Difference between pre and postdebonding (ΔT1-T2)		*P*
	Mean	SD	Mean	SD	Mean	SD	
Nasolabial angle	99.82	9.12	100.15	9.42	- 0.33	4.83	0.69
Mentolabial angle	128.12	11.20	130.21	11.75	- 2.09	5.79	0.04*

*Significant difference, $P < 0.05$.

Table 2 Pearson Correlation between the soft tissue changes and underlying skeletal configurations

Skeletal configuration	Soft tissue changes			
	Mean different Nasolabial angle		Mean different Mentolabial angle	
	Pearson Correlations (r)	*P*	Pearson Correlations (r)	*P*
SNA	0.13	0.46	- 0.24	0.19
SNB	0.20	0.26	- 0.00	0.98
ANB	- 0.08	0.68	- 0.33	0.07

*Significant difference, $P < 0.05$

The Pearson correlation analysis between the soft tissue changes and underlying skeletal configurations indicated that there were no significant differences. The statistical analysis of the data revealed that most results tended to show a weak correlation and were not significant for all examinations.

The parameters measured from SNA, SNB and ANB were classified into 3 types for each parameter, maxillary and mandibular positions that comprised retrognathic, orthognathic and prognathic classification and skeletal configuration (Class I, II, III). These parameters were used to find the relationship with the mean difference in the nasolabial angle and mean difference in the mentolabial angle using one-way ANOVA. The results demonstrated that there were no significant differences between the maxillary position and the mean different nasolabial angle ($P = 0.40$) and mean different mentolabial angle ($P = 0.51$). Furthermore, the mandibular position to the mean different nasolabial angle ($P = 0.64$) and to the mean different mentolabial angle ($P = 0.80$) was not significant. Similarly, the skeletal configurations reported no significant differences to the mean different nasolabial angle ($P = 0.70$) and the mean different mentolabial angle ($P = 0.15$).

Discussion

Patients' demands for an esthetic lip and facial profile have increased. There is a need to anticipate the change in soft tissues around the lips after debonding orthodontic brackets. The 2D images were used to evaluate the changes in the facial soft tissue based on the accuracy and reproducibility of the photographs at different time points. Our study focused on the angular changes from the profile photograph analysis of the nasolabial angle and mentolabial angle using profile photograph analysis because they correspond to cephalometric landmarks for evaluating the effects of different treatment plans for different skeletal configurations.

A previous study has shown the association of gender differences with several angles on the nasal and mandibular contours; individual disparity in the nasolabial and mentolabial angles were also found.[3] Another study discovered sexual dimorphism in the chin height and prominence and deeper mentolabial sulcus in boys.[17] Although their method was similar to our research, the present study did not analyze the facial dimension according to gender. However, there were clinical limitations in the collection of samples in our research, causing the number of males and females to be unequal. Based on our results on mixed genders with the majority being female (2/3), the nasolabial angle showed no significant change, however, the mentolabial angle significantly increased after bracket debonding. furthermore, after orthodontic labial appliance removal there was greater lower lip retrusion. These changes may affect lip attractiveness as a deeper mentolabial sulcus was found to be more attractive in females.[18] When the mentolabial angle was increased after debonding, the depth related to the lower lip and chin was decreased. These results are in contrast with another study that found that the increase in the mentolabial angle was considered to be more attractive in females.[19] The prominence of the lips was also one of the important parameters in defining the perfect lip fullness, the upper and lower lip should be located 3.50 and 2.20 mm in front of the line traced from subnasale to the pogonion, i.e., the upper lip should be more advanced than lower lip in a 1.6:1 ratio.[20] When the orthodontic bracket removal markedly affects lip position, the orthodontist should consider the final lip position to optimize esthetics.

The relationship of each skeletal configuration and the change in the mentolabial and nasolabial angle was not found in our study. If the sample size was increased in each type of skeletal configuration and each type was divided equally, the results may be different. This study mainly focused on the changes of the lip at the mentolabial and nasolabial angles, however, nearby structures, such as nose and chin, can be evaluated by constructing landmarks for angular measurement. It would also be beneficial to compare this profile photograph analysis with the corresponding cephalometric landmarks, and to evaluate the effects of different treatment modalities, age changes, and various ethnic populations, on soft tissue photographic profiles. Moreover, the lip posture at the end of the treatment after debonding may not reach the maximum change in the short time between debonding and taking the photographs. The progression can observed using the same head fixer tool to examine the longer effects of labial orthodontic brackets on the lip profile to make sure that the orthodontist does not set the lower lip in a dish-in position after bracket removal.

The increased mentolabial angle observed postdebonding has clinical implications, suggesting a tendency for lower lip retrusion and a shallower mentolabial sulcus, potentially affecting facial esthetics and patient satisfaction.[14] This knowledge allows orthodontists to consider these changes during treatment planning, potentially adjusting mechanics or considering adjunctive procedures[15] Furthermore, patient communication regarding potential soft tissue alterations is crucial.[21] While this study offers valuable insights, further research exploring long-term stability and incorporating additional factors is needed to refine our understanding of postdebonding soft tissue dynamics for optimized individualized treatment.

In a future study, the accuracy can be improved by attaching a measuring tool to the head fixer so that the images can be traced and measured in millimeters. Thus, more soft tissue parameters could be measured. Moreover, the Frankfort Horizontal plane was used as a reference plane for the head fixer in our study. It could be beneficial to change from skeletal landmarks on the cephalometric radiograph to the soft tissue landmarks on photographs.

Conclusion

1. There was a significant in change of the mentolabial angle, however, there was no change in the nasolabial angle immediately after debonding the labial orthodontic appliances. Therefore, planning the final esthetics of the mentolabial angle before debonding the orthodontic brackets may need to be considered.

2. The cephalometric parameters maxillary position, mandibular position and skeletal configuration were not significantly correlated to the mean different nasolabial angle and mentolabial angle.

Author contributions

KK: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization, Supervision, Project administration; SL: Methodology, Validation, Formal analysis; HC: Supervision; RI: Investigation; AV: Project administration.

Ethical statement

This prospective study was approved by the Ethics Committee on Human Research at College of Dental Medicine, Rangsit University (COA.No.RSUERB2023-086). All participants provided informed consent before participating in this study.

Disclosure statement

The authors have no conflicts of interest.

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References

1. Ackerman JL, Proffit WR, Sarver DM. The emerging soft

tissue paradigm in orthodontic diagnosis and treatment planning. Clin Orthod Res 1999;2(2):49-52.

2. Abed Y, Har-Zion G, Redlich M. Lip posture following debonding of labial appliances based on conventional profile photographs. Angle Orthod 2009;79(2):235-9.
3. Fernández-Riveiro P, Smyth-Chamosa E, Suárez-Quintanilla D, Suárez-Cunqueiro M. Angular photogrammetric analysis of the soft tissue facial profile. Eur J Orthod 2003;25(4):393-9.
4. Milosević SA, Varga ML, Slaj M. Analysis of the soft tissue facial profile of Croatians using of linear measurements. J Craniofac Surg 2008;19(1):251-8.
5. Ahn HW, Chang YJ, Kim KA, Joo SH, Park YG, Park KH. Measurement of three-dimensional perioral soft tissue changes in dentoalveolar protrusion patients after orthodontic treatment using a structured light scanner. Angle Orthod 2014;84(5):795-802.
6. Eidson L, Cevidanes LH, de Paula LK, Hershey HG, Welch G, Rossouw PE. Three-dimensional evaluation of changes in lip position from before to after orthodontic appliance removal. Am J Orthod Dentofacial Orthop 2012;142(3):410-8.
7. Jang KS, Bayome M, Park JH, Park KH, Moon HB, Kook YA. A three-dimensional photogrammetric analysis of the facial esthetics of the Miss Korea pageant contestants. Korean J Orthod 2017;47(2):87-99.
8. Jeon H, Lee SJ, Kim TW, Donatelli RE. Three-dimensional analysis of lip and perioral soft tissue changes after debonding of labial brackets. Orthod Craniofac Res 2013;16(2):65-74.
9. Kim YK, Lee NK, Moon SW, Jang MJ, Kim HS, Yun PY. Evaluation of soft tissue changes around the lips after bracket debonding using three-dimensional stereophotogrammetry. Angle Orthod 2015;85(5):833-40.
10. Hayashida H, Ioi H, Nakata S, Takahashi I, Counts AL. Effects of retraction of anterior teeth and initial soft tissue variables on lip changes in Japanese adults. Eur J Orthod 2011;33(4):419-26.
11. Farias Gomes A, Moreira DD, Zanon MF, Groppo FC, Haiter-Neto F, Freitas DQ. Soft tissue thickness in Brazilian adults of different skeletal classes and facial types: a cone beam CT - Study. Leg Med (Tokyo) 2020;47:101743.
12. Proffit WR, Fields HW, Sarver DM. Contemporary orthodontics 6th ed. Mosby Elsevier 2018.
13. Arnett GW, Bergman RT. A soft tissue cephalometric analysis. Am J Orthod Dentofacial Orthop 1993;104(4):348-66.
14. Ackerman JL, Proffit WR. Soft tissue considerations in orthodontic treatment. Angle Orthod 1997;67(1):9-20.
15. Sarver DM. The importance of soft tissue in the assessment of the orthodontic patient. World J Orthod 2015;16(1):4-19.
16. Evans JD. Straightforward statistics for the behavioral sciences. Brooks/Cole Publishing 1996.
17. Moshkelgosha V, Fathinejad S, Pakizeh Z, Shamsa M, Golkari A. Photographic facial soft tissue analysis by means of linear and angular measurements in an adolescent Persian population. Open Dent J 2015;9:346-56.
18. Esmaeili S, Mohammadi NM, Khosravani S, Eslamian L, Motamedian SR. Evaluation of facial profile characteristics of aesthetically pleasing Iranian faces. J World Fed Orthod 2023;12(2):76-89.
19. Penna V, Fricke A, Iblher N, Eisenhardt SU, Stark GB. The attractive lip: a photomorphometric analysis. J Plast Reconstr Aesthet Surg 2015;68(7):920-9.
20. Sarnoff DS, Gotkin RH. Six steps to the “perfect” lip. J Drugs Dermatol 2012;11(9):1081-8.
21. Seeholzer C, Klug A. Patients’ perception of soft tissue changes after orthodontic treatment. J Orofac Orthop 2019;80:47-56.

Original Article

Differences between Posteroanterior Cephalometric Analysis By 2D Conventional Posteroanterior Cephalograms and 3D Models Generated from Cone Beam Computed Tomography

Natthiya Rueangnithithanakit* Kulthida Parakonthun **

Abstract

Background: This study compared the differences in posteroanterior (PA) cephalometric analysis on a two-dimensional (2D)-PA cephalogram with cone beam computed tomography (CBCT) via Dolphin imaging software®. **Materials and methods:** Retrospective data from 35 patients who required orthodontic treatment (35 2D-PA cephalograms and 35 CBCT images) were obtained. All radiographs were imported into the Dolphin imaging program®, aligned, and calibrated for magnification using patients' tooth sizes derived from dental models. Landmarks were identified, and linear measurements modified from Grummons analysis were evaluated. 2D-PA cephalograms and CBCT measurements were compared via paired *t* tests ($P < 0.05$). **Results:** According to Grummon PA cephalometric analysis, significant differences ($P < 0.05$) were observed in 10 horizontal, 2 vertical, and 2 mandibular length variables between 2D-PA cephalograms and CBCT. **Conclusion:** Compared with CBCT, 2D-PA cephalography could acceptably indicate the degree of menton deviation. However, the measurements above the maxillary area from 2D-PA cephalograms are significantly different from those from CBCT. PA cephalograms could be used as an initial tool to evaluate lower facial asymmetry. However, for cases requiring detailed analysis and comprehensive planning, CBCT might be necessary.

Keywords: CBCT, Dolphin imaging software®, Grummons analysis, PA cephalometric analysis, 2D PA cephalogram

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Introduction

During clinical examination for orthodontic treatment, various tools, such as the study model, intra- and extraoral photographs, and associated radiographs, are necessary for making an accurate diagnosis and proper treatment planning. Typically, the most common radiographs used for orthodontic evaluation are lateral cephalometric radiographs, which are used to examine the relationships among the cranial base, maxilla, and mandible in the anteroposterior and vertical dimensions,[1] and panoramic radiographs, which provide an overview of the teeth, basal bones, and peripheral structures, such as the temporomandibular joint (TMJ), and various parts of the mandible.[2,3]

Additional radiographs, such as posteroanterior cephalometric radiographs (PA cephalograms) and periapical films, which are frequently taken in conjunction with previous radiographs for evaluating abnormalities in all three dimensions (transverse, anteroposterior, and vertical), may be considered in cases of facial or dental asymmetry. If a patient has severe malocclusion or facial deformity or has undergone orthognathic surgery, cone beam computed tomography (CBCT) should be used.[2,3] There are several benefits of CBCT in orthodontics, including the assessment of anomalies in the dental position, impacted teeth, and the detection of any supernumerary teeth. CBCT can be utilized in craniofacial orthodontics to assess the effects of maxillary expansion and evaluate clefts; it also provides a three-dimensional (3D) assessment for alveolar boundary conditions, assesses the relationship between dentition and jaw bones, and detects root resorption in the labial and palatal surfaces of the teeth that are not visible in two-dimensional (2D) radiographs. Additionally, CBCT can provide information regarding the bony structure of the TMJs and help in deciding on mini-implant placement.[2,4-7] However, there are still some drawbacks to using CBCT in orthodontics, such as higher radiation doses than conventional techniques do, difficulty in distinguishing soft tissue types, greater time consumption for landmark identification, lower accuracy for caries detection, the presence of inherent artifacts from metal orthodontic brackets and bands, and greater time and greater cost than conventional radiography does.[3,4,7]

The analysis of 2D cephalometric radiographs, both lateral and posteroanterior, frequently reveals problems with magnification, distortion, and superimposition of the surrounding structures. These are significant issues that could result in landmark identification errors in cephalometric analysis,[8] leading to incorrect diagnoses and treatment plans, particularly in posteroanterior cephalometric radiographs. Therefore, CBCT images have been widely used in orthodontics[3,4,9] due to the lack of magnification, overlap, and distortion of structures, and CBCT can generate real-size 3D images of patients, allowing for precise and accurate analysis and measurements.[7,10]

Several previous studies have examined the validity and accuracy of landmark identification via PA cephalograms and reported that midline landmarks are more reproducible than bilateral skeletal landmarks.[11] Most landmarks showed good reproducibility, except for some landmarks located in the zygomatic arch, mandible, and dentition. This factor could cause inaccurate PA cephalometric analysis when evaluating dental discrepancies or maxillary–mandibular relationships.[12] Bajaj K. et al., compared the reliability of landmark identification between PA cephalograms and CBCT images. They reported that CBCTs were more accurate and reliable than were PA cephalograms.[8] Damstra J. et al., reported that, compared with PA cephalograms, CBCT images were more reliable and accurate in detecting mandibular asymmetry.[13] In contrast, some studies reported that there was no difference between the PA cephalogram and CBCT in measuring and diagnosing landmarks and evaluating asymmetry. However, CBCT provides more comprehensive and detailed information about craniofacial anatomy.[14,15]

Many previous studies[8,11-15] focused on the accuracy and reliability of landmark identification, including the comparison of linear or angular measurements in PA cephalometric analysis on 2D PA cephalograms and on CBCT-generated PA cephalograms. Reports on differences in posteroanterior cephalometric analysis between 2D PA cephalograms and 3D skull models generated from CBCT images directly are still limited. Therefore, the aim of this study was to compare the differences in linear measurements in PA cephalometric analysis between 2D PA cephalograms and 3D skull models generated from CBCT images.

Materials and methods

Sample size

This retrospective study used original radiographic data from 35 patients who underwent orthodontic treatment at the Faculty of Dentistry, Srinakharinwirot University, from 2018-2023. All 35 patients had received initial records and examinations with additional tools, such as dental models and cephalometric radiographs. Ethical approval for this study was obtained from the Human Research Ethics Committee of Srinakharinwirot University (Certificate Number SWUEC/E-213/2565). The inclusion and exclusion criteria were as follows:

Inclusion criteria

1) Patients aged 20 years and over.

2) The patients had previously undergone 2D PA cephalometric radiography (Soredex Cranex D Panoramic & Ceph X-ray) and CBCT imaging (Acteon Whitefox) before the beginning of orthodontic treatment.

3) The quality of the 2D PA cephalograms was good (proper density, blackness, contrast, and proper head position).

4) All patients had dental models that were in perfect condition, especially upper or lower central incisors.

Exclusion criteria

1) Patients with congenital genetic abnormalities such as cleft lip and palate or craniofacial anomalies, including a history of facial and jaw injuries.

2) The radiographs revealed signs of head tilting or rotation or where the occlusion was not positioned in centric occlusion.

3) Radiographs with full crown restorations on the upper or lower central incisors.

Patients with any skeletal classification (Classes I, II, or III) were eligible for inclusion in this study if they satisfied the specified criteria.

A sample size calculation was performed with G*power software version 3.1.9.6 (Heinrich Heine, Universitat Dusseldorf, Germany), assuming that the effect size was 0.5 (d = 0.5), $\alpha = 0.05$ with 80 % statistical power. The total sample size was 34 patients per study group.

Methods for importing 2D PA cephalograms and 3D reconstructions from CBCT images via Dolphin Imaging Software®

For 2D PA cephalography

1) The file of the PA cephalogram was imported into Dolphin Imaging Software®.

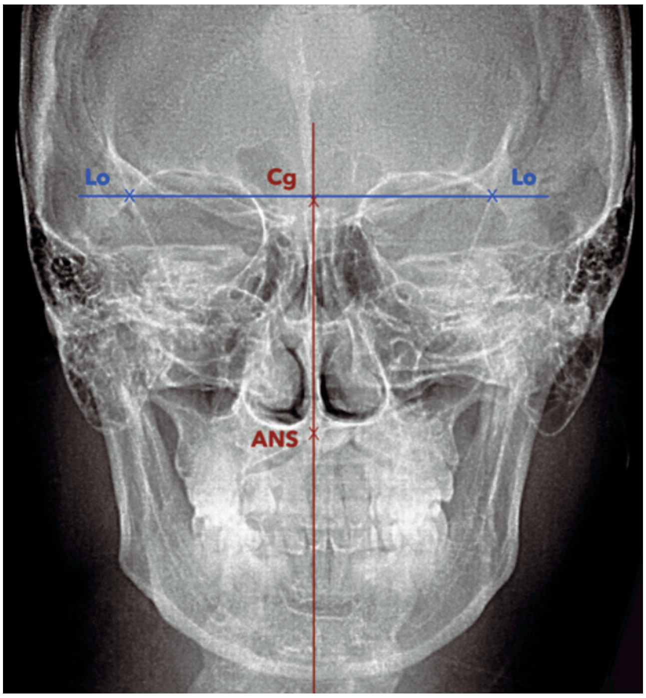

Figure 1 Orientation of a 2D PA cephalogram, with the midsagittal reference plane aligned perpendicular to the Latero-Orbital Line.

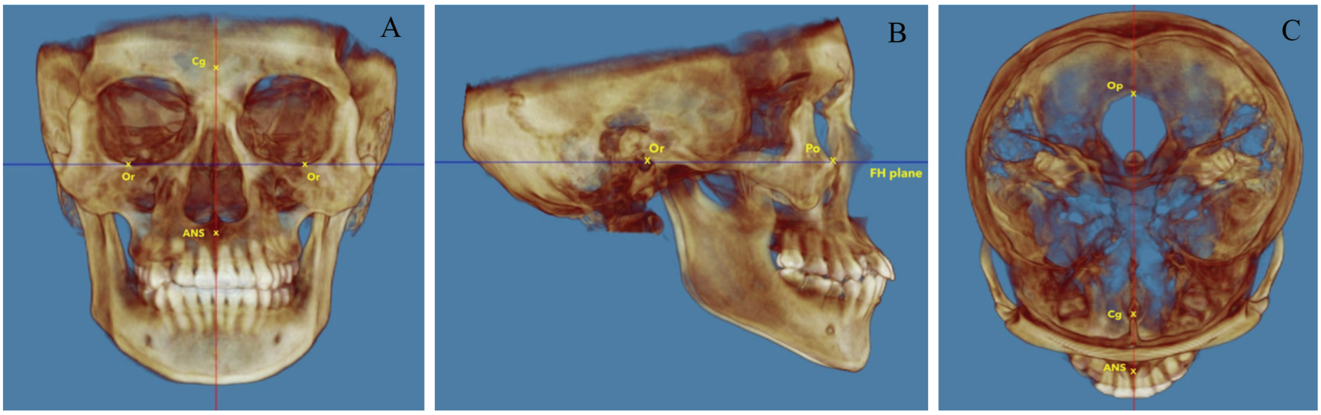

Figure 2 Orientation of 3D CBCT: (A, C) The midsagittal plane passing through Cg (Crista galli), ANS (anterior nasal spine), and Op (opisthion) was aligned perpendicular to the Frankfort Horizontal Plane. (B) The Frankfort Horizontal Plane was defined by Po(R) (Porion Right), Or (Orbitale), and Po(L) (Porion Left).

2) The radiographs were adjusted to the proper position, ensuring that the midsagittal plane (a line passing through the Crista galli and anterior nasal spine) was perpendicular to the horizontal reference plane (latero-orbital line: Lo-Lo),[16,17] as shown in Figure 1.

CBCT data

1) The DICOM data of the CBCT image were copied to the computer.

2) By using Dolphin Imaging Software®, the patient's DICOM data were downloaded with 30 % downsizing (recommended by the company).

3) The program processed and rendered the data into a 3D skull model.

4) The head position was reoriented by aligning the midsagittal reference plane (Cg-ANS-Op)[18] perpendicular to the horizontal reference plane (Po(R)-Or-Po(L)). Unrelated parts, such as the cervical vertebrae, were trimmed off for clarity, as shown in Figure 2.

The landmark measurements on the 2D PA cephalogram and 3D skull model generated from CBCT according to the Grummons PA cephalometric analysis

The measurement in this study was performed by one examiner (NR) who has had orthodontic treatment experience for 4 years. The data from 35 patients were divided into 2 groups.

Group 1–2D PA cephalometric radiographs

Group 2–3D skull model generated from CBCT images

1) The landmark points were determined in both groups (Figure 3). The definitions of each landmark on the 2D PA cephalogram and 3D skull image are shown in Table 1.

2) The midsagittal reference plane (MSR), which was the line from the Crista galli (Cg) to the anterior nasal spine (ANS), was set in Group 1, and the MSR from the Cg to the ANS and opening (Op) were set in Group 2.

3) Linear horizontal distances were measured from landmark points on each side to the midsagittal reference plane (MSR), linear vertical distances were measured from the Cg (Crista galli) point to the given landmarks, and the mandibular length was measured according to the Grummons PA cephalometric analysis on both 2D PA cephalogram and 3D skull image to compare the differences between the two groups. In 3D imaging, linear horizontal and vertical distances are measured by projecting the landmark points onto the anterior facial plane, resulting in 2D distances, whereas the mandibular length is measured directly in 3D distances, as shown in Figures 4-6.

4) Owing to the different magnifications of different radiographs, the size of the upper or lower

Table 1 Abbreviations and definition of reference points and midsagittal plane used in this study.[1]

The reference points and midsagittal plane in the Grummons PA cephalometric analysis		
AG(R)/AG(L)	: Antegonial notch	The deepest point of the antegonial depression
ANS	: Anterior nasal spine	The most anterior point above the hard palate and below the nasal cavity
Cg	: Crista galli	The highest point of the triangular protrusion of the ethmoid bone that protrudes from the cribriform plate
Co(R)/Co(L)	: Condylion	The highest point on the mandibular condyle
J(R)/J(L)	: Jugal process	The highest point on the maxillary alveolar process
Me	: Menton	The lowest point of the mandibular symphysis
NC(R)/NC(L)	: Nasal cavity	The outermost point of the nasal cavity
ZA(R)/ZA(L)	: Zygomatic arch	The outermost (lateral) point of the zygomatic arch
MSR	: Mid-Sagittal reference plane	The mid-facial line through the Cg and ANS points

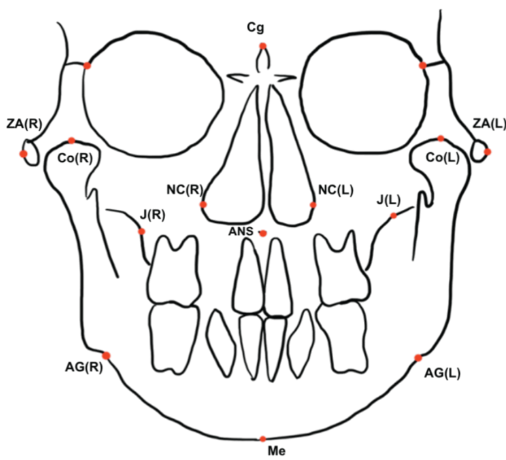

Figure 3 Reference points on PA cephalogram according to the Grummons analysis.[19]

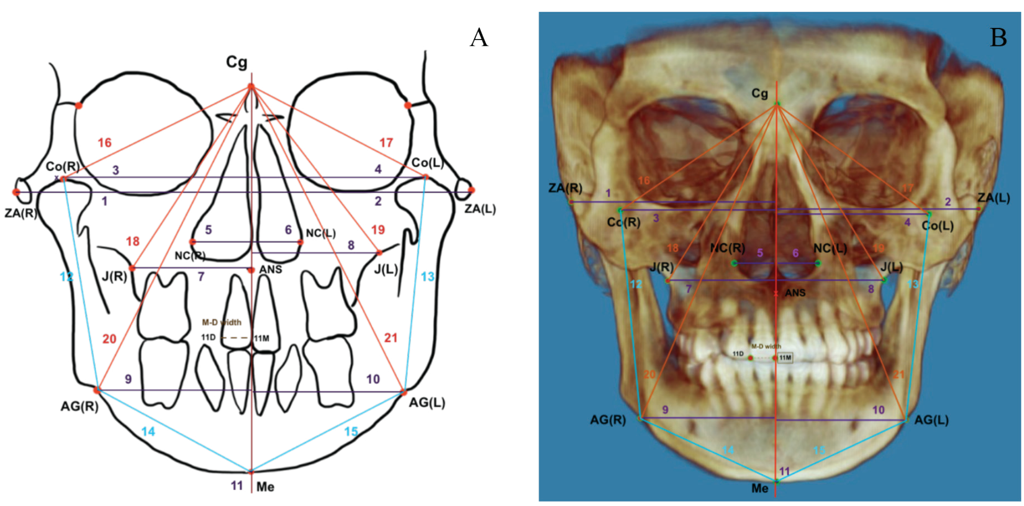

Figure 4 (A) The horizontal-vertical linear measurements and mandibular length used in this study.[19] Purple lines were linear horizontal measurements that represented the distances between the bilaterally skeletal landmarks and MSR. Orange lines were linear vertical measurements that represented the distances between the given landmarks and Cg. Blue lines were mandibular length measurements that represented the distances of Co-AG and AG-Me. (B) 3D skull generated by the Dolphin imaging software.

incisors was used to calibrate scales (depending on the skeletal relationship type I, II, or III). The tooth size was measured directly from the patient's dental model. All the measurements were repeated twice at least one week apart, and the average of the measurements was used for further analysis and interpretation. All measurements were recorded in millimeters (mm).

5) All samples in each group were identified at landmark positions and measured twice within 1-week intervals to assess intraexaminer reliability.

Figure 5 An example of a 2D PA cephalogram with all variables measured.

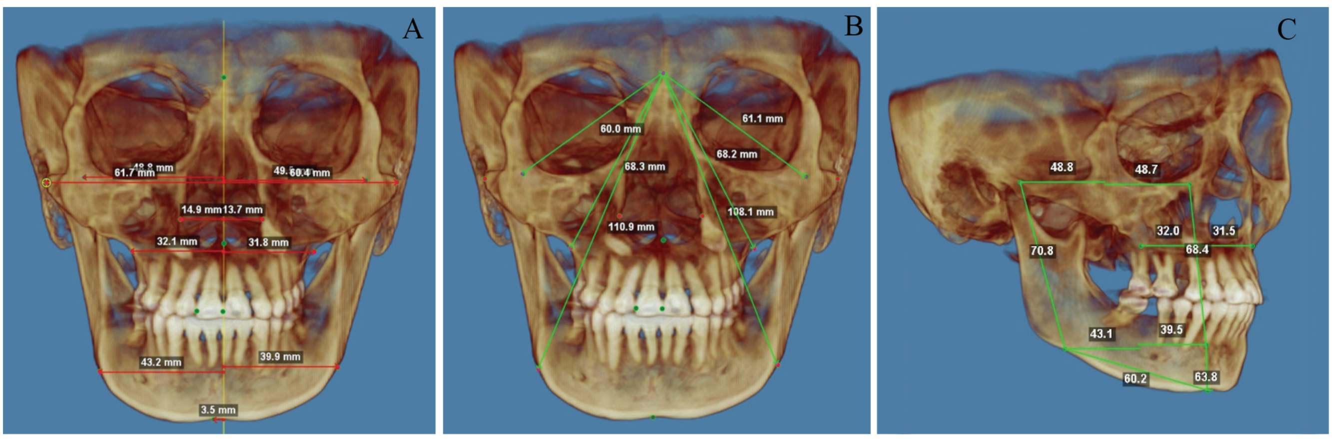

Figure 6 An example of CBCT in Dolphin Software with all variables measured. (A) Linear horizontal distances, (B) linear vertical distances, and (C) mandibular length measurements.

Statistical analysis

1) Intraexaminer reliability was analyzed via the intraclass correlation coefficient (ICC).

2) All the data were tested for normality via the Shapiro–Wilk test, and the mean difference between the two groups was compared via paired t tests or Wilcoxon tests (IBM SPSS Statistics, Version 28.0.1.0 (IBM, Armonk, NY)). A *P* value < 0.05 was considered statistically significant.

Results

All variables were normally distributed. The intraclass correlation coefficient was high (the average ICC value of the 2D group was 0.925 [0.833-0.974], and the ICC value of the 3D group was 0.963 [0.895-0.998]), indicating good to excellent intraexaminer reliability.

In this study, 21 variables were measured from thirty-five 2D PA cephalometric radiographs and a 3D skull model generated from CBCT images. The results from the measurements are summarized in Table 2. The results of the Grummons PA cephalometric analysis revealed significant differences (*P* < 0.05) in 10 horizontal variables (ZA(R)-MSR, ZA(L)-MSR, Co(R)-MSR, Co(L)-MSR, NC(R)-MSR, NC(L)-MSR, J(R)-MSR, J(L)-MSR, AG(R)-MSR, AG(L)-MSR), 2 vertical variables (Cg-Co(R), Cg-Co(L)), and 2 mandibular length variables (AG(R)-Me, AG(L)-Me) when the PA cephalometric analysis of the 2D-PA cephalogram and CBCT data was compared. All the significant variables are shown in the figure below (Figure 7). However, other areas were not significantly different.

Table 2 The results of the 21 variables measured in this study were presented, with those showing significant differences highlighted.

	Variables	n	Paired differences (mm) Mean	Std. Deviation	Std. Error Mean	95 % Confidence Interval of the Difference Lower	Upper	t	df	*P* value
Horizontal measurements	(2D) ZA(R)-MSR - (3D-P) ZA(R)-MSR	35	4.92	4.60	0.77	3.34	6.50	6.32	34	< 0.001*
	(2D) ZA(L)-MSR - (3D-P) ZA(L)-MSR	35	4.84	5.53	0.93	2.94	6.74	5.17	34	< 0.001*
	(2D) Co(R)-MSR - (3D-P) Co(R)-MSR	35	6.40	4.21	0.71	4.95	7.85	8.99	34	< 0.001*
	(2D) Co(L)-MSR - (3D-P) Co(L)-MSR	35	5.20	4.78	0.80	3.55	6.84	6.43	34	< 0.001*
	(2D) NC(R)-MSR - (3D-P) NC(R)-MSR	35	4.85	1.74	0.29	4.25	5.45	16.44	34	< 0.001*
	(2D) NC(L)-MSR - (3D-P) NC(L)-MSR	35	4.15	2.13	0.36	3.41	4.88	11.49	34	< 0.001*
	(2D) J(R)-MSR - (3D-P) J(R)-MSR	35	0.94	2.47	0.41	0.09	1.79	2.25	34	0.031*
	(2D) J(L)-MSR - (3D-P) J(L)-MSR	35	1.50	3.02	0.51	0.46	2.54	2.94	34	0.006*
	(2D) AG(R)-MSR - (3D-P) AG(L)-MSR	35	2.45	3.47	0.58	1.26	3.64	4.17	34	< 0.001*
	(2D) AG(L)-MSR - (3D-P) AG(L)-MSR	35	3.73	4.34	0.73	2.24	5.22	5.08	34	< 0.001*
	(2D) Me-MSR - (3D-P) Me-MSR	35	-0.75	2.68	0.45	-1.67	0.17	-1.65	34	0.108
Vertical measurements	(2D) Cg-Co(R) - (3D-P) Cg-Co(R)	35	4.08	5.21	0.88	2.29	5.87	4.63	34	< 0.001*
	(2D) Cg-Co(L) - (3D-P) Cg-Co(L)	35	2.29	6.22	1.05	0.15	4.42	2.17	34	0.037*
	(2D) Cg-J(R) - (3D-P) Cg-J(R)	35	1.23	5.73	0.96	-0.73	3.20	1.27	34	0.213
	(2D) Cg-J(L) - (3D-P) Cg-J(L)	35	1.62	5.99	1.01	-0.43	3.68	1.60	34	0.117
	(2D) Cg-AG(R) - (3D-P) Cg-AG(R)	35	2.09	8.86	1.49	-0.94	5.14	1.40	34	0.171
	(2D) Cg-AG(L) - (3D-P) Cg-AG(L)	35	2.24	9.27	1.56	-0.94	5.42	1.43	34	0.161
Mandibular length	(2D) Co(R)-AG(R) - (3D) Co(R)-AG(R)	35	0.83	6.33	1.07	-1.34	3.00	0.77	34	0.442
	(2D) Co(L)-AG(L) - (3D) Co(L)-AG(L)	35	1.34	6.15	1.04	-0.76	3.46	1.29	34	0.204
	(2D) AG(R)-Me - (3D) AG(R)-Me	35	-16.20	5.34	0.90	-18.03	-14.36	-17.94	34	< 0.001*
	(2D) AG(L)-Me - (3D) AG(L)-Me	35	-17.58	5.53	0.93	-19.48	-15.67	-18.79	34	<.001*

Abbreviations: 2D, two-dimensional distances; 3D-P. 3D-projected distances; 3D, three-dimensional distances.

* Statistically significant at *P* value < 0.05

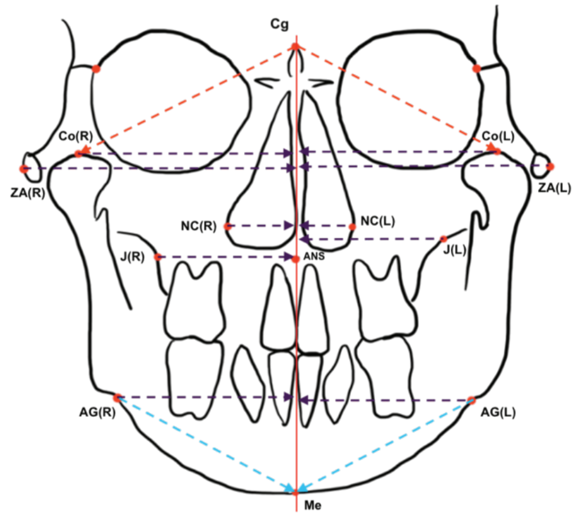

Figure 7 The diagram indicated significant differences in 10-horizontal (purple dashed line), 2-vertical (orange dashed line), and 2-mandibular body length (blue dashed line) measurements when comparing the PA cephalometric on 2D-PA cephalogram and CBCT.

Discussion

Posteroanterior (PA) cephalograms are additional radiographs that are frequently taken in conjunction with lateral cephalograms and panoramic radiographs to assess abnormalities, especially in cases of facial or dental asymmetry.[2,19,20] PA cephalometric analysis is usually performed on conventional 2D PA skull images, which frequently reveals problems with magnification, distortion, and superimposition of the surrounding structures. Although the PA cephalogram has several limitations, it is nevertheless widely used because of its simplicity, rapidity, cost-effectiveness, and minimal radiation exposure.[4,8,21] When the advantages and disadvantages of this image are compared with the benefits that the patient receives, the 2D PA cephalogram is generally considered sufficient for initial diagnosis, treatment planning, monitoring, and posttreatment evaluation in uncomplicated cases.[4] CBCT, on the other hand, is increasingly regarded as the gold standard for oral and maxillofacial imaging, particularly in orthodontics, including the assessment of dental position anomalies, as well as in patients with severe malocclusion, facial deformity, or those undergoing orthognathic surgery. Unlike conventional radiographs, CBCT provides volumetric data, enabling the generation of real-size 3D images without distortion or overlapping structures, thus offering more precise and reliable landmark identification and measurement.[6] Our study corroborates these benefits, with high intrarater reliability observed in both imaging modalities (ICC for 2D = 0.925; ICC for 3D = 0.963). This is consistent with findings by Bajaj et al., who reported higher accuracy and reliability in CBCT imaging than in PA cephalograms.[8]

Dolphin imaging software® was used in this study, and we found that the results from this study were similar to those of the studies by Damstra et al., and Tai et al. The right and left mandibular body lengths (AG(R)-Me and AG(L)-Me), including the mandibular width (AG(R)-MSR and AG(L)-MSR), which were measured in the 2D group, were significantly different from those in the 3D CBCT group.[13, 22] Furthermore, our study revealed contrasting results with prior studies, particularly in the PA cephalometric analysis of the upper face, where significant differences were observed for ZA(R)-MSR, ZA(L)-MSR, Co(R)-MSR, Co(L)-MSR, NC(R)-MSR, NC(L)-MSR, J(R)-MSR, J(L)-MSR, Cg-Co(R), and Cg-Co(L). No significant differences were found for mandibular ramus length (Co(R)-AG(R), Co(L)-AG(L)), lower facial height (Cg-J(R), Cg-J(L), Cg-AG(R), Cg-AG(L)), or menton deviation from the midline (Me-MSR)). These findings highlight the differential reliability of 2D imaging across craniofacial regions and align with previous studies emphasizing the challenges posed by magnification and beam divergence in conventional radiographs. However, the results of this study differed from those of prior studies using Ricketts analysis and software such as Viewbox (for conventional PA cephalograms) and Simplant Ortho Pro 2.00 (for CBCT).[13,22] By employing Grummons PA cephalometric analysis, a comparative and quantitative approach, we focused on differences in landmark-based measurements rather than normative data.[1,15,20]

Clinical Significance of Findings

While statistically significant differences were observed in several variables, their clinical relevance varies. For example, a difference of approximately 0.94 mm in (2D) J(R)-MSR - (3D-P) J(R)-MSR may fall within clinically acceptable limits for routine orthodontic evaluations. However, larger differences, such as mandibular body lengths (AG(R)-Me, AG(L)-Me) exceeding 16 mm, are likely to have significant clinical implications, particularly in cases involving facial asymmetry or surgical planning. Furthermore, a consistent trend of overestimation in horizontal and vertical distances was identified in 2D imaging compared with 3D projections, with statistically significant differences across multiple variables (e.g., ZA(R)-MSR, ZA(L)-MSR, Co(R)-MSR, Co(L)-MSR, NC(R)-MSR, NC(L)-MSR; all P values < 0.001). This overestimation is attributed primarily to the inherent limitations of traditional 2D cephalometric radiography, particularly magnification and distortion effects. Conversely, mandibular length measurements (e.g., AG(R)-Me and AG(L)-Me) were significantly underestimated in 2D imaging relative to 3D imaging (- 16.20 mm and - 17.58 mm, respectively; P values < 0.001). This discrepancy can be explained by the fundamental differences in landmark positioning in 3D space. While 2D imaging captures linear distances along a perpendicular axis, which results in a lack of depth perception, 3D imaging accounts for complex spatial trajectories, leading to increased measured distances. This limitation is particularly relevant in mandibular assessments, where anatomical curvatures and spatial positioning necessitate precise measurement techniques. The observed discrepancies emphasize the need for caution when relying solely on 2D imaging for transverse discrepancy or asymmetry evaluations. While 2D imaging may suffice for uncomplicated cases, CBCT is advantageous in scenarios requiring high precision, such as craniofacial surgery, severe malocclusions, or detailed assessments of anatomical structures.

Utility of Dolphin Imaging Software

This study utilized Dolphin Imaging Software® to perform measurements based on the Grummons method for both 2D and 3D images. The software facilitated the projection and identification of landmarks within 3D images; however, measurements were conducted in 2D due to the positioning of landmarks and reference planes in different planes within the 3D dataset. Notably, the software's ability to measure true 3D distances, such as mandibular ramus and body lengths, highlights the advantages of CBCT imaging over conventional 2D techniques by providing more accurate and clinically relevant measurements.[23,24]

While CBCT is currently recommended as the gold standard method and has many advantages in orthodontics, it is not universally indicative or a standard diagnostic radiograph for all orthodontic patients. Clinicians must carefully weigh the potential risks, such as increased radiation exposure and additional costs, against the benefits of enhanced diagnosis and treatment planning before recommending CBCT for their patients.[2,4,25]

Limitations of research

Several limitations of this study should be acknowledged. First, the retrospective design of this study inherently limits control over the consistency of data collection, particularly with respect to radiograph quality and initial positioning. Additionally, the calibration method used to adjust for magnification in the 2D X-ray images was a modification of the standard approach due to the absence of a ruler on the radiographic images. Second, the sample size (n = 35) was relatively small, which limits the generalizability of the findings. A larger sample population could have provided greater statistical power and enabled subgroup analyses based on factors such as skeletal classification or age group to explore the potential influence of demographic or clinical variations. Finally, differences between imaging modalities present inherent limitations. While CBCT provides volumetric data, enabling more precise localization of landmarks, conventional 2D radiographs are subject to magnification and superimposition of anatomical structures. Despite efforts to calibrate for magnification differences, eliminating this bias has proven challenging.

For further research, a prospective design with standardized imaging protocols and larger, more diverse sample populations should be included to validate these findings. Additionally, comparisons between conventional 2D PA cephalograms and CBCT-reconstructed 2D images could provide further insight into the clinical value of CBCT in orthodontics.

Conclusions

This study led to several important conclusions regarding imaging techniques used to assess facial asymmetry. 2D PA cephalograms were found to be useful for evaluating menton deviation. However, significant differences were observed in measurements of the upper facial region when compared to CBCT, indicating limitations of 2D imaging in this area. Additionally, caution is recommended when using 2D PA cephalograms to assess lower facial asymmetry, particularly in the mandibular angle and body regions, due to notable discrepancies in measurements compared with CBCT. Overall, CBCT provided more accurate and reliable landmark identification and cephalometric measurements, highlighting its importance in cases that require precise anatomical assessment.

Author contributions

NR: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing-Original draft, Writing-Review & Editing, Visualization; KP: Conceptualization, Writing-Review & Editing, Supervision, Project administration.

Ethical statement

The study protocol was approved by the Human Research Ethics Committee of Srinakharinwirot University (Certificate Number: SWUEC/E-213/2565).

Disclosure statement

The authors have no conflicts of interest.

References

1. Athanasiou AE. Orthodontic cephalometry. London: Mosby-Wolfe; 1995.p.9-11
2. Proffit WR, Fields HW, Sarver DM. Contemporary orthodontics. 5th ed: Elsevier Health Sciences; 2014:147-275.
3. Dindaroglu F, Yetkiner E. Cone beam computed tomography in orthodontics. Turk J Orthod 2016;29(1):16-21.
4. Abdelkarim A. Cone-beam computed tomography in orthodontics. Dent J (Basel) 2019;7(3):89
5. Premkumar S. Textbook of orthodontics. New Delhi: Elsevier; 2015:253-313.
6. Venkatesh E, Elluru SV. Cone beam computed tomography: basics and applications in dentistry. J Istanb Univ Fac Dent 2017;51(3 Suppl 1):S102-21.
7. Meena R, Chauhan R, Bharvada K. A review on cone beam computed tomography in orthodontics. SVOA Dent 2022;3(1):47-51.
8. Bajaj K, Rathee P, Jain P, Panwar VR. Comparison of the reliability of anatomic landmarks based on PA cephalometric radiographs and 3D CT scans in patients with facial asymmetry. Int J Clin Pediatr Dent 2011;4(3):213-23.
9. Hechler SL. Cone-beam CT: applications in orthodontics. Dent Clin North Am. 2008;52(4):809-23.
10. Kaygisiz E, Tortop T. Cone beam computed tomography in orthodontics. In: Halefoglu AM, Editor.Computed Tomography - Advanced Applications. intechopen 2017. p.117-38.

11. Leonardi R, Annunziata A, Caltabiano M. Landmark identification error in posteroanterior cephalometric radiography: a systematic review. Angle Orthod 2008; 78(4):761-5.
12. Sicurezza E, Greco M, Giordano D, Maiorana F, Leonardi R. Accuracy of landmark identification on postero-anterior cephalograms. Prog Orthod 2012;13(2):132-40.
13. Damstra J, Fourie Z, Ren Y. Evaluation and comparison of postero-anterior cephalograms and cone-beam computed tomography images for the detection of mandibular asymmetry. Eur J Orthod 2013;35(1):45-50.
14. Yousefi F, Rafiei E, Mahdian M, Mollabashi V, Saboonchi SS, Hosseini SM. Comparison efficiency of posteroanterior cephalometry and cone-beam computed tomography in detecting craniofacial asymmetry: a systematic review. Contemp Clin Dent 2019;10(2):358-71.
15. Sfogliano L, Abood A, Viana G, Kusnoto B. Cephalometric evaluation of posteroanterior projection of reconstructed three-dimensional Cone beam computed tomography, two-dimensional conventional radiography, and direct measurements. J World Fed Orthod 2016;5(1):22-7.
16. Chen C-M, Tseng Y-C, Ko EC, Chen M, Chen K-J, Cheng J-H. Comparisons of Jaw Line and Face Line after Mandibular Setback: Intraoral Vertical Ramus versus Sagittal Split Ramus Osteotomies. BioMed Res Int 2018;2018:1-7.
17. Kang H-J, Kim J-R, Kim Y-I. Validity of Horizontal Reference Planes on Cone-Beam Computed Tomography Generated Postero-Anterior Cephalogram. Maxillofac Plast Reconstr Surg 2011;33(4):346-51.
18. Hwang HS, Hwang CH, Lee KH, Kang BC. Maxillofacial 3-dimensional image analysis for the diagnosis of facial asymmetry. Am J Orthod Dentofacial Orthop 2006;130(6):779-85.
19. Szuhanek C, Nagib R, Sabo-Meze A, Buzatu R, Malita D. Cephalometric antero-posterior parameter evaluation in orthodontic patients with facial asymmetries. J Dent Oral Implants 2020;2(3):8-15.
20. Edgren B. The frontal cephalometric analysis – the forgotten perspective. Orthod Pract US 2013;4(5):28-33.
21. Garib DG, Calil LR, Leal CR, Janson G. Is there a consensus for CBCT use in orthodontics? Dental Press J Orthod 2014;19(5):136-49.
22. Tai B, Goonewardene MS, Murray K, Koong B, Islam SMS. The reliability of using postero-anterior cephalometry and cone-beam CT to determine transverse dimensions in clinical practice. Aust Orthod J 2014;30(2):132-42.
23. Patterson Dental Holdings, Inc. Dolphin Imaging: Comprehensive Software Guide. 2020 Available from: https://www.dolphinimaging.com/product/ThreeD.
24. Wang CH, Randazzo L. Evolution of imaging and management systems in orthodontics. Am J Orthod Dentofacial Orthop 2016;149(6):798-805.
25. Scarfe WC, Pinheiro LR, Farman AG. CBCT and the orthodontic patient: Cone-beam computed tomography offers key benefits in all phases of orthodontics-from diagnosis to post-treatment. Dimensions of Dental Hygiene 2014;12(8):18-21.

Original Article

The Differences of Perception of Asymmetry on Chin and Lip in Facial Asymmetry Patients Rated by Laypersons and Orthodontists

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Abstract

Background: The perception of facial asymmetry plays a critical role in the diagnosis and treatment planning in orthodontics. **Objective:** This study aimed to evaluate the perception of chin deviation and lip canting and to compare the differences in perception between laypersons and orthodontists. **Materials and methods:** Fifty-five new patients presenting with facial asymmetry were examined. Subjects were categorized into four groups based on the severity of chin deviation and lip canting. Three-dimensional (3D) facial images and corresponding mirror images were generated. A total of twenty-six laypersons and orthodontists were asked to compare the original and mirror images, after which they categorized the asymmetry into three levels: normal, acceptable, and unacceptable. **Results:** For chin deviations of 0–2 mm, laypersons generally perceived the asymmetry as normal, while orthodontists classified it as either normal or acceptable. In cases of chin deviation exceeding 2–4 mm, laypersons tended to rate it as acceptable, whereas orthodontists judged it as unacceptable. When the chin deviation exceeded 4 mm, both groups perceived it as unacceptable. Regarding lip canting of 0–1 mm, both laypersons and orthodontists classified it as normal. When lip canting increased to over 1–2 mm, laypersons still considered it normal, while orthodontists classified it as acceptable. Lip canting exceeding 2–3 mm was generally perceived by both groups as acceptable, and canting greater than 3 mm was considered unacceptable by both laypersons and orthodontists. **Conclusion:** Orthodontists exhibited greater sensitivity than laypersons in perceiving both chin deviation and lip canting.

Keywords: Chin deviation, Facial asymmetry, Lip canting, Perception

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Introduction

A symmetrical face is rare in the general population. Most human faces exhibit some degree of asymmetry, particularly in the midface and lower facial regions.[1] Jacobson et al. reported that 36 % of individuals displayed asymmetry in the midface, while 74 % showed asymmetry in the lower face. As noted in previous studies, the lower face is the most common region where asymmetry is observed.[2] For example, chin deviation refers to the misalignment of the soft tissue Menton (Me') relative to the midsagittal plane, whereas lip canting is defined as the discrepancy in the level between the right and left Cheilion (Ch) compared with a horizontal reference line.

In recent years, patients have become increasingly concerned with facial esthetics.[3] In cases where facial asymmetry is noticeable, it may affect not only esthetic appearance but also function and psychosocial well-being. Before initiating treatment, it is essential to assess the chief complaint, medical and dental history, the patient's perception of asymmetry, and both extraoral and intraoral examinations. Therefore, in addition to objective facial asymmetry assessments and comprehensive clinical evaluations, subjective perception also plays a crucial role in informing appropriate treatment planning.[4] Despite this, there is currently no clinical guideline defining the degree of chin deviation or lip canting that should be accepted or corrected.

The perception of chin deviation and lip canting has been the subject of study for decades. Some research has shown that laypersons can detect chin deviations greater than 4 mm.[5] One study reported that the normal range of chin deviation was 5.60 ± 2.70 mm when evaluated by laypersons and 3.60 ± 1.50 mm when assessed by orthodontists.[6] However, many prior studies have certain limitations. For example, some created artificial chin deviation and lip canting using computer software, resulting in unnatural images that may have influenced perception. Additionally, other studies relied on two-dimensional (2D) photographs, where improper head positioning during image capture may have led to inaccurate assessments.[7,8] However, there remains limited evidence regarding the perception of chin deviation and lip canting using unaltered three-dimensional (3D) images. Therefore, this study utilizes unmodified 3D facial images from a diverse Thai population. The findings may inform orthodontic, surgical, or cosmetic treatment considerations. The perception of orthodontists should be used as a reference for ideal treatment planning, whereas the perception of laypersons may be useful for planning acceptable or compromised treatment outcomes. Consequently, this study aims to evaluate the range of chin deviation and lip canting classified as normal, acceptable, or unacceptable, as rated by both laypersons and orthodontists, and to compare the differences in their perception.

Materials and methods

A consecutive sampling method was initially used to screen all new patients presenting at the Orthodontic Clinic, Faculty of Dentistry, Khon Kaen University, who met the inclusion criteria. Subsequently, purposive sampling was used to select participants based on varying degrees of facial asymmetry. The study population comprised the following:

1) Subjects were new patients with facial asymmetry, aged between 18 and 35 years, who had no history of orthodontic treatment, cosmetic procedures, or facial trauma. Individuals with congenital malformations or systemic diseases were excluded from the study.

2) Raters were candidates who assessed the degree of chin deviation and lip canting. They were divided into two groups:

a. Laypersons were orthodontic patients aged between 18 and 60 years who voluntarily participated in the study. They had no affiliation with medical or dental education or employment.

b. Orthodontists were those who had completed a postgraduate orthodontic program and either had at least five years of clinical experience in orthodontic treatment or held diplomate status from the Thai Board of Orthodontics.

The required sample size was calculated based on the study by Kaipainen et al.,[9] using a 95 % confidence level, $\propto = 0.05$ ($Z_{\propto}/2 = 1.96$), and an allowable error (e) of 0.50 mm. As a result, the number of subjects assessed was 16 patients, with 13 laypersons and 13 orthodontists included as raters.[10]

All subjects underwent comprehensive orthodontic record collection, which included intraoral and extraoral clinical examinations, two-dimensional intraoral photographs, three-dimensional extraoral photographs (Bellus 3D Inc., Campbell, CA, USA), study models, and both lateral and posteroanterior cephalometric radiographs (Sirona Dental Systems Inc., Long Island, NY, USA).

3D Image Collection and Preparation

Patients were positioned with relaxed lips and in a natural head position, maintaining a distance of 30 centimeters from the camera (Apple Inc., Cupertino, CA, USA). The scanning software captured each subject over a 10-second period and generated a three-dimensional (3D) facial image, saved in Object file (OBJ) format. These OBJ files were subsequently imported into the Dolphin Imaging software (Patterson Dental Supply Inc., Chatsworth, CA, USA).

Each 3D image was then analyzed by identifying six midline and one pair of bilateral soft tissue anatomical landmarks for the purpose of asymmetry measurement (Table 1, Figure 1).

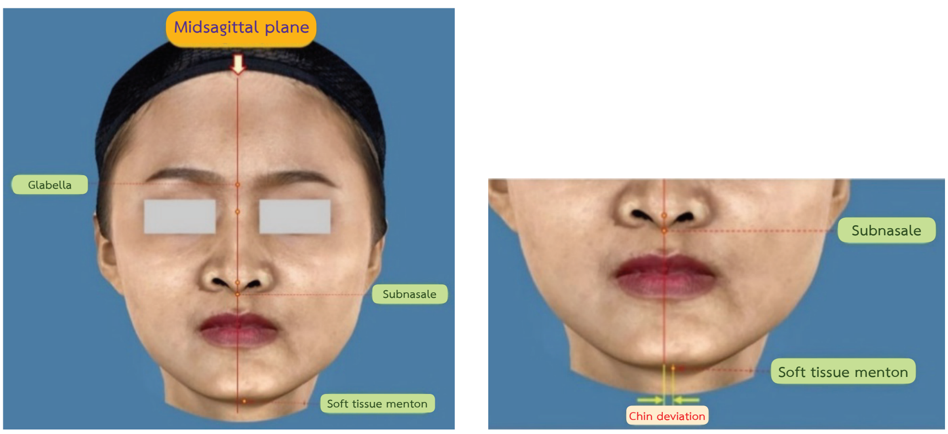

Figure 1 Landmark identification and measurement of chin deviation

Figure 2 Landmark identification and measurement of lip canting

Table 1 Description of 3D landmarks used in the study

Landmark	Abbreviation	Definition
Midline structures		
Glabella	G	The most prominent center point between the eyebrows
Soft tissue nasion	N’	The most posterior center point of the nasal root
Pronasale	Prn	The most prominent midpoint on tip of the nose
Subnasale	Sn	The point at which philtrum merges with columella in the midsagittal plane
Soft tissue pogonion	Pog’	The most prominent center point of the chin
Soft tissue menton	Me’	The lowest median landmark on the lower border of the chin
Bilateral structure		
Cheilion	Ch	The point located at the angle of the mouth

Table 2 Group classification by amount of chin deviation and lip canting

Group	Amount of chin deviation (mm)	Amount of lip canting (mm)
1	0 - 2	0 – 1
2	> 2 - 4	> 1 – 2
3	> 4 - 6	> 2 - 3
4	More than 6	More than 3

The assessment of facial asymmetry included the following measurements:

1) Chin deviation: Defined as the linear distance from the soft tissue menton (Me’) to the midsagittal plane (Figure 1).

2) Lip canting: Determined by comparing the height difference between the right and left cheilion (Ch) relative to a horizontal reference line perpendicular to the midsagittal plane (Figure 2).

Subjects were categorized into four groups based on the severity of asymmetry, as described by previous research.[11] Four subjects were randomly selected from each group to compile the dataset for rating (Table 2).

Three-dimensional mirror images (symmetry images) were used for comparison with the original facial images. These were created by establishing a midsagittal plane and merging one side of the face using the Dolphin Imaging program.

File Preparation for Raters

A PowerPoint file was used to present the rating protocol. It randomly displayed both original and 3D mirror images (Figure 3). Raters were blinded to which images were mirrored and were required to answer each question within 10 seconds.

1) Question I: Are there any noticeable differences between the left and right images?

If the answer was Yes, the rater proceeded to Question II.

If the answer was No, the rater confirmed the absence of perceived asymmetry. In this case, the response, combined with the corresponding soft tissue measurement, was categorized as a normal asymmetry value.

2) Question II: Based on your perception of chin deviation and lip canting, please classify this patient into one of the following groups:

Group A: Symmetry

Group B: Mild asymmetry, no treatment required

Group C: Obvious asymmetry, treatment required

Rater responses were subsequently categorized into three levels of perceived asymmetry as follows:

Group A: Normal asymmetry

Group B: Acceptable asymmetry

Group C: Unacceptable asymmetry

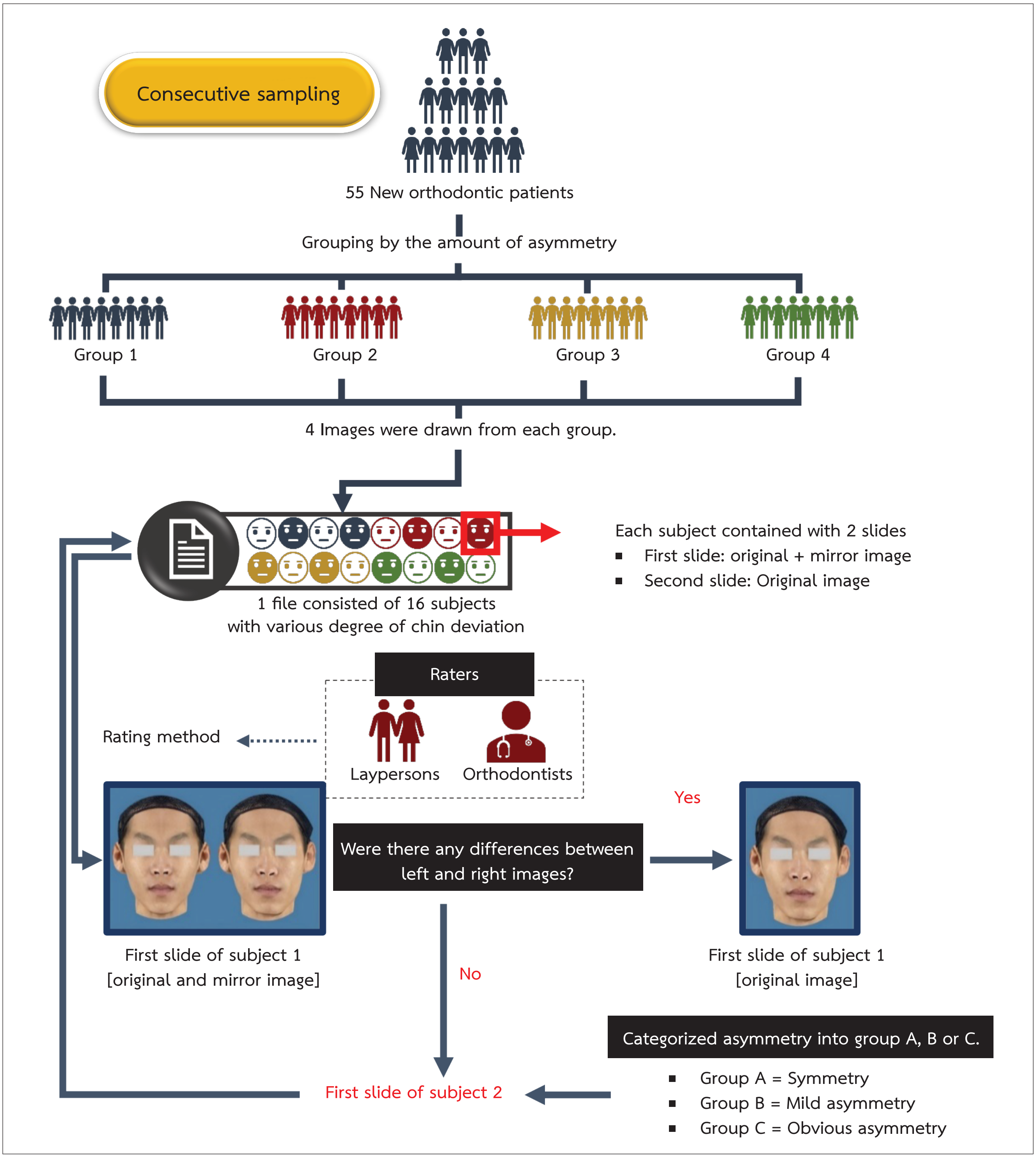

Figure 3 Overview of the study design

Table 3 Demographic information of subjects

N (%)		Age (years) (mean ± sd)	Chin deviation (mm) (mean ± sd)	Lip canting (mm) (mean ± sd)
Gender				
Male	22 (40 %)	25.00 ± 6.09	3.30 ± 3.55	1.10 ± 1.14
Female	33 (60 %)	22.97 ± 5.37	2.85 ± 3.01	0.92 ± 1.07
Total	55 (100 %)	23.78 ± 5.71	3.03 ± 3.21	1.00 ± 1.09

Statistical analysis

Clinical characteristics and the distribution of facial asymmetry among the subjects were described using mean ± standard deviation (SD). The levels of perceived asymmetry were described in terms of proportion.

The reliability and validity of soft tissue landmark identification were assessed using the intraclass correlation coefficient (ICC). The ICC ranged from 0.88 to 0.98, indicating a high level of reliability and validity in the measurements. To compare the proportions of normal, acceptable, and unacceptable asymmetry across the chin deviation groups, a Chi-square test was employed. The significance level was set at $P < 0.05$. All statistical analyses were conducted using SPSS version 28.0.0.0 (IBM Corp., Armonk, NY, USA).

Results

A total of 55 patients with facial asymmetry participated in this study, consisting of 22 male with a mean age of 25 ± 6.09 years and 33 female with a mean age of 22.90 ± 5.37 years. According to research methodology, 16 subjects were randomly selected from this pool for the perception assessment of chin deviation and lip canting. The rater group consisted of 26 participants, including 13 laypersons (mean age = 27.85 ± 7.89 years) and 13 orthodontists (mean age = 40.15 ± 6.99 years).

Measurement analysis revealed that the average chin deviation was 3.03 ± 3.21 mm, and the average lip canting was 1.00 ± 1.09 mm. (Table 3)

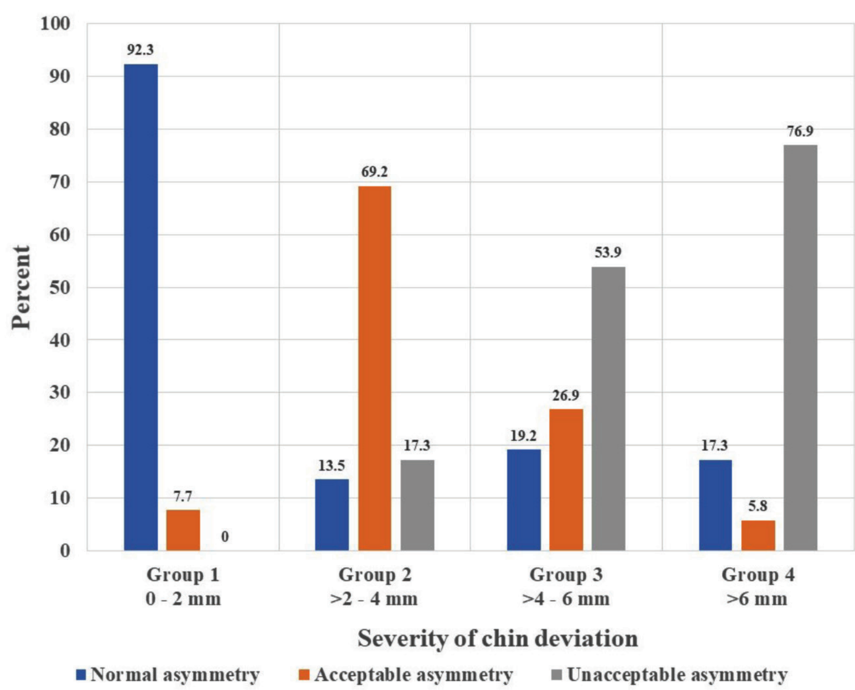

Figure 4 The proportion of chin deviation perception rated by laypersons

Table 4 Comparisons of the proportions of perception among the severity of chin deviation rated by laypersons

	Chin Deviation (N, %)				
	Group 1 0-2 mm	Group 2 > 2-4 mm	Group 3 > 4-6 mm	Group 4 > 6 mm	*P* value
Perception					
Normal asymmetry	48 (92.30 %)	17 (13.50 %)	10 (19.20 %)	9 (17.30 %)	< 0.001*
Acceptable asymmetry	4 (7.70 %)	36 (69.20 %)	14 (26.90 %)	3 (5.80 %)	< 0.001*
Unacceptable asymmetry	0 (0.00 %)	9 (17.30 %)	28 (53.80 %)	40 (76.90 %)	< 0.001***
Total	52 (100 %)	52 (100 %)	52 (100 %)	52 (100 %)	

* Chi-square test: statistically significant difference at $P < 0.05$

** P value was adjusted by Bonferroni method: statistically significant difference at $P < 0.05$

*** Fisher's exact test: statistically significant difference at $P < 0.05$

THE PERCEPTION OF CHIN DEVIATION

Laypersons

Laypersons perceived group 1 chin deviation as normal asymmetry in 92.30 % of cases, while 69.20 % rated group 2 chin deviation as acceptable. Additionally, chin deviation greater than 6 mm was perceived as unacceptable asymmetry in 76.90 % of cases. (Figure 4)

A statistical comparison of the perceptions revealed that group 1 chin deviation was considered normal asymmetry, and group 2 chin deviation was categorized as acceptable asymmetry, which was significantly different from other chin deviation groups (*P* value < 0.05). In contrast, for unacceptable asymmetry, groups 3 and 4 had higher proportions compared to groups 1 and 2, though no significant difference was found between groups 3 and 4. (Table 4)

Orthodontist

53.80 % of orthodontists recognized group 1 chin deviation as an acceptable asymmetry, while 46.20 % perceived it as a normal asymmetry. For group 2 chin deviation, the majority of orthodontists (67.30 %) classified it as unacceptable asymmetry. There was an obvious tendency among orthodontists to categorize group 3 and group 4 chin deviations as unacceptable asymmetry. (Figure 5)

The perception of normal asymmetry in group 1 chin deviation was statistically different from that in the other groups. Acceptable asymmetry was more frequently classified in groups 1 and 2, but no significant difference was found between these two groups. Similarly, unacceptable asymmetry was more commonly perceived in groups 3 and 4, with no significant difference between these two groups (Table 5).

The comparison of perception between laypersons and orthodontists

In group 1 chin deviation, the majority of laypersons (92.30 %) perceived it as normal asymmetry, while 53.80 % of orthodontists rated it as acceptable, followed by 46.20 % who considered it normal asymmetry.

For group 2 chin deviation, most laypersons (69.20 %) classified it as acceptable asymmetry, while the majority of orthodontists (67.30 %) perceived it as unacceptable. No orthodontists considered this chin deviation normal asymmetry.

In group 3, more than half of the laypersons (53.80 %) regarded the chin deviation as unacceptable,

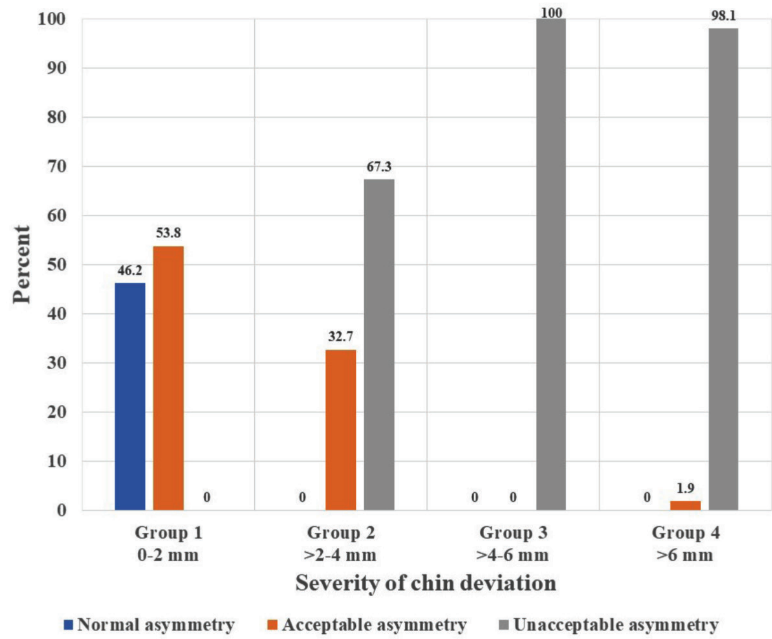

Figure 5 Proportion of chin deviation perception rated by orthodontists

Table 5 Comparisons of the proportions of perception among the severity of chin deviation rated by orthodontists

	Chin Deviation (N, %)				
	Group 1 0-2 mm	Group 2 > 2-4 mm	Group 3 > 4-6 mm	Group 4 > 6 mm	*P* value
Perception					
Normal asymmetry	24 (46.20 %)	0 (0.00 %)	0 (0.00 %)	0 (0.00 %)	< 0.001*
Acceptable asymmetry	28 (53.80 %)	17 (32.70 %)	0 (0.00 %)	1 (1.90 %)	< 0.001*
Unacceptable asymmetry	0 (0.00 %)	35 (67.30 %)	52 (100 %)	51 (98.10 %)	< 0.001*
Total	52 (100 %)	52 (100 %)	52 (100 %)	52 (100 %)	

* Fisher's exact test: statistically significant difference at $P < 0.05$

** P value was adjusted by Bonferroni method: statistically significant difference at $P < 0.05$

*** P value was adjusted by Bonferroni method: statistically significant difference at $P < 0.05$

while all orthodontists (100 %) classified it as unacceptable. For group 4 chin deviation, the majority of both laypersons (76.90 %) and orthodontists (98.10 %) perceived it as unacceptable asymmetry. (Figure 6)

The comparison of normal asymmetry perception between laypersons and orthodontists revealed that laypersons had a statistically higher perception of normal asymmetry compared to orthodontists in all groups of chin deviation ($P < 0.05$). (Table 6)

For group 1 chin deviation, orthodontists rated acceptable asymmetry significantly higher than laypersons. However, laypersons rated acceptable

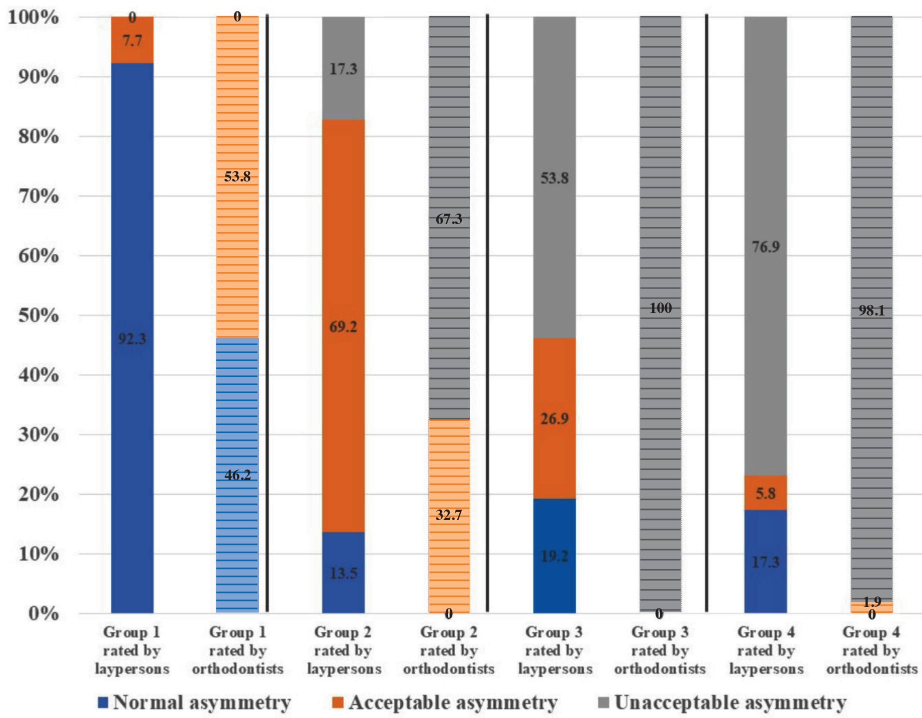

Figure 6 Proportion of chin deviation perception rated by laypersons and orthodontists

Table 6 Comparisons of proportions of perception within the chin deviation groups between laypersons and orthodontists

Preception	Group of chin deviation							
	Group 1 (0-2 mm)		Group 2 (> 2-4 mm)		Group 3 (> 4-6 mm)		Group 4 (> 6 mm)	
	L	O	L	O	L	O	L	O
	*		*		*		*	
Normal asymmetry	48 (92.30 %)	24 (46.20 %)	7 (13.50 %)	0 (0.00 %)	10 (19.20 %)	0 (0.00 %)	9 (17.30 %)	0 (0.00 %)
	*		*		*			
Acceptable asymmetry	4 (7.70 %)	28 (53.80 %)	36 (69.20 %)	17 (32.70 %)	14 (26.90 %)	0 (0.00 %)	3 (5.80 %)	1 (1.90 %)
			*		*		*	
Unacceptable asymmetry	0 (0.00 %)	0 (0.00 %)	9 (17.30 %)	35 (67.30 %)	28 (53.80 %)	52 (100 %)	40 (76.90 %)	51 (98.10 %)
Total	52 (100 %)	52 (100 %)	52 (100 %)	52 (100 %)	52 (100 %)	52 (100 %)	52 (100 %)	52 (100 %)

L = Laypersons, O = Orthodontists

* Chi-square test: statistically significant difference at $P < 0.05$

asymmetry significantly higher than orthodontists in groups 2 and 3 chin deviation. In contrast, for unacceptable asymmetry, orthodontists rated it higher than laypersons in groups 2, 3, and 4 chin deviation.

THE PERCEPTION OF LIP CANTING

Laypersons

For group 1 and group 2 lip canting, the majority of laypersons (98.10 % and 88.50 %, respectively)

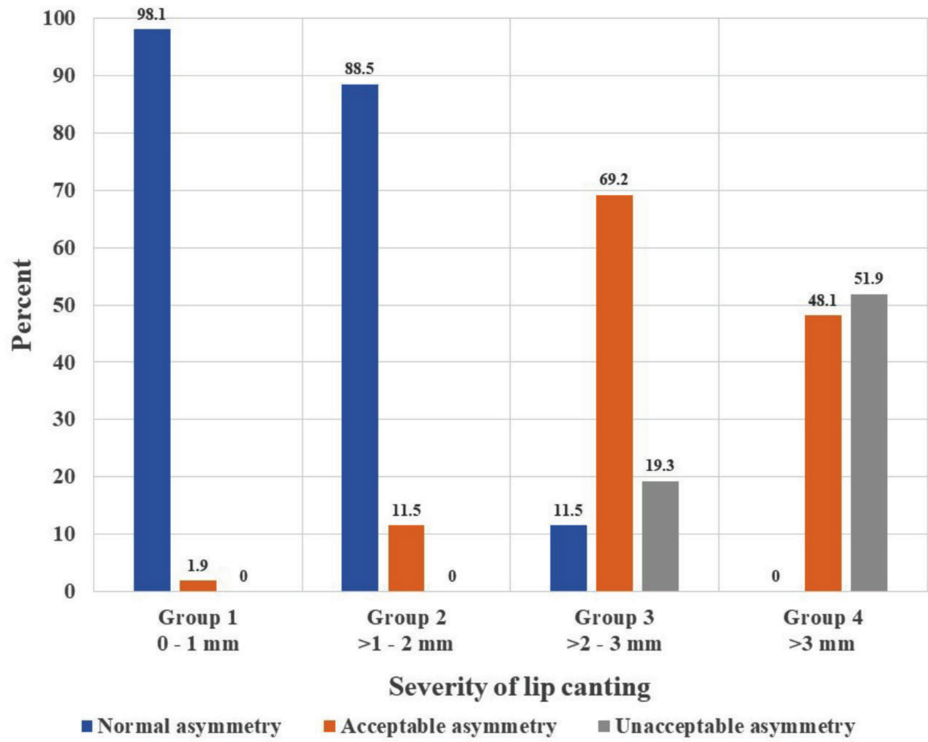

Figure 7 Proportion of lip canting perception rated by laypersons

Table 7 The comparisons of the proportions of perception among the severity of lip canting rated by laypersons

	Lip Canting (N, %)				
	Group 1 0-1 mm	Group 2 > 1-2 mm	Group 3 > 2-3 mm	Group 4 > 3 mm	*P* value
Perception					
Normal asymmetry	51 (98.10 %)	46 (88.50 %)	6 (11.50 %)	0 (0.00 %)	< 0.001*
Acceptable asymmetry	1 (1.90 %)	6 (11.50 %)	36 (69.20 %)	25 (48.10 %)	< 0.001*
Unacceptable asymmetry	0 (0.00 %)	0 (0.00 %)	10 (19.30 %)	27 (51.90 %)	< 0.001*
Total	52 (100 %)	52 (100 %)	52 (100 %)	52 (100 %)	

* Chi-square test: statistically significant difference at $P < 0.05$

** P value was adjusted by Bonferroni method: statistically significant difference at $P < 0.05$

*** Fisher's exact test: statistically significant difference at P value < 0.05

perceived it as a normal asymmetry. Additionally, no participants considered 0–2 mm lip canting to be an unacceptable asymmetry.

For group 3 lip canting, most laypersons (69.20 %) perceived it as an acceptable asymmetry, and 51.90 % perceived group 4 lip canting as an unacceptable asymmetry. (Figure 7)

In terms of normal asymmetry, there was no significant difference between group 1 and group 2 (0–2 mm of lip canting). Similarly, the perception of acceptable asymmetry between groups 3 and 4 (> 2–3 mm, > 3 mm) also showed no significant differences.

For unacceptable asymmetry, the perception of group 4 lip canting as an unacceptable asymmetry was significantly different from the other groups of lip canting (Table 7).

Orthodontists

All orthodontists perceived lip canting of 0–1 mm as normal asymmetry. Furthermore, more than 80 % of orthodontists classified group 2 and group 3 lip canting as acceptable asymmetry.

Regarding the perception of group 4 lip canting, 65.40 % of orthodontists identified it as unacceptable asymmetry. However, a notable portion (34.60 %) categorized it as acceptable asymmetry. (Figure 8)

The Chi-square test revealed statistically significant differences in the perception of group 1 lip canting as normal asymmetry and group 4 lip canting as unacceptable asymmetry (*P* value < 0.001). However, no significant difference was observed in the proportion of acceptable asymmetry between group 2 and group 3. In terms of comparisons within the perception of unacceptable asymmetry, the perception of group 4 lip canting was significantly different from that of the other groups. (Table 8)

The comparison of perception between laypersons and orthodontists

In group 1 lip canting, almost all laypersons (98.10 %) perceived it as normal asymmetry, which was consistent with the perception reported by all orthodontists.

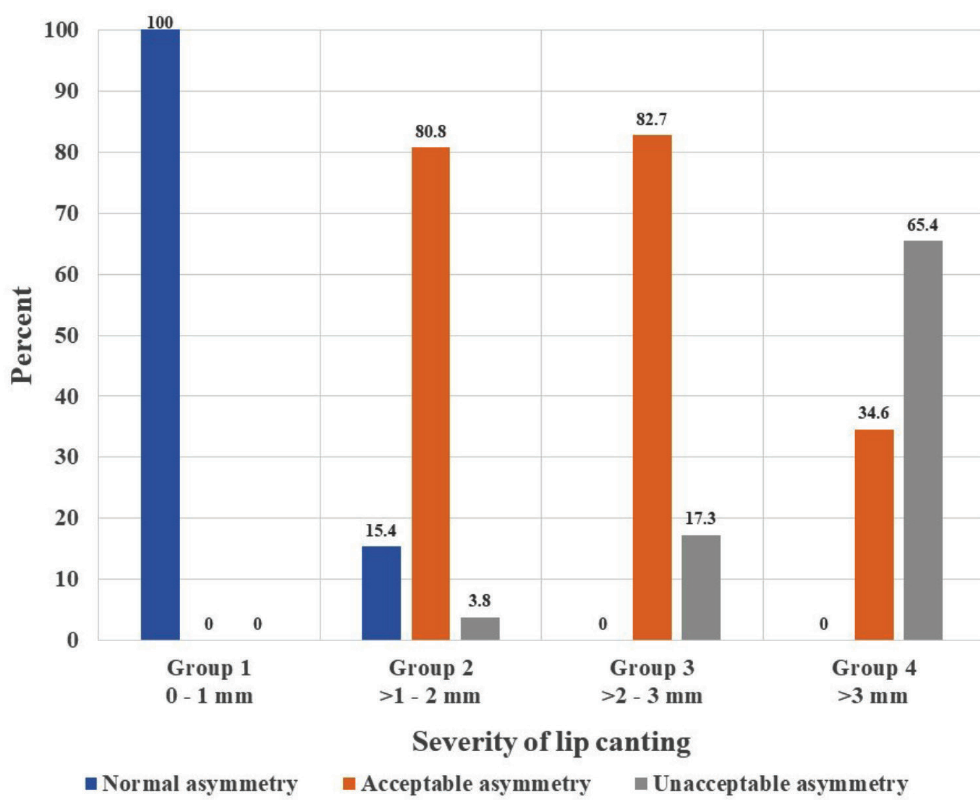

Figure 8 Proportion of lip canting perception rated by orthodontists

Table 8 The comparisons of proportions of perception among the severity of lip canting rated by orthodontists

	Lip Canting (N, %)				
	Group 1 0-1 mm	Group 2 > 1-2 mm	Group 3 > 2-3 mm	Group 4 > 3 mm	*P* value
Perception					
Normal asymmetry	52 (100 %)	8 (15.4%)	0 (0.00 %)	0 (0.00 %)	< 0.001*
Acceptable asymmetry	0 (0.00 %)	42 (80.80 %)	43 (82.70 %)	18 (34.60 %)	< 0.001*
Unacceptable asymmetry	0 (0.00 %)	2 (3.80 %)	9 (17.30 %)	34 (65.40 %)	< 0.001*
Total	52 (100 %)	52 (100 %)	52 (100 %)	52 (100 %)	

* Chi-square test: statistically significant difference at $P < 0.05$

** P value was adjusted by Bonferroni method: statistically significant difference at $P < 0.05$

*** Fisher's exact test: statistically significant difference at $P < 0.05$

In group 2 lip canting, most laypersons (88.50 %) also perceived it as normal asymmetry, whereas 80.80 % of orthodontists classified this degree of lip canting as acceptable asymmetry.

Regarding group 3 lip canting, most laypersons (69.20 %) and orthodontists (82.70 %) perceived it as acceptable asymmetry.

For group 4 lip canting, more than half of laypersons (51.90 %) and orthodontists (65.40 %) identified it as unacceptable asymmetry, while 48.10 % of laypersons and 34.60 % of orthodontists classified it as acceptable asymmetry. (Figure 9)

There was no statistically significant difference between laypersons and orthodontists in the perception of normal asymmetry for group 1. Similarly, no significant differences were found in the perception of acceptable asymmetry between laypersons and orthodontists in groups 3 and 4.

In terms of unacceptable asymmetry, there was also no statistically significant difference in the perception between the two groups. (Table 9)

Discussion

Chin Deviation

With respect to normal asymmetry, the majority of laypersons (92.30 %) and nearly half of orthodontists (46.20 %) perceived a chin deviation of 0–2 mm as a normal asymmetry. However, more than half of the orthodontists (53.80 %) classified chin deviation in this range as an acceptable asymmetry. Previous studies have reported that facial asymmetry becomes perceptible when the chin deviates more than 2 mm. Moreover, Keulen and Masuoka et al. further suggested that facial asymmetry is recognizable when the chin deviates more than 4 mm.[5,12] Therefore, the present findings indicate that both laypersons and orthodontists generally perceive a chin deviation of 0–2 mm as representing normal asymmetry.

Among laypersons, 69.20 % identified a chin deviation of more than 2 to 4 mm as an acceptable asymmetry. In contrast, only 32.70 % of orthodontists classified this range of deviation as acceptable. The comparison revealed that the proportion of

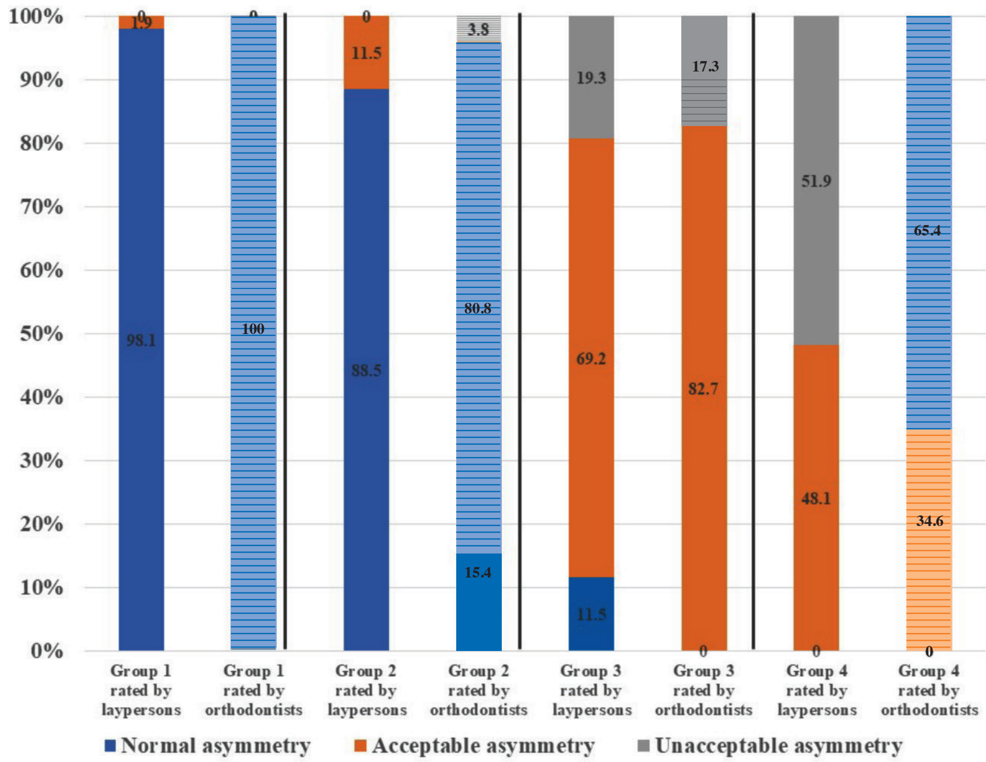

Figure 9 Proportion of lip canting perception rated by laypersons and orthodontists

Table 9 Comparison of the proportions of perception within each lip canting group between laypersons and orthodontists

Perception	Group of lip canting							
	Group 1 (0-1 mm)		Group 2 (> 1-2 mm)		Group 3 (> 2-3 mm)		Group 4 (> 3 mm)	
	L	O	L	O	L	O	L	O
			*		**			
Normal asymmetry	51 (98.10 %)	52 (100 %)	46 (88.50 %)	8 (15.40 %)	6 (11.50 %)	0 (0.00 %)	0 (0.00 %)	0 (0.00 %)
			*					
Acceptable asymmetry	1 (1.90 %)	0 (0.00 %)	6 (11.50 %)	42 (80.80 %)	36 (69.20 %)	43 (82.70 %)	25 (48.10 %)	18 (34.60 %)
Unacceptable asymmetry	0 (0.00 %)	0 (0.00 %)	0 (0.00 %)	2 (3.80 %)	10 (19.30 %)	9 (17.30 %)	27 (51.90 %)	34 (65.40 %)
Total	52 (100 %)	52 (100 %)	52 (100 %)	52 (100 %)	52(100 %)	52 (100 %)	52 (100 %)	52 (100 %)

L = Laypersons, O = Orthodontists

* Chi-square test: statistically significant difference at $P < 0.05$

** Fisher's Exact test: statistically significant difference at $P < 0.05$

acceptable asymmetry perception rated by laypersons was statistically higher than that of orthodontists ($P < 0.05$). However, orthodontists rated the 0–2 mm chin deviation as the most acceptable (53.80 %). As noted in Table 9, although there was no statistically significant difference in the acceptable asymmetry ratings by orthodontists between the 0–2 mm group and the > 2–4 mm group, the proportion rated as acceptable by orthodontists was statistically higher than that of laypersons ($P < 0.05$). These findings suggest that laypersons tend to perceive a chin deviation of 2–4 mm as acceptable, whereas orthodontists consider this deviation more severe and likely requiring correction. These findings were consistent with previous studies by Krystian et al. and Zhang et al., which concluded that orthodontists were more sensitive and accurate in detecting facial asymmetry compared to laypersons.[13,14] Similarly, McAvinchey et al., who compared the perception of facial asymmetry across five observer groups, including laypersons, dental students, dental care professionals, dental practitioners, and orthodontists found that orthodontists demonstrated the highest sensitivity to chin deviation.[6]

In terms of unacceptable asymmetry, more than half of laypersons identified chin deviations of > 4–6 mm and > 6 mm as requiring correction (53.80 % and 76.90 %, respectively). This perception was consistent with that of orthodontists. When unacceptable asymmetry perceptions between laypersons and orthodontists were compared, statistically significant differences were found across all groups, except between the > 4–6 mm and > 6 mm chin deviation groups. This suggests a consensus among both laypersons and orthodontists that chin deviations exceeding 4 mm warrant correction. These findings are supported by Ting et al., who reported that facial asymmetry becomes perceptible when the chin deviation exceeds 4 mm. Additionally, Kim et al. found that among 48 patients who underwent orthognathic surgery, the average chin deviation was 5.70 ± 2.60 mm.[15]

Lip Canting

The perception of normal asymmetry rated by laypersons primarily included the lip canting range of 0–1 mm (98.10 %) and > 1–2 mm (89.50 %). In contrast, all orthodontists classified only the 0–1 mm range as normal asymmetry. A previous study by Choi et al. reported that both professionals and non-professionals considered lip canting within 0–2 degrees to be within the normal asymmetry range.[16] However, direct comparisons with the present study are difficult due to differences in the methods used to analyze lip canting.

Regarding acceptable asymmetry, 69.20 % of laypersons and 82.70 % of orthodontists perceived lip canting of more than 2–3 mm as acceptable. Notably, most orthodontists (80.80 %) also considered the 1–2 mm range as acceptable. Statistical comparison revealed no significant difference in perceptions of acceptability between laypersons and orthodontists for the 2–3 mm group. However, orthodontists rated the 1–2 mm range as acceptable at a significantly higher rate than laypersons. These findings suggest that laypersons regarded 2–3 mm of lip canting as acceptable, while orthodontists perceived the broader range of 1–3 mm as acceptable.

In terms of unacceptable asymmetry, more than half of the laypersons (51.90 %) believed that lip canting greater than 3 mm warranted correction. This view aligned with orthodontists, who also perceived lip canting beyond 3 mm as unacceptable.

Soft tissue asymmetry, particularly in visible areas like the lips, has significant implications for facial esthetics and psychosocial well-being. Therefore, accurate assessment of soft tissue asymmetry is essential in treatment planning. This study focused on soft tissue asymmetries, particularly chin deviation and lip canting, which are commonly seen in the lower third of the face. Samman et al. reported that asymmetries in this region are prevalent,[17] and Severt and Proffit found that over 70 % of patients in North Carolina exhibited asymmetry in the lower facial third.[18] Studies by Lee et al. and Zhang et al. further identified chin deviation as the most influential and frequently reported concern among patients.[7,14] Moreover, lip canting often occurs in conjunction with chin deviation and maxillary canting, reinforcing the importance of evaluating both features.

Another complicating factor in the assessment of facial asymmetry is improper head posture, which may be used by patients to compensate for deformities.[7,8] Such compensations can distort the actual perception of asymmetry, making it appear less severe. To address this, Fourie et al. advocated for 3D imaging techniques such as 3D laser scanning and 3D stereophotogrammetry as being more accurate and reliable than 2D methods.[19] Patel et al. also supported the use of 3D facial scanning, noting its simplicity and speed.[20] Accordingly, this study employed 3D images and analysis software for the evaluation of chin deviation and lip canting.

In facial asymmetry assessment, accurate identification of the vertical reference plane is crucial. However, deviations in midface structures such as the nasal tip can compromise this identification. Notably, the subjects in this study did not exhibit nasal deviation. The anatomical landmarks used for establishing the vertical plane were based on the study by Kim et al., and included a line connecting the soft tissue glabella (G'), soft tissue nasion (N'), pronasale (Prn), and subnasale (Sn).[15] Reddy et al. found the mean chin deviation to be 2.60 ± 1.42 mm.[21] Choi et al. reported average lip canting of 1.60° ± 1.00° based on frontal photographs of 585 Korean patients.[16] In the current study, which included 55 subjects, the mean chin deviation and lip canting were 3.03 ± 3.21 mm and 1.00 ± 1.09 mm, respectively. It is important to note that, unlike previous studies which used angular measurements, this study assessed lip canting in millimeters due to the visual difficulty of evaluating angles.

The findings from this study would be beneficial in clinical decision-making. While orthodontists' assessments can serve as expert guidelines for ideal treatment planning, individual treatment decisions ultimately depend on each patient's perception and preference. Thus, layperson perspectives should also be incorporated into alternative treatment strategies.

Besides chin deviation and lip canting, other structural factors such as ramus inclination and gonial angle asymmetries may also influence the perception of lower facial asymmetry. These aspects should be explored in future studies.

This study had several limitations. First, due to the use of unaltered 3D images, the sample included few subjects with severe lip canting. Second, subjects with marked nasal deviation and zygomatic asymmetry were excluded through purposive sampling, as such features could interfere with perception assessments.

Conclusion

The perceptions of chin deviation and lip canting based on its severity are summarized as follows:

Chin deviation of 0-2 mm: Laypersons perceived this as a normal asymmetry, whereas orthodontists considered it either normal or an acceptable asymmetry. Chin deviation of more than 2-4 mm: Laypersons regarded this range as an acceptable asymmetry, while orthodontists viewed it as unacceptable asymmetry.

Lip canting of 0-1 mm: Both laypersons and orthodontists considered this to be a normal asymmetry. Lip canting of more than 1-2 mm: Laypersons continued to perceive this range as normal, whereas orthodontists classified it as an acceptable asymmetry. Lip canting of more than 3 mm: Both laypersons and orthodontists perceived this level of asymmetry as unacceptable.

Author contributions

TT: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing-Original draft, Writing-Reviewing and Editing, Visualization, and Project administration; PP: Methodology, Writing-Reviewing and Editing, Visualization, Supervision and Funding acquisition; AP: Methodology, Validation, Formal analysis, Writing-Reviewing and Editing and Visualization; NP: Conceptualization, Methodology, Validation, Formal analysis, Resources, Data curation, Writing-Reviewing and Editing, Visualization, Supervision, Project administration and Funding acquisition.

Ethical statement

The Khon Kaen University Ethics Committee ethically approved this prospective study in human research (KKUEC; HE632082).

Disclosure statement

The authors have no conflicts of interest.

References

1. Haraguchi S, Takada K, Yasuda Y. Facial asymmetry in subjects with skeletal Class III deformity. Angle Orthod 2002;72(1):28-35.
2. Jacobson A. The prevalence of facial asymmetry in the dentofacial deformities population at the University of North Carolina. Am J Orthod Dentofacial Orthop 1998;113(6):697-8.
3. Manosudprasit M, Manosudprasit A, Manosudprasit A, Traisrisin K. Dentofacial asymmetry: a literature review. J Med Assoc Thai 2017;100(Suppl 6):S50-60.
4. Thiesen G, Gribel BF, Freitas MP. Facial asymmetry: a current review. Dental Press J Orthod 2015;20(6):110-25.
5. Masuoka N, Muramatsu A, Ariji Y, Nawa H, Goto S, Ariji E. Discriminative thresholds of cephalometric indexes in the subjective evaluation of facial asymmetry. Am J Orthod Dentofacial Orthop 2007;131(5):609-13.
6. McAvinchey G, Maxim F, Nix B, Djordjevic J, Linklater R, Landini G. The perception of facial asymmetry using 3-dimensional simulated images. Angle Orthod 2014;84(6):957-65.
7. Lee MS, Chung DH, Lee J-w, Cha K-s. Assessing soft-tissue characteristics of facial asymmetry with photographs. Am J Orthod Dentofacial Orthop 2010;138(1):23-31.
8. Kim H, Hwang HS. Frontal cephalogram study on the natural head position of facial asymmetry patients. Korean J Orthod 2000;30:535-42.
9. Kaipainen AE, Sieber KR, Nada RM, Maal TJ, Katsaros C, Fudalej PS. Regional facial asymmetries and attractiveness of the face. Eur J Orthod 2016;38(6):602-8.
10. Lee SF, Dumrongwongsiri S, Lo LJ. Perception of lip cant as a sign of facial deformity: assessment by laypersons and professionals on composite face photographs. Ann Plast Surg 2019;82(1S Suppl 1):S140-3.
11. Sakunteo P, Nisalak P, Verayangkura P, Charoenying H, Pongpirul K. Frontal symmetrical facial esthetic perception and treatment judgements: the differences among dental professionals, orthodontic patients and laypeople. Bangkok: Mahidol University; 2006.
12. Van Keulen C, Martens G, Dermaut L. Unilateral posterior crossbite and chin deviation: is there a correlation? Eur J Orthod 2004;26(3):283-8.
13. Jarosz KF, Bosio JA, Bloomstein R, Jiang SS, Vakharia NS, Cangialosi TJ. Perceptions of chin asymmetries among dental professionals and laypersons. Am J Orthod Dentofacial Orthop 2018;154(2):201-12.
14. Zhang M, Lyu L, Li J, Yan H, Zhu Y, Yu T, et al. Subjective evaluation of facial asymmetry with three-dimensional simulated images among the orthodontists and laypersons: a cross-sectional study. BMC Oral Health 2023;23(1):500.
15. Kim EJ, Palomo JM, Kim SS, Lim HJ, Lee KM, Hwang HS. Maxillofacial characteristics affecting chin deviation between mandibular retrusion and prognathism patients. Angle Orthod 2011;81(6):988-93.
16. Choi J, Kim S-D, Cho J-H, Kim S-H, Kim† M-S. Evaluation of the perception of lip-line canting. Korean J Oral Anatomy 2020;41(1):21-8.
17. Samman N, Tong AC, Cheung DL, Tideman H. Analysis of 300 dentofacial deformities in Hong Kong. Int J Adult Orthodon Orthognath Surg 1992;7(3):181-5.
18. Severt TR, Proffit WR. The prevalence of facial asymmetry in the dentofacial deformities population at the University of North Carolina. Int J Adult Orthodon Orthognath Surg 1997;12(3):171-6.
19. Fourie Z, Damstra J, Gerrits PO, Ren Y. Evaluation of anthropometric accuracy and reliability using different three-dimensional scanning systems. Forensic Sci Int 2011;207(1-3):127-34.
20. Patel A, Islam SM, Murray K, Goonewardene MS. Facial asymmetry assessment in adults using three-dimensional surface imaging. Prog Orthod 2015;16:36.
21. Reddy MR, Bogavilli SR, Raghavendra V, Polina VS, Basha SZ, Preetham R. Prevalence of facial asymmetry in Tirupati population: a posteroanterior cephalometric and photographic study. J Int Soc Prev Community Dent 2016;6(Suppl 3):S205-12.

Thai Journal of Orthodontics

Original Article

Orthodontic Debonding Procedures: A Survey of Thai Orthodontists

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Abstract

Background: Orthodontic debonding procedures impact enamel integrity. Despite various proposed techniques, no standardized protocol exists. Understanding commonly used methods among Thai orthodontists may aid in developing practical, evidence-based guidelines. **Objective:** To investigate current practices of Thai orthodontists regarding bracket removal, adhesive removal, and enamel polishing during debonding, aiming to identify prevailing clinical trends and support standardized protocol development. **Materials and methods:** A structured four-part questionnaire was distributed to 726 active members of the Thai Association of Orthodontists via electronic message and postal mail. It covered: 1) respondents' general background; 2) bracket type, surface preparation, and adhesive system frequently used; 3) debonding instruments and procedures for metal and ceramic bracket debonding; and 4) adhesive removal, enamel polishing, and time spent. Descriptive statistical analyses were performed. **Results:** 389 orthodontists (53.58 %) responded; and 388 responses were analyzed. Bracket debonding pliers were most frequently used, typically applying squeezing force occlusogingivally. For adhesive removal, up to four instruments were used sequentially, with high-speed white stone bur favored in both one- and multi-step methods. Rubber cup with slurry pumice was common for enamel polishing. Water was the primary coolant used in both adhesive removal and enamel polishing. Most entire procedures took under 15 minutes per arch. **Conclusion:** Variability in orthodontic debonding practices among Thai orthodontists was observed, the findings suggest that instrument selection is influenced by the need to balance clinical effectiveness with procedural efficiency, aiming to achieve optimal outcomes within a reasonable chair time.

Keywords: Adhesive removal, Bracket debonding, Enamel polishing, Orthodontic debonding, Survey

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Introduction

With the success and popularity of direct bonding in orthodontics, conventional fixed orthodontic treatment necessitates enamel surface preparation using an acidic etchant, typically a viscous gel of phosphoric acid pioneered by Buonocore.[1] This step roughens and develops microporosity on the enamel surface, allowing brackets to be adhered. The increased surface energy enables the hydrophobic monomer of the resin adhesive to spread across the surface, penetrate the microporosities and form a mechanical interlock between the adhesive and enamel.[2]

The orthodontic debonding procedure, including bracket removal and adhesive residue elimination, also impacts the enamel surface.[3] Post-debonding, the enamel surface should be restored to as close to its original pretreatment condition as possible, for both aesthetic and hygienic reasons. Adhesive remnants can affect the appearance and color of the enamel surface.[4] These procedures inevitably alter the enamel surface.[5] Therefore, minimizing enamel surface damage is crucial. Awareness of enamel surface modifications caused by both orthodontic bonding and debonding procedures should be emphasized.

Various orthodontic debonding methods have been studied and advocated.[3] A range of instruments have been employed for bracket removal, such as a sharp ligature cutter, bracket debonding pliers, How pliers and anterior band slitting pliers.[6-11] Different bracket removal techniques result in varying amounts of adhesive on the enamel surface.[9] The direction and magnitude of debonding forces can influence the risk of enamel fractures or cracks, making the site of bonding breakage between the bracket base and enamel surface significant. Cohesion failures within the adhesive or adhesion failures between adhesive and bracket are more favorable.[12] Multiple of mechanical methods for adhesive removal and enamel polishing have been studied in order to minimize iatrogenic damage to the enamel surface and achieve acceptable aesthetic outcomes. Suggested methods include a green rubber wheel, a tungsten carbide bur, multistep Sof-Lex discs, a fiber-reinforced composite bur, and a fiber glass bur.[5,6,8,11,13-16] However, no universal protocol has been established. Improper instrument selection and inconsistencies in each step of the debonding process can lead to significant enamel damage and compromise the treatment outcomes.

Due to the variability in clinical practice surrounding these delicate procedures, the purposes of this study were: 1) to survey the orthodontic debonding procedures employed by the orthodontists in Thailand; and 2) to identify the most commonly used methods for bracket removal and adhesive cleanup after fixed orthodontic treatment by Thai orthodontists. This information aims to reflect current clinical trends and support the development of practical guidelines for safer and more consistent orthodontic debonding procedures.

Materials and methods

The population of this study comprised 726 active ordinary members of the Thai Association of Orthodontists. Other categories of membership, as well as deceased ordinary members, were excluded from the study.

A preliminary questionnaire was developed based on a comprehensive literature review. Validity and reliability assessments were conducted to ensure the quality of the instrument. For validity testing, the preliminary questionnaire was revised and refined in accordance with feedback and recommendations provided by advisory committee. Subsequently, content validity was evaluated using the Index of Item-Objective Congruence (IOC), followed by pilot testing. Reliability was assessed using Cronbach's alpha coefficient to confirm the internal consistency and dependability of the questionnaire responses. The finalized questionnaire was distributed in two formats - online and postal mail - both containing identical content. An electronic message containing a link to the online questionnaire was sent to all 726 active ordinary members of the Thai Association of Orthodontists via the association's official social media platform. One month later, a hard-copy version of the questionnaire, along with a pre-stamped return envelope and a link to the online form, was mailed to each member. A reminder message was sent electronically one month after the postal distribution. Respondents who completed the online form were instructed not to submit the paper version. Only one submission per respondent was accepted. The questionnaire comprised four parts: 1) background information of the respondent; 2) frequently used type of bracket, enamel surface preparation, and adhesive material; 3) preferred bracket debonding instruments and procedures used separately for metal and ceramic bracket removal; and 4) details on adhesive removal, enamel polishing (e.g., bur types or coolant used), and the time spent on the entire debonding procedure per arch. The results were analyzed using descriptive statistical analyses.

Results

At the end of the survey period, 389 orthodontists responded, yielding a response rate of 53.58 %. 76.09 % (296 responses) were submitted online, while 23.91 % (93 responses) were received by post. One postal respondent was excluded from analysis due to no longer using fixed appliances, resulting in a final sample of 388 responses. In part 1 of the survey, respondents ranged in age from 29-94 years old with an average of 44.29 ± 9.70 years. Orthodontic practice experience ranged from 0 to 51 years, with an average of 13.20 ± 9.64 years. A total of 306 respondents (78.76 %) obtained their orthodontic degrees from certified universities in Thailand, while 82 (21.24 %) graduated from institutions abroad, including those in Australia, England, Germany, Hong Kong, Japan, Norway, the Philippines, Scotland, Taiwan, and the United States. The distribution of responses by institution is presented in Figure 1.

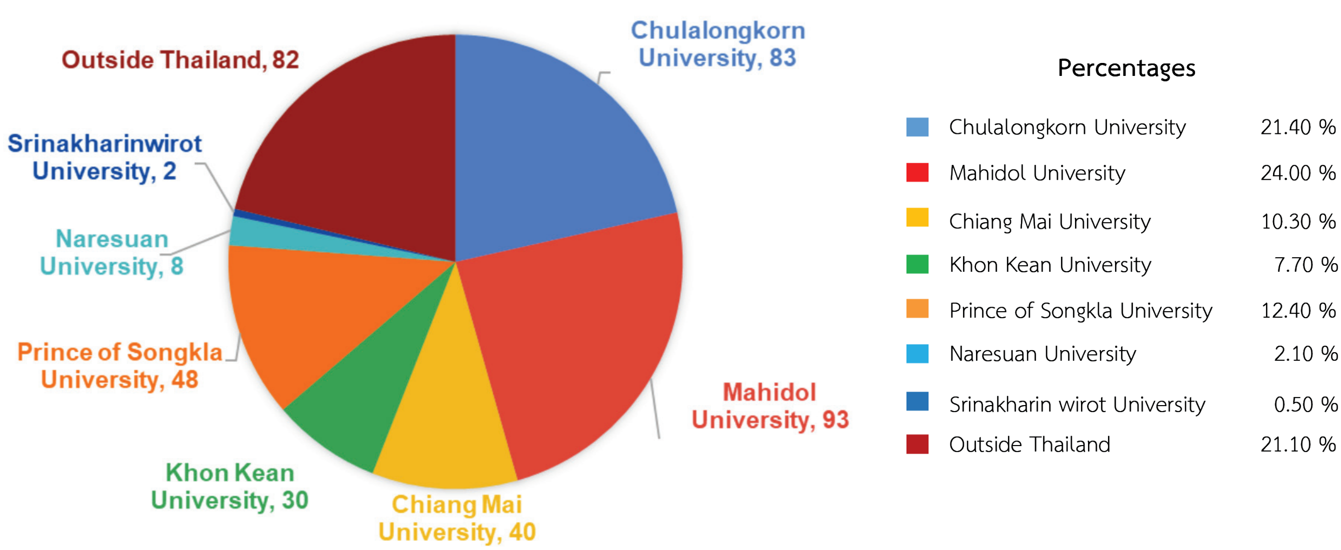

Figure 1 The numbers and percentages of responses in each institute.

In part 2 as seen in table 1, most respondents mainly used stainless steel bracket (99.20 %) with a total etch system for enamel surface preparation (97.20 %) and light cure (85.30%) composite resin adhesive (99.50 %).

In part 3 of the survey on bracket debonding, 96.60 % of respondents debonded brackets while the main archwire was still engaged. Bracket debonding pliers were the most commonly used instrument for both stainless steel (88.10 %) and ceramic (34.80 %)

Table 1 Orthodontic appliances frequently used.

Orthodontic appliances frequently used	Respondents (%)
Type of bracket	
Stainless steel	385 (99.20)
Ceramic	3 (0.80)
Surface preparation method	
Total-etched	377 (97.20)
Self-etched	11 (2.80)
Adhesive material	
Composite resin	386 (99.50)
Resin-modified glass ionomer	2 (0.50)
Adhesive system	
Light cure	331 (85.30)
Dual cure	1 (0.30)
Self-cure	56 (14.40)

Table 2 Instruments commonly used in stainless steel and ceramic bracket debonding.

Instrument used	Respondents (%)	
	Stainless steel bracket removal	Ceramic bracket removal
Bracket debonding pliers	342 (88.10)	135 (34.80)
Ligature cutter	30 (7.70)	12 (3.10)
Weingart pliers	5 (1.30)	5 (1.30)
Band remover	4 (1.00)	-
How pliers	2 (0.50)	1 (0.30)
Hard wire cutter	2 (0.50)	-
Band slitter	2 (0.50)	-
LODI pliers	1 (0.30)	-
Ceramic bracket debonding pliers*	-	28 (7.20)
Grinding with aerotor	-	2 (0.50)
Jarabak pliers	-	1 (0.30)

*Ceramic bracket debonding pliers provided by manufacturer

Table 3 Method used and direction of instrument placement in bracket removal.

Bracket removal	Respondents (%)	
	Stainless steel bracket removal	Ceramic bracket removal
Method used		
Squeezing	216 (55.70)	101 (26.00)
Peeling, Shearing	163 (42.00)	69 (17.80)
Tensile	9 (2.30)	6 (1.50)
Direction of instrument placement		
Occlusogingival	355 (91.50)	121 (31.20)
Mesiodistal	33 (8.50)	57 (14.70)

Table 4 Position of instrument placement in bracket removal.

Position	Respondents (%)	
	Stainless steel bracket removal	Ceramic bracket removal
Bracket base-enamel junction (Point A)	84 (21.60)	87 (22.40)
Bracket base (Point B)	57 (14.70)	49 (12.60)
Bracket wings (Point C)	247 (63.70)	42 (10.80)

brackets; ligature cutter (7.70 %) and Weingart pliers (1.30 %) followed in metal bracket removal; while the specific ceramic bracket remover (7.20% %) and ligature cutter (3.10 %) were next most frequently used in ceramic bracket removal (Table 2).

For both metal and ceramic brackets, the most common method was to squeeze the pliers occlusogingivally (Table 3). However, the placement position of the pliers for metal brackets was on the bracket wings (Point C in Figure 2, Table 4), whereas the position for ceramic brackets was on the bracket base-enamel junction (Point A in Figure 2, Table 4).

In part 4 of the survey, numerous different individual protocols were utilized for adhesive removal and enamel polishing.

For adhesive removal, multiple instruments were used consecutively, ranged from one to four instruments used in total. One-step (145 responses or 37.40 %) and two-step (157 responses or 40.50 %) protocols were most common (Figure 3). Among one-step users, the most popular instrument was a high-speed (HS)

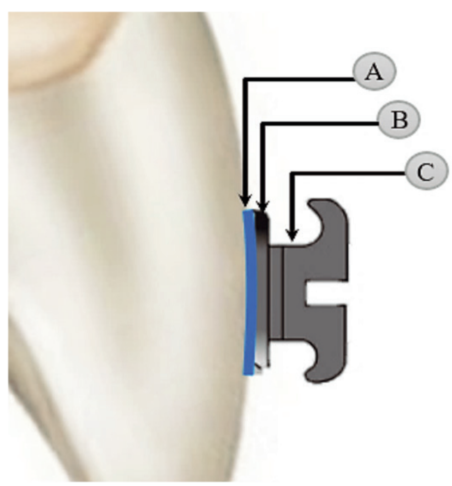

Figure 2 Position of instrument placement in bracket debonding. (A) Bracket base-enamel junction, (B) Bracket base, and (C) Bracket wing

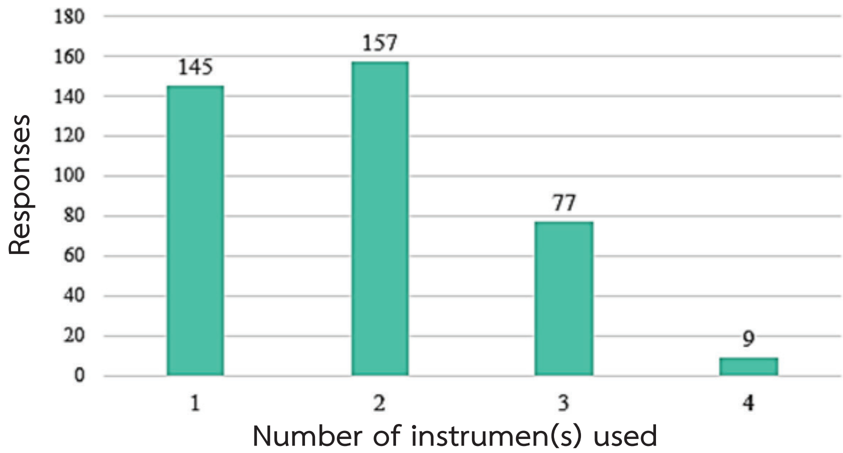

Figure 3 Number of steps used consecutively in adhesive removal

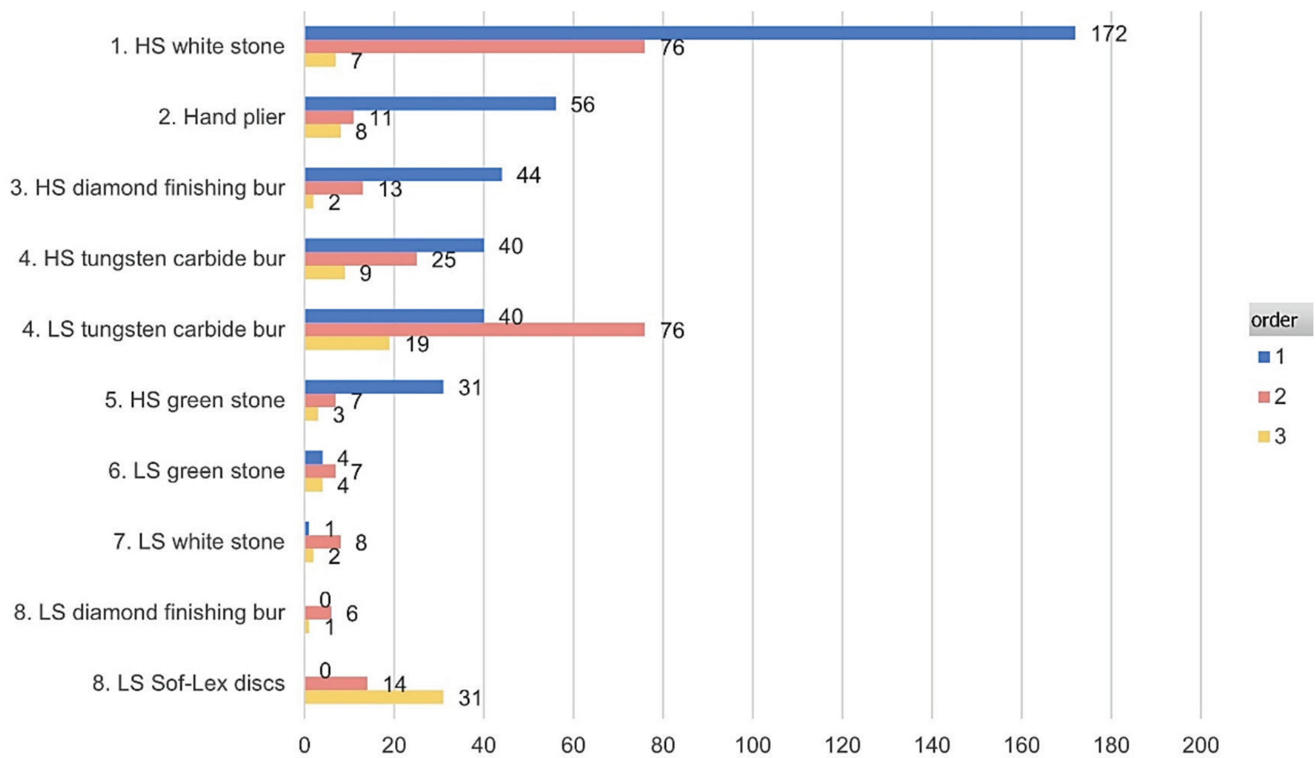

Figure 4 Overall instruments used in adhesive removal

Table 5 Instruments used in one-step adhesive removal.

Instrument used	Respondents (%)
HS white stone bur	90 (62.10)
LS tungsten carbide bur	25 (17.20)
HS tungsten carbide bur	10 (6.90)
HS diamond finishing bur	10 (6.90)
Hand pliers	6 (4.10)

white stone bur (62.10 %), and the second-most popular was a low-speed (LS) tungsten carbide bur (17.20 %) (Table 5). For multiple-step users, the most commonly used instruments in first step were a HS white stone bur (44.30 %), hand pliers (14.40 %), and HS diamond finishing bur (11.30 %) (Figure 4). The instruments most frequently used in second step were a HS white stone bur and LS tungsten carbide bur (31.30 % each). The most common coolants for removing remnant adhesive were water (87.40 %), none (10.60 %), and air (2.10 %).

Enamel polishing was also performed in various ways. With respect to frequency of enamel polishing steps, 55.40 % of respondents always polished enamel after adhesive removal (Table 6). Up to three instruments were used, but 85 % of respondents utilized only one instrument. The most frequently used instruments were a rubber cup with slurry pumice, Sof-Lex abrasive discs, and Enhance points (Figures 5 and 6). The most common coolants used were water (49.10 %), none (45.70 %), and air (5.20 %).

Table 6 Frequency of enamel polishing.

Frequency of enamel polishing	Respondents (%)
Always (100 %)	215 (55.40)
Usually (75 %)	40 (10.30)
Sometimes (50 %)	39 (10.10)
Rarely (25 %)	34 (8.80)
Never	60 (15.50)

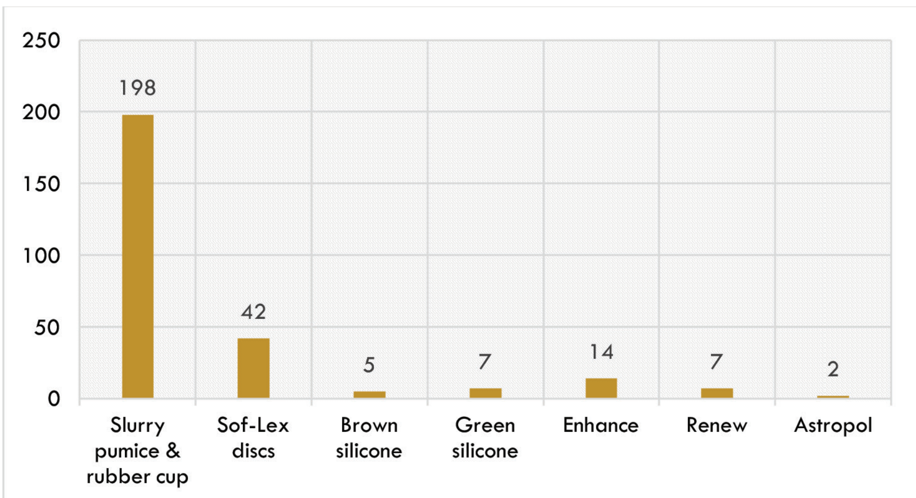

Figure 5 Instruments used in one-step enamel polishing

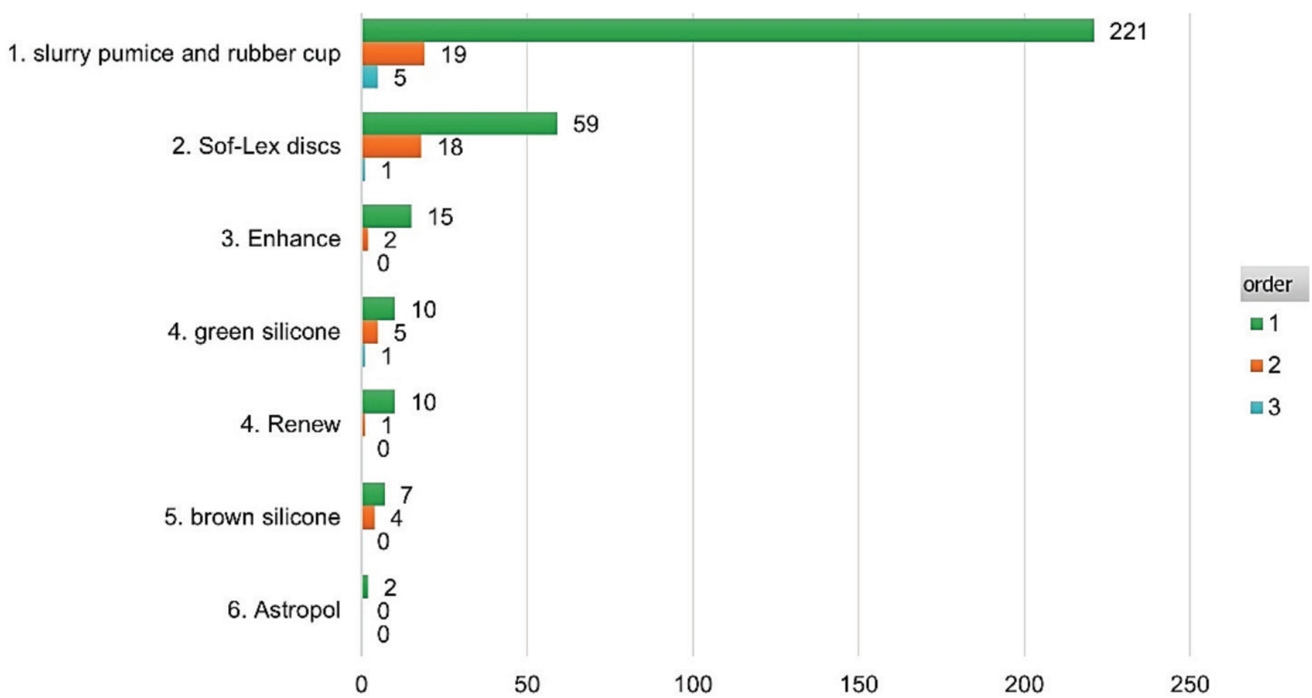

Figure 6 Overall instruments used in enamel polishing

Time spent on the entire orthodontic debonding procedure per arch was mostly less than 15 minutes (64.70 %).

Discussion

Based on the survey among the active ordinary members of Thai Association of Orthodontists, stainless steel bracket was the most commonly used fixed appliance in clinical practice (99.20 %), as in the study by Sfondrini et al.[17] Although the esthetic of metal brackets is inferior to that of the ceramic ones, the metal appliance remains more popular. A total of 97.20 % of respondents etched the enamel surface before bracket bonding using total-etched system as in the survey by Webb et al.[18] Even though the use of self-etched primer shows a statistically significant time saving compared to the use of total-etched,[19] the total-etched system was still mostly used among the respondents. Light cure composite resin was the most favored bonding agent used in bracket bonding, followed by self-cure composite resin - which is similar to the survey results of Webb et al.[18] The shear bond strength obtained from using both light cure and self-cure adhesive materials reached the minimal requirement for orthodontic bonding, but the light cure composite resin produced higher shear bond strength.[20] Furthermore, before the light-curing polymerization, orthodontists have a period of time to place the bracket at the correct position before light activation to initiate polymerization. On the other hand, self-cure adhesive has an advantage over light cure adhesive in areas that the light from the tip of the light curing unit cannot fully reach. In those areas, declination of the bond strength of the light cure adhesive occurs.[20]

As shown in Table 2, bracket debonding pliers were the most common instrument used (88.10 %), followed by ligature cutter (7.70 %). This is in line with the survey results of Webb et al.,[18] but contrasts with the survey findings of Campbell[5] and Sfondrini[17] where a ligature cutter was mostly used. For ceramic bracket debonding, there has not yet been a survey study specifically about the instrument used. Bracket debonding pliers were the most typical instrument used (34.80 %), followed by the specific ceramic bracket debonding pliers provided by the bracket manufacturer (7.20 %), and a ligature cutter (3.10 %). Bracket debonding pliers are easy to apply and can be used in both metal and ceramic bracket removal which might be due to the existence of instruments and experience that orthodontists already have from metal bracket debonding. Placement position of debonding appliances affects area of bonding breakage and adhesive remnant on enamel surface. Adhesion failure between adhesive and enamel surface leaves the least adhesive remnant, however, orthodontist has to place the debonding appliance nearest to enamel surface (Point A in Figure 2) to obtain this type of breakage which usually causes enamel gouges and damage due to the scraping of the remover.[7,9] To minimize the enamel damage, the adhesion failure between adhesive and bracket or the cohesion failure within the adhesive layer itself is more favorable. From this reason and according to previous studies[7,9,13,21], the suggestion in metal bracket removal was to squeeze the bracket debonding pliers on the bracket wing (Point C in Figure 2) mesiodistally to reduce the stress transmitted to the tooth and to avoid enamel scarring. Nevertheless, removal of the increased residual adhesive certainly takes more time in the subsequent procedure. Most respondents utilized the advised instrument and method, but the instrument placement direction was different. According to the survey, 96.60 % of respondents debonded the brackets while the main archwire was still engaged, whereas in a laboratory situation in previous studies this was not the case.[7,9,13,21] As a result, due to blockage from the main archwire to access mesiodistally, respondents had to place the debonding instrument occlusogingivally instead. However, the effect of these two different directions in the same squeezing method has not been investigated. Further study is suggested to clarify this aspect.

In ceramic bracket removal, most respondents squeezed the pliers at the bracket base-enamel junction, which is congruent with Bishara's studies.[22-25] The bracket base of the ceramic bracket was the strongest and bulkiest part, which can decrease the chance of bracket fracture during debonding as the ceramic bracket had far less deformation resistance than the metal bracket.[26] Furthermore, the squeezing force transmitted less force to the enamel compared to shear force.[25]

Concerning the instruments used in orthodontic adhesive removal, the survey showed that there were several combinations used by orthodontists to remove adhesive and polish the enamel surface. The data collected in this survey differed from other surveys due to differences in questionnaire design. The similarity in trends of instruments used among respondents who graduated from different institutes with accredited orthodontic program were interestingly found. As shown in Table 5 and Figure 4, a HS white stone bur was apparently the most popular instrument used in single-step adhesive removal, and also the most first-used if multiple instruments were applied. In contrast, a fluted tungsten carbide bur was the most typical instrument used in all other surveyed studies.[5,17,18] With respect to the second-used item of multiple instruments used, a HS white stone was still the most popular and usually used after coarser instruments such as hand pliers, HS green stone, or diamond finishing bur. The white stone bur was found to produce a smoother enamel surface than tungsten carbide bur with clinically acceptable result.[16] Its widespread use among respondents in this survey may be attributed to its versatile properties. The white stone bur is commonly used for finishing and polishing composite restorations. It is inexpensive, durable, and suitable for use in all areas of the oral cavity, while still providing an acceptable level of enamel surface smoothness. However, it has been reported to cause enamel loss, surface scratches, and the formation of facets.[6,21] In contrast, the use of coarse instruments alone, such as hand pliers, green stone burs, or diamond finishing burs, produces grooves and notches on the enamel surface, which may persist even after subsequent polishing.[5,13] Considering the coolant in adhesive removal, water was mostly used (87.40 %), in line with the study by Sfondrini et al.[17] This was congruent with the use of all HS instruments for adhesive removal indicated in the survey. HS instruments produce a large amount of heat and can lead to pulpal damage or patient discomfort. Water diminishes the vision performance of adhesive and enamel isolation.[27] For the enamel polishing procedure, there was also variability of survey results. The most used instrument was a slurry pumice and rubber cup, which was also reported as the most common polishing material in the survey by Campbell[5] and Webb et al.[18] Sandpaper abrasive discs were the next-most common instrument used, as in the survey by Campbell[5] and Sfondrini et al.[17] The coolant used in enamel polishing was not evaluated in other studies.[5,17,18] Nonetheless, the enamel polishing step is necessary because this process can remove fine enamel scratches and polish the enamel surface back to its pretreatment glossy condition.[6] Slurry pumice with rubber cup was recommended.[5,6,8,13]

Most of the respondents reported spending less than 15 minutes per arch for the entire debonding procedure. Our finding differs from the approach used in the survey by Webb et al.,[18] in which participants were asked to report the amount of time allocated for a full-mouth debonding appointment. In their findings, the majority of orthodontists scheduled approximately 15 minutes for the entire debonding process. This is different from the time spent metric in our study which was mostly less than 15 minutes "per arch." This emphasizes the need to consider the relationship between instrument selection and procedure duration as a potentially influential factor in clinical efficiency and outcomes.

Previous studies have recommended a multistep approach to adhesive removal with; 1) initial bulk removal using a HS tungsten carbide finishing bur with adequate air cooling; 2) subsequent polishing with composite polishers such as Sof-Lex discs or Enhance points and cups, using light pressure and adequate air cooling;[5,11,15,16] and 3) final enamel polishing with a rubber cup and water slurry of pumice.[8] Although the sequence of steps reported by respondents in our study was generally consistent with these recommendations, the instruments used differed. The most commonly used tool for adhesive removal was the white stone bur with water coolant, often followed by the use of composite polishers. Final enamel polishing with a rubber cup and pumice slurry was also commonly performed. These findings may reflect practical adaptations in clinical protocols and highlight the variations in routine orthodontic debonding procedures among practitioners.

A limitation of this study might be the questionnaire design for the adhesive removal and enamel polishing parts, where respondents were allowed to sort their usage order and instruments used individually. Each orthodontist has their preferred personal protocol with different institutional background and practice conditions; therefore, a variety of different protocols was submitted. With the increasing popularity of clear aligner treatment, there are situations where multiple composite attachments must be applied. The protocol for removing these attachments is a very interesting area to be investigated.

Conclusion

This survey demonstrates considerable variation among Thai orthodontists in the instruments, techniques, and time allocation used for orthodontic debonding procedures. Bracket debonding pliers were most commonly employed for both metal and ceramic bracket removal, while HS white stone burs and rubber cups with pumice were the preferred choices for adhesive removal and enamel polishing, respectively. A common approach involved either a one-step adhesive removal with HS white stone bur or a two-step technique using HS white stone bur with water cooling for bulk reduction, followed by a finer bur and final polishing with a rubber cup and pumice. These findings reflect current clinical practices rather than establish the standards, and no single ideal debonding protocol was identified. Orthodontists are encouraged to adopt evidence-based techniques that minimize enamel damage, shorten chair time, and enhance patient comfort while maintaining satisfactory clinical outcomes.

Author contributions

BA: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data Curation, Writing-Original Draft, Writing-Review & Editing, Visualization, Project administration; SS: Conceptualization, Methodology, Formal analysis, Investigation, Resources, Writing-Review & Editing, Visualization, Supervision, Project administration, Funding acquisition.

Ethical statement

The research protocol was approved by the Ethics Committee of the Faculty of Dentistry, Chiang Mai University (No. 48/2019).

Disclosure statement

The authors have no conflicts of interest.

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References

1. Buonocore MG. A simple method of increasing the adhesion of acrylic filling materials to enamel surfaces. J Dent Res 1955;34(6):849-53.
2. Nicholson JW. Adhesive dental materials—a review. Int J Adhes Adhes 1998;18(4):229-36.
3. Janiszewska-Olszowska J, Szatkiewicz T, Tomkowski R, Tandecka K, Grocholewicz K. Effect of orthodontic debonding and adhesive removal on the enamel–current knowledge and future perspectives–a systematic review. Med Sci Monit 2014;20:1991.
4. Joo HJ, Lee YK, Lee DY, Kim YJ, Lim YK. Influence of orthodontic adhesives and clean-up procedures on the stain susceptibility of enamel after debonding. Angle Orthod 2011;81(2):334-40.
5. Campbell PM. Enamel surfaces after orthodontic bracket debonding. Angle Orthod 1995;65(2):103-10.
6. Gwinnett AJ, Gorelick L. Microscopic evaluation of enamel after debonding: clinical application. Am J Orthod 1977;71(6):651-65.
7. Bennett CG, Shen C, Waldron JM. The effects of debonding on the enamel surface. J Clin Orthod 1984;18(5):330.
8. Zachrisson BU, Årthun J. Enamel surface appearance after various debonding techniques. Am J Orthod 1979;75(2):121-37.
9. Oliver RG. The effect of different methods of bracket removal onthe amount of residual adhesive. Am J Orthod Dentofacial Orthop 1988;93(3):196-200.
10. Su MZ, Lai EHH, Chang JZC, Chen HJ, Chang FHF, Chiang YC, et al. Effect of simulated debracketing on enamel damage. J Formosa Med Ass 2012;111(10):560-6.
11. Zarrinnia K, Eid NM, Kehoe MJ. The effect of different debonding techniques on the enamel surface: an in vitro qualitative study. Am J Orthod Dentofacial Orthop 1995;108(3):284-93.
12. Bishara SE, VonWald L, Laffoon JF, Warren JJ. Effect of a self-etch primer/adhesive on the shear bond strength of orthodontic brackets. Am J Orthod Dentofacial Orthop 2001;119(6):621-4.
13. Retief DH, Denys FR. Finishing of enamel surfaces after debonding of orthodontic attachments. Angle Orthod 1979;49(1):1-10.
14. Karan S, Kircelli BH, Tasdelen B. Enamel surface roughness after debonding: comparison of two different burs. Angle Orthod 2010;80(6):1081-8.
15. Özer T, Başaran G, Kama JD. Surface roughness of the restored enamel after orthodontic treatment. Am J Orthod Dentofacial Orthop 2010;137(3):368-74.
16. Mohebi S, Shafiee H-A, Ameli N. Evaluation of enamel surface roughness after orthodontic bracket debonding with atomic force microscopy. Am J Orthod Dentofacial Orthop 2017;151(3):521-7.
17. Sfondrini MF, Scribante A, Fraticelli D, Roncallo S, Gandini P. Epidemiological survey of different clinical techniques of orthodontic bracket debonding and enamel polishing. J Orthod Sci 2015;4(4):123.
18. Webb BJ, Koch J, Hagan JL, Ballard RW, Armbruster PC. Enamel surface roughness of preferred debonding and polishing protocols. J Orthod 2016;43(1):39-46.
19. Fleming PS, Johal A, Pandis N. Self-etch primers and conventional acid-etch technique for orthodontic bonding: a systematic review and meta-analysis. Am J Orthod Dentofacial Orthop 2012;142(1):83-94.
20. Shukla C, Singh G, Jain U, Swamy K. Comparison of mean shear bond strength of light cure, self-cure composite resins, self-etching and moisture-insensitive primers: An in vitro study. J Indian Orthod Soc 2012;46(4 suppl 1):254-7.
21. Hong YH, Lew KKK. Quantitative and qualitative assessment of enamel surface following five composite removal methods after bracket debonding. Eur J Orthod 1995;17(2):121-8.
22. Bishara SE, Trulove TS. Comparisons of different debonding techniques for ceramic brackets: an in vitro study: part I. Background and methods. Am J Orthod Dentofacial Orthop 1990;98(2):145-53.
23. Bishara SE, Trulove TS. Comparisons of different debonding techniques for ceramic brackets: an in vitro study: part II. Findings and clinical implications. Am J Orthod Dentofacial Orthop 1990;98(3):263-73.
24. Bishara SE, Fonseca JM, Boyer DB. The use of debonding pliers in the removal of ceramic brackets: force levels and enamel cracks. Am J Orthod Dentofacial Orthop 1995;108(3):242-8.
25. Bishara SE, Fonseca JM, Fehr DE, Boyer DB. Debonding forces applied to ceramic brackets simulating clinical conditions. Angle Orthod 1994;64(4):277-82.
26. Scott Jr GE. Fracture toughness and surface cracks—the key to understanding ceramic brackets. Angle Orthod 1988;58(1):5-8.
27. Uysal T, Eldeniz AU, Usumez S, Usumez A. Thermal changes in the pulp chamber during different adhesive clean-up procedures. Angle Orthod 2005;75(2):220-5.

Case Report

Correction of Anterior Open Bite with Clear Aligner: A Case Report

Pornpimon Kamchai* Nicha Kukongviriyapan* Bancha Samruajbenjakun**

Abstract

Background: This case report describes the orthodontic management of a 22-year-old Thai male with anterior open bite and a skeletal Class II hyperdivergent pattern. The patient exhibited a convex profile, increased lower anterior facial height, and severe crowding in the lower arch. Malocclusion presented as a large overjet (6 mm), negative overbite (–3 mm), and Class II canine and Class III molar relationships. A clear aligner system was chosen to address both aesthetic concerns and functional needs. Treatment objectives included correction of anterior open bite, establishment of Class I canine and molar relationships, resolution of crowding, improvement of dental midlines, and enhancement of facial profile. A total of 51 pairs of aligners were used in two sets, with interproximal reduction and expansion employed to create space and correct arch form discrepancies. After 26 months of treatment, normal overjet and overbite were achieved, both arches were well aligned, and a Class I molar and canine relationship was established. The patient’s profile improved with a normal smile line and reduced buccal corridor. Posttreatment records confirmed the stability of results with no root resorption or temporomandibular joint symptoms. Cephalometric evaluation showed improved incisor inclinations and a normalized interincisal angle. The patient successfully entered the retention phase with full-time wear of clear retainers. This case highlights the efficacy of clear aligners in treating complex malocclusions that include anterior open bite when case selection, biomechanics, and compliance are carefully managed.

Keywords: Anterior open bite, Clear aligner, Malocclusion, Orthodontic treatment, Skeletal Class II

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Introduction

Anterior open bite is a complex dentofacial anomaly characterized by the absence of vertical overlap between the maxillary and mandibular incisors when the posterior teeth are in full occlusion. This condition can present both functional and esthetic concerns that are often associated with tongue-thrust habits, mouth breathing, and skeletal discrepancies, particularly increased vertical facial dimensions or posterior dentoalveolar extrusion. The etiology of open bite is multifactorial, which involves a combination of genetic, environmental, and functional factors.[1]

Traditionally, the treatment of anterior open bite in adults has posed a significant challenge due to its tendency to relapse and the need to control the vertical dimension. Conventional treatment modalities include fixed appliances with vertical elastics, temporary anchorage devices[2] and orthognathic surgery in severe skeletal cases. However, with the advancement of clear aligner technology, aligner-based treatment has emerged as a viable alternative for selected cases of open bite that offers improved esthetics, comfort, and oral hygiene.

In recent years, clear aligners have become increasingly favored by adult patients due to their superior esthetics, enhanced comfort, ease of maintaining oral hygiene, and reduced chair time compared to conventional fixed appliances.[3] Studies have reported favorable outcomes in tooth movement efficiency, particularly in controlled tipping, intrusion, and space closure, when using aligners. Despite their advantages, clear aligners also have certain limitations, which include reduced efficacy in derotating cylindrical teeth, difficulties in achieving molar uprighting, and decreased aligner retention in teeth with short clinical crowns.[4,5] Such factors must be carefully considered during case selection and treatment planning.

This case report describes the treatment of an anterior open bite using clear aligners, which focused on the biomechanics involved, digital setup considerations, and clinical outcomes. The case highlights the potential of aligner therapy as a viable solution for managing open bite malocclusion in appropriately selected patients.

Case report

A 22-year-old Thai male sought orthodontic treatment at the Orthodontic Clinic of the Dental Hospital, Faculty of Dentistry, Prince of Songkla University, with the chief complaint of anterior open bite. The patient reported no known underlying diseases or allergies and was not taking any medication. The extraoral examination presented normal facial

Figure 1 Pretreatment extraoral examination.

development. The frontal view showed a symmetrical mesofacial type. In the rest position, the patient had competent lips. A low smile line presented while smiling. The patient exhibited a convex facial profile and an obtuse nasolabial angle (Figure 1). Although the patient showed no signs or symptoms of temporomandibular disorders,[6] tongue thrusting was detected during the functional assessment. The patient had with symmetrical arches, with a tapered upper arch and a square lower arch. Bolton's tooth size analysis revealed a discrepancy. The anterior ratio, calculated as (36/45) × 100 = 80.43 %, exceeded the reported mean values of 75.50–77.20–78.90 %,[7] indicating that the lower anterior teeth were 1.20 mm larger than normal, assuming the upper anterior teeth were of standard size. The overall ratio, calculated as (91/98) × 100 = 91.79 %, fell within the reported mean range of 89.40–91.30–93.20 % (Bolton, 1958),[7] suggesting consonance between the upper and lower posterior teeth. suggesting consonance between the upper and lowerposterior teeth (Table).

The intraoral examination found a large overjet (5 mm) and open bite (–3 mm). According to Angle's classification of malocclusion, the molars were Class III relationship (1 mm on the right side and 3 mm on the left side) and the canines were Class II relationship (3 mm on the right side and 2 mm on the left side) (Figures 2 and 3). The upper dental midline coincided

Figure 2 Pretreatment extraoral examination

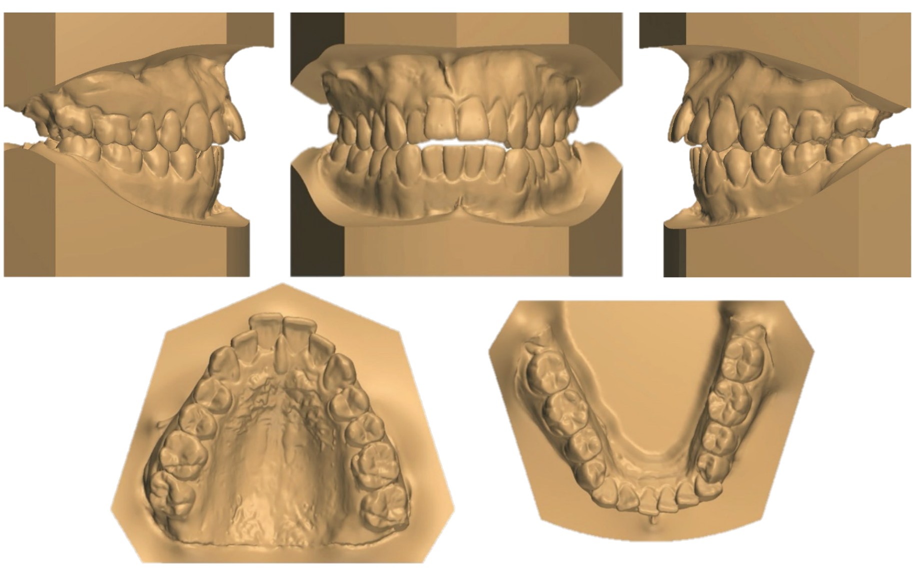

Figure 3 Pretreatment dental casts.

Table 1 Pretreatment tooth size measurements.

Tooth number	18	17	16	15	14	13	12	11	21	22	23	24	25	26	27	28
Size (mm)	-	10	10.5	7.5	8	8	7	8	8	7	8	7.5	7	11	10	-
Size (mm)	-	10	11.5	8	7	7	6	5.5	5.5	6	7	7	7.5	11.5	11	-
Tooth number	48	47	46	45	44	43	42	41	31	32	33	34	35	36	37	38

Table 2 Pretreatment Korkhaus's analysis.

	Maxillary arch		Mandibular arch	
Type	Thai norm[8]	Pretreatment	Thai norm[8]	Pretreatment
Arch height (mm)	19.10 ± 2.40	21.00	17.3 ± 2.30	15.00
Anterior arch width (mm)	36.40 ± 1.90	31.00	36.2 ± 2.10	34.00
Posterior arch width (mm)	46.80 ± 2.20	46.50	45.7 ± 2.20	46.50

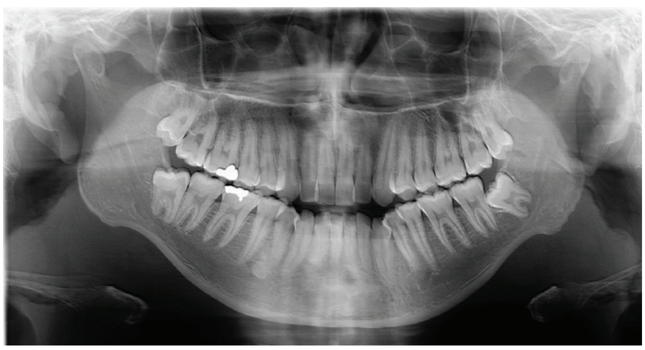

Figure 4 Pretreatment panoramic radiograph.

with the facial midline, and the lower dental midline deviated from the facial midline to the left by 2 mm. Space analysis demonstrated mild crowding of the upper arch and severe crowding on lower arch (Figures 2 and 3). Neither dental interference nor functional shift was detected. The soft tissue presented normal oral soft tissue, mucosa, and adequate attached gingiva. The tongue size and position were normal. The periodontium was diagnosed with gingivitis.

The Korkhaus analysis[8] showed that the upper anterior arch width (AAW) was narrower than the lower AAW, but the upper posterior arch width (PAW) was equal to the lower PAW. Upper and lower AAW were narrower than the standard values, whereas upper and lower PAW were equal to the standard values. The upper arch height (AH) was larger than the lower AH. Upper and lower AH were equal to the standard values (Table 2). Space analysis measurements revealed that the upper arch had a space deficiency of 3 mm and the lower arch had a space deficiency of 7 mm.

A panoramic radiograph showed dental development at the permanent dentition stage. The maxillary nasal septum, bone density, and trabeculation were within normal limits with no other visible pathology. The patient had symmetrical mandibular condyles (Figure 4). A well-defined radiopaque mass was observed at the apex of tooth 44, which was diagnosed as idiopathic osteosclerosis (IO), a benign

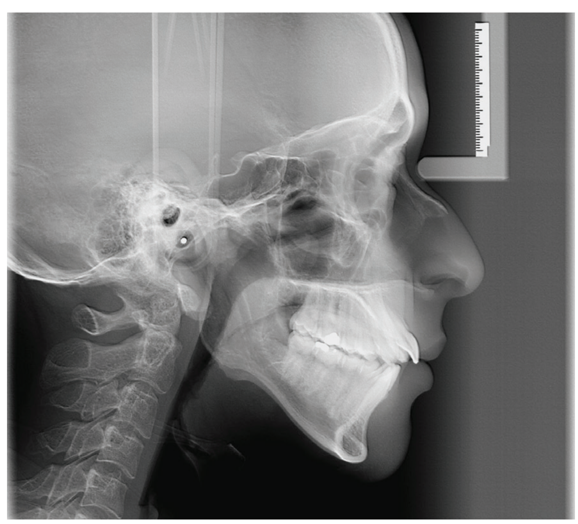

Figure 5 Pretreatment lateral cephalogram.

and asymptomatic bone density variation. Orthodontic treatment in areas affected by IO can be successfully performed without complications.[9]

A lateral cephalometric analysis[10] indicated a skeletal Class II hyperdivergent pattern with an orthognathic maxilla and retrognathic mandible. Also observed were proclined but normally positioned upper incisors, normally inclined and positioned lower incisors, acute interincisal angle, increased posterior dentoalveolar height (PDH), normally positioned upper and lower lips, and an obtuse nasolabial angle (Figure 5 and Table 3).

This patients had skeletal, dental, and soft tissue problems. The skeletal problems included skeletal Class II relationship with retrognathic mandible and hyperdivergent pattern. The dental problems included dental Class I malocclusion with crossbite on 23/33, open bite of the anterior teeth, mild crowding

Table 3 Pretreatment cephalometric analysis.

Area		Measurement	Norm (Mean ± SD)	Pretreatment	Interpretation
Reference line		FH-SN (deg.)[10]	6 ± 3	14	Steep SN plane
Skeletal	Maxilla to cranial base	SNA (degree)[11]	84 + 4	83	Orthognathic maxilla
		A-Nperp (mm)[12]	5 ± 4	6	Orthognathic maxilla
		SN-PP (degree)[12]	9 ± 3	15	Hyperdivergent pattern
	Mandible to cranial base	SNB (degree)[11]	81 ± 4	74	Retrognathic mandible
		Pg-Nperp (mm)[12]	0 ± 6	−3	Orthognathic mandible
		SN-Pg (degree)[11]	82 ± 3	73	Retrognathic mandible
		SN-MP (degree)[11]	29 ± 6	43	Hyperdivergent pattern
		NS-Gn (degree)[11]	68 ± 3	73	Hyperdivergent pattern
	Maxillo-mandibular	ANB (degree)[11]	3 ± 2	9	Skeletal Class II
		Wits (mm)[10]	−3 ± 2	−3	Skeletal Class I
		FMA (degree)[12]	23 ± 5	34	Hyperdivergent pattern
		MP-PP (degree)[11]	21 ± 5	28	Hyperdivergent pattern
Dental	Maxillary dentition	$\underline{1}$ to NA (degree)[11]	22 ± 6	30	Proclined upper incisors
		$\underline{1}$ to NA (mm)[11]	5 ± 2	3	Normally positioned upper incisors
		$\underline{1}$ to SN (degree)[11]	108 ± 6	118	Proclined upper incisors
		ADH (mm)[13]	27.23 ± 2.79	30	Normal ADH
		PDH (mm)[13]	22.24 ± 2.23	26	Increased PDH
	Mandibular dentition	$\overline{1}$ to NB (degree)[11]	30 ± 6	34	Normally inclined lower incisors
		$\overline{1}$ to NB (mm)[11]	7 ± 2	9	Normally positioned lower incisors
		$\overline{1}$ to MP (degree)[10]	99 ± 5	92	Normally inclined lower incisors
	Maxillo-mandibular	$\underline{1}$ to $\overline{1}$ (degree)[11]	125 ± 8	110	Acute interincisal angle
Soft tissue	Soft tissue	E line U. lip (mm)[12]	−1 ± 2	−2	Normally positioned upper lip
		E line L. lip (mm)[12]	2 ± 2	0	Normally positioned lower lip
		NLA (degree)[10]	91 ± 8	108	Obtuse nasolabial angle
		H-angle (degree)[11]	14 ± 4	18	Normally positioned upper lip

of the upper teeth, severe crowding of the lower teeth, proclined upper incisors, acute interincisal angle, increased PDH, negative overbite, large overjet, and lower dental midline shifts to the left side. The soft tissue problems included a convex facial profile and obtuse nasolabial angle. Therefore, the treatment objectives were: 1) to correct anterior open bite by created normal overjet and overbite; 2) to improve the skeletal relationship to obtain normally inclined and positioned upper incisors, 3) to obtain normal alignment and Class I canine and molar relationship, 4) to center the lower dental midline, and 5) to improve the facial profile. The etiology of the malocclusion[14] was due to hereditary factors from the father who also had skeletal Cl II hyperdivergent pattern with anterior open bite and tooth and arch size discrepancies with a tapered upper arch with mild crowding and square lower arch with severe crowding. According to the collected information, the patient was diagnosed as Class II skeletal relationship with orthognathic maxilla with retrognathic mandible and hyperdivergent pattern, dental Class I malocclusion with large overjet and negative overbite, increased PDH, convex facial profile, and obtuse nasolabial angle. We decided to manage this patient using non-extraction clear aligner therapy.

Clear aligners were used to treat the patient as retroclined upper incisors, intruding the upper posterior teeth, solving crowding, shifting the lower dental midline without requiring complex tooth movements while addressing the esthetic concerns of the patient. Space in the upper arch was obtained by expanding and reshaping the arch form with interproximal reduction to adjust the inclination of the upper incisors, intruding the upper posterior teeth, and resolving the crowding. In the lower arch, space was created by proclining the lower incisors and performing interproximal reduction, which addressed the Bolton discrepancy and resolved the issues of crowding and the shifted lower dental midline. The computer-generated virtual setup provided by the aligner company was reviewed, modified, and approved. The treatment was carried out using 29 aligners for both the upper and lower arches in the first set, with interproximal reduction performed at stage 13 for the upper arch and stage 16 for the lower arch. The treatment protocol was implemented with set 2 following the identification of crowding on tooth 33, lower dental midline that shifted to the left, a slight posterior open bite, and a buccal overjet on the right side. The patient was provided with 22 aligners for both the upper and lower arches. The space obtained through the expansion of the lower right jaw was utilized to alleviate the crowding and correct the shifted lower dental midline.

Figure 6 Posttreatment extraoral examination.

After 26 months of treatment, facial evaluation revealed a normal vertical facial proportion and a convex profile. Of particular note, the smile line had improved to a normal smile line. An improvement in the buccal corridor was observed during smiling compared to the pre-treatment condition. The upper dental midline was aligned with the facial midline, whereas the lower dental midline deviated 0.25 mm to the left. The dentition exhibited proper alignment and demonstrated good coordination with both the maxillary and mandibular arch forms. The final occlusion showed a Class I relationship of both canines and molars with normal overjet and overbite (Figures 6, 7, 8, and Table 4).

Figure 7 Posttreatment intraoral examination.

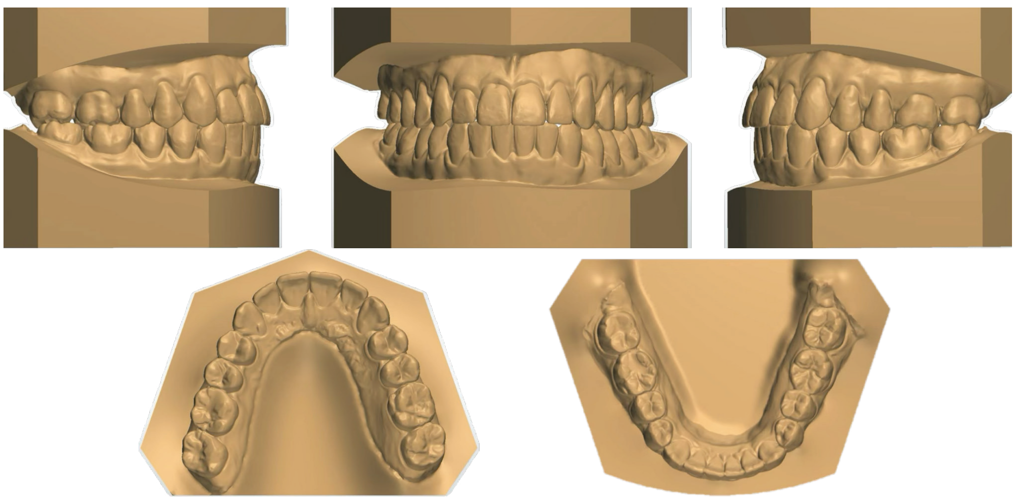

Figure 8 Posttreatment dental casts.

Table 4 Comparison of the pretreatment and posttreatment dental cast analysis.

Parameters		Pretreatment	Posttreatment
Overjet		6 mm	2 mm
Overbite		–3 mm	2 mm
Canine relationships	Right	Cl II 3 mm	Cl I
	Left	Cl II 2 mm	Cl I
Molar relationships	Right	Cl III 1 mm	Cl I
	Left	Cl III 3 mm	Cl I
Upper	Midline	Center	Center
	Arch form	Taper	Paraboloid
	Anterior arch width	31 mm	37 mm
	Posterior arch width	47 mm	50 mm
Lower	Midline	Shift to the left 2 mm	Shift to the left 0.25 mm
	Arch form	Square	Paraboloid
	Anterior arch width	34 mm	36.5 mm
	Posterior arch width	47 mm	49 mm

The post-treatment lateral cephalometric radiograph revealed; 1) skeletal Class II hyperdivergent pattern with orthognathic maxilla and rethognathic mandible, 2) normally inclined and positioned upper mandible, 2) normally inclined and positioned upper and lower incisors, 3) normal interincisal angle, 4) normal PDH, 5) convex soft tissue profile, 6) normally positioned upper and lower lips, and 7) improved obtuse nasolabial angle (Figure 9 and Table 5).

The panoramic radiograph revealed nearly parallel roots and no external root resorption (Figure 10). Additionally, the idiopathic osteosclerosis detected at the initial stage of treatment remained unchanged in both size and location. A cranial base superimposition revealed no growth of either the nasion or basion points, the maxilla, or the mandible. The mandible was found to rotate counterclockwise. The maxillary superimposition represented the upper incisor, which was retroclined and extruded, while the upper molar intruded. Furthermore, an examination of the mandibular superimposition showed that the lower incisor had proclined, while the lower molar was maintained (Figure 11).

Following the removal of all orthodontic appliances, the treatment entered the retention phase. A clear retainer was custom-fitted to maintain the posttreatment dental alignment. The patient was instructed to wear both maxillary and mandibular retainers full-time, removing them only during meals and oral hygiene routines. Follow-up evaluations were scheduled at 1 week, 1 month, and 3 months post-debonding, and subsequently every 6 months, to assess function, esthetics, and stability. At each follow-up, the patient demonstrated a stable occlusion with an acceptable facial profile, proper

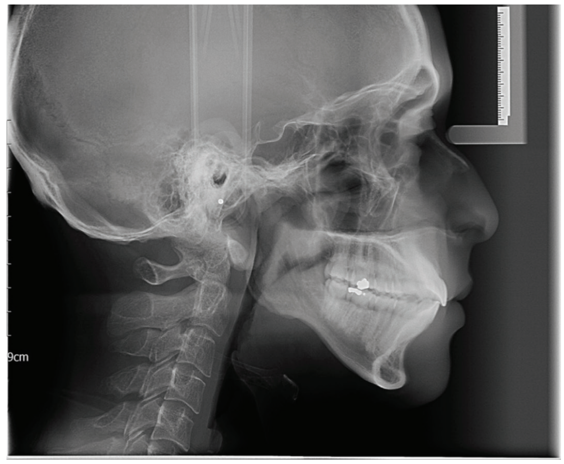

Figure 9 Posttreatment lateral cephalogram.

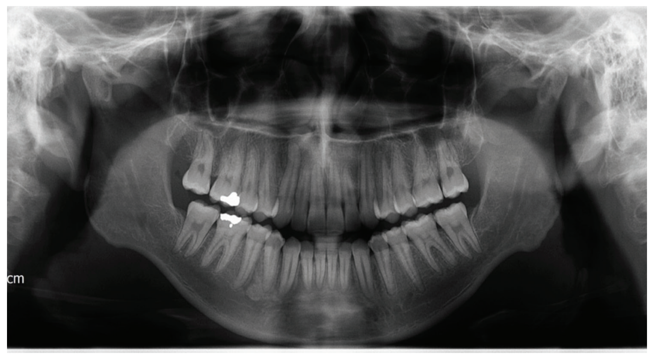

Figure 10 Posttreatment panoramic radiograph.

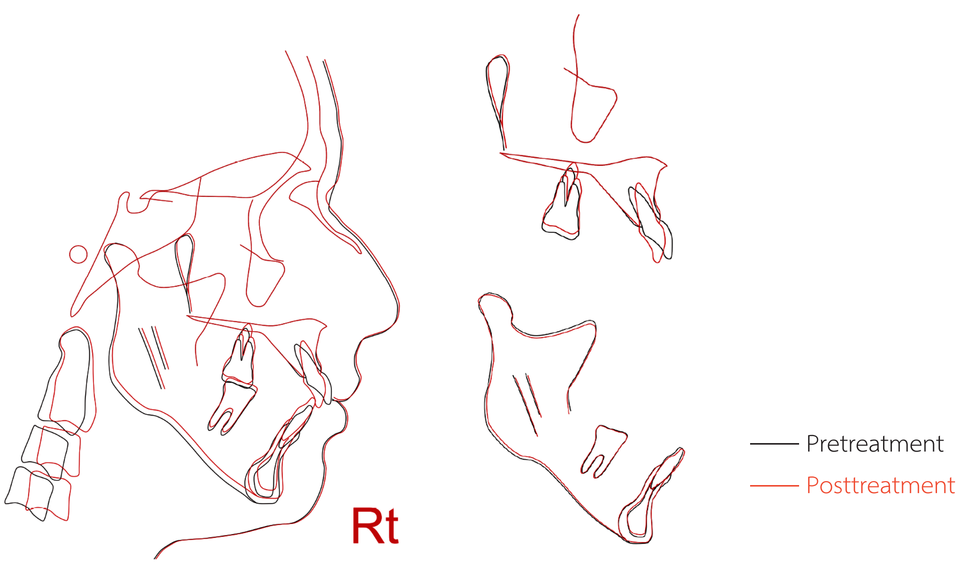

Figure 11 Cephalometric superimposition of pretreatment (black) and posttreatment (red) tracings.

Table 5 Posttreatment cephalometric analysis.

Area		Measurement	Norm (Mean ± SD)	Pretreatment	Posttreatment	Difference
Reference line		FH-SN (deg.)[10]	6 ± 3	14	14	0
Skeletal	Maxilla to cranial base	SNA (degree)[11]	84 + 4	83	83	0
Skeletal	Maxilla to cranial base	A-Nperp (mm)[12]	5 ± 4	6	6	0
Skeletal	Maxilla to cranial base	SN-PP (degree)[12]	9 ± 3	15	15	0
Skeletal	Mandible to cranial base	SNB (degree)[11]	81 ± 4	74	75	+1
Skeletal	Mandible to cranial base	Pg-Nperp (mm)[12]	0 ± 6	−3	−2	+1
Skeletal	Mandible to cranial base	SN-Pg (degree)[11]	82 ± 3	73	75	+2
Skeletal	Mandible to cranial base	SN-MP (degree)[11]	29 ± 6	43	41	−2
Skeletal	Mandible to cranial base	NS-Gn (degree)[11]	68 ± 3	73	72	−1
Skeletal	Maxillo-mandibular	ANB (degree)[11]	3 ± 2	9	8	−1
Skeletal	Maxillo-mandibular	Wits (mm)[10]	−3 ± 2	−3	−1	+2
Skeletal	Maxillo-mandibular	FMA (degree)[12]	23 ± 5	34	32	−2
Skeletal	Maxillo-mandibular	MP-PP (degree)[11]	21 ± 5	28	26	−2
Dental	Maxillary dentition	1 to NA (degree)[11]	22 ± 6	30	16	−14
Dental	Maxillary dentition	1 to NA (mm)[11]	5 ± 2	3	2	−1
Dental	Maxillary dentition	1 to SN (degree)[11]	108 ± 6	118	110	−8
Dental	Maxillary dentition	ADH (mm)[13]	27.23 ± 2.79	30	32	+2
Dental	Maxillary dentition	PDH (mm)[13]	22.24 ± 2.23	26	23	−3
Dental	Mandibular dentition	1 to NB (degree)[11]	30 ± 6	34	35	+1
Dental	Mandibular dentition	1 to NB (mm)[11]	7 ± 2	9	9	0
Dental	Mandibular dentition	1 to MP (degree)[10]	99 ± 5	92	93	0
Dental	Maxillo-mandibular	1 to (degree)[11]	125 ± 8	110	127	+17
Soft tissue	Soft tissue	E line U. lip (mm)[12]	−1 ± 2	−2	−2	0
Soft tissue	Soft tissue	E line L. lip (mm)[12]	2 ± 2	0	0	0
Soft tissue	Soft tissue	NLA (degree)[10]	91 ± 8	108	105	−3
Soft tissue	Soft tissue	H-angle (degree)[11]	14 ± 4	18	18	0

intercuspation, and no interferences during lateral or protrusive mandibular movements. The patient complied well with the full-time wear protocol and showed strong motivation to maintain the alignment that was achieved through orthodontic treatment.

Discussion

This case report presents the successful non-extraction orthodontic management of anterior open bite in an adult patient exhibiting a skeletal Class II hyperdivergent pattern using clear aligner therapy.

The outcome highlights the expanding role of aligners as an effective non-surgical option for selected open bite cases, particularly those with complex vertical and sagittal discrepancies.

Anterior open bite in adults is a multifactorial malocclusion that is often complicated by skeletal growth patterns, soft tissue dysfunctions, and high relapse potential. Conventional treatment modalities typically involve vertical elastics, temporary anchorage devices for molar intrusion, or orthognathic surgery in severe cases.[15] However, recent advances in clear aligner technology have broadened non-invasive treatment possibilities by providing enhanced biomechanical control alongside improved patient comfort and esthetics.

In this patient, factors contributing to the open bite included a hyperdivergent growth pattern, mandibular retrognathia, increased PDH, proclined maxillary incisors, and a familial skeletal pattern. Additionally, significant crowding in the lower arch and an anterior tooth size discrepancy (Bolton's discrepancy) necessitated strategic space management and arch form modification.

Transverse arch expansion was incorporated into the treatment protocol to alleviate the lower arch crowding. Although arch expansion in adults frequently risks exacerbating anterior open bite by causing buccal tipping of posterior teeth and altering occlusal contacts, the use of clear aligners in this case effectively mitigated such side effects. The inherent interocclusal thickness of the aligners provided vertical support that minimized the potential for excessive bite opening during expansion.[16] Furthermore, this thickness generated a favorable intrusive force on the posterior teeth during occlusion, which, while potentially problematic in patients with normal or deep overbite, was advantageous in this anterior open bite case by promoting molar intrusion and facilitating bite closure. Digital treatment planning enabled precise control over incisor inclination, posterior tooth intrusion, and midline correction. The combined use of arch expansion, interproximal reduction, and biomechanical strategies successfully addressed the crowding and Bolton discrepancy while optimizing occlusal relationships and esthetic outcomes.

Posttreatment evaluation confirmed correction of the anterior open bite with normalized overjet and overbite, achievement of Class I molar and canine relationships, and well-aligned dental arches. Cephalometric superimposition demonstrated counterclockwise mandibular rotation, upper incisor retroclination, and upper molar intrusion that contributed to improved vertical dimension control. No signs of root resorption were observed, which underscored the biological safety of aligner therapy over the treatment period. Stability was maintained through clear retainers, with patient compliance and follow-up confirming long-term success.

This case demonstrates the successful management of anterior open bite in a non-growing adult patient using clear aligner therapy. The outcome is consistent with recent evidence supporting the effectiveness of clear aligners in treating open bite malocclusions. In such cases, the bite-plane effect of the aligner's thickness promotes posterior intrusion, which facilitates anterior bite closure and provides a favorable approach for hyperdivergent skeletal patterns.[17,18]

In contrast, managing deep bite with aligner therapy remains challenging. Clinical studies consistently report that posterior extrusion is among the least predictable movements, with only about 30–40 % of the planned extrusion achieved clinically.[19] Moreover, the accuracy of overbite correction after the initial aligner set averages only 33 %.[20] Although some degree of incisor intrusion is achievable, the overall bite reduction is frequently under-expressed compared with the virtual setup, and refinement stages provide limited additional improvement.[20]

Therefore, careful case selection is crucial. Clear aligners are well suited for anterior open bite patients, particularly those with hyperdivergent skeletal patterns, because of their capacity to induce posterior intrusion. In contrast, patients with deep bite malocclusion may require hybrid protocols or adjunctive mechanics to achieve reliable vertical correction. Recognizing these biomechanical differences allows clinicians to better tailor treatment planning and set realistic expectations for outcomes.[21]

Conclusion

This case illustrates the successful management of anterior open bite in an adult patient through clear aligner therapy. The treatment achieved favorable dental and skeletal outcomes that included normalized overjet and overbite, Class I molar and canine relationships, dental midline correction, and enhanced facial esthetics. Cephalometric superimposition confirmed effective vertical control and stable post-treatment results. Clear aligners may serve as an effective alternative to conventional mechanics in selected adult open bite cases. Nevertheless, the success of such treatment is critically dependent on patient compliance throughout the course of therapy.

Author contributions

PK, NK: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization; BS: Conceptualization, Methodology, Software, Validation, Investigation, Resources, Writing - Review & Editing, Visualization, Supervision, Project administration.

Ethical statement

The patient's consent was obtained before publication.

Disclosure statement

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References

1. Lone IM, Zohud O, Midlej K, Paddenberg E, Krohn S, Kirschneck C, et al. Anterior open bite malocclusion: from clinical treatment strategies towards the dissection of the genetic bases of the disease using human and collaborative cross mice cohorts. J Pers Med 2023;13(11):1617.
2. Alsafadi AS, Alabdullah MM, Saltaji H, Abdo A, Youssef M. Effect of molar intrusion with temporary anchorage devices in patients with anterior open bite: a systematic review. Prog Orthod 2016;17:9.
3. AlMogbel A. Clear aligner therapy: up to date review article. J Orthod Sci 2023;12:37.
4. Simon M, Keilig L, Schwarze J, Jung BA, Bourauel C. Treatment outcome and efficacy of an aligner technique--regarding incisor torque, premolar derotation and molar distalization. BMC Oral Health 2014;14:68.
5. Zhou C, Feng Z, Ren J, Luo H, Ieong HC, Li R, et al. The effects of clinical crown length on the sagittal movement of maxillary central incisor in clear aligner treatment: a finite element exploration. BMC Oral Health 2025;25(1):357.
6. Schiffman E, Ohrbach R, Truelove E, Look J, Anderson G, Goulet JP, et al. Diagnostic criteria for temporomandibular disorders (DC/TMD) for clinical and research applications: recommendations of the international RDC/TMD consortium network and orofacial pain special interest groupdagger. j oral facial pain headache 2014;28(1):6-27.
7. Bolton WA. Disharmony in tooth size and its relation to the analysis and treatment of malocclusion. Angle Orthod 1958;28(3):113-30.
8. Chintawongvanich J, Thongudomporn U. Arch dimension and tooth size in class i malocclusion patients with anterior crossbite. J Dent Assoc Thai 2013;63(1):31-38.
9. Mishra G, R B, Bhogte SA, Chitra P. Idiopathic osteosclerosis in orthodontic patients: a report of two cases. Cureus 2024;16(2):e53426.
10. Sorathesn K. Craniofacial norm for Thai in combined orthodontic surgical procedure. J Dent Assoc Thai 1988;38(5):190-201.
11. Suchato W, Chaiwat J. Cephalometric evaluation of the dentofacial complex of Thai adults. J Dent Assoc Thai 1984;34(5):233-43.
12. Dachkunakron S. Thai adult norms in various lateral cephalometric analyses. J Dent Assoc Thai 1994;44(5):202-14.
13. Pornsirianand V, Chavanavesh J, Kanpittaya P, Somboonsavatdee A. Retrospective cross-sectional study of quadratic-linear

correlations between cephalometric measurements and profile esthetics in adult orthodontic patients. Int Dent J 2025;75(3):1472-81.

14. Proffit WR, Fields HW, Larson B, Sarver DM. Contemporary orthodontics. 6th ed. South Asia ed. St. Louis: Elsevier Health Sciences; 2018.p.664-7.
15. Hsu JY, Cheng JH, Feng SW, Lai PC, Yoshida N, Chiang PC. Strategic treatment planning for anterior open bite: a comprehensive approach. J Dent Sci 2024;19(3):1328-37.
16. Li N, Wang C, Yang M, Chen D, Tang M, Li D, et al. Effects of different tooth movement patterns and aligner thicknesses on maxillary arch expansion with clear aligners: a three-dimensional finite element study. Front Bioeng Biotechnol 2024;12:1424319.
17. Olteanu ND, Romanec C, Cernei ER, Karvelas N, Nastri L, Zetu IN. Scoping review-the effectiveness of clear aligners in the management of anterior open bite in adult patients. Medicina (Kaunas) 2025;61(6):1113.
18. Iunes TF, A.P, Urzal, V. The effectiveness of aligners in the treatment of anterior open bite in adult patients: a systematic review and critical appraisal. Oral 2024;4(2):173-84.
19. Blundell HL. Deep bite correction with clear aligners – after 26 years where are we at? Semin Orthod 2025:1–5.
20. Shahabuddin N, Kang J, Jeon HH. Predictability of the deep overbite correction using clear aligners. Am J Orthod Dentofacial Orthop 2023;163(6):793-801.
21. Papadimitriou A, Mousoulea S, Gkantidis N, Kloukos D. Clinical effectiveness of Invisalign(R) orthodontic treatment: a systematic review. Prog Orthod 2018;19(1):37.

Review Article

Issues of Fake Braces: A Review of Literature

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Abstract

The rising trend of fake braces, particularly in Southeast Asia, has raised significant health concerns. Regarded as a fashion statement, fake braces are unregulated orthodontic appliances sold through social media and online marketplaces. Unlike conventional braces, fake braces are often self-applied or installed by unqualified individuals, lacking the oversight of licensed professionals. Adolescents and young adults are drawn to fake braces because of their perception as a status symbol, affordability and potential to be aesthetically customised. However, serious concerns exist around oral health, including periodontal damage, infection, allergic reactions and unintentional ingestion due to the low-quality materials. These risks are further highlighted by reports of mortality and morbidity. According to studies, fake braces exhibit irregular surface textures, encouraging the growth of germs and the creation of biofilms, which exacerbates oral problems such as caries. Despite these risks, research on the toxicity and clinical impacts of fake braces remains sparse. Laboratory analyses indicate the presence of standard alloy components, but the long-term safety of these materials in unregulated devices is unverified. Efforts to regulate the sale and installation of fake braces are undermined by their easy accessibility online. This review examines the sociocultural drivers, material composition, associated risks and regulatory challenges surrounding the use of fake braces. It also emphasises the need for public education, stricter enforcement of medical device regulations, and further research on the detrimental effects of fake braces on oral and systemic health. Robust evidence is crucial for policy interventions to curb this alarming trend.

Keywords: Cytotoxicity, Fake braces, Fashion braces, Material composition

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Introduction

A growing demand exists among communities around the world for orthodontic treatment. The desire for a better dental appearance (65 %) and to obtain straight teeth (48 %) are the most significant factors affecting patients in Malaysia when pursuing orthodontic treatment.[1] Orthodontic treatment is seen by the public as a method to enhance personal appearance, oral health and self-confidence. Several studies have linked malocclusion to quality of life.[2,3] However, long waiting lists for government clinics make these issues difficult to address. The downside of orthodontic treatment by specialists from the public perspective is that it is costly, patients must attend clinical appointments regularly every 6–8 weeks and treatment may last up to 3 years.[4] Fake braces, artificial removable and fixed orthodontic appliances, have recently become popular among adolescents and young adults.[5] Tooth surfaces decorated with various designs and colourful orthodontic rubber bands (also known as O-rings) are considered accessories just like earrings or necklaces. Fake braces are mostly advertised on online shopping platforms. Some can also be found on social media such as Instagram, Facebook and Twitter. They can be self-fixed, or the fixation can be performed by illegal practitioners at beauty salons, hotels or even homes. Fake braces can be purchased much cheaper than genuine ones, and the duration of wear is only 3–5 months, with no follow-up review to monitor the teeth.[5-7] For adolescents and young adults, fake braces are an easier option. This article examines issues pertaining to fake braces, along with a few factors that contribute to their detrimental effect on oral tissues, whether they have been studied or not.

Issues regarding fake braces

No scientific evidence documents the origin of fake braces. However, the issue has been receiving attention in Thailand since 2004, when the deaths of two adolescents were linked to the use of fake braces. A non-professional practitioner in the northeast city of Khon Kaen left a 17-year-old girl with an infected thyroid that led to heart failure, causing death. In Chonburi, the death of a girl aged 14 years was linked to fake braces bought at an illegal stall.[8] In Malaysia, an Annual Report by the Ministry of Health Malaysia published in December 2019 noted that between 2015 and 2018, a total of 42 complaints included 27 about the installation of fake braces. All offences were prosecuted, with fines ranging from RM30,000–RM100,000 or imprisonment ranging from 2 to 12 months.[9] Fake braces are currently very popular in Southeast Asian countries such as Thailand, Malaysia, Indonesia and China as a fashion statement. Cases of fake braces have also been reported in the Middle East[10] and seemed to gain popularity in Brazil since 2016.[11] Wearing an orthodontic fixed appliance is considered a sign of status, style and wealth due to the high treatment cost. This is partially due to its popularity among young celebrities and social media influencers. Hollywood actors and singers such as Britney Spears, Emma Watson, Gwen Stefani and Miley Cyrus have played a role in making these adornments popular among young generations.[12] In contrast, young people in Western countries consider wearing orthodontic appliances and other facial accessories stigmatised and the epitome of an awkward adolescent period.[4] Due to the increasing trend of braces, various terms have been used to describe these fake adornments. The terms fake, fashion and faux braces have been used interchangeably. Nasir et al. attempted to classify these accessories into two categories. 'Fake' braces are fashion appliances that are not bonded to the teeth; orthodontic brackets and elastics are attached to the wire, and the wire is bent at the end and inserted between the molars. Thus, no direct tooth movement is caused. 'Real' braces are fixed to the teeth and can induce tooth movement.[13] However, these definitions could be confusing to lay consumers because the term 'real' might suggest that these fake accessories are legitimate. Another term widely used to refer to these artificial braces, mainly in literature from Middle Eastern countries, is fashion braces. This

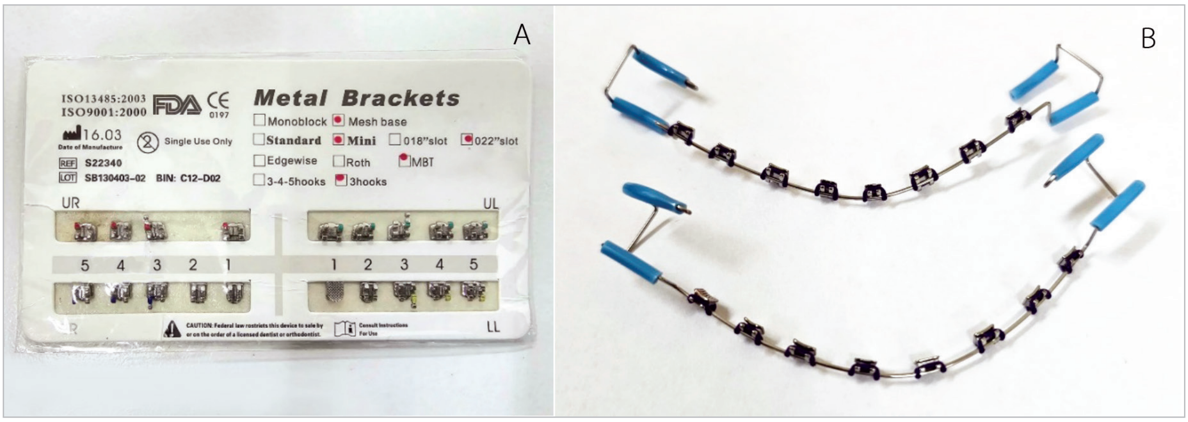

Figure 1 Two types of fake braces sold in online marketplaces. (A) Bonded-type fake braces; (B) removable-type fake braces or 'click braces'.

refers to both the bonded and non-bonded types of artificial braces.[7,14,15] The non-bonded type is also known as click braces in some online marketplaces in Malaysia[16] or simply removable braces. Figure 1 shows the two most common types of fake braces that are readily available in online marketplaces.

Fake braces can be easily purchased via social media platforms such as Instagram, Facebook and Twitter, as well as various online marketplaces such as Shopee and Lazada in Malaysia[17] and other global shopping platforms such as Alibaba, AliExpress, eBay and Amazon.[18] Bonded-type fake braces are usually provided by non-professional practitioners or self-proclaimed dentists in unlicensed premises such as hotel rooms, customers' homes and beauty spas. These unqualified practitioners have never received any formal dental education and have often learned about braces and how to fix them through YouTube and other online video platforms.[19] The status of these illegal materials is also unknown. The risks associated with wearing these kinds of braces include pain, damage to the surrounding tooth-supporting structures (such as the periodontal ligaments), accidental swallowing or aspiration of the appliance, infection from unsterilised equipment, lead poisoning,[13,20] worsening of crowding, discolouration of the teeth due to prolonged leaching of composite at the bracket base, and poor maintenance of oral hygiene leading to the development of white spot lesions, caries and poor gingival health.[10] Conversely, conventional or medical-grade braces are produced by medical device manufacturers and widely used by licensed orthodontic specialists at dental clinics or hospitals. These conventional brackets are thoroughly tested for safety and efficacy in producing the desired tooth movement.[13,21]

Elemental composition of fake braces

To date, very little scientific research has been published regarding fake braces. The topic has been discussed in several[15-17,20,22] articles raising concerns with "YouTube-based orthodontics", but not in terms of material composition, cytotoxicity or bacterial contamination. A recent study by Nasir[13,23] discussed the chemical and microstructural analysis of fake braces. Each bracket ('fake', 'real' and conventional braces) was manufactured from different alloys, predominantly iron, chromium, nickel, copper and carbon. No significant difference existed between the three types of braces in terms of material composition, and no toxic metals such as lead, mercury or arsenic were detected. However, only three samples were tested from each group, and these results should be interpreted cautiously. Haleem further tested the chemical and microstructural changes in fake braces immersed in simulated body fluids (SBF) at various intervals (days 0, 7, 14 and 28). The changes in the surface microstructure of the fake braces and changes in the pH of the SBF were recorded. The fake braces had increased irregularity and rough surfaces, with obvious large alloy particles in the surface texture. In comparison with the control stainless steel standard orthodontic archwire, the fake braces had identical ion components, surface irregularities and pH changes. However, this study did not represent the real oral environment because SBF was used as the medium and the pH was not manipulated to simulate the oral environment. Furthermore, the fake braces used in the study were of the click braces type and not the type that is bonded to the teeth. Both studies by Nasir and Haleem also did not investigate the toxicity effects of fake braces against human cells or tissues.

Cytotoxicity of fake braces

Cytotoxicity is an in vitro test to determine whether any cell death may be caused by the medical device due to the leaching of toxic substances or direct contact. Detailed procedures on how to perform cytotoxicity tests are found in ISO 10993-5.[24] Even conventional orthodontic appliances may corrode over time due to exposure to chemical, thermal and physical agents such as food, liquid and toothbrushes in the mouth[25] if left longer than the intended treatment duration, which is usually approximately 2 years. This effect may be worse with an inferior stainless steel grade, which may be the case with fake braces, probably worn longer due to social pressure. The major corrosion products are nickel, chromium and iron. These products can be absorbed into the body.[26] Nickel allergy is the most common contact allergy in developed countries; patch test evidence from general populations in many studies has shown that this allergy affects 10 % – 30 % of women and 1 % – 3 % of men.[27] Of the general population, 10 % are allergic to nickel.[28] Allergic reactions to chromium released from orthodontic components have also been reported.[29] Ahrari[30] categorised cytotoxicity as 1) more than 90 % cell viability (no cytotoxicity), 2) 60 % – 90 % cell viability (slight toxicity), 3) 30 % – 59 % cell viability (moderate cytotoxicity), and 4) less than 30 % cell viability (severe cytotoxicity). Metal orthodontic materials used in the clinic (such as orthodontic bands, brackets and archwires) can be considered non-cytotoxic to slightly cytotoxic.[31,32] Investigation into the cytotoxicity of a material used in the body is important because it can guide clinicians in choosing materials to avoid irritation or reactions towards soft tissue and danger to the body systemically.[33,34] Although some sellers state on their fake braces packaging that the consumer should only wear it as an accessory and oral hygiene is important, proper follow-up by an authorised dentist is crucial to monitor their dental health. Users may wear the device for a long duration, which may cause unwanted tooth movement and soft tissue irritation.

Plaque retention

Another parameter that has not been investigated by any researchers to date is the dental plaque retention on these materials, either in vitro or in vivo. Metal brackets used in orthodontic practice have been found to inflict ecological changes in the oral environment, such as decreased pH of the saliva and increased plaque accumulation.[35] Generally, the formation of dental plaque on teeth is composed of numerous bacterial species. One of the bacterial strains that is prominently involved in dental plaque and caries formation is Streptococcus mutans.[36] This bacterium is the primary cariogen that produces several virulence factors.[37] Streptococcus species have long filamentous structures similar to the pili observed on bacteria surfaces. These structures exhibit adhesive properties and may play a key role in adhering to host cells and tissues, as well as in biofilm formation.[38] Studies have also found that isolates of Streptococcus mutans have a higher ability to produce biofilm or plaque-like substances in the oral cavity, compared to isolates of other Streptococcus species.[39,40] In the context of caries aetiology, the ability of Streptococcus mutans to form biofilm on tooth surfaces or dental materials is significant from a clinical viewpoint. Studies have reported that the surface roughness of dental materials has a crucial impact on bacterial adhesion and the subsequent biofilm formation, and microorganisms adhere best to a bracket surface that is more porous and less smooth.[41,42] Fake braces have unpolished and irregular surface textures, with most showing large alloy particles.[13] This can ultimately cause a higher affinity of bacterial plaque film formation on fake braces surfaces, compared to conventional ones.[13,23,43]

Discussion

According to the Medical Device Act 2012, any medical devices, or in this case any orthodontic products, to be sold in Malaysia must be registered with an authorised local representative, who must also registered with the Malaysian Dental Association.[17] This is important because the representative is responsible for any harm caused by the appliance sold, not the dental practitioner.[20] This also gives a sense of security to the patient and practitioner because the origin and quality of the products acquired are known. Orthodontic materials and products sold via online platforms are poorly regulated and at a very high risk of contamination due to poor handling and packaging. They suffer from improper labelling, and most even come without an expiry date disclosure.[17] The fact that these products can be easily obtained via online shopping platforms adds to these risks. Despite restrictions imposed by some online shopping platforms on selling medical devices,[44] irresponsible sellers will always find a loophole to sell their products. A review of some of these platforms showed that the number of fake braces sold reaches thousands, and the numbers keep increasing. This shows that the trend of wearing fake braces and the illegal practice of providing such treatments are increasing at an alarming rate. The leading reason that this trend is gaining traction is a lack of awareness and education on the dangers of these products. To date, only a few laboratory studies have attempted to expose the dangers of fake braces. All studies found that fake braces were of lower quality, with poor surface finishing, higher surface roughness and higher toxic metal leaching.[4,13,23,45] However, among these studies, none attempted to look into the destructive effect of fake braces directly towards the oral tissues. Further studies focusing on the level of cytotoxicity towards human oral tissues, plaque retentiveness and bacterial adhesion of fake braces would be clinically relevant.

Conclusion

The increasing availability and use of fake braces through online platforms pose a serious threat to patient safety and professional integrity. While existing regulations under the Medical Device Act 2012 aim to ensure product safety and accountability, enforcement and public awareness remain insufficient. Strengthening regulatory oversight, enhancing public education, and conducting more comprehensive clinical studies on the biological risks of fake braces are essential steps toward mitigating this growing concern.

Author contributions

MZ: Conceptualization, Methodology, Software, Formal analysis, Investigation, Data Curation, Writing - Original Draft, Visualization; AA: Validation, Writing - Review & Editing, Supervision; NN: Resources, Writing - Review & Editing, Supervision; NA: Writing - Review & Editing, Supervision.

Disclosure statement

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References

1. Abdullah A.A.A., Yasssin Z. ZN. Reasons for seeking orthodontic treatment. Ann Dent Univ Malaya 2001;8(1):13–9.
2. Sardenberg F, Martins MT, Bendo CB, Pordeus IA, Paiva SM, Auad SM, et al. Malocclusion and oral health-related quality of life in Brazilian school children: a population-based study. Angle Orthod 2013;83(1):83–9.
3. Scapini A, Feldens CA, Ardenghi TMH, Kramer PF.

Malocclusion impacts adolescents' oral health-related quality of life. Angle Orthod 2013;83(3):512–8.

4. Haleem R, Shafiai NAA, Noor SNFM. Metal ions leachables from fake orthodontic braces incubated in simulated body fluid. BMC Oral Health 2021;21(1):1–7.
5. Kamarudin Y, Zakaria NN, Xinhui VO. Orthodontics on sale: fixed appliances on E-commerce platforms. Australas Orthod J 2022;38(1):22–8.
6. Idaham NI, Wan Othman WMN, Hassan H. Exploring the experience of klang valley youths on fake braces by bogus dentists. Malaysian J Sci Heal Technol 2021;7(1):69–74.
7. Alhazmi AS, Al Agili DE, Aldossary MS, Hakami SM, Almalki BY, Alkhaldi AS, et al. Factors associated with the use of fashion braces of the Saudi Arabian Youth: application of the Health Belief Model. BMC Oral Health 2021;21(1):1–9.
8. Malik S. Deadly fashion braces are big in Thailand [Internet]. VICE. 2012 Apr 11 [cited 2021 Apr 1]. Available from: https://www.vice.com/en/article/nn47z8/deadlyfashion-braces-are-big-in-thailand.
9. Ministry of Health Malaysia. Annual report [Internet]. 2019 [cited 2024 May 1]. Available from: https://www.moh.gov.my/moh/resources/Penerbitan/Penerbitan%20Utama/ANNUAL%20REPORT/LAPORAN_TAHUNAN_KKM_2019.pdf.
10. Kumar Rai A. "Zeena" Practice or Malpractice? Prim Heal Care Open Access 2015;5(2):5–6.
11. Pereira MA, Souza FM de, Queiroz PA de, Vilela DDC, Cardoso JA. Illegal practice of orthodontics exercising and its clinical implications: case report. Rev Bahiana Odontol 2016;7(2):126-31.
12. Davis G. 38 celebrities who had braces or retainers (and the pics to prove it!) [Internet]. Women's Health Magazine. 2020 Aug 9 [cited 2021 Sep 12]. Available from: https://www.womenshealthmag.com/health/g33500609/celebrities-with-braces-retainers.
13. Nasir SH, Abu Bakar N, Samad R. Elemental and microstructural analysis of fake, real, and standard orthodontic brackets. J Phys Conf Ser 2018;1073(5): 052002.
14. Sorooshian S, Kamarozaman AA. Fashion braces: an alarming trend. Sao Paulo Med J 2018;136(5):497–8.
15. Hakami Z, Chung HS, Moafa S, Nasser H, Sowadi H, Saheb S, et al. Impact of fashion braces on oral health related quality of life: a web-based cross-sectional study. BMC Oral Health 2020;20(1):1–9.
16. Azlida N, Nor M, Nurazreena W, Hassan W, Zambri M, Makhbul M. Fake braces by quacks in Malaysia: an expert opinion. Ann Dent 2020;27(1):33–40.
17. Shahrul Naing AI, Abd Rahman ANA. Orthodontic product sold via online marketplaces in Malaysia. Malays Dent J 2021;1:106–12.
18. Press Association. Dentists warned of counterfeit equipment following huge haul [Internet]. The Guardian. 2014 Oct 17 [cited 2022 Oct 2]. Available from: https://www.theguardian.com/society/2014/oct/17/dentists-warn-counterfeit-equipment-seized-haul.
19. Zeya DS, Sharma DJB, Chaturvedi DP, Doshi DA, Mathur DS, Shah DN, et al. Dental quacks: liars to the society. Int J Appl Dent Sci 2021;7(3):289–91.
20. Behrents RG. Adverse responses to products or treatments. Am J Orthod Dentofac Orthop 2014;146(5):541–3.
21. Lin M-C, Lin S-C, Lee T-H, Huang H-H. Surface analysis and corrosion resistance of different stainless steel orthodontic brackets in artificial saliva. Angle Orthod 2006;76(2):322–9.
22. Mulimani P, Vaid N. Through the Murky Waters of "Web-based Orthodontics" Can Evidence Navigate the Ship? APOS Trends Orthod 2017;7(5):207-10.
23. Haleem R, Shafiai NAA, Noor SNFM. Microstructural changes and elemental analysis of fake braces in simulated body fluid. AIP Conf Proc 2020;2267: 020061.
24. Ramakrishna S, Tian L, Wang C, Liao S, Teo WE. Safety testing of a new medical device. Med Devices 2015;137–53.
25. Geis-Gerstorfer J. In vitro corrosion measurements of dental alloys. J Dent 1994;22(4):247–51.
26. Grimsdottir MR, Gjerdet NR, Hensten-Pettersen A. Composition and in vitro corrosion of orthodontic appliances. Am J Orthod Dentofac Orthop 1992;101(6):525–32.
27. Chakravarthi S, Padmanabhan S, Chitharanjan AB. Allergy and orthodontics. J Orthod Sci 2012;1(4):83–7.
28. Peltonen L. Nickel sensitivity in the general population. Contact Dermatitis 1979;5(1):27–32.
29. Ramadan AA-F. Effect of nickel and chromium on gingival tissues during orthodontic treatment: a longitudinal study. World J Orthod 2004;5(3):230–4.
30. Ahrari F, Tavakkol Afshari J, Poosti M, Brook A. Cytotoxicity of orthodontic bonding adhesive resins on human oral fibroblasts. Eur J Orthod 2010;32(6):688–92.
31. Mockers O, Deroze D, Camps J. Cytotoxicity of orthodontic bands, brackets and archwires in vitro. Dent Mater 2002;18(4):311–7.
32. Rongo R, Valletta R, Bucci R, Rivieccio V, Galeotti A, Michelotti A, et al. In vitro biocompatibility of nickel-titanium esthetic orthodontic archwires. Angle Orthod 2016;86(5):789–95.
33. Wataha JC. Principles of biocompatibility for dental practitioners. J Prosthet Dent 2001;86(2):203–9.

34. Vidal MNP, Granjeiro JM. Cytotoxicity tests for evaluating medical devices: an alert for the development of biotechnology health products. J Biomed Sci Eng 2017;10(09):431–43.
35. Menzaghi N, Saletta M, Garattini G, Brambilla E, Strohmenger L. Changes in the yeast oral flora in patients in orthodontic treatment. Prev Assist Dent 1991;17(4):26–30.
36. Kozmos M, Virant P, Rojko F, Abram A, Rudolf R, Raspor P, et al. Bacterial adhesion of streptococcus mutans to dental material surfaces. Molecules 2021;26(4):1–15.
37. Wang B-Y, Deutch A, Hong J, Kuramitsu HK. Proteases of an early colonizer can hinder Streptococcus mutans colonization in vitro. J Dent Res 2011;90(4):501–5.
38. Kreikemeyer B, Gámez G, Margarit I, Giard J-C, Hammerschmidt S, Hartke A, et al. Genomic organization, structure, regulation and pathogenic role of pilus constituents in major pathogenic Streptococci and Enterococci. Int J Med Microbiol. 2011;301(3):240–51.
39. Jaykus LA, Wang HH, Sl. Food-borne microbes: shaping the host ecosystem. In: ASM Press, editor. Washington (DC): ASM Press; 2009.p.124.
40. Tamura S, Yonezawa H, Motegi M, Nakao R, Yoneda S, Watanabe H, et al. Inhibiting effects of Streptococcus salivarius on competence-stimulating peptide-dependent biofilm formation by Streptococcus mutans. Oral Microbiol Immunol 2009;24(2):152–61.
41. Magdy NM, Kola MZ, Alqahtani HH, Alqahtani MD, Alghmlas AS. Evaluation of surface roughness of different direct resin-based composites. J Int Soc Prev Community Dent 2017;7(3):104–9.
42. Brusca MI, Chara O, Sterin-Borda L, Rosa AC. Influence of different orthodontic brackets on adherence of microorganisms in vitro. Angle Orthod 2007;77(2):331–6.
43. Barcellos Fernandes R, Bárbara Polo A, Novaes Rocha V, Willer Farinazzo Vitral R, Carolina Morais Apolônio A, José da Silva Campos M. Influence of orthodontic brackets design and surface properties on the cariogenic Streptococcus mutans adhesion. Saudi Dent J 2022;34(4):321–7.
44. Lazada. Prohibited and controlled products. Lazada Seller Policies [Internet]. 2023 [cited 2023 Jan 15]. Available from: https://sellercenter.lazada.com.my/seller/helpcenter/Prohibited-and-Controlled-Products-List.html.
45. Nasir SH, Mohamad Amran MS, Abidin Mustaffar MM. Metal release of standard and fake orthodontic braces: an in vitro study. IIUM Med J Malaysia 2021;20(2):75–80.