Thai Journal of Orthodontics

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

Received: 29-Apr-2024 **Revised:** 12-Feb-2025 **Accepted:** 24-Feb-2025

Corresponding author: Khitparat Kamoltham
E-mail: info@rsu.ac.th

* Lecturer, College of Dental Medicine, Rangsit University, Pathum thani, Thailand
** Assistant Professor, College of Dental Medicine, Rangsit University, Pathum thani, Thailand

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

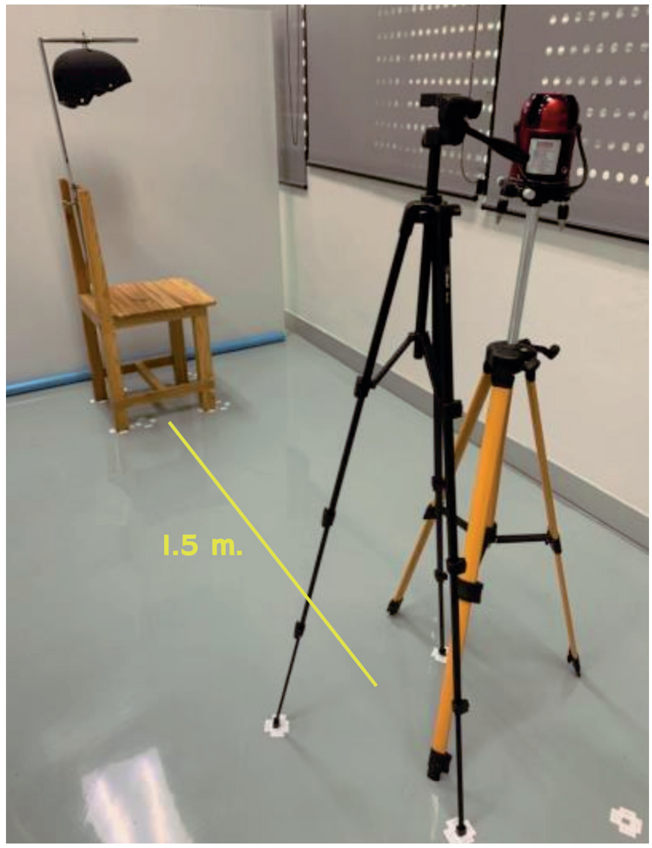

Figure 1 The settling of the head fixer

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

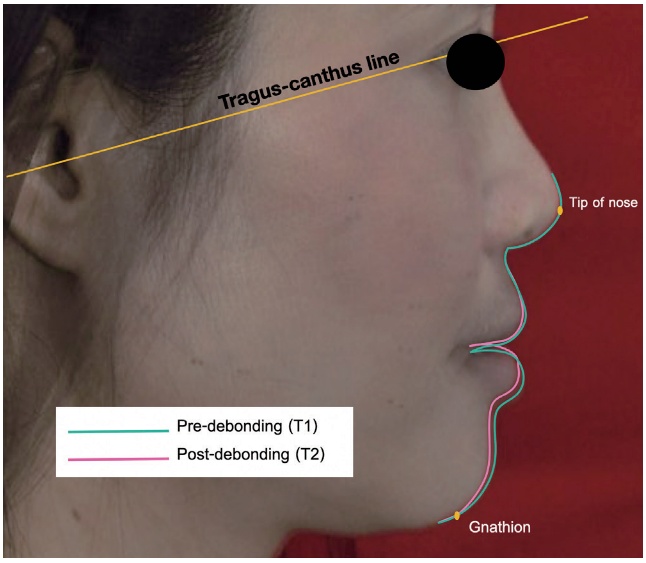

Figure 3 Pre and Posttreatment photographs were superimposed by digitalizing in the Adobe Photoshop computer program

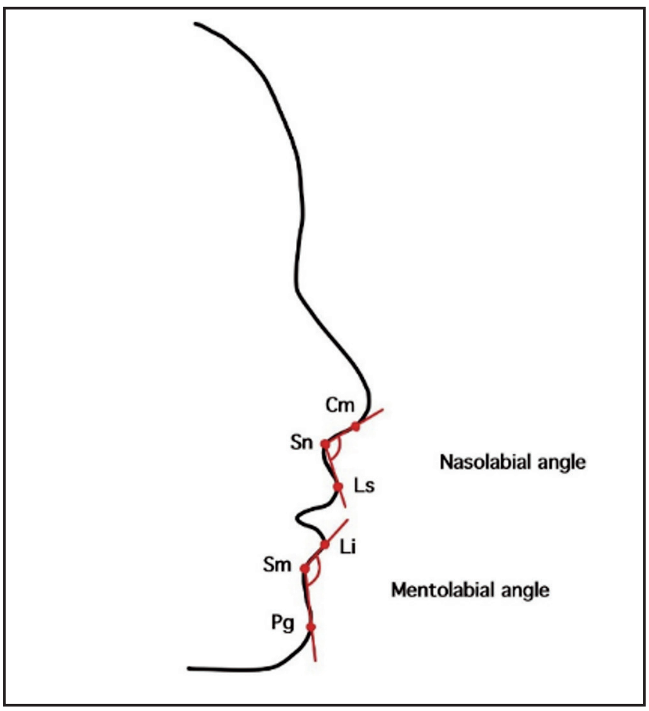

Figure 4 Nasolabial and mentolabial angle measurement

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.

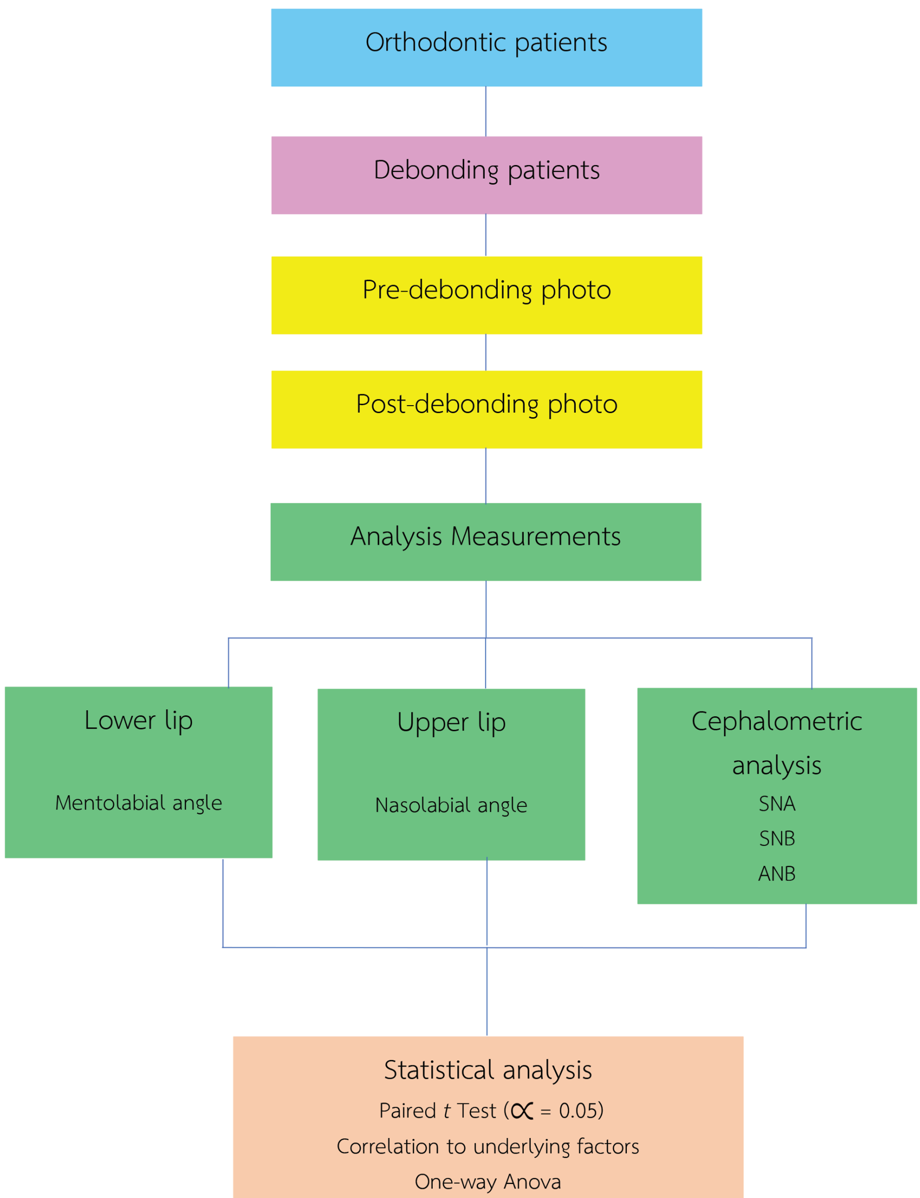

Figure 5 The flowchart

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.

Acknowledgements

Runchida Thepchatri, Suchanun Terkteaw, Suveera Mekareeya, Charma Suriyawanakul, Kevalin Jaroenpat and Staff at Orthodontic clinic, College of Dental Medicine, Rangsit University who contributed and fabricated the instrument in the research project.

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.