

Upper Lip Changes After Upper Incisor Proclination in Deep Bite Patients

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Abstract

Background: No previous studies examined the effects of upper lip (UL) change following upper incisor (UI) intrusion by labial proclination in deep bite (DB) non-growing patients. **Objective:** To compare changes in the UI and UL after labial proclination between UI retroclination (RI) and normal inclination (NI) groups in DB patients. **Materials and methods:** Pretreatment (T1) and posttreatment (T2) lateral cephalograms of 41 subjects who underwent UI labial proclination were divided into two groups according to UI inclination: RI group ($UI-THL < 113^\circ$) and NI group ($113^\circ \leq UI-THL \leq 119^\circ$). Cephalograms used the true horizontal and true vertical lines to measure the UI and UL parameters. Treatment changes were compared both within and between the groups. **Results:** At T1, the RI group showed significantly more retroclined and retruded UI, increased incisal show at rest (ISR) and overbite compared to the NI group. Soft tissues were comparable, except for thicker lip in RI. At T2, the RI group exhibited normal inclination and position, while greater proclination and protrusion were observed in NI. No significant differences were observed in the ISR, overbite, or soft tissue variables between the groups. The treatment change (T2-T1) in both groups exhibited a significant proclination of the UIs. However, the RI group showed no significant change in the UL, while NI group revealed significant UL protrusion. **Conclusion:** The UL changes in the RI group did not show significant differences. In contrast, the NI group showed more UL protrusion, although it exhibited lesser proclination of UI compared to RI group.

Keywords: Deep bite, Inclination, Intrusion, Lip change, Proclination

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Introduction

Deep bite (DB) is one of the malocclusions that leads patients to seek orthodontic treatment. It is defined by an excessive vertical overlap of the upper incisors (UI) over the lower incisors when the teeth are in centric occlusion.¹ The prevalence of DB in Thailand ranges from 20.50 % to 24.50 %.^{2,3} DB can cause traumatic occlusion, which has a negative effect on dental health, including the teeth, periodontal tissue, muscles, and temporomandibular disorder.⁴ This condition not only affects the masticatory system but also impacts facial aesthetics.⁵ Therefore, correcting a DB improves functional occlusion and enhances the aesthetic smile.

One of the options for correcting a DB is relative intrusion by labial proclination of the incisor teeth.⁶ Exploring the changes in dental position that affect the soft tissue profile after correction is essential for treatment planning because successful orthodontic treatment not only establishes good occlusion but also achieves an attractive facial appearance.⁷

Previous studies that reported on DB correction used various methods and dentoalveolar changes after treatment.⁸⁻¹¹ However, few reports discussed the effects on the soft tissue profile following treatment.⁹ Furthermore, the existing studies tend to focus on children who have not completed their growth.⁹⁻¹¹ Only one study examined the flaring of incisor teeth, which revealed that for every 1 mm of UI protraction, the upper lip (UL) protruded by 0.10 mm but it was not conducted in DB patients, and no categorization was made based on the inclination of the UIs before treatment.¹²

Since inclination and anteroposterior position of the UIs play an essential role in aesthetics,¹³ the purpose of this study was to investigate the position of the UIs and UL in the facial profile before and after relative intrusion, as well as the changes during treatment in non-growing patients.

Materials and methods

Subjects

This retrospective study was conducted following approval from the Ethics Committee, Faculty of Dentistry, Prince of Songkla University (No: EC6407-050). The subjects were selected from a population who underwent labial proclination of the UI using Roth's prescription preadjusted bidimensional edgewise fixed appliances (Ormco™) with 0.018 × 0.025-inch slots on the incisors and 0.022 × 0.028-inch slots on the canines and posterior teeth. Treatment was performed at the Faculty of Dentistry, Prince of Songkla University between 2014 and 2020.

The inclusion criteria were non-growing patients verified from their cervical vertebrae maturation index in sixth stage,¹⁴ aged between 18 and 35 years to minimize the effect of the growth and aging process,¹⁵ overbite ≥ 3.50 mm, availability of pretreatment (T1) and posttreatment (T2) lateral cephalograms, and no craniofacial deformity. The subjects that satisfied the inclusion criteria were divided into two groups according to the inclination of the UIs compared to the true horizontal reference line (THL°) at T1: retroclination group (RI) with UI-THL < 113° and normal inclination group (NI) with UI-THL between 113° and 119° (norm = 116 ± 3°).¹⁶

Methods and landmarks

Lateral cephalograms were taken using an Orthopantomograph® OP300 (Instrumentarium Dental, Tuusula, Finland) with magnifications of 10.45 %. All lateral cephalograms were obtained in the natural head position with centric occlusion at T1 and T2. All cephalograms were manually traced. Each tracing was scanned and saved as a JPEG image, and the enlargement correction was integrated into the analysis process using ImageJ software, version 1.53a (NIH, Bethesda, MD, USA). The true vertical reference line (TVL) was set on the sella and parallel

to the front edge of T1 cephalograms. THL was set to the plane that passed the sella and was perpendicular to the TVL.¹⁶ Cephalometric landmarks, reference

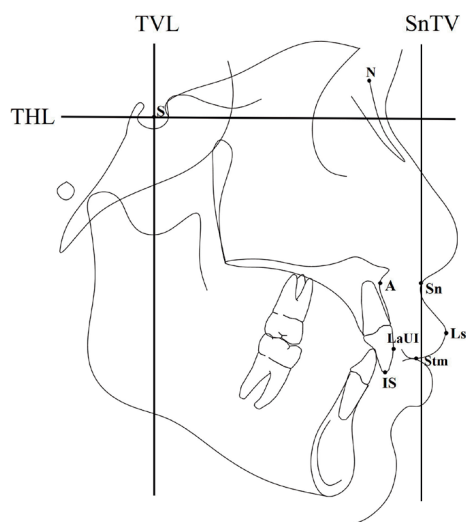


Figure 1 Cephalometric landmarks and reference planes.

S: sella, N: nasion, A: point A, LaUI: the midpoint of labial surface of upper incisor, IS: incisor superior, Sn: subnasale, Ls: labrale superioris, Stm: stomion, THL: true horizontal reference line, TVL: true vertical reference line, SnTV: a line parallel to the TVL passing through Sn

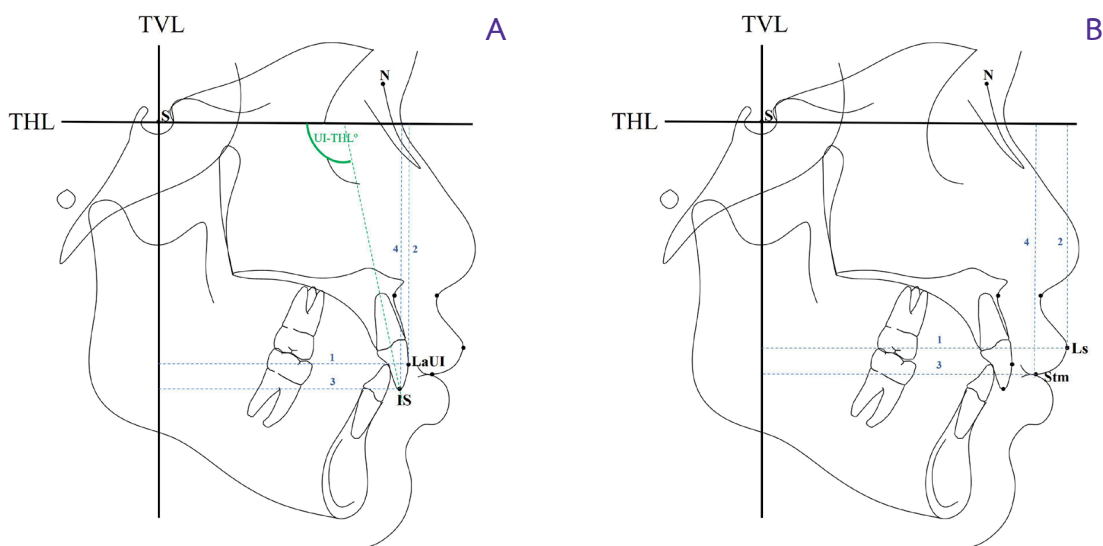


Figure 2 (A) Angular and linear measurements of dental variables; 1: TVL-LaUI, 2: THL-LaUI, 3: TVL-IS, 4: THL-IS
(B) Linear measurements of soft tissue variables; 1: TVL-Ls, 2: THL-Ls, 3: TVL-Stm, 4: THL-Stm

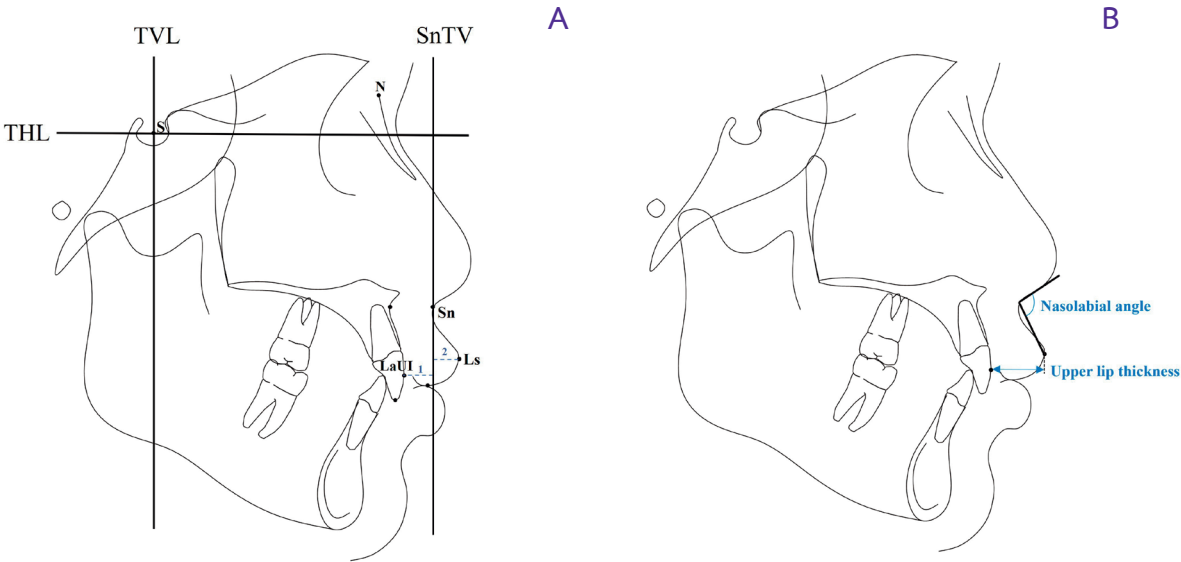


Figure 3 (A) Linear measurements at SnTV; 1: SnTV-LaUI, 2: SnTV-Ls
(B) Additional cephalometric measurements: nasolabial angle and upper lip thickness

Table 1 Definitions of angular and linear measurements

Angular and linear measurements	Definitions
Dental	
UI-THL (degree)	Angle between the THL and long axis of the upper incisor
TVL-LaUI (mm)	Perpendicular distance from the TVL to LaUI
THL-LaUI (mm)	Perpendicular distance from the THL to LaUI
TVL-IS (mm)	Perpendicular distance from the TVL to incisor superior (IS)
THL-IS (mm)	Perpendicular distance from the THL to IS
SnTV-LaUI (mm)	Perpendicular distance from the SnTV to LaUI
ISR, Incisal show at rest (mm)	Distance parallel to TVL from the IS to Stm
Soft tissue	
TVL-Ls (mm)	Perpendicular distance from the TVL to Ls
THL-Ls (mm)	Perpendicular distance from the THL to Ls
TVL-Stm (mm)	Perpendicular distance from the TVL to Stm
THL-Stm (mm)	Perpendicular distance from the THL to Stm
SnTV-Ls (mm)	Perpendicular distance from the SnTV to Ls
Upper lip thickness (mm)	Distance parallel to THL from the LaUI to Ls

Reliability

All lateral cephalometric tracings and measurements were performed by the same operator who is an orthodontic resident supervised by a Thai Board-Certified Orthodontist. Two weeks after the first tracing, 30 randomly selected lateral cephalograms were retraced and remeasured.

Method error was calculated using Dahlberg's formula ($ME = \sqrt{\frac{\sum D^2}{2n}}$), where n represents the number of duplicated measurements and D represents the difference between two measurements in a pair. This calculation revealed that the differences were less than 0.50 mm and less than 0.50 degree without significant clinical difference. The result of testing the internal reliability with the intraclass correlation coefficient was ≥ 0.938 , which demonstrated an excellent level of reliability.¹⁷

Statistical analysis

The sample size was calculated using G*power software, version 3.1.9.4 (Franz Faul, Kiel University, Germany). The calculation was performed at a significance level of 0.05, a test power of 0.80, and an effect size of 1.20 based on a previous study.¹² Therefore, a sample size of 12 subjects per group was required. The Shapiro-Wilk test was used to test the normality of the data distribution. If the data had a normal distribution, parametric statistics were used

but if the data did not have a normal distribution, non-parametric statistics were used. The differences in gender between the two groups were analysed using the Chi-squared test. Paired t test or Wilcoxon signed-rank test was used to compare the changes during treatment (T2-T1) within the same group. Independent t test or Mann-Whitney U test was used to compare the differences between the variables in T1, T2, and T2-T1 between the two groups.

Results

The demographic characteristics of the subjects are shown in Table 2.

At T1, there were significant differences in all dental variables between the RI and NI groups. No significant differences were found in SnTV-Ls (mm) and the nasolabial angle. However, lip thickness was the only soft tissue variable to show a significant difference between the groups. The RI group showed more thickness than the NI group (Table 3).

At T2, there were significant differences in UI-THL (degree), SnTV-LaUI (mm), and UI-NA (degree) (mm). Specifically, the UIs in the RI group exhibited normal inclination and position, while the UIs in the NI group were proclined and protruded compared to the norm values. On the other hand, no significant

Table 2 Demographic characteristics of the subjects

Variable	RI group (n = 21)	NI group (n = 20)	P value
Gender ¹ (male/female)	3/18	5/15	0.387
Age ² (years)	23.33 \pm 3.14	22.90 \pm 5.61	0.831
Treatment duration ² (years)	3.00 \pm 1.28	2.60 \pm 0.97	0.426

Values are presented as number or mean \pm standard deviation.

¹Chi-squared test was performed.

²Independent t test was performed.

Table 3 Comparison of pretreatment (T1) cephalometric variables between the RI and NI groups

Variable	Norm ¹⁶	RI group	NI group	P value
Dental				
UI-THL ¹ (degree)	116 ± 3	101.42 ± 8.28	115.84 ± 3.00	< 0.001***
SnTV-LaUI ¹ (mm)	-8 ± 1	-10.82 ± 2.03	-8.08 ± 2.37	0.002**
UI-NA ² (degree)	22 ± 6	10.81 ± 5.92	24.73 ± 3.90	< 0.001***
UI-NA ¹ (mm)	5 ± 2	1.62 ± 2.76	5.73 ± 1.94	< 0.001***
ISR ² (mm)	N/A	4.60 ± 1.26	3.50 ± 0.88	0.013*
Overbite ² (mm)	2 ± 1	5.71 ± 1.54	4.23 ± 0.98	0.002**
Soft tissue				
SnTV-Ls ¹ (mm)	5 ± 1	3.96 ± 2.00	3.94 ± 1.77	0.974
Nasolabial angle ¹ (degree)	90 ± 10	94.23 ± 7.62	93.50 ± 7.52	0.784
Lip thickness ¹ (mm)	N/A	15.71 ± 2.16	12.92 ± 2.01	0.001*** ^a

Values are presented as mean ± standard deviation.

¹Independent *t* test or ² Mann-Whitney *U* test was performed to compare between two groups.

P* < 0.05, *P* < 0.01, ****P* < 0.001

Table 4 Comparisons of posttreatment (T2) cephalometric variables between the RI and NI groups

Variable	Norm ¹⁶	RI group	NI group	P value
Dental				
UI-THL ¹ (degree)	116 ± 3	113.52 ± 9.39	121.12 ± 2.97	0.002**
SnTV-LaUI ¹ (mm)	-8 ± 1	-8.64 ± 1.73	-6.59 ± 2.81	0.013*
UI-NA (degree)	22 ± 6	22.89 ± 7.43	29.65 ± 4.46	0.006**
UI-NA ¹ (mm)	5 ± 2	4.50 ± 2.80	7.38 ± 2.09	0.003**
ISR ² (mm)	N/A	2.44 ± 0.61	2.15 ± 0.66	0.248
Overbite ² (mm)	2 ± 1	2.59 ± 0.80	2.13 ± 0.46	0.080
Soft tissue				
SnTV-Ls ¹ (mm)	5 ± 1	4.02 ± 1.93	5.01 ± 1.74	0.140
Nasolabial angle ¹ (degree)	90 ± 10	94.35 ± 7.09	90.11 ± 8.43	0.125
Lip thickness ¹ (mm)	N/A	14.00 ± 2.40	12.42 ± 1.87	0.052

Values are presented as mean ± standard deviation.

¹Independent *t* test or ² Mann-Whitney *U* test was performed to compare between the two groups.

P* < 0.05, *P* < 0.01, ****P* < 0.001

differences were observed in the incisal show at rest (ISR), overbite, or soft tissue variables between the two groups. The UL parameters in both groups were in the normal range as indicated by the SnTV-Ls (mm) and nasolabial angle that were within the normal limits (Table 4).

The dental differences between T2 and T1 indicated significant differences in all variables in both the RI and NI groups. Specifically, the UIs of the RI group

showed more significant labial movement along with a greater reduction in ISR and overbite compared to the NI group. The soft tissue differences between T2 and T1 revealed that the RI group did not show significant differences, except for a reduction in lip thickness. In contrast, the NI group showed significant differences in all soft tissue parameters with more labial movement of the UL compared to the RI group (Table 5).

Table 5 Comparison of treatment changes (T2-T1) between RI and NI groups

Variables	RI group (T2-T1)	NI group (T2-T1)	Between-group test <i>P</i> value
Dental			
UI-THL ¹ (degree)	12.09 ± 3.80	5.27 ± 3.03	< 0.001***
SnTV-LaUI ¹ (mm)	2.17 ± 1.23	1.48 ± 0.46	0.027*
UI-NA ¹ (degree)	12.08 ± 4.12	4.92 ± 3.06	< 0.001***
UI-NA ² (mm)	2.88 ± 1.16	1.65 ± 0.66	< 0.001***
ISR ² (mm)	-2.15 ± 0.80	-1.35 ± 0.55	0.005**
Overbite ¹ (mm)	-3.12 ± 1.20	-2.10 ± 0.93	0.014*
TVL-LaUI ¹ (mm)	1.93 ± 0.75	1.40 ± 0.64	0.045*
THL-LaUI ¹ (mm)	-2.00 ± 0.72	-1.50 ± 0.65	0.050
TVL-IS ² (mm)	2.58 ± 1.11	1.96 ± 0.72	0.043*
THL-IS ² (mm)	-1.98 ± 0.78	-1.46 ± 0.61	0.013*
Soft tissue			
Ls-SnTV ² (mm)	0.06 ± 0.43	1.08 ± 0.86	0.002**
Nasolabial angle ² (degree)	0.11 ± 2.73	-3.38 ± 2.89	0.001**
Lip thickness ¹ (mm)	-1.71 ± 1.01	-0.50 ± 0.82	0.001**
TVL-Ls ² (mm)	0.06 ± 0.51	1.03 ± 0.43	< 0.001***
THL-Ls ² (mm)	0.00 ± 0.98	-0.37 ± 0.46	0.045*
TVL-Stm ² (mm)	0.04 ± 0.14	0.84 ± 0.55	< 0.001***
THL-Stm ² (mm)	0.12 ± 0.64	-0.34 ± 0.51	0.022*

Values are presented as mean ± standard deviation.

¹ Paired *t* test/ Independent *t* test.

² Wilcoxon signed-rank test/Mann-Whitney *U* test

P* < 0.05, *P* < 0.01, ****P* < 0.001

Discussion

This study focused on DB patients who had completed their growth. Thus, this study aimed to limit the influence of growth on soft tissues during treatment. Therefore, the results obtained were solely attributed to changes that resulted from orthodontic treatment. The THL and TVL in the natural head position were used as reference planes, which offered the advantage of stability and lack of variability among individuals.¹⁸ This method is suitable for assessing facial beauty as it represents the genuine head position to reveal the clinical characteristics in patients.¹⁶

Although cone beam computed tomography is currently useful in studying both soft and hard tissues, it is not yet widely used in every clinic due to the high cost and concerns of radiation exposure.^{19,20} As a result, the use of lateral cephalograms still has advantages and is more widely used. Therefore, this study was conducted using lateral cephalograms.

This study divided subjects into two groups based on inclination of the UIs (UI-THL °) at pretreatment. The RI group had an UI-THL of $101.42 \pm 8.28^\circ$ and an UI-NA of $10.81 \pm 5.92^\circ$. The NI group had an UI-THL

of 115.84 ± 3.00 degree and an UI-NA of $24.73 \pm 3.90^\circ$. The UI of the RI group resembled the UI in Angle Class II Division 2 malocclusion characterized by retroclined and retruded UIs, increased overbite, and greater ISR,²¹ whereas the UI of NI group had increased overbite and ISR but normal inclination (Table 3).

After treatment, UI proclination of 2.58 ± 1.11 mm ($P < 0.001$) was observed in the RI group (Figure 6). However, UL protraction of 0.06 ± 0.51 mm ($P = 0.353$) resulted in a ratio of UI proclination to UL protraction of 1:0.02. Additionally, the thickness of the UL decreased by 1.71 ± 1.01 mm ($P < 0.001$). In contrast, the NI group with an UI proclination of 1.96 ± 0.72 mm ($P = 0.001$) and an UL protraction of 1.03 ± 0.43 mm ($P = 0.001$) resulted in a ratio of UI proclination to UL protraction of 1:0.52. The thickness of the UL decreased by 0.50 ± 0.82 mm ($P = 0.047$). This occurrence can be explained in a study by Mirabella et al.¹² who found that for every 1 mm of protraction, the UL protruded by 0.10 mm, and the thickness of the UL decreased by 0.80 mm. The decrease in the thickness of the UL is attributed to the UIs pressing down on the lip. Therefore, the lips only protrude slightly.

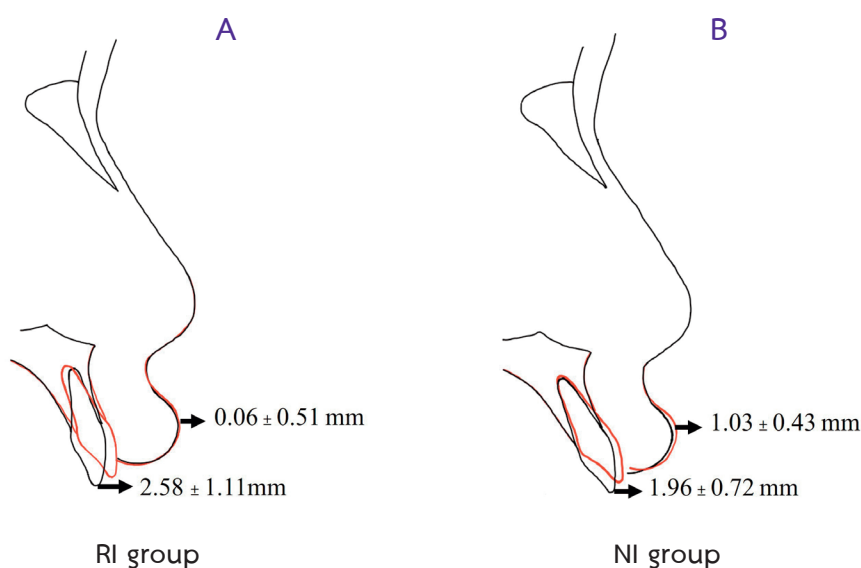


Figure 6 Representation of the UI and UL changes in the RI group (A) and NI group (B)

Since the ISR impacts smile aesthetics, a range of 2-4 mm is appropriate.²² Patients with excessive ISR may have a gummy smile.^{23,24} Furthermore, the degree of inclination of the UIs was related to the amount of ISR, with more retroclined UIs associated with increased ISR,²⁵ which was in agreement with this study. It was found that ISR before treatment in the RI group was significantly higher than the NI group (RI = 4.60 ± 1.26 mm, NI = 3.50 ± 0.88 mm; $P = 0.013$). When correction of DB is performed by proclination, the UIs can reduce ISR. This study revealed a reduction in ISR to 2.15 ± 0.80 mm and 1.35 ± 0.55 mm in the RI and NI groups, respectively.

The nasolabial angle is a parameter commonly used to assess facial beauty.^{26,27} Nandini et al.²⁸ Emphasized that the nasolabial angle should be within a normal range for a pleasing facial profile. In this current study, the nasolabial angles at T1 for both the RI and NI groups were $94.23 \pm 7.62^\circ$ and $93.50 \pm 7.52^\circ$, respectively. Following proclination of the UIs, it was observed that the nasolabial angle in the RI group did not show a significant change ($P = 0.372$), which was consistent with no significant changes in the UL after treatment. In contrast, the NI group showed a significant decrease in the nasolabial angle by $3.38 \pm 2.89^\circ$ ($P = 0.001$), which corresponded to protrusion of the UL. Nevertheless, this change did not have harmful effects on the soft tissue profile.

The increased responsiveness of the NI group to UI labial movement compared to the RI group may be attributed to the initially thinner UL. Unfortunately, there is no existing study in a proclination situation, but only in a study by Oliver, which found that patients with thinner lips are more responsive to changes when teeth are moved in a retraction situation.²⁹ In this study, the NI group had a significantly thinner UL at the beginning (12.92 ± 2.01 mm) compared to the RI group (15.71 ± 2.16 mm) that resulted in a greater response to tooth movement.

Limitations of this study need mentioning. First, the results cannot be applied in adolescent subjects or in cases of long-term soft tissue changes after retention. Second, due to the limited number of studies conducted in non-growing patients, it is challenging to draw comparisons between the current research and existing publications. Third, this study did not examine the effects of changes by the lower incisors on the UL. Fourth, as this was a retrospective study, the patients were not treated with the same mechanics. Therefore, a randomized controlled trial is suggested.³⁰ In addition, the amount of crowding and the relationship between sagittal and vertical skeletal patterns were not included in this study. These points should be considered in future studies.

The clinical applications for correction of DB from this study include two points. First, performing proclination in RI patients results in no change in the UL with normal inclination, normal overbite, and normal ISR. Second, performing proclination in NI patients would finish with a more protruded UL but within normal limits, normal overbite, normal ISR, and slight UI proclination. Therefore, careful treatment is necessary to prevent excessive proclination.

Conclusion

The UL changes in the RI group did not show significant differences. In contrast, the NI group showed more UL protrusion, although it exhibited less proclination of the UI compared to the RI group.

Author contributions

PT: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Resources, Data Curation, Writing, Visualization, Project administration; CC: Conceptualization, Methodology, Validation, Formal analysis, Resources, Writing, Visualization, Project administration, Supervisions.

Ethical statement

This research protocol was approved by the Human Ethics Committee, Faculty of Dentistry, Prince of Songkla University (No: EC6407-050).

Disclosure statement

The authors have no conflicts of interest.

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