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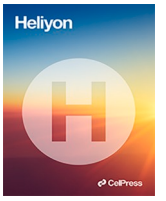

Research article

Reference points to evaluate changes in the upper lip after labial incisor movement between tipping and translation in crowding patients: A retrospective study

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ABSTRACT

Objective: This study aimed to compare the changes of reference points on the labial surface of upper incisors (U1) to upper lip (UL) after U1 labial movement between a translation group (TSL) and tipping group (TIP). Correlations between changes in U1 and UL were determined.
Methods: Lateral cephalometric radiographs were selected and divided into TSL and TIP groups by pre- and post-treatment superimpositions. Skeletal, dental, and soft tissue of pre- and post-treatment and variables were evaluated. Independent *t*-test and Mann-Whitney U test were applied for the statistical analysis between TSL and TIP. Spearman's correlation coefficients and multiple linear regression analysis were used to verify the association between lip profile changes and other variables in TSL and TIP group separately.
Results: After U1 labial movement, the incisal edge (LaU1e), middle (LaU1m), and cervical (LaU1c) points of TSL moved evenly labially, whereas the TIP group had incisal edge that moved greater labially than the middle and cervical points. UL moved more labially in TSL (0.87–1.05 mm) than the TIP (0.31–0.41 mm). UL changes to the E-line in TSL showed significant positive correlations to all three LaU1(e, m, c)-SnTV changes. In the TIP group, only a positive correlation presented for the LaU1m-SnTV and LaU1c-SnTV changes. Nevertheless, Multiple linear regression analysis indicated the unfeasibility of predicting the upper lip changing.
Conclusion: LaU1e in TSL and TIP moved almost equally labially but less labially in TIP at the middle and cervical points. The UL moved more labially in TSL than TIP. Rather than using the incisal edge to estimate upper lip changes, it would be better to use the middle and cervical points of U1, which coincide with Labrale superioris (Ls).

1. Introduction

Extraction is the common treatment for crowding but in some cases nonextraction is recommended [1,2] since the primary objective of conventional orthodontic treatment is to obtain an ideal functional occlusion, overbite, and overjet, with proper alignment of the teeth and facial profile [3].When the lips and upper incisors (U1) are in decent positions with mild to moderate crowding, labial movement to align the teeth can be appropriately applied. Moving the U1 anteriorly can be done by either translation (TSL) or tipping (TIP) which depends on the final plan of U1 inclination.

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An estimate of upper lip (UL) changes after treatment must be based on the changes previously reported [4,5]. However, knowledge from research on UL changes after U1 labial movement is limited. Mirabella et al. reported it was unfeasible to predict lip changes following U1 labial movement. They found that the correlation coefficient was 0.1 for most variables, which indicated a poor relationship between the tooth and lip variables. Moreover, the research was conducted without reporting how the teeth moved whether U1 movement was by TSL or TIP [6].

Landmarks on the labial surfaces of the U1 are important since they are covered by the upper lip. The landmarks can be identified as incisal edge (e), middle (m), and cervical (c) points as introduced by Kuhn et al. [7] or only one or two of them [8]. Research is needed to explore the association between these points and the UL with reference points that coincide to the U1.

Therefore, the objective of the study was to compare the changes of three reference points on the labial surface of U1 and their related points on the UL after U1 labial movement by TSL or TIP. The correlations between U1 and UL were also analyzed.

2. Material and methods

2.1. Subjects

The subjects presenting with upper anterior crowding who had undergone orthodontic treatment with non-extraction at the dental school, faculty of dentistry Prince of Songkla University between 2014 and 2021, were retrospectively evaluated in this study.

The inclusion criteria were (1) adult patients 20–35 years old who received conventional orthodontic treatment without tooth extraction by labial movement of the upper anterior teeth, (2) mild or moderate crowding, (3) overjet 1–3 mm, (4) normal overbite 1–3 mm, (5) good quality lateral cephalograms and the same X-ray machine for both TSL and TIP movements, (6) no craniofacial deformity, and (7) complete records including pre-treatment and post-treatment cephalometric radiographs and plaster models. The exclusion criteria were (1) previous orthodontic treatment or orthognathic surgery, (2) growth modification or orthognathic surgery, (3) medical history related to bone metabolism, (4) rotation of upper incisor, and (5) missing teeth in the maxilla.

The subjects who satisfied the inclusion criteria were divided into two groups by superimposition of pre-treatment and post-treatment cephalometric tracings. The TSL group had crown and root apex movement in the same direction and a dental axis that changed $<10^{\circ}$. The TIP group had crown and root apex movement in the opposite direction and a dental axis that changed $>10^{\circ}$ [9,10].

This retrospective study was performed after approval from the Ethics Committee at the dental school, faculty of dentistry, Prince of Songkla University.

2.2. Cephalometric analysis

Lateral cephalograms were taken with the same X-ray machine (Orthopantomograph® OP300 Instrumentarium Dental, Tuusula, Finland) with a magnification of 10.45 %. All lateral cephalograms were obtained in the natural head position with teeth in maximum intercuspation and passive lips. Lateral cephalograms of TSL and TIP were manually traced with 0.003-inch acetate paper with a 0.3

Table 1
Definitions of cephalometric landmarks and reference planes.

Landmarks and planes	Definitions
Landmarks	
S (Sella)	The center of the hypophyseal fossa
N (Nasion)	The most anterior point of the frontonasal suture which joins the nasal part of the frontal bone and nasal bone
ANS (Anterior nasal spine)	The tip of the anterior nasal spine
A (Subspinale)	The deepest point of the anterior border of the maxillary alveolar ridge concavity
LaU1e	The incisal tip of the most anterior maxillary central incisor
LaU1m	The middle point of the most anterior maxillary central incisor
LaU1c	The cervical point of the most anterior maxillary central incisor
UIA (Upper incisor apex)	The root apex of the most anterior maxillary central incisor
Prn (Pronasale)	The most prominent point on the tip of the nose
Sn (Subnasale)	The point in the midsagittal plane where the base of nose columella of the nose meet the upper lip (midsagittal)
UL//A	The most anterior point of upper lips that corresponds to subspinale (A)
UL//e	The most anterior point of upper lips that corresponds to LaU1e
UL//m	The most anterior point of upper lips that corresponds to LaU1m
UL//c	The most anterior point of upper lips that corresponds to LaU1c
Ls (Labrale superioris)	The most anterior point of the upper lip vermillion
Sts (Upper lip stomion)	The lowest point of the margin of upper lip vermilion
Pg' (Soft tissue pogonion)	The most anteriorly positioned point of the soft tissue chin
Reference planes	
SN	The line between the sella and nasion
NA	The line between nasion and subspinale (A)
U1	The long axis of the most anterior maxillary central incisor
E-line	The line between Prn and Pg'
NTV	True vertical line passing through nasion
SnTV	True vertical line passing through subnasale
THL	True horizontal line perpendicular to true vertical line

mm 2H lead mechanical pencil. Each tracing was scanned as a JPEG image. A correction for enlargement was performed during the process of analysis by ImageJ software (version 1.53a, NIH, Bethesda, MD, USA). All measurements were performed twice to reduce measurement error, and the mean value was calculated and used for evaluation. The cephalometric landmarks and reference planes, and measurements are shown in Table 1, Table 2, and Fig. 1.

Angular and linear measurements of skeletal, dental, and soft tissue were evaluated on the lateral cephalometric tracings (Table 2). The points and planes were analyzed using modified previous studies [7,11,12]. The vertical reference lines of the TSL and TIP radiographs were set to the plane that passed through the nasion (NTV) and subnasale (SnTV) [11,13,14]. The horizontal reference lines were a line perpendicular to SnTV and another line through the sella and nasion points (sella-nasion line). Skeletal, dental, and soft tissue variables of pre- and post-treatment were measured as distance and angle.

2.3. Reliability of measurements

The intraclass correlation coefficient (ICC) was determined by ten randomly selected lateral cephalograms that were traced and remeasured after the first measurement. Measurement error was determined using Dahlberg's formula [15]. The measurements were performed by two clinicians certified by the Thai Board of Orthodontics and were full time educators in an academic institution. Calibration between the two examiners was performed before the analysis.

2.4. Statistical analysis

Descriptive and analytical statistical analyses were performed with SPSS version 25.0 (SPSS Inc., Chicago, IL, USA). Based on a previous study [6], a minimum sample size of 5 per group was required. The calculation was done with G*Power software (version 3.1.9.6, Dusseldorf, Germany) at a significance level of $P < 0.05$, power of 95 %, and an effect size of 2.23 to detect differences in treatment changes between the two groups using a dependent *t*-test with DxCs parameter (DxCs: The horizontal distance changing of maxillary crown incisor). The final numbers of subjects in TSL and TIP group were 31 and 45, respectively, for a better representation of the population.The Shapiro-Wilk test was used to test the normality of the data distribution. The differences in demographic features concerning gender between the two groups were analyzed with the χ^2 test. Independent *t*-test and Mann-Whitney U test were used to compare the differences between the two groups. Spearman's correlation coefficients and multiple linear regression analysis were calculated to verify the association between lip profile changes and other variables in TSL and TIP group separately.

3. Results

The ICC results of all variables were 0.92–0.98 for the linear variables and 0.99 for the angular variables, which indicated good reliability. Dahlberg's errors for linear and angular measurements were 0.3 mm and 0.5°, respectively. There were no significant differences in demographic data (sex, age, and treatment duration) between the two groups (Table 3).

Table 4 shows comparisons of the pre-treatment variables between TSL and TIP. All skeletal parameters in both groups

Table 2
Definitions of cephalometric variables.

Variables	Definitions
SNA (°)	The angle formed by the intersection of SN and NA
A-NTV (mm)	The horizontal distance from A to NTV
A-SnTV (mm)	The horizontal distance from A to SnTV
U1-NA (°)	The angle formed by the intersection of U1 and NA
U1-NA (mm)	The distance from the incisal tip of the most anterior maxillary central incisor to NA
U1-THL (°)	The angle formed by the intersection of U1 and THL
LaU1-THL (°)	The angle formed by the intersection of lines passing through the most anterior maxillary incisor and THL
LaU1e-SnTV (mm)	The horizontal distance from LaU1e to SnTV
LaU1m-SnTV (mm)	The horizontal distance from LaU1m to SnTV
LaU1c-SnTV (mm)	The horizontal distance from LaU1c to SnTV
UADH (mm)	The vertical distance parallel to SnTV from ANS to LaU1e
ADH (mm)	The vertical distance perpendicular to SN from ANS to LaU1e
Overbite (mm)	The horizontal distance from the tip of the lower incisor to the tip of the upper incisor
Overjet (mm)	The vertical distance from the tips of the upper and lower incisor
Crowding (mm)	The amount of disharmony between the size of the teeth and the space available from the plaster model
UL-E-line (mm)	The distance from UL to E-line
UL//A-SnTV (mm)	The horizontal distance from UL to SnTV that corresponds to A
UL//e -SnTV (mm)[a]	The horizontal distance from UL to SnTV that corresponds to LaU1e
UL//m-SnTV (mm)	The horizontal distance from UL to SnTV that corresponds to LaU1m
UL//c-SnTV (mm)	The horizontal distance from UL to SnTV that corresponds to LaU1c
Ls-SnTV (mm)	The horizontal distance from Ls to SnTV
NLA (Nasolabial angle) (°)	The angle formed by the intersection of lines at the base of the nose (columella) and the most anterior upper lip
ULL (Upper lip length) (mm)	The distance from Sn to Sts
Lip thickness (mm)	The distance from Ls to labial surface of the maxillary incisors

[a] In cases of no Ls anterior to the LaU1, no measurement was taken; therefore, N/A indicates no data available.

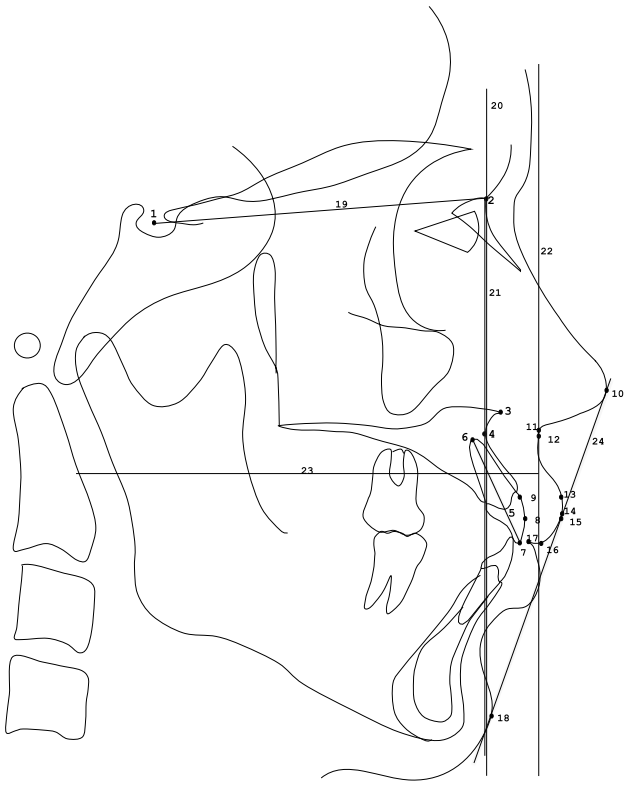

Fig. 1. Cephalometric landmarks and reference planes used in the study: 1 S (sella); 2 N (nasion); 3 ANS; 4 A (subspinale); 5 U1; 6 IXA; 7 LaU1e; 8 LaU1m; 9 LaU1c; 10 Prn; 11 Sn; 12 UL//A; 13 UL//c; 14 Ls; 15 UL//m; 16 UL//e; 17 Sts; 18 Pg'; 19 SN line; 20 NTV; 21 NA; 22 SnTV; 23 THL; 24 E-line.

demonstrated no significant differences. The U1 in both the anteroposterior and vertical positions and the amount of crowding in both groups presented no significant differences except for U1 inclination parameters that showed more retroclination in the TIP group. Most of the upper lip parameters showed no significant differences between the two groups; however, the TIP group had a greater UL//A-SnTV but more acute NLA. Most UL//e-SnTV in both groups were not measurable due to no upper lip cover at this point. Since only 2 out of 31 patients in the TSL group and 1 out of 45 in the TIP group could be measured, the amount of data was too small to report.

Significant differences in maxillary changes were observed in the between-group data of SNA and A-NTV during the treatment period. Point A of TSL moved labially whereas palatal movement indicated TIP. Changes in the inclination were different between the two groups. TSL showed little proclination (0.15°) for both U1-NA and U1-THL, whereas slight retroclination (0.23°) was observed in LaU1-THL. In contrast, TIP showed significantly more proclination than TSL in all parameters (U1-NA = 5.87°, U1-THL = 7.02°, and LaU1-THL = 7.21°). The amount of movement of the labial surface of the upper incisor in the anteroposterior direction at the incisal edge (U1-NA [mm] and LaU1e-SnTV) showed no significant differences. The middle and cervical points of the upper incisor showed significantly greater labial movement in TSL than TIP. All upper lip anteroposterior position parameters increased greater labially in the TSL group compared to the TIP group. The NLA became significantly more acute in TSL (Table 5 and Fig. 2).

Changes in UL to the E-line in TSL showed significant positive correlations in all three LaU1(e, m, and c)-SnTV changes and

Table 3
Demographic feature of the subjects.

Variable	TSL ($n = 31$)	TIP ($n = 45$)	*P*-value
Sex	Male 27 % Female 73 %	Male 25 % Female 75 %	0.828[a]
Meang age (year)	28.05 ± 5.59	27.58 ± 5.97	0.729[b]
Range of age (year)	22.46–33.64	21.61–33.55	
Treatment duration (month)	28.49 ± 14.69	31.42 ± 10.49	0.315[b]

Data are presented percentages or mean ± standard deviation.
TSL translation group, TIP tipping group.
[a] χ^2 test was performed.
[b] Independent *t*-test was performed.

Table 4
Comparison of pre-treatment variables between the TSL and TIP groups.

Variable	Thai norm	TSL ($n = 31$)	TIP ($n = 45$)	*P*-value
Skeletal				
SNA (°)	84 ± 4	84.07 ± 5.24	83.41 ± 5.25	0.471[b]
A-NTV	1 ± 3	0.00 ± 4.21	−0.52 ± 4.22	0.601[a]
A-SnTV	–	−11.73 ± 10.22	−13.36 ± 4.19	0.37
Dental				
U1-NA (°)	22 ± 6	26.43 ± 6.73	20.64 ± 6.90	0.001[ad]
U1-NA (mm)	5 ± 2	6.52 ± 3.09	6.32 ± 3.05	0.789[a]
U1-THL (°)	116 ± 3	115.92 ± 6.21	104.94 ± 17.58	<0.001[be]
LaU1-THL (°)	93 ± 3	96.17 ± 7.11	85.37 ± 11.39	<0.001[ae]
LaU1e-SnTV	−8 ± 6	−7.67 ± 4.62	−7.47 ± 4.56	1.00[b]
LaU1m-SnTV	–	−6.77 ± 4.36	−6.04 ± 4.06	0.533[b]
LaU1c-SnTV	–	−7.27 ± 5.91	−6.99 ± 4.25	0.260[b]
UADH (mm)	29 ± 1	29.93 ± 3.02	29.88 ± 2.57	0.932[a]
ADH (mm)	29 ± 3	29.55 ± 3.53	29.72 ± 2.78	0.814[a]
Overbite (mm)	2 ± 1	2.52 ± 0.68	2.56 ± 0.44	0.454[b]
Overjet (mm)	2 ± 1	2.20 ± 1.02	1.98 ± 0.74	0.310[b]
Crowding (mm)	–	2.88 ± 1.63	3.19 ± 2.01	0.657[b]
Soft tissue				
UL-E plane (mm)	−1 ± 2	0.38 ± 2.11	0.12 ± 1.95	0.352[a]
UL//A-SnTV	–	0.55 ± 1.64	1.41 ± 2.26	0.034[bc]
UL//e-SnTV	–	N/A	N/A	N/A
UL//m-SnTV	–	5.17 ± 1.95	5.20 ± 2.70	0.939[a]
UL//c-SnTV	–	6.13 ± 2.48	6.74 ± 2.59	0.307[a]
Ls-SnTV	5 ± 1	5.62 ± 1.94	5.87 ± 2.54	0.304[a]
NLA (°)	90 ± 10	89.12 ± 13.12	82.12 ± 15.86	0.049[ac]
ULL (mm)	23 ± 2	22.68 ± 3.96	22.59 ± 3.05	0.546[a]
Lip thickness		11.93 ± 3.74	11.29 ± 3.49	0.614[a]

Values are presented as mean ± standard deviation.
TSL translation group, TIP tipping group.
[a] Independent *t*-tests were performed to compare the two groups.
[b] Mann-Whitney U tests were performed to compare the two groups.
[c] $P < 0.05$.
[d] $P < 0.01$.
[e] $P < 0.001$.

crowding; however, NLA presented a negative correlation. TIP showed only a positive correlation to the LaU1m-SnTV and LaU1c-SnTV changes (Table 6).The multiple linear regression analysis indicated the unfeasibility of predicting the dependent variables (Upper lip changing) due to the $r^2 = 0.1$ (TSL) and $r^2 = 0.2$ (TIP) which indicated relatively low relationship between variables.

4. Discussion

This study showed that TIP had a greater UL//A-SnTV that was probably caused by greater anterior location of point A in TIP (TIP = 1.41 mm, TSL = 0.55 mm) underneath the upper lip as explained by van der Linden [16]. The more acute NLA in TIP could be related to the greater proclination of U1 [17]. There is no upper lip cover at the incisal edge (LaU1e-SnTV) since most subjects had incisal show at rest of 1–3 mm. Therefore, the anterior to incisal edge could be either nothing or lower lip in cases of incompetent or competent lips, respectively.

The skeletal changes in TSL at point A moved labially whereas palatal movement was observed in TIP. These changes occurred according to upper incisor root movement where the root in TSL moved labially while TIP had palatal movement of the root apex with simultaneous bone apposition and resorption [10,18–20]. The small change in inclination in TSL confirmed that translation occurred in this group, whereas a significantly greater inclination in TIP also confirmed the tipping in this group.

This study was conducted to investigate movement of the U1 clinical labial surface in the anteroposterior direction in detail; therefore, three points at the incisal edge, middle, and cervical points were studied. Generally, the incisal edge in orthodontics has the same amount of labial movement in both groups. However, when the types of movement are different, movement at the middle and cervical points exhibited less labial movement in TIP as found in this study. Unfortunately, only two U1 labial movement studies were reported in the literature that measured only one point of the labial surface of U1. The first study used the anterior-most point but the other study used the incisal point [6,21]. Therefore, no previous study can be compared to our study. Another report that used three labial points of U1 in a study of inclination change in palatal retraction found that all three points moved almost equally with small changes in U1 inclination [7]. Those results were similar to our study but in the opposite direction. All parameters for the changes in soft tissue moved significantly labially in both groups due to hard tissue underneath the lip that moved forward according to tooth movement. However, UL//A-SnTV in the TIP group was almost maintained (0.09 mm) due to palatal movement of point A that led to labial bone resorption [10,18–20]. Labial movement of UL was greater in the TSL group compared to TIP because of increased movement of U1 and alveolar bone in TSL that was greater than TIP. The NLA was more acute in the TSL group due to greater labial

Table 5
Comparison of the variables during treatment between TSL and TIP.

Variable	TSL (n = 31)	TIP (n = 45)	P-value
Skeletal			
SNA (°)	0.62 ± 0.77	−0.36 ± 0.55	<0.001[bd]
A-NTV (mm)	0.80 ± 1.21	−0.33 ± 0.43	<0.001[bd]
A-SnTV	0.77 ± 0.77	−0.29 ± 0.49	<0.001[bd]
Dental			
U1-NA (°)	0.15 ± 0.71	5.87 ± 6.37	<0.001[ad]
U1-NA (mm)	1.38 ± 1.12	1.45 ± 1.40	0.969[a]
U1-THL	0.15 ± 1.60	7.02 ± 8.79	<0.001[bd]
LaU1-THL	−0.23 ± 2.36	7.21 ± 13.83	<0.001[bd]
LaU1e-SnTV	1.50 ± 0.89	1.62 ± 1.22	0.965[b]
LaU1m-SnTV	1.47 ± 0.76	0.98 ± 1.08	0.017[bc]
LaU1c-SnTV	1.53 ± 0.66	0.83 ± 0.85	<0.001[bd]
UADH	0.50 ± 1.62	−0.17 ± 1.15	0.074[a]
ADH	0.52 ± 1.89	−0.01 ± 1.03	0.202[a]
Overbite	0.13 ± 0.91	−0.57 ± 0.47	<0.001[ad]
Overjet	0.05 ± 1.21	0.08 ± 0.76	0.948[a]
Soft tissue			
U lip-E plane	0.86 ± 0.82	0.38 ± 0.68	0.004[bc]
UL//A-SnTV	0.53 ± 0.59	0.09 ± 0.56	<0.001[bd]
UL//e-SnTV	N/A	N/A	N/A
UL//m-SnTV	0.87 ± 0.78	0.41 ± 0.76	0.002[bc]
UL//c-SnTV	1.05 ± 0.90	0.35 ± 0.64	<0.001[bd]
Ls-SnTV	0.92 ± 0.81	0.31 ± 0.67	0.002[bc]
NLA	−2.57 ± 3.30	−0.38 ± 2.92	0.001[bc]
ULL	0.35 ± 1.39	0.13 ± 1.04	0.342[b]

Values are presented as mean ± standard deviation.
TSL translation group, TIP tipping group.
*$P < 0.05$.
[a] Independent t-tests were performed to compare the two groups.
[b] Mann-Whitney U tests were performed to compare the two groups.
[c] $P < 0.01$.
[d] $P < 0.001$.

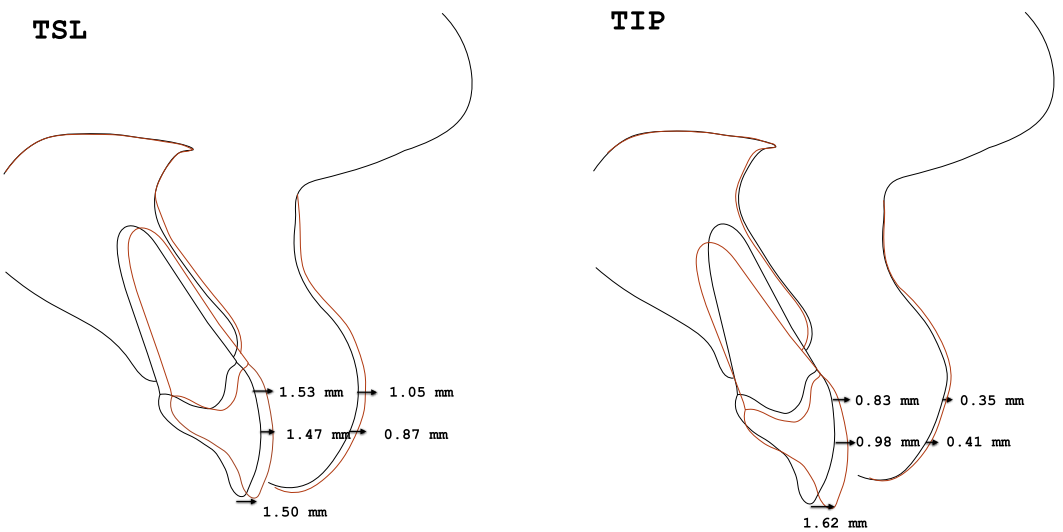

Fig. 2. Comparison of treatment changes between TSL and TIP.

movement of Ls.

The positive correlation of UL to the E-line in both groups to other U1 parameters indicated that greater labial movement of U1 at the middle and cervical points led to greater anterior movement of Ls, which is the landmark for the U lip-E plane measurement. The LaU1e-SnTV showed a correlation only in TSL but not in TIP. Even though LaU1e had no upper lip cover, a correlation was shown in TSL that was probably due to translational tooth movement. Therefore, the values at the incisal edge, middle, and cervical points were almost the same (1.5 mm). The correlation between incisal edge and upper lip to the E-plane was likely from the same amount of

Table 6
Spearman's coefficients between upper lip profile changes and other variables.

Variables	TSL ($n = 31$)	TIP ($n = 45$)
Dental		
LaU1e-SnTV change (mm)	0.554[b]	–
LaU1m-SnTV change (mm)	0.768[c]	0.531[c]
LaU1c-SnTV change (mm)	0.605[c]	0.552[c]
Soft tissue		
NLA change (°)	−0.728[c]	–
Crowding (mm)	0.378[a]	–

TSL translation group, TIP tipping group.
[a] $P < 0.05$.
[b] $P < 0.01$.
[c] $P < 0.001$.

movement to the other variables. However, in the TIP group no correlation appeared because movement of the incisal edge (1.62 mm) was more than the midpoint (0.98 mm) and cervical point (0.83 mm). The incisal edge of U1, which clinicians commonly use to predict lip change, could not be studied since its location is usually behind the lower lip. Therefore, Kuhn et al. found that a positive correlation of the U1 edge had more significance associated with the lower lip than the upper lip [7]. Probably the midpoint or cervical point should be used to estimate upper lip change instead of the incisal edge. Furthermore, it would be better if the middle or cervical points of U1 coincided with Ls to estimate changes in the upper lip rather than using the incisal edge. Some confounding lip factors of initial volume of the upper lip, difficulty of lip sealing, lip straining, and lip pressure should be included in further studies for a better understanding of the changes.

5. Conclusions

The incisal edge, middle, and cervical points in the TSL group moved labially and evenly, whereas patients in the TIP group exhibited greater labial movement of the incisal edge than the middle and cervical points. The upper lip moved more labially in the TSL group than in the TIP group. The middle and cervical points of U1, which could be used to coincide with Ls for estimating changes in the upper lip, would be better than using the incisal edge.

CRediT authorship contribution statement

Paku Ruengprom: Writing – review & editing, Writing – original draft, Visualization, Validation, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Chairat Charoemratrote:** Writing – review & editing, Validation, Supervision, Project administration, Funding acquisition, Conceptualization.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

Data available statement

Data are available from the authors upon reasonable request.

Ethics declaration

The study complies with all ethics regulations.

- This study was reviewed and approved by the ethics committee, Faculty of dentistry, Prince of Songkla University, with the approval number EC6407-046.
- Patient consent was waived because the patient's identity is neither disclosed nor compromised

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to

influence the work reported in this paper.

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