The lower lip profile change during total distalization of the mandibular dentition

Hwa Sung Chae (✉ hwasingchae@gmail.com)

Ajou University School of Medicine, Suwon, South Korea <https://orcid.org/0000-0002-7738-2532>

Christine Hong

Department of Orofacial Science, School of Dentistry, University of California, San Francisco, California, USA

Research Article

Keywords: skeletal Class III, lower arch total distalization, camouflage treatment, lower lip response, CKA, CKHA

Posted Date: February 3rd, 2022

DOI: <https://doi.org/10.21203/rs.3.rs-1321085/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Abstract

Objectives

This study aimed to determine the factors that influence the lower lip profile during Class III lower total arch distalization camouflage treatment.

Materials and Methods

The cohort included 45 patients diagnosed with skeletal Class III malocclusion. These patients underwent camouflage orthodontic treatment with lower arch total distalization. Lateral cephalograms at the pre-treatment stage and post-treatment stage were taken. Cephalometric measurements were analyzed to uncover the influencing factors of the lower lip profile. This study defined new variables; i.e., CK and CKA, for detailed soft tissue analysis.

Results

Novel soft tissue measurements presented in this study showed statistically significant changes after treatment. The CK angle and L1 to A Pog, L1 to NB, and IMPA were statistically correlated. Simple regression analysis was conducted between variables. The formulas were $\Delta\text{CKA} = 0.79(\Delta\text{L1 to NB}) - 1.6$ and multiple regression resulted in $\Delta\text{CKA} = 0.5(\Delta\text{L1 to NB}) - 0.42$ ('LL to Eline', before treatment)

Conclusions

The present study provided evidence that the lower lip evaluation including the novel CKA and CKHA, were significantly related to the mandibular incisal position during total distalization of the mandibular dentition. The results demonstrated that, clinically, significant lip retraction can be obtained. Therefore, non-extraction with distalization must be suggested as the first treatment option in mild skeletal Class III malocclusion patients.

Introduction

The standard for orthodontic treatment is shifting from a hard tissue-based treatment to a soft tissue-based treatment paradigm¹. To establish a standard for soft tissue-based orthodontic treatment, several researchers have published the ideal anterior and posterior positions of the soft tissue of the face^{2,3}. In addition, Holdaway defined the harmony line (H-line) and H-angle on the basis of the position of the upper lip and set the standard for the upper aesthetic value⁴. A Class III malocclusion is a skeletal disharmony in which the growth of the mandible is relatively more dominant than that of the maxilla. In addition, the incidence of Class III malocclusion is much higher in Asians than in Westerners⁵.

Compensation treatment is known as one of the representative treatment methods along with orthognathic surgery for patients with a skeletal Class III malocclusion⁵. It is known that a satisfactory soft tissue position can be obtained through compensation treatment in patients with a skeletal Class III malocclusion⁶. However, unlike orthognathic surgery, compensation treatment may cause an excessive labial tilting of the maxillary incisors and lingual tilting of the mandibular incisors⁷⁻⁹.

In many cases, mandibular extraction is necessary as part of the treatment plan to obtain an appropriate occlusion for a Class III malocclusion. As an alternative to mandibular premolar extraction, recently, Class III malocclusion compensation treatment has been actively performed with total distalization of the mandibular arch using a TAD¹⁰⁻¹³. Although such rearward movement of the mandibular arch has the advantage of being a possible treatment within the anatomical limitations, there has been no study that has determined whether the change in the anterior and posterior soft tissue position will be appropriately esthetic in the soft tissue-centered treatment planning paradigm described above. Excessive retraction of the lower lip also has the side effect of making the protrusion of the mandible more clearly visible. In evaluating Class III malocclusions before and after treatment, the protrusion of the lower lip and the ratio of the upper lip should also be evaluated.

The purpose of the present study was to evaluate the soft tissue index changes before and after treatment in patients who underwent Class III malocclusion compensation treatment through total mandibular dentition posterior movement. Especially, this study introduced new variables, CK angle (CKA) and CKH angle (CKHA), for detailed soft tissue analysis and aimed to analyze whether there is a correlation between the amount of lower incisor lingual movement and retraction of the lower lip employing known indicators and new CKA and CKHA. In addition, the usefulness of these two new variables for diagnosis and comparisons before and after treatment was also estimated.

Material And Methods

Study sample

Among the patients who visited the Department of Orthodontics, Institute of Oral Health Science, Ajou University School of Medicine, Suwon, South Korea and received orthodontic treatment, 45 patients (average age, 26.8 years; 15–40 years old) who met the inclusion criteria of this study and did not meet the exclusion criteria were evaluated before treatment. Twenty-six females and nineteen males were selected.

Posterior lateral head radiographs were obtained.

The inclusion criteria were as follows:

- 1) Patients who were diagnosed with a skeletal Class III malocclusion ($ANB < 0^\circ$);
- 2) Patients who had received Class III malocclusion compensation treatment other than jaw surgery.

The exclusion criteria were as follows:

- 1) Patients with a history of orthodontic treatment;
- 2) Patients with impacted teeth;
- 3) Patients with a history of head and face trauma;
- 4) Patients with a systemic disease that could affect tooth movement, such as clavicle dysplasia and cleft palate;
- 5) Patients with previous orthognathic surgery and anterior segmental osteotomy(ASO) surgery.

All patients were treated by the same orthodontist. The.022-slot MBT prescription bracket was used, mostly followed by a.016 nickel titanium.018 ×.025 Bioforce and a.019 ×.025 stainless steel wire, sequentially. Temporary Anchorage Devices (TADs) were used in the posterior buccal shelf or retromolar area for posterior movement of whole mandibular dentition. This study was conducted with permission and approval from the Institutional Review Board of Ajou University Hospital (IRB no.: AJIRB-MED-MDB-20-265).

Cephalometric measurement

The radiographs that were obtained showed the patient in a natural head posture, and all radiographs were measured and analyzed by a researcher (BJ Kim) using V-ceph 8.3.0.3 (Osstem, Seoul, Korea) software. To verify the measurement error of the operator, all lateral radiographs were repeatedly measured at 4-week intervals and the absence of errors was verified using Dahlberg's formula¹⁴.

Fourteen landmarks and seven reference lines were set for evaluation of the anterior-posterior position of the face before and after compensation treatment (Fig. 1, Fig. 2). In this study, one line and two angles obtained from the line were presented for evaluation of the position at the initial visit of the lower lip and the position before and after treatment. The linear measurements are illustrated in Figure 3. Figure 4 demonstrates the new lines and angles. The CK line was defined as a line connecting the soft tissue pogonion and the lower lip anterior (LLA) as a newly defined reference line in this study. The angle between the CK line and the facial plane was defined as the CK angle (CKA) A, and the difference between the H-angle and the CK line was defined as the CKH angle (CKHA). A more protruded lower lip relative to the upper lip results in high negative values for the CKHA, which is similar to the ANB.

Statistical analysis

The SPSS (IBM SPSS Statics Version 25) and R (4.0.3 version) programs were used for the statistical analysis of the measured values. Paired *t*-tests with significance levels of 0.05 and 0.01 were performed to check whether the measured values changed before and after the compensation treatment.

Pearson's correlation coefficients with significance levels of 0.05 and 0.01 were used to analyze the variables expected to be related to the change in measured values before and after compensation

treatment. Afterward, regression analyses of the variables (single and multiple) were performed.

Results

SNA, SNB, and ANB were not significantly changed. The amount of lower incisor retraction based on L1 to NB was -3.7 ± 1.7 mm, and that of the lower lip retraction was -2.1 ± 1.8 . Statistically significant correlation ($P < 0.01$) was found between these variables. The hard to soft tissue response ratio was 1.7:1 (56%).

The results of paired *t*-tests showed that there were statistically significant differences related to lower incisors before and after treatment for the values of ODI, APDI, AB to the mandibular plane, Wits, IMPA, L1 to A Pog, and L1 to NB. Among them, soft tissue factors related to changes in the lower lip, CKA, CKH, true vertical line (TVL) lower lip, and TVL soft tissue B also showed statistically significant differences before and after treatment (Table 1, $P < 0.01$, $P < 0.05$).

Table 1
Comparison of measurements at the initial and final stages.

	Initial stage		Final stage		
Measurements	Mean	SD	Mean	SD	P value
H angle	11.70	5.24	11.19	4.47	0.192
CK angle	18.07	7.48	14.35	6.59	0.000**
CKH angle	-6.37	4.07	-3.16	3.68	0.000**
TVL soft tissue A	-0.91	0.95	-1.01	1.21	0.533
TVL upper lip	5.42	1.79	5.08	2.09	0.203
TVL lower lip	5.94	3.42	4.44	3.62	0.000**
TVL soft tissue B	0.49	6.25	0.62	5.88	0.001**
TVL soft tissue pogonion	-0.88	4.85	-2.03	4.69	0.688
A' to ULA	-6.34	1.80	-6.09	1.85	0.242
ULA to LLA	-1.95	1.86	-1.84	1.33	0.639
LLA to B'	-6.83	2.77	-6.47	2.10	0.182
B' to Pog'	-2.13	1.80	-2.74	2.00	0.001**
LLA to Pog'	-5.85	3.71	-4.36	2.59	0.000**
* $P < 0.05$, ** $P < 0.01$, statistically significant; paired <i>t</i> -test. SD, standard deviation					

The results of a Pearson's correlation analysis showed that before treatment, the lower lip to E line ("LL to E") was also correlated with the retraction amount of CKA ($P < 0.01$, $r = -0.47$). Initial lower lip protrusion quantity was associated with that of the lower lip retraction. According to the treatment change, the factors correlated with L1 to A-Pog and L1 to NB, were CKA, CKHA, and IMPA. The results for the CKA showed a statistically significant correlation with L1 to A-Pog, L1 to NB, CKHA, Wits, IMPA, and APDI, and the CKH angle showed a statistically significant correlation with L1 to A-Pog, L1 to NB, CKA, and IMPA (Table 2).

Table 2
Correlation analysis of L1 to A-Pog, L1 to NB, CK and CKH angles, and potential influencing factors; r value (P value).

	L1 to A-Pog	L1 to NB	CK angle	CKH angle	Wits	IMPA	APDI
L1 to A-Pog	1	0.868** (0.000)	0.902** (0.000)	0.319* (0.017)	-0.185 (0.177)	-0.937** (0.000)	0.249 (0.067)
L1 to NB	0.868** (0.000)	1	0.927** (0.000)	0.445** (0.000)	0.001 (0.997)	-0.864** (0.000)	0.007 (0.997)
CK angle	0.902** (0.000)	0.927** (0.000)	1	0.449** (0.001)	-0.318* (0.018)	-0.907** (0.000)	0.345** (0.010)
CKH angle	0.319* (0.017)	0.445** (0.000)	0.449** (0.001)	1	-0.159 (0.249)	-0.332* (0.013)	0.113 (0.409)
* $P < .05$, ** $P < .01$, statistically significant; Pearson's correlation coefficient							

As a result of the regression analysis of "L1 to NB", and CKA, which can indicate the position of the mandibular incisors, the amount of change in the CKA was positively correlated with the amount of change in L1 to NB [$\Delta CKA = 0.79(\Delta L1 \text{ to NB}) - 1.6$].

In a multiple regression analysis, the relationship between the amount of change in the CKA, L1 to NB, and "LLtoE" indicated that [$\Delta CKA = 0.5(\Delta L1 \text{ to NB}) - 0.42(LLtoE) - 1.48$].

Discussion

Modern orthodontic treatment is progressing as a paradigm of soft tissue-based treatment in many areas¹. Holdaway published a baseline called the harmony line (H-line) and presented a standard for a harmonious appearance⁴. Subsequently, in a paper published in 1999, Arnett emphasized the importance of the TVL on the basis of a natural head position and announced the ideal soft tissue position using a method called soft tissue cephalometric diagnosis².

Camouflage treatment of skeletal Class III malocclusion is the most suitable and realistic treatment method for patients who want nonsurgical treatment¹⁵. The traditional method for Class III malocclusion is to extract the mandibular premolars and then retract the mandibular incisors, which has a risk of root

exposure or root resorption due to excessive retroclination⁷⁻⁹. A systematic study of soft tissue change after extraction reported that lower lip retraction amounted to 2 mm to 4.5 mm based on “LL to Eline” in adults patients¹⁶. A class III research in patients with growing class III patients with lower second premolars extraction indicated that -2.8mm lower incisors retracted resulted in 0.9mm lower lip retraction¹⁷. After the development of orthodontic TADs, posterior movement of the mandibular anterior teeth has been widely used as an alternative treatment to mandibular extraction for patients with Class III malocclusion¹⁰⁻¹³. Obtaining an esthetic look with compensation treatment that is as good as expected with orthognathic surgery may be difficult, but patient satisfaction should be higher if soft tissue changes can be maximized¹⁸. It is difficult, however, to predict the position before and after treatment because the soft tissues of the face, including the lips, are viscoelastic¹⁹.

This study aimed to determine the factors affecting the ratio of the lower labial protrusion and the lower lip change with compensation treatment of Class III malocclusions and to quantify the expected retraction amount of the lower lip. The CKA, CKH angle, TVL lower lip, TVL soft tissue B, B' to Pog', and LLA to Pog' showed statistically significant differences when the measured values before and after the treatment of patients who received the Class III malocclusion compensation treatment were compared (Table 1). The rearward movement of the mandibular anterior incisor, which is currently mainly used for the compensation treatment of Class III malocclusion, was strongly correlated with the amount of lower lip retraction, CKA (Table 2).

An additional regression analysis was performed on the CKA, which is statistically correlated with L1 to NB, indicating the position of the mandibular incisors. An interpretation of the result suggested that the lower lip position, which changes according to the movement of the mandibular incisors, can be quantitatively predicted through the CKA. In other words, when the mandibular anterior teeth move 1 mm posteriorly, the lower lip can retrovert about 79% compared to the facial plane (N'-Pog'). This can be expected even with posterior movement of the mandibular incisors through non-extraction, suggesting that the mandibular full arch disatolization treatment will be highly effective in soft tissue changes.

In multiple regression analysis, $\Delta\text{CKA} = 0.5(\Delta\text{L1 to N B}) - 0.42(\text{LLtoE}) - 1.48$. was formulated. The result explained that the more protrusive lip retracted further while the lower incisors moved backward, and the retraction ratio was 42%. When the initial lower lip protrusion became a constant, lower incisor 1 mm retraction resulted in 0.5° retraction of the lower lip (CKA). Because the initial lower incisor position affected the initial lower lip position, the effect of lower incisor movement decreased when the lower lip became a constant.

A limitation of this study is that the study was conducted only on patients who had undergone treatment for posterior movement of the anterior teeth of the mandible; that is, non-extraction treatment. Although 3.7 mm retraction on average of the lower incisors presented significant lower lip retraction (2.1mm), which was comparable to reported amount with extraction^{16,17}, a comparison study with extraction or mandibular ASO will provide further insight into the differences and limitations between extraction and nonextraction treatments.

Declarations

Competing interests: The authors declare no competing interests.

Conclusion

1. The results of this study showed ODI, APDI, AB to the mandibular plane, Wits, IMPA, L1 to A Pog, L1 to NB, and TVL, CHA, CKHA were significantly correlated with lower incisor retraction in patients who underwent Class III malocclusion compensation treatment.
2. Among them, changes in the CK and CKH angles before and after treatment were correlated with the L1 to A Pog, L1 to NB, CKA, and IMPA. The regression analysis results confirmed that the CKA could be predicted by the amount of mandibular anterior movement and initial lower lip position.
3. The amount of lower lip retraction was significantly correlated with that of lower incisor retraction during treatment. The quantity of the initial lower lip protrusion also influenced the lower lip profile change.
4. Therefore, the CKA and CKHA newly presented in this study can be guidelines for soft tissue-centered diagnosis and treatment planning.

References

1. Ackerman JL, Proffit WR, Sarver DM. The emerging soft tissue paradigm in orthodontic diagnosis and treatment planning. *Clinical orthodontics and research*. May 1999;2(2):49–52.
2. Arnett GW, Jelic JS, Kim J, et al. Soft tissue cephalometric analysis: diagnosis and treatment planning of dentofacial deformity. *American journal of orthodontics and dentofacial orthopedics: official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics*. Sep 1999;116(3):239–253.
3. Gianelly AA, Bednar JR. *Bidimensional Technique: Theory and Practice*. GAC International; 2000.
4. Holdaway RA. A soft-tissue cephalometric analysis and its use in orthodontic treatment planning. Part I. *American journal of orthodontics*. 1983;84(1):1–28.
5. Azamian Z, Shirban F. Treatment options for class III malocclusion in growing patients with emphasis on maxillary protraction. *Scientifica*. 2016;2016.
6. Burns NR, Musich DR, Martin C, Razmus T, Gunel E, Ngan P. Class III camouflage treatment: what are the limits? *American journal of orthodontics and dentofacial orthopedics*. 2010;137(1):9. e1-9. e13.
7. McFadden WM, Engstrom C, Engstrom H, Anholm JM. A study of the relationship between incisor intrusion and root shortening. *American Journal of Orthodontics and Dentofacial Orthopedics*. 1989;96(5):390–396.
8. Kaley J, Phillips C. Factors related to root resorption in edgewise practice. *The Angle Orthodontist*. 1991;61(2):125–132.

9. Wishney M. Potential risks of orthodontic therapy: a critical review and conceptual framework. *Australian dental journal*. 2017;62:86–96.
10. Ngan P, Moon W. Evolution of Class III treatment in orthodontics. *American Journal of Orthodontics and Dentofacial Orthopedics*. 2015;148(1):22–36.
11. Jing Y, Han X, Guo Y, Li J, Bai D. Nonsurgical correction of a Class III malocclusion in an adult by miniscrew-assisted mandibular dentition distalization. *American Journal of Orthodontics and Dentofacial Orthopedics*. 2013;143(6):877–887.
12. Yanagita T, Kuroda S, Takano-Yamamoto T, Yamashiro T. Class III malocclusion with complex problems of lateral open bite and severe crowding successfully treated with miniscrew anchorage and lingual orthodontic brackets. *American journal of orthodontics and dentofacial orthopedics*. 2011;139(5):679–689.
13. Chen K, Cao Y. Class III malocclusion treated with distalization of the mandibular dentition with miniscrew anchorage: a 2-year follow-up. *American Journal of Orthodontics and Dentofacial Orthopedics*. 2015;148(6):1043–1053.
14. Houston W. The analysis of errors in orthodontic measurements. *American journal of orthodontics*. 1983;83(5):382–390.
15. Proffit WR, Fields Jr HW, Sarver DM. *Contemporary Orthodontics, 5e*. Elsevier India; 2012.
16. Leonardi R, Annunziata A, Licciardello V, Barbato E. Soft tissue changes following the extraction of premolars in nongrowing patients with bimaxillary protrusion: a systematic review. *The Angle Orthodontist*. 2010;80(1):211–216.
17. Lin J, Gu Y. Lower second molar extraction in correction of severe skeletal Class III malocclusion. *The Angle Orthodontist*. 2006;76(2):217–225.
18. Bailey L, Haltiwanger L, Blakey G, Proffit W. Who seeks surgical-orthodontic treatment: a current review. *The International journal of adult orthodontics and orthognathic surgery*. 2001;16(4):280–292.
19. Hodgkinson D, Firth FA, Farella M. Effect of incisor retraction on facial aesthetics. *Journal of orthodontics*. 2019;46(1_suppl):49–53.

Figures

Figure 1

Landmarks used in the cephalometric analysis. Nasion, N; soft tissue nasion, soft tissue N; porion, Po; orbitale, Or; subnasale, Sn; A point, soft tissue A point; upper lip anterior, ULA; lower lip anterior, LLA; B point, soft tissue B point; pogonion, Pog; soft tissue pogonion, soft tissue Pog.

Figure 2

Reference lines used in the cephalometric analysis. Frankfort plane, Po-Or, FH plane; facial plane, soft tissue N-soft tissue Pog; true vertical line, TVL; H-line, ULA-soft tissue Pog; CK line, LLA-soft tissue Pog; N-B line; A-Pog line.

Figure 3

Linear measurements used in the cephalometric analysis. The distance between the TVL and the soft tissue A point, ULA, LLA, soft tissue B point, and soft tissue pogonion were measured. Differences in adjacent measurements were calculated. The distances between L1, N-B lines, and the A-Pog line were measured.

Figure 4

Angular measurements used in the cephalometric analysis. H-angle, angle between facial plane and H-line; CK angle, angle between facial plane and CK line; CKH angle, difference between H-angle and CK angle.