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Soft Tissue Profile Changes following Orthodontic Treatment in Unilateral Cleft Lip and Palate Patients

Running title: Soft Tissue Profile Changes

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Abstract

Background: Anterior crossbite is a common malocclusion in unilateral cleft lip and palate. (UCLP) patients.

Several studies have investigated the effects of orthognathic surgery or orthopedic treatment on correction of this malocclusion. Only few studies evaluated the effect of conventional orthodontic treatment on growing patients.

Objective: The objective of the study was to scrutinize significant changes of facial profile as well as the underlying hard tissue following conventional orthodontic treatment in growing UCLP subjects

Methods: Lateral cephalograms of 32 non-syndromic UCLP children (15 boys, 17 girls), mean age 10.91 ± 2.00 years were retrospectively collected. All patients had complete orthodontic records before and after treatments indicating the acceptable treatment result when considered from degree of overbite, overjet, maximum intercuspation occlusion and facial profile. Cephalometric measurements represented dento-skeletal and soft tissue profile before and after treatments were evaluated, and significant changes were tested by paired t-test. One sample t-test was used to analyse significant differences between these measurements and the clinical norm.

Results: The initial characteristics of the UCLP patients were skeletal Class III maxillary retrusion with relative mandibular prognathism, retroclination of the incisors, negative overjet, increase overbite and concave facial profile. After conventional orthodontic treatment, mainly maxillary arch expansion and Class III elastic traction, the acceptable overbite and overjet were achieved by proclination of the upper incisors. Significant changes of the soft tissue profile due to facial growth and treatment were increase of facial convexity, nose length, nose depth, columellar length, soft-tissue face height ratio, upper and lower lip lengths and upper lip protrusion. The soft tissue profile after treatment was acceptable when compared with the clinical norm.

Conclusions: The early correction of the anterior crossbite with maxillary arch expansion and Class III traction could improve the soft-tissue facial profile of UCLP patients.

Keywords: Anterior crossbite, Class III traction, Maxillary arch expansion, Soft tissue profile, Unilateral cleft lip and palate

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Introduction

Cleft involving the lip and/or palate are the most common congenital anomalies of the face (1). Among them, unilateral cleft lip and palate (UCLP) patients always present with dento-skeletal and profile problems comprising anterior crossbite, skeletal class III maxillary retrusion and concave facial profile (2-10). Orthognathic surgery is a treatment option for adult patients and its effect upon improvements of the skeleton and facial profile were reported (11-15). Early orthodontic treatment in growing subjects mainly relies on orthopedic mechanics with fixed appliance and protraction headgear (16-19), Class III traction via mini plate and screw (20). One study investigated soft tissue profile changes from growing children to adult without mention about treatment procedure (9). Another study investigated the effect of orthodontic treatment in adult patients (21). This study intended to investigate the effect of orthodontic treatment on UCLP children under the hypothesis that acceptable occlusion and facial profile could be achieved by conventional treatment modalities comprising arch expansion and Class III traction.

The objectives of the study were to scrutinize significant changes of dento-skeleton and facial profile following early orthodontic treatment in UCLP children and to compare the treatment results with the clinical norm.

Methods

The retrospective study was undertaken after the approval of The Human Research Ethic Committee, Faculty of Dentistry, Chulalongkorn University (HREC-DCU 2017-007).

The sample size was estimated by computer program: The PS: Power and Sample Size Calculation Software, Version 3.0.43 (Vanderbilt University, Nashville, TN). Mean difference of the nasolabial angle between UCLP and control groups reported by the previous study was used for sample size calculation (9). The estimated 27 subjects proved to be sufficient to achieve 80% power in detecting differences between groups.

The sample comprised 32 non-syndromic UCLP patients (15 boys, 17 girls), aged 7-15 years, purposively selected from Craniofacial Anomalies Clinic, Dental Hospital, Faculty of Dentistry. All presented with anterior crossbite and were treated with the same treatment protocol comprising: lip closure without presurgical orthopedic treatment at 3 months, palatal closure at 1-1 1/2 years, secondary bone grafting at the early mixed dentition, and orthodontic treatment with fixed appliance was performed by the same orthodontist. The treatment as a non-extraction case comprised: maxillary arch expansion with quad helix before bone grafting to correct arch constriction, followed by fixed appliance edgewise technique to correct dental crowding and anterior crossbite. Class III elastic traction was prescribed to obtain maximum intercuspation occlusion with acceptable overbite and overjet. The maxillary lateral incisor adjacent to the cleft site was extracted to facilitate the bone grafting procedure and complete space closure was achieved after completed orthodontic treatment in 21 of 32 cases.

All patients had complete orthodontic records before and after treatments indicating acceptable treatment result when considered from degree of overbite, overjet, maximum intercuspation occlusion and facial profile.

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The lateral cephalograms before (T1) and after treatment (T2), were obtained under standardized conditions from the same radiographic machine with the teeth in occlusion and the lips in relaxed position. Each radiograph was traced on an acetate paper and reference points (Figure 1) were located for measurement of the soft tissue profile changes (Figure 2).

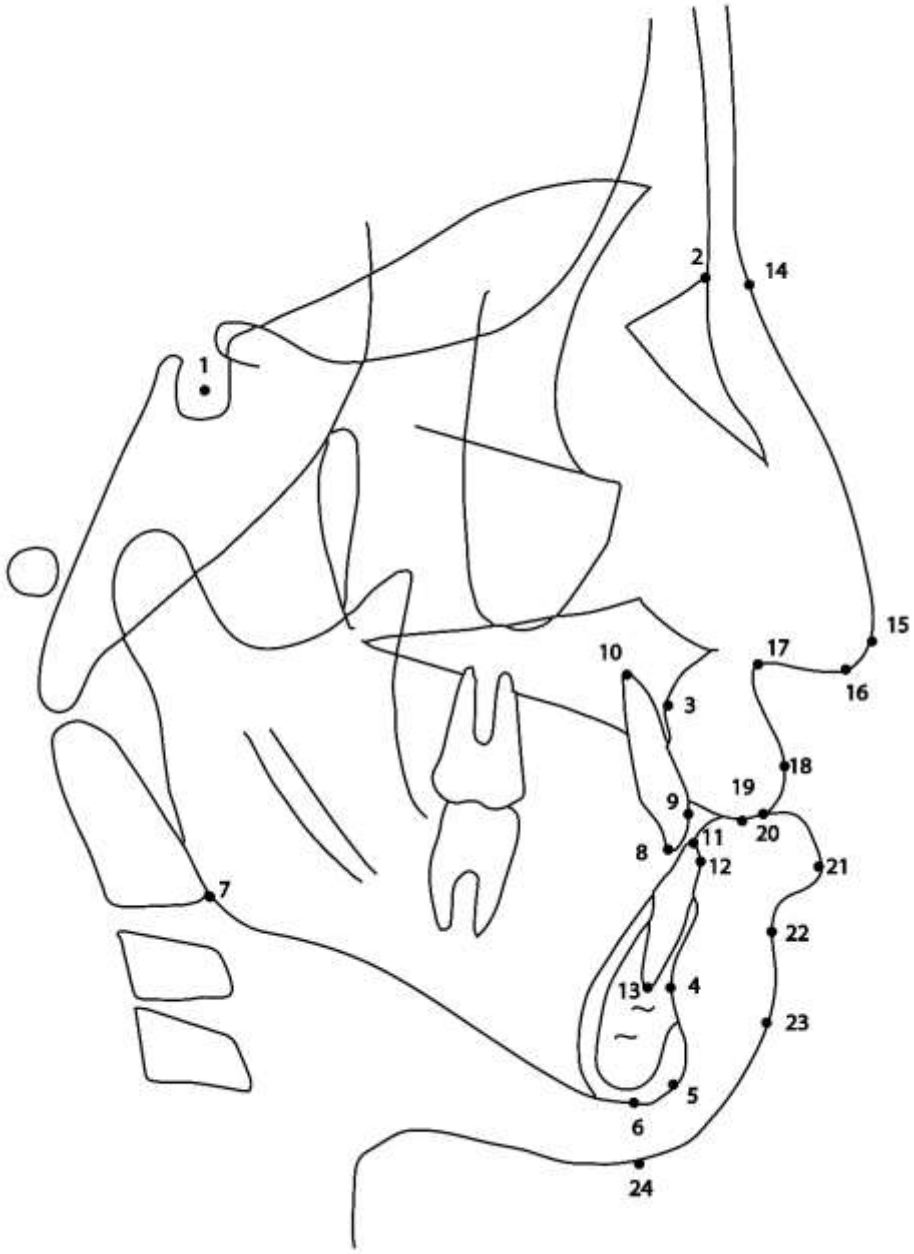

Figure 1 Cephalometric landmarks. 1 S (sella turcica), 2 N (nasion), 3 A (subspinale), 4 B (supramentale), 5 Gn (gnathion), 6 Me (menton), 7 Go (gonion), 8 Isi (maxillary central incisor edge), 9 U1 (the most anterior labial point of maxillary central incisor), 10 Isa (maxillary central incisor apex), 11 Iii (mandibular central incisor edge), 12 L1 (the most labial point of mandibular incisor), 13 Iia (mandibular central incisor apex), 14 N' (soft tissue nasion), 15 Prn

(pronasale), 16 Cm (columella), 17 Sn (subnasale), 18 Ls (labial superius), 19 Sts (stomion superius), 20 Sti (stomion inferius) , 21 Li (labial inferius), 22 Ils (inferior labial sulcus), 23 Pg' (soft tissue pogonion), 24 Me' (soft tissue menton)

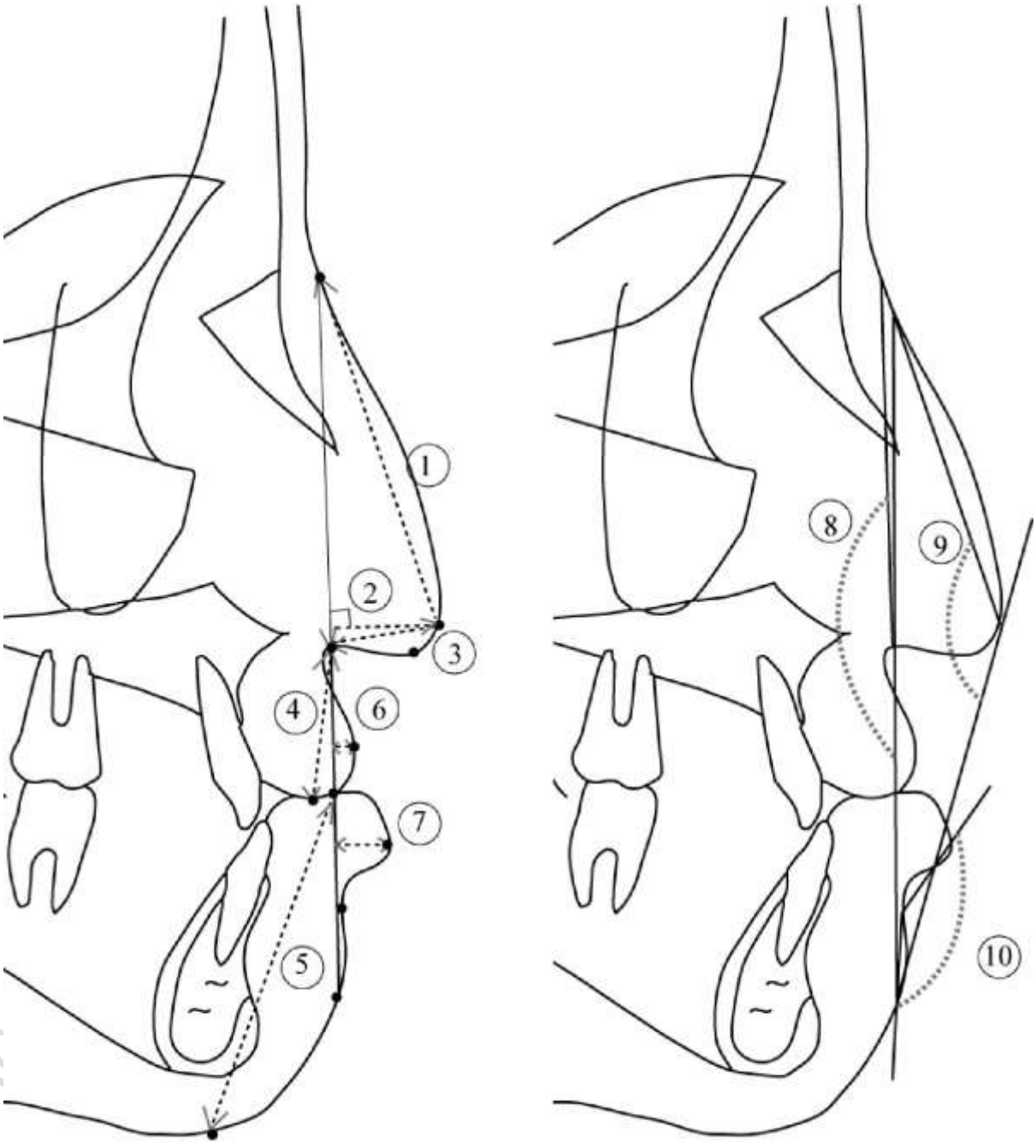

Figure 2 Cephalometric measurements utilized for evaluation of soft tissue profile changes. 1 Nose length (N'- Prn) 2 Nose depth (Prn to N'- Sn) 3 Columellar length (Sn - Prn) 4 Upper lip length (Sn - Sts) 5 Lower lip length (Sti - Me') 6 Upper lip protrusion (Ls to Sn - Pg') 7 Lower lip protrusion (Li to Sn - Pg') 8 Soft tissue convexity without nose (N'- Sn - Pg') 9 Soft tissue convexity with nose (N'- Prn – Pg') 10 Inferior labial sulcus angle (Li – Ils - Pg')

Method error study

Pretreatment (T1) and posttreatment (T2) radiographs of 10 patients were randomly selected and retraced for two times with at least 2 week interval to avoid recognition of the reference points. The error of linear and angular measurements was determined by Dahlberg's formula (22).

$$ME = \sqrt{\frac{\sum(d)^2}{2n}}$$

Where d is the difference between the first and second measurements (millimeters or degrees) and n is the number of duplicated measurements.

Statistical analysis

Significant changes of dento-skeletal and soft tissue profile after treatment were evaluated by a paired t-test and one sample t-test was used to compare with the clinical norm. All were tested at 0.05 significant level.

Results

The reliability of measurement was tested. The method errors for linear and angular measurements ranged from 0.23 - 0.87 mm and from 0.17 - 1.84 degrees, respectively. Shapiro-Wilk test indicated that the variables were normally distributed and parametric statistics was used.

The mean age of the patients before and after treatments were 10.91 ± 2.00 and 16.19 ± 2.47 years, respectively. The treatment duration was 5.27 ± 2.21 years. At the beginning of treatment, when compared with the clinical norm (Table 1), the patients presented retrusive facial pattern, skeletal Class III with significant retrusion of the maxilla, retroclination of the upper and lower incisors, negative overjet and deep overbite. There was significant difference of the soft tissue profile of the cleft at the upper lip area, the nasolabial angle was significant larger than the clinical norm.

After treatment (Table 1), significant changes of the dental and soft tissue profile were found at the upper incisal position and the lower lip. To obtain acceptable overjet and facial profile, the maxillary incisors had been proclined significantly resulted in increasing of the nasolabial angle until there was no significant difference with the clinical norm.

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Table 1. Cephalometric comparisons between before treatment (T1), after treatment (T2) and clinical norm

	T1 Mean ± SD	T2 Mean ± SD	T1 vs T2 t-value (p-value)	Clinical norm Mean ± SD	T1 vs Clinical norm t-value (p-value)	T2 vs Clinical norm t-value (p-value)
Skeleton						
SNA(°)	78.11 ± 3.66	77.81 ± 4.24	-0.69 (0.50)	83 ± 4	-7.56 (0.00**)	-6.91 (0.00**)
SNB(°)	78.47 ± 2.82	78.16 ± 3.55	-0.90 (0.38)	79 ± 3	-1.07 (0.30)	-1.34 (0.19)
ANB(°)	-0.28 ± 2.36	-0.25 ± 2.34	0.11 (0.90)	4 ± 2	-10.25 (0.00**)	-10.27 (0.00**)
SN to GoGn(°)	33.05 ± 5.50	33.67 ± 7.65	0.89 (0.38)	34 ± 6	-0.98 (0.33)	-0.24 (0.81)
Dental						
U1 to NA(°)	18.28 ± 6.01	33.55 ± 7.10	15.26 (0.00**)	28 ± 4	-9.14 (0.00**)	4.42 (0.00**)
U1 to NA(mm)	3.17 ± 2.13	8.39 ± 2.67	12.43 (0.00**)	6 ± 2	-7.52 (0.00**)	5.08 (0.00**)
L1 to NB(°)	24.45 ± 5.89	24.38 ± 5.33	-0.08 (0.93)	32 ± 6	-7.24 (0.00**)	-8.10 (0.00**)
L1 to NB(mm)	5.64 ± 2.19	5.98 ± 2.04	1.22 (0.23)	6 ± 2	-0.93 (0.36)	-0.04 (0.97)
L1 to GoGn(°)	92.20 ± 6.87	92.28 ± 6.82	0.08 (0.94)	99 ± 4	-5.60 (0.00**)	-5.58 (0.00**)
Overjet(mm)	-3.06 ± 1.02	1.78 ± 0.94	21.11 (0.00**)	2 ± 1	-28.02 (0.00**)	-1.32 (0.20)
Overbite(mm)	4.03 ±1.90	1.30 ± 0.63	-7.85 (0.00**)	2 ± 1	6.05 (0.00**)	-6.28 (0.00**)
Soft tissue						
Lower lip to E-line(mm)	3.77 ± 2.17	2.73 ± 2.58	-2.77 (0.01*)	3.5 ± 2	0.69 (0.49)	-1.68 (0.10)
Nasolabial angle(°)	94.69 ± 11.27	92.00 ± 9.25	-1.43 (0.16)	90 ± 9	2.35 (0.03*)	1.22 (0.23)

* = $p \leq 0.05$, ** = $p \leq 0.01$

Changes of the soft tissue profile in specific areas were presented in Table 2. After treatment, soft tissue profile convexity with and without nose increased significantly (decreased N'- Sn - Pg', N'-Prn-Pg' angles).There were significant increases of nose length (N'-Prn), nose depth (Prn to N'-Sn), columellar length (Sn - Prn), face height ratio (Sn - Me'/ N'- Me'), lip lengths (Sn – Sts, Sti - Me') and upper protrusion (Ls to Sn - Pg').

* = $p \leq 0.05$, ** = $p \leq 0.01$

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Table 2. Cephalometric comparisons of soft tissue profile before treatment (T1) and after treatment (T2)				
	T1	T2	Mean differences	t value (p-value)
1. N'- Sn - Pg' (°)	176.22 ± 6.58	174.59 ± 5.42	-1.63	-2.36 (0.03*)
2. N'- Prn - Pg' (°)	149.69 ± 6.65	146.44 ± 5.13	-3.25	-3.94 (0.00**)
3. N'- Prn (mm)	47.03 ± 4.28	51.95±3.99	2.55	9.61 (0.00**)
4. Prn to N'- Sn (mm)	11.94 ± 2.03	14.48±2.23	4.92	7.78 (0.00**)
5. Sn - Prn (mm)	16.83 ± 1.78	19.13±2.27	2.30	7.45 (0.00**)
6. Sn - Me'/ N'- Me'	0.55 ± 0.03	0.57±0.02	0.01	2.73 (0.00**)
7. Sn – Sts (mm)	19.86 ± 3.17	21.97±2.49	2.11	7.58 (0.00**)
8. Sti – Me'(mm)	48.72 ± 5.53	53.11±4.87	4.39	7.72 (0.00**)
9. Ls to Sn – Pg' (mm)	4.02 ± 1.25	5.38±1.39	1.36	6.52 (0.00**)
10. Li to S' – Pg' (mm)	8.08 ± 1.73	7.73±1.93	-0.34	-1.05 (0.30)
11. Li – Ils -Pg' (°)	133.39 ± 11.46	132.34±12.05	-1.04	-0.53 (0.60)

Discussion

Correction of facial deformities and dental malocclusions of UCLP patients is one of the most challenging responsibilities of orthodontists. Sufficient information about the effect of orthodontic treatment on such patients is necessary for selection of treatment modalities.

The studied patients presented skeletal Class III retrusive maxilla and relative mandibular prognathism, retroclined and retruded maxillary incisors that were coincided with the finding of previous studies (3, 5). It is remarkable that in cleft patients, the pressure from scar tissue of the upper lip prevents the maxillary incisors from proclination to compensate with the abnormal position of the maxilla.

After treatment, the SNA angle was reduced. This effect could be explained as follows. First, the retrognathic maxilla in UCLP patients was pronounced by scar tissue after lip closure procedure (23). Second, proclination of the maxillary incisors by conventional orthodontic treatment caused a resorptive remodeling of the A point (24-26). However, this treatment procedure is necessary to achieve the proper interincisal angle as well as stability of deep bite correction (24, 25) and this should be beneficial for improvement of the upper lip retrusion. The study prevailed significant proclination of the upper incisors as well as upper lip protrusion after treatment.

Class III elastic traction was one of the treatment mechanics in this study. Jinxiang et al (26) found that this mechanics could reduce the SNB angle, procline the upper incisors, retrocline the lower incisors and reduce the lower lip protrusion in the noncleft subjects. Our study found that the lower incisor inclination was maintained throughout treatment, the lower lip position considered from the Li to Sn-Pg' seemed to be stable meanwhile the distance from the lower lip to E plane was reduced. This could be explained by the increased nose depth resulting in relatively reduced of the distance of the lower lip to E plane. Another reason for the low response of the lower lip to the treatment could be functional distortion comprising increased functional movements of the lower lip to assure mouth closure, swallowing and phonation as

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a compensation and adaptation to an impaired function of the upper lip (5, 10, 27). These findings point to a need for further studies on the muscular activity of the lips to clarify lip function of cleft and noncleft subjects.

The retrusive facial pattern of the cleft patients at both time points analyzed corresponded with the finding of previous studies (6, 9, 28, 29). This may be a specific characteristic of UCLP patients as a syndromic appearance regardless of ethnic. The study also indicated that the retrusive facial pattern could not be altered by conventional orthodontic treatment. Therefore, orthognathic surgery should be prescribed if the treatment goal aims to correct the retrusive facial pattern and/or lower lip protrusion.

Previous studies on growing UCLP subjects reported a progressive reduction of facial convexity (9, 29). Result of this study indicated that early orthodontic treatment in growing patients could contribute to the improvement of the soft tissue profile especially the upper lip area and facial convexity. Long term follow-up is mandatory for the early orthodontic treatment without orthopedic appliances as the treatment effect is mainly dentoalveolar effect based upon significant proclination of the upper incisors.

Conclusion

The effect of early orthodontic treatment upon correction of anterior crossbite in the growing UCLP patients was investigated. Dental compensation comprising significant proclination of the upper incisors was achieved to obtain acceptable overbite and overjet as well as improvement of facial profile. Significant changes of the facial profile after treatment could be detected at the nasal and upper lip areas. Facial convexity as well as the upper lip protrusion increased significantly.

Competing interests

The authors declare that they have no competing interests.

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