Soft tissue profile changes of reverse headgear treatment in Chinese boys with complete unilateral cleft lip and palate

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One of the primary objectives of orthodontic treatment is to improve facial esthetics. Sometimes the esthetic result is more important to the patient than the occlusal changes. Hence, good occlusion and improved facial appearance are distinct yet parallel objectives of orthodontic treatment.

Attractiveness is a major component of self-concept, and dentofacial appearance has an effect on both physical and social attractiveness.[1-4] It is especially important during the early adolescent years because negative self-esteem developed then is likely to have effects during adulthood.[5] Children who are bullied, harassed, or rejected by others can develop a negative and self-depreciating attitude.

The appearance of the lower face has been found to influence social acceptance and psychological well-being of the individual.[1] Modification in the lip area definitely influences facial appearance.[6] The combination of midface retrusion, acute nasolabial angle, and relatively excessive lower facial height often contributes to the characteristic unattractiveness of cleft lip faces.[7] The stigma related to cleft lip and palate greatly influences social behavior,[8] with only obese children viewed less favorably than children with facial disfigurement.[9]

The majority of children with cleft lip and palate show features of severe malocclusion at an early age,[10] suggesting unfavorable growth will occur in the future. Because the soft tissue profile and its supporting bony structures are closely related,[6,11-19] protraction of the maxilla at either the deciduous or mixed dentition period[20-24] may improve the soft tissue facial pro-

Abstract

Midface retrusion in cleft lip and palate patients often results in personal, social, and psychological problems, along with the functional difficulty. Hence, soft tissue profile improvement in early childhood is of obvious importance. The purpose of this study was to investigate the soft tissue changes that occur during reverse headgear treatment in a homogenous sample of Chinese boys born with unilateral complete cleft lip and palate. Boys with a similar congenital deformity and presenting similar skeletal morphology and maturity status were included for comparison. After 7.8 months of reverse headgear treatment, the soft tissue profile improved significantly as the concave tendency associated with maxillary deficiency decreased. The sagittal maxillomandibular lip relationship and the Holdaway angle increased significantly by 4.25 and 3.94 degrees, respectively.

Key Words

Unilateral complete cleft lip and palate • Reverse headgear • Soft tissue profile

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Figure 1A-D
Characteristic improvement of the facial appearance by the reverse headgear treatment.
A-B:Before interceptive treatment.
C-D: After 8 months of protraction.


Figure 1A


Figure 1B


Figure 1C


Figure 1D

Figure 2
Intraoral picture showing the silver splint with hooks for elastics at canine regions.

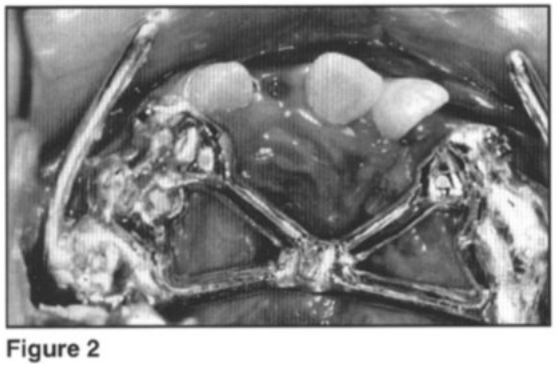
Figure 2

file (Figure 1A-D).

The aim of the present investigation was to study the sagittal soft tissue profile changes immediately following maxillary protraction with reverse headgear among Chinese boys born with unilateral complete cleft lip and palate.

Materials and methods

The test group consisted of 10 southern Chinese boys born with unilateral complete cleft lip and palate who were treated using reverse headgear for a mean period of 7.8 months (±1.23 months) to achieve positive overjet. The mean age at the start of protraction was 9.67 years (range 7.08 to 12.33 years). None of the subjects reached maximal pubertal growth as assessed by radiographic examination of the hand and wrist.[25] Although each subject had an anterior crossbite before the reverse headgear treatment, no abnormal mandibular displacement was found after thorough clinical examination. None of these subjects had a history of previous orthodontic treatment.

Ten boys born with a similar deformity were selected from registered patients of the Cleft Lip and Palate Center at this dental faculty as control subjects; they were matched individually with the test subjects for age, skeletal maturity status, timing of the primary repairs (lip at 3 months and palate at 18 months), type of malocclusion, and skeletal morphology. The control subjects were followed on a parallel basis with the treated subjects. No orthodontic treatment was performed on the controls during the observation period, as agreed to by their parents.

Appliance design and treatment procedure

The intraoral component consisted of an appliance fixed onto the maxillary dental arch. It included a cast silver splint (Figure 2) cemented from the maxillary primary first molars or first premolars to the permanent first molars. Protraction was carried out with a Tubinger® facemask (Dentarum). Two parallel elastics were applied to intraoral hooks in the canine area. The direction of the protraction force was 10 degrees inferior to the occlusal plane (Figure 3-B). The force was 450-500 grams on each side. The facemask was to be worn 12-14 hours a day. All patients used a reverse activator as a retainer (Figure 4) immediately after attaining 5 mm of overjet.

Analysis of lateral cephalometric radiographs

Sagittal soft tissue profile changes that occurred during the examination period were analyzed by means of two lateral cephalometric radiographs—the first taken at the start of treatment before appliance insertion and the second at the time of appliance removal following protraction (Figure 5-B). The mandible was placed in the most retruded position with lips relaxed when the lateral cephalograms were taken.[26,27] In the control group, radiographs were taken before and after the observation period.

Most cephalometric soft tissue reference points and lines used in this study are well known (Figure 6).[6,16,28-32] All reference points were marked directly on tracing paper under optimal illumination. Reference points were digitized twice by the same operator (KFC), with an interval of at least 1 month, and average values were used. No correction was made for linear enlargement, which was approximately 8% in the median sagittal plane and constant for all lateral cephalograms. The ref-

Figure 3A

Figure 3B

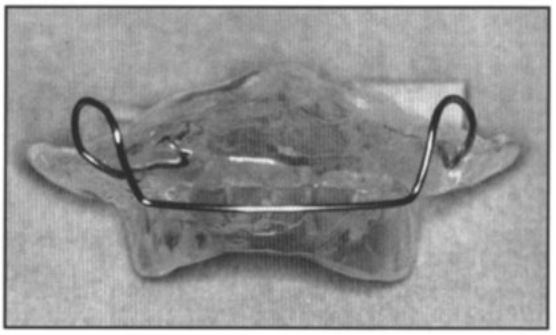

Figure 4

Figure 3A-B
Reverse headgear therapy.
A: Patient wearing reverse headgear.
B: Reverse headgear for anterior and slightly downward protraction by elastics from intraoral hooks.

Figure 5A

Figure 5B

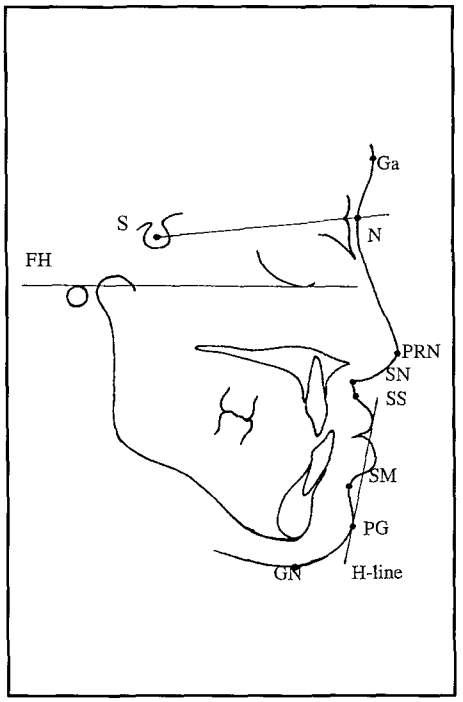

Figure 6

erence points and the reference lines used were defined as follows:

The center of sella turcica, S (sella), was used as the registration point for all radiographs.

Soft tissue reference points

Ga (glabella) - the most anterior point on the forehead, in the region of the supraorbital ridges.

N (soft tissue nasion) - the deepest point on the frontonasal contour.

PRN (apex nasalis) - the most anterior point on the nasal tip.

SN (subnasale) - the deepest point of the concavity at the junction of the lower border of the columella with the philtrum of the lip.

SS (superior labial sulcus) - the most dorsal point of the soft tissue profile of the maxillary alveolar area.

SM (supramental groove) - the most dorsal point of the soft tissue profile of the mandibular alveolar area.

PG (soft tissue pogonion) - the most anterior point of the soft tissue profile of the chin.

GN (soft tissue gnathion) - the most inferior point on the soft tissue profile inferior to the mandibular symphysis.

Reference lines

FH (Frankfort horizontal line) - line through the cartilaginous porion and orbitale.

N-PG line - line through soft tissue nasion and soft tissue pogonion.

H-line - line drawn tangent to the soft tissue chin and the upper lip.

Statistical methods

The arithmetic mean and standard error of the mean (SEM) were calculated for each cephalometric variable. Paired *t*-tests were performed to compare the changes that occurred during the treatment/observation period. The cephalograms were traced and digitized twice with a time interval of at least 1 month. The lateral cephalometric radiographs taken before

Figure 4
Reverse activator.

Figure 5A-B
A: Pretreatment lateral cephalogram showing dental occlusion.
B: Posttreatment lateral cephalogram showing changes after 8 months of protraction treatment.

Figure 6
Reference points and lines used in cephalometric analysis.

Table 1
Cephalometric measurements describing the soft tissue morphology before treatment/observation period

Variables (mm or degree)	Test group (n=10) Mean	SEM	Control group (n=10) Mean	SEM	Group differences Mean *
Angular measurements					
Upper lip position (s-N-SS)	85.20	1.95	91.03	1.89	-5.83
Lower lip position (s-N-SM)	87.57	2.11	87.99	1.79	-0.42
Sagittal lip relationship (SS-N-SM)	-2.26	1.05	4.07	1.16	-6.33
Nose tip position (s-N-PRN)	101.43	2.28	107.74	1.74	-6.31
Chin position (s-N-PG)	85.60	2.02	85.92	1.53	-0.32
Soft tissue facial angle (FH-NPG line)	93.00	1.42	90.00	1.02	3.00
Soft tissue convexity (N-PRN-PG)	152.23	2.21	144.10	1.59	8.18
Facial convexity (Ga-SS-PG)	185.20	2.46	172.20	2.21	13.07
Holdaway angle (NPG line-H line)	3.67	1.58	10.45	1.45	-6.78
Nasolabial angle (PRN-SN-SS)	76.02	6.58	86.81	6.17	-10.79
Linear measurements					
Upper facial height (N-PRN)	41.43	1.44	37.29	1.08	4.14
Total facial height (N-GN)	114.13	2.61	109.44	2.23	4.69

*All mean values were not statistically significant at P<0.01

and after this investigation period of four boys from each group were randomly chosen to be retraced, resuperimposed, and remeasured on two different occasions with a 2-week interval. The error of measurement (τ) representing the total uncertainty in tracing, point localization, and digitizing the same cephalogram twice was estimated by the formula $\tau^2 = \Sigma d^2/2n$, where d was the difference between corresponding first and second measurements. The errors of measurement were generally small and within acceptable limits.

Results

Pretreatment soft tissue profile

Cephalometric variables of the test and control groups at the start of the study are shown in Table 1. The groups were comparable, with no variables being significantly different at P<0.01.

Soft tissue profile changes during protraction treatment

Table 2 shows the changes that occured during the 7.8 months of treatment/observation. The group differences represented the protraction effect of the reverse headgear as changes shown in the test group were a combination of treatment and growth while in the control group they were effects of natural growth.

Nose: Although prominence of the nose (angle s-N-PRN) improved, it did not increase significantly.

Lips: During protraction, the positions of both upper and lower lips (angles s-N-SS and s-N-SM) did not increase significantly. However, the overall change in the sagittal lip relationship (SS-N-SM) did improve significantly (P<0.001). The significant increase of 3.94 degrees in the Holdaway angle further supported the forward positioning of the upper lip in the test group.

Soft tissue chin: There was no obvious change of soft tissue chin prominence during protraction.

Vertical dimension: Total facial height (N-GN) increased in both the test and control groups.

Soft tissue convexity: Soft tissue convexity (N-PRN-PG [d]) increased significantly (P<0.005) by almost 6.4 degrees in the test group but remained more or less stable in the control group. Hence the protraction treatment did correct the concave facial profile.

Discussion

Reverse headgear treatment has long been advocated to improve the intermaxillary basal relationship and eliminate dysfunction, allowing more harmonious conditions for midfacial growth and development in children with cleft lip and palate.[21-24,33,35] Most of the previous reports discuss treatment effects in rather heterogeneous groups. Their samples included both males and females with various cleft types all pooled together for analyses. Some authors did not distinguish between functional crossbite with anterior mandibular displacement or skeletal crossbite due to genuine sagittal jaw discrepancy without abnormal mandibular displacement. Some reported treatment durations spanning variable and often long periods of time, ranging from 3 to 58 months.[22-24,34] Comparisons were usually made with noncleft control individuals of similar chronological age. The main reason for making such comparisons seemed to be centered on ethical issues.

Table 2
Changes occurring during treatment/observation period

Variables (mm or degree)	Test group (n=10) Mean	SEM	Control group (n=10) Mean	SEM	Group differences "treatment effects" Mean	P value
Angular changes						
Upper lip position (s-N-SS)	2.60	0.70	0.21	1.43	2.39	n.s.
Lower lip position (s-N-SM)	-0.71	0.88	0.64	1.18	-1.35	n.s.
Sagittal lip relationship (SS-N-SM)	4.17	0.78	-0.08	0.68	4.25	<0.001
Nosetip position (s-N-PRN)	3.52	0.89	-0.11	1.76	3.63	n.s.
Chin position (s-N-PG)	-0.95	0.87	-0.03	0.98	-0.92	n.s.
Soft tissue facial angle (FH-NPG line)	-1.85	0.70	-1.05	1.56	-0.80	n.s.
Soft tissue convexity (N-PRN-PG)	-6.39	1.10	-0.39	1.14	-6.00	<0.005
Facial convexity (Ga-SS-PG)	-8.45	1.52	0.11	1.21	-8.56	<0.0005
Holdaway angle (NPG line-H line)	5.01	1.21	1.07	0.89	3.94	<0.05
Nasolabial angle (PRN-SN-SS)	4.96	4.13	-1.73	3.81	6.69	n.s.
Linear changes						
Upper facial height (N-PRN)	-1.25	0.72	1.40	1.57	-2.65	n.s.
Total facial height (N-GN)	2.58	0.77	2.74	1.77	-0.16	n.s.

n.s. = not statistically significant at P<0.01

However, results from such comparisons could easily be masked by the heterogeneous nature of the group studied with their different growth potentials and patterns, natural growth superimposing with effects of the protraction appliance. Hence this study was carried out in an as homogeneous a group as possible: boys with unilateral complete cleft lip and palate. The effects of the treatment were analyzed within a short period of time, 7.8 months. Comparison was made with a group of boys having the same deformity and maturity status. The differences found in the present study should be due only to the effects of treatment.

The combination of mild increases in nose prominence and upper lip protrusion, together with the mild reduction of chin and lower lip protrusion, resulted in a significant and desirable change in the soft tissue profile. The characteristically concave soft tissue profile was changed to a more normal profile. This study found increased soft tissue convexity after protraction treatment (Table 2). The change in the Holdaway angle indicated a favorable position of the upper lip. The overall changes helped to improve the facial profile. Although the vertical lower facial height increased, the change was not significant. As reported in other studies,[22,24,35-37] the increase in the lower facial height was induced mainly by clockwise rotation of the mandible during protraction. All of these changes favored the improvement of facial esthetics in the cleft lip and palate patients. Reduced face height and overclosure of the mandible were frequently observed.

Reduced soft tissue profile convexity with increasing age in cleft lip and palate patients is reportedly due mainly to thinning of the upper lip and some flattening of the tip of the nose.[30,38-42] Profile convexity tends to increase in noncleft children.[12,29] The treatment effects for cleft lip and palate children had a favorable

and lasting influence on the soft tissue profile.[21]

Habitual posture of the lips was an important factor in the soft tissue profile.[43] Lip morphology influenced the reliability of the measurements, especially in children with incompetent lips.[26] This problem might be more aggravated in cleft lip and palate patients. Hence, other variables, such as initial lip strain, muscle tonicity, and lip thickness also strongly influence lip form and positioning, especially in cleft lip and palate patients. Such factors might modify the soft tissue response to the treatment-induced changes of the underlying hard tissue structure.

Improvement in lip positioning in cleft lip and palate patients during protraction would require more change of the underlying bone.[44] In order to achieve the most ideal facial appearance, the upper lip needs adequate and well-positioned bony support.[45] Therefore early orthopedic treatment in children with cleft lip and palate with maxillary deficiency may lead to increased growth and development of the maxilla and upper alveolar process, resulting in improvement of soft tissue lip relationships.[22-23,39,45-46]

In the present study, the sample size was small and there was marked individual variation in response to the reverse headgear treatment. Hence, the results should be interpreted with great caution. In addition, the long-term benefits of this therapy have not been and cannot be substantiated by the present study alone. Further investigation into the long-term effect of reverse headgear treatment is needed.

Conclusions

The 7.8 months of reverse headgear treatment produced statistically significant soft tissue changes in the sagittal plane for Chinese boys born with unilateral complete cleft lip and palate. The changes consisted of improved sagittal lip relationship and soft tissue convexity.

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