Effects of lip repair on maxillary growth and facial soft tissue development in patients with a complete unilateral cleft of lip, alveolus and palate

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SUMMARY. Purpose: To examine the relationship between lip repair and inhibition of maxillary growth, and to investigate the characteristics of upper lip in patients with complete unilateral clefts of lip, alveolus and palate. Material and methods: Lateral cephalometric radiographs and photographs (anterior–posterior and profile) were taken for 3 groups of patients: (1) 35 complete unilateral cleft lip, alveolus and palate cases in whom only a labioplasty was performed as infants; (2) 47 cases who had both lip and palate repaired; and (3) 37 non-cleft peers as controls. Results: There was maxillary retrusion in groups (1) and (2). Surface area and height of the upper lip was reduced in both these groups when compared with the normal controls. Conclusion: Lip repair is a most important factor in the restraint of maxillary growth in patients with complete unilateral clefts of lip, alveolus and palate. And height and projection of the upper lip are reduced following lip repair.

INTRODUCTION

Retroposition of the maxilla is typical for patients with clefts of the lip, alveolus and palate. Most patients with unrepaired cleft lip and palate do not have this retroposition. This implies that lip repair may be an important factor inhibiting maxillary growth (Herfert, 1958). Many researchers considered that palatoplasty is the only reason for midfacial retroposition, and lip repair may have an influence on the upper front teeth, and the alveolar bone but never on the development of maxilla (in any direction) (Ros, 1987; Sommerlad et al., 1994). Although Bardach (1990) was certain that lip repair has a negative effect on maxillary growth, he failed to find a way to separate the effects of these two operations because both operations were performed during the first 2 years of age, while growth aberrations do not become evident until several years after the operations (Bardach, 1990). To control his thesis, several patients were studied with a complete unilateral cleft of lip, alveolus and palate (UCLAP) in whom only the lip had been repaired during infancy. Consequently there was no effect of palatal repair and it was possible to analyse the impact of the lip repair alone on maxillary growth and development of the facial soft tissue.

MATERIAL AND METHODS

Patients

The participants included 82 children with complete UCLAP ranging between 10.1 and 18.8 years in age (49 boys and 33 girls). None of them had any other congenital anomaly or any known syndrome. All patients were operated upon between the years of 1986 and 1993 in the West China Hospital of Stomatology. Lip repair was performed at approximately 9 months of age with rotation-advancement technique (groups 1 and 2). The average age of palatoplasty (group 2) was at 38 months with a mucoperiosteal pushback procedure. None of the patients had received any presurgical orthopaedic treatment, alveolar bone grafting, or secondary nasolabial surgery. Twenty boys and 17 girls with symmetrical faces and normal occlusions from a middle school served as normal controls. None of these had ever undergone any orthodontic treatment or any kind of wounds of the facial soft tissue (Table 1).

Since the degree of development and maturity is quite different between persons, they may not reach puberty at the same time. To maintain consistency and comparability, several criteria were used to judge whether the test persons in this study were pubertal, including recent changes of stature and weight, appearance of secondary sexuality and bone age.

METHODS

Measurements and analysis of cephalograms

(1) X-ray: EASYMTIC 3298-125 Cephalometry X-ray machine (Chemetron Co., USA) was used to obtain lateral cephalograms. The subjects were told to adopt a standard position in centric occlusion.
Measurements: To ensure maximum uniformity, all determinations of reference points and measurements were performed by one of the authors with several measuring instruments. Nineteen reference points were identified and 15 parameters were measured (Fig. 1).

Computer-assisted measurement and analysis: A Calcomp (USA) was used to digitize the figures. The data were analysed by some self-designed software on computer. Significant differences between and within groups were tested by t-tests ($\alpha = 0.05$, bilateral).

Measurement and analysis of photos

1. Anterior–posterior and profile photos: All photos were taken with a Pantex1000 camera (Japan). Parameters of the lens were $f = 35–200\text{ mm}$, focus $= 120\text{ mm}$, aperture $f = 11$, shutter speed $= 1/30\text{ s}$. An Achiever115A flashlight provided illumination. The films were Lucky HD 100 (China).

The subjects’ heads were fixed in a cephalostat in an upright position, with a pointer on the right infraorbital margin. They were asked to remain in centric occlusion, lips relaxed. The camera was fixed on a frame in front of the anticathode of the X-ray tube. So it moved synchronously with the cephalostat and kept a uniform distance to the subjects’ heads.

Two rulers were placed along the coronal plane and the central sagittal plane when the photos were taken. This served as a frame of reference when magnifying and evaluating the photos.

2. Indicators on photographs: The photos were magnified to life size. The following anatomical and constructed points were marked (Figs. 2 and 3).

A–P photo: inferior points of alar grooves (1,2), midpoint of columella base (3), cheilion (4,5), top of cupid’s bow (6,7), midpoint of distance 6–7 (8), bottom of the cupid’s bow (9), stomion (10; Fig. 2).

Profile photo: soft nasion (11), nasal base point (12), most protrusive point of upper lip (13), most protrusive point of lower lip (14), most protrusive point of chin (15; Fig. 3).

3. Data collection: Calcomp 2500(USA) and AutoCAD software were used. The infraorbital cursor was applied to put in coordinate reference points on the photos, set up the ratio of magnification and eliminate systematic error. All measurements were performed to a precision of 0.01 mm. The indices in A–P photos (Fig. 2) were: S: surface area of upper white lip (enclosed by the points 4-1-3-2-5-7-9-6-4); L1: height of upper white lip (3-8); L2: height

### Table 1 – Study population

<table>
<thead>
<tr>
<th></th>
<th>Lip repair only</th>
<th>Lip and palate repair</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
<td>Male</td>
</tr>
<tr>
<td>Subjects</td>
<td>21</td>
<td>14</td>
<td>28</td>
</tr>
<tr>
<td>Age at evaluation</td>
<td>14.1±1.31</td>
<td>13.3±1.60</td>
<td>14.2±2.31</td>
</tr>
<tr>
<td>± SD (range) [years]</td>
<td>(12.3–15.4)</td>
<td>(11.8–16.5)</td>
<td>(10.1–18.8)</td>
</tr>
<tr>
<td>Age at lip repair [months]</td>
<td>9</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Age at palate repair [months]</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

SD, standard deviation.
of upper red lip (8-10); L3: intercheilion width (4-5). The indices in profile photos (Fig. 3): with Line 11 as a line of reference, the distances between 12, 13, 14 and the line 11~15 were measured separately. L4: projection of nasal base; L5, projection of upper lip; L6, projection of lower lip (Fig. 3). In addition, L7: length of upper lip (L1 + L2); In: index of lip projection (L5/L6).

(4) Statistical analysis: The data were put into Foxpro database and analysed by SPSS/PC software pack and t-test (α = 0.05, bilateral). The correlation between the height of the upper white lip and intercheilion width was also calculated.

RESULTS

Tables 2 and 3 demonstrate that in comparison with normal controls, the maxilla on radiographs of male/female patients in both groups (1) and (2) were positioned relatively posterior to the cranial base; and maxillary length (A-Ptm) was decreased significantly. Both surgical groups (with or without palate repair) had similar facial growth except for the ratio of upper facial height/full facial height. The female patients of group 2 (labioplasty plus palatoplasty) had a more significant posteriorly located “A” point and thus the angles ANB and N-A-Pg were significantly smaller than in males.

When the photos were assessed, similarities and differences were noted between both the patient groups and the children without clefts (Tables 4 and 5). The patients had smaller upper white lip surfaces (S), height of upper white lips (L1), length of upper lips (L7) and intercheilion width (L3) than the controls, and these differences were significant. The differences between upper red lip heights (L2) were non-significant. When comparing the profile photos of the non-cleft group with the cleft groups, the projection of nasal base and projection of upper lip were significantly reduced among the patients. No significant difference was noted in the projection of

Table 2 – Means and standard deviations of the parameters on cephalograms

<table>
<thead>
<tr>
<th>Item</th>
<th>Lip repair</th>
<th></th>
<th>Lip and palate repair</th>
<th></th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
<td>Male</td>
<td>Female</td>
<td>Male</td>
</tr>
<tr>
<td>Mean SD</td>
<td>Mean SD</td>
<td>Mean SD</td>
<td>Mean SD</td>
<td>Mean SD</td>
<td>Mean SD</td>
</tr>
<tr>
<td>SNA (degree)</td>
<td>72.64</td>
<td>5.28</td>
<td>75.13</td>
<td>3.37</td>
<td>73.46</td>
</tr>
<tr>
<td>Cm-Sn-UL (degree)</td>
<td>64.59</td>
<td>13.04</td>
<td>69.08</td>
<td>27.17</td>
<td>74.67</td>
</tr>
<tr>
<td>PP-SN (degree)</td>
<td>13.04</td>
<td>4.36</td>
<td>17.84</td>
<td>4.79</td>
<td>13.86</td>
</tr>
<tr>
<td>S-Ptm (mm)</td>
<td>13.68</td>
<td>1.30</td>
<td>15.71</td>
<td>1.95</td>
<td>15.15</td>
</tr>
<tr>
<td>A-Ptm (mm)</td>
<td>38.22</td>
<td>4.80</td>
<td>41.45</td>
<td>3.80</td>
<td>40.77</td>
</tr>
<tr>
<td>N-ANS/N-Me</td>
<td>0.48</td>
<td>0.02</td>
<td>0.49</td>
<td>0.03</td>
<td>0.46</td>
</tr>
<tr>
<td>S-Ar/S-Go</td>
<td>0.42</td>
<td>0.05</td>
<td>0.39</td>
<td>0.03</td>
<td>0.42</td>
</tr>
<tr>
<td>SNB (degree)</td>
<td>73.25</td>
<td>4.29</td>
<td>75.15</td>
<td>6.03</td>
<td>74.75</td>
</tr>
<tr>
<td>G-No-Pg (degree)</td>
<td>1.83</td>
<td>6.49</td>
<td>1.48</td>
<td>11.81</td>
<td>1.52</td>
</tr>
<tr>
<td>Ar-Go-Me (degree)</td>
<td>130.03</td>
<td>4.09</td>
<td>131.92</td>
<td>6.02</td>
<td>129.84</td>
</tr>
<tr>
<td>Go-Pg (mm)</td>
<td>71.24</td>
<td>4.24</td>
<td>70.15</td>
<td>3.18</td>
<td>72.75</td>
</tr>
<tr>
<td>Ar-Go (mm)</td>
<td>42.15</td>
<td>4.72</td>
<td>42.35</td>
<td>1.20</td>
<td>42.80</td>
</tr>
<tr>
<td>Sn-Stms (mm)</td>
<td>20.54</td>
<td>4.05</td>
<td>19.54</td>
<td>3.22</td>
<td>21.29</td>
</tr>
<tr>
<td>N-A-Pg (degree)</td>
<td>−3.16</td>
<td>8.67</td>
<td>−1.72</td>
<td>10.08</td>
<td>−4.87</td>
</tr>
</tbody>
</table>
the lower lip between groups. There were no significant correlations between upper white lip surface (S) and the variables of upper white lip height (L1) and intercheilion width (L3) in the non-cleft group (Table 6). However, in the cleft groups, a significantly positive correlation was noted between S and L1, but not between S and L3.

**DISCUSSION**

Maxillary growth of untreated cleft lip, alveolus and palate patients

Since Ortiz-Monasterio et al. (1959, 1966) reported that there could be normal growth potential of...
maxillae in patients with UCLAP, many researchers have continued in trying to examine his conclusion. Bishara et al. (1985) analysed the craniofacial growth of normal persons and patients with different cleft types. He found that the anteroposterior development of the maxilla in patients with unoperated UCLAP was identical to that in non-cleft persons, or even more forward than in the latter. Mars and Houston (1990) concluded that there was no difference between the size of the maxilla in unoperated UCLAP patients and in those without clefts. Capelozza et al. (1993) evaluated cephalograms of unoperated UCLAP patients and normal controls. He noted that unoperated UCLAP patients had a more protrusive maxilla. Stellzig et al. (1999) tried to find out some particular factors that may affect the growth increments in UCLAP patients in their first 6 months of age. Maxillary casts were measured and compared to putative factors influencing growth. The result was that only gender played a certain role in growth changes within the first 6 months of age. Patients with cleft lip, alveolus and palate had a normal sized cranial base (Harris, 1993; Sherwood et al., 2001). Thus it is widely accepted that unoperated UCLAP patients have a normal anteroposterior length of the maxilla.

**Effects of lip repair on maxillary growth and facial soft tissue development in patients with complete UCLAP**

Mars and Houston (1990) found that the angle of SNA was only smaller in the UCLAP patients with a repaired lip and not in normal controls and untreated patients, but there was no significant difference. They considered that lip repair could not significantly interfere with the anteroposterior growth of the maxilla. More observations indicated that the maxillary length (Ar-ANS) and the position of the upper incisor (Ar-UIK) were similar in the lip repaired group and the lip and palate repaired group, and both of them have a smaller length than the control group ($p<0.05$). Our research also found that the maxilla was more posteriorly positioned relative to the cranial base in both the lip-repaired group and the lip and palate repaired group. This implied that the decrease in maxillary length was similar in lip-repaired patients with or without the palate being repaired. Smahel and Mullerova (1986) thought that the maxilla was restricted relative to the cranial base before repair of the palate. So it was concluded that the deficiency was correlated with the operation.

### Table 6 – Correlation analysis of the surface area of upper white lip (S), height of upper white lip (L1) and intercheilion width (L3)

<table>
<thead>
<tr>
<th>Correlation coefficient</th>
<th>L1</th>
<th>L3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control S</td>
<td>0.385</td>
<td>0.196</td>
</tr>
<tr>
<td>UCLAP S</td>
<td>0.738**</td>
<td>0.192</td>
</tr>
</tbody>
</table>

**$p<0.001$, significant difference.**

From a series of animal experiments and clinical observations, researchers concluded that lip repair causes a short and tight lip, and consequently there was pressure on the maxilla after lip repair (Bardach and Eisbach, 1977; Bardach et al., 1982; Bardach and Mooney, 1984; Bardach, 1989; Mooney et al., 1991). Lip repair is an important factor affecting facial growth, but it is not certain whether the pressure could affect growth of the maxilla. Bishara et al. (1985) deemed that the tissue continuity is an important factor influencing maxillary growth. It is obvious that a maxilla with a continuous alveolar ridge and hard palate has advantages in withstanding lip pressure, and anteroposterior growth of the maxilla may not become apparent. This is in contrast to increased lip pressure forced on separate maxillary sections. The forward growth tends to be restrained or the maxilla may even be pushed back. The severity of the maxillary defect must be taken into account when analysing the effects of lip repair on maxillary growth. A retrospective study indicated that patients who had more palatal tissue at cheiloplasty showed better maxillofacial growth (Honda et al. 2002).

### Probable mechanism of how the lip repair restrains growth of the maxilla

Yoshida et al. (1992) thought that maxillary retrusion after lip repair is not caused by operations, but by intrinsic deficiency instead. However, Bardach considered the malformation to be a result of operations. Bing Shi et al. (1998) found that a deficiency of the maxilla in animals causes maxillary malformations; thus repair of a cleft could reduce the severity of this malformation. Coupe and Subtelny (1960) found in cephalograms that patients with CLAP or CP demonstrate apparent tissue deficiency, but this deficiency could not be found in patients with cleft lip and cleft alveolus only. It can be concluded that the severity of the malformation is determined by the maxillary anatomy. Lip repair has a smaller effect on it with no apparent tissue deficiency and replacement, as is the case in cleft lip and alveolus. And there is a greater effect on maxillae with an apparent tissue deficiency, as has been proven by many researchers. In this study, we did not find an apparently greater restraint of the maxilla after palatal repair, but the ratio of upper anterior facial height/full facial height was reduced and the ratio of lower anterior facial height/full facial height was increased in the lip and palate repaired group. In the lip-only repaired group, the ratio of upper anterior facial height/full facial height was greater with the ratio of lower anterior facial height/ full facial height being smaller. The differences between these two groups were statistically significant. These differences maybe the result of palate repair. In other words, palate repair may restrain vertical growth of the maxilla, counteracting the compensative vertical growth of maxilla, caused
by the increased lip pressure. This may result in a more disharmonious ratio of upper/lower facial height to full facial height in the lip and palate repaired group.

**Effect of lip repair on the morphology of soft tissues in patients with complete unilateral clefts of lip, alveolus and palate**

This study demonstrated that the surface area, the height of the upper lip, and the intercheilion width were significantly reduced in patients with UCLAP who had a lip repair only. As Bing Shi and Dian-zhi Deng (1992) had found that Millard’s technique of lip repair would not lead to abnormal growth, it was concluded that the reduction of upper lip surface area, upper lip height and intercheilion width were the results of a congenital deficiency in growth and development. The posterior position of the upper lip without a good bony support beneath then caused the decrease of the intercheilions width. There was a positive correlation between S and L1 and no correlation between S and L3 in cleft patients (Table 5). This implied that the reduction of upper lip height caused the reduction of upper lip surface area.

Susami et al. (1993) reported that deficiency in the upper lip of Japanese with UCLAP was caused by a reduction of the upper red lip, and there was no difference between patients with UCLAP and control persons. This was probably due to the fact that patients with cleft lip only were also involved in the study group to increase the number of cases. Moreover, the gender had not been taken into account. The present study demonstrated there were differences in upper lip surface area, height and intercheilion width between genders. So the gender should also be taken into account.

In profile photo evaluation, it was found that the protrusion of the lower lip was often similar across all three groups. However, protrusion of the upper lip was less in cleft patients, which is consistent with the “collapse” of maxillary bone. Therefore it was concluded that the degree of projection alteration was affected by the condition of hard tissue support, not by the soft tissue itself. The relationship of lips just represents the relationship of the underlying bones.

**CONCLUSION**

The severity of anteroposterior growth deficiency of the maxilla was identical in CLAP patients in whom only the lip and in those in whom lip and palate had been repaired. Lip repair apparently restrains maxillary growth. Upper lip surface area, upper lip height and intercheilion width were reduced significantly in patients with UCLAP who had had lip repair only. But the reduction of upper lip height was not caused by the operation but by maxillary growth deficiency instead. And the reduction of upper lip surface area was the result of a smaller upper lip height, while the reduction of intercheilion width was due to a reduced bony support.

**References**


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