Original article

Effects of Hotz' plate-based two-stage palatoplasty in unilateral cleft lip and palate

— A comparative study of subjects treated with one-stage palatoplasty and normal subjects —

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Abstract : PURPOSE ; The purpose of this study was to investigate effects of two-stage palatoplasty combined with Hotz' plate on craniofacial development of mixed dentition patients with complete unilateral cleft lip and palate (UCLP). MATERIALS AND METHODS : The subjects selected for this study were 42 Japanese boys, 9 to 11 years old, from following three different groups : Group A (two-stage group) consisting of 15 UCLP subjects whose cleft palates were closed with two-stage palatoplasty combined with Hotz' plate (soft palatal closure at 18 months and hard palatal closure at 6 years) ; Group B (one-stage group) consisting of 14 subjects whose cleft palates were closed with one-stage palatoplasty within 2 years of age ; Group C (control group) consisting of 13 subjects who had non-cleft Class I occlusion. Lateral headfilms of each group (mean age=9.8, 10.0, 10.3 years for group A, B, C respectively) were examined. Cephalometric measurements including 14 angles, 7 distances, and 2 ratios were obtained and the findings from three groups were compared with each other by Fisher's PLSD ($p<0.05$). RESULTS : Measurements in which both Group A (two-stage group) and Group C (control group) showed significantly larger values than Group B (one-stage group) and there was no significant difference between Group A and C were SNA, ANB, and maxillary length. Measurements in which Group C showed significantly larger values than Group B and there was no significant difference between Group A and C were anterior upper facial height (AUFH) and ratio of AUFH to anterior lower facial height. Measurement in which both cleft groups (Group A and B) showed significantly smaller values than Group C (control group) and there was no significant difference between Group A and B was U1 to S-N in the non-cleft side. CONCLUSION : The findings in this study showed that craniofacial development up to mixed dentition in UCLP subjects with two-stage palatoplasty combined with Hotz's plate was better than that in UCLP subjects with one-stage palatal closure, and relatively similar to that of subjects with normal occlusion, indicating that this procedure for palatal closure could be advantageous for craniofacial development.

Key words : unilateral cleft lip and palate, two-stage palatoplasty, Hotz' plate, cephalometric study
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Introduction

Since 1983, patients seeking to correct clefts of the lip and palate, at our Dental Hospital, have been treated with two-stage palatoplasty, in combination with a Hotz' plate, in order to minimize the adverse effects of the surgery on craniofacial development. Our regimen follows standard guidelines set out by Zurich university[1]. We establish normal stomatognathic function in newborns, within days, by inserting the Hotz' plate[2,3]. This simplifies feeding, while exerting a positive orthopedic influence. At 6 months, the lip is closed, using Cronin's procedure. Then, at 18 months, the soft palate is repaired by means of the modified Widmier technique, described by Perko. From that time, for the next 6 years, the patients use a type of palatal plate that obturates the cleft. At the end of this period, the hard palate is closed by means of a vomer flap (Fig. 1, Table 1).

Our studies[4~6] of maxillary casts have been completed, in clinica. During the course of those investigations, it was found that patients' maxillary development was very satisfactory, and, in fact, not unlike that of normal non-cleft subjects.

Furthermore, Arai *et al.*[7] conducted a semi-longitudinal cephalometic study, involving unilateral cleft lip and palate (UCLP) subjects, treated with our 2-stage strategy, and compared these only with the one-stage palatoplasty group, revealing that the forward maxillary growth component in two-stage subjects was greater, and that, as a consequence, sagittal jaw relationships could be more satisfactory.

Until now, no comparative cephalometric studies of craniofacial growth patterns, in cleft subjects with two-stage palatoplasty, and normal (non-cleft) subjects have been attempted by our team. In fact, they are, in general, rare.

In this instance, we examined differences in craniofacial structure, at mixed dentition, among one normal, and two UCLP groups. The latter groups were treated, using either single-or two-stage palatoplasty.

Materials and methods

This cross-sectional study was based on a comparison of craniofacial features among three groups of Japanese

Fig. 1 Procedures at Niigata University Dental Hospital
A: Hotz' Plate, B: Cheiloplasty (Cronin), C: Soft Palatal Closure (Perko), D: Palatal Plate, E: Hard Palate Closure (Picher), F: Secondary Bone Graft

Table 1 Timing of Procedures at Niigata University Dental Hospital

Birth	Hotz's Plate (Presurgical Orthopedic Plate)	
6 months	↓	Cheiloplasty (Cronin)
18 months	Palatal Plate	Soft Palatal Closure (Perko)
	↓	
6 years	Hard Palate Closure (Picher)	
8 years	Secondary Bone Graft	

boys aged 9 to 11 years. The two-stage group, whose average age was 9.8, consisted of 15 UCLP patients whose palates were closed, using procedures that included the insertion of a Hotz' plate, at Niigata University Dental Hospital. The one-stage group consisted of 14 subjects, whose average age was 9.9 years, and whose cleft palates were closed in single-stage procedures, within 2 years of birth, at our Hospital, and other facilities. The control group consisted of 13 Class I subjects (average age: 10.3 years) who underwent single-tooth repositioning, at our orthodontic clinic. None of the above patients exhibited evidence of syndromes. Table 2 gives details for the first phase of orthodontic treatment for UCLP patients. Of the total, the number of patients who received bone-grafts in the two-stage group totaled 5, while 6 received treatment in one-stagers;-average ages, here, being 9.1 years, and 9.2 years, respectively.

Lateral headfilms of each group were examined. Twenty-three cephalometric measurements were obtained, with Fisher's PLSD being used to compare them. Then, in order to make craniofacial features more visible, average facialgrams of the three groups were constructed, based on the S-N line and the vertical line perpendicular to the S-N through S.

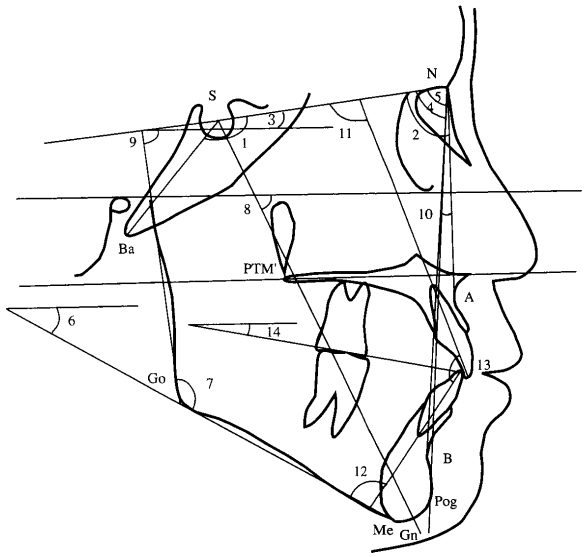

Fig. 2 Angular measurements on the lateral cephalogram.
1. NSBa angle, 2. SNA angle, 3. SN-palatal plane angle, 4. SNB angle, 5. SNP angle, 6. Mp angle, 7. Gonial angle, 8. Y-axis angle, 9. Ramus plane/S-N line angle (GZN), 10. ANB angle, 11. U1 to S-N angle, 12. L1 to Mp angle, 13. Interincisal angle (I. I.), 14. Occlusal plane/FH plane angle (Occ. plane)

Table 2 Orthodontic treatment for UCLP patients

	#of patients in Two-stage group	#of patients in One-stage group
Treatment for anterior cross bite	4	4
Maxillary expansion	1	3
Both treatments for anterior cross bite and maxillary expansion	1	3
No treatment	9	4

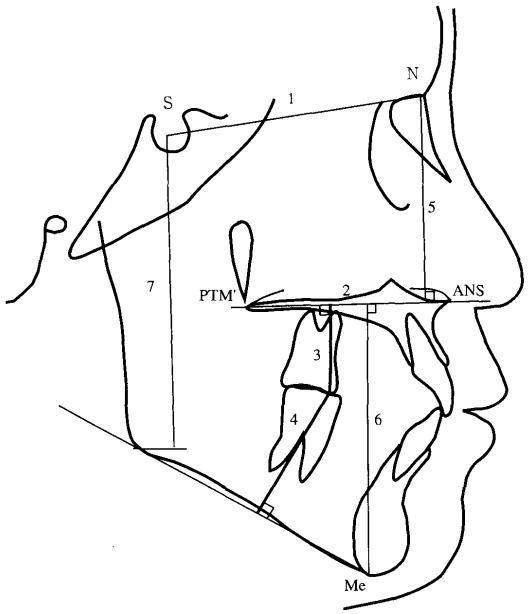

Fig. 3 Linear measurements on the lateral cephalogram
1. S-N distance, 2. Maxillary length (ANS-PTM'), 3. PP-U6 distance, 4. Mp-L6 distance, 5. Anterior upper facial height (AUFH), 6. Anterior lower facial height (ALFH), 7. Posterior total facial height (PTFH)

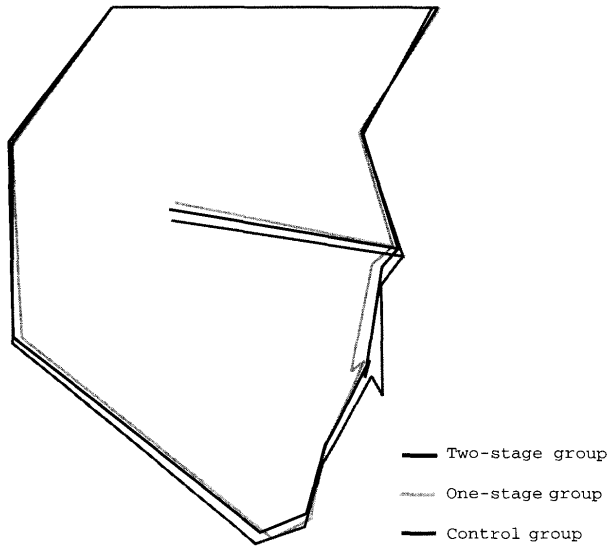

Fig. 4 Comparison of the average facial diagrams
The maxilla of single-stage individuals was located further toward the posterior than those of the other two groups. Additionally, with regard to the vertical dimension of the maxilla, the control exhibited the most growth, overall; the single-stager, the least; the two-stagers' growth was moderate

Results

1. Comparison of measurements taken at the cranial base

No significant disagreements were noted, in measurements taken from any of the subjects.

2. Comparison of maxillary measurements

In SNA, both the two-stage and control groups showed significantly larger values than the one-stage group, with no relevant discrepancies noted in the two-stage and control groups. Regarding maxillary length, both the two-stage and control participants showed much larger values than the one-stagers, while there was no effective dissimilarity between the two-stage and control participants.

3. Comparison of mandibular measurements

In SNB, SNP, Mp angle, Gonial angle, GZN, Y-axis, there was no notable difference among groups.

4. Comparison of anteroposterior jaw relationships

Both the two-stage and control subjects showed larger ANB than the single-stage individuals, while little discordance was evident in the two-stage and control subjects.

5. Comparison of facial heights

The anterior upper facial heights of single-stagers were significantly shorter than those of controls. There was no consequential distinction between the controls and two-stagers. However, as regards anterior lower-and posterior total facial height, meaningful differences could not be discerned, between the three groups.

6. Comparison of dental measurements

In U1 to SN, the control group showed larger values than both cleft groups, while there was very little difference between the two cleft groups, themselves. On the contrary, in L1 to Mp, the one-stage subjects showed smaller values than the two-stage patients, with no significant difference evident, between controls and either cleft group. However, average values for the control-group were larger than those of the one-stage participants. Finally, as regards alveolar molar-heights in both

Table 3 Comparisons of measurements among the two-stage, one stage and control groups

Variables	Two-stage (A)	One Stage (B)	Control (C)
	Mean SD	Mean SD	Mean SD
Measurements of craial base			
S-N (mm)	68.1±2.6	68.6±2.9	67.0±1.9
NSBa (°)	131.8±3.8	130.7±5.7	131.2±3.3
Maxillary measurements			
SNA (°)	78.1±2.9*	75.2±2.8★★★	80.1±3.2
SN-palatal plane (°)	9.7±3.3	11.3±3.7	10.0±2.6
ANS-PTM' (mm)	48.7±3.4*	46.6±1.6★	49.2±2.3
Mandibular measurements			
SNB (°)	75.4±2.8	75.2±2.7	77.0±2.5
SNP (°)	75.3±3.2	75.7±2.7	76.3±2.4
Mp angle (°)	28.6±3.8	29.0±5.3	29.0±3.4
Gonial angle (°)	126.1±5.5	126.9±5.9	125.5±3.7
GZN (Ramus angle) (°)	93.8±12.3	90.1±5.5	92.3±4.2
Y-Axis (°)	62.8±2.1	63.1±2.6	63.7±2.5
Anteroposterior jaw relationships			
ANB (°)	2.6±2.9*	−0.03±3.2★★	3.2±1.4
Dental measurements			
U1 to SN (°)	97.3±5.5	95.6±5.2★★★	105.5±5.7▲▲▲
L1 to Mp (°)	93.9±5.3*	88.9±6.8	91.5±7.6
I. I. (°)	131.7±6.6*	138.3±7.7★★★	125.5±7.5▲
Occ. Plane (°)	12.4±3.2	14.2±3.6	13.6±2.9
PP-U6 (mm)	20.3±1.9	21.3±2.5	20.5±2.1
Mp-L6 (mm)	31.3±4.1	31.6±2.0	32.3±2.0
Facial height			
AUFH (mm)	51.0±3.1	50.7±3.1★	53.2±2.4
ALFH (mm)	62.8±3.6	64.3±4.4	63.0±4.1
PTFH (mm)	71.3±4.1	71.1±3.8	72.6±3.8
AUFH/ALFH	0.82±0.07	0.79±0.05★	0.85±0.07
(AUFH+ALFH)/PTFH	1.6±0.09	1.60±0.09	1.6±0.08

A vs B: *p<0.05; **p<0.01; ***p<0.001 B vs C: ★p<0.05; ★★p<0.01; ★★★p<0.001
C vs A: ▲p<0.05; ▲▲p<0.01; ▲▲▲p<0.001

jaws, the three groups showed no appreciable difference.

7. *Comparison of the average facial diagrams*

As figure 4 shows, the maxilla of single-stage individuals was located further toward the posterior than those of the other two groups. Additionally, with regard to the vertical dimension of the maxilla, the control exhibited the most growth, overall; the single-stager, the least; the two-stagers' growth was moderate.

Discussion

From this interim study, it was determined that the maxilla of the two-stage group showed excellent growth characteristics, anteroposteriorly, in much the same way as the control group, while this growth component was somewhat retarded in single-stage subjects. This could also account for the improvements observed in sagittal jaw relationships, in two-stage group-members, as long as the disparity in the position of the mandible was not too great. Further, according to the facial diagram, the two-stagers were likely to experience more vertical growth, both in the anterior and posterior areas of the maxilla. These findings regarding two-stage palatoplasty correspond well with the experiences of Hotz, *et al.*[3], Friede, *et al.*[8] and Friede, *et al.*[9].

Our two-stage subjects demonstrated superior maxillary development, that we believe very strongly, is directly connected with our efforts to minimize the negative effect of the surgery on maxillary growth. The use of the Hotz plate, from birth to veloclosure (a process requiring 18 months), aids the alignment and growth of both segments[5], minimizing surgical damage. Lip-closure, at 6 months, also reduces surgical damage, because the maxilla grows rapidly, during that time[10]. Our team also requires that patients begin to use their Hotz plate once again, immediately after lip-closure, in order to reduce pressure on the alveolar bone, and then, that they must wear their palatal plate, until closure of the hard palate, at 6 years of age.

Ono, *et al.*[11] reported that the remaining cleft was dramatically reduced, during this time, and that it is easily repaired with a vomer flap, which is used in conjunction with atellocollagen, the artificial dermis applied to the raw surface. Iida, *et al.*[12] confirmed that subjects treated with vomer flaps alone suffered only

minor scarring, with reduced blood-loss, and fistular rates nearly identical to those derived from the combined use of vomer and palatal flaps, and concluded that the use of vomer flaps by themselves resulted in less damage to maxilla, while, at the same time preventing retardation of its growth.

Ono, *et al.*[13] reported that the Hotz plate was extremely effective, in normalizing the position of the tongue, which would otherwise move about, within the cleft lip and palate, as well as improving the overall balance in pressure, both inside and outside the oral cavity. Further, he added that the Hotz plate also improved infants' ability to suckle, which, in turn, is believed to increase oral blood flow and have a favorable effect on maxillary growth. Ono *et al.*[11] also reported that the palatal plate seemed to work in a manner similar to the Hotz plate.

Finally, with regard to dental measurement, acute lingual inclination of the upper central incisor (non-cleft side) was noted, in both of the cleft groups. This was a distinctive characteristic, in patients with UCLP, no matter what type of treatment was executed. This, presumably due to the increase in the tension applied to the lip by its closure, as previous studies had noted[14,15]. In addition, the lower incisors of the single-stage patients were much further retroclined than those of two-stage subjects. It is well-known that, as Class III malocclusion worsens, the lingual inclination of the lower incisors increases. In this study, the single-stage group was particularly marked by the Class III relationship of their jaws, as opposed to two-stagers, such that the more lingually inclined lower incisors were assumed to be recognized in the one stage group.

Conclusions

Comparative cephalometric analyses of subjects treated with two-stage palatoplasty, in combination with Hotz' plate, versus those treated with early one-stage palatoplasty, vs. normal controls, revealed that the growth of the maxilla in the two-stage group was superior to that of the one-stage group, and almost identical to that of normal controls. As a result, sagittal jaw relationships could be as satisfactory in two-stagers, as in controls, while those of the one-stage group were deemed unsatisfactory. These findings indicate that the palate closure technique we employ is far more conducive to craniofacial development up to mixed dentition.

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