Tokai J Exp Clin Med., Vol. 29, No. 3, pp. 111-122, 2004

Influences of different palatoplasties on palatal growth and speech development: Comparison between Osada's two-stage palatoplasty and one-stage mucosal flap procedure

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(Received July 12, 2004; Accepted August 2, 2004)

Palatal growth and articulation in two different palatal closure techniques, Osada's two-stage procedure and the conventional one-stage procedure, were evaluated in 12 patients. Osada's procedure (hard palate closure using a vomer flap with complete closure of the raw surface by a full thickness skin graft) is a two-stage operation that consists of early soft palate closure at the time of lip closure (3 to 6 months of age).
The palatal sizes and the depth of the palatal arch were significantly greater in the two-stage group than in the one-stage group at 1 year of age and, 3 to 5 years of age. There were no differences between the two groups at the velopharyngeal closure evaluation after hard palate closure and at final speech evaluation. Osada's two-stage palatoplasty has many advantages and we believe that this is one of the most recommendable procedures at present.

Key words : cleft palate, two-stage palatoplasty, growth, speech

INTRODUCTION

For treatment of cleft palate patients, Wardill's [1] conventional one-stage palatoplasty using the mucoperiosteal push-back procedure has been successful in terms of normal speech development, and it is still widely used.

However, extensive surgical intervention in cleft palate patients who are only 1 to 2-years-old is considered to interfere somewhat with palatal or even maxillary growth, resulting in jaw deformity accompanied by malocclusion.

To address this problem, in 1974, Osada introduced a new procedure involving two-stage palatoplasty [2, 3]. Osada's procedure is a two-stage operation that consists of early soft palate closure at the time of lip closure (3 to 6 months of age). This procedure involves hard palate closure using a vomer flap with complete closure of the raw surface by a full-thickness skin graft. This allows hard palate closure with minimal surgical intervention, preserving the palatal mucosa over the maxillary tuberosity and adjacent to the alveolar process. We previously reported [4] that less interference with palatal or maxillary growth was observed with Osada's procedure than in the mucoperiosteal flap push-back procedure (Wardill [1]).

The objective of this study was to investigate differences in the palatal growth and articulation between patients treated with Osada's two-stage procedure and patients treated with the mucosal flap one-stage procedure.

MATERIAL AND METHODS

1) Patients

Before starting the treatment, at Tokai University Hospital, parents of cleft palate patients were given the precise information about two types of cleft palate operation, one stage and two stage procedure, and about advantages and disadvantages of each operative procedure. After they chose the operation which their child takes, the clefts were closed by the procedures described below, by the same surgeon with the same technique. From a patient population treated at Tokai University Hospital from 1973 to 1985,

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patients with similar types of complete unilateral cleft lip, alveolus, and palate but without Simonart's band were selected retrospectively. Patients from "one-stage group" were six, and also six patients of "two-stage group" were randomly selected.

Preoperative orthodontic treatment was not applied. Follow-up duration was between 4 years and 5 years 8 months (average 4 years 6 months).

2) Operative procedures

(1) Two-stage Group (Osada's procedure)

A detailed description of the surgical procedures used in Osada's two-stage palatoplasty is contained in a previous report [4].

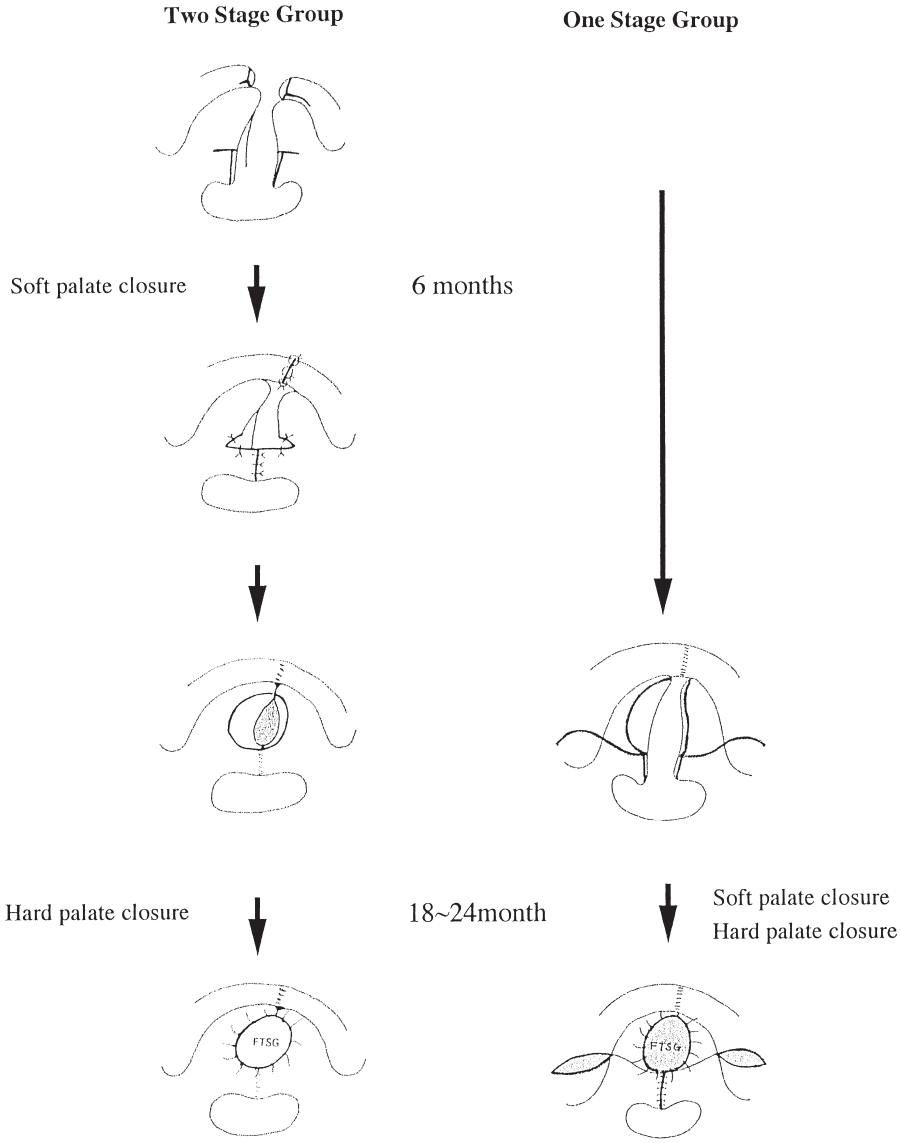


Fig. 1 Operative procedure for each group
In the Two-stage group, the hard palate was closed by insertion of turned over mucoperiosteal flap from the non-cleft side palate after Pichler's vomer flap into the subperiosteal pocket along the cleft margin. The raw surface was covered with full-thickness skin graft from the inguinal region.
In the one-stage group, the soft and hard palateas were closed simultaneously. Note the mucosal flap on the soft palate was designed widely anteroposteriorly to include the maxillary tuberculum.

Operative procedures are illustrated in Fig. 1.

a) Lip closure and early soft palate closure. The cleft lip was closed using a modified Millard procedure [5] with small triangular flap at 3 to 7 months of age. At the time of lip closure, early soft palate closure was performed using the procedure described by Slaughter [6].

The mucous membrane of the cleft margin of the soft palate was cut, and the cleft muscles were explored and dissected from the posterior margin of the palatal bone. Mucous membranes of both the oral and nasal sides were cut transversely and released. The nasal side mucosa was closed first. The palatal muscle sling was then reconstructed by suturing the released muscle bundles together, and finally the oral side mucosa was closed.

b) Hard palate closure. The hard palate was closed at 1 year of age (1 year 5 months to 2 years), before "the period of echolalia" using the following procedures. The hard palate was closed by insertion of turned over mucoperiosteal flap from the non-cleft side palate after Pichler's vomer flap into the subperiosteal pocket along the cleft margin. The raw surface was covered with full-thickness skin graft from the inguinal region, fixed with a tie-over dressing and surgical pack. The surgical pack and sutures were removed under general anesthesia on post operative day 7. In all patients, the grafted skin took well on the turned over flap. A pharyngeal flap operation were added simultaneously in 2 cases (case 10, case 11) in which the velopharyngeal closure

Table 1 Dental casts and patient age
For these 12 cases, dental casts of the upper jaw were taken at 1 year of age (1 year 4 months to 2 years: at the time of palatal closure in the one-stage group, and the time of hard palate closure in the two-stage group), and 4 to 5 years of age (4 years 0 month to 5 years 8 months).

(Age of operation and dental impression taking)

	LC	SPC and HPC	3 to 5y
One-stage group			
case1	4 mo	1 y 4 mo	4 y 0 mo
case2	5 mo	1 y 8 mo	4 y 4 mo
case3	4 mo	1 y 6 mo	5 y 7 mo
case4	7 mo	1 y 6 mo	5 y 2 mo
case5	3 mo	1 y11 mo	5 y 8 mo
case6	5 mo	1 y 6 mo	4 y11 mo
mean	4.7 mo	1 y 6.8mo	4 y11 mo
	LC and SPC	HPC	3 to 5y
Two-stage group			
case7	3 mo	1 y 6 mo	4 y 4 mo
case8	5 mo	2 y 0 mo	4 y 5 mo
case9	4 mo	1 y 5 mo	4 y 3 mo
case10	3 mo	1 y 6 mo	4 y 2 mo
case11	4 mo	1 y 6 mo	3 y 6 mo
case12	7 mo	1 y 7 mo	4 y 6 mo
mean	4.3 mo	1y 7.0 mo	4y 2mo

LC = lip closure
SPC = soft palate closure
HPC = hard palate closure
mo = months
y = year

function during gag reflex after soft palate closure was evaluated as "poor" by posterior rhinoscopy.

(2) One-Stage group

a) Lip closure. The cleft lip was closed using a modified Millard procedure with small triangular flap at 3 to 7 months of age.

b) Palatal closure. In the one-stage group, at 1 year of age (from 1 year 4 months to 1 year 11 months, mean: 1 year 7 months), the soft and hard palateas were closed simultaneously. The mucosal flap on the soft palate was widely designed antero-posteriorly to include the maxillary tuberculum. The mucous membrane of the cleft margin was cut, and the cleft muscles were explored and dissected from the posterior margin of the palatal bone. The mucous membranes of the oral side were cut and released. Palatal muscle sling was then reconstructed by suturing the released muscle bundles together, and the oral side mucosa was closed. The hard palate was closed using the following procedures as in the two stage group, by insertion of a turned over mucoperiosteal flap from the non-cleft side palate after Pichler's vomer flap into subperiosteal pocket along the cleft margin. All the raw surface was covered by a full-thickness skin graft from the inguinal region. All skin grafts took well on the vomer flap.

No pharyngeal flaps were added in the one-stage group. Small oronasal fistulae on the soft and hard palate junction were observed in two cases.

3) Method of dental cast analysis

For these 12 cases, dental impression of the upper jaw were taken at the time of palatal closure in the one-stage group, and the time of hard palate closure in the two-stage group (1 year 4 months to 2 years). At 3 to 5years of age (3 years 6 month to 5 years 8 months) dental impression were taken again in order to evaluate maxillary growth of these patients. (Table 1) (Fig. 2)

The palatal size (palatal width and antero-posterior length) and depth of the palatal arch (cross sectional area) were measured on

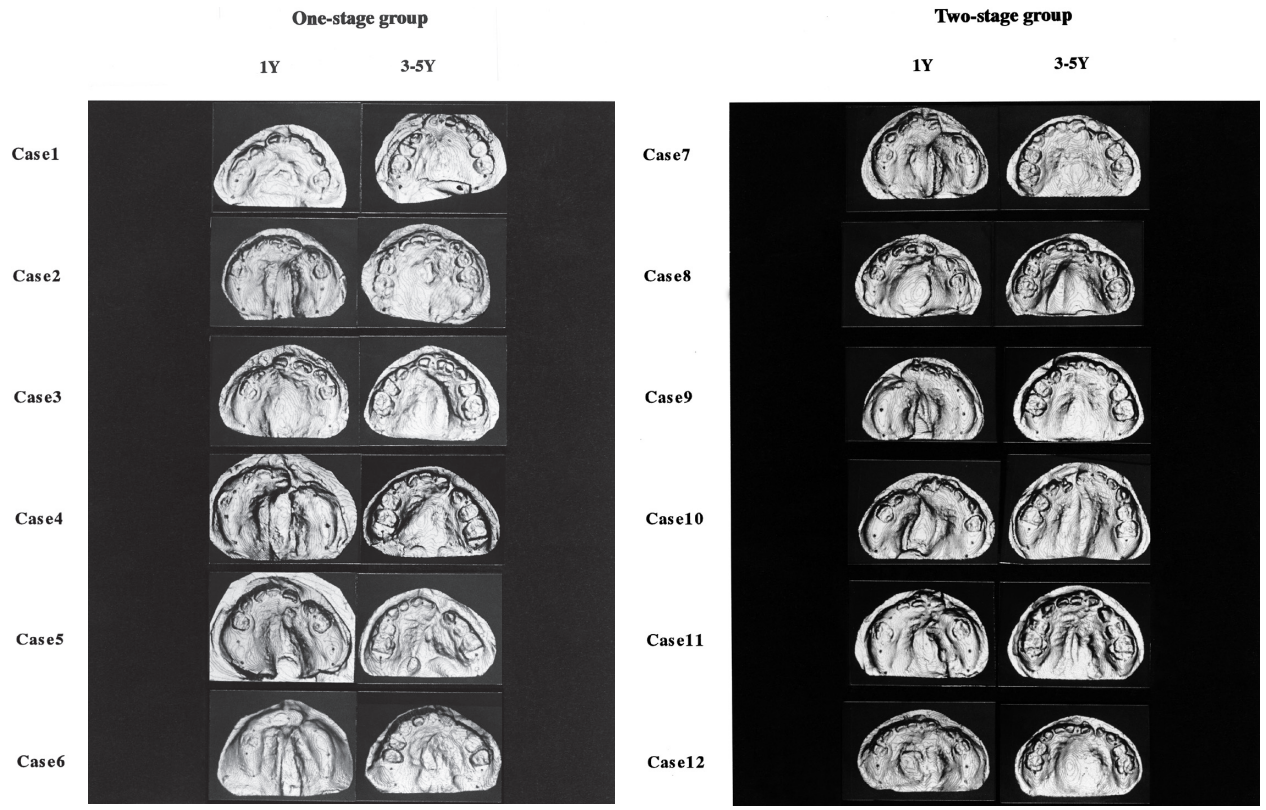


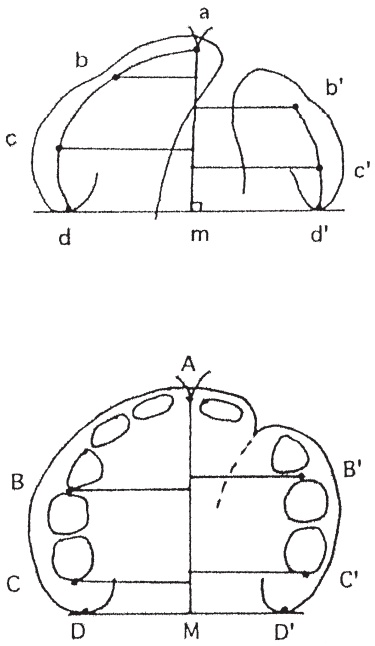
Fig. 2 Dental casts of each group

these casts and analyzed to compare changes between the two groups. The standard plane and the points projected onto the plane used for measurement are illustrated in Fig. 3. The plane made by joining the incisive papilla and the left and right points of maxillary tuberosities was defined as the standard plane.

The configurations of the dental casts of the upper jaw were scanned, keyed in (processed in) via 3D Laser Digitizer (Cubist CD100, Topcon Co.), and analyzed with 3D image analyzing software, 3D-SPHINX (Kashimura Co.).

Measurement precision tolerance was 0.05 mm in the vertical direction. Horizontally, the tolerance was 0.20 mm after decomposing the 100 mm × 100 mm measurement area into a matrix of 512 × 512.

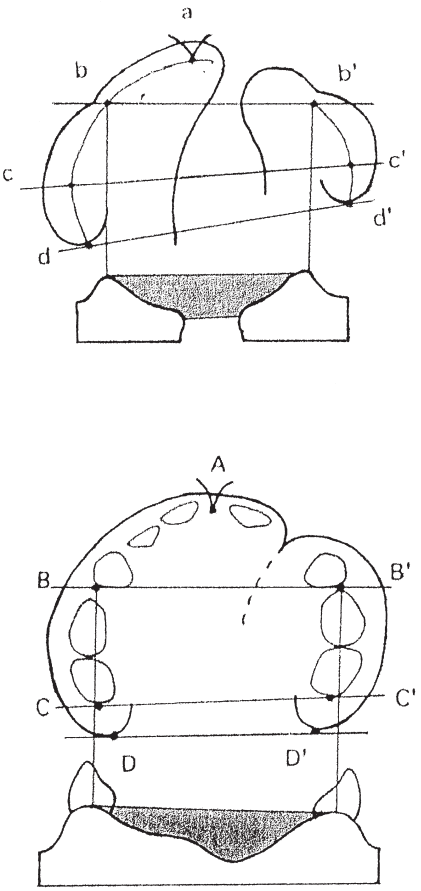
a) points of measurement on dental cast before and after dentition



a , A : incisal papilla between primary central incisor
b,b', B,B' : points of canines, distal points of canines on the alveolar ridge lines
c,c', C,C' : distal points of second primarymolars, mesial points of first molars or points of maximum width of alveolar ridge lines
d,d', D,D' : points of maxillary tuberosities

Palatal A-P length : a-dd' or A-DD'
Palatal Width 1 : b-am+b'-am or B-AM+B'-AM
Palatal Width 2 : c-am+c'-am or C-AM+C'-AM
Palatal Width 3 : d-am+d'-am or D-AM+D'-AM
Palatal Area : The area surrounded by the points of measurement

b) Cross-sectional area of dental cast before and after dentition



Cross sectional area 1 : Area surrounded by b-b' or B-B' and palatal arch.
The same measurements were conducted for cross- sectional areas 2 and 3.

Fig. 3 Points of measurement on dental cast

4) Evaluation of velopharyngeal closure (VPC) and speech

After soft palate closure, patients were examined every 3 to 4 months. Velopharyngeal closure (VPC) during the gag reflex was observed using posterior rhinoscopy. After hard palate closure, VPC function was evaluated by a speech pathologist using standard techniques: on blowing, on enunciating "a", and with a nasal mirror. Resonance and articulation were also evaluated until age 4 or 5 years, and speech therapy was given as needed. The results of the VPC at gag reflex evaluations were divided into following three grades as we previously reported [4]: good, border, poor.

The results of the speech evaluations were divided into three grades [4]: perfect, acceptable, poor.

RESULTS

1) Dental cast analysis

(1) Dental cast analysis at 1 year of age. The palatal size and depth at 1 year of age (the time of palatal closure in the one-stage group, and the time of hard palate closure in the two-stage group) were as follows: (Table 2)

At 1 year of age, the palatal sizes (palatal width 1, 2, 3, palatal A-P length) and the depth of the palatal arch (Cross sectional area 1, 2) were larger in the two-stage group than in the one-stage group. Significant differences were noted in cross sectional area 2 ($p < 0.05$).

(2) Dental cast analysis at 3 to 5 years of age. The palatal size and depth at 3 to 5 years of age were as follows: (Table 2) (Fig. 4)

In 3 to 5 year olds, the palatal size (Palatal width 1, 2, 3) and depth of palatal arch (Cross sectional area 1, 2,) in the two-stage group were significantly greater than in the one-stage group ($p < 0.05$).

(3) Growth ratio between 1 year and 3 to 5 years of age in dental cast analysis. The growth ratio in palatal size and depth between the age of 1 year and the age of 3 to 5 years were as follows: (Table 2) (Fig. 5)

The palatal size (palatal width 1, 2, 3) and depth of the palatal arch (Cross sectional area 1, 2,) revealed a significantly greater growth ratio in two-stage group than in the one-stage group ($p < 0.05$).

2) Evaluation of velopharyingeal closure and speech

Table. 3 shows velopharyngeal closure and speech results for all patients.

In the one-stage group, velopharyngeal closure after hard palate closure resulted in two "borderline" and four "good" cases. The final speech evaluations resulted in four "perfect" and two "acceptable" cases. In the two-stage group, velopharyngeal closure after soft palate closure resulted in three "borderline" and three "poor" cases. The evaluations after hard palate closure were four "good" and two "borderline" cases, a result similar to that in one-stage group. The final speech evaluations resulted in four "perfect" and two "acceptable" cases, and also proofed of the same result with one-stage group. One patient from the two-stage group, evaluated as "acceptable" had an IQ of 80 to 90, and needed intensive speech therapy.

DISCUSSION

Dental cast analysis. In 1974, Osada introduced a new two-stage palatoplasty procedure aimed at obtaining good speech results without interfering with maxillary growth and then published reports in 1980 [2] and 1985 [3]. One of main features of Osada's procedure is hard palate closure using a vomer flap with complete closure of the raw surface by a full-thickness skin graft. This procedure provides hard palate closure with minimal surgical intervention, and preserves the palatal mucosa over the maxillary tuberosity and adjacent to the alveolar process. We previously reported [4] that less interference with palatal or maxillary growth was observed with Osada's procedure than in the muco-periosteal flap push-back procedure (Wardill) [1].

Osada's procedure provides two-stage operation with early soft palate closure at the time of lip closure (at 3 to 6 months of age). Early soft palate closure and reconstruction of the palatal muscle sling is regarded as to promote maxillary growth processes by creating a muscle balance around the defect. Immediately after soft palate closure, Osada follows the velopharyngeal closure during gag reflex by posterior rhinoscopy to evaluate the necessity of a pharyngeal flap operation. This permits the pharyngeal flap operation to be added with hard palate closure at 1 year 6 months of age.

Table 2 Palatal size and depth
* : significant defference was noted ($p < 0.05$)
Growth ratio = $\frac{4 \text{ year} - 1 \text{ year}}{1 \text{ year}}$
CSA = cross sectional area (Fig. 3)
PW = palatal width (Fig. 3)
A-PL = antero-posterior length (Fig. 3)

		CSA1			CSA2			CSA3		
		1 y	3to5y*	Growth ratio*	1 y*	3to5y*	Growth ratio*	1 y	3to5y	Growth ratio
One stage group	mean	104.06	78.65	-0.244	200.71	156.25	-0.222	166.3	121.02	-0.272
	SD	27.4	16.3	0.08	45.19	59.32	0.2	38.83	53.18	0.32
		CSA1			CSA2			CSA3		
		1 y	3to5y*	Growth ratio*	1 y*	3to5y*	Growth ratio*	1 y	3to5y	Growth ratio
Two stage group	mean	109.83	111.63	0.016	262.62	256.18	-0.025	161.07	162.8	0.011
	SD	30.24	39.41	0.17	37.35	59.6	0.16	24.23	50.29	0.24

		PW1			PW2			PW3			A-PL		
		1 y	3to5y*	Growth ratio*	1 y	3to5y*	Growth ratio*	1 y	3to5y*	Growth ratio*	1 y	3to5y	Growth ratio
One stage group	mean	29.94	29.15	-0.026	38.11	39.27	0.03	35.48	37.19	0.048	28.48	31.02	0.089
	SD	2.65	2.39	0.05	2.3	1.61	0.05	2.93	2.32	0.05	2.24	1.06	0.07
		PW1			PW2			PW3			A-PL		
		1 y	3to5y*	Growth ratio*	1 y	3to5y*	Growth ratio*	1 y	3to5y*	Growth ratio*	1 y	3to5y	Growth ratio
Two stage group	mean	31.15	32.57	0.046	38.77	42.82	0.105	35.94	39.67	0.104	28.65	31.74	0.108
	SD	2.66	2.08	0.06	2.37	1.7	0.08	2.36	1.69	0.03	1.81	2.97	0.08

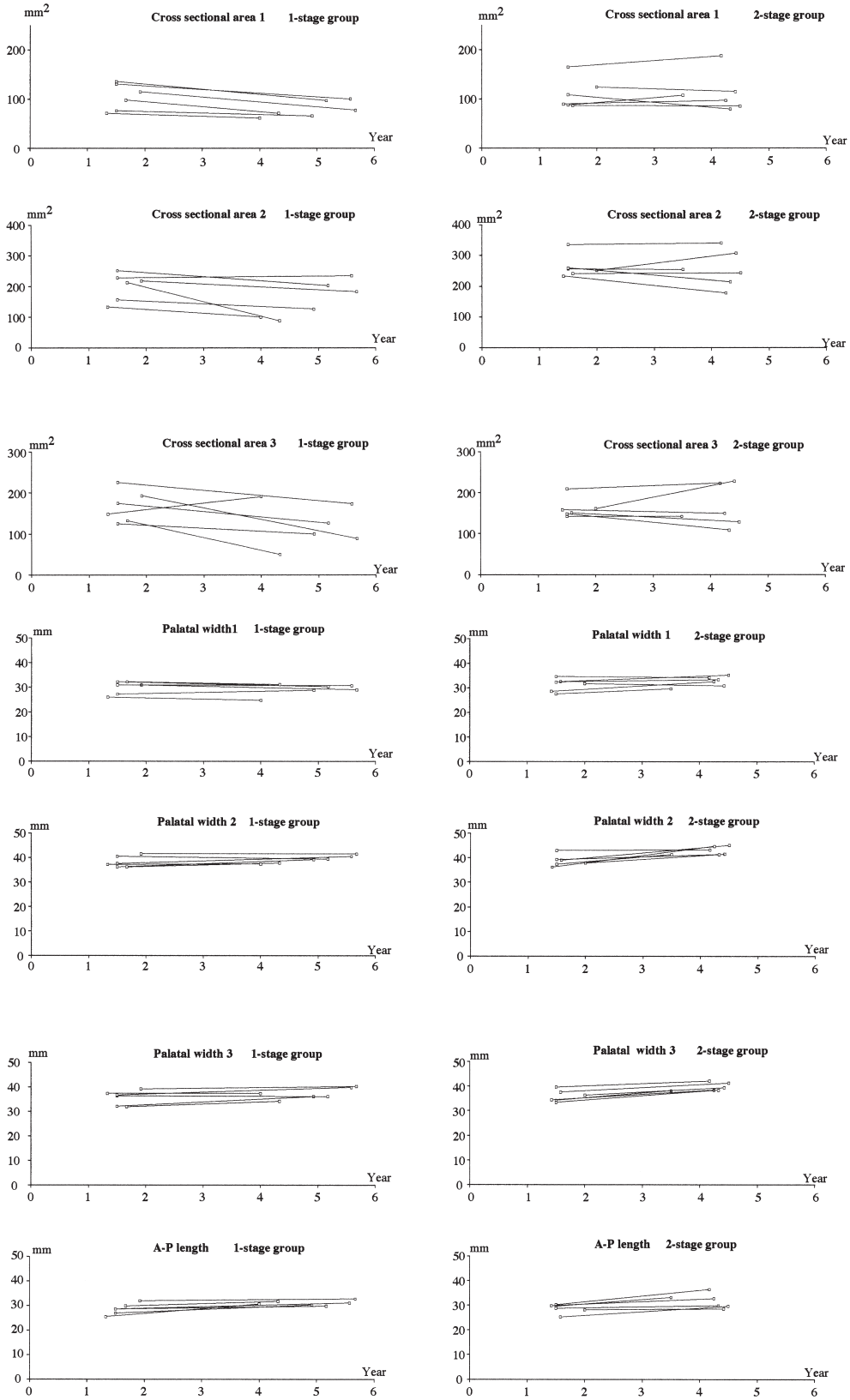


Fig. 4 The graphic charts of palatal size and depth of individual cases in each group

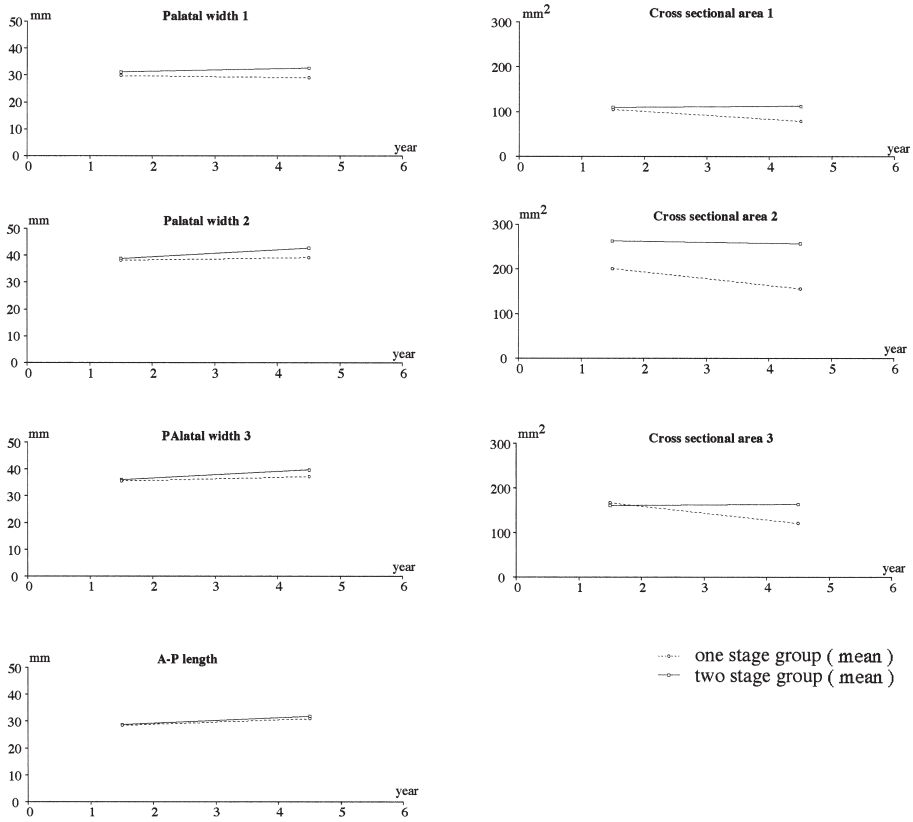


Fig. 5 The graphic charts of the change in palatal size and depth of each group

Table 3 Velopharyngeal closure and speech results
* One patient from the two-stage group, evaluated as "acceptable" had an IQ of 80 to 90, and needed intensive speech therapy.
** A pharyngeal flap operation were added in 2 cases (case 10, case 11) in which the velopharyngeal closure function during gag reflex after soft palate closure was evaluated as "poor" by posterior rhinoscopy.
*** Small oronasal fistulaes were observed on the soft and hard palate junction and the site of alveolar cleft.

	VPC		Fistel***	PF**	Speech Result (age of final evaluation)	ST
One-stage group	after SPC	after HPC				
case1		B	-	-	A 22 y (22 y)	+
case2		G	+	-	P 4 y (22 y)	-
case3		B	+	-	P 6 y (15 y)	-
case4		G	-	-	P 6 y (14 y)	-
case5		G	-	-	A 2 y 9mo (2y9mo)	-
case6		G	-	-	P 4 y (9 y)	-
Two-stage group						
case7	P	G	-	-	P 4 y (12 y)	-
case8	B	B	-	-	A 15 y (15 y)	-
case9	B	G	-	-	P 2 y 6mo (2y 6mo)	-
case10	P	G	+	+	P 3 y (18 y)	-
case11	P	G	-	+	P 4 y (18 y)	-
case12	B	B	+	-	A *11 y (11 y)	+

VPC = velopharyngeal closure : G = good, B = border, P = poor
PF =pharyngeal flap
Speech result (the age of final evaluation) : P = perfect, A = acceptable
ST =Speech therapy

To close a cleft without interfering with palatal or maxillary growth, several authors reported delaying surgery, especially the surgery for hard palate closure. Graber [7] stated that early traumatic palatoplasty can interfere with maxillary growth laterally, anteroposteriorly, and vertically, and recommended that palatoplasty should be postponed until the end of the fourth year, when five-sixths of the total maxillary width has been attained.

Fara [8] stated that the cleft palate should be closed as soon as the child is 3 years old and that this is the optimum age for palatoplasty, compromising two opposite considerations, developmental and phoniatric.

Blocksma *et al.* [9] closed the soft palate at 18 to 24 months, and the hard palate by a simple turnover of the vomer flap after age of 5 years.

Schweckendiek [10] reported that early soft palate closure at 7 to 8 months of age followed by secondary hard palate closure at 12 to 24 months of age resulted in good maxillary growth. Perko [11, 12] further developed his technique to a two-stage palatoplasty, in which soft palate closure is performed at 18 months of age using modification of Widmaier's [13] technique and hard palate closure is delayed until 5 to 8 years of age using a single mucoperiosteal flap taken from the non-affected side. Ohashi [14] reported good maxillary growth using Hots [15] plate with Perko's two-stage palatoplasty. They all concluded that maxillary growth showed satisfactory results, though precise evaluation of velopharyngeal closure and speech results were not performed.

On the other hand, Kaplan [16] suggested that early palate surgery does not interfere with palatal growth, maintaining that it is the surgery itself, not the age at which surgery is performed, that leads to deformity. Ross [17, 18] reported that variations in the timing of palatoplasty within the first decade, except for very early hard palate surgery, do not influence facial growth in the anteroposterior or vertical dimensions, and, therefore, speech and psychosocial factors should determine the most appropriate time to act.

Other investigators suggested that maxillary growth can be promoted by early soft palate closure. Slaughter [6] performed the soft palate closure at 11 months to 4 years of age and suggested that the primary suture of the velum should promote growth processes by creating a muscle balance around the defect (theory of the functional matrix). Malek and Psaume [19] closed the soft palate at 3 months without raising mucoperiosteal flaps and closed the hard palate at 6 months simultaneous to lip closure, leaving the mucoperiosteum intact. Ross [17, 18] compared these patients with his own patients by cephalometric analyses and concluded that Malek's procedure had produced excellent growth at 10 years of age.

In our study, the two-stage group showed significantly better palatal growth than the one-stage group. At 1 year of age, two-stage group already showed significantly wider palatal size. This finding is in agreement with Slaughter and Malek who reported growth promotion of the maxilla by early soft palate closure.

At 3 to 5 years of age evaluation, apparent differences between two groups were observed. We consider the better palatal growth in two-stage group resulted from the following: Growth promotion by early soft palate closure, and in the two stage procedure, because of the narrow palatal cleft at 3 to 6 months of age, soft palate closure could be performed without surgical intervention on the maxillary tuberculum.

At the time of palatal closure in the one-stage operation, we observed wider palatal clefts that could not be closed without a wide back cut of the soft palate mucosal flap involving the maxillary tuberculum. The difference in palatal growth was rather apparent from the measurements of the dental casts taken from these patients. Even in cases with severe cross bite due to maxillary hypoplasia, it is possible to restore a well balanced profile with good occlusion by orthodontic procedure and orthognathic surgery.

However, considering the economic and time burdens for these patients and the quality of life in their youths before surgical orthodontics, we should, as a matter of course, choose a procedure that allows for maximal maxillary growth, now that we are able to obtain good, stable speech results.

Velopharyngeal closure, articulation. To compromise between the developmental and phoniatric requirements, Fara and Bronsilova [8] delayed the age of palatoplasty until 3 years, and Graber [7] until the

end of the 4th year. However, in both the Fara and Bronsilova and Graber's studies, the patient's speech was poor without intraoral prosthese, such as an obturators and/or speech aids, and intensive speech therapy before and after palatoplasty. Copeland [20] advocated very early palatal repair, before 6 months, and he obtained "acceptable" speech in 87 of 100 subjects. It should be noted that his criterion for "acceptable" speech includes both the "perfect" and "acceptable" classifications that we used. His speech evaluation standard is less stringent than ours, though we agree that earlier palatoplasty results in better articulation and is preferable when maxillary growth is not considered important. Schweckendiek and Doz [10] closed the soft palate at 7 to 8 months of age and the hard palate at 12 to 14 years of age. They concluded that the speech results were comparable to those obtained with the conventional mucoperiosteal push-back procedure, although a precise evaluation of VPC and speech results was not described.

Osada [2, 3] reported that the hard palate should be closed before the period of echolalia (between 18 and 23 months of age) to obtain better articulation.

Osada examined the velopharyngeal closure function during gag reflex, at every 3 to 4 months immediately after soft palate closure, using posterior rhinoscopy in order to evaluate the necessity of a pharyngeal flap operation.

This permits the pharyngeal flap operation to be added with hard palate closure at 1 year 6 months of age. Although VPCs during the gag reflex and articulation are controlled by different sets of musculature, and the exact movements of VPC as a whole differ, in our experience we have found a high coincidence between the results of VPC noted during gag reflex and those obtained by other examinations. This can be accomplished quickly without difficulty and is easy to learn. We consider the evaluation of VPC during gag reflex one of the most reliable methods for determining whether a pharyngeal flap should be added at the time of hard palate closure.

Well developed maxilla, well arranged teeth, a large dental arch and a deeply constructed palate are important to obtain good speech results. Better final articulation results were expected in the patients from the two-stage group, because they had significantly better maxillary growth and had started adaptation of the reconstructed oropharyngeal muscle for velopharyngeal closure. However there were no differences between the two groups in this study in terms of VPC function and the final articulation results after hard palate closure.

CONCLUSION

We investigated difference in the palatal growth and articulation between patients treated with Osada's two-stage operation and the one-stage operation. The palatal sizes and the depth of the palatal arch were significantly greater in the two-stage group than in the one-stage group at 1 year of age and, 3 to 5 years of age. There were no differences between the two groups at the velopharyngeal closure evaluation after hard palate closure and at final speech evaluation.

Although even in cases with severe cross bite due to maxillary hypoplasia, it is possible to restore a well balanced profile with good occlusion by orthodontic procedure and orthognatic surgery. However, considering the economical and time burden which patients pay for these procedures and the quality of life in their youths before surgical orthodontics, we should choose a procedure which allows for sufficient maxillary growth and stable speech results. Of these new procedures Osada's two-stage palatoplasty has many advantages as described above. We believe that this is one of the most recommendable procedures at present.

ACKNOWLEDGMENTS

The authors are grateful to Michiko INAEDA, Department of Otolaryngology, Tokai University School of Medicine for assistance in speech evaluation.

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