Secondary Bone Grafting of Alveolar Clefts with the Autogenous Particulate Cancellous Bone and Marrow

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Summary

In cases of cleft lip and palate, closure of the residual fistula and subsequent autogenous cancellous bone grafting are important for esthetic reasons and for preserving nasopharyngeal function. They are known to have many advantages, e.g., favorable effects on physiological tooth eruption and preservation of tooth arrangement and jawbones. We have performed fistula closure and autogenous particulate cancellous bone and marrow grafting (using iliac bone as the donor site) in 10 cases of unilateral cleft lip and palate and 4 cases of bilateral cleft lip and palate.

Of these patients, 13 could be followed for more than 6 months after treatment, and all 13 showed bone bridge formation. The amount of postoperative ossification was also satisfactory in these cases.

Introduction

In cases of cleft lip and palate, surgical closure of the fistula remaining in the alveolus and/or palate after palatoplasty is one of the last steps of treatment. This surgery is important for aesthetical and functionally restoring the lip, alveolus and palate. In recent years, closure of the fistula has often been accompanied by autogenous bone grafting to the alveolar and palatal clefts[1-18]. These procedures have been shown to have the following advantages: (1) improvement in speech, (2) reduction in the flow of fluids from the oral cavity to the nose, (3) guidance of unerupted teeth into the bone graft, (4) prevention of backward movement of the teeth after orthodontic treatment, (5) correction of deformation of the base of the ala, and (6) completion of the alveolus and dental arch through alveolar ridge formation. However, in patients with cleft lip and palate, the fistula is often surrounded by marked scars caused by repeated surgery. Selection of optimal recipient sites and collection of adequate amounts of fresh bone for grafting are essential for successfully performing autogenous bone grafting. The bone bridge formation rate following this surgery is reported to be high[19-23]. It is however important to quantitatively and qualitatively assess the postoperatively formed bone. We recently assessed bone formation after closure of the residual fistula of the alveolus and palate and simultaneous autogenous particulate cancellous bone and marrow graft harvesting iliac bone in cases of cleft lip and palate.

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Subjects and Methods

1. *Subjects*

The subjects were 14 patients with cleft lip and palate who visited our department with a chief complaint of residual fistula. There were 10 males and 4 females, ranging in age from 9 to 26 years. Of the 14 patients, 8 had complete unilateral cleft lip and palate, 4 had bilateral cleft lip and palate, and 2 had cleft lip. One patient (Case 10) had undergone iliac bone grafting to treat cleft of the jaw.

2. *Operative technique*

The operative technique used for individual cases differed depending on the size of the residual fistula, the shape of the margin of the fistula, the location of the fistula, and the features of the scarred area around the fistula. As a rule, the side of the fistula closer to the nasal

cavity was closed completely, and the bone graft was covered adequately with oral mucosa. It has been thought that the success or failure of this surgery depends on whether or not adequate amounts of bone can be grafted and whether or not the graft can be covered with mucosa under minimal tension. In 2 cases where bilateral cleft lip and palate was accompanied by extensive bone defects, pedunculated labiobuccal flap or tongue flap was used. In the other cases, incision lines in the area from the alveolar ridge to the palate were determined so that the immobile mucosa of the alveolar and palatal areas could be utilized as much as possible. For patients between 9 and 15 years of ages, particulate cancellous bone and marrow were collected, taking care to avoid injury of the epiphyseal cartilage. While the bone was being collected, the recipient site was washed and disinfected, and hemostasis was achieved. Donated bone pieces were grafted in layers with marrow suspension, while fibrin glue was applied from the piriform aperture margin to the palate and the alveolar ridge. The alveolar ridge was filled with particularly large amounts of bone pieces. A palatine mucosal flap was freed as widely as possible. Artificial oral mucosa Terudermis® was used to cover the exposed palatine bone. Prior to surgery, the upper dental arch of each patient was dilated laterally.

3. *Observation and evaluation*

The extent of the bone defect often differs from that estimated from the surface of soft tissue before surgery. During surgery, the width of the bone defect was measured at three points: the piriform aperture, the root apex, and the alveolar ridge.

After surgery, patients were observed periodically. Postoperative bone formation was assessed by comparing radiograms (dental, occlusal and status X-rays and 3-dimensional CT), with the study model prepared before and after surgery. The alveolus of the tooth (often the central incisor) adjacent to the grafted area was used as a reference. It was four equal segments, which were numbered 1 (the lowest segment), 2, 3 and 4 (the highest segment). At the center of the grafted area, we determined which segment of the reference alveolus corresponded to the tip of the bone formed in the grafted area and regarded this segment as a bone formation rate. In Case 8, where the bone defect was great, postoperative bone formation was evaluated using three-dimensional CT.

Table 1 The cases of bone grafting

No	Name	Sex	Age (y)	Cleft Type
1.	S.H.	f	15	CCLP (Lft)
2.	H.N.	m	11	CCLP (Lft)
3.	M.K.	m	26	CBCLP
4.	N.Y.	m	14	CBCLP
5.	K.N.	m	13	CCLP (Lft)
6.	Y.R.	m	15	CCLP (Lft)
7.	K.M.	f	9	CCL (Lft)
8.	K.K.	m	19	CBCLP
9.	I.T.	m	18	CBCLP
10.	Y.M.	f	21	CCLP (Lft)
11.	A.Y.	m	12	CCLP (Rt)
12.	M.Y.	f	15	CCL (Rt)
13.	T.K.	m	18	CCLP (Rt)
14.	I.Y.	m	9	CCLP (Rt)

CCLP: complete cleft lip and palate
CBCLP: complete bilateral cleft lip and palate
CCL: complete cleft lip

Results

1. *Age distribution*

Boyne and Sands et al[1,2]. divided bone grafting into two types depending on the age at the time of grafting: secondary bone grafting (at ages 6–15) and late secondary bone grafting (in adulthood). Of the 14 patients examined, 9 were between 9 and 15 years of age, and 5 were adults.

2. *Bone defects of the alveolus and piriform aperture*

In the 10 patients with unilateral cleft lip or unilateral cleft lip and palate, the size of the bone defect ranged from 5 to 20 mm (mean$\pm$SD=14.3$\pm$4.22 mm) in the piriform aperture, from 4 to 13 mm (8.7$\pm$3.03 mm) in the root apex, and from 3 to 10 mm (6.1$\pm$1.92 mm) in the alveolus. In the 4 patients with bilateral cleft lip and palate, the bone defect size ranged from 5 to 15 mm (10$\pm$1.35 mm) in the piriform aperture, from 4.0 to 10.0 mm (7.25$\pm$2.48 mm) in the root apex and from 2 to 7.5 mm (4.88$\pm$2.13 mm) in the alveolus. Thus, in both the unilateral cleft group and the bilateral cleft group, the bone defect of the piriform aperture were greater than that of the alveolus.

Table 2 The condition of bone defect

No	Name	Age (y)	Cleft Type		Bone Defect (mm) Piriform	Root Tip	Alveolus
1.	S.H.	15	CCLP (Lft)		8	4	6
2.	H.N.	11	CCLP (Lft)		19	14	10
3.	M.K.	26	CBCLP	(rt)	5	4	2
				(lft)	7	5	4
4.	N.Y.	14	CBCLP	(rt)	13	10	7
				(lft)	11	8	5
5.	K.N.	13	CCLP (Lft)		11	7	5
6.	Y.R.	15	CCLP (Lft)		12	10	8
7.	K.M.	9	CCL (Lft)		12	9	5
8.	K.K.	19	CBCLP	(rt)	12	10	15
				(lft)	15	7	
9.	I.T.	18	CBCLP	(rt)	5	4	2
				(lft)	12	10	4
10.	Y.M.	21	CCLP (Lft)		18	13	8
11.	A.Y.	12	CCLP (Rt)		11	8	6
12.	M.Y.	15	CCL (Rt)		20	10	3
13.	T.K.	18	CCLP (Rt)		12	7	5
14.	I.Y.	9	CCLP (Rt)		20	5	5

Table 3 The bone volume and the mucousmembrane flaps

No	Name	Age(y)	Cleft Type	PCBM(gr)	Flap
1.	S.H.	15	CCLP (Lft)	5.2	LSF
2.	H.N.	11	CCLP (Lft)	3.3	LSF
3.	M.K.	26	CBCLP	7.5	LBRF
4.	N.Y.	14	CBCLP	4.2	ASTF
5.	K.N.	13	CCLP (Lft)	3.5	LSF
6.	Y.R.	15	CCLP (Lft)	4.5	LSF
7.	K.M.	9	CCL (Lft)	2.5	LSF
8.	K.K.	19	CBCLP	8.5	LSF
9.	I.T.	18	CBCLP	5.3	LBRF
10.	Y.M.	21	CCLP (Lft)	4.2	LSF
11.	A.Y.	12	CCLP (Rt)	4.8	LSF
12.	M.Y.	15	CCL (Rt)	2.5	LSF
13.	T.K.	18	CCLP (Rt)	2.3	LSF
14.	I.Y.	9	CCLP (Rt)	1.5	LSF

LSF: Labiosulcus flap
LBRF: labiobuccal Rotation Flap
ASTF: Anterior Stealed Tongue Flap

3. *Amount of bone grafts and the type of mucosal flap used*

The weight of bone grafted ranged from 1.5 to 8.5 g (mean: 4.3 g). The mean graft weight for patients between 9 and 15 years of age was 4.3 g. Of the two 9-year-old patients, one received a 1.5 g graft and the other a 2.5 g graft. The type of the mucosal flap used for closure was the labiosulcus flap in 11 case, the labiobuccal rotation flap in 2 cases and the anterior pedicled tongue flap in 1 case.

Table 4 The evaluation of new bone formation and complication

No	Name	Age(y)	Cleft Type	Bone Formation rate	Infection	Passage(y.m)
1.	S.H.	15	CCLP (Lft)	>3/4	—	3
2.	H.N.	11	CCLP (Lft)	4/4	—	3
3.	M.K.	26	CBCLP	4/4	—	3
4.	N.Y.	14	CBCLP	2/4	—	2
5.	K.N.	13	CCLP (Lft)	>3/4	—	2
6.	Y.R.	15	CCLP (Lft)	4/4	—	2
7.	K.M.	9	CCL (Lft)	2/4	—	2
8.	K.K.	19	CBCLP	4/4	—	1.8
9.	I.T.	18	CBCLP	4/4	—	1.8
10.	Y.M.	21	CCLP (Lft)	4/4	—	1.6
11.	A.Y.	12	CCLP (Rt)	4/4	—	1.2
12.	M.Y.	15	CCL (Rt)	4/4	—	6
13.	T.K.	18	CCLP (Rt)	4/4	—	6
14.	I.Y.	9	CCLP (Rt)	under observation	—	2

4. *Closure of fistula and bone formation*

Bone formation was assessed 3, 6 and 12 months after surgery, by evaluating bone bridge formation and bone height on dental, occlusal and status X-ray films. Of the 14 patients, 11 were followed for 1-3 years after surgery, 2 were followed for 6–12 months and 1 was followed for 2 months. Bone formation was assessed in 13 patients followed for more than 6 months. Bone bridge was formed in all 13 of these patients. In 9 (69.2%), the height of the bone formed after surgery was 4/4, i.e., equal to the height of the neighboring alveolar bone. The bone height was between 3/4 and 4/4 in 2 patients (15.4%) and 2/4 in 2 (15.4%). Thus, adequate bone formation (to a height of 3/4 or more) occurred in 11 (85.6%) of the 13 patients. Graft elimination did not occur in any case. The percentage of patients in whom the bone height was 3/4 or more did not differ significantly between the bilateral cleft group (75.0%, 3/4) and the unilateral cleft group (88.8%, 8/9). In Case 4, bone height was inadequate (2/4) although bone bridge was formed. This was a case of bilateral cleft lip and palate, with marked defects of the palatine bone (Fig. 1). One patient from the unilateral cleft group (Case 7) showed inadequate bone formation (bone height: 2/4). In this case, bone was partially resorbed while canine was erupting.

Fig. 1 Presurgical clinical view of Case No. 4

Case report

1. Case No. 2 (11-year-old male)

In this case of complete unilateral cleft of the left side of the lip and palate, an extensive fistula remained in the labial alveolus through the palate (Fig. 2, 3). After surgery, the palate through the alveolus was well covered with mucosa (Fig. 4), and satisfactory bone formation was seen radiographically (Fig. 5, 6, 7).

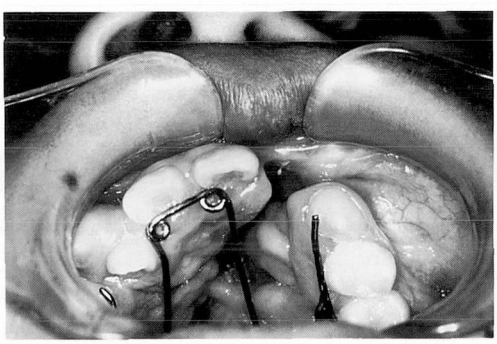


Fig. 2 Case 1. Presurgical clinical view of Case No. 2 with a cleft maxilla and palate.

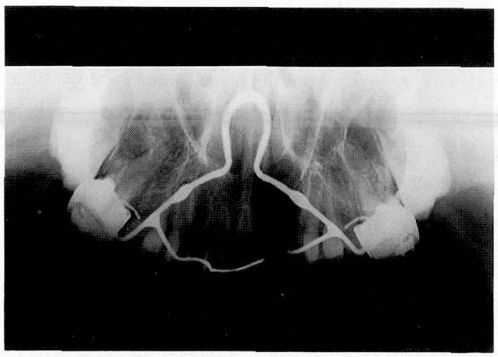


Fig. 3 Radiograph representing the presurgical condition of a unilateral cleft maxilla and plate. (case 1)

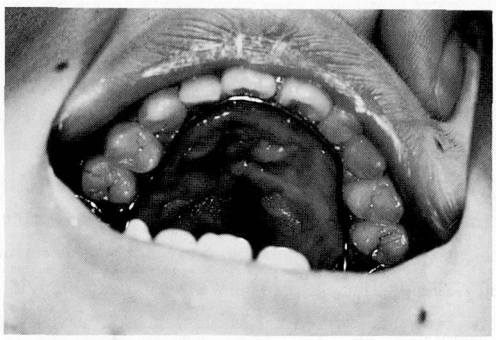


Fig. 4 Postsurgical condition reflects the improved alveolar ridge contour and arch form. (case 1)

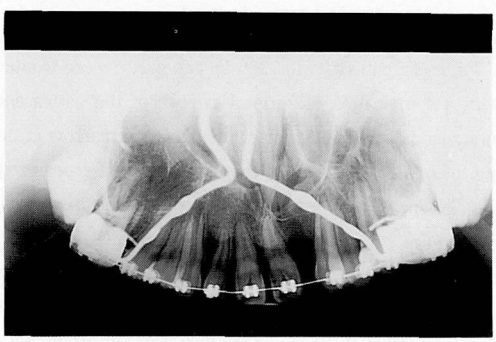


Fig. 5 Twelve months postoperatively, the bone graft has completely matured. (case 1)

2. Case No. 6 (15-year-old male)

Fig. 8 shows the preoperative oral cavity of this boy with residual cleft of the left side of the maxilla and palate. A fistula was seen in the left alveolus and palate. The gingiva in the alveolar ridge was relatively closed. Preoperative X-rays(Fig. 9) revealed bone defects of the

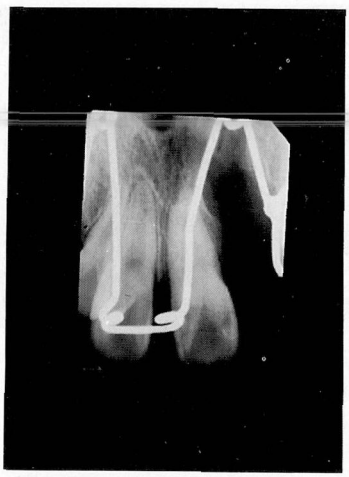


Fig. 6 Case 1. Radiograph piror to bone graft reveals the unfavorable bone support for incisor.

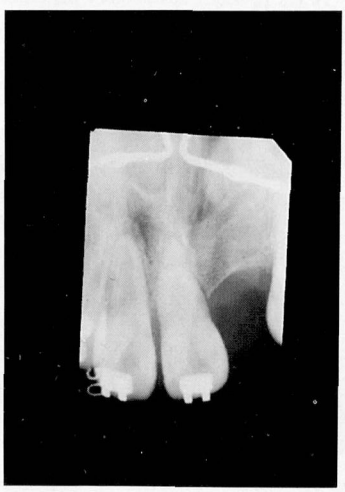


Fig. 7 One year postoperatively, radiograph represnet-ing, the maturation of the bone graft. (case 1)

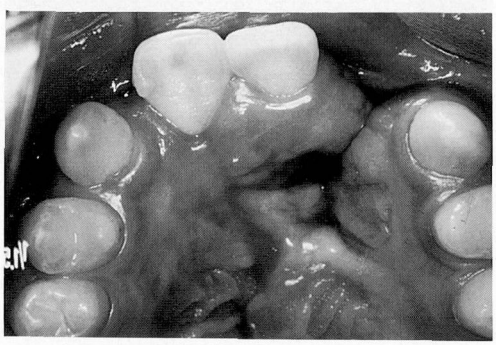


Fig. 8 Case 2. Presurgincal condition of Case No. 6 with residual oral nasal fistula.

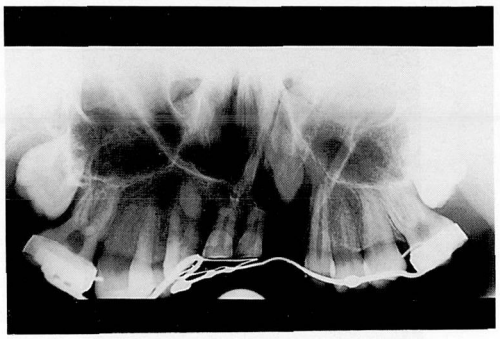


Fig. 9 Radiograph representing the presurgical condition.

alveolus, the palate and the base of the nasal cavity. After bone grafting, palatine mucosal and labial flaps were used to cover the graft. The mucosa in the operated area remained in good condition after surgery (Fig. 10). Postoperative X-rays revealed satisfactory bone height, bone width and bone trabecula (Fig. 11). Cortical bone formation was also noted (Fig. 12).

Fig. 10 Postsurgical oral view revealing the improved alveolar ridge. (case 2)

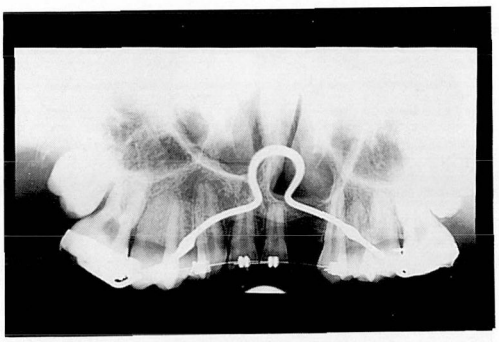


Fig. 11 Seven months postoperatively, the bone graft obliterated the defect and is beginning to mature. (case 2)

3. Case No. 8 (19-year-old male)

In this case of complete bilateral cleft lip and palate, extensive bone detect of the alveolus and palate between the right and left lateral incisor were observed, accompanied by small intermediate jaw and residual roots (Fig. 13). Preoperative X-rays revealed an impacted tooth in the intermediate jaw area as well as an extensive bone defect of the piriform aperture (Fig. 14).

The defects were filled with a sufficient amount of particulate cancellous bone and marrow, and the graft was covered with local mucosa. Although the bone defect in this case was extensive before surgery, the oral cavity was restored to a satisfactory shape after surgery (Fig, 15), and postoperative X-rays revealed adequate bone formation, and no depression at the alveolar ridge (Fig. 16, 17). One year and 8 months after surgery, the intermediate jaw area was found to be in tight junction with the bilateral jaws, and no jaw retrusion was seen (Fig. 18).

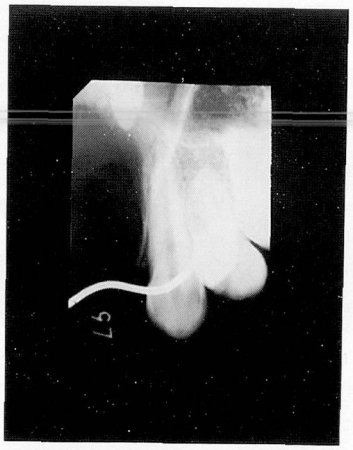
4. Case No. 10 (21-year-old woman)

This patient with complete unilateral cleft lip and palate had undergone iliac bone grafting to the jaw at another hospital. After that operation, bone formation occurred only slightly (Fig. 19, 20). We performed Le Fort-I osteotomy and grafted particulate cancellous bone, collected from the iliac bone. The surgery resulted in satisfactory closure of the fistula and bone formation (Fig. 21, 22).

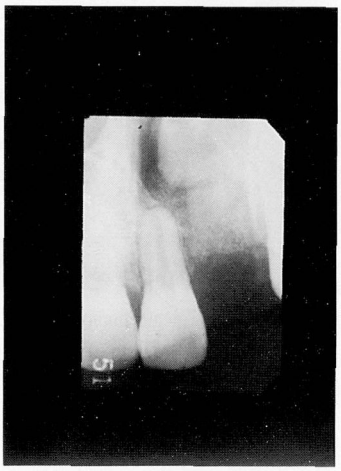
Discussion

Fourteen patients with cleft lip and palate were treated with a combination of surgical closure of the fistula and autogenous particulate cancellous bone and marrow grafting, using the iliac bone as the donor site. According to the classification of bone grafting proposed by Boyne and Sands et al.[1,2], the grafting can be regarded as secondary bone grafting in 9 cases between 6 and 15 years of age and as late secondary bone grafting in 5 adult cases. In both the unilateral cleft group and the bilateral cleft group, bone defects of the piriform aperture were greater than those of the alveolus. This indicates that fairly large amounts of particulate cancellous bone need to be grafted in the piriform aperture even when the fistula of the oral cavity is small.

Sources of grafts, reported to date, include cranial bone (Wolfe, Berkowitz and Harsha et al.[19,20], particulate allogenic bone (Nique, et al.[22]), bone of the symphysis of the mandible (Sindet-Pederson and Enemark[23], and graft-



(A)



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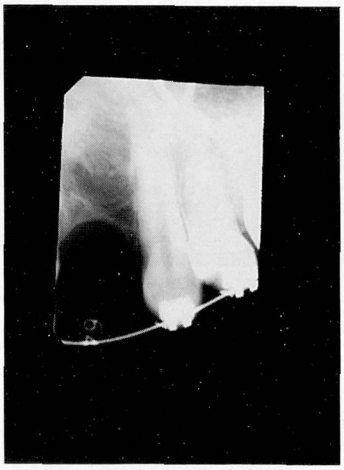

(C)

Fig. 12 Composite periapical radiographic series demonstrating the presurgical condition (A), one month postsurgically (B), and the condition of one year (C). (case 2)

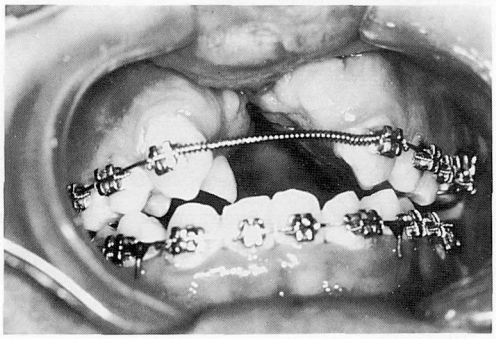

Fig. 13 Presurgical condition of No 8 with a bilateral cleft maxilla and palate. (case 3)

Fig. 14 Radiograph representing the presurgical condition of a bilateral cleft and premaxilla with right incisor. (case 3)

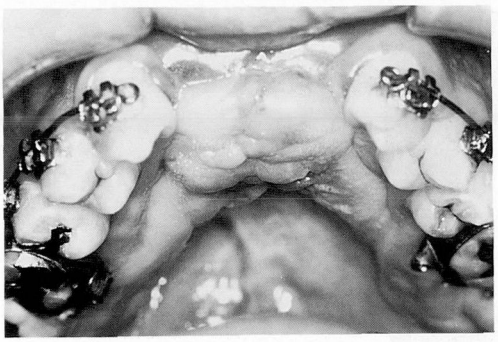

Fig. 15 Postsurgical oral view reveals the extremly improved palatoalveolar ridge. (case 3)

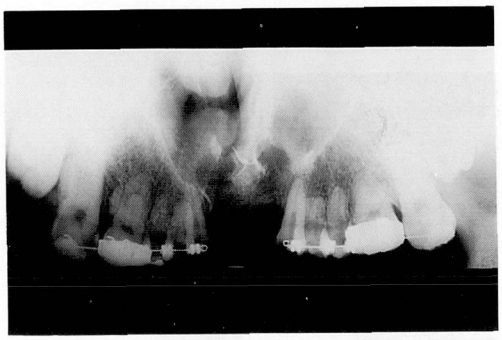

Fig. 16 Radiograph reveals the immediate post surgical condition. (case 3)

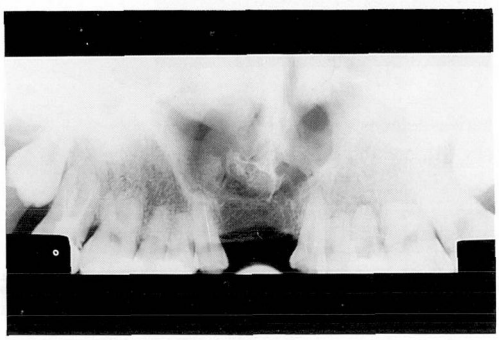

Fig. 17 Radiograph of 20 months posttreatment documents the continuity of the premaxilla with the lateral segments. (case 3)

ing procedure from tibia (Kalaaji,et al,[18]). Boyne and Sands[1,2] reported that particulate cancellous bone and marrow, donated from the iliac crest, are suitable for grafting, on the grounds that they can fix the upper jaw well while allowing physiological and functional movement of teeth. This grafting technique has been adopted

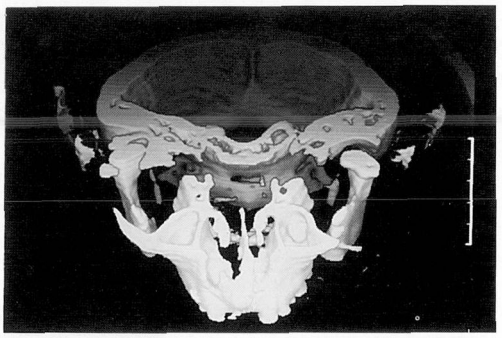

Fig. 18 Postsurgical 3 dimensional computed Tomograph of case No. 8 showing the broad bone formation from alveole to nasal floor. (case 3)

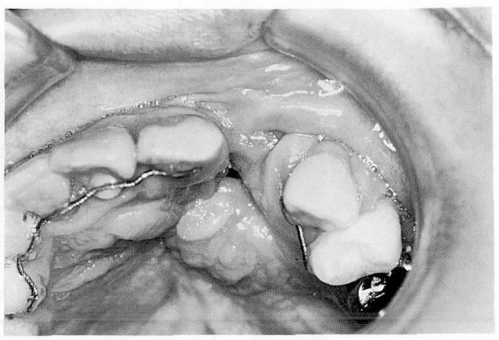

Fig. 19 Presurgical condition of No 10 with unilateral cleft maxilla and palate, who was undewent the iliac bone graft several years ago. Note the persistent of oral and nasal fistula and alveolar ridge defect. (case 4)

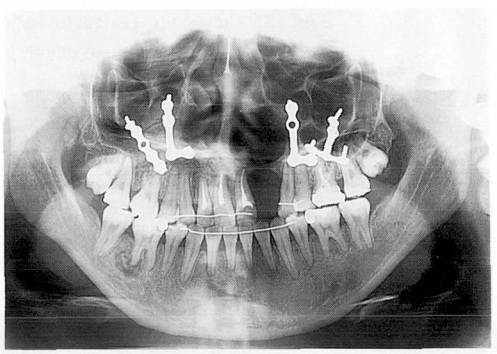

Fig. 20 Presurgical radiograph reveals the very thin bone bridge. (case 4)

widely[20].

We collected particulate cancellous bone and marrow from the iliac bone immediately before grafting. When

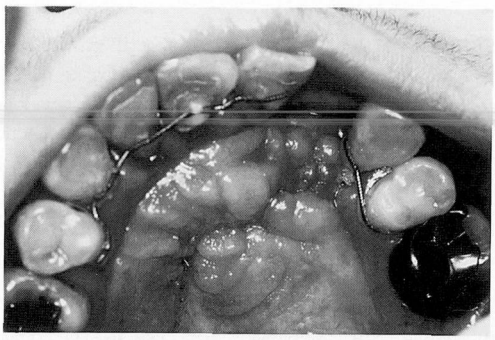

Fig. 21 Postsurgical Oral view reveals the improverd alveolar ridge without fistula. (case 4)

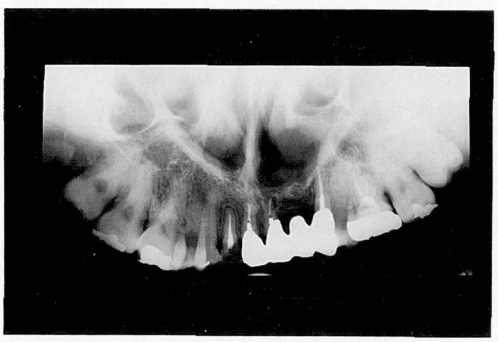

Fig. 22 Radiograph of 8 months posttreatment reptresenting the new bone bridge. (case 4)

this technique of grafting was used, bone formation and bone bridge formation were seen in all 13 cases followed for more than 6 months after surgery. Thus, the success rate was 100%, although the number of cases was small. Boyne[1,2] and Ames[5] found that this technique of grafting was successful in 85% of all cases. Abyholm et al[4] and Berz[6]. reported success rates of 91% and 90%, respectively. Kochi et al.[25] reported that this grafting technique was successful in 90 (84.9%) of 106 patients with jaw cleft. Kortebein, et al.[26] noted slightly lower success rates (83.9% for a total of unilateral and bilateral clefts and 84.6% for unilateral cleft). Although the number of cases studied was not large, all 13 patients showed bone bridge formation. The degree of bone formation (the height relative to the neighboring alveolar bone) was inadequate (1/4 or 2/4) in 2 of the 13 patients, but the other patients (85.0%) showed quantitatively and qualitatively satisfactory bone formation. Thus, the results of this grafting technique in our cases were good.

Factors considered to be related to post-grafting bone formation include age and cleft type. Ames[5], Hall et al.[10] and Bergland et al.[11] reported that success rates varied depending on the age of patients or on whether or not canines had erupted. In the present study, the bone formation rate did not differ between the two age groups (the 9–15 group and the 18–26 group). Of the 5 patients who were between 18 and 26 years old, 3 had bilateral cleft. In these 3 patients, both the quality and quantity of bone formation were good. Although the ability to ossify is thought to be higher in younger patients, our results suggest that satisfactory ossification occurs at a high rate even in adults (between 20 and 29 years) if a sufficient amount of bone is grafted and the grafts are adequately covered with mucosa. Soft tissue seems to play an important role in this technique of grafting. It is essential to made a mucosa incision line so that immobile palatine mucosa and attached gingiva can be fully utilized to cover the palate through the alveolar ridge. To this end, it is recommended that nasal mucosa be used for closure of the nasal side and that oral mucosa be fully utilized for closure of the oral side. In the future, it is necessary to develop mucosa substitutes and subperiosteal material which can physically prevent mucosal contraction. When teeth are guided towards the bone graft, the relationship between periodontal tissue and teeth is important. It needs to be borne in mind that bone resorption can occur following inflammation caused by pocket formation or prosthetic appliances.

Conclusion

Fourteen patients with unilateral or bilateral cleft lip and palate underwent closure of fistula and autogenous particulate cancellous bone and marrow grafting ,using the iliac bone as the donor site during the same operation. Bone bridge formation following this surgery was excellent. This surgical technique is recommended for functional and morphological repair of the alveolus and palate.

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