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Chang Gung Technique of Alveolar Bone Grafting

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19.1 Introduction

A patient with cleft lip and palate usually has a residual alveolar cleft after primary lip and palate repair. The alveolar cleft, together with the adjacent buccal and palatal oronasal fistulae, will cause food particle retention or fluid regurgitation into the nasal cavity during eating. The inferior turbinate on the cleft side will become hypertrophic, resulting in nasal obstruction or sometimes allergic rhinitis [1] (Fig. 19.1). It is easy to develop dental caries as it is difficult to maintain good oral hygiene in the presence of these fistulae. The life span of the teeth next to the cleft is decreased, mainly because of lack of bony support. The malocclusion and dental gap are usually difficult to correct orthodontically as there is no bone across the cleft [2]. There is downward tilting of the nasal pyramid and a vertical discrepancy of the nostrils, caused by bony deficiency under the alar base and nostril floor on the cleft side [3] (Figs. 19.2 – 19.3). It is difficult to correct this kind of nasal deformity by performing soft tissue revision. For bilateral clefts, the patients will usually have some difficulty in biting hard food, as the premaxilla is separated from the lateral maxillary segments and is mobile (Fig. 19.4). All of these problems related to the alveolar cleft can be corrected by a well-performed alveolar bone grafting procedure [2]. Alveolar bone grafting for cleft patients was first reported in 1901 by von Eiselsberg [4] and subsequently by Lexer [5] and Drachter [6]. The technique, however, was not popular until several surgeons reported their approaches and experience for primary and secondary bone grafting in cleft patients in the mid-1950s [7, 8]. The procedure is now accepted in most

craniofacial centers as a routine procedure in cleft lip and palate rehabilitation.

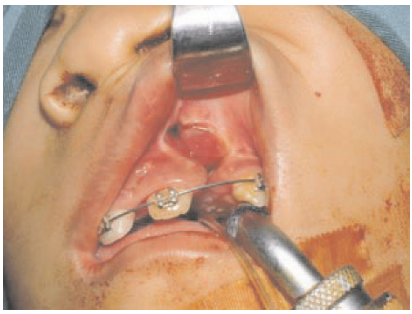

Fig. 19.1 A patient with left alveolar cleft shows the hypertrophic inferior turbinate seen through the buccoalveolar fistula the cleft side

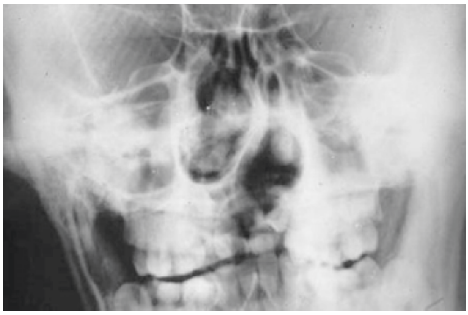

Fig. 19.2 A patient with unrepaired alveolar cleft. Cephalometric X-ray shows the bony deficiency on the nasal floor of

Fig. 19.3 Photo of the same patient shows the deficiency on nasal floor and alar base

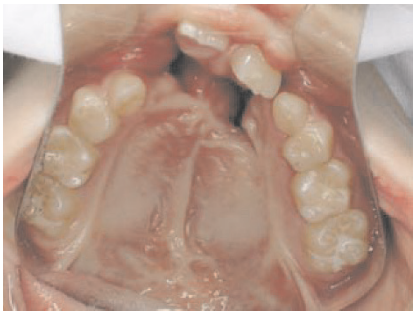

Fig. 19.4 The mobile premaxilla in bilateral clefts. This patient also has huge post-alveolar fistulae, sagittal discrepancy between the premaxilla and right maxillary segment and deviation of the premaxilla with wider cleft on the right side

19.2 Timing of Alveolar Bone Grafting

The timing of alveolar bone grafting is generally classified into four groups [2]: primary bone grafting performed in patients younger than 2 years of age, early secondary bone grafting between 2 and 5 years, secondary bone grafting between 6 and 15 years and late secondary bone grafting in physically mature patients. Although Rosenstein [9] and Nordin [10] claimed consistently good results following early primary repair of the bony cleft, most centers have abandoned the technique and reached a general agreement that facial growth was worse after the primary bone grafting procedure [11, 12]. It is now generally accepted that the best times for alveolar bone grafting are at 5 to 7 years of age, before the eruption of the cleft side central incisor, and at 9 to 11 years of age, when the cleft side canine root is

1/2 to 2/3 formed [13] (Fig. 19.5). In considering facial development, maxillary alveolar growth is mostly complete at 8 to 9 years, and a procedure performed after this age will have minimal adverse effects on facial growth. If successful, the central incisor or canine will erupt through the bone graft after surgery. This will stabilize the bone graft and increase the alveolar process, as an erupting tooth is known to have the potential to induce alveolar bone generation [14, 15].

Fig. 19.5 The general consensus for the timing of alveolar bone grafting is when the cleft side canine root (the left side in this patient) is 1/2 to 2/3 formed

19.3 Presurgical Preparation

All cleft patients are regularly followed in the author's Center with a 6-month interval since 7 years old. Serial cephalometric, panoramic and occlusal X-rays are first taken at the age of 5 years and then every two years. The timing of alveolar bone grafting is decided by the orthodontist according to the extent of root formation of the teeth adjacent to the cleft. Patient and parents have to arrange the surgical date 6 to 12 months in advance to allow enough time to optimize dental care and oral hygiene. Panoramic and occlusal X-rays are taken one week before surgery as the baseline to evaluate the surgical result. For patients who have already fully erupted permanent dentition and a residual alveolar cleft, a bone grafting procedure is still indicated in order to improve orofacial esthetics and function [16].

19.4 Indications for Presurgical Orthodontic Treatment

Although it is difficult to correct the malocclusion and close the dental gap with orthodontic treatment before an alveolar bone grafting procedure, it is the consensus in author's center that the following situations should be the indications for presurgical orthodontic treatment:

(1) Tilting or rotation of the central incisor adjacent to the cleft (Figs. 19.6 – 19.7).

(2) Sagittal discrepancy between the greater and lesser segment in unilateral clefts and the premaxilla and lateral segments in bilateral clefts (Fig. 19.4).

(3) Vertical discrepancy between the greater and lesser segment in unilateral clefts and the premaxilla and lateral segments in bilateral clefts (Fig. 19.8).

(4) Laterally displaced premaxilla with asymmetric dental gaps in bilateral clefts (Fig. 19.4).

Fig. 19.6 A patient with tilting of the cleft side central incisor in front of the cleft

Fig. 19.7 A patient with tilting of the cleft side central incisor in front of the cleft

Fig. 19.8 A patient of bilateral clefts with downward displacement of the premaxilla and vertical discrepancy between the premaxilla and both lateral maxillary segments

It usually takes 6 months of treatment to correct these conditions. Another benefit of the presurgical orthodontic treatment is the better oral hygiene and dental care before the operation as the patients are seen by the orthodontists every month [17].

19.5 Surgical Technique

The technique of alveolar bone grafting in the Chang Gung Craniofacial Center is adopted and modified from the technique used by Dr JC Posnick, when the author did his fellowship in the Hospital for Sick Children in Toronto [18].

19.6 Flap Design

In earlier reports, little attention was given to flap design for soft tissue coverage of the bone graft, and a variety of local mucosal flaps have been advocated [19]. Abyholm [20] was the first to emphasize the importance of flap design in secondary bone grafting in cleft patients and to stress its importance for the outcome of surgery. Histologically, the gingiva consists of a layer of keratinized stratified squamous epithelium and dense lamina propria with immovable attachments to the underlying alveolar bone. It can tolerate the masticatory load and provide protection against chemical and bacterial damage. The labial or buccal mucosa, on the other hand, is covered by non-keratinized epithelium with a thin lamina propria which contains more elastic fibers. It is fixed to the underlying muscles and is highly movable [21], and has less tolerance to masticatory load. If a mucobuccal or mucolabial flap is used to cover the graft, it will increase the chance of further surgical exposure of teeth as it will impede tooth eruption [14]. These mucosal flaps might also cause more bone graft resorption [22].

19.7 Source of Bone Graft

Although controversies still exist with respect to the best donor site for alveolar bone grafting, it is generally agreed that cancellous bone particles give the best result [2]. Evidence increasingly shows that iliac bone is better than calvarium or rib as a donor site owing to its abundance of cancellous bone [2, 11, 20, 23, 24]. A report by Steckeler showed that 3 to 7 ml of cancellous bone could be harvested from iliac crest compared with only 1.5 to 2.5 ml from parietal bone [25]. As the volume of the bone graft needed in unilateral clefts usually exceeds 5 ml, iliac bone is clearly the better donor site than the skull. Post-operative pain is the major disadvantage in using the iliac crest as a donor site. The discomfort can be effectively reduced by routine post-operative analgesics such as oral Codeine phosphate (Figs. 19.9 – 19.10).

Fig. 19.9 Incision line on iliac crest

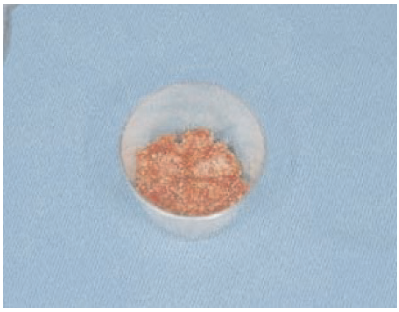

Fig. 19.10 Cancellous bone particles harvested from iliac crest

19.8 Operative Techniques for Unilateral Clefts

Operative techniques for unilateral clefts [16] start with general anesthesia, in which the gingiva and upper buccal sulcus are infiltrated with 1% xylocaine with 1 : 200,000 epinephrine solution for hemostasis and easier dissection. Incisions are made along each side of the alveolar cleft. A superiorly based gingival mucoperiosteal flap is designed and raised sharply from the gingival margin on the lesser segment (Fig. 19.11). The flap is extended posteriorly to the first molar then curved up to the lateral buttress of the maxilla. This curved incision splits the gingiva in an oblique fashion that not only facilitates medial advancement of the flap but also maintains some attached gingiva on the alveolar bone after advancing the gingival flap. The flap on the medial segment is elevated in a similar fashion towards the midline (Fig. 19.12). The palatal mucoperiosteal flaps are raised to a level beyond the deepest margin of the buccoalveolar fistula (Fig. 19.13). The fistula margins at the palatal side are freshened to facilitate wound closure. The nasal floor tissue is completely separated from the palatal mucoperiosteum after raising the palatal flaps and could then be stripped off the bony cleft. The nasal floor tissue is dissected upwards reaching the piriform aperture on the lateral segment and the cartilaginous septum on the medial segment. This allows a tension-free closure of nasal floor tissue and adequate correction of the vertical discrepancy of the nostril sill (Fig. 19.14). The nasal floor fistula is securely repaired. The medial margins of the palatal flaps are freshened and approximated with mattress sutures (Fig. 19.15). Cancellous bone chips, which have already been harvested from iliac bone by a separate team, are packed firmly into the bony defect to the level of the alveolar process (Fig. 19.16). If there is any bony deficiency under the alar base on the cleft side, this is also corrected with an onlay bone graft on the piriform aperture. The periosteum of the lateral gingival flap is scored to reduce the tension, especially at the lateral end of the incision (Fig. 19.24). The lateral gingival flap is then advanced and sutured to the medial flap and palatal flap to provide a watertight and tension-free closure (Fig. 19.17).

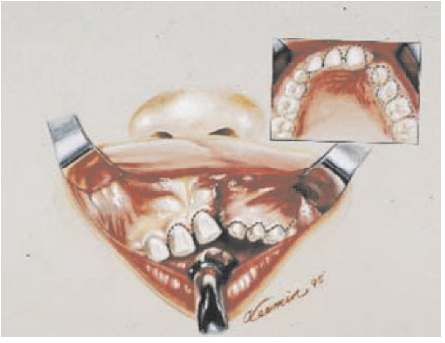

Fig. 19.11 Incisions for the superiorly based gingival flaps are shown by dotted lines. Note the oblique incision line curved upward on the molar region for splitting the attached gingiva. *Inset*: the incision lines on the palatal side (With permission from Noordhoff Craniofacial Foundation)

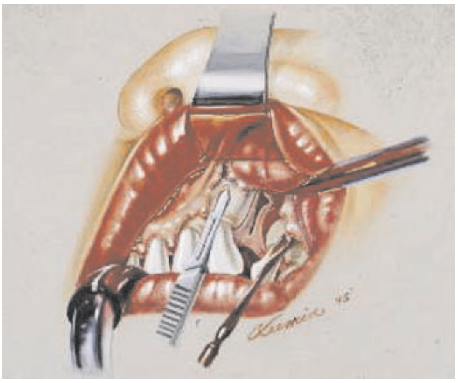

Fig. 19.12 Superiorly based gingival flaps are raised on the labial side with exposure of the cleft margin (With permission from Noordhoff Craniofacial Foundation)

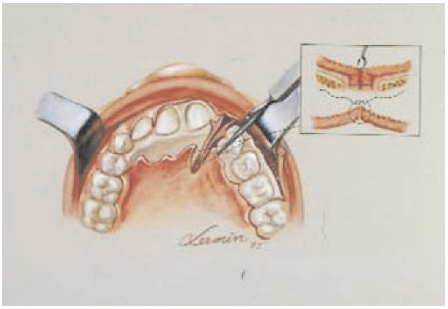

Fig. 19.13 Palatal flaps are raised to a level beyond the deepest margin of the buccoalveolar fistula. This procedure can separate the nasal floor tissue from the palatal mucoperiosteum thus completely expose the bony cleft. *Inset*: The incision lines in the cleft margin is deep toward the nasal side to leave more tissue attached to the palatal flap to facilitate wound closure on the palatal side (With permission from Noordhoff Craniofacial Foundation)

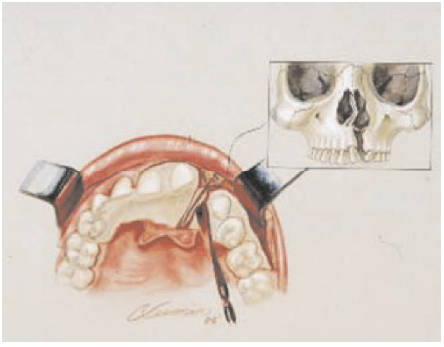

Fig. 19.14 Nasal mucosal flaps are sutured for nasal floor reconstruction up to the level matched to the non-cleft side. *Inset*: Dissection of the nasal floor upward to facilitate wound closure without excessive tension (With permission from Noordhoff Craniofacial Foundation)

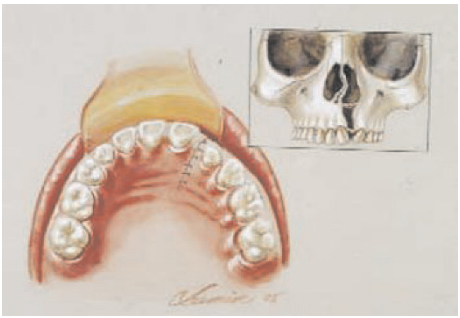

Fig. 19.15 The margins of the palatal flaps are freshened and sutured. *Inset*: Complete closure of the nasal floor and palatal tissue leaving a pocket in the cleft region (With permission from Noordhoff Craniofacial Foundation)

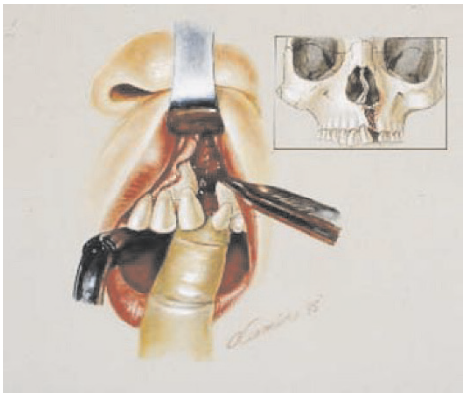

Fig. 19.16 Cancellous bone chips from iliac crest are packed into the bony defect and the cleft side pyriform aperture. *Inset*: Bone chips are packed into the pocket to an adequate level (With permission from Noordhoff Craniofacial Foundation)

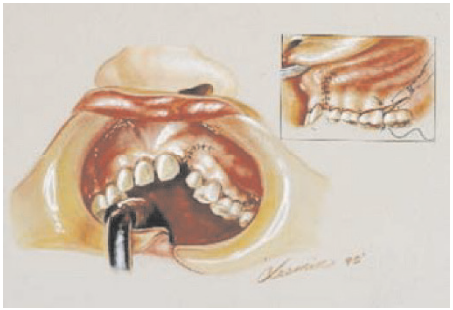

Fig. 19.17 Closure of labial incisions after advancement of lateral gingival flap (with scoring of the periosteum). The gingival flap is sliding along the oblique incision above the molar thus the alveolar margin is covered by gingival tissue instead of buccal mucosa. *Inset*: There is no raw surface in lateral part of the maxilla (With permission from Noordhoff Craniofacial Foundation)

19.9 Operative Techniques for Bilateral Clefts

The technical difference between the unilateral clefts and bilateral clefts is the dissection on the premaxilla. The mucoperiosteum on the premaxilla is dissected for only 2 mm inside the cleft margin and leaves most of the tissue attached to the bone. The palatal mucoperiosteum on the premaxilla is also left intact except for a small portion along the cleft margin. The attached mucoperiosteum on the labial side of the premaxilla can maintain a better blood supply to the premaxilla and the palatal mucoperiosteum on the premaxilla. The author's preference is to do a one-stage bone grafting procedure on both sides unless the size of the premaxilla is too small, e.g. in the presence of a median facial dysplasia. It is much easier to repair the nasal floor in a one-stage procedure, as the premaxilla is still mobile and the soft tissue re-distribution is much better. The techniques of bone grafting in bilateral clefts are shown in Figs. 19.18 – 19.25.

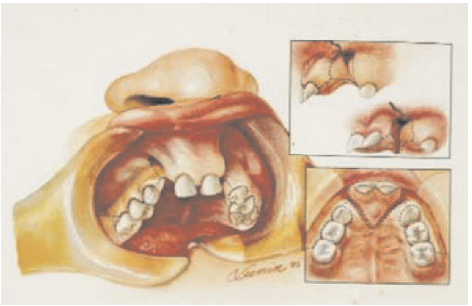

Fig. 19.18 The buccal incision lines in bilateral clefts. *Upper inset*: The trident incision lines on the cleft margins in both the premaxilla and lateral maxillary segments. *Lower inset*: Incision lines on the palatal side (With permission from Noordhoff Craniofacial Foundation)

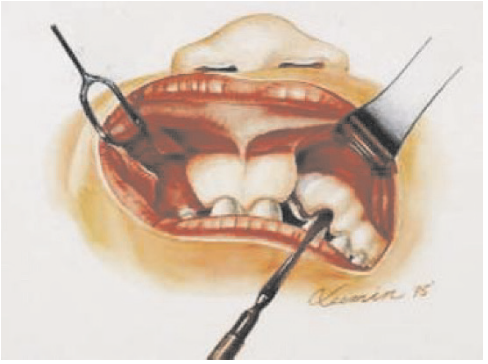

Fig. 19.19 Elevation of the superiorly based gingival flaps on the lateral maxillary segments (With permission from Noordhoff Craniofacial Foundation)

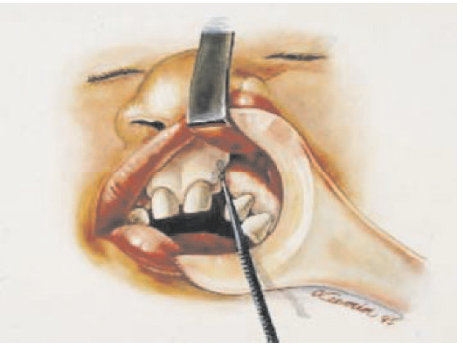

Fig. 19.20 Limited dissection of the gingiva (less than 2 mm) along the wound margins on premaxilla to ensure the blood supply to the soft tissue on the palatal side (With permission from Noordhoff Craniofacial Foundation)

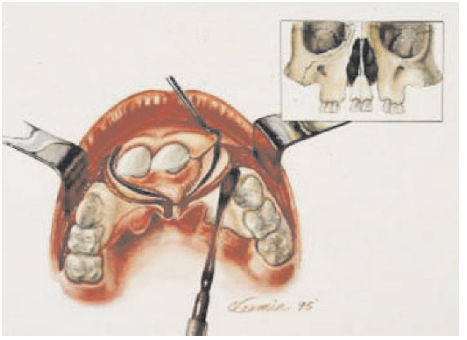

Fig. 19.21 After raising the palatal flaps, the nasal floor mucosa can be completely separated from the palatal tissue. The soft tissue of the premaxilla on the palatal side is also undermined in a limited extent. *Inset*: Dissection of the nasal mucosa to an adequate level can facilitate wound closure without tension (With permission from Noordhoff Craniofacial Foundation)

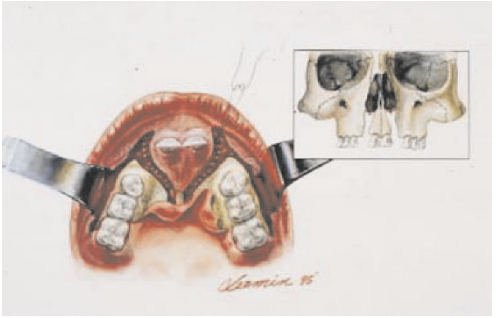

Fig. 19.22 Closure of the nasal floor tissue to an adequate level. *Inset*: Complete wound closure in nasal floor (With permission from Noordhoff Craniofacial Foundation)

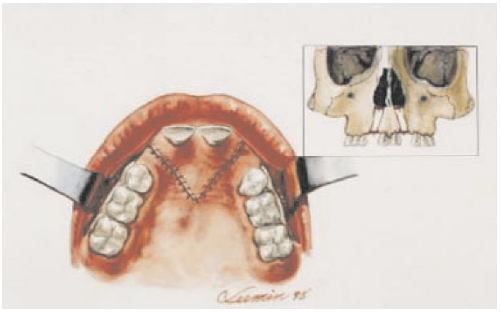

Fig. 19.23 Suturing of the palatal flaps to the premaxilla. *Inset*: Complete closure of the nasal floor and palatal tissue leaving a pocket in the cleft region (With permission from Noordhoff Craniofacial Foundation)

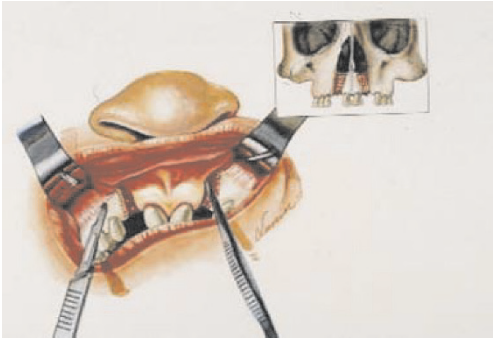

Fig. 19.24 Scoring of the periosteum of the superiorly based gingival flap (shown on the left side of the figure with a blade) and packing of the bone chips into the cleft (shown on the right side of the figure). *Inset*: Packing the bone chips to an adequate height (With permission from Noordhoff Craniofacial Foundation)

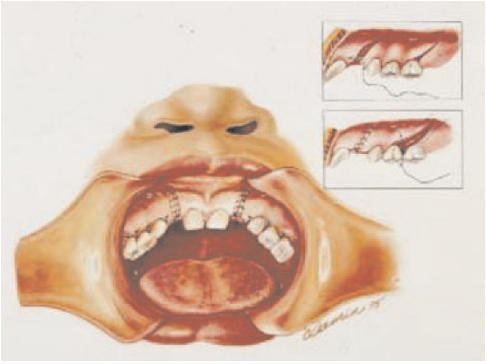

Fig. 19.25 Complete closure of the wounds. *Upper inset*: Water tight closure at the cleft site with sutures passing through the gingival flap, the premaxilla and the palatal flaps. *Lower inset*: Advancing the gingival flap along the oblique incision line on the molar region to maintain the attached gingiva in this region (With permission from Noordhoff Craniofacial Foundation)

19.10 Post-operative Care

Peri-operative antibiotic coverage is given with broad-spectrum parenteral antibiotics. The patient is instructed to start oral hygiene care using a waterpik or toothbrush soon after they return to the ward. Analgesics (codeine phosphate 0.5 mg/kg/dose, QID for two days) are routinely prescribed to reduce discomfort at the donor site. Most patients are discharged on the second post-operative day and kept on oral antibiotics for a further five days.

19.11 Evaluation of Results

All patients were seen by both surgeon and orthodontist during the post-operative follow-up. Panoramic and occlusal X-rays were taken at one week, 6 months and one year after surgery. The results of bone grafting were evaluated on the basis of:

(1) The marginal bone levels and morphology of bone in the grafted area. The height of the inter-dental septum was related to the length of adjacent tooth roots and divided into three types according to Abyholm et al. [20] (Table 19.1). Although dental computed tomography is more popular in modern practice, the traditional occlusal and panoramic X-rays remain the best tool for evaluation of the results.

(2) Eruption and migration of teeth into the grafted area.

(3) Closure of the alveolar oronasal fistula.

(4) The gingival height and nostril floor fullness.

Table 19.1 Classification of bone graft results according to dental X-ray measurements (the interdental septum height or marginal bone level)

Type I	Approximately normal
Type II	At least 3/4 of normal
Type III	Bony bridge less than 3/4 of normal
Failure	No bony bridge across the cleft

* According to (Abyholm et al., 1981) [20]

19.12 Results

Among the 97 patients receiving an alveolar bone grafting procedure from 1991 to 1999 by the author, 71 were unilateral clefts, and 26 bilateral. Their age varied from 8 to 28 years. Their follow-up varied from 13 months to 8 years.

19.12.1 Dental X-ray Measurements

Among the 71 unilateral cleft lip and palate patients receiving alveolar bone

grafting, 68 (95.8%) had a result rated as type I. Two patients (2.8%) were rated as type II and one patient as type III (1.4%). The success rate in terms of dental X-ray evaluation was 98.6% in this study as both types I and II were evaluated as a success according to Abyholm's classification. Among the 26 bilateral clefts (52 sites), 4 were rated as type I (7.1%), 42 as type II (82.2%), 5 as type III (8.9%) and 1 as failure (1.8%).

19.12.2 Canine Eruption

Among the 123 sites of alveolar bone grafting, 84 sites (67.9%) already had erupted canines on the cleft side before the bone grafting procedure. In these patients, the purpose of the bone graft was to close the oronasal fistula, increase support to the teeth adjacent to the cleft, help orthodontic movement of the teeth into the grafted area, and improve nasal esthetics. The high eruption rate in this series is due to the late timing of alveolar bone grafting in the author's center in the early 1990s. The canine had not erupted in 39 sites (32%) by the time of the alveolar bone graft. Thirty of them (25%) had canine eruption through the grafted area several months after surgery. In 9 sites (7%), the canine teeth had not erupted one year after the procedure.

19.12.3 Fistulae Closure

Sixty nine patients with unilateral clefts (97.2%) and 45 sites in bilateral clefts (86.7%) had their buccoalveolar oronasal fistulae successfully closed. No fluid leakage to the nasal cavity was reported following the operation.

19.12.4 Nasal Esthetics

Among the 71 unilateral clefts, three patients (2.8%) had a persistent discrepancy in the nostril sill after surgery. All other patients had a balanced nostril sill after bone grafting. The alar base or alar-facial groove on the cleft side frequently bulged excessively in the immediate post-operative period, but this bulging gradually resolved within 6 months in most patients. Three patients with bilateral clefts (11.5%) had persistent asymmetry in their nasal floor after bone grafting.

19.12.5 Gingival Height

The height of the attached gingiva on the grafted area was evaluated by the

orthodontist. Six patients among the 71 unilateral clefts (8.4%) and 2 sites in bilateral clefts (3.6%) lost their attached gingival height on the grafted area. The vestibule became shallow and part of the alveolar process was covered by buccal mucosa instead of attached gingival tissue in these two patients.

19.13 Complications

Some minor complications were encountered, especially in older patients. Minor bone graft exposure was noted in 6 cases with unilateral clefts (8.4%) and 11 sites in bilateral clefts (21.4%), all of which healed with conservative treatment. One unilateral cleft (1.4%) and 6 sites in bilateral clefts (11.5%) had wound infection with major dehiscence and bone graft exposure. They were treated in a conservative way and healed eventually but with some unsatisfactory results.

Examples of the results of bone grafting are shown in Figs. 19.26 – 19.37.

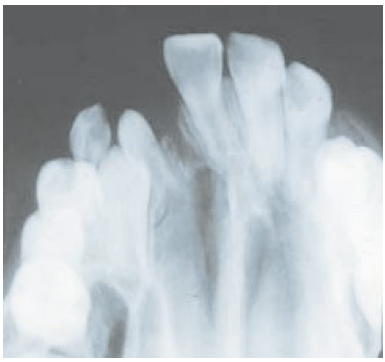

Fig. 19.26 A 10 years old boy with right side cleft lip and palate. The occlusal X-ray before the bone grafting procedure shows the bony cleft

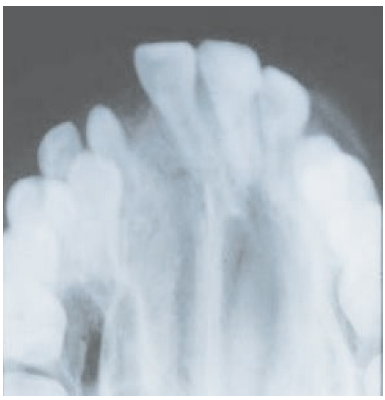

Fig. 19.27 Immediate after the alveolar bone grafting. X-rays shows well packed bone graft

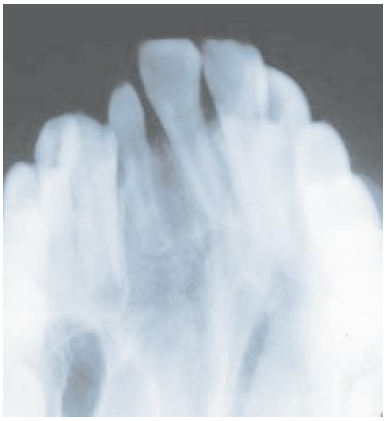

Fig. 19.28 One year after the alveolar bone grafting. X-rays shows good maintenance of the bone graft

Fig. 19.29 A very wide alveolar cleft in an adult. The cleft side central incisor is already lost

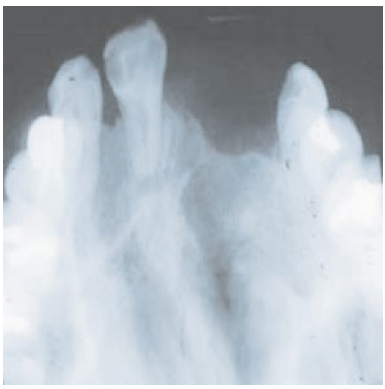

Fig. 19.30 Occlusal X-ray one year after the bone grafting. The bone graft is well maintained

Fig. 19.31 A 9 years old girl with bilateral alveolar clefts

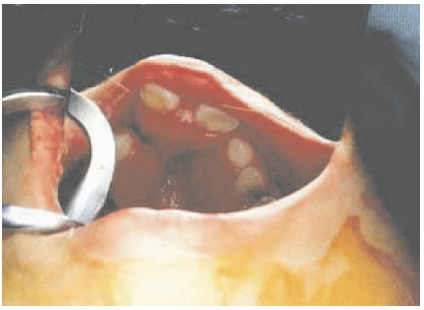

Fig. 19.32 Palatal side of the same patient showing the mobile premaxilla with wide alveolar clefts on both sides

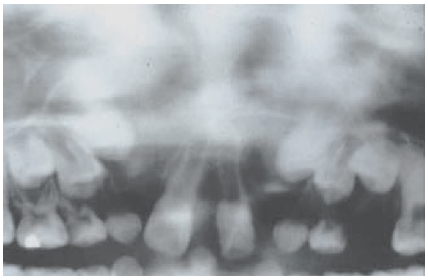

Fig. 19.33 Panoramic X-ray shows the bony defects on both sides

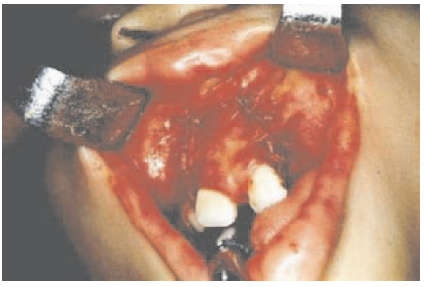

Fig. 19.34 Immediately after the bone grafting. The soft tissue is completely closed

Fig. 19.35 Complete soft tissue closure on the palatal side

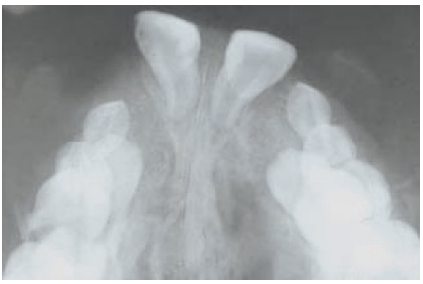

Fig. 19.36 Occlusal X-ray immediately after the bone grafting showing well-packed bone graft

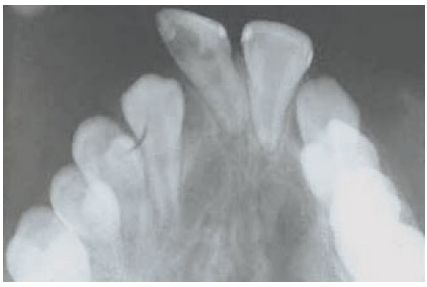

Fig. 19.37 Occlusal X-ray one year after the bone grafting procedure shows the bone graft is well maintained

19.14 Discussion

Autologous bone graft of an alveolar cleft area has following advantages: 1) assistance in the closure of buccoalveolar oronasal fistula, 2) provision of bony support for unerupted teeth and teeth adjacent to the cleft, 3) formation of a continuous alveolar ridge to facilitate orthodontic correction of malocclusion, 4) supporting the nostril floor and alar base to improve nasal esthetics. Autologous bone grafting has been accepted in most craniofacial centers as a routine

procedure in cleft lip and palate rehabilitation

Timing is an important factor to achieve a good result. While there is a general consensus that early bone grafting may result in severe facial growth disturbance, other reports have shown that the success rate decreases in older patients. The best timing for alveolar bone grafting is dependent on the timing of tooth eruption in the cleft area, i.e. the central incisor or the canine. Alveolar bone grafting performed in patients older than 16 years gives less optimal results. This is probably because the general health of the oral tissue deteriorates with age. Older patients had a higher risk of wound infection and dehiscence which probably represented a less satisfactory healing process and lesser tolerance to infection. On the other hand, minor dehiscence or gingivitis was sometimes encountered in younger patients, but all healed successfully after conservative treatment. Optimizing oral hygiene before bone grafting, especially in the older patient, is extremely important in contributing to the success of the procedure: post-operative oral hygiene is also important. Gingivitis was frequently observed in patients who did not brush their operative wound during the first week following surgery.

Flap design is another important issue. Although raising a superiorly based gingival flap on the lesser segment is more extensive compared with a local rotational mucosal flap, it is very important to use a gingival flap and palatal flaps to cover the bone graft [20, 22, 23, 26]. The gingival tissue is histologically different from the buccal mucosa (detailed above). The gingival tissue can better tolerate masticatory force and has less bone graft resorption after operation. By splitting the gingiva in a curvilinear fashion in the molar region, one can advance the gingival flap into the cleft for easy cleft closure and still maintain some attached gingiva on the posterior part of the segment. Other methods usually make a vertical back-cut in the posterior part of the flap. This will often leave a raw surface on the alveolus of the molar teeth which will heal under less optimal conditions.

Another important step for obtaining a good result is the extent of the palatal flaps. Abyholm and Bergland suggested raising the palatal flap along the cleft margin and around the gingival margins for just one tooth on each side of the cleft to ensure blood supply to the graft. Lilja preferred a wide exposure of the cleft on the palatal side. The author's preference is to raise the palatal flap in a wide fashion. Raising the palatal flap can help to separate the nasal floor tissue from the palatal tissue to which it is tethered in the cleft. The nasal floor tissue can be stripped away from the cleft area after complete separation from the palate and can then be pushed upwards to a normal level as in the non-cleft side. The bony cleft can be well exposed in this technique and the bone graft volume needed to fill the gap is markedly increased. This might be an important factor in contributing to a good result as the depth of the bone graft is markedly increased. Another important point of the procedure is the extensive dissection of the nasal floor tissue, which allows an adequate correction of the vertical discrepancy of the nostril floor, thus giving significant improvement in nasal esthetics.

19.15 Summary

In summary, alveolar bone grafting is a routine procedure in cleft lip and palate rehabilitation. A satisfactory result can be achieved by optimizing pre-operative preparation, patient selection, surgical technique and post-operative care.

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