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Dental Reconstruction Using Secondary Bone Graft Followed by Implant Placement in Alveolar Cleft of Patients with Cleft Lip and/or Palate

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1. Introduction

Alveolar cleft is the major problem during the formation of the ideal dental arch and dental reconstruction in cleft lip and/or palate (CLP) patients. In 1972, Boyne and Sands introduced secondary autogenous particulate cancellous bone and marrow (PCBM) grafting for the treatment of alveolar and residual palatal clefts (Boyne and Sands, 1972) Nowadays, a golden standard protocol for the dental reconstruction of patients with CLP is to perform bone grafting (BG) before canine eruption and subsequent orthodontic closure of the dental arch without using prosthesis, as described in previous reports. (Abyholm, et al., 1981; Enemark, et al., 1985; Bergland, et al., 1986). However, because of the excessively long treatment period or a wide interdental space resulting from several congenitally missing teeth, prosthodontic treatment such as bridgework or denture is sometimes necessary.
Verdi et al. firstly reported the use of osseointegrated implant for dental rehabilitation in patients after the repair of the alveolar cleft (Verdi et al., 1991). Since then, numerous reports indicated that the use of dental implants placed in grafted alveoli after repair of an alveolar cleft using a secondary BG with particulate PCBM is a viable option for the dental reconstruction of patients with cleft lip or palate (CLP) (Ronchi et al., 1995; Takahashi T et al., 1997; Jasma et al., 1999; Härtel et al., 1999; Dempf et al., 2002). Since 1993, we have used this treatment procedure in patients with graft alveolar clefts. (Takahashi et al., 1997, 2008). In this chapter, dental reconstruction using secondary BG followed by dental implant placement in alveolar cleft of patients with CLP is described. The main purpose of this chapter to demonstrate the surgical procedure, long-term clinical outcome, and the impact on the preservation of the grafted alveoli after implant placement of this treatment procedure.

2. Use of dental implants for dental reconstruction in clp patients with grafted alveolar cleft

2.1 Secondary alveolar bone grafting for osseous reconstruction of the alveolar and palatal cleft

The management of the dentoalveolar cleft is a significant challenge for the surgeon. Timing is generally described as “primary,” “secondary,” and “delayed.” Primary bone grafting is

generally defined as that taking place before eruption of the primary dentition or before 1 year of age. Secondary bone grafting is that performed after developing of the permanent dentition, and delayed bone grafting takes place after eruption of the permanent canine. Historically, primary bone grafting was used from 1950 to 1968, and was found to inhibit normal growth and to impede later treatment using orthopedic forces of arch expansion. Nowadays, early secondary (5 to 6 years of age) or secondary (7 to 11 years of age) before canine eruption is recommended for osseous reconstruction followed by orthodontic dental arch closure. The erupting tooth stimulates alveolar and graft bone growth and produces a more normal-appearing canine eminence. Late bone grafting is not recommended because root resorption and graft failure sometimes observed when bone grafts are placed after eruption of the canine and when the bone graft is placed in contact with exposed tooth root surfaces. As bone graft source, the standard bone graft is autogenous particulate cancellous bone and marrow (PCBM) from the ilium. This bone is highly cellular, making it both resident to infection and able to heal rapidly. The graft materials are clinically and radiographically indistinguishable from alveolar bone by 3 months after operation and function as alveolar bone. Orthodontic treatment, thus, could be started 3 months after bone grafting. The purposes of bone grafting to the alveolar cleft are (1) closure of the oronasal fistula; (2) stabilization of the expanded arch, and in the case of bilateral clefts, of the premaxilla; (3) bone to support the canine eruption; (4) improved bone and periodontal status for the central incisor and lateral, if present; (5) support for the ala of the nose; and (6) a more normal appearance of the alveolar process, teeth, and gingival of the anterior maxilla. Now, another important purpose of bone grafting should be added to the list. Seventh purpose of bone grafting to the alveolar cleft would be to give osseous support for dental implant placement.

2.2 Problems related to the dental reconstruction of the grafted alveolar cleft

Although golden standard procedure of dental reconstruction in CLP patients is to perform bone grafting between the ages of 7 and 11 years, followed by orthodontic closure of the cleft dental gap without the use of a prosthesis, CLP is often associated with congenital absence of the lateral incisor adjacent to the cleft. Many patients therefore require prostheses such as a denture or bridge, particularly when the cleft-dental gap might not result in a good occlusion relationship between the upper and lower jaws. For such patients, we propose the option of dental reconstruction with dental implants after repair of the alveolar cleft by autogenous PCBM grafting.

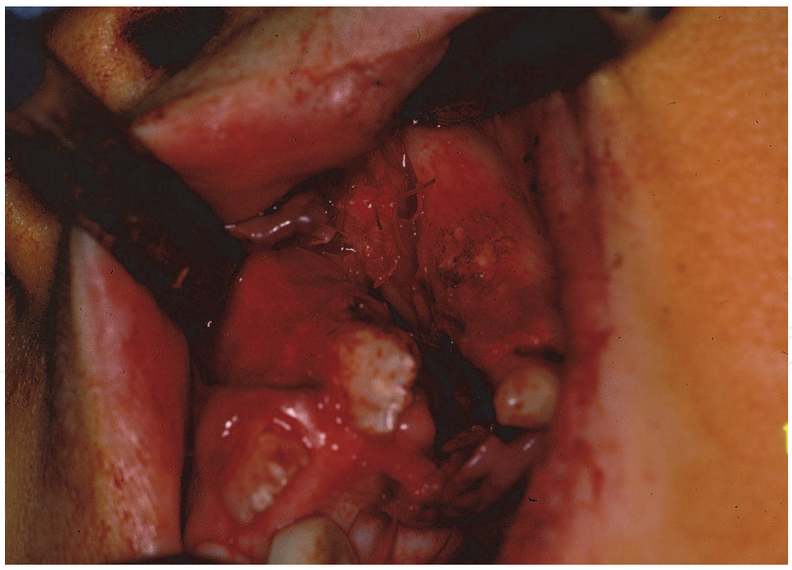
2.3 Subjects and methods

2.3.1 Subjects

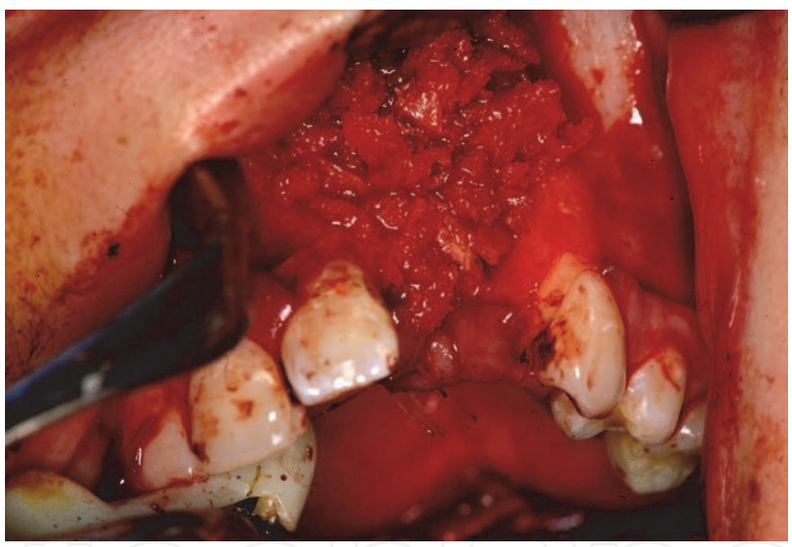
Twenty-one (7 male, 14 female) patients with CLP underwent implant placement between February 1993 and May 1995. Thirteen of the patients had unilateral cleft lip and palate (UCLP), and three had unilateral cleft lip and alveolus (UCLA). The mean age at first implant surgery was 19.1 ± 4.7 years (range: 13.9 to 33.6 years).

2.3.2 Bone grafting

Surgical procedure was shown in Fig 1 (Fig. 1a and 1b).



a: closure of the nasal mucosa at the cleft site



b: PCBM filled in the cleft gap

Fig. 1. Secondary bone grafting of alveolar cleft

All patients received autogenous particulate cancellous bone and marrow (PCBM) grafts from the ilium beaten 8.3 and 31.7 years of age under general anesthesia. Epinephrine 1:00, 000 is administered in the labial tissues to reduce bleeding. Incisions are made, and the labial flaps are reflected on either side of the cleft and these two incisions connected by sharp and blunt dissection deep to the orbicularis oris muscle on the nasal mucosa. This dissection is extended superiorly to the level of the floor of the nose. The nasal mucosa is reflected from the bone of the cleft and extended to the palatal tissues. Subperiosteal reflections of the palatal tissues on either side of the cleft are performed from the gingival margin to the depth of the palate. The reflection of mucosa through the alveolar cleft is completed. The nasal mucosa that passes through the cleft and is attached to the palatal tissues is separated from the palatal mucosa to the depth of the palate. If a palatal fistula

extends further posteriorly, the separation and reflection are carried to the posterior end of the fistula. Then, nasal mucosa is closed with 4-0 Vicryl. The edges of he palatal fistula are freshened and closed with 4-0 Vicryl. Specifically, the very end of the fistula is closed using through-and-through suture using 4-0 Vicryl. PCBM is packed firmly from the level of the floor of the nose to the crest of the ridge. Releasing incisions are made through the periosteium of the posterior buccal flap, allowing anterior and inferior advancement. The labial and palatal flaps are closed with sutures. For the subsequent implant placement, the most important point of BG bed preparation is the level of the floor of the nose. The level of the floor of the nose at the BG bed should be the same level of the contra-lateral side. If inferior nasal turbinate is obstructive for the preparation of the floor of the nose, it should be removed. Usually, inferior nasal turbinate is easily removed without any bleeding.

2.3.3 Evaluation of the grafted alveoli around the implants

The marginal bone level around the implants was evaluated radiologically as previously described. (Takahashi et al., 2008). Using the reference points of the dimension of the implants, especially the fixture length and screw pitch (0.6 mm), the marginal crest level of the bone was calculated relative to the baseline (Fig. 2).

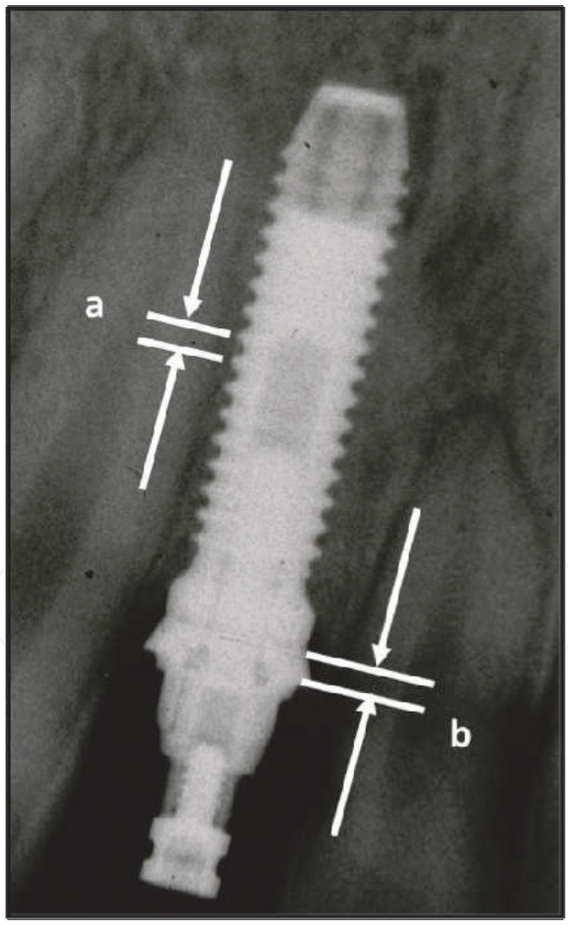


Fig. 2. **Measuring the marginal bone level**. a, A screw pitch (0.6 mm); b, baseline to bone level (marginal bone level) (Takahashi T, et al. Oral Surg Oral Med Oral Pathol Oral Radiol Endod2008: 105: 297-302)

An average of the mesial and distal values was used. All assessments were performed at three stages after abutment connection, at 1 (stage I), 3 (stage II), and 6 (stage III) years after abutment connection.

2.3.4 Evaluation of the marginal interdental alveolar bone height (IABH)

The interdental alveolar bone height (IABH) was estimated and was indicated by 4 score values (Fig. 3). (Enemark, et al., 1987).

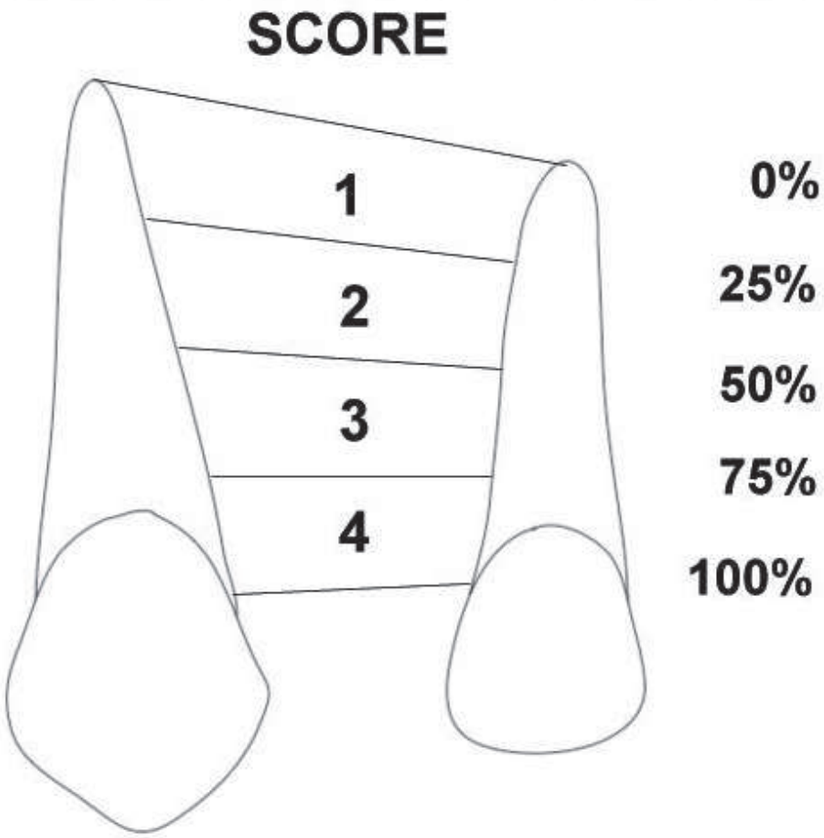


Fig. 3. Score of interdental alveolar bone height (IABH)

Briefly, The extent of the vertical bone height was determined in relation to the interdental bone height and assessed on a 4-point scale: score 4= 0 % to 25 % bone loss, score 3= 25 % 50% bone loss, score 2= 50 % to 75 % bone loss, score 1= 75% to 100 % bone loss. All assessments were performed 1, 6, 12, 24, 36, and 72 months after implant placement.

2.4 Clinical outcomes in a long-term follow-up

A total of 23 implants were placed in bone-grafted alveoli in 21 patients between February 1993 and May 1995. One patient was lost to follow-up, two implants were lost in one patient, and three implants in three patients were still temporary restoration because of the prolonged orthodontic treatment. The implant length ranged from 10 to 18 mm; the most frequently used length was 15 mm. The duration from bone grafting to first implant surgery ranged from 1.4 to 10.2 years (mean: 5.0 ± 2.7 years). In five patients with insufficient IABH,

which was evaluated as Score 1 or 2, a chin bone-onlay graft (CBOG) was used during implant placement as described later. Two of these patients had wound dehiscence, and the exposed chin bone was partially lost. Ultimately, however, all five implants were osseointegrated, and the alveolar bone height was increased in these patients. The follow-up period ranged from 7.2 to 9.4 years (mean period: 8.6 ± 0.6 years). Twenty implants placed in 19 patients survived, and the overall rate of implant survival was 90.9%. IABH was reduced in 2 of 16 (12.5%) of the implant-placed grafted alveoli, in which score 4 was reduced to score 3, and score 3 was reduced to score 2, 6 years after implant placement, respectively. In other 14 cases, there was no change in score of IABH up to 6 years after implant placement (Fig. 4). These results clearly suggested that placement implants in the grafted alveoli would maintain alveolar bone height in the region.

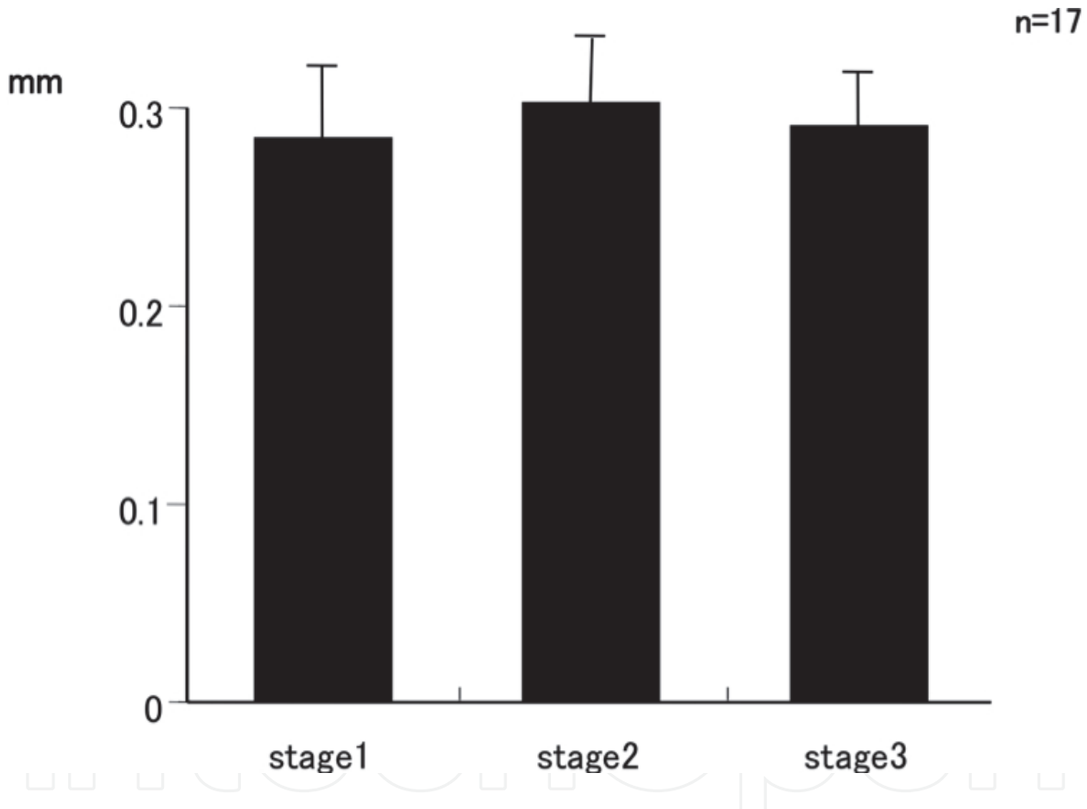


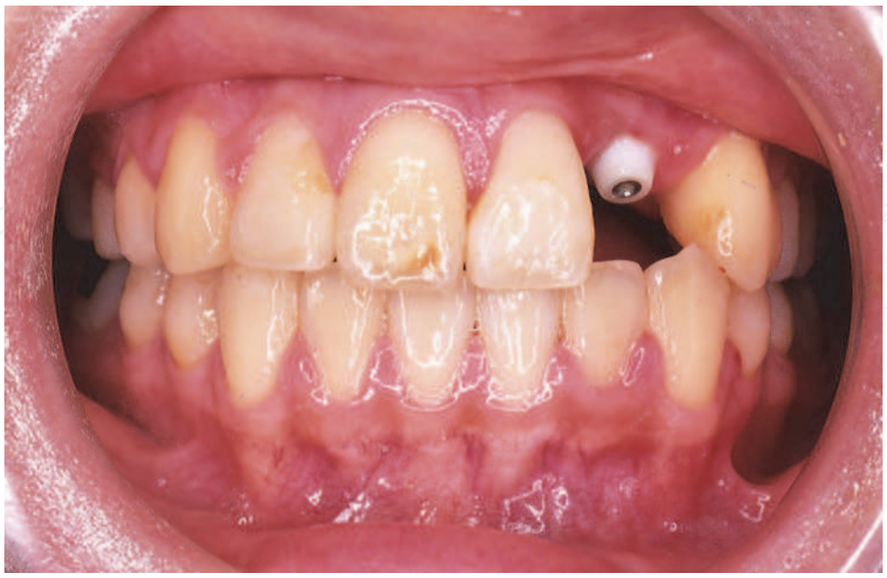
Fig. 4. Marginal bone loss around the implant

The mean marginal bone levels were 0.29 ± 0.18, 0.29 ± 0.19, and 0.28 ± 0.15 mm at stages I to III, respectively. In addition, there was no mobility of the implants and was no pain, swelling, or inflammation around the peri-implant tissue. Clinically, all the implants were functioning in excellent condition 7.2 to 9.4 years after implant placement. A long-term follow-up of a typical case was shown in Figure 5a-c and Figure 6a-c. These data satisfied the implant success criteria according to Albrektsson et al., (Albrektsson, et al., 1986), who stipulated that the vertical bone loss should be less than 0.2 mm annually after the first year of implant service. In addition, our long-term follow-up study showed that the use of dental

implants placed in the grafted alveoli is an excellent treatment modality for the dental rehabilitation of patients with alveolar clefts and congenitally missing teeth.



a: After orthodontic alignment and space making for an implant placement of the grafted alveolar cleft.



b: Postoperative view after implant placement



c: 13 years after implant placement

Fig. 5. A Long-term follow-up in a unilateral cleft lip and palate (UCLP) patient.



a: Periapical radiograph immediately after implant placement



b: Periapical radiograph years after implant placement (marginal bone level: -1.0 mm).



c: 13 years after implant placement (marginal bone level: -1.0 mm)

Fig. 6. Radiological evaluation of the long-term follow up in a UCLP patient.

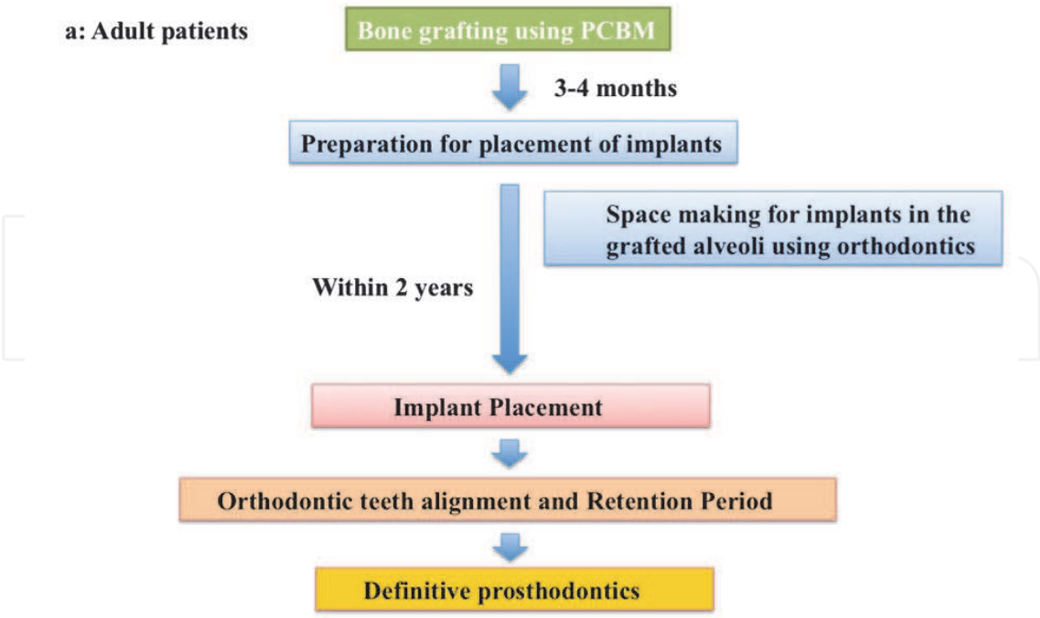
2.5 Timing for BG and for implant placement

Generally, secondary BG is recommended to perform before canine eruption. (Enemark, et al., 1985; Bergland, et al., 1986). The reasons for this are the better clinical results seen in younger individuals, and the greater osteogeneic activity in younger than older patients. It was shown that there was a tendency to an inverse correlation between IABH and age at the time of BG (Takahashi, et al., 1999). Therefore, from the clinical point of view, secondary BG for alveolar clefts should be performed when the patient is young. On the other side, generally implant placement before the growth spurt is assumed to be contraindication. (Lekholm, 1993) because implants are immobile similar to ankylotic teeth (Adell, et al., 1981; Shapiro and Kokich, 1988) and do not accompany other parts of the jaw bone during rapid growth in the adolescence. Adhering to this rule, the time lag between BG and implant placement is required. Actually, the mean duration from BG to implant placement was 4.6 ±2.5 years. It is well known that the grafted alveoli undergoes resorption 3-dimensionally (Van der Meji, et al., 1994), and the interdental alveolar bone height (IABH) also decreases (Takahashi et al., 1999). The mean net bone height 1 month after BG was approximately 17 mm, and the mean width 1 month after BG was 12. 9 mm, both of which were enough for the implant placement. However, almost half of the grafted alveoli required another bone graft within 24 months after the original bone graft to increase IABH level for implant placement (Takahashi et al., 1999).

None the less, the grafted alveoli with PCBM are suitable for implant placement. If the grafted alveoli do not have sufficient bone volume and IABH, another bone augmentation procedure such as onlay graft or guided bone regeneration (GBR) should be considered. The flow chart of the dental reconstruction of alveolar cleft using PCBM BG and implant placement was shown in Fig. 7. According to this flow chart, BG with PCBM should be performed followed by orthodontic teeth movement and space making for an implant bed in adult CLP patient with un-repaired alveolar cleft. Subsequently, implant placement should be performed within 2 years after BG to avoid another bone augmentation procedure (Fig. 7a). If the patient is young and is on the line of multi-disciplinary team approach, secondary BG to the alveolar cleft should be performed between 7 to 11 years of age before canine eruption. Orthodontic dental arch closure without prosthodontic treatment should be the primary choice as golden standard procedure for dental reconstruction of the grafted alveolar cleft. However, in cases of excessively long treatment period or a wide interdental space resulting from several congenitally missing teeth, use of dental implant placement in the grafted alveoli should be considered after the growth spurt (Fig. 7b) as an alternative treatment protocol. Please keep in mind that another bone augmentation procedure may be required for implant placement in the grafted alveoli as will be discussed later.

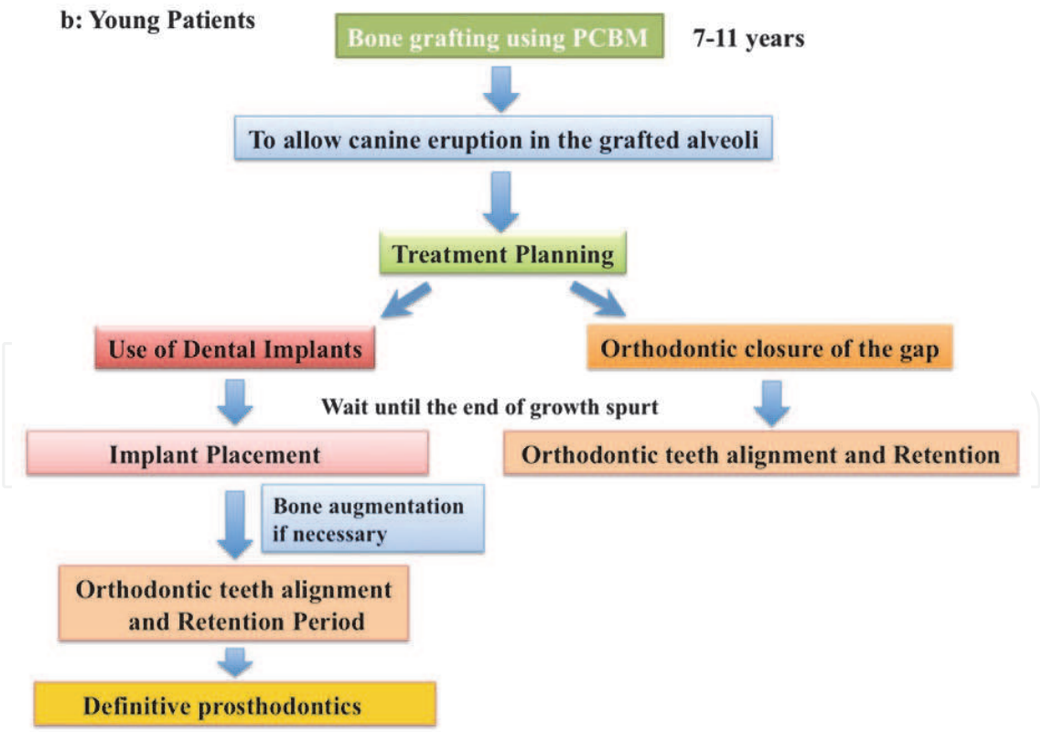
2.6 Bone augmentation procedure for implant placement in grafted alveoli

For the dental reconstruction of the grafted alveoli, insufficient bone volume and IABH seems to be a limiting factor for implant placement. Therefore, another bone augmentation procedure is sometimes necessary. Generally speaking, the treatment modality depends on the shape and the volume of the residual grafted alveoli. Small defect could be repaired by GBR (Buser et al., 1990) as a simultaneous augmentation procedure with implant placement. Sometimes however, greater bone volume is necessary for esthetic and functional dental reconstruction in the maxillary anterior region of the grafted alveoli. A various augmentation procedures including onlay bone graft (Fukuda et al., 1998, 2000), titanium mesh and particulate bone graft (Von Arx, et al., 1996; Miyamoto et al., 2011) and alveolar distraction osteogenesis (ADO) (Buis, et al., 2001) could be available for bone augmentation.



Flow Chart of Dental reconstruction of the alveolar cleft using BG and dental implant

a: Adult patients



Flow Chart of Dental reconstruction of the alveolar cleft using BG and dental implant

b: Young patients

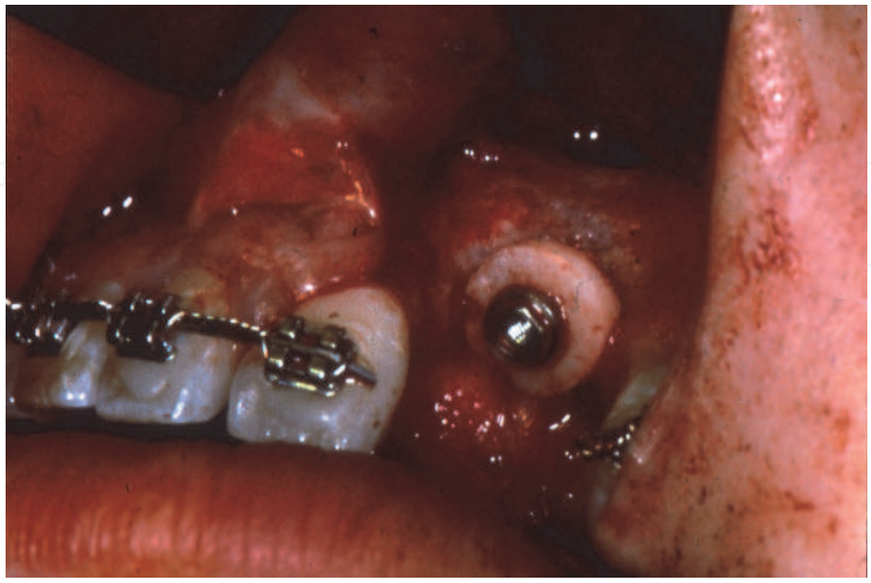
Fig. 7. Flow Chart of Dental reconstruction of the alveolar cleft using BG and dental implant

2.6.1 Chin bone onlay graft

Onlay grafting provides for appropriate alveolar bone height and width in patients with alveolar local bone defects. We have been using chin bone onlay grafting with simultaneous implant placement in patients with insufficient IABH (Fukuda et al., 1998 and 2000). Surgical procedures are as follows. At the grafted alveolus with insufficient IABH, the gingival on top of the alveolar ridge is incised. Mesially and distally to the alveolus, releaf incisions are made buccally. A buccal mucoperiosteal flap is raised to expose the nasal floor. The thickness of the chin bone graft needed, i.e. the height from top to bottom of the inter-dental alveolar bone margin is calculated using calipers. Drilling for implant installation is performed following a surgical protocol, without perforating the nasal mucosa. In the mandibular symphysis region, a vestibular sulcus incision is made through the mucosa. The periosteium is elevated to allow a hand-driven instrument (Leibinger® Fritsch™ Bone Graft Set; Leibinger GmbH, Freiburg, Germany) to be introduced. The tip of a self-tapping implant is inserted into the chin bone without penetration of the lingual cortical bone. The instrument is rotated around the placed implant perpendicularly to the chin bone surface until the labial cortical bone plate has been passed through to the cancellous bone. The implant and monocorticocancellous bone complex are removed by rotating the instrument. This complex (Fig. 8a) is then placed at the prepared recipient site, and the implant is inserted in the cortical bone of the nasal floor (Fig. 8b). Small gap between the complex and the alveolus are filled with cancellous bone chips obtained from the donor site. The periosteium of the mucoperiosteal flap is incised to allow this flap to cover the complex without any tension, and the wound is closed. Six months later, the abutment connection was performed, and prosthetic rehabilitation was completed with a single-unit implant-supported prosthesis. In 7 patients with CLP, simultaneous chin bone onlay graft (CBOG) was performed for implant placement. Although four of the seven patients had an uneventful course, three had some wound dehiscence and exposed chin bone underwent partial (2 cases) or total necrosis (one case). Ultimately, all seven implants were integrated, and the alveolar bone height had increased in all patients except one. A typical case is shown in Fig. 8 (Fig. 8a-d) .



a: Fixture and corticocancellous chin bone complex



b: Clinical appearance after placement of complex



c: Intra-oral view after secondary BG with PCBM followed by completion of orthodontic alignment of maxillary arch.



d: Occlusal view showing final prosthesis rehabilitation. Interdental alveolar bone height (IABH) was increased by CBOG. (Takahashi T, et al. J Oral Maxillofac Surg 1997: 55: 576-583)

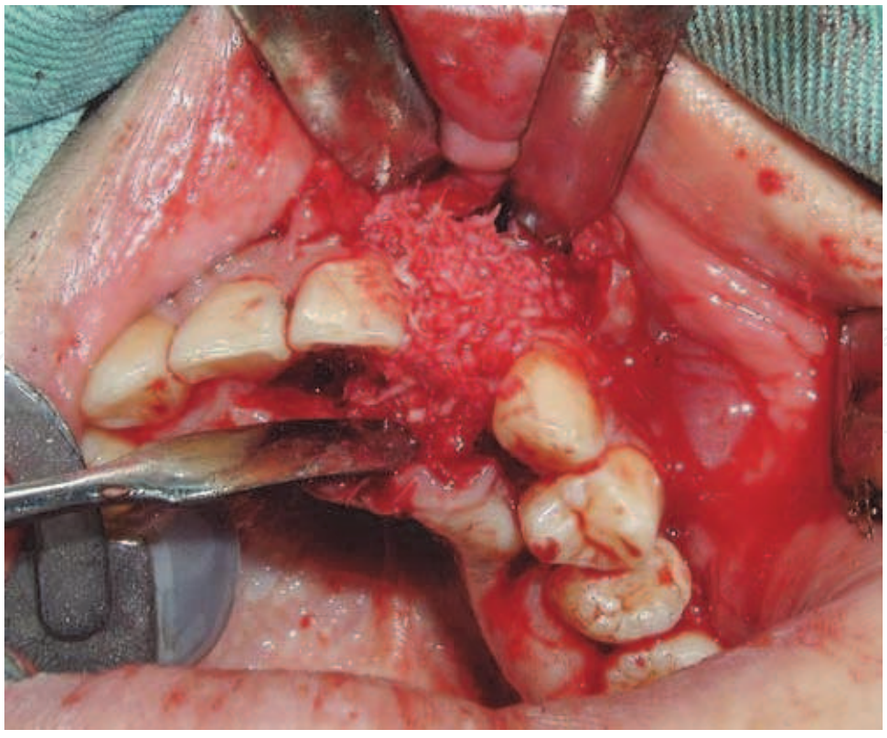
Fig. 8. Augmentation procedure using chin bone onlay graft (CBOG) for dental implant placement

2.6.2 Titanium mesh and particulate bone graft

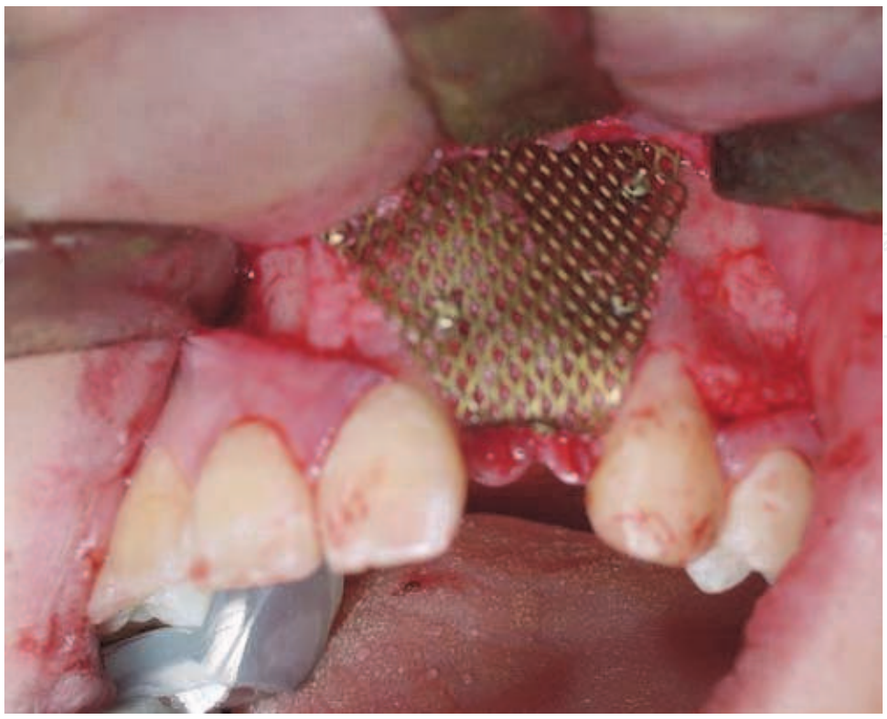
The titanium mesh technique is one alternative, based on bone grafting with a stiff occlusive titanium membrane. Titanium meshes were used according to the shape of the defects. Harvested bone was set on the defects and a shaped titanium mesh was fixed with small titanium screws. A typical case is shown in Fig.9a-e. In this case, grafted alveolus underwent resorption and bone volume as well as IABH was decreased. For the surgical procedure, at the grafted alveolus with insufficient IABH, crestal incision was always used. Mesially and distally to the alveolus, relief incisions are made buccally. A buccal mucoperiosteal flap is raised to expose the nasal floor. Decortication of the drill holes was performed by using round burr to ensure vascular nutrition of the grafted bone. Titanium mesh (0.1- or 0.2-mm thickness; M-TAM, Stryker Leibinger GmbH & Co., USA) were trimmed to ensure to cover the bone grafts. Autogenous particulate bone grafts were obtained from intraoral, mainly from mandibular retromolar region with a scraper (mx-grafter; Maxilon Laboratories, Inc., Hollis, NH, USA). Bone grafts are filled in the recipient site. Then, the titanium mesh was stabilized with several small titanium screws buccally and palatally. With sufficient saline irrigation for a clean surgical field, tension free 5-0 nylon sutures were placed across the incision on the periosteal membrane over the mucoperiosteal flap. A staged approach was used for implant installation.



a: Preoperative view after secondary GB with PCBM followed by completion of orthodontic alignment of maxillary arch.



b: Bone graft (BG) using particulate bone harvested from mandibular ramus.



c: Intra-oral view after secondary BG with PCBM followed by completion of orthodontic alignment of maxillary arch.



d: After implant placement and abutment connection



e: Occlusal view showing final prosthesis rehabilitation. IABH was increased by titanium mesh and BG.

Fig. 9. Augmentation procedure using titanium mesh for dental implant placement

A major complication of the titanium mesh technique is mesh exposure during healing period. Mesh exposure would result in infection, which can jeopardize the results. Therefore, two-stage approach is strongly recommended. Usually, implant placement is suitable 6 months after the titanium mesh and particulate autogenous and bone graft.

2.6.3 Alveolar distraction Osteogenesis

Alveolar distraction Osteogenesis (ADO) is another alternatives of augmentation in the insufficient grafted alveoli. The advantages of ADO include avoiding autogenous bone harvest, and simultaneous soft tissue expansion. However, ADO is very technically sensitive, and many complications are reported. Disadvantages of DO are difficulty in vector control, the exposure of distraction device, necessary for long treatment time. Nonetheless, since the mucosa around the grafted alveoli is abundant in scar tissue, and is difficult in soft tissue cover, the soft tissue expansion by ADO seems to be a big advantage. Clinical data concerning the use of ADO in the grafted area are lacking, and further study will be necessary for ADO.

2.7 Preservation of the grafted bone after implant placement

Our study demonstrated that the IABH did not change for up to 6 years after implant placement. Actually, in this study, IABH was reduced only in 2 of 16 (12.5%) of the implant-placed grafted alveoli. Furthermore, the marginal bone level at 6 years averaged 0.28 mm, showing extremely low resorption around the implant. Although no linear measurement of the IABH bone loss of the grafted alveoli was made in this study, these results clearly demonstrate that implant placement in grafted alveoli maintain the grafted bone after secondary PCBM.

The reason of the maintenance of the implant-placed grafted alveoli in a long-term follow-up may be achieved through functional loading of the grafted bone. Dempt et al. suggested

that the endosseous implants into the grafted alveoli not only closed the gap, but exert functional stimulation of the transplanted bone by mastication (Dempf, et al., 2002). Our data support this hypothesis.

3. Conclusion

This study further confirmed that the use of dental implants placed in the alveoli after PCBM grafting is an excellent treatment modality for the dental rehabilitation of patients with alveolar clefts and congenitally missing teeth and that it is a great tool for preventing grafted bone resorption after cleft repair with secondary BG. However, the grafted alveoli undergo bone resorption in time-dependent manner. Therefore, the loss of width and height of the bone bridge must also be considered for implant installation. If the grafted alveoli do not have sufficient bone volume and IABH, another bone augmentation procedure such as onlay graft, GBR, or titanium mesh and cancellous bone graft technique should be considered.

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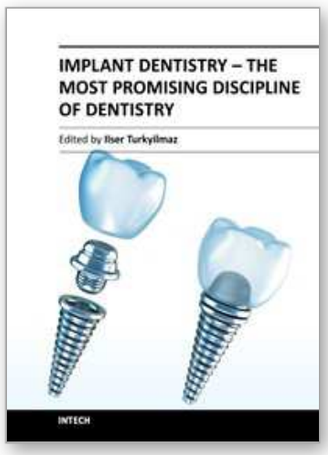
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Implant Dentistry - The Most Promising Discipline of Dentistry

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Since Dr. Branemark presented the osseointegration concept with dental implants, implant dentistry has changed and improved dramatically. The use of dental implants has skyrocketed in the past thirty years. As the benefits of therapy became apparent, implant treatment earned a widespread acceptance. The need for dental implants has resulted in a rapid expansion of the market worldwide. To date, general dentists and a variety of specialists offer implants as a solution to partial and complete edentulism. Implant dentistry continues to advance with the development of new surgical and prosthodontic techniques. The purpose of Implant Dentistry - The Most Promising Discipline of Dentistry is to present a comtemporary resource for dentists who want to replace missing teeth with dental implants. It is a text that integrates common threads among basic science, clinical experience and future concepts. This book consists of twenty-one chapters divided into four sections.

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