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Alveolar Cleft Reconstruction Using Chin Bone and Autogenous Tooth Bone Graft Material: Reports of 5 Cases

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Purpose: To report the successful results of using chin bone graft and autogenous tooth bone graft material (AutoBT) in alveolar cleft patients.

Materials and Methods: Five patients with alveolar cleft defects underwent alveolar bone grafting. Three patients were treated using chin bone graft, and the other two patients underwent AutoBT graft. After implant site development using chin bone graft in the first three cases, endosseous implant restorations were placed. In case #4 and 5, AutoBT graft material was placed to guide the normal eruption of partially impacted maxillary right canine and to the upper docking site after distraction osteogenesis.

Result: Successful implant restorations with closure of the oronasal fistula were achieved in alveolar cleft defect reconstruction using either chin bone graft (Case #1, 2, 3) or AutoBT graft material (Case #4, 5). Case #4 showed enlarged follicle of the right maxillary canine, indicating a normal eruption guide pattern.

Conclusion: Both chin bone graft and AutoBT graft showed favorable outcomes in reconstructing alveolar cleft defects. Autogenous tooth bone graft opens up the possibility of avoiding harvesting autogenous bone graft with complications and morbidities.

Key Words: Alveolar bone; Autogenous tooth; Cleft

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Introduction

The reconstruction of alveolar cleft with bone grafting is an essential part in the management of cleft patients. Alveolar cleft repair is necessary to stabilize alveolar segments, close the oronasal fistula, support the alar base of the nose, reconstruct the nasolabial soft tissue, and provide bony support and volume for tooth eruption or future implant placement. Note, however, that choosing the right bone grafting materials in the rehabilitation of patients with alveolar cleft defects has not been simple. Since Boyne and Sands[1] used autogenous iliac cancellous bone for the reconstruction of alveolar cleft defects at the age of 8~11 years during the transitional dentition phase, autogenous iliac crest cancellous bone grafting has apparently been the material of choice. Cancellous iliac crest bone showed osteoconductivity, osteoinductivity, and bone remodeling capacity. If more adequate alveolar bone volume is necessary for successful dental implant restoration, however, mandibular bone grafting has been the preferred donor material of choice due to less grafted bone resorption. Mesenchymal bone-derived mandibular bone showed lesser bone resorption compared to endochondral bone (e.g., iliac crest bone)[2,3].

Nonetheless, autogenous bone grafting requires extensive surgeries associated with infection risks, postoperative pain, and additional costs. Recently, clinicians have explored the alternative option of using autogenous tooth bone graft (AutoBT; Korea Tooth Bank Co., Seoul, Korea) material in alveolar cleft reconstruction. The organic and inorganic contents in AutoBT are very similar to those in alveolar bone. Moreover, AutoBT possesses the same capabilities as the autogenous bone graft since it showed osteoconduction, osteoinduction, and bone remodeling[4,5].

This article reports five cases of the successful use of chin bone graft and AutoBT in alveolar cleft repair.

Materials and Methods

The study was approved by the Seoul National University Bundang Hospital institutional review board (IRB) for clinical studies (IRB No. B-1205-153-103).

1. Case #1 (Fig. 1)

A 22-year-old healthy Korean male with right maxillary alveolar cleft defect visited the oral and maxillofacial surgery clinic at the Seoul National University Bundang Hospital for future implant treatment for a missing maxillary right lateral incisor. Oronasal fistula was not present at the time of visit. The clinical examination and x-ray revealed insufficient bone level for implant restoration. The patient was prepared and sterilely draped in the usual fashion for intraoral surgery. Preoperative rinse with 2% chlorhexidine was provided to the patient before the surgery. Autogenous chin block bone grafting was performed and stabilized with

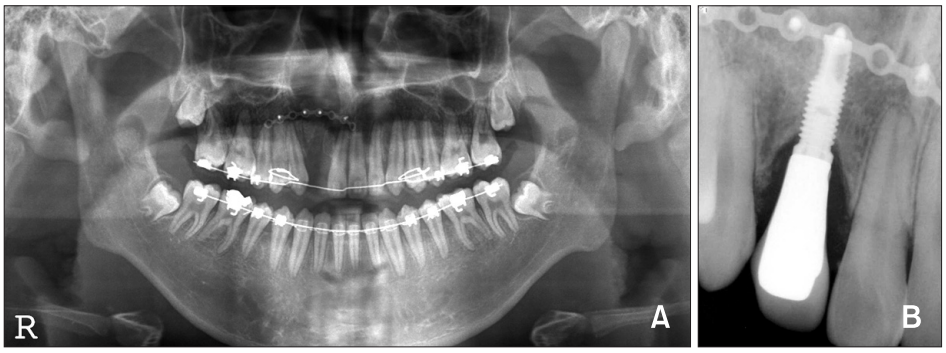

Fig. 1. (A) Chin block bone was grafted and fixed using titanium microplate. (B) Implant prosthesis was completed. The clinical crown became longer than expected because of crestal bone resorption.

plate and screws in combination with DBX (Synthes, Westchester, PA, USA). The bone graft site was covered with Ossix Plus membrane (OraPharma Inc., Warminster, PA, USA). The surgery was uneventful, and post-operative recalls were not significant. After an 18-month healing period, an implant (Nobel Biocare AB, Gothenburg, Sweden) with diameter of 3.75 mm and length of 11.5 mm was placed at the repaired site. Osstell Mentor (Integration Diagnostics AB, Göteberg, Sweden) was used to measure the implant stability quotient (ISQ). Finally, screw-type implant restoration was done with custom cast abutment with screw retention (UCLA) abutment 6 months after the implant placement surgery.

2. Case #2 (Fig. 2)

A 42-year-old Korean male visited the oral and maxillofacial surgery clinic at the Seoul National University Bundang Hospital with 10 missing teeth from the maxillary left second premolar to the maxillary right second premolar. He primarily wanted to be able to eat and smile with implant fixed prosthesis. The patient was prepared and sterilely draped in the usual fashion for intraoral surgery. Preoperative rinse with 2% chlorhexidine was provided to the patient before the surgery. Significant maxillary anterior bone loss with oronasal fistula on the right side was noted. A large alveolar defect at the sites of the missing teeth was unsuitable for implant placement. Autogenous chin block bone was harvested and secured in the maxillary anterior region after splitting the graft in half with plate and screws. Additionally, DBX (Synthes) and BioCera (Oscotec Inc., Cheonan, Korea) were added at the grafted site after raising the labial finger flap. A resorbable membrane (Bio-Arm; Purgo Inc., Oakland, CA, USA) was then placed over the graft material. Implants were placed on the maxillary right (diameter of 3.8 mm, length of 10 mm; Dentium, Seoul, Korea) and left (diameter of 4 mm, length of 8 mm; Dentium) lateral incisor sites 14 months after the alveolar cleft reconstruction surgery. After a 23 month loading period, additional implants were installed in both premolar areas. After 11 months, ready-made cementation abutments were replaced with milled screw-cement-retained prosthesis (SCRP), with the final prosthesis delivered.

3. Case #3 (Fig. 3)

A 34-year-old Korean male visited the oral and

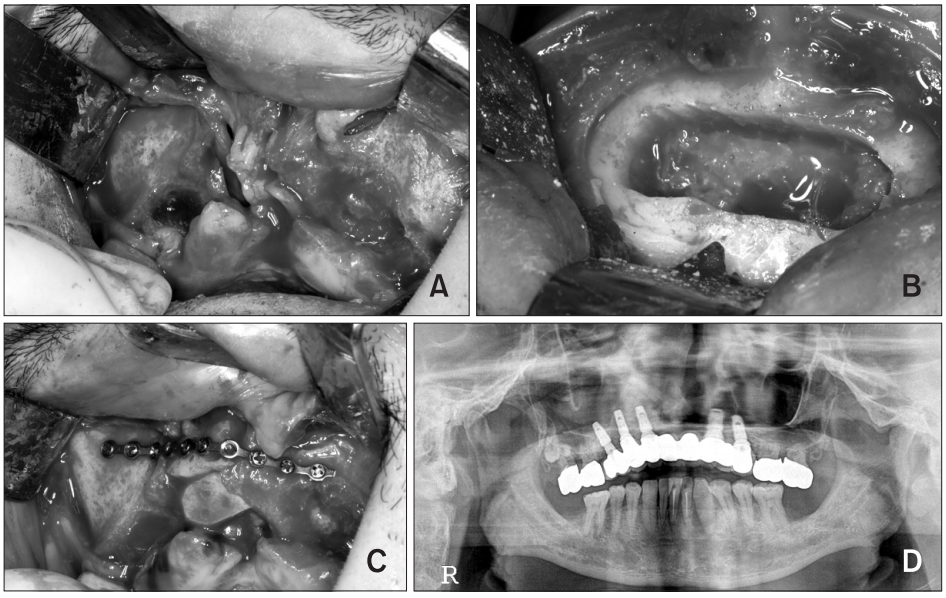

Fig. 2. (A) Preoperative intraoral view. Severe oronasal fistula was observed. (B) Chin corticocancellous block bone was harvested. (C) Chin block bone was fixed with titanium plate and screws. (D) Huge cleft alveolus was rehabilitated with chin bone grafting and implants.

maxillofacial surgery clinic at the Seoul National University Bundang Hospital seeking implant treatment for a missing maxillary right lateral incisor. The clinical examination showed oronasal fistula that was otherwise insignificant. The patient was prepared and sterilely draped in the usual fashion for intraoral surgery. Preoperative rinse with 2% chlorhexidine was provided to the patient before the surgery. Due to the alveolar bony defect, autogenous chin block bone was used for grafting after exposing the cleft defect. DBX, Bio-Oss (Geistlich Pharma AG, Wolhusen, Switzerland), and double layer Bio-Arm were placed over the graft material, and the mucosa layer was closed with No. 3-0 vicryl suture. Seven months after the alveolar cleft repair, an implant (diameter of 3.5 mm, length of 11 mm; Astra Tech AB, Mölndal, Sweden) was placed uneventfully. Once the implant was stable and integrated at 2 months, the zirconia abutment IPS Empress II (Shikosha Dental Laboratory, Inc., Portland, Oregon) crown was finally cemented.

4. Case #4 (Fig. 4)

A 10-year-old Korean female in orthodontic treatment was referred to the oral and maxillofacial surgery clinic at the Seoul National University Bundang Hospital for alveolar bone graft. The clinical examination and x-ray revealed the absence

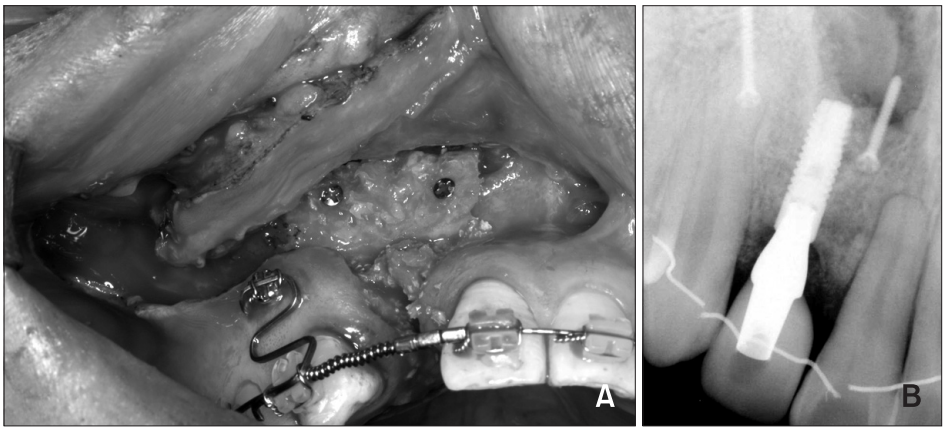

Fig. 3. (A) Oronasal fistula was filled with chin block bone. (B) Periapical radiograph 1 year after implant prosthetic delivery. Crestal bone level was stable.

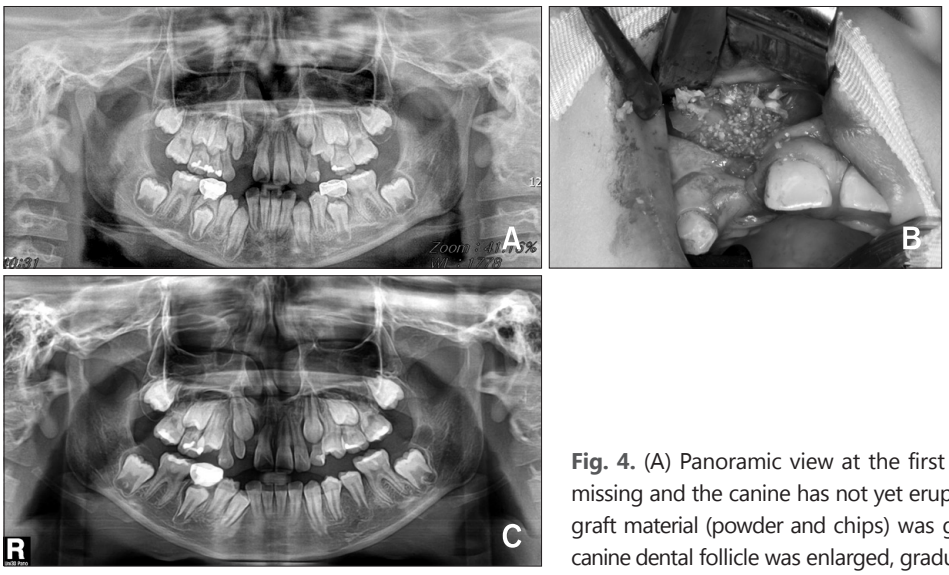

Fig. 4. (A) Panoramic view at the first visit. The right lateral incisor is missing and the canine has not yet erupted. (B) Autogenous tooth bone graft material (powder and chips) was grafted. (C) After 9 months. The canine dental follicle was enlarged, gradually erupting.

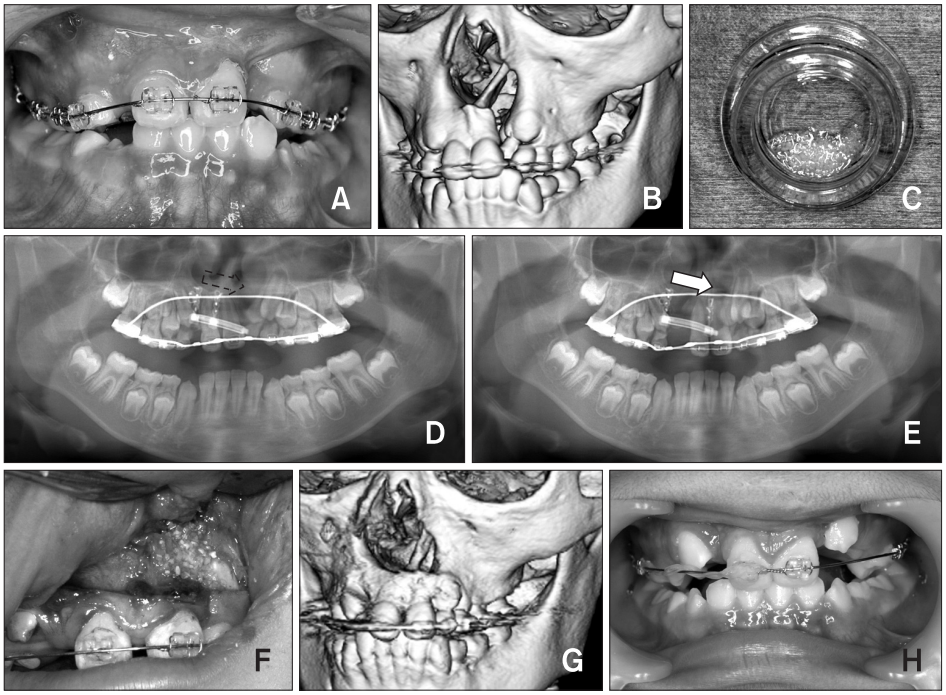

Fig. 5. Maxillary bone transport for alveolar cleft repair and AutoBT graft. (A) Pre-surgery intraoral photograph. (B) Pre-surgery 3-dimensional computed tomography (3D-CT) image. (C) AutoBT powder from supernumerary teeth. (D) Maxillary bone transport to reduce the amount of bone grafting. (E) Alveolar maxillary bone was transported in the planned direction. (F) AutoBT grafting to the upper docking site. (G) Post-surgery 3D-CT image. (H) Intraoral photograph show a good result of the alveolar cleft repair.

of both maxillary right lateral incisor dental follicle and oronasal fistula. The ultimate goal of the treatment was guiding the normal eruption of the maxillary right canine after providing space through orthodontic treatment. The deciduous maxillary right first molar was extracted before the alveolar bone graft to prepare the AutoBT grafting material. The patient was prepared and sterilely draped in the usual fashion for intraoral surgery. Preoperative rinse with 2% chlorhexidine was provided to the patient before the surgery. AutoBT chip and powder type were used for grafting. All surgeries were uneventful.

5. Case #5 (Fig. 5)

A 9-year-old Japanese female patient suffering from unilateral cleft lip and palate (left-side) was treated with AutoBT grafting. She underwent cheiloplasty 2 months earlier and palatoplasty 1 year and 6 months earlier. Note, however that alveolar cleft and fistula (left-side) were left. Upper midline deviation from the facial midline and impacted canines on both sides at the upper and distal positions were observed. She had 3 supernumerary teeth, so we extracted them for use as AutoBT materials. There are both enamel and dentin powder amounting to 0.16 grams. Thus, we planned maxillary bone transport to reduce the amount of bone grafting. Operation was performed under local anesthesia with i.v. sedation. After sagittal interdental right-side maxillary osteotomy between #11 and #12 is performed completely to the nasal floor, alveolar maxillary bone (#11 and #21) was transported in the planned direction (left) using an alveolar transporter, and the alveolar cleft was closed. Bone transporter removal was performed after a 3-month consolidation period, but the bony defect at the upper docking site remained. Therefore, we tried to perform AutoBT grafting simultaneously to the upper docking site under local anesthesia at the time of removal of the device. The post-surgery 3-dimensional computed tomography images and intraoral photograph show a good result of the alveolar cleft repair.

Result

The anagraphic data and clinical features of the

Table 1. Anagraphic data and clinical features of patients

Variable	#1	#2	#3	#4	#5
Age/gender	22/M	42/M	34/M	10/F	9/F
Location of cleft alveolus	Rt	Rt	Rt	Rt	Lt
Oronasal fistula	No	Yes	Yes	No	Yes
Missing teeth	#12	#15~25	#12	#12	#22
Graft materials	S+DBX	S+DBX+BioCera	S+DBX	A	A
Healing periods (mo)[a]	18	14	7	-	-
Implant location	#12	#12, 22	#12	-	-
Complication	No	Wound dehiscence	No	No	No
Loading periods (mo)[b]	35	23	38	-	-

M: male, F: female, Rt: right alveolus, Lt: left alveolus, S: symphysis block bone, A: autogenous tooth bone graft material.
[a]Periods from alveolar bone grafting~implant placement except #4, 5. [b]Loading periods after temporary crown restoration except #4, 5.

patients are summarized in Table 1.

1. Case #1

The post-operative course of examinations was uneventful, without any evidence of infection. Moreover, there was no evidence of clinically significant resorption of alveolar cleft reconstruction. The implant was well-osteointegrated, with ISQ measurement of 62. The patient's periodontal health was insignificant, with normal probing depth.

2. Case #2

During the first post-operative recall exam following the alveolar cleft defect repair, partial wound dehiscence of flap was noted. Wound dressing and intraoral gargling were performed, and favorable secondary healing was obtained. Besides the partial tear of the flap, there was no evidence of infection or significant absorption at the grafted site. Oral hygiene was well-maintained and implants were osteointegrated with ISQ measurement of 61 at the maxillary right lateral incisor site and 44 at the maxillary left lateral incisor site. All implants were stabilized with stable crestal bone position without any mobility.

3. Case #3

There were no complications during surgery, and post-operative recall clinical examinations were uneventful. The Periotest (Siemens AG, Benssheim, Germany) value was -6. The implant as replacement of the maxillary right lateral incisor was well-osteointegrated without any infection or bone resorption around the implant.

4. Case #4

No infection or fistula was observed after the grafting was completed. The patient's oral hygiene was well-controlled. The 9-month recall x-ray showed enlarged canine dental follicle with normal eruption pattern.

5. Case #5

Surgical closure of the alveolar cleft was achieved by maxillary bone transport and Auto-tooth bone grafting simply under local anesthesia without any problem, and good positioning of the canines was gained with postoperative orthodontic treatment. Maxillary bone transport allowed the simultaneous correction of nasal septal deviation as well as the correction of maxillary arch deformities and malocclusion since the dental arch is expanded without donor sacrifice and soft tissue expansion. AutoBT grafting to the docking site allowed good repair of the alveolar cleft and better bone connection.

Discussion

The essential objectives of alveolar cleft reconstruction are to stabilize the maxillary alveolus and to facilitate tooth eruption. A more recent goal, however, is to maximize bone volume for future implant restoration in the edentulous space.

The choice of grafting material has been the subject of debate over time. Traditionally, cancellous bone graft was widely used in the management of alveolar clefts because of successful bone remodeling through rapid vasculation and osteoblastic activity. After the study by Bosker and van Dijk in 1980, however, the clinical use of mandibular chin bone for secondary bone grafting of residual alveolar cleft procedure became the material of choice in most cases. The mandibular bone graft is easier to obtain, requiring shorter operating times with invisible intra-oral scar compared to iliac crest bone grafting[6-8]. Moreover, intramembraneous mandibular bone graft can retain more bone space through less resorption than endochondral bone graft in the area of alveolar cleft for future implant placement. Furthermore, mandibular bone graft is expected to provide some resistance due to the presence of cortical bone. As a result, when future implant restoration is needed at the site of alveolar cleft, mandibular block bone becomes the donor material of choice.

Generally, mandibular block bone has been required to harvest more bone volume than actually needed due to its irregular resorption rate[9]. In fact, due to the resorption of mandibular bone graft, the longer clinical crown was fabricated in implant restoration than the first clinical assumed measurement of crown length soon after bone graft was done in case #1 and #2. Additionally, mandibular bone grafting requires firm stabilization with screws[2,8]. As a result, it took us 18 months (case #1), 14 months (case #2), and 7 months (case #3) to place an implant after grafting was done. It is important to wait until the mandibular bone graft is fully integrated with the present alveolar bone to avoid failure.

AutoBT consists of 55% inorganic and 45% organic substances by weight. These constituents, especially type I collagen, are very similar to those in dentin and alveolar bone. Previous studies on AutoBT demonstrated active bone formation and remodeling through osteoconduction and osteoinduction, with little or no infection risk despite the partially opened wound after surgery[4,5,10,11]. More importantly, since AutoBT was fabricated by bio-recycling the patient's own extracted tooth, it is less technique-sensitive and is patient-friendly without any major surgery. Case #4 also used AutoBT as grafting material in reconstructing alveolar cleft defects to guide the normal eruption of maxillary right canine. Studies have demonstrated that restoring alveolar cleft from the crest of the alveolus to the base of the nose early in the developmental stage of maxillary canine promotes normal eruption through the grafted area[12-14]. Although the recommended time in alveolar bone grafting is controversial, secondary bone grafting in mixed dentition is normally done between the ages of 9 and 11 when the canine root is one-fourth to two-thirds developed[13]. The patient in Case #4 received AutoBT grafting at the age of 10. By associating between the canine position and the status of adjacent lateral incisor, the x-ray taken 9 months after the grafting revealed that the maxillary right canine in Case #4 was gradually erupting with enlarged dental follicle. This case is the first reported case wherein AutoBT was used as grafting material instead of other autogenous bone grafts, and the results could be carefully anticipated.

In Case #5, the combination of maxillary bone transport and AutoBT grafting for alveolar cleft repair was performed by several operations simply under local anesthesia without requiring hospital stay. AutoBT has already been used for bone grafting in implant surgery and periodontal surgery but can also be used in oral and maxillofacial

surgery. Thus, we tried to use AutoBT grafting for alveolar cleft repair. In the original procedure (Maxillary Bone Transport), bone graft is harvested from the new bone in the transportation gap to the upper docking site. We tried to perform AutoBT grafting to the upper docking site. As the advantages of AutoBT grafting, there is no need for the autogenous donor sites used for alveolar bone grafting (including iliac crest, rib, calvarium, tibia, and mandibular symphysis), and there is less graft failure caused by infection and wound rupture. The frequency of wound rupture occurring in cases using AutoBT was the same as that in other cases using other synthetic grafting materials, but the complete loss of grafted AutoBT materials has yet to be reported[11]. The extracted deciduous teeth can be useful for AutoBT materials if preserved. Further, the combination with maxillary bone transport can further delay the timing of bone grafting for alveolar cleft. The extracted wisdom tooth or extracted premolar tooth for orthodontic treatment may be recycled if preserved. The disadvantages of AutoBT grafting include the limited number of teeth for extraction. Nonetheless, the combination of bone transport can reduce the volume of AutoBT materials required.

Conclusion

Generally, chin block bone graft has been the donor material of choice in the reconstruction of alveolar cleft defects with future implant fixture placement. This study showed both successful results in alveolar cleft reconstruction achieved by chin block bone and AutoBT without complications or infections. Implant restorations were successfully done at the grafted sites in all three cases. Moreover, AutoBT was a successful grafting material of choice in a patient with mixed dentition for restoring alveolar cleft defects to guide normal tooth eruption through the grafted area. Even though there were only two cases using AutoBT in alveolar cleft repair, the use of AutoBT opens up the possibility of avoiding harvesting autogenous bone and its associated complications and costs.

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