



Toby J Gillgrass Mark Devlin and Alan J Gowans

Alveolar Bone Grafting: CLP Series Part 7

Abstract: Alveolar bone grafting is a key surgical procedure for a child with a cleft involving a significant alveolar defect. It allows permanent tooth eruption around the cleft and subsequent orthodontic tooth movement and optimal aesthetic outcomes.

Clinical Relevance: Alveolar bone grafting is a key stage within the care pathway of a child with a cleft of the alveolus. A successful outcome is essential for the optimal dental aesthetic outcome.

Ortho Update 2013; 6: 78–80

Clefts of the lip and palate also affect the alveolar area, resulting in a bony defect or gap within the lateral incisor and canine tooth region of the maxilla. The alveolar cleft may be complete or incomplete, unilateral or bilateral and, in keeping with unilateral cleft lip and palate, is twice as common on the left side as the right. Clefts involving the alveolus have significant effects on the dentition, affecting tooth development and eruption (Figures 1a and b). Bone grafting of the cleft alveolus is required in order to allow the eruption of the permanent canine tooth (and occasionally the lateral incisor) within the cleft site and to provide adequate bony support for the long-term health of the adjacent teeth. Good bone support also allows optimal orthodontic treatment within the upper arch. An oro-nasal fistula or communication may also exist within the cleft alveolus which, if symptomatic, can allow escape of foods or fluids from the mouth to the nose. Successful bone grafting will repair the fistula and close any abnormal communication.

The aims of alveolar bone grafting are to:

- Facilitate tooth eruption in the region of the cleft (especially the permanent canine and sometimes the lateral incisor, if present);
- Provide good bone support for the teeth on either side of the cleft;
- Enable subsequent orthodontic tooth alignment;

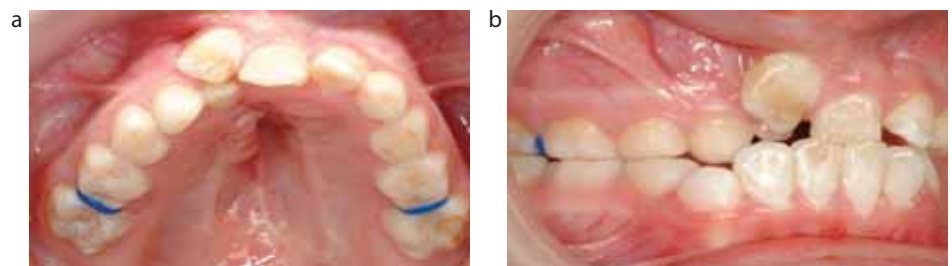


Figure 1. (a, b) Showing a patient in the mixed dentition with right unilateral cleft lip and palate prior to bone grafting. There is constriction of the lesser segment leading to crossbite. The upper right central incisor is also diminutive, hypoplastic and rotated.

- Close any oro-nasal communication in the alveolar region;
- Unite the bony segments of the maxilla;
- Improve the bone support at the base of the nose.

Investigations, timing and preparation

It is widely accepted that the optimal timing for alveolar bone grafting is before the eruption of the permanent maxillary canine tooth.¹ A radiographic assessment of the canine tooth development is therefore carried out at 7–8 years of age and the treatment planned such that, ideally, the bone graft surgery is carried out when the canine tooth root is between one-half and two-thirds developed (Figure 2). The precise timing of the treatment is

decided jointly between the orthodontist and the surgeon. In many cases, therefore, the operation takes place when the child is between 9 and 11 years of age. In some cases, earlier bone grafting may be recommended, if a favourable unerupted lateral incisor tooth is also present on the mesial side of the cleft. It has been suggested that this earlier bone grafting may provide a better periodontal outcome.²

The requirement for grafting is clear when the cleft of the alveolus is complete. However, where only a partial cleft of the alveolus exists, determining whether a graft is required can be difficult. The evolution of cone-beam computer tomography (CBCT) has allowed a more accurate assessment of the defect (Figure 3a). It is also more straightforward to locate

Toby J Gillgrass, BDS, FDS(Orth), Consultant Orthodontist Cleft Lip and Palate, Hon Senior Clinical Lecturer, Glasgow University, **Mark Devlin**, FRCSEd(OMFS), FRCSEd, FRCS(Glasg), FDS RCPS, Consultant Cleft and Maxillofacial Surgeon, Hon Clinical Senior Lecturer, Royal Hospital for Sick Children, Glasgow and **Alan J Gowans**, BDS, FDS(Orth), Lead Consultant Orthodontist Cleft Lip and Palate (Northern & Yorkshire), Hon Senior Lecturer, University of Leeds, Leeds, UK.

supernumerary teeth frequently found with the defect. The extra teeth will often be removed during surgery (Figure 3b).

Orthodontic preparation

Optimal treatment outcomes are dependent on a good standard of oral health, and it is imperative that active carious lesions are treated before any orthodontic preparation or surgery and that the child maintains a good standard of oral hygiene.

A short period of orthodontic appliance treatment is often required before the bone graft operation. The benefits of this pre-surgical orthodontic treatment are to:

- Provide better access to the graft site for the surgeon;
- Improve the relationship of the maxillary bony segments;
- Correct some crossbites.

Pre-surgical orthodontic assessment most frequently involves transverse expansion and, in some cases, incisor Class III correction where growth permits (Figures 4a and b). The most common appliance to produce the transverse expansion is the quad- or tri-helix appliance cemented to the first molars (Figure 4c). Difficulties can be encountered owing to the limited eruption of the first molars, resulting in reduced crown height for attachment and unusual form of the teeth

and palate, making location difficult.

Once expansion or preparation is complete, the appliance may be changed to a trans-palatal arch to improve access for the surgeon, especially if an anterior palatal fistula is present. Alternatively, it can be removed and replaced during surgery.

When the alveolar clefts are bilateral, then it is very important to stabilize the mobile premaxillary segment after surgery with a rigid labial archwire, to prevent excessive movement which would compromise healing.

Surgical procedure

The operation is carried out under general anaesthesia. Local mucoperiosteal flaps are raised around the alveolar cleft to define the bony defect fully. To increase the amount of attached mucosa for closure, deciduous teeth in the region are often removed a few months before grafting. Important steps within the procedure are:

- To repair the nasal floor carefully;
- Overfill the bony defect with well-condensed autogenous cancellous bone chips. The bone is often harvested from the anterior iliac crest region, although a suitable alternative site is the upper tibia;
- Minimize the surgical time between the graft harvest and subsequent placement into the vascularized recipient alveolar defect;

- Obtain a ‘water-tight’ soft tissue close around the graft with well-vascularized keratinized local flaps. Teeth will not erupt through non-keratinized mucosa;
- Ensure good post-operative pain relief: a bupivacaine local anaesthetic infusion into the iliac crest bone harvest site is highly effective.

Post-operative assessment of outcome

A successful outcome is dependent on the following:

- No residual oro-nasal fistula within the alveolar region;
- Good in-fill of the previous bony defect on radiological assessment;
- Eruption of the permanent canine tooth (and lateral incisor, if present) through the grafted site;
- Good periodontal supporting bone for the teeth adjacent to the grafted site.

Radiological assessment of the bone graft is carried out between 3 and 6 months post-operatively. Bergland *et al* described a system of bone graft assessment

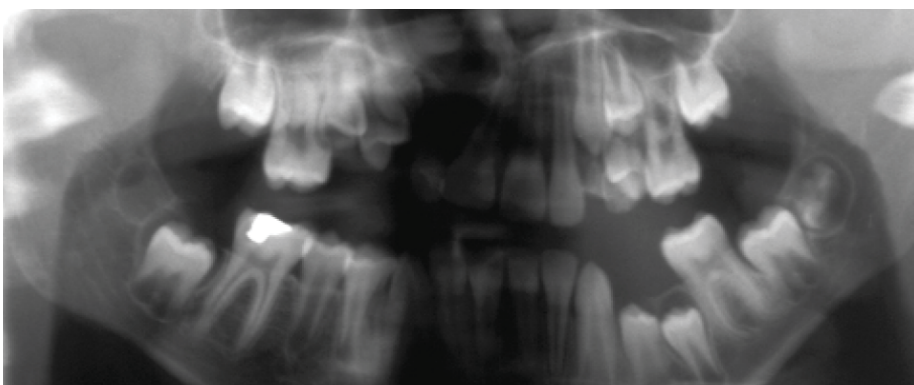


Figure 2. Radiograph of a patient with a unilateral right cleft lip and palate, showing absence on the upper right lateral incisor and an unerupted upper right permanent canine with a root length approximately two-thirds formed.

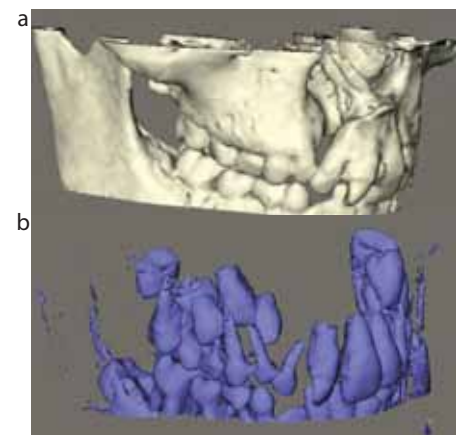


Figure 3. (a) CBCT for a patient with cleft lip and alveolar cleft showing a clear alveolar defect. (b) CBCT for patient with cleft lip and alveolar cleft showing the erupted and unerupted dentition. The root of the canine is a third formed and there is a diminutive upper right lateral incisor lying palatally.



Figure 4. Right unilateral cleft lip and palate showing cleft alveolus (a) before and (b) after orthodontic expansion using a quad-helix appliance. This has resulted in buccal and anterior crossbite correction and improved access to the cleft site for grafting. (c) Occlusal photograph of the patient shown in (a) and (b) with the quad-helix in place pre-bone graft.

based on the height of interdental bone on a radiograph taken after canine tooth eruption.³ More recently, Kindelan *et al* described a different system of radiographic bone assessment, which can be applied prior to canine tooth eruption.⁴ Nightingale *et al* compared the reproducibility of three different scoring systems, although none was found to be particularly superior.⁵ Anterior occlusal radiographs are often used for this purpose (Figures 5a, b).

The orthodontic expansion device is maintained post-operatively and often removed after radiographic assessment, suggesting success 3–6 months post-graft. The canine tooth erupts spontaneously in most cases, usually within 1–2 years after grafting. The erupting tooth promotes bone development within the grafted site through the functional stimulus. Occasionally, the canine may fail to erupt and surgical exposure may be necessary.

Computed tomography (CT scan) gives a more accurate 3-dimensional assessment of bone volume achieved after grafting and accurately shows the relationship of the tooth roots to assist definitive orthodontic planning.

Longer-term bone graft resorption can occur when the graft is unloaded and non-functional, which may occur if space maintenance is favoured over orthodontic tooth space closure within the alveolus. In poor outcome cases, when no permanent tooth is present, and/or bone grafting is delayed, then the subsequent bone loss following grafting can be up to 95%.⁶ Implant placement into the grafted site and subsequent loading with a fixed prosthesis, such as a crown or bridge, offers a better chance of long-term alveolar bone retention.

Complications of surgery

Outcomes following alveolar bone grafting are predictably good when co-ordinated within a cleft team and carried out by experienced surgeons. A national audit of cleft lip and palate alveolar bone grafts in 2006 (CRANE) showed a high level of success, especially in unilateral cases with a 92% success rate.⁷ This compares favourably with a previous national audit carried out before cleft centralization in 1998 (Clinical Standards Advisory Group report on cleft lip and palate), which reported a 58% successful outcome in unilateral cleft lip and palate after bone grafting.⁸

Although complications are infrequent, they include:

- Wound dehiscence;
- Recurrent oro-nasal fistula;
- Wound infection;

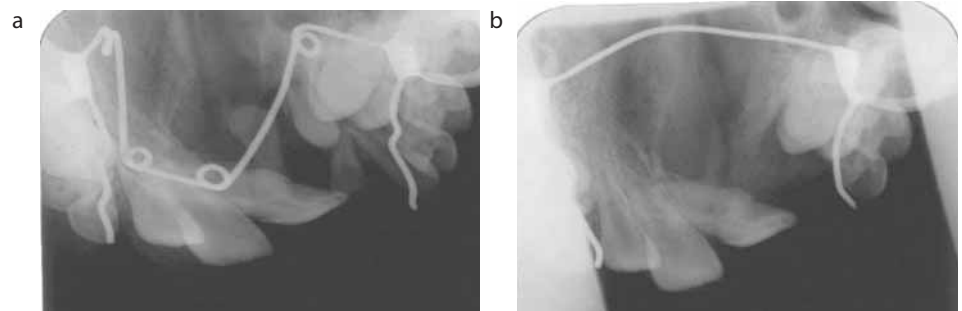


Figure 5. (a) Upper anterior radiograph for a patient with a unilateral cleft lip and palate showing two supernumeraries in the cleft site pre-bone graft. (b) Upper anterior radiograph for the same patient as (a) post bone graft operation showing good bony filling of the previous defect. The supernumerary teeth were also removed at operation.

- Inadequate interdental bone height;
- Granuloma or fibrous epulis formation;
- Tooth root resorption, possibly due to tooth root cemental damage during the procedure.

Graft harvest site complications are also infrequent, especially the anterior iliac crest site, but would include infection and local paraesthesia of the skin. Rare complications of the anterior tibial harvest site would also include epiphyseal plate damage or actual tibial fracture.

Summary

Alveolar bone grafting is a very important operation for children with cleft lip and palate. Outcomes are good, enabling canine tooth eruption and subsequent definitive orthodontic treatment to align the teeth. A debate continues as to the relative merits of space closure with medial movement of the canine versus space maintenance and subsequent implant placement with replacement of the missing lateral. Implant replacement will however almost certainly require further grafting of the missing lateral incisor.

Important factors to consider with regard to final outcomes are:

- Timing of the surgery: before canine tooth eruption – ideally, when canine root development is one-half to two-thirds;
- Skilled pre-surgical orthodontic preparation to facilitate surgical access;
- Careful soft tissue repair of the oro-nasal cleft, especially the nasal floor;
- Autogenous cancellous bone graft particles fully-packed into the defect;
- Tension-free closure with attached (keratinized) mucoperiosteal flaps;
- Maintenance of a high standard of oral hygiene;
- Co-ordination of care by a designated specialist cleft centre;

- Operation performed by an experienced surgeon.

Research into the use of bone substitutes (eg hydroxyapatite) and bone-induction agents, such as bone morphogenetic proteins (BMP), continues. Whilst these agents may offer some benefit in special cases, it is difficult at present to foresee a time when they would replace autogenous cancellous bone as the donor material of choice owing to the consistently good outcomes.

References

1. Boyne PJ, Sands NR. Combined orthodontic-surgical management of residual palato-alveolar cleft defects. *Am J Orthod* 1976; **70**: 20–37.
2. Precious DS. A new reliable method for alveolar bone grafting at about 6 years of age. *J Oral Maxillofac Surg* 2009; **67**: 2045–2053.
3. Bergland O, Senb G, Abyholm F. Elimination of the residual alveolar clefts by secondary bone grafting and subsequent orthodontic treatment. *Cleft Palate J* 1986; **23**: 175–205.
4. Kindelan J, Nashed R, Bromige M. Radiographic assessment of secondary autogenous alveolar bone grafting in cleft lip and palate patients. *Cleft Palate Craniofac J* 1997; **34**: 195–198.
5. Nightingale C, Witherow H, Reid FD, Edler R. Comparative reproducibility of three methods of radiographic assessment of alveolar bone grafting. *Eur J Orthod* 2003; **25**: 35–41.
6. Feichtinger M, Zemmann W, Mossbock R, Karcher H. Three-dimensional evaluation of secondary alveolar bone grafting using a 3D-navigation system based on computed tomography: a two-year follow-up. *Br J Oral Maxillofac Surg* 2008; **46**: 278–282.
7. CRANE – National Audit of Alveolar Bone Graft Outcomes. CRANE Database, 2006.
8. Clinical Standards Advisory Group (CSAG). *Cleft Lip and Palate. Report of a CSAG Committee*. London: HMSO, 1998.