

Alveolar Bone Grafts: The Surgical/Orthodontic Management of the Cleft Maxilla

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Abstract

The purpose of this paper is to discuss the management of the cleft maxilla with emphasis on the controversies concerning the decisions which a cleft palate team makes with limited evidence but strong beliefs in the anticipated outcomes. The orthodontist and the surgeon need to collaborate in determining the timing and sequencing of alveolar bone grafting. Currently the emphasis on secondary bone grafting has superseded primary bone grafting in its effectiveness and efficiency. Contemporary management of infants born with clefts of the lip and palate is to delay bone grafting until the early mixed dentition stage of dental development with the optimal timing being related to the development of the unerupted permanent canine. In the management of patients with cleft palate, the surgeon and the orthodontist need to evaluate the mixed dentition stage of dental development to determine the optimum timing of treatment to coincide with the most favourable eruption of the maxillary canine or the lateral incisor when this tooth is on the distal side of the cleft.

The issues which have led to controversy relate to (i) the age at which alveolar bone grafting should be performed, (ii) the type of bone graft and the site from which the donor bone will be harvested and (iii) the timing of the maxillary expansion and whether this should be performed before or after the alveolar bone graft is placed. A review of contemporary management of the palatal and alveolar cleft is discussed and illustrated in unilateral and bilateral clefts of the maxilla.

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Introduction

Secondary alveolar bone grafting, which was pioneered in Europe, was reported in the German literature at the beginning of this century.^{1,2} However, it was not until the 1970s that secondary or delayed bone grafting became popular in the United States. Primary bone grafting in infants was introduced in the 1950s and had preceded secondary bone grafting by almost twenty years in its popularity.^{3,4} This intervention united the cleft alveolus and palate by filling the cleft defect with autogenous bone, typically a split rib graft. This logical and desirable situation came under scrutiny when long-term results indicated that those infants who underwent early/primary bone grafting became more midface deficient in their subsequent midfacial craniofacial growth and development.⁵ Additionally, in Europe, neonatal maxillary orthopaedics was being adopted in the 1960s as an adjunctive method to move the maxillary segments into approximation before primary surgical lip repair. This allowed the surgeon to perform the lip repair more easily with the benefits of shorter operating time and a reduction in the number of dehiscences and an im-

proved result both aesthetically and functionally.^{6,7} Although many claims were made for the effectiveness of neonatal maxillary orthopaedics, the strength of evidence was mainly from anecdotal case reports, case series and retrospective studies rather than that achieved by a randomised controlled prospective clinical trial. However, this was not unexpected as the methodology and design for conducting the more rigorous type of clinical trials was not available at the time when neonatal maxillary orthopaedics was introduced. As with all controversies, they are usually fuelled by strong conviction, weak evidence and imperfect theory and the early treatment intervention of neonatal maxillary orthopaedics was no exception. Three decades later, new information has become available from a multicentre clinical trial in the Netherlands where the uncertainty of the efficacy of neonatal maxillary orthopaedics has resulted in a randomised clinical trial.⁸ To determine the efficacy of treatment requires strict protocols with well-defined inclusion and exclusion criteria. As many of the centres engaged in maxillary orthopaedics in infants were also doing this in conjunction with primary bone grafting,

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the contribution of each intervention to the multidimensional outcome was difficult to assess. The current status of presurgical orthopaedics is still controversial, but as the more rigorous design of clinical studies produces stronger evidence, so the risks, costs and benefits of this early intervention should provide a revised and rational approach to infant orthopaedics.⁹

The purpose of this paper is to review contemporary issues in the surgical and orthodontic management of the patient for whom bone-grafting the cleft maxilla and palate is recommended. The concerns in alveolar bone grafting include (i) the age at which grafting should be performed; (ii) the type of bone graft and the site from which the donor bone should be harvested; and (iii) the timing of maxillary expansion before or after the bone graft is placed. Emphasis will be focused on secondary bone grafting.

Management of Alveolar Clefts

By the end of the 19th century, a social awareness of missing teeth and the role of the prosthodontist was giving way to the emerging concept of a functional occlusal relationship. One of the earliest team collaborations in the management of patients with clefts resulted from the interaction of Harvold,¹⁰ an orthodontist, and Bohn,¹¹ a prosthodontist who collaborated as a team to reposition the maxillary segments by expansion and retention. The Norwegian approach at Oslo, whose goal was to preserve the dentition and manage the mutilated cleft maxilla more conservatively, was innovative at a time when surgical repair was performed by general surgeons.¹² This pioneering approach to the management of patients with clefts resulted in a more rational approach and the concept of multiple specialists working together in the planning and treatment aspects of interdisciplinary treatment.

The interdisciplinary management of patients by the cleft palate-craniofacial team requires an interactive approach to the timing and sequencing of treatment interventions. An understanding of the skeletal and dental components of malocclusion and how these may be modified to provide optimal aesthetic, anatomic and functional results have been reported and evaluated in diverse ways. This has resulted in a need to compare alternative methods and their outcomes to provide a rational approach to the team management of care.¹³

Alveolar Bone Grafting

In the past, rehabilitation of the maxillary dentition in the patient with cleft lip and/or palate was dependent on the expertise of the prosthodontist in the replacement of both teeth and alveolus in closing the cleft defect. In the late 19th century, surgical correction of the cleft defect was the treatment of choice with the effective surgical closure of the palate by von Langenbeck.¹⁴ Clo-

sure of the cleft defect in the past century was often traumatic as the surgeon attempted to close the cleft with inadequate tissue and anaesthesia, which resulted in constriction and collapse of the segments, resulting in subsequent distortions of future growth and development of the naso-maxillary complex. The prosthodontist was typically involved in constructing an over-denture to correct the three-dimensional maxillary deficiency. The challenge of rehabilitation of the cleft site has changed dramatically this century by the introduction of bone grafting the cleft alveolus by Boyne and Sands.^{15,16} This surgical procedure eliminated the need for prosthetic replacement by providing continuity of the cleft alveolus with bone grafted into the site at the appropriate time. The elimination of the residual cleft was a major advance in the surgical/orthodontic management of the cleft maxilla. This contemporary management of the cleft maxilla is predicated on the close collaboration of the surgeon and orthodontist on the team in the context of a closely co-ordinated and problem orientated approach of the team members.

The benefits of alveolar bone grafting include

- (i) provision of bone into which the unerupted teeth adjacent to the cleft may erupt. The timing and sequencing of the alveolar bone graft relates to the position of the unerupted teeth and the development of the dentition rather than the chronological age of the patient (Fig. 1).
- (ii) At the time of the surgical placement of the bone graft into the cleft site, any supernumeraries or patent oronasal fistulas either in the palate or the nasolabial vestibule may be closed. Fistula closure is achieved by utilising a three-layered closure technique with the grafted bone sandwiched between the two soft tissue planes.
- (iii) Support and elevation of the alar base on the affected side, from the grafted bone in the alveolar defect, contribute to restoration of the nasal and lip symmetry and facial aesthetics.
- (iv) By providing continuity of the alveolar ridge, even if teeth are missing, provides the restorative dentist with support for a more aesthetic and hygienic prosthetic replacement or the placement of implants into alveolar bone grafts.
- (v) In repaired bilateral clefts of the lip and palate, the placement of grafts bilaterally in the cleft defects stabilises the premaxilla while providing bone into which the adjacent unerupted teeth may erupt (Figs. 2, 3 & 4).

A Rational Basis to Resolve Current Controversies

There are three major controversies concerning alveolar bone grafting for which an evidence-based rationale needs to be established:

- 1) The timing of surgery for the alveolar bone graft;

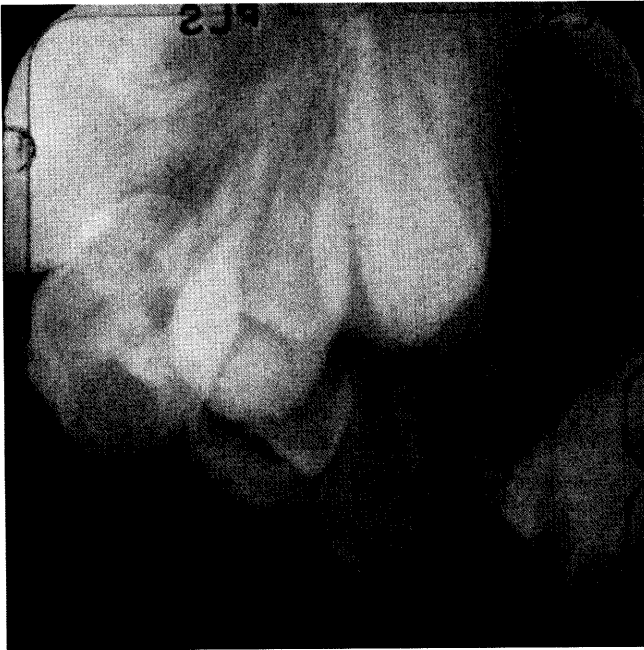


Fig. 1a. Cleft site before bone graft

- 2) The sequencing of the orthodontic treatment to correct, the transverse discrepancy by expansion before or after the surgical procedure to place the alveolar bone graft;
- 3) The sites and types of bone for the alveolar bone graft.

In resolving controversies, evidence is needed to support or refute the different alternatives. Clearly, there is

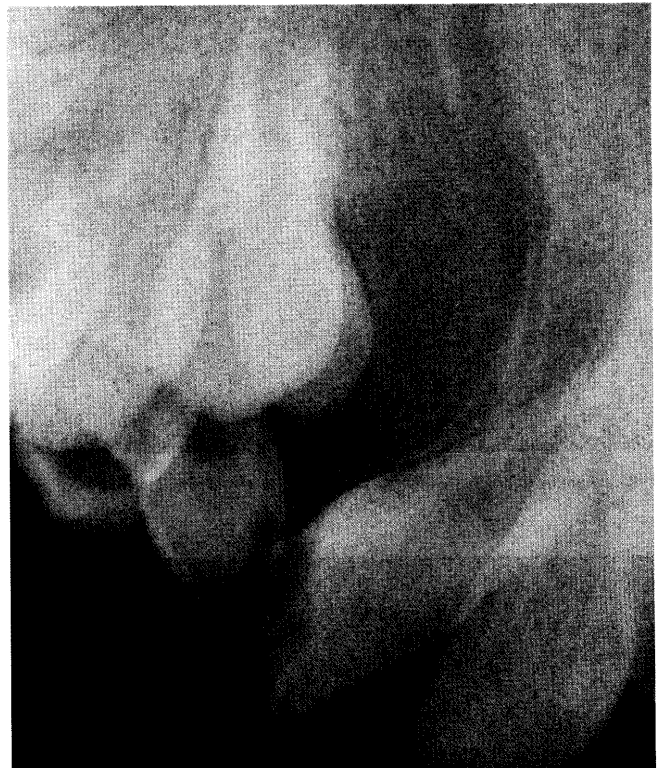


Fig. 1b. Three months after alveolar bone graft. Note migration of unerupted teeth into the grafted site.

a need for clinicians to have the necessary information to recommend one alternative over another based on the prior probability estimates of one procedure having a

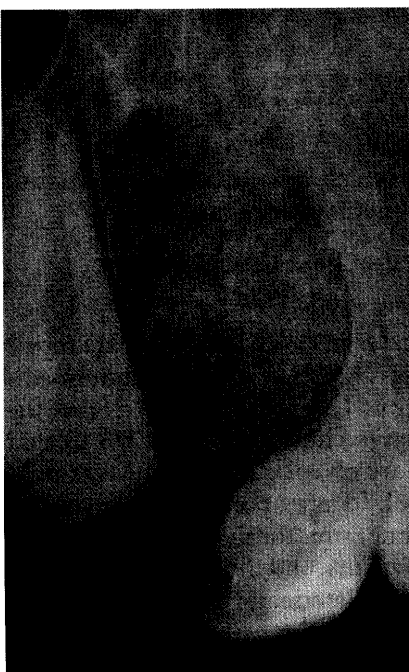


Fig. 2a. Premaxilla stabilised with alveolar bone graft. Unerupted right canine to be moved adjacent to hypoplastic central incisor through the bone graft.

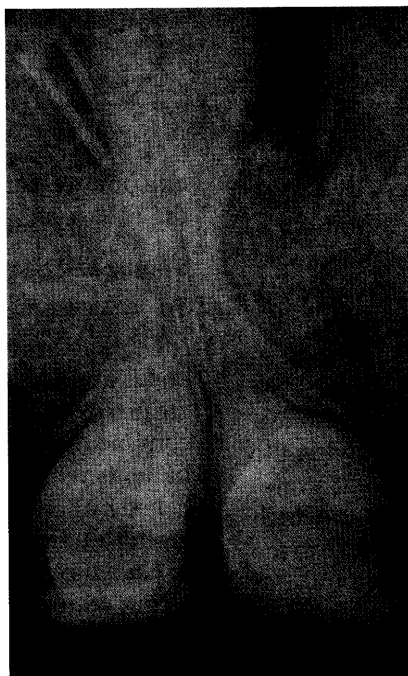


Fig. 2b. Hypoplastic central incisors premaxilla stabilised with alveolar bone grafts.

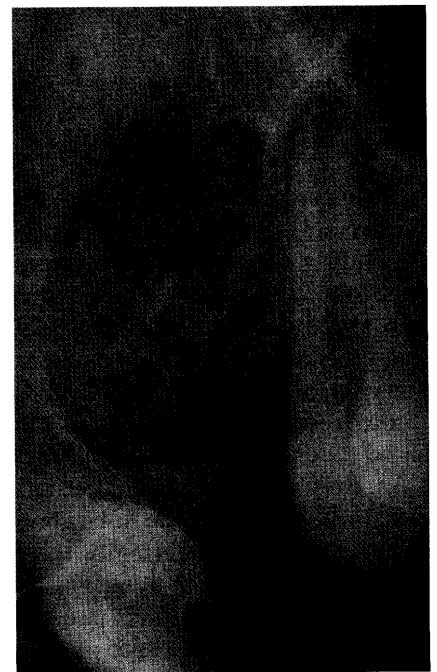


Fig. 2c. Unerupted left canine erupting through graft adjacent to central incisor.

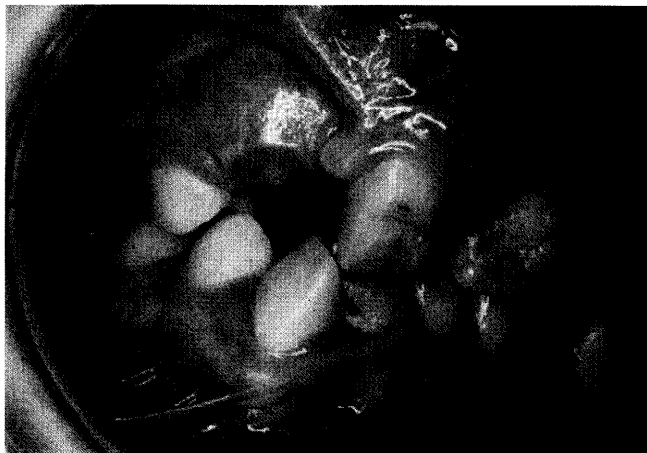


Fig. 3a. Intraoral view of right cleft before orthodontic treatment and alveolar bone graft.

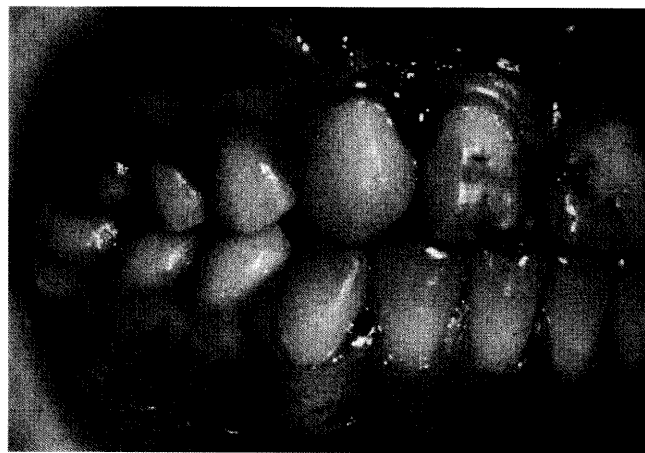


Fig. 3b. Intraoral view of right cleft region after orthodontic alignment of canines adjacent to central incisors before cosmetic recontouring of hypoplastic central incisors.

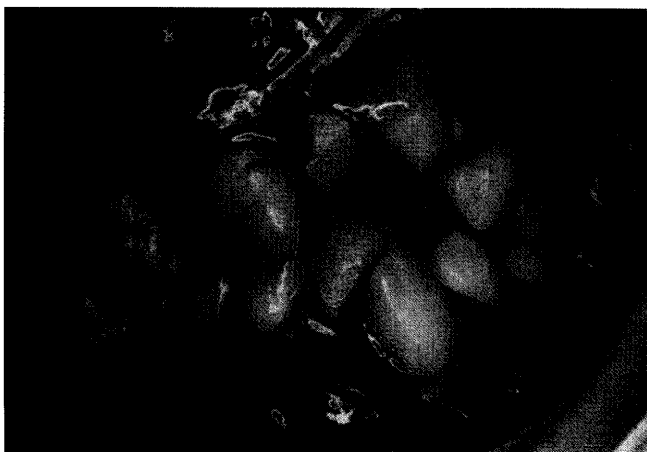


Fig. 4a. Intraoral view of left cleft site presurgery. At the time of the alveolar bone graft, the left lateral incisor was extracted.



Fig. 4b. Left buccal occlusion after orthodontic treatment to move the canines adjacent to the maxillary central incisors. The hypoplastic incisors to be restored with cosmetic build-ups and recontouring.

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more beneficial outcome than the alternative. There is a hierarchical approach to evidence-based information, depending on whether the information was from an anecdotal case report, a case series, a cohort study, a retrospective controlled study or the strongest evidence or gold standard derived from a randomised prospective controlled clinical trial. Until the methodology for clinical research is more widely adopted and evidence-based medicine espoused by clinicians in resolving the risks, costs and benefits of alternative treatment strategies, there will continue to be controversy as to which approach is the best. Certainly, there is some merit to the different alternatives; otherwise clinicians would not recommend them for their patients. If the alternatives did not have some measure of success, they would not continue to be competitive. However, as all clinicians believe that their method of treatment is the best for their patients, there is a need to define valid and reliable

outcome measures by which a quantitative evaluation of the risks, costs and benefits may be assessed.

Timing and Sequencing of Bone Grafting

Secondary Alveolar Bone Grafting

This is performed after primary lip and palate repair and is divided into Early (2 to 5 years of age), Intermediate (6 to 15 years old) and Late (16 to adult).^{15,16} Since the convincing retrospective clinical study of 378 treated patients with secondary alveolar bone grafts was published by Bergland et al,¹⁷ contemporary opinion considers the Intermediate time frame for alveolar bone grafting to have the greatest benefits, and the least risk for interfering with midfacial skeletodental growth and development.

Indications for recommending an alveolar bone graft by the cleft palate team include:

- i) closure of patent oro-nasal fistulas;

- ii) bone to support eruption or movement of teeth into the cleft;
- iii) continuity of the alveolar ridge;
- iv) support to the alar base with improvement in nasolabial facial appearance.

The goal of cleft palate rehabilitation is to maintain and promote retention of the patients own dentition, thus eliminating the need for prosthetic replacement of missing teeth and alveolar bone deficits. Orthodontists and surgeons, in the context of team management, must identify the optimal time and sequencing of treatment.¹⁸ With other competing needs for the patients' well-being, the team approach to management requires an understanding of the competing needs of the interdisciplinary team, with a prioritising of a problem list before the timing and sequencing of treatment is ultimately planned.¹⁹⁻²¹

The optimum time for alveolar bone grafting was recommended by Bergland et al¹⁷ to coincide with the unerupted canine root development at approximately 9 to 11 years. The two-thirds development of the canine root occurs at the time of accelerated eruption of the canine. As the canine erupts through the graft, it brings alveolar bone with its eruptive path into the alveolar cleft site.²² If the orthodontist moves a canine or incisor into the cleft site before the bone graft has been placed, an irreversible periodontal defect will result even if the area is bone grafted at a later date (Fig. 5).

Sequence of Orthodontic Expansion

Expansion with a quadhelix type of palatal appliance or by rapid palatal expansion is operator-dependent, although most clinicians believe that slow expansion is intuitively preferable. The concept supporting rapid palatal expansion resides in the biological response of the maxillary midpalatal suture which, when separated, will generate new bone and hence increase the transverse dimension of the maxillary arch. When there is a cleft, the maxillary expansion is predicated on the stretching of the scar tissue which has resulted from surgical palatal repair. The amount of presurgical expansion should be determined by the surgeon and orthodontist so that oronasal fistulas and soft tissue closure is possible without extensive undermining of the palatal flaps. If the orthodontic expansion has resulted in a defect so large that it compromises the surgeons' ability to close the defect, then contraction of scar tissue post-surgically will result not only in relapse of the transverse expansion but also increase the risk of dehiscence.

In those cases where closure of the palate will be difficult, if the ideal amount of orthodontic expansion to correct the dental crossbite is achieved presurgically, a combination of presurgical and post surgical expansion may be prudent. This judgement requires close collaboration between the surgeon and orthodontist when plan-

ning the presurgical phase of orthodontics. Likewise in those cases where sagittal maxillary and transverse discrepancy exists in the early mixed dentition, a protraction headgear may be recommended with expansion²³ (Figs. 6 & 7). The forward movement of the maxilla into the narrower anterior mandibular dentition results in the transverse discrepancy being reduced. With the vertical as well as sagittal vectors of force, rotation of the mandible downwards and backwards with modification and redirection growth in the sagittal and vertical dimensions may temporarily mask the jaw discrepancy. As this is usually performed before ten years of age, the correction may then be outgrown during the peak height velocity growth spurt at the time of puberty.

Types and Sites of Donor Bone

Alveolar cleft grafting in the maxilla has traditionally been associated with autogenous bone harvested from the hip or iliac crest. This donor site provides a generous amount of cancellous bone and is the preferred site of harvesting bone, especially in the bilateral cleft of the maxilla when bone is required for two cleft sites if the premaxilla is to be stabilised from its presurgical traumatic and mobile position while providing adequate bone into which the canines may erupt. Because of the morbidity associated with iliac crest grafts, attention was directed to another source of cancellous bone, namely calvarial bone. Calvarial bone was popularised in the 1980s largely because of its convenient location and the lack of morbidity associated with its donor site.^{24,25} As less cancellous bone is available in the younger patients, this may not always be an alternative donor site from which to harvest bone. It depends on the age and timing of the graft and the size of the alveolar defect. The mandibular symphysis has also been suggested as a good source for harvesting bone with an intraoral approach which avoids any scarring postoperatively. The amount of bone available is limited and dependent on the timing of the graft and the age of the patient. The surgeon needs to avoid the unerupted mandibular canine, the proximity of the incisor roots and the mental nerve, which are all potential risks when harvesting bone from this site. In deciding where the source of autogenous bone should be harvested, the difference between the outcome of endochondral bone from the iliac crest and intramembranous bone from the mandibular symphysis and the calvarium has resulted in unsubstantiated claims that membranous bone will retain its original volume unlike endochondral bone.²⁶ Suggestions have also been made that more rapid vascularisation also occurs in membranous bone in experimental studies.²⁷

The Choice of Process and Outcome Measures

Precision in terminology is essential in developing and implementing protocols and outcome measures for a



Fig. 5a.

Fig. 5a. Periapical radiograph of maxillary right canine erupting through cleft site with no alveolar bone graft.

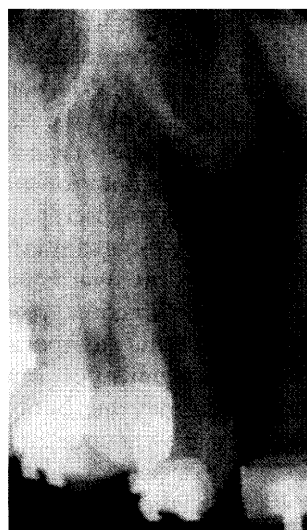


Fig. 5b.

Fig. 5b. Periapical radiograph of canine moved adjacent to central incisor. Note lack of periodontal bony support on central incisors and canine adjacent to the cleft as a consequence of moving teeth into the cleft without an alveolar bone graft. The periodontal support cannot be restored by bone grafting at this stage.

team approach in the management of patients with multiple specialists involved in their care. Moyers²⁸ translated Aristotle into contemporary English:

"It is the mark of an educated man to demand that degree of precision in the treatment of a subject which the nature of the subject allows. To accept mere guesses from a mathematician is as bad as expecting positive proofs of a politician."

In identifying appropriate outcome measures, they should capture the essence of the risks, costs and benefits of an intervention. They may be assessed on a temporal basis ranging from the immediate results of treatment to long-term survival of the treatment. These measurement scales should be both reproducible and valid for patients with clefts of the maxilla.^{29,30}

Evaluating the outcomes of alveolar bone grafts has been traditionally by a descriptive approach to the radiographic appearance of the grafted bone. Bergland¹⁷ has suggested a semi-quantitative approach to assess the height of the interalveolar septum on the teeth adjacent to the cleft. He divided this evaluation into four types anchored by normal height of the crestal bone designated as Type I to failure of the graft to form a bony bridge across the cleft site as Type IV. The two intermediate categories are more difficult to consistently score both between and among the raters. The level of bone supporting the teeth adjacent to the cleft has been considered an important measure in predicting the long-term periodontal health and survival of the teeth, and therefore, a reliable and valid measure of the outcome of alveolar bone grafting.



Fig. 6. Intraoral palatal view of maxillary palatal expander with bands on primary second molars and canines and palatal hooks for attachment of intraoral elastics to a protraction face mask.



Fig. 7. Protraction face mask with elastics attached to intraoral palatal hooks to correct anterior cross bite.

Treatment strategies tend to be based on the specialists' best judgement in spite of the controversies concerning the needs, benefits, risks and what is considered optimal or ideal treatment. Within the context of the team approach to care, often the timing and sequencing of alveolar bone grafting may be competing with other surgical needs for the patient such as nose and lip revision or the need for a pharyngoplasty to improve speech outcomes. The prioritising of the problems in a multidisciplinary approach to treatment requires col-

laboration and interaction of the multiple specialists in the total management of the patient's overall care.

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