Current concept in alveolar cleft management

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Abstract

The alveolar cleft is known as the developmental defect of bone in alveolar process of maxillae which occurs in 75% of the cleft lip and palate patients with different types of clinical presentation like unilateral or bilateral and complete or incomplete. Secondary alveolar cleft reconstruction with autogenic spongy bone grafting (osteoplasty) at the stage of mixed dentition is commonly accepted treatment to help in the maintenance of maxillary arch continuity, repairing of oronasal fistula, eruption of the permanent dentition, enhancement of nasal symmetry through providing alar base support and improving speech. As of late, conflicting argument of alveolar cleft management is continuing regarding treatment planning with timing, graft materials, surgical techniques as well as methods of evaluation of the progress of alveolar osteoplasty. Now-a-days, experiments have made for the application of allogeneic bone, artificial bone, and recombinant human bone morphogenetic protein (rhBMP), along with growth factors to diminish the donor-site morbidity associated autogenic bone grafting. The purpose of this review is to discuss about pathogenesis and aetiology of cleft defects, surgical techniques, assessment of progress of alveolar bone graft and proposed future materials for bone graft.

Introduction

Orofacial clefts have intrigued the clinician for very long time. It is the second most common congenital malformation following clubfoot[1] and is characterized by the incomplete formation of structures in the nasal and oral cavities. It is a group of conditions that includes the lip, alveolar process and hard and soft palates which may be occurred alone or together. World-wide, the rate of incidence is in between 1 and 2.2 per 1000, based on the geographical variations.[2] Males with cleft lip and palate and females with isolated cleft lip are usually found.[3]

Orofacial clefts may be in the syndromic or non-syndromic form. van der Woude is the most common syndrome usually related with the lip. Orofacial clefts usually are divided into the cleft lip with or without palatal involvement. The cleft lip may be unilateral or bilateral and associated with an ipsilateral cleft of the alveolus. The alveolar involvement affects 75% of the patients with clef lip[4] and area between lateral incisor and the canine is the most commonly affected. Primary cleft palate consists of cleft lip, alveolar process and palate (part of hard palate), while secondary cleft palate composed of CP (rest of hard and soft palate, from the incisive foramen).[5]

Aetiologically, several factors are associated with orofacial clefts mainly environmental and genetic factors.[6-8] The exogenous factors, such as nutritional deficits, hormonal and metabolic disturbances, immunological, infectious, chemical and drug effects, in only about 10% of cases, and the causative role of genetic factors is confirmable in about 20% of cases.[9] Quality of life has been effected remarkable by orofacial clefts on the aspects of aesthetics, physical (especially growth and mental) and functional.

It is intricate and several steps procedure to repair the cleft structures for their normal functioning and requires the involvement of physician from multidiscipline. After birth, the treatment starts and continues throughout the whole developmental period and often needs up to adulthood. Cosmetic repair of cleft lip and palate is taking precedence with excellent result, while alveolar cleft repair is crucial for closure of an oronasal communication/fistula, providing bony support for adjacent teeth, stabilizing the maxillary segments,[10] and also improving support for the alar base.[11]

This osseous defect of the alveolar process of the maxilla requires a particular osseous resolution that plays a special role in management. Alveolar bone grafting is the method used to add bone for correction of this defect. The ideal bone graft material is fresh autogenous bone because it supplies immunocompitable bone cells which are essential for osteogenesis.[12]

Harvesting of bone can be done from the several areas and ilium is the area of choice due to its simple access and availability of huge amount of bone.[13-15] To surpass the donor site morbidity of the autograft, assaying to get new alternatives by utilizing the synthetic bone materials, bone morphogenic proteins (BNP) and allografts (demineralized freeze-dried bone allograft or mineralized freeze-dried bone allograft).

This review will discuss the pathogenesis and etiology of cleft defects, technique of operation, and assessment of the progress of alveolar bone graft and proposed future materials for the bone graft.

Pathogenesis and Classification

In the developmental period, the nose, lips and palate are divided into primary and secondary palates. During the gestation period, medial and lateral sides of the nasal pits grow to form medial and lateral nasal prominence respectively. Maxillary prominence lies inferior and lateral to the nasal pits, and grows medially to fuse with the medial nasal process and form the primary palate[16] which will form the bony and soft tissue components anterior to the incisive foramen (nose, lips, prolabium and pre-maxillae).[17] Maxillary prominence also exhibits two shelves-like out-ward growth (palatine shelves) which course in several directions and finally fuse to form secondary palate[16] which will be formed posterior portion of maxillae or hard palate and soft palate. This fusion process starts from incisive foramen and continues up to uvula positioned at midline and complete by nine weeks of gestation.[18]

When palatine shelves failed to fuse each other will lead to forming the cleft palate. On the basis of anatomical disruption of the primary and secondary palate, this abnormality can be categorized into complete or incomplete; unilateral or bilateral. Complete cleft palate indicates primary and secondary palate failed to unite which is usually related with unilateral or bilateral cleft lip.[19] Incomplete cleft palate indicates only primary palate or secondary palate fail to unite which may be confined within the soft palate only or may continue through soft and hard palate up to incisive foramen or may be limited within the primary palate causing alveolar cleft.[20]

Etiology

Orofacial clefts are etiologically differ in syndromic and non-syndromic form. Non-syndromic form of orofacial clefts occurs in 70% of cases, while 30% with orofacial clefts associate with additional congenital anomalies, known to be part of syndrome.[21-22] Aetiology of orofacial clefts is multifactorial and relate with gene factors, environmental factors, and teratogens.[23-24] Genetic susceptibility is the major element of orofacial clefts. Genetics account for 40–60% of orofacial cleft has identified through Monozygotic twin studies.[25] The most widely investigated variants are TGFα and MTHFR genes. Phenotypes significantly associated with particular partial aneuploidies have identified through the survey of chromosomal deletions and duplications and found 1q25, 3p21, 4p15, 4q32 and 10p15 regions significantly associated with orofacial clefts. However, the identification of candidate genes is made intricate by some factors like genetic heterogeneity, departure from Mendelian inheritance patterns, limited availability and the high cost of genomic tools, and the necessity for very large datasets.[21, 24, 26-32]

Orofacial clefts can be influenced by environmental factors. In early pregnancy, folate supplementation has reduced the risk from 25[33] up to 75%,[34] although not all studies have reported statistical significance.[35] Deficiency of zinc causes orofacial clefts in animals[36] and may increase risk in humans.[37] Maternal diabetes may be associated with non-cardiac defects including orofacial clefts.[38] In case of maternal age, the chance of orofacial clefts is more in above 40 years old comparison with 20-29 years old.[39] Maternal smoking enhances the risk of orofacial clefts up to 30%[40] and indirect smoke exposure does not seem to affect.[41] It is controversial with maternal alcohol consumption, but binge drinking increases the possibility.[42] Maternal exposures to effective teratogens like retinoic acid, phenytoin, and valproic acid[43] have been noticed. Other possible causative agents such as chemical or radiation exposures, stress, maternal obesity or infection and hormonal drugs.[21, 44]

Management of Alveolar Cleft

Management of orofacial clefts is perplexing in nature. An extreme multidisciplinary collaboration team with the maxillofacial surgeon, orthodontist, phoniatric specialist, otolaryngologist, speech therapist, pediatrician and dentist is necessary for treating the patient from birth to maturity.[44-46] Remarkable interaction is present between positive treatment outcome and the availability of centralized care by the qualified devoted team. Maximum patients are diagnosed only after birth, although orofacial clefts can be detected from 17 weeks of intrauterine life by the help ultrasound scanning techniques. Cleft status, patient's age as well as medical status are the factors to determine the service and treatment option for orofacial clefts patient. Surgery is the choice of treatment to repair the deformities usually started from few months of life and most of the cases also need additional

surgical interventions later in life. Improvement of aesthetics as well as function like feeding, speech, breathing and hearing problems, can be achieved by surgical treatment. Patients also need orthodontic care, speech therapy as well as social and psychological services. Treatment plan of orofacial clefts contains a range of services and needs to follow the manner from birth may up to adulthood stages.[47-52]

The alveolar osteoplasty is the process of fill up the cleft gap with alveolar bone grafts, is the choice of treatment with the aim of remove the oronasal fistula, establishes maxillary arch continuity, limits growth disturbance and movement of permanent dentition into the graft bone, enhance nasal symmetry, orthodontic movement and insertion of dental implants, speech improvement, oral hygiene maintenance and improves of periodontal health.[1]

On the basis of development of palate, alveolar osteoplasty can be classified into-

1. Primary alveolar osteoplasty is made after lip repair but before repair of the palate and should be done less than 2 years of age.[53-54] Only rib graft and calvarial bone graft are usually used for primary alveolar osteoplasty.[55]
2. Secondary alveolar osteoplasty is made after repair of the palate. It can be categories into early secondary (2-5 years), early (6-8 years) or late (9-12 years) mixed dentition, and late secondary grafting (after 13 years age).[56-57]

Complete palatal cleft and exactly aligned (end to end) alveolar segment are prerequisites for the primary alveolar osteoplasty, because of available space between the maxillary segments will be exerted tension on flap over the graft bone and enhance the possibility post-operative wound dehiscence, disclosure of graft and subsequent collapse of graft.[53] Secondary alveolar osteoplasty helps to form the stable united alveolar arch as well as provide mature bony for supporting the tooth eruption.[58-59] Secondary alveolar osteoplasty is the most acceptable and popular for treating alveolar cleft and commonly chose for the patient with age of 6-13 years, usually before the permanent canine eruption.

Various sort of bone graft material includes autografts, allografts, xenografts as well as bone graft substitutes are available to use in alveolar cleft repair. Cortical, cancellous and cortico-cancellous are different types of autogenic bone grafts. Alveolar cleft is considered as marginal bony defect and autologous cancellous graft play an important role in formation and healing of bone due to its property related with osteoconduction and act as source of bony cells; is better to use for correcting the defect.[60] Available bone volume and morbidity related to harvesting from definitive sites are concerning issues for selection of donor area.[60] Graft tissue can be harvested from various sites like iliac crest or wing, tibia, mandibular symphysis, radius, calvarial bone, proximal humerus, distal ulna and ribs.[61-66]

The autologous bone of the iliac crest is known as the optimum source and called as the gold standard for the alveolar cleft reconstruction. Easy access and availability of sufficient amount of both cancellous and cortical bones are the remarkable benefits of harvesting bone grafts from the iliac crest over other donor sites.[62, 63, 67] 'Trephine' technique can be helped to harvest sufficient amount cancellous bone[68] as well as will be minimized hospitalization period and duration of surgery, severity of pain; and painkiller use.[69]

At the beginning, it was a high expectation to achieve a good result by the reconstruction of clefts with the symphysis of mandible bone because of similar embryonic origin (intramembranous), but the actual problem is that only small amount of bone can be harvested from this site which is not sufficient for large unilateral or bilateral clefts repair.[60, 70, 71] However, having the chance of teeth's root and mental nerve damage and the merits are rapid revascularization, low rate of resorption, same operative field, less post-operative pain.[72]

Unremarkable scar formation, absence of functional deformity, expediential surgical field, and availability of sufficient amount bone are positive findings for reducing the operative adverse effects[73] as well as having chance of wound infection, small amount of cancellous bone and intracranial complications (like hematoma, seroma, dural tear, dural exposure and cerebrospinal fluid leakage),[74] while choosing calvarial bone graft. Study revealed that survival rate of cranial bone grafts is same as iliac bone grafts which are approximately 85.0% and 84% respectively.[75-76]

Regarding tibial bone graft in children, the outcome is not satisfactory due chance of trauma causing hamper in growth.[60] It is simple to harvest with minimal bleeding, less post-operative pain and permits quick ambulation as well as minimal period of hospitalization; but the amount of graft bone is very small with an adult patient.

It is one of the most common methods for alveolar osteoplasty. Improper fitting with cleft bone, failure of eruption of teeth, insufficient support to alar base; and chance of pneumothorax and pain postoperatively are the common complaints with rib grafts.

Operative Technique

The surgical procedure is performed under general anesthesia and the cleft area is infiltrated with vasoconstrictor infiltration (1% xylocaine with epi-

Figure 1: Incisions are made on the buccal and palatal aspects of the alveolar cleft (A); For creating two full-thickness mucoperiosteal flaps called medial and lateral mucoperiosteal flaps (B); Deposition of graft bone collected from donar site on the cleft region which finally lies beneath the tension free sutured flaps (C)

nephrine) on the buccal and palatal aspect of the alveolar cleft. Two full-thickness mucoperiosteal flaps are created by making incision (Figure 1A) along the cleft margins which extend laterally through the gingival sulcus of teeth up to molar teeth for getting sufficient mobility of flaps and raise the medial and lateral mucoperiosteal flaps (Figure 1B). Then flaps are lifted from surrounding structures as well as from the area of the cleft. The nasal mucosal layer is performed by interrupted suturing while bony areas are fully visualized. Then the palatal flaps are turned back and closed it by interrupted suturing for making a soft-tissue pocket. Now, this isolated pocket is filled with grafted cancellous bone collected from ilium. The cleft defect should be compressed by the grafted bone to increase the number of bone particles per unit graft volume. During inserting graft materials, level of acceptance is related to making the proper shape of the cleft area comparison with nearest surrounding structures for maintaining similarity as well as aesthetic. Finally, flaps are closed by suturing and need to make sure that sutured flap remains in lack of tension (Figure 1C).

Risk associated with Surgery

Risks associated with the alveolar bone graft include graft resorption and alveolous notching may be happening with using of excessive graft materials; and exposure of wound by excessive tension or trauma during recovery after surgery. Study revealed that no more than 5% of patients are associated with graft failure.[75]

During iliac crest harvesting, serious damage to nearby structures rarely happens. If such damage occurs, usually it is associated with different types of things mainly vessel and nerve. Nevertheless, diminished bone graft operation as minimum as possible will diminish the risk related operation, and appropriate technique of operation as well as making caution with vital structures of the operative area are important while choosing bone grafting surgery.

Major risks include infection, hematomas formation, different types of abnormalities (like subluxation and destabilization) of related joint, long-term (6 months) standing pain, lack of sensation, abdominal contents herniation, fracture of related bones, and abnormalities (like heterotopic) in hard tissues regeneration (0.7 to 25%)[77-79] and minor risks such as problems with wound and infection, lack of sensation for short while and mild pain (4 to 49%).[77]

Assessment of Progress of Alveolar Bone Graft

The success of the bone graft can be assessed by clinical and radiological assessment. Clinical evaluation of alveolar bone graft includes eruption of cleft teeth, periodontal status,[80] alveolar height[81-84] and alar base support.[80] Radiologically, the outcome will be assessed on the basis of appearance of the bone[85] by using the Bergland scale and Chelsae scale[86] which will continue at least six months postoperatively.

Moreover, radiographic assessment seems to be effective and superior to clinical methods.[83-84] Accuracy of conventional (periapical, occlusal, and orthopantogram) radiographs are not sufficient to get exact details of the cleft area for alveolar cleft assessment, CT scan should be used to overcome these draw-backs in evaluating the alveolar cleft.[87] CT scan and specialized software are necessary to assess the defect, for determining the amount to be required for grafting as well as evaluation for post-operative bone formation.[88-89]

Proposed Future Materials for Bone Graft

Interest in bone graft substitutes arose due to surpass the side effect of autografts. A number of demerits are related with autogenous bone grafts like donor site morbidity associated with hematoma formation, infection, chronic pain, neurological

deficits, iatrogenic fractures, and issues with cosmesis[90-94] and availability of sufficient amount of grafting bone which is a momentous issue while deformity is large.

Calcium phosphate graft materials like β-tricalcium phosphate (β-TCP) and hydroxyapatite known as synthetic bone materials[95-98] which have excellent biocompatibility[99] with easily producible, less chance to spread diseases from one to another as well as their same composition (structural and chemical) with that of bone (inorganic part) assist in formation of bone.[100] Outstanding properties of hydroxyapatite (biocompatibility and osteoconductivity) makes it to choice able material for bone graft in the implant dentistry.[95-96]

BMP have osteoinductive property. BMP-2, BMP-4 and BMP-7 (different types of rhBMP) in along with appropriate carrier assist in reformation of missing tissue while associated with irregular hard tissue defects.[101-103]

Techniques of allograft for materials preparation (specially Tutoplast® and freeze-drying) also reduce transmission of infection.[104-105] Demineralized freeze-dried bone allograft and mineralized freeze-dried bone allograft are two different types of Freeze-dried bone. It allows slower desorption than demineralized freeze-dried bone allograft due to its mineralization and shows an osteoconductive scaffold while used in mesenchymal tissues. Demineralized freeze-dried bone allograft may have a higher osteoinductivity due to its demineralization process than mineralized freeze-dried bone allograft.[106-108] Demineralized freeze-dried bone allograft quickly revascularizes, and plays an important role on the extracellular matrix (especially growth factors and proteins) for the effect of their biological function.[109] While replacing autologous grafting, these two bone substitutes can be used for getting a better response.

Conclusion

With the passes of time, the treatment protocols of alveolar cleft are becoming modified to improve the functional as well as the esthetic purpose for better service of patients. Secondary alveolar osteoplasty is the treatment of choice accepted by the majority for alveolar cleft management. Autologous bone grafts are constantly remained as gold standard for the reconstruction of alveolar cleft despite having the risk and benefit feedbacks. Different types of clinical circumstances are available which influence the local or systemic bone regeneration, and as of late different types of approaches are applied to enhance bone repair, related with the potentiality of healing as well as the necessities of the individual case. When it comes to bone graft substitutes, the evidence remains in vague, largely owing to the vast array of available product types, and needs further well-conducted prospective clinical trials which might offer new exciting alternatives in the near future.

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