Medical and Research Publications
International Open Access

Literature Review **Journal of MAR Dental Sciences (Volume 5 Issue 6)**

Autogenous Dental Graft Materials in Alveolar Cleft Children

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Received Date: July 08, 2022

Published Date: August 01, 2022

Abstract

Background: *Cleft lip and palate CLP is a frequent congenital malformation that manifests in several varieties including unilateral or bilateral anomalies due to either genetic or acquired causes. Alveolar cleft graft ACG remains controversial as regard timing, grafting materials and surgical techniques. The primary goal of alveolar cleft grafting in ACG patients is to provide an intact bony ridge at the cleft site to allow maxillary continuity for teeth eruption, proper orthodontic treatment for dental arch alignment, oronasal fistula closure and providing alar support for nasal symmetry.*

Summary: *Reconstruction of the alveolar cleft is very important for providing both aesthetic as well as functional benefits to the patients with cleft lip and palate. The autogenous iliac crest is the most widely used bone graft in SABG procedures. There are very few published studies in the literature where tooth as an autogenous graft is used in dentoalveolar defects.*

Keywords: *Reconstruction, autogenous, dental arch alignment, congenital malformation*

Abbreviations

BMPs: Bone morphogenetic proteins

HA: hydroxyapatite

PRF: platelet-rich fibrin

PRP: Plasma Rich in Platelets

rhBMP: Recombinant human bone morphogenetic protein

ß-TCP: ß-tricalcium phosphate

Introduction

Early around 1900, attempts to transplant the alveolus began. However, the justification for the process has evolved through time. It began as a technique for creating continuity over a defect, but it has since developed and become essential in both orthognathic surgery and orthodontics relating to clefts. The process has changed throughout time, and the materials used have likewise undergone continuous study and advancement. This chapter explains the alveolar cleft's morphology, how it affects the teeth and facial skeleton, as well as numerous treatment techniques and emerging trends (1).

Normal Alveolus Anatomy

The area of the jaw that houses the tooth sockets and acts as a link between the teeth and the basal bones is known as the alveolar process. Both the mandible and the maxilla have an alveolar process. The condition of the alveolar process and how it develops are dependent on the health of the teeth; if they are missing or lost later in life, the alveolar process shrinks and finally vanishes entirely (2).

Creation of the Alveolar Process

At the conclusion of the second month of the foetal life, the alveolar process starts to develop. A groove-like structure that expands toward the oral cavity's surface develops between the maxilla and mandible. The nerves, vessels, and tooth germs are all located in this groove.

Alveolar Anatomy in Patients with Cleft

The alveolar cleft is often shown as a gap between the alveolar segments or as a full notch in the alveolus on the labial surface. The smaller segment of the maxilla, which is on the cleft side in unilateral alveolar clefts, is undeveloped, leading to anomalies in the alveolus, lip, nose, and palate (3).

Procedure for Alveolar Bone Grafting

History

Grafting attempts on the alveolus first appeared in the early 1900s. The first objective was to stop the alveolar ridge from collapsing. As a result, it was completed during infancy. The best age for cleft grafting, according to reconstructive surgeons like Boyne in 1970, was between 9 and 11 years old. This was done to enable the canine to explode (4).

Classification

Based on the patient's age and the time of the surgery, there are four categories for alveolar bone grafting procedures (5): Primary—an infant undergoing this procedure must be under the age of two. This is carried out after lip repair but before palate restoration. Early secondary—this procedure is carried out between the ages of 2 and 5, before the eruption of incisors. Secondary—performed between the ages of 8 and 11, before the maxillary permanent canine emerged. Late secondary—Conducted after the canine has erupted, at ages above 12;

Components of alveolar bone grafting

Secondary cleft malformations have been treated by grafting using a range of materials (3).

These materials might be autogenous, allogenic, or alloplastic.

Each kind has a different success rate, but fresh autologous cancellous bone is thought to be the best because it enables immune-compatible cells to integrate completely into the maxilla and start osteogenesis. Additionally, it is the only bone source that has osteogenesis, osteo-conduction, and osteo-induction, all of which stimulate bone formation (6).

Inventive Materials

For the purpose of alveolar bone transplantation, the following locations are often employed as sources of autogenous material:

Cranium: Both cortical and cancellous bone may be found in the skull, sometimes known as the calvarial bone. There is little postoperative discomfort and minimal morbidity at this location. Early discharge and a favourable prognosis will result in a scar that is hidden inside the hair. In comparison to the iliac crest bone, it performs poorly (4).

Crest of Iliac: It contains an enormous amount of cancellous bone, which promotes osteogenesis. The dependability of this bone is improved by the procedure of condensing bone chips into the defect (5).

Jawbone's symphysis: The available bone is more cortical and smaller than the ilium. There have been reports of damage to the nearby teeth and brain nerve. Four percent of surgeons in Europe utilise it (7).

Tibia: It is easy to harvest and contains enough bone. The patient may be mobilised early and there is little scarring, although sports are prohibited for three weeks.

Rib: Because it only offers a little quantity of bone, this is seldom employed. Chest infections and ongoing pain are potential postoperative risks.

Femur: The femur's intermedullary canal may also be used to harvest bone, although the morbidity rate is quite high (8).

Alloplastic Substances

Recombinant human bone morphogenetic protein (rhBMP-2), undecalicified freeze-dried bone, tissue-engineered osteogenic material (TEOM), and bioglass are examples of alloplastic materials that have been utilised for ABG (9).

rhBMP-2: This is recombinant bone morphogenic protein, and the BMP-2 group has claimed higher bone quality.

TEOM: Mesenchymal stem cells, platelet-rich plasma, human thrombin, and mixed air are all present in this substance, easily accessible in gel form. A 70% success rate is said to be the average (10).

Bioactive Glasses

Silicone dioxide, sodium dioxide, calcium oxide, and phosphorus pentoxide make up this material, which is marketed for use.

Allogenic Substances

These materials allow for tooth eruption while preventing donor site morbidity and are equivalent to autogenous materials. They lack osteogenic potential; however, which delays graft integration (3).

The majority of the aforementioned items use bone from people with different genetic compositions. To guarantee that the allogenic graft material is free of any microbial contamination while keeping the organic matrix and the inorganic components, these allogenic bone particles are put through a number of treatments. They may be found in different particle sizes, as block grafts, or even manufactured using CAD/CAM technology for particular patients (11).

Auto-BT: Currently employed in dentistry clinics as bone transplant materials include autogenous bone, allogenic bone, xenogenic bone, and alloplastic materials. They may be divided into substances that stimulate osteogenesis, osteoinduction, and osteoconduction based on the process of bone healing.

Recently, the utilisation of human dentin from removed teeth in the context of autogenous bone transplants has attracted the attention of researchers and doctors (7).

Bone morphogenetic proteins (BMPs) are also found in dentin, and they help mesenchymal stem cells differentiate into chondrocytes, which improves bone production. Additionally, neural crest cells are the source of alveolar bone and teeth (12).

Bessho, et al. effectively secured new bone development in situ by BMP from human DDM, whereas Butler, et al., Conover and Urist, et al. successfully isolated bone BMP from rabbit DDM. In addition, Ike and Urist transported recombinant human bone morphogenetic protein in the dentin root matrix (rhBMP). Starting in 1993, we created bone graft materials and tested those experimentally using human teeth (17).

Auto BT Osteoinduction

Because dental dentin's biological makeup is so similar to that of alveolar bone, several researchers have looked at it as a possible transporter for human proteins and as a grafting material. Alveolar bone and teeth both come from neural crest cells and are composed of the same kind of collagen, Type I.

In other words, two varieties of BMP have the same physiological effect. About 20% of the weight of dentin is made up of organic material, the majority of which is type I collagen. Additionally, it was shown that BMP promoted the synthesis of cartilage and bone and converted undifferentiated mesenchymal stem cells into chondrocytes and osteogenic cells (8).

LIM mineralization protein 1 (LMP-1) is a critical positive regulator of osteoblast development and maturation and bone formation, according to Boden et al. LIM-1 was discovered by Wang et al. to be predominantly expressed in predentin, odontoblasts, and endothelial cells of teeth's blood vessels (6).

An autogenous tooth-bone graft method was used to fill the gap between the root and the alveolar socket after a 37-year-old man's removed right third molar was transplanted into the first molar region. The reattachment was successful. As a result, the autogenous tooth bone graft material is thought to be appropriate for promoting bone growth and healing during tooth autotransplantation (8).

The Bradford experiment demonstrated that AutoBT contains noncollagenous proteins. Electrophoresis and immunoblotting tests, however, revealed that rhBMP-2 could not be extracted from AutoBT. In conclusion, our investigation showed that AutoBT th rough noncollagenous proteins are osteoinductive (13).

Auto BT osteo-conduction

According to the analytical findings, AutoBT included minerals that were comparable to those found in human bone tissues, including low-crystalline hydroxyapatite (HA) and perhaps additional calcium phosphate minerals, including ß-tricalcium phosphate (ß-TCP), ACP, and OCP. Similarly, the dental crown section was composed mostly of low-crystalline calcium phosphate minerals with a relatively low Ca/P ratio, whereas the root portion was composed primarily of high-crystalline calcium phosphate minerals (primarily HA) with a higher Ca/P ratio (14).

The AutoBT root and allograft shown in the XRD investigation had a low crystalline structure resembling autogenous cortical bone. The quantity of calcium and phosphorus that was lost from AutoBT in the CaP dissolving test was noticeable right away and showed a pattern like that of autogenous cortical bone. In conclusion, it may be said that autogenous dental bone transplant materials have physicochemical traits with autogenous bone (15).

Nampo, et al. pioneered the use of removed teeth as the graft material in alveolar bone regeneration. A noncollagenous protein called DSP that is particular to dentin is involved in the calcification of dentin. According to immunohistochemical staining with anti-DSP antibody, the positive response was limited to the dentin of the broken-down tooth pieces, indicating that dentin has a strong affinity for and pronounced osteoconductive impact on the jaw bone (13).

Use of AutoBT in medicine

In 2008, Kim et al. created a unique autogenous tooth-based bone grafting material (AutoBT) and laid the groundwork for its clinical use. AutoBT is made from autogenous grafting material and contains both organic and inorganic mineral components, removing the possibility of an immune response that might cause rejection. During implant implantation, autoBT was employed in conjunction with guided bone regeneration, and good bone repair was validated by osteoinduction and osteoconduction.

A retrospective investigation was carried out by Lee and Kim to assess the clinical effectiveness of AutoBT. 37 patients (54 implants) who had AutoBT grafts between October 2008 and December 2009 were included in this research. A 31-month follow-up on average was required.

Evaluation of Alveolar Bone Grafting Following Surgery

Alveolar bone grafting's effectiveness is dependent on a number of outcomes, including: Determines the Success of ABG: The oronasal fistula's closure, a sufficient amount of bone support that supports the neighbouring teeth and permits canine eruption and building design of the grafted bone (16).

Based on the aforementioned criteria, a variety of measures are employed to evaluate success. Radiographs taken with these scales may be periapical, panoramic, or occlusal. Below are a handful of these scales:

Bergland metric scale

The height of the post-graft interdental bone septum is used to determine success on this scale, which is the industry standard for evaluation. After the emergence of the permanent canine, it is evaluated. There are specified four types of success, including (8).

Chelsea metric

The teeth next to the cleft are measured in respect to the presence of bone using this scale. Six categories have been established as a result of this. Only Types A and C indicate results that are acceptable (17).

Scale of Trindade-Suedam

The Bergland scale as previously described was changed by these writers, who instead utilised alphabets to indicate success or failure:

The interdental septum height is normal, the bony septum is evident with no impairment, and the bone graft is sufficient to allow for canine eruption, earning the grade of E (Excellent). B (Bad): Insufficient bone in the nasal area, which prevents tooth movement. F (Failure): Bone graft is entirely resorbed. However, tooth movement is insufficient, or a defect that is more than 25% of root length is visible (15).

Alveolar Bone Graft Complications

Alveolar bone grafting problems may be seen both at the donor site and the recipient site (18).

Problems at the donation site

Iliac crest: Significant blood loss, Hematoma, delay in healing of wounds, scars that may be painfully long and tenacious, are hidden by belts or garments and over the lateral femoral cutaneous nerve and the places where it is distributed, there may be hypoesthesia or anaesthesia (19). Cranium: The potential for table penetration (20). Rib grafts: Chest infection after surgery and pneumothorax (16). Mandible grafts: Damage to the mental nerve. Complexities at the recipient site

Roots of the central or canine incisors are damaged.

Graft resorption: Graft resorption denotes the full failure of ABG and may happen for the reasons listed below: Osteoresorptive cells and an environment conducive to bone resorption—this takes place with the excision of deciduous teeth, excessive stress or trauma after surgery, which exposes the graft and causes it to fall out, The graft being overpacked, which results in alveolar notching and graft resorption and Negligent oral hygiene (21).

Plasma Rich in Platelets (PRP)

It is frequently employed in many surgical specialties, such as head and neck surgery, otolaryngology, cardiovascular surgery, and maxillofacial surgery. Platelet Rich Plasma (PRP) is a novel method of tissue regeneration. PRP is often utilised as a gel, which is created by combining it with thrombin, calcium chloride, and PRP (which is obtained by centrifuging autologous whole blood).

Although autogenous bone grafts remain the gold standard in the reconstruction of bony defects, there are drawbacks including the limited amount of available bone, donor site morbidity, bone graft resorption, donor site morbidity, and artificial bone substitutes such as silicone and titanium phosphate that may be used but expose the patient to the risk of foreign body reactions and infection (22).

Recent research has shown that growth factors that are osteoinductive or osteoconductive, such as platelet products like platelet-rich fibrin (PRF), greatly enhance bone regeneration.

PRF was used to maintain the alveolar socket from vertical and horizontal bone loss, according to research by Anwandter et al. and Wang et al. on the dimensional alterations of the alveolar ridge after tooth extraction. Gurler et al. observed that the use of PRF did not considerably improve the condition in another trial they conducted on the impact of PRF coupled with bone graft on sinus lifting.

The bone defect situation in the aforementioned studies was completely dissimilar from the one examined in our study, in which grafts were applied to close the cleft site. However, it is clear from this research that using PRF as a regenerative material is not advantageous (23).

The benefits of PRP on bone transplant are important to note. The maturity of transplanted bone coupled with PRP is much larger than that without PRP, and grafted bone combined with PRP exhibits a mature Harversian system and a higher percentage of lamellar phases, according to reports (24).

When combined with an iliac bone transplant, PRP improves bone density. According to studies, PRP-supported grafts have been shown to enhance bone mineral density by 1.6 to 2.2 times more than non-PRP-supported grafts. Other studies, however, indicated that it appeared to be insufficient as a long-term preventative measure against bone resorption following secondary bone graft. In contrast to another author, who employed additional demineralized bone matrix and allograft, PRP was most often paired with full canine eruption. Platelet rich plasma may improve density of osteoblast in rabbit maxillary bone graft, collagen and osteoblast in early stage of hard callus formation were both impacted by PRP and ultimately induce osteogenesis in rabbit maxillary bone graft (24).

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