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Comprehensive Evaluation and Prospectives of Ridge Augmentation in Prosthodontics: A Review

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ABSTRACT:

Vertical and/or horizontal ridge augmentation may be necessary, often utilizing bone substitutes and grafting techniques. However, performing one-wall reconstruction remains difficult due to its limited blood supply and the lack of stability of the grafts. The importance of selecting the appropriate bone substitutes with autogenous bone being a particularly favourable choice. They also highlight the need for ridge augmentation surgery to follow established principles to reduce the risk of complications. Furthermore, the decision to proceed with ridge augmentation should be made with the patient's full consent, taking into account the potential drawbacks, complications, and uncertain outcomes of the procedure.This paper addresses the challenges of dental implant placement in patients with inadequate bone height and width, which complicates achieving an optimal pathway and avoiding critical anatomical structures.

Introduction

Various surgical methods have been developed to address severe alveolar bone defects in dental implants. The clinician's goal is to achieve successful outcomes in the shortest possible time using the most appropriate techniques. The ideal technique should be simple, minimally invasive, and associated with a lower risk of complications.[1] Ridge augmentation is a delicate procedure that depends on both the technique used and the skill of the operator. However, not all of the augmented volume turns into viable bone tissue. Implant success is more closely related to the condition and quantity of the remaining host bone than to the volume of the grafted bone. Vertical and/or horizontal ridge augmentation is used to address one-wall defects, where the blood supply primarily comes from the recipient bone, with minimal contribution from the surrounding soft tissue. The soft tissue may be damaged during flap elevation and is often protected using a barrier membrane. When a significant amount of bone grafting is done either vertically or horizontally, only a portion of the grafted material may transform into viable bone, typically within 3 mm. The remaining areas tend to form immature woven bone for an extended period, eventually being replaced by fibrous granulation tissue due to poor blood supply. As a result, understanding the healing process of ridge augmentation is essential for successful dental implant placement.[2] Horizontal ridge augmentation tends to yield more stable results compared to vertical ridge augmentation. This may be due to greater pressure from the coronal side compared to the lateral side. Increased pressure can lead to graft material loss and a higher likelihood of wound dehiscence, worsened by chronic irritation from temporary prostheses and masticatory forces.

Available Graft Materials

Autogenous Bone Graft

Autogenous bone is regarded as the gold standard for bone grafting because of its ability to promote bone growth, resist infection, and heal effectively, even in cases of wound dehiscence. However, it comes with significant drawbacks, including the need for additional surgeries, limited donor material, and the potential for

Journal of Chemical Health Risks

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substantial resorption. As a result, many researchers suggest combining autogenous bone with other bone substitutes and using a resorbable barrier membrane to enhance the healing process.[3-9]

Other Bone Substitutes

Various alternatives to autogenous bone have been investigated, including allogenic, xenogenic, and alloplastic bone substitutes. However, there are limited reports of success when these substitutes are used alone for ridge augmentation. Specifically, block-type bone substitutes are strongly advised against due to their poor performance and high complication rates.[10-12]

Bone Growth Factors

Bone tissue engineering has been researched to address the limitations of autogenous bone grafts. Many studies have demonstrated successful outcomes when combining an appropriate scaffold with bone growth factors such as recombinant human platelet-derived growth factor (rhPDGF) and recombinant human bone morphogenetic protein-2 (rhBMP-2).[13,14] More recently, studies have shown positive bone healing results with the use of platelet-rich plasma (PRP) or platelet-rich fibrin (PRF), which can be harvested and prepared from a patient's venous blood.[15] For instance, Jeon et al.[16] reported a 3.3 mm increase in vertical ridge augmentation using β-tricalcium phosphate combined with PRP.

Barrier Membranes

There are no definitive guidelines for selecting barrier membranes, allowing clinicians to choose based on their preferences. Membranes can be effective in maintaining the stability of grafted bone, especially when using particulate-type bone grafts in larger volumes. Both resorbable and non-resorbable membranes have distinct characteristics, with no one type clearly superior to the other. However, titanium meshes have proven particularly effective in stabilizing grafts in one-wall defect reconstructions, owing to their shape, rigidity, and ability to protect the graft material beneath.[17]

Particulate vs Block Type Autogenous Bone

There is no significant difference in bone regeneration capacity between particulate and block-type autogenous bone. In clinical practice, a combination of both particulate and block-type autogenous bone, often mixed with other bone substitutes, is commonly used.[18,19]

Particulate Autogenous Bone Graft

The sandwich technique is a method where autogenous bone is grafted in direct contact with the implant, followed by demineralized freeze-dried allogenic bone or bovine hydroxyapatite bone placed over the autogenous graft, and a collagen membrane covering the site.[20] Many bone augmentation procedures follow similar principles to the sandwich technique. Some surgeons prefer using non-resorbable membranes, such as titanium meshes, to cover the grafts. This approach has proven effective for both vertical and horizontal augmentations due to the stable mechanical properties of the membrane.[21]

Block Autogenous Bone Graft

Block-type autogenous bone, typically harvested from intraoral sites, is secured with screws after being closely adapted to the recipient surface. Particulate autogenous bone or other bone substitutes are then packed into the surrounding spaces. A resorbable membrane is commonly used to provide additional graft stability.[22-24]

Types of Ridge Augmentation Procedures

Ridge augmentation is generally categorized into horizontal or vertical procedures, although both are often performed together.

Horizontal Ridge Augmentation

In recent implant dentistry, minimally invasive horizontal ridge augmentations are commonly performed using particulate or block autogenous bone grafts, combined with ridge splitting or ridge expansion, and guided bone regeneration (GBR). Each technique has its own advantages and disadvantages, but clinical results do not differ significantly. Surgeons should choose the most suitable method based on evidence and established principles. Horizontal ridge augmentation is generally associated with more predictable outcomes and higher success rates compared to vertical ridge augmentation. The typical target for reconstruction in horizontal ridge augmentations is 3 to 4 mm.[25]

Vertical Ridge Augmentation

For reconstructing one-wall defects, onlay grafts are typically used in conjunction with GBR, utilizing either particulate or block-type autogenous bone grafts. However, onlay grafts carry a higher risk of complications, including wound dehiscence, infection, bone resorption, and graft failure.[25] Alternative techniques like interpositional bone grafts (sandwich osteotomy) and alveolar bone distraction have been developed to mitigate these risks. The sandwich osteotomy technique, in particular, is known for its favourable prognosis due to optimal soft tissue coverage and blood circulation. The vertical portion of the graft is placed on cortical bone, which is better suited to withstand occlusal forces and reduce absorption. Onlay grafts typically result in an increase of 3 to 4 mm, while

Journal of Chemical Health Risks

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sandwich osteotomies can lead to an increase of approximately 5 to 7 mm. However, some cases may not be suitable for sandwich osteotomy due to anatomical limitations, such as the location of the inferior alveolar canal or maxillary sinus. Alternatively, a technique called supraplant has been introduced to simultaneously increase vertical bone height while placing implants on top of the alveolar crest. Although several studies have reported acceptable results, long-term clinical outcomes are seldom discussed. In clinical practice, the supraplant technique has been associated with a high incidence of complications, with most surrounding grafted bone showing signs of resorption.[26-29]

Complications

Ridge augmentation carries a significant risk of complications such as wound dehiscence, exposure of the grafts, infection, failure of integration, and late-stage bone resorption. These issues can ultimately result in the complete loss of the graft. To minimize these risks, the surgeon must adhere to the following precautions:[16,25,30-32]

1. Ensure adequate blood supply to the graft
2. Proper modelling and fixation of the bone block
3. Cover the bone block with slowly resorbable xenografts
4. Use releasing incisions to create a tension-free flap
5. Avoid applying load or compression to the reconstructed area with removable prostheses
6. Allow sufficient healing time to enable successful graft integration before placing dental implants
7. Avoid over-contouring with block-type autogenous bone grafts, which could lead to wound dehiscence

Implant Placement Timing

If the implant can achieve initial stability, it may be placed simultaneously with ridge augmentation. However, this approach carries a high risk of complications, such as wound dehiscence, infection, and graft failure. For more stable and successful outcomes, it is recommended to delay implant placement after ridge augmentation. Patients should be fully informed that the overall treatment duration may be prolonged, and surgery should only proceed with careful operative consent. When using autogenous bone grafts, implants can typically be placed after 4 to 6 months. Block-type autogenous bone grafts may require a longer healing time than particulate autogenous bone grafts. In cases of insufficient healing, block bone separation from the implants has been reported. If the bone grafts include allogenic, xenogenic, or alloplastic substitutes rather than autogenous bone, a longer healing period is necessary. The authors recommend a minimum healing period of at least 12 months for these cases.[33]

Conclusion

Vertical or horizontal ridge augmentation for one-wall defects remains challenging and carries a high risk of complications. To optimize the effectiveness of bone grafts, autogenous bone should be the primary choice, supplemented by other bone substitutes, covered with barrier membranes, and followed by primary wound closure. Adequate healing time is essential for successful dental implant placement. A healing period of 4 to 6 months is recommended for autogenous bone, and at least 12 months is advised if autogenous bone is not used. For successful outcomes, clinicians should adhere to the principles of bone graft procedures and have a thorough understanding of each surgical technique and bone substitute's characteristics. Ridge augmentation should only be performed after obtaining informed consent, with a clear explanation of alternative methods available.

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Journal of Chemical Health Risks

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