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Bone formation in oral surgery, the concept and limitation: A review of literature

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Abstract

The process of bone formation is a crucial component of oral surgery, particularly in instances where bone deficiencies or defects exist. The success of bone formation in oral surgery depends on different factors, such as the quality and quantity of the bone graft, the patient's local and systemic conditions, and surgical techniques. The major aim of this review is to provide a brief overview of the basics of bone formation and describe the concepts related to the regeneration of bone in oral surgery. This article also highlighted different factors leading to bone loss and the potential risks related to dental implant surgery. The article places particular emphasis on osteonecrosis, which occurs due to an improper supply of blood to the bone tissue. This article concludes that further research is needed to explore different techniques to encourage efficient and safe formation of bone in oral surgery.

Keyword: Bone formation; Osteonecrosis; Regeneration; Implant

1. Introduction

The process of bone formation is a crucial component of oral surgery, particularly in instances where bone deficiencies or defects exist. The capability to promote the growth of new bone is essential for successful results in procedures including orthognathic surgery, dental implant placement, and bone grafting. Multiple techniques and materials have been developed to stimulate bone formation; however, a comprehensive understanding of the underlying mechanisms of bone growth is crucial to improving the efficacy of these procedures [1].

The success of bone regeneration in oral surgery depends on different factors, such as the quality and quantity of the bone graft, the patient's local and systemic conditions, and surgical technique. Different sources of bone grafts utilized in oral surgery are autogenous, xenogeneic, synthetic, and allogeneic (2). Autogenous bone grafts are recognized as the benchmark material due to their exceptional osteoconductive and osteoinductive properties (3). Nevertheless, autogenous bone grafts have limitations, including circumscribed availability, donor site morbidity, and enhanced surgical time (4).

Allografts are sourced from a human benefactor and undergo processing to remove immunogenic elements while conserving the osteoconductive and osteoinductive features (5). Xenogeneic bone grafts refer to grafts procured from different animal sources, including porcine or bovine bone, which undergo processing to remove antigenic elements while maintaining the biological and structural characteristics (6, 7). Artificial bone replacements are made up of a

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variety of materials, including polymers, bioactive glasses, and calcium phosphate, which are designed to replicate the structure and composition of human bone (7).

Numerous growth factors, including bone vascular endothelial growth factor (VEGF), morphogenetic proteins (BMPs), transforming growth factor-beta (TGF-), and platelet-derived growth factor (PDG-VEGF), have been found to increase bone regeneration by facilitating wound healing, angiogenesis, and osteogenesis. Nevertheless, the clinical application of these growth factors is restricted due to their expensive nature, adverse effects, and short half-life (9). The purpose of this review is to provide an up-to-date and extensive understanding of bone regeneration in oral surgery, with a special focus on the mechanism of bone formation.

2. Discussion

2.1. Basics of bone formation

Ossification and osteogenesis refer to the process of bone formation and are often used interchangeably. This process comprises three major types of cells: osteoclasts, osteoblasts, and osteocytes, which are accountable for bone growth, remodeling, and development. Specifically, osteoblasts generate bone tissue, whereas osteocytes are highly developed bone cells. In contrast, osteoclasts are responsible for breaking down and reabsorbing bone. There are two major kinds of ossification: intramembranous and endochondral.

2.1.1. Intramembranous

Intramembranous ossification is a mechanism that involves the transformation of connective tissue membranes into bony tissue, leading to the generation of intramembranous bones. This kind of process is responsible for the generation of specific flat bones in the skull and several irregular bones. Initially, connective tissue membranes develop into future bones, which are then infiltrated by osteoblasts. These cells form a bony matrix around them, and once they are completely surrounded by it, they are known as osteocytes.

2.1.2. Endochondral Ossification

Endochondral ossification is the process of replacing hyaline cartilage with bone tissue, which makes endochondral bones. The majority of the skeletal structure is formed via this mechanism. In this mechanism, the future bones are initially developed as models made of hyaline cartilage. Around the third month of gestation, the surrounding perichondrium transforms into periosteum, which subsequently generates a compact bone collar around the diaphysis. Concurrently, blood vessels and osteoblasts migrate into the area, and the cartilage located in the middle of the diaphysis initiates the process of deterioration, creating an opportunity for osteoblasts to deposit spongy bone and form a primary site known as an ossification center. Ossification then progresses towards the extremities of the bone. Subsequently, newly formed bone tissue is broken down by osteoclasts, which helps form a cavity within the bone called the medullary cavity.

The growing cartilage in the epiphyses makes the developing bone grow longer. Following birth, secondary ossification centers emerge in the epiphyses and undergo an ossification process that is comparable to that of the diaphysis. Nevertheless, in contrast to the diaphysis, the spongy bone present in the epiphyses is not dismantled to form a medullary cavity. Upon the completion of secondary ossification, bone replaces hyaline cartilage entirely, with the exception of two regions: the articular cartilage, which surrounds the epiphysis surface, and the epiphyseal plate found between the diaphysis and epiphysis [10, 11].

2.2. Implant considerations

Dental implants are a very popular way to replace missing teeth, but their success depends on many things. One of the most crucial factors is the quantity and quality of bone available for the placement of the implant [12]. In accordance with the study conducted by Mauer, Shadrav, and Dashti (2021), the quality and quantity of bone are critical factors to observe before the placement of implants. The quality and quantity of the patient's bone should be evaluated to determine the most convenient approach to implant placement. In a few circumstances, sinus elevation or bone grafting may be required for the successful placement of an implant [13, 14].

Fathi et al. (2023) say that clinicians need to think about how different surface changes and implant materials affect osseointegration. It is crucial to choose implant systems that encourage remodeling and prompt bone formation to ensure the success of dental implants [15, 16].

Bone augmentation can also be utilized as an alternative approach for dental practitioners. It was suggested that different bone augmentation techniques, including growth factors, guided bone regeneration, and bone substitutes, can be used to improve the quality and quantity of bone [17].

In addition, the quality and quantity of bone can also be affected by different local and systemic factors, including smoking, health disorders, age, and the use of medication. Hence, dental practitioners should conduct a thorough observation of the individual's dental and medical histories as well as their overall health status [17-20].

2.3. Bone loss and osteonecrosis

Jaw osteonecrosis, or ONJ, is characterized as necrotic bone that becomes exposed in the maxillofacial area for a period of almost eight weeks. In individuals who underwent treatment with antiresorptive therapy for bone-related ailments, including metastatic non-small cell lung cancer, Paget's disease, and osteoporosis, without the medical history of radiation therapy [21, 22],

The oral and maxillofacial area may experience negative outcomes related to bone formation due to osteonecrosis. Periodontal disorders, which result in bone loss, can lead to a reduction in bone density and jaw mass, causing weaker bones and an enhanced risk of tooth decay [23]. Osteonecrosis, conversely, can interfere with the circulation of blood to the affected bone tissue, resulting in compromised bone formation and bone death [21].

2.4. Treatment for bone loss, guided bone regeneration

Guided bone regeneration (GBR) is an approach utilized to address bone loss in the jaw region, which is commonly related to dental implant placement [24]. This method entails the application of bone graft substances and barrier membranes to stimulate the production of new bone tissue in the intended region [25]. Employing dynamic navigation and a static surgical approach in implant placement can facilitate the accurate placement of implants during GBR interventions, resulting in more predictable outcomes and a decreased risk of complications [24].

3. Conclusion

In conclusion, the process of bone formation is a crucial component of oral surgery, particularly in instances where bone deficiencies or defects exist. Although guided bone regeneration has shown positive outcomes in the treatment of bone loss, additional research is needed to optimize its effectiveness.

Compliance with ethical standards

Disclosure of conflict of interest

There is no conflict of interest between the authors.

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