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PROGRESS IN THE STUDY OF THE METHOD AND MATERIAL OF ALVEOLAR RIDGE PRESERVATION

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ABSTRACT
Tooth extraction is a surgical trauma. Some problems like alveolar absorption will appear after the surgery. The bone healing of tooth-pulling and the shape of the groove are closely related to the aesthetic effect and function of implant repair. The alveolar ridge preservation technique is a method that can achieve the goal of reducing or even blocking the absorption of the alveolar bone. In this paper, we discuss the method of saving the post-tooth point and the current situation of material research.

Keywords: tooth extraction; alveolar absorption; implantrepair; alveolar ridge preservation

INTRODUCTION
The extraction of a tooth triggers a series of physiological reactions. After tooth extraction, whether due to trauma, decay, or periodontal disease, the alveolar ridge at the extraction site will inevitably undergo resorption and remodeling, and although this dynamic process varies from person to person, the resorption and remodeling of the alveolar ridge is a progressive and irreversible phenomenon(Barone et al. 2013).Immediately after the tooth is extracted, a large amount of blood fills the extraction wound, after which the bleeding stops, and a blood clot forms. Within the first week after extraction, the clot that first filled the wound begins to remodel and transform into granulation tissue, which is then replaced by connective tissue. Epithelial growth toward the surface of the clot begins to occur 3 to 4 days after the extraction. The formation of new bone unfolds 5 to 8 d after surgery and bone tissue begins to replace granulation tissue(Rich 2009), The whole reconstruction process is completed in 3-6 months, and normal bone structure appears.

After tooth extraction, the process of bone remodeling in the extraction wound is characterized by a dynamic balance between osteoblast-dominated new bone formation and bone resorption (Albanese et al. 2013). The rate of alveolar bone resorption is fastest during the postoperative wound healing period, decreases significantly at approximately 6 months, and stabilizes two years after extraction. Studies have shown that the resorption of the buccolingual alveolar ridge at the extraction site can be expected to be about 50% in the first postoperative year (Schropp et al. 2003), The resorption of alveolar bone in the horizontal direction is more than that in the vertical direction, and the resorption of buccal alveolar bone is more obvious than that of lingual bone (Tomlin, Nelson and Rossmann 2014, Tan et al. 2012). Over time, the change in the contour of the alveolar bone tissue will increase the difficulty of implant restoration after tooth extraction.

1. Methods of alveolar ridge preservation

1.1 Minimally invasive tooth extraction

The purpose is to maintain horizontal and vertical alveolar ridge morphology during the healing process of the extraction socket (Kalsi, Kalsi and Bassi 2019). Damage to the alveolar bone during tooth extraction is one of the important causes of postoperative alveolar bone resorption. Minimally invasive extraction instruments such as high-speed turbine hand pieces are used to remove teeth by cutting the tooth tissue, cutting the periodontal membrane, and widening the periodontal space, to reduce intraoperative damage, reduce alveolar bone resorption, and better preserve the alveolar site. The application of minimally invasive extraction instruments such as minimally invasive extraction forceps, minimally invasive dental jaws, implant machines, ultrasonic bone knives, and the use of minimally invasive extraction procedures to reduce flap surgery is more conducive to reducing periodontal tissue damage, preserving the integrity of periodontal soft and hard tissues, and facilitating soft tissue augmentation and aesthetic restoration at a later stage.(Jung et al. 2018, Nevins and Said 2018).The use of flap surgery has also been documented to cause shallowing of the vestibular sulcus, gingival atrophy, and reduced closure of the extracted tooth, which can lead to secondary alveolar bone loss. (Urban et al. 2015, Kotsakis et al. 2014).

1.2 Guided bone regeneration

The technique of guided bone regeneration was introduced into oral implant surgery in the 1980s, and the introduction of this technique played an important role in the development of oral implant surgery. To prevent the growth of connective tissue and epithelial cells in the soft tissue to the bone defect area and to maintain the necessary space for bone tissue regeneration, a barrier membrane is placed on the surface of the bone defect area to guide bone formation in the defect area, improve the height and width of the alveolar bone at the extraction site, and provide good alveolar bone conditions for implant restoration in the defect area.(Tay et al. 2022).The bone condition is the basis for the long-term success of implant restorations (Rakhmatia et al. 2013).

1.3 Immediate Implant

Immediate implant placement is also a common clinical method for the preservation of extraction sites, first developed by Schulte in 1976 and first introduced in 1978: the concept of immediate implant placement is the immediate placement of an implant after the extraction of a tooth that cannot be retained. Studies have shown that the early loading after immediate implant placement produces physiological stimulation of the bone tissue, prevents physiological resorption of the alveolar bone, and better preserves the periodontal tissue in the extraction wound, thus achieving the preservation of the alveolar site. (Esposito et al. 2010). However, the presence of periapical infection or periodontitis can increase the difficulty of preserving the tooth socket, which can affect the effect of immediate implantation. (de Oliveira-Neto et al. 2019).

2. Biological materials related to site-specific conservation

2.1Autogenous Bone

The transplantation technology of Autogenous bone has developed considerably so far. The source of autogenous bone is mainly the iliac bone, skull, upper and lower jaw bone, etc. The bone morphogenetic proteins contained in them play a key role in the bone formation process (Moslemi et al. 2018).This technique is considered the "gold standard" for post-alveolar ridge restoration because it combines all the necessary features for bone regeneration without the risk of adverse immune reactions and is highly osteogenic (Urban et al. 2019). The bone extraction area can be intraoral or extraoral, and the graft is performed using the split bone block technique, which can take the form of a small, juxtaposed, or mixed bone block (Khoury and Hanser 2019). Autogenous bone has unique advantages over other bone graft materials in terms of bone growth, osteoconductivity, and osteoinduction, as well as non-antigenicity and non-immune rejection. (de Sousa et al. 2018).There is also a possibility of revascularization in the bone after grafting. However, Autogenous bone grafting requires the opening of a second surgical area, which increases surgical trauma, and the scaffolding effect of Autogenous bone is limited due to its rapid resorption rate. (Bell et al. 2002).

2.2 Allogeneic bone

Allogeneic bone has evolved over 100 years and is now also widely used in site-preserving treatments. Allogeneic bone refers to bone graft material obtained from the same species but from different individuals, which has the advantages of a wide range of sources, unlimited size and morphology, good bioactivity, and osteoconductivity, but has problems such as low osteoinductive capacity, rapid resorption, slow bone formation and the risk of immunogenicity (Baldwin et al. 2019, Zou et al. 2021, Ippolito et al. 2019).Allogeneic bone includes cortical, cancellous, and highly processed bone derivatives (i.e., demineralized bone matrix) (Wang and Yeung 2017). Borg (Borg and Mealey 2015) The study concluded that freeze-dried bone and demineralized freeze-dried bone possess some bone-guided heel osteoinduction, but there is also the possibility of infection and immune reaction. Although the use of Allogeneic bone may be ideal for site-specific preservation, Allogeneic bone has no advantage over other biomaterials in terms of osteogenesis time or osteogenic volume (Natto et al. 2017).”Autogenous bone marrow" and "freeze-dried bone plus membrane" have been reported to be the most effective in reducing changes in alveolar ridge width and height, respectively (Iocca et al. 2017).

2.3 Bone Xenograft

Bone xenograft graft material is derived from xenobiotics, and currently, site-preserved progressive bone xenograft grafting is considered one of the best bone graft materials (Canellas et al. 2021).A bone xenograft is widely available, easy to obtain, and avoids the problems associated with opening a second surgical area. A representative one is inorganic bovine bone (Schmitt et al. 2015), a non-resorbable bone replacement material with good osteoconductivity without osteoinductive properties. Bio-Oss is a bone scaffold material derived from the bovine bone without organic components (Carmagnola, Adriaens, and Berglundh 2003). (Fan et al. 2021). Although Bio-oss is biocompatible as a site-preserving material, it does not contain organic components and has a loose bone powder structure, which makes it difficult for cell adhesion. Currently, scholars are focusing on the use of Bone xenograft graft materials in combination with other materials to enhance the effect of site preservation. (Serrano, Castellanos and Botticelli 2018, Keranmu et al. 2022, Cook and Mealey 2013).

2.4 Artificial bone

There are many types of Artificial bone, including single Artificial bone material and composite Artificial bone material. Artificial bone is degradable and biocompatible. Single Artificial bone currently used for extraction site preservation is more studied in hydroxyapatite (HA), β-tricalcium phosphate (β-TCP), etc. Rui Ge(Ge et al. 2019) found that β-tricalcium phosphate has good biocompatibility, good osteoconductivity, and no osteoinductivity (Pina, Oliveira and Reis 2015).AlgiPore^{TM} is a natural HA derived from seaweed, and studies have shown that combining AlgiPore^{TM} with beta-TCP reduces bone resorption time while maintaining the volume support needed for bone healing (Galindo-Moreno et al. 2020, Zarrintaj et al. 2020).Coralline hydroxyapatite (CHA) is commonly used in clinical settings in combination with autogenous bone graft material to enhance bone healing in bone defect areas (Bhatt and Rozental 2012).Other Artificial bone graft materials such as titanium material and bioglass ceramic have good osteogenic results.

2.5 Barrier membrane

Barrier membranes are required for guided bone regeneration techniques and serve to prevent the growth of epithelial tissue, connective tissue, etc., and to preserve space for new bone formation. The types of barrier membranes are non-resorbable membranes (polytetrafluoroethylene membranes, titanium metal membranes, titanium mesh, etc.), bioresorbable membranes (natural collagen membranes, synthetic membranes), etc. Non-absorbable membranes are biocompatible, but their clinical application is limited to some extent because they are not absorbable and have problems such as postoperative complications. Polytetrafluoroethylene membrane is one of the hot spots being investigated for use as a non-absorbable barrier membrane. A prospective cohort study showed that the use of a new non-porous dense polytetrafluoroethylene membrane (d-PTEF) to seal alveolar sockets was effective in reducing resorption of alveolar bone, suggesting that d-PTEF is an effective non-resorbable barrier membrane material for use in site-preservation techniques (Papi et al. 2020).The biocollagen membrane is resorbable, acts as a barrier and stabilizes blood clots, and facilitates the binding of bone tissue to the membrane. Lyu found that the use of collagen membranes was found to preserve alveolar sites well and to produce new bone of better quality. (Lyu et al. 2020).

2.6 Biological factors

Bioactive factors are a family of peptide molecules that regulate cellular responses such as cell adhesion, survival, value addition, chemotaxis, and differentiation, and are an integral part of biological tissue engineering. (Moslemi et al. 2018).The bioactive factors used for extraction site preservation are as follows, parathyroid hormone, Vascular endothelial growth factor, Platelet derived growth factor (PDGF), Platelet rich fibrin (PRF), Recombinant human bone morphogentic protein (rhBMP-2). The more widely used ones are PDGF, PRF, and rhBMP-2. Studies show that PRF use is effective in promoting bone tissue production.(Niu et al. 2018, Kotsakis et al. 2016) However, a study by foreign scholars found that although PRF combined with Autogenous bone increased the density of new bone formation compared to Autogenous bone alone, the difference was not statistically significant(Shawky and Seifeldin 2016). In fact, the effect of PRF on soft tissues is still controversial (Kumar et al. 2016). The bone morphogenetic protein (BMP) has a key role in bone formation and is considered to be a relatively good osteogenic factor at present. Jung-Seok Lee showed more new bone formation at sites transplanted with rhBMP-2, suggesting that rhBMP-2 facilitates site saving. (Lee et al. 2015).Although rhBMP-2 significantly promotes the formation of new bone after tooth extraction, some foreign studies have found it to be less effective than Allogeneic bone or Autogenous bone grafts in maxillary sinus floor surgery (Kelly, Vaughn and Anderson 2016).

4. Prospect

Although tooth extraction inevitably leads to progressive and irreversible resorption of the alveolar bone, there are nowadays various methods and materials for extraction site preservation aimed at reducing resorption and promoting the production of new bone for possible implant restoration. Each method of site preservation has its indications, but in clinical practice, a combination of methods is usually used to solve practical problems. The advantages and shortcomings of the materials used in site preservation today are the same, and even with site preservation, the alveolar ridge is still not fully preserved after extraction, but it is believed that with increasing clinical practice and technological advances it will make up for its shortcomings. At the same time, it is only through the continuous practice and research of countless dental clinicians on site-preservation technology that the technology will become more and more mature, and more difficult dental problems can be solved.

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