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# Application of filling materials in autologous tooth transplantation

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***Abstract:*** *As a treatment method for replacing missing teeth, autologous tooth transplantation (ATT)has shown more indications and ideal clinical effects with the continuous development of mature clinical applications and new technologies. The initial stability is an important factor to promote the healing of periodontal ligament. However, due to the fact that the alveolar fossa in the recipient area is difficult to completely match the donor tooth, and there will be different sizes of defect space around the root of the donor tooth after transplantation, which makes the transplanted tooth loose obviously, fall off and fail. This article reviews and analyzes the filling materials used in tooth transplantation.*

***Keywords:*** *ATT, filling materials, prognosis*

## 1. Introduction

ATT refers to the surgical process of transplanting teeth from one location to another location of the same individual. It is common to transfer ambushed, impacted, misplaced or ectopically erupted teeth to other alveolar sockets that need extraction or missing teeth, or to replace the physiological function of missing teeth in the alveolar socket prepared by surgery to repair dentition defects[1-3]. In 1915, Vidman et al.first reported ATT. Since then, this method has become popular in premolars and canines. In 1974, Slagsvold and Bjercke reported the results of autologous transplantation of 34 root agenesis premolars from 1959 to 1970, with an average follow-up of 6 years. He showed a 100 % survival rate and maintained the ability of transplanted teeth to complete root development[4]. Chung et al reported that the estimated 1-year and 5-year survival rates of mature autologous transplanted teeth were 98.0 % and 90.5 %, respectively[5]. Therefore, ATT can be considered as a versatile technique that can be used for multiple indications in adolescents and adults. Similarly, it has been demonstrated that the lifespan and prognosis of autotransplanted teeth are comparable to dental implants.

The success of ATT mainly depends on the regeneration ability of donor periodontal tissue and the infection control of the recipient area[6]. The initial stability of the donor teeth after implantation is crucial to the stability and healing process of the transplanted teeth at the initial stage of healing (2-4 weeks after surgery). Studies have shown that maintaining good initial stability of transplanted teeth is an important factor in promoting periodontal ligament healing [7]. The early healing rate of transplanted teeth with good initial stability was significantly higher than that of patients with poor initial stability. Therefore, good initial stability is helpful for early healing[8]. The periodontal ligament condition of the transplanted tooth plays a vital role in the ATT. The shorter the time of the transplanted tooth is, the less likely the periodontal ligament is dehydrated and the periodontal ligament stem cells are damaged [9]. The periodontal ligament condition before tooth surgery, the time of in vitro, the suitability of the root surface and the alveolar fossa in the recipient area, and the postoperative fixation time will affect the periodontal ligament activity. In addition, filling materials can be used to promote periodontal cell healing, alveolar bone healing and initial stability.

Usually, the alveolar fossa in the recipient area is difficult to match the donor tooth completely, and there will be a defect gap of different sizes around the root of the donor tooth after implantation, which makes the transplanted tooth loose obviously. After transplantation, the gingival epithelium grows into the alveolar fossa and the defect gap around the root along the root surface, which is easy to be polluted by bacteria and saliva, thus causing deep periodontal pocket, root fiber attachment or root bone adhesion, and finally making the transplanted root absorb and fall off[10]. For this reason, many scholars have applied biological filling materials such as artificial bone, autologous bone and platelet concentrate

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products to autogenous tooth transplantation to promote the stability of transplanted teeth and the healing of periradicular bone defects, and improve the success rate of ATT.

In the immediate transplantation of autogenous teeth, the cementum and periodontal ligament of the transplanted teeth are easily damaged, which affects the implanted root surface. In addition, due to the influence of the matching degree between the donor teeth and the recipient teeth, there are different gaps in the apical and periradicular areas after implantation. Therefore, in order to promote the healing of soft and hard tissues and improve the success rate of implantation, biological filling is needed. The success rate of filling is affected by the filling of biological materials in periodontal bone defect area [11]. It is reported in the literature that there are great differences in the available filling materials during tooth transplantation, because there are many and inconsistent views on the factors such as the condition of the recipient area, the matching degree of the transplanted teeth and the views of the surgeon. The following discusses the common filling materials for ATT.

## 2. Platelet concentrates

### *2.1 PRF*

Bone healing Platelet-rich fibrin (PRF) is rich in platelets, white blood cells, a variety of growth factors and cytokines. Animal experiments and clinical applications have proved that it has the biological characteristics of promoting bone tissue and soft tissue regeneration and anti-infection[12]. PRF contains many growth factors that promote rapid healing, which may repair and maintain periodontal health. The commonly used periodontal gap supplement material PRF can promote the immediate transplantation of autogenous teeth to repair and reconstruct bone defects.

PRF was introduced by Choukroun et al.in 2001, as a second-generation platelet concentrate, it is composed of fibrin matrix rich in white blood cells and platelets, and contains a variety of mitogenic factors such as platelet-derived growth factor, vascular endothelial growth factor, and transforming growth factor released by alpha granules. PRF can be prepared by centrifugation of the patient 's own blood at 3000 rpm for 10 minutes without thrombin or anticoagulant additives[13]. PRF stimulates angiogenesis through endothelial cell migration, division and phenotypic changes. It also promotes cell mitosis and induces osteogenesis without inflammation. These effects lasted at least one week and up to 4 weeks in a slow process. Dohan Ehrenfest et al.showed that PRF can induce strong and continuous differentiation and stimulation of osteoblasts with fibroblasts for 14 days[14] . The application of PRF tissue constructs may be a potential therapy for the treatment of dental pulp regeneration or revascularization[15].

In addition, PRF has shown successful results when used as the only agent for periodontal regeneration in clinical attachment loss and bone defects[16]. PRF also showed efficacy in the treatment of regenerated dental pulp. PRF can induce sustained and accelerated healing, and can also induce periodontal tissue regeneration and pulp formation. Hamzah Alkofahi et al.immediately transplanted the third molar of the unformed root into the extraction socket of the first molar and implanted the PRF. After 2 years of follow-up, there was evidence that the root continued to form [4]. Wang et al.evaluated the role of PRF in the regeneration of immature permanent teeth [17]. PRF can increase the thickness of tooth-related mineral tissue. After a 12-month follow-up, Bakhtiar et al. reported radiological evidence of further root development and apical closure in four immature teeth with pulp necrosis[18]. The application of PRF in immature root autotransplantation plays an active role in the regeneration process at that time and later stage.

Liu Junping et al.randomly divided 130 patients who underwent tooth extraction and immediate autologous tooth transplantation into three groups according to the patient 's wishes and the order of treatment. PRF combined with autologous bone, PRF, and autologous bone were filled in the bone defect area around the transplanted teeth. The patients were followed up for 12 months to evaluate the mobility and imaging findings of the transplanted teeth. It was found that the implantation of PRF combined with autogenous bone in autologous tooth transplantation can promote periodontal osteogenesis and facilitate the stability of transplanted teeth[12]. PRF contains many growth factors that promote rapid healing, which may repair and maintain periodontal health[19] .

### *2.2 CGF*

The latest generation of platelet concentrate-concentrated growth factor ( CGF ), with a special three-

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dimensional polymer network fibrin, contains a high concentration of a variety of growth factors, platelets, fibrin, and has a strong role in promoting tissue regeneration and wound healing and anti-infection. CGF is a new blood-derived biological scaffold material discovered in recent years, which is made by differential centrifugation after venous blood collection. As a new generation of platelet concentrate after platelet-rich fibrin ( PRF ) and platelet-rich plasma ( PRP ), CGF is not only a new generation of biological scaffold material, but also rich in a variety of highly concentrated fibrin and growth factors, including platelet-derived growth factor ( PDGF ), transfer growth factor-β ( TGF-β ), insulin-like growth factor ( IGF ) and fibroblast growth factor ( FGF )[20, 21]. Studies have reported that CGF is not only beneficial to the differentiation of bone marrow mesenchymal stem cells, but also promotes the proliferation, adhesion and collagen fiber synthesis of gingival cells, and accelerates soft tissue healing. In addition, the preparation of CGF does not require special additives, and the three-dimensional network structure of its fibrin is more similar to the natural fibrin network. Various growth factors captured after preparation can be released slowly in the later rhythm, making CGF have broad clinical application prospects in the field of pulp injury repair and tissue engineering regeneration [22]. Its application in bone defects can effectively promote angiogenesis, periosteal cell proliferation and bone tissue repair[23].

CGF was proposed by Sacco in 2006. Unlike PRF, it uses a special centrifuge for centrifugation, and different centrifugation speeds produce a larger, denser, and richer growth factor fibrin matrix[24]. Clinical studies have shown that CGF can promote the proliferation and differentiation of periodontal ligament stem cells, so that the damaged periodontal ligament repair and regeneration, because CGF contains high concentrations of growth factors, platelets, fibrin, with anti-inflammatory and antibacterial potential, bone induction and bone induction ; CGF filling in the recipient area around the donor tooth root can reduce the defect gap between the alveolar fossa and the root, form biological contact, and prevent bacteria from entering the root tip[25].

Li et al.selected 82 patients with autogenous tooth transplantation, a total of 84 teeth completed autogenous tooth transplantation, and 42 teeth in each group were randomly divided into CGF group and simple transplantation group to evaluate the clinical application effect of CGF in autogenous tooth transplantation. It was found that the initial stability of the donor teeth in the CGF group was better than that in the simple transplantation group. After 1 year of follow-up, the success rate of CGF group was higher than that of simple transplantation group. CGF filling in the recipient area can better surround the donor tooth root around the alveolar fossa, which can reduce the defect gap between the tooth root and the alveolar fossa[7]. Because CGF contains high concentration of growth factors, platelets and fibrin, it has great tensile strength, agglutination and adhesion, which can provide a certain degree of stability for transplanted teeth. At the same time, CGF can prevent direct contact between root and alveolar bone, which may reduce the occurrence of root bone adhesion to a certain extent. The application of CGF in autologous tooth transplantation has achieved good clinical application effect, which can reduce the postoperative symptoms of patients, facilitate the stability of transplanted teeth and improve the success rate of autologous tooth transplantation.

CGF has both osteoinductivity and osteoinductivity. It can induce mesenchymal stem cells to differentiate into osteoblasts and guide the growth of periodontal and bone tissues. CGF can be used as a barrier membrane to block the growth of gingival epithelium along the root to the alveolar bone defect area, promote periodontal ligament healing, accelerate new bone regeneration and inhibit bone resorption[26]. In a study, 42 patients with inflammation in the recipient area (42 transplanted teeth) were randomly divided into CGF group and control group, 21 cases in each group, and autologous tooth transplantation was performed. The results showed that the healing rate of alveolar bone in CGF group was significantly higher than that in control group at 3 months after operation. It was found that the application of CGF in autogenous tooth transplantation with inflammation in the recipient area was helpful to reduce the pain in the early stage of postoperative healing, accelerate the absorption of inflammation, promote the early healing of alveolar bone, shorten the healing period and promote the early healing of alveolar bone[9]. CGF comes from the patient 's autologous venous blood, without any additives, non-toxic, effectively avoid the possible immune rejection, cross infection, its high safety, more in clinical application.

## 3. Auto-tooth bone graft material

In the Department of Stomatology, different bone graft materials, including autologous bone graft, allogeneic bone graft, xenogeneic bone graft and allogeneic bone graft, are used to promote new bone formation. Autologous bone transplantation is considered to be the gold standard because they have

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osteogenesis, osteoinduction and bone conduction, and can also accelerate healing. However, due to the limited area of transplantation, reabsorption problems and the second wound site are the disadvantages of autologous bone transplantation, allogeneic, xenogenic and synthetic graft materials are also used. Compared with autologous bone transplantation, allogeneic bone transplantation has a weaker osteogenic effect, a stronger immune effect, and an increased risk of infectious diseases. In addition, xenografts and allografts have stronger bone conduction and cannot promote the required regeneration[27].

In recent years, autogenous tooth grafts have been gradually used in clinical practice as a new bone augmentation material. Autologous teeth are not only easier to obtain than autogenous bone, in vitro and in vivo experiments have confirmed that the tooth tissue has the characteristics of both bone guidance and bone induction, especially the dentin is more prominent[28]. Kim et al.implanted human demineralized dentin particles into subcutaneous muscle pockets of nude mice. After 2 weeks, histological observation showed that osteoblasts, mineralized collagen and osteocytes appeared on the surface of dentin particles. Experimental animal studies have shown that demineralized dentin induces osteoblast proliferation by differentiating mesenchymal cells and osteoblasts, thereby stimulating bone formation. Some studies have also shown that the type I collagen scaffold obtained after dentin demineralization can be used as a potential carrier of growth factor BMPs and a scaffold for stem cells to play a continuous role in inducing new bone formation in bone defect areas [29].

The structure of bones and teeth is similar. From the perspective of embryology, teeth, upper and lower jaws are developed from cells derived from neural crests. Their components are also similar to bone tissue, and have the advantages of no antigenicity and avoiding disease transmission, which suggests the potential use of tooth tissue in bone regeneration engineering. Dentin and bone contain the same percentage of inorganic and organic components. Dentin includes type I collagen ( 90 % ), biopolymers, lactic acid, lipids, citric acid and non-collagen proteins. Type I collagen induces bone formation by stimulating osteoblast activity. In addition, dentin and cementum contain a variety of growth factors, which induce osteogenic differentiation, participate in the regulation of collagen mineralization and crystal growth, and play a major role in promoting bone formation. Autologous tooth bone transplantation is a method using the characteristics of dentin and cementum [27, 30]. At present, autologous tooth bone has been proved to be a safe and biocompatible material, which can accelerate bone healing, because it has the characteristics of bone induction and bone conduction [30].

Dentin is composed of extracellular matrix, which contains a large number of type I collagen and protein. Studies have shown that demineralization procedures must be used before using dentin. After the demineralization procedure, dentinal tubules will expand, collagen fibers will be released, and basic proteins in dentin will be secreted. Bone regeneration using human dentin depends on the degree of demineralization and particle size [27]. Murata et al. [31]performed root canal therapy in vitro during immediate autologous tooth transplantation and implanted partially demineralized dentin / cement particles around the transplanted teeth. After 18 months, the hard bone plate and periodontal ligament space were found around the root by X-ray. The results showed that 70 % decalcified human demineralized dentin/cementum matrix(DDM)granules had better bone formation properties than 100 % decalcified DDM and non-decalcified dentin in rat skull defects. Ideal bone graft materials should be able to induce bone formation and safe biodegradation. Several biomaterials have been used as bone substitutes in the treatment of periodontal disease and bone defects. The use of dental bone tissue materials in dentistry has several advantages: no chemical or physical application, no risk of disease transmission, and they can be combined with other implant materials and PRF to stimulate bone regeneration [27].

## 4. Autologous bone powder

The earliest successful autologous bone transplantation was first seen in 1875 and has become one of the main methods of clinical repair. However, its application is often limited. The commonly used sources of autogenous bone are ribs, iliac bones, molar pads, maxillary nodules, skull outer plate, and chin. From the embryology, the mandible, skull and maxilla belong to intramembranous bone tissue with high survival rate, more cortical bone and low bone resorption rate[32].

In previous studies, the implantation of artificial bone materials such as hydroxyapatite, a-tricalcium phosphate cement, bone induction materials such as BMP complex, although the induction of alveolar bone growth is easy to combine with bone tissue, but the cost is high and the operation is complicated. Allogeneic bone and xenogeneic bone were implanted to repair bone defects. Although the shape and long-term effect were satisfactory, the rejection was serious and the treatment failed. In 2016, Liu Junping

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et al. [12] used PRF combined with autologous bone filling to repair the bone defect around the transplanted root immediately after tooth extraction, showing good repair effect.The results of Pan Xiaoling 's study in 2018 also showed that PRF combined with autogenous bone filling and immediate transplantation of autogenous teeth in periodontal space could improve the complete cure rate [33] . In 2021, Du Jixiu et al.[11] In the immediate transplantation of autologous teeth, autologous bone implantation combined with platelet-rich fibrin found that the complete healing rate of periodontal bone defects was significantly improved, and the treatment success rate and total effective rate were significantly improved. Autologous bone transplantation is safe and reliable, and there is no immune rejection concern. After non-vascularized autologous cortical bone transplantation, most of the osteocytes form new bone through bone creeping substitution, which can provide some mechanical support at the implanted site before new bone formation.

## 5. Allogeneic bone powder

### *5.1 Artificial bone powder*

Artificial bone was first used in the field of orthopedics. It has less damage and less pain than autogenous bone. It is the focus of research on repairing bone defects, and then gradually extended to the oral field. Bio-Oss is a biomaterial commonly used in stomatology to repair tooth defects. It is used to fill tooth defects in immediate autologous tooth transplantation. It has achieved good results in improving the success of implantation and reducing the infection rate before and after stitch removal. Bio-Oss is a porous bone graft material that has been specially treated to remove all organic components from bovine bone and preserves fine trabecular bone structure. Because its physical and chemical properties are very similar to the human bone tissue matrix, it provides a scaffold for the growth of osteoblasts, and thus has a natural bone guiding effect. Bio-Oss contains less hydroxyl and more carbonate, which can be absorbed after rapid integration with the patient's autologous bone, so it has a certain osteoinductive effect. Bio-Oss bone powder is a commonly used artificial bone graft material. It is made of carbonate apatite crystals extracted from bovine bone, which is basically the same as human bone structure.[34].

Chen Zhifang et al observed the clinical effect of Bio-Oss in filling periodontal bone defects during immediate autologous tooth transplantation. There were 6 cases in the treatment group and 11 cases in the control group. Bio-Oss was filled in the bone defect around the transplanted teeth in the treatment group. The patients were followed up for 6-12 months. After Bio-Oss implantation, the transplanted teeth achieved early stability. X-ray images showed that the periodontal ligament images disappeared and the alveolar ridge height did not decrease significantly. The control group was higher than the treatment group in terms of fixation time, mobility, alveolar bone reduction and the incidence of bone bags. It shows that the implantation of Bio-Oss in autogenous tooth transplantation can promote periodontal osteogenesis and is conducive to the stability of transplanted teeth. Bio-Oss is a bone graft material with natural bone guidance, which contributes to the growth of bone in periodontal and jaw defects. The authors applied it to transplanted teeth and achieved good clinical results.[35]

### *5.2 Hydroxyapatite*

Since the 1980 s, many scholars have been engaged in the development of polycrystalline hydroxyapatite particles-artificial bone, and have made great progress in theory and clinical application. In the Department of Stomatology, it has also achieved remarkable results in atrophic alveolar bone increase, filling of jaw cyst cavity, repair of periodontal bone defect, root canal filling and pulp capping[36]. Hydroxyapatite-artificial bone has been successfully developed and used in animal experiments and clinical repair of bone defects. Many scholars have reported that it is a bone-guided repair material with good biocompatibility, small immune response and strong anti-infection.

Yu Liying et al used hydroxyapatite for autologous tooth transplantation in 30 cases, including 17 males and 13 females, aged 23-59 years, with an average age of 36 years. The results were satisfactory. After 1 year, X-ray showed that the implanted hydroxyapatite was closely combined with the root surface and mucoperiosteum of the donor teeth. After 2-3 years, the alveolar ridge increased and new bone formed. 4-5 years of hydroxyapatite and alveolar bone fusion. The 1 ~ 5 year success rate was 93.3 %. From the effect of transplantation, hydroxyapatite has good adhesion and induction of new bone formation[36] .

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## 6. Conclusion

Autologous tooth transplantation is a safe and predictable technology, which is widely used in many disciplines of stomatology. With the deepening of research and the continuous practice of clinical cases, it is believed that autologous tooth transplantation will be better applied and developed in various oral related professional fields. In summary, periodontal bone defects are inevitable in immediate autologous tooth transplantation, but effective biological filling materials can promote tissue repair, reduce inflammation, and promote wound healing. At present, autologous bone implantation combined with platelet-rich fibrin has a good effect, which can be popularized and applied to patients with tooth implantation needs and available for tooth transplantation. The growth factors provided may help maintain the vitality of transplanted teeth, promote root formation and neurosensory development. Researchers are encouraged to conduct multicenter randomized clinical studies to study the effects of such different types of filling materials such as plasma and / or growth factors, artificial bone, and autogenous tooth grafts.

With the continuous application of various new technologies, autologous tooth transplantation technology will also be more perfect and applied to more clinical indications, showing more successful cases and having a broader application prospect. This review provides a theoretical reference for clinical autologous tooth transplantation. However, the current clinical research on the application of autogenous tooth grafts in bone augmentation technology is still in the preliminary exploration stage, and there is a lack of long-term clinical follow-up and large-sample trials. The most suitable preparation conditions for autogenous tooth grafts, as well as the factors affecting the effect of bone augmentation and the long-term survival rate of autogenous tooth transplantation still need further study.

In a word, there are many factors affecting the success of transplanted teeth, such as the factors of donor teeth, the factors of alveolar bone in the recipient area, the age of patients, the degree of cooperation and postoperative health maintenance. This requires oral clinicians to comprehensively consider and evaluate these influencing factors to improve the survival rate of transplanted teeth. With the continuous improvement of tooth transplantation methods and the continuous updating of new equipment and materials, autologous tooth transplantation will gain a broader space for development. Autologous tooth transplantation should be a valuable alternative to dental implantation or bridge formation.

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