Chapter 9

Hard Tissue Regeneration Treatment Protocols in Contemporary Oral Surgery

Bahattin Alper Gultekin and
Gamze Zeynep Adem Siyli

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/intechopen.74944

Abstract

Dental implant placement is one of the most reliable and predictable treatment choices in modern oral surgery. It requires available bone volume to resist the force during loading. There are many ways to regenerate the bone to place the implants with the desired dimensions. Guided bone regeneration, socket grafting, allograft bone block grafting, and intra- and extraoral autogenous bone block grafting are the most popular treatment approaches to reconstruct hard tissues. Autogenous bone graft is still considered the gold standard for the reconstruction of hard tissues. In addition, there are many scaffold biomaterials available that are used as templates for new bone formation. These biomaterials are helpful to not only eliminate the usage of autogenous bone grafts but also decrease patient morbidity. Another advantage of biomaterial usage in tissue regeneration is to reduce the learning curve of treatments by facilitating operative approaches. The aim of this chapter is to evaluate contemporary biomaterials that are used to reconstruct hard tissue defects in oral surgery.

Keywords: hard tissue engineering, bone defect, biomaterials, scaffold, dental implant

1. Introduction

The main reasons for tooth defects include periodontal diseases, decay, trauma, failed endodontic treatments, congenital anomalies, oncologic diseases, oral infections, and orthodontic treatment [1]. Functional and esthetic treatment for tooth loss is important but time-consuming. Dental implant applications are among the many methods developed to treat this problem [2]. Since the definition of osseointegration, dental implants have been a proven and frequently used method in the treatment of total and partial tooth loss [3, 4].

The success of dental implants is assessed by criteria such as implant survival, stability of prosthetic treatment, radiological bone loss, and presence of peri-implant infection [5]. The accepted general consensus for the success of dental implants in recent years is that both functional and esthetic results are satisfactory [6]. There are risk factors that should be considered for the success of an accomplished outcome. Some of these factors include age, sex, general health status, habits, the region where the implant is placed, the number of implants, and the condition of the bone [7].

For dental implant indications, the presence of adequate bone and the relationship between both jaws are important. Studies have reported that a non-ideal three-dimensional implant placement may cause peri-implantitis, esthetic and functional failure, and may even result in removal of the implant [8]. To achieve optimal esthetics and function, the position of implant in the alveolar crest has to be in a biologically correct and prosthetically driven location [9]. When the implant is placed in an inappropriate position, for example, a bone-directed position, the use of pink porcelain and/or angulated abutments would be inevitable. Besides, non-axial masticatory forces will increase the risk of complications, such as screw loosening or fracture and chipping on implant-supported restoration [10]. Insufficient alveolar ridges may require bone augmentation procedures to achieve optimal bone volume before implant placement. These applications ensure that the implant is placed in the correct position and that an appropriate restoration can be performed [11].

The amount and location of bone resorption are important factors in the selection of the augmentation technique. In addition, the relationship between the jaws in radiological and clinical evaluations should be considered in the sagittal, frontal, and transverse planes [12]. Alveolar bone augmentation procedures include applications for increasing residual crest width and/or height using grafts and/or biomaterials or for optimizing bone contours with repair of bone defects [13]. In an attempt to correct bone defects, many techniques have been extensively described for bone augmentation and grafting materials. Although autografts remain the "gold standard," the use of biomaterials in orthopedics and dentistry is increasing [14].

2. Bone augmentation

Bone augmentation procedures usually involve bone block grafts, guided bone regeneration, ridge expansion/splitting, sinus floor elevation, and distraction osteogenesis. In addition, socket preservation is often used for the protection of the existing bone. Despite the availability of these techniques, guided bone regeneration has been widely used for implant site development [15]. This is attributed to its predictability, easiness while handling, and less-invasive nature than other advanced bone augmentation techniques [16]. Another advantage of this procedure is that it can be performed prior to or simultaneously with implant placement [17]. The results of horizontal bone augmentation are more reliable than those of vertical bone augmentation. Achieving bone gain in the vertical dimension is more difficult than that in the horizontal dimension [18].

Using a bone graft does not always guarantee clinical success. There are many major and minor factors that affect clinical success [19].

http://dx.doi.org/10.5772/intechopen.74944

Major factors:

- Patient selection, patients without medical problems
- Defect morphology: multiwalled bone defects
- Graft types: autografts are preferred for allografts and allografts are preferred for alloplasts
- Healing capacity of the patient

Minor factors:

- Flap design
- Graft placing method
- Epithelial retardation

3. Bone graft healing mechanism

The main component of bone healing is the selection of the materials for the bone graft. Bone grafts have different bone-forming capacities; therefore, we need to understand the mechanisms of bone regeneration for the grafts used at the recipient regions. The requirement of the region can be determined in advance and the graft is chosen accordingly. Bone healing in the region where the graft is placed is supported through osteogenic, osteoconductive, and/or osteoinductive mechanisms.

3.1. Osteogenesis

Osteogenesis is defined as the formation of bone in the region where osteoblasts and osteoblast precursors do not have bone tissue. New bone formation occurs when osteoblasts and osteoblast precursors are produced by cancellous bone and bone marrow. Osteogenesis (bone formation) is characterized by the presence of living osteoblast cells in the graft material. The only bone graft with osteogenesis is the autogenous bone [20]. Autogenous bone grafts, also called autografts, are grafts transplanted from one site to another. The most effective type in terms of osteogenesis is cancellous bones, due to the migration of bone cells at high concentrations. Autografts have been observed to have bone formation capacity even when bone tissue is placed underneath the skin [21]. Vascularization of the graft site is necessary for continued osteogenesis. Some studies have reported loss of osteogenic properties of free autogenous grafts without vascular support within 5 days and that they continued osteoinductive and osteoconductive effects at the end of the study [20, 21]. Therefore, free autogenous bone grafts show osteogenic characteristics only for a few days. We should pay attention to the viability of the cells when placing the autogenous graft in the recipient region. Once the autogenous bone has been obtained, it should not be left in the dry area, and if possible, it should be used as soon as possible with saline in a sterile environment [22].

3.2. Osteoinduction

Osteoinduction is an active process in which the bone graft causes the bone-forming cells to penetrate the recipient region and stimulates them to form new bones. Osteoinduction refers to the ability of the graft to send a signal to attract, proliferate, and differentiate early-lineage cells (e.g., mesenchymal stem cells or osteoprogenitor cells) into bone-forming cells, resulting in the formation of a mineralized bone. Bone morphogenetic proteins (BMPs) support these signals. BMP is measured as the amount of picograms in the normal bone. In recent studies on osteoinduction, Urist et al. isolated BMP, a soluble glycoprotein. They described BMP as a growth factor of the transforming growth factor (TGF)-β family and as an inductive agent. They also reported that at least 15 different types of BMPs were found, and the most important were BMP-2 and BMP-7 [23]. BMP is naturally released during trauma or the regeneration process and acts as an osteoinductive agent.

Demineralized bone matrix (DBM) allograft materials have osteoinductive healing mechanisms. DBM allografts can provide a matrix for bone cells to infiltrate and produce bone. Its healing mechanism manifests through osteoinductive pathways, and bioactive molecules stimulate mesenchymal cells to differentiate into bone-forming cells [24].

3.3. Osteoconduction

Osteoconduction is described as the growth of a superficial bone on a surface. Osteoconductive materials are biocompatible and have an osteoconductive surface: on its pores, in its ducts, or in its tubes. Materials with osteoconductive properties form a matrix and guide osteogenesis. Grafts with osteoconductivity have no bone formation capacity and can only function as a roof for bone formation. If osteoconductive materials are placed in ectopic areas such as subcutaneous bones, bone formation does not occur and the material remains unchanged or resurfaced [22]. Examples of osteoconductive properties are autografts, allografts, xenografts, calcium sulfates, calcium phosphate cements, ceramics, collagen, and synthetic polymers. It is also known that bone graft materials may be supplemented with materials such as exogenous growth factors, to create inductive effects [22].

3.4. Creeping substitution

Creeping substitution indicates the movement of new tissues through channels made by blood vessels invading a transplanted bone. The dynamic healing and reconstructive process of bone transplantation was described by Axhausen in 1907; he reported that bone transplants undergo necrosis. The necrotic bone is then replaced by the new bone via creeping substitution [25].

Improvement of the graft material differs according to graft type in terms of duration and content. Vascular support in the recipient region and the survival rate of cells in the graft have a direct impact on graft recovery. Morphologically, the cortical bone, which is the tight structure around the haversian and Volkmann channels, consists of circular, parallel, and interstitial bone lamellar. The cancellous bone is porous and trabecular in shape and contains the bone marrow. There is a less surface area in the cortical bone than in the cancellous bone; therefore,

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the cells and blood vessels can reach the receiving region. The vascular support in the organization of the cancellous bone in the graft is 30% better than that in the cortical bone [26].

4. Bone augmentation techniques

4.1. Sinus lifting

Prostheses that are supported on maxillary dental implants are now the optimum way to give patients an admissible quality of life. In cases with a vertical insufficient alveolar bone, a maxillary sinus lift with a bone graft using a crestal or lateral approach is needed. Elevation of the sinus floor permits the correct number and length of endosseous implants to be applied for adequate mechanical support of the atrophic posterior maxilla [27].

Previous studies proved that dental implants related to maxillary sinus augmentation have a satisfactory long-term success and survival rate [28]. Implant application may be simultaneously combined with maxillary sinus lifting procedure as a" one-stage" surgery, or sinus lifting may be conducted at first, and implants are then applied as a" two-stage" operation. There are many options for graft material to augment the maxillary sinus. Autogenous grafts can be harvested from the chin and ramus intraorally or iliac crest, calvarium, and tibia extraorally. The disadvantages of autogenous grafts are resorption rate and morbidity. Allografts (cadaveric bone) are harvested and different techniques such as irradiation and freeze-drying are used to reduce antigenicity. Allografts are found in tissue banks. Xenografts consist of anorganic bovine or equine bone. The organic components of these types of grafts are chemically removed and a mineral scaffold is obtained. Alloplasts are synthetic materials; there are many types of structures of alloplastic grafts such as micro- or macroporous, dense, amorphous, or crystalline grafts. Structure and porosity directly influence the performance of the material [29].

4.2. Socket preservation

Following tooth extraction, alveolar bone remodeling begins by means of vertical and/or horizontal bone resorption [30] so that a proper prosthetic and esthetic position of dental implants can be influenced. Alveolar socket preservation techniques have been introduced to conserve the alveolar bone vertically and horizontally [31].

Socket preservation could be considered when:

- Implant placement needs to be delayed for patient- or site-related reasons;
- In cases where implant placement needs to be postponed for >6 months for some reason; and
- If partially fixed pontic site is planned [32].

There are various graft materials used in socket preservation surgery such as autografts, allografts, xenografts, alloplasts, or platelet concentrates. Allogenic bone is described as the

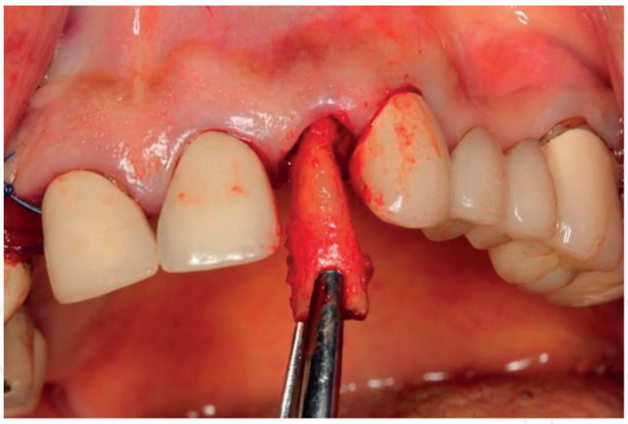

Figure 1. Extraction of lateral incisor.

most suitable material to obtain optimum results for socket preservation techniques. Freeze-dried bone allograft (FDBA) and demineralized freeze-dried bone allograft (DFDBA) are used in socket preservation techniques. Recently, platelet concentrates have been widely used for socket preservation. The platelet concentrates contain a high concentration of growth factors, such as PDGF, TGF-β, IGF, and VEGF, as well as anti-inflammatory molecules, such as IL-1β, IL-4, IL-6, and TNF-α, which accelerate the healing process. This results in better bone repair and regeneration [33].

Primary closure of the flap is important and should be performed if possible. The other methods to seal the surgery site are free gingival grafts, collagen membranes, or nonresorbable membranes [34]. The socket-shield technique is currently performed. Applying this technique, a buccal part of the tooth root is retained in the alveolar socket during tooth extraction. This is done to prevent the resorption of the vestibular bony lamella [35].

Several studies have reported that the socket preservation technique is very successful and useful compared to nongrafted sockets [31]. If immediate implantation is not possible, the socket preservation technique should be used to increase esthetic outcome as well as alveolar bone quality (**Figures 1–4**) [35].

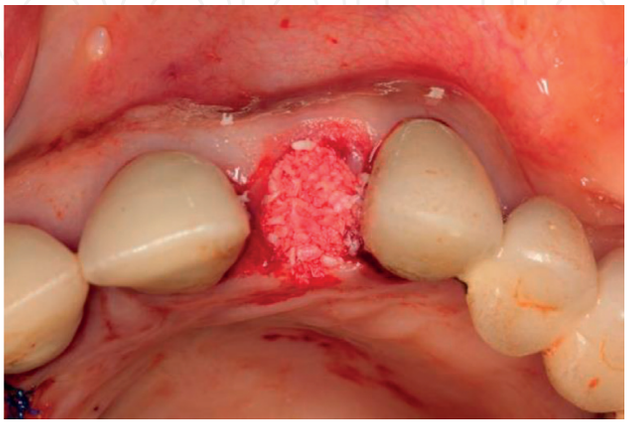

Figure 2. Applying of bone graft material.

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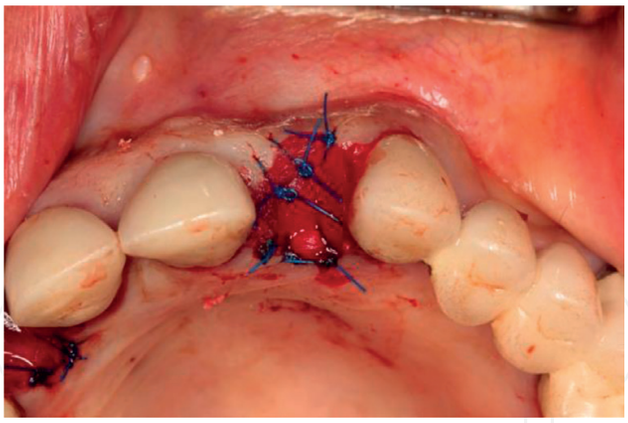

Figure 3. Sutures and closure.

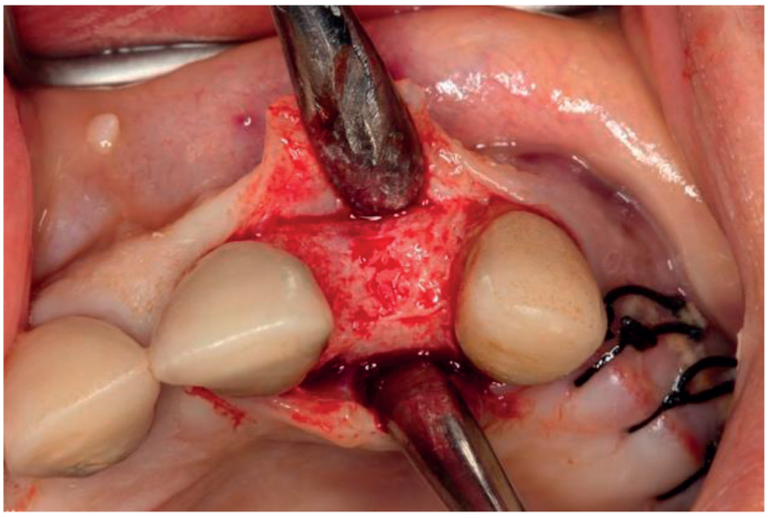

Figure 4. Post-op 6 months.

5. Types of bone grafting materials

Graft materials may be synthetic or natural materials that are placed in a biological environment for reconstructive purposes, and are prepared to be accepted by the surrounding tissues. The most commonly used biomaterials include autografts, xenografts, allografts, and alloplasts. Ideally, the material for bone regeneration should be able to form a new bone, and the formation of the new bone should balance with resorption [36].

The first biomaterials used for grafting areas with bone deficiencies were autografts. Autogenous bone is considered the gold standard for grafting biomaterials for its three main properties: osteogenesis, osteoinduction, and osteoconduction. Advantages of autogenous bone grafts include early vascularization, osteoinductive properties, low cost, and minimal morbidity. Recent research on cortical bone chips revealed that the paracrine effect of bone chips has a significant impact on bone regeneration. Autogenous bone can be harvested near

the receiving site to reduce morbidity. Using a bone scraper may reduce the treatment time and simplify harvesting of the autogenous bone [37].

Allografts are bone grafts collected for transplantation purposes from one person to another and have widespread use. They are important for the treatment of congenital, traumatic, degenerative, and neoplastic bone defects. The advantages of allografts include availability and reduced morbidity, since harvesting bone from an intraoral site is no longer required. The main disadvantage is the possibility of transmission of infection from the donor to the recipient. Possible transmittable infections include malignant neoplasms, degenerative bone diseases, hepatitis B, hepatitis C, and HIV. Donors are carefully screened, and graft materials are meticulously processed to reduce disease transmission. Allografts are not osteogenic and thus, healthy bone formation takes longer compared to that with autogenous bone grafts. There are two main forms of allografts: mineralized freeze-dried bone allografts (MFDBA) and DFDBA. In FDBA, the graft is dried at low temperatures throughout the entire process. In DFDBA, the mineralized phase of MFDBA is removed so that collagen and BMPs are exposed. If this mineral phase is not removed, the bone induction process is not observed. MFDBA is mainly used for its osteoconductive properties and space maintenance. Cortical bone chips are generally preferred for allografts because of their low antigenic activity and high levels of collagen [36].

Grafts obtained from a donor in a different species are xenografts (also called heterogeneous grafts). Xenografts are composed of deproteinized spongiform bones naturally obtained from other species such as horses or cows. Heterogeneous bone grafts have been proposed to fill bone defects; many clinicians have reported that these grafts have little to no osteogenic potential and may instead be used as scaffolds for space maintenance and long-term bone formation. Bovine bone is the best and most commonly preferred source of xenografts. The risk of transmission of diseases, such as spongiform encephalopathy in cattle, is insignificant due to the grafts deproteinization process. Inorganic and protein-free bones are materials in which only the natural calcium phosphate in the bone is retained. This material consists of unsaturated calcium apatite crystals, and provides long-term low resorption space maintenance, shown to remain 10 years postoperatively. Xenografts inhibit resorption of the grafted site but may negatively impact healing by decreasing the rate at which the implant surface area is integrated with the newly formed bone. Used in cystic cavities, alveolar ridge augmentation, extraction sites for implant placement, and sinus lifting, xenografts are viable materials, when a high osteogenic potential is not imperative. Xenografts can also be mixed with autogenous bone grafts. Such a composite graft material with osteogenic properties can be successfully used for horizontal and vertical ridge augmentations [19].

Alloplastic biomaterials are synthetic graft materials. Biocompatible synthetic graft materials have been used for the last two decades to avoid the disadvantages of allografts and xenografts. Alloplastic materials are not osteoinductive, but they can provide space maintenance and act as a scaffold for new bone formation; this means that they are osteoconductive. Advantages of alloplastic materials include being risk free in terms of cross infection, their availability, being sterilizable, and their biocompatibility. Alloplasts used in augmentations are solid or porous polymers, hydroxyapatite (HA), and calcium triphosphate ceramics, or combinations of these materials [20].

Calcium phosphate ceramics can be both osteoinductive and osteoconductive. Osteoinductivity occurs with the formation of a hydroxyapatite (HA) layer immediately after implantation. Ca2 + and PO4 ions required to form this layer are removed from the bone surrounding the graft. With excellent biocompatibility and without systemic toxicity or foreign body reactions, calcium phosphate ceramics are promising biomaterials that require further clinical investigation. Synthetic hydroxyapatite is one of the most commonly used alloplastic materials because of its chemical composition, which is similar to the human bone. It is nontoxic, has high chemical stability, and causes less inflammation and antigenic reactions. Another important property of HA is that the microstructure can be controlled to induce the formation of pores in the material that permits the migration of new bone tissue and blood vessels. Clinical applications, such as bone defect repair, alveolar ridge preservation after tooth extraction, ridge augmentation, and sinus grafting possibly combined with autogenous bone, are possible with HA [36].

Tricalcium phosphate (TCP) is a biocompatible and bioabsorbable material. However, due to rapid dissolution within 6 weeks, it is not an optimal bone substitute in terms of space maintenance. It is similar to the mineral structure of the bone in terms of its chemical composition and crystal structure. It follows similar healing steps with other graft materials. The known disadvantages of TCP are indicated as unpredictable and rapid resorption rate [19].

6. Membranes

Various types of membranes have been used for tissue regeneration, with the aims of support and maintenance of the treatment area. The barrier membrane allows the migration of regenerative cells within the confinement area, while this technique prevents the migration of undesired cells into the wound area. There are two main groups of membranes: resorbable and nonresorbable.

6.1. Resorbable membranes

Graft materials have been used with resorbable membranes for guided bone regeneration. Ever since resorbable membranes have no stable fixed shape, it is feasible to utilize them for GBR. Resorbable membranes that are developed nowadays are prepared from glycosides and lactic polymers. Absorption of these membranes by hydrolysis takes a minimum of 6 weeks and is completed in exactly 8 months. Traditional resorbable membranes, using polymers like polylactic acid, demonstrated therapeutic problems due to their inflammatory properties and reaction to foreign bodies upon degradation. Due to premature membrane resorption, minimal inflammatory reaction may occur, but clinical observations show that the inflammation does not prevent healing. Resorbable membranes possess qualities such as low possibility of complication, membrane subtraction after healing, reduced morbidity, and easy manipulation. These types of membranes as effective as conventional expanded polytetrafluoroethylene (e-PTFE) in recent experiments [37].

Polymers have had long and widespread use as biomaterials. Resorbable polymers have a remarkable advantage since they do not require a second operation after implant placement.

The body can absorb these materials over time. Polylactic acid membranes can retain their long-term durability. They can be prepared in small sizes and yield more moderate foreign body reactions. Furthermore, slow degradation makes the substance less aggressive. Thus, the surrounding tissue produces less reactions. The clinical use of polylactic acid membranes is that they can serve as barrier materials that can guide the periodontal ligament and bone cells that in turn can be shaped according to the morphology of the defect when manipulation is evaluated. When evaluated in terms of membrane reliability and toxicity, any negative tissue reaction that can be attached to this membrane in surgically created defects does not show any anatomical defects in the regenerated portions [38].

Collagen membranes have recently been preferred due to their biological advantages. They are strong and resistant to deformation and have high-calcium-binding properties. In addition, collagen membranes are biocompatible and are as matrix materials in guided tissue regeneration and with hydroxyapatites. Collagen membranes do not possess immunogenicity; they are well-qualified and have demonstrated excellent long-term clinical outcomes (**Figures 5** and **6**) [39].

Synthetic barriers, such as collagen and PTFE barriers, also yield successful clinical results. They occur in the form of lactic acid and glycolic acid polymers. Although directed tissue regeneration membranes are widely accepted as a treatment modality, their clinical use should be approached with care. These membranes may cause problems such as exposures, risk of bacterial infiltration, and incomplete closure of the operative site. Degradation is usually through hydrolysis when membranes that are resorbed are used. This leads to the formation of an acid cycle, which is a negative effect on bone formation [40].

6.2. Nonresorbable membranes

Reinforced nonabsorbable membranes are used when higher bone augmentation is required. e-PTFE, titanium-reinforced e-PTFE, dense polytetrafluoroethylene (d-PTFE), nano-PTFE, and titanium mesh membranes are known as nonresorbable membranes. Nonresorbable membrane barriers require a second surgical procedure to remove them from the site of augmentation. In large bone defects, the e-PTFE membrane cannot adequately cover the existing

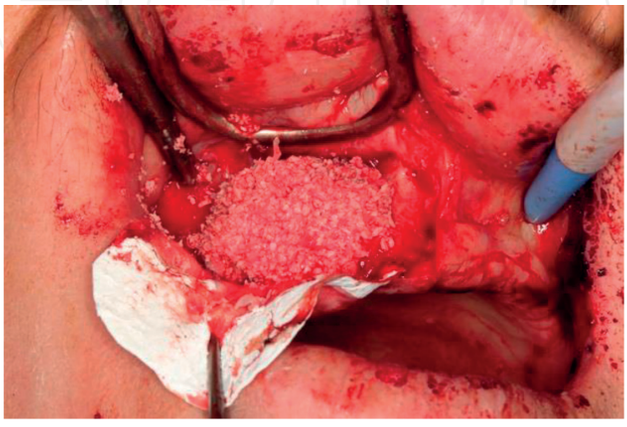

Figure 5. Horizontal augmentation of alveolar ridge, application of xenograft and collagen membrane.

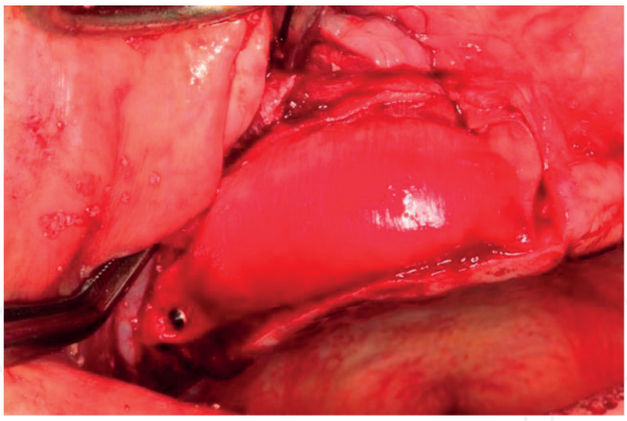

Figure 6. Stabilization of collagen membrane with miniscrews.

space unless supported by graft material. The most important disadvantage is that it requires a second surgical operation because it cannot be resurfaced. It has become preferable to use membranes that are resorbed because of the risk of tissue damage and economic damages to the patients due to a second operation. In addition, nonresorbable e-PTFE membranes are disadvantageous because these membranes involve a high incidence of soft tissue problems, such as exposure, especially when compared to resorbable membranes [41].

Comparison of e-PTFE and resorbed membranes reveals that bone regeneration with e-PTFE membranes is greater, if no exposures occur [40]. Because e-PTFE has no tolerance to exposure, e-PTFE membranes must be completely healed during the primary healing procedure. Currently, because of the complications related to membrane exposure, e-PTFE membranes are not commonly used in GBR treatments. Instead, d-PTFE membranes, which are titanium-reinforced nonresorbable membranes, are used for the reconstruction of critically sized defects. A d-PTFE membrane is used because unlike e-PTFE, d-PTFE continues to be functional even if exposed to the oral cavity. Nano-PTFE membrane is more flexible than e-PTFE; therefore, manipulation and adaptation in this type of membrane is easier. Nano-PTFE has 0, 2–0, and 3 pores. These small pores limit the access of epithelial growth and bacterial infiltration in the augmentation area [41].

The advantage of strengthening membranes with titanium is that it maintains regeneration of the region and obstructs pressure on graft material, soft tissue subsidence, and resorption. Its surface structure and pores are designed to prevent bacterial migration and retention. Soft tissue provides a suitable environment for bone formation and neovascularization in the region by reducing migration to the defect site. They are strained membranes and do not bend but are also resilient enough to prevent perforation of the soft tissue [42].

7. Platelet concentrates

Recently, there has been increasing interest to promote bone formation. Platelet-rich plasma (PRP), growth factors, and BMPs are used to accelerate bone augmentation [43]. Coagulated blood acts as a scaffold for bone formation [44].

7.1. Platelet rich plasma (PRP)

The plasma rich in thrombocytes obtained from autogenous blood tissue is called PRP. PRP contains high proportions of thrombocytes as well as growth factors and other components [45]. PRP is obtained by centrifugation of blood, and 95% of the platelets comprise 4% red blood cells and 1% white blood cells. The most common advantage of PRP is that it accelerates hard and soft tissue healing. PRP can be injected directly into the wound area to accelerate tissue healing or it can be used with graft materials [46].

PRP has a long shelf life, but it should be used quickly. This is because 95% of the growth factors available in PRP are released within 1 h and the activity lasts for 7 days [47].

The use of PRP in oral maxillofacial surgery has been increasing. PRP secreted by growth factors accelerate the healing mechanism of the bone tissue. It has been shown that PRP increases mature bone density by 15–30% [48].

Furthermore, PRP allows a nonspecific immunoreaction to occur. Leukocytes in this context and interleukins secreted from these leukocytes are also activated by the activation of macrophages. Bacteria exhibiting antimicrobial activity of PRP are *Escherichia coli*, *Staphylococcus aureus*, *Candida albicans*, and *Cryptococcus neoformans* [49].

7.2. Platelet rich fibrin (PRF)

The PRF protocol was developed by Choukroun in 2001. The goal of PRF is to obtain a membrane that is rich in plagioclase-like factors. The acquisition protocol is not dependent on a specialized medical device but can easily be implemented by clinicians. PRF is obtained by removing autogenous venous blood from the dry glass tubes and then centrifuging it at low speed.

Since no anticoagulant is added to the blood in PRF, blood coagulation mechanism begins. PRF has three layers: red blood cell at the bottom, cells plasma at the top, and PRF clot in the middle. This clot is a 3D strong fibrin matrix structure, in which leukocytes and platelets are present in high concentrations [50].

Previous studies have reported the positive clinical and radiographic results for the efficacy of PRF in intrabony and mandibular defects [51].

Platelets help repair damaged tissues by releasing growth factors such as PDGF, TGF-β, VEGF, IGF-1, FGF, and EGF. The granules in the platelets also stimulate cellular growth and proliferation; similarly, chemokines and cytokines are involved in the regulation of tissue regeneration and treatment of inflammation. Platelet granules are important protein sources for the activation of other cells [52].

7.3. Bone morphogenetic protein (BMP)

Recombinant human bone morphogenetic proteins (rhBMP) are used in osteogenic regenation in addition to its use in pulp amputation treatment for new osteodentin formation in the presence of inflammation [53]. It has been reported that the recombinant human proteins

repairs the pulp to form new dentin [54]. However, half of the morphogenesis is achieved due to the limited lifetime of the carrier at very high concentrations [55].

An ideal carrier has not yet been identified, since the cost for this is high. These factors directly influence gene therapy instead of being applied along with morphogenesis, which is a desirable treatment approach [55].

8. Conclusions

This chapter is concerning the dental implant placement. It is one of the most reliable and predictable treatment choices in modern oral surgery. The ways to regenerate the bone to place the implants with the desired dimensions are as follows: (1) guided bone regeneration, (2) socket grafting, (3) allograft bone block grafting, (4) intra- and extraoral autogenous bone block grafting. There are many scaffold biomaterials available that are used as templates for new bone formation. In recent years, biomaterial usage for the reconstruction of hard tissue defects has dramatically increased. Combination of scaffold biomaterials with growth factors presents promising results. In the future, there is no doubt that autologous bone usage will be replaced with artificial tissue engineering.

Conflict of interest

There is no conflict of interest in this study.

Author details

Bahattin Alper Gultekin[1]* and Gamze Zeynep Adem Siyli[2]

*Address all correspondence to: alpergultekin@hotmail.com

1 Istanbul University, Faculty of Dentistry, Department of Oral Implantology, Istanbul, Turkey

2 Okmeydani Dental and Oral Health Hospital, Department of Periodontology, Istanbul, Turkey

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