Surgical and Prosthetic Oral Implantology

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Cambridge
Scholars
Publishing

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This book first published 2024

Cambridge Scholars Publishing

Lady Stephenson Library, Newcastle upon Tyne, NE6 2PA, UK

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

ISBN: 978-1-0364-1024-7
ISBN (Ebook): 978-1-0364-1025-4

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1.

THE HISTORY OF DENTAL IMPLANTS

Prototypes of modern implants were used 4,000 years ago in ancient China in the form of bamboo pegs to replace missing teeth[1]. Various materials have been found in the archaeological finds of the jaws of ancient skulls: metal, jade, shells, ivory, corrugated porcelain, iridium tubes chromium, cobalt, iridium, platinum, silver.

Around 2,000 years later, the Egyptians adopted a similar practice of carving precious metals and pegging them onto the jawbone. Pharoah's were having pegs made of copper hammered into their jaws in to replace the missing teeth. The first recorded case of a metal implant was found in an Egyptian king from 1,000 B.C. Archeologists have also found numerous skulls with artificial and transplanted teeth made from elephant ivory or rare gems like jade[1].

Mayan population around 600 AD. i.e., using pieces of shells as implants to replace the teeth of the lower jaw[2,3].

Fig. 1 Ancient Maya mandible with shell implants.
(Found by Amedeo Bobbio. Image Source NCBI)

In 1931, Dr. Wilson Popenoe, together with his wife Dorothy Popenoe, found the skull of a young woman in Honduras. Her lower jaw had three missing teeth, which had been replaced by shells. The shells had been shaped to mimic the structure of the teeth. Bone growth and calculus were present, so these teeth were made for function and not aesthetics[4].

In the eighteenth-century gold and alloys were used to make dental implants however they were not very successful.

Major innovations in implants dentistry occurred in the 1700s and 1800s. Dentists and doctors began to experiment with gold and other metal alloys to help support false teeth[5].

These early attempts were ineffective since the body often rejected these early implants. It would take time before a proper alloy for implants could be identified[6].

Throughout the 1900s, many doctors tried different materials, but none produced long-term results.

In the 1930s and 1940s, doctors of these eras began to use orthopedic screws to fix false teeth in place. A special spiral post design was used to encourage bone to grow around these early implants.

In the 1930s, Drs. Alvin and Moses Strok made one from vitalium (an alloy of chromium and cobalt). The Strok brothers were also credited with being the first to place the first successful endosteal (into the bone) implant[6].

These devices were more durable, and the brothers were recognized as the first people to successfully place an implant in the jawbone.

The post-type intraosseous implant was developed by Formigini in the 1940s. The spiral stainless steel implant design allowed bone to grow into the metal[4].

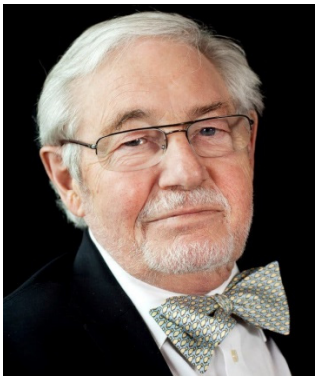
Dr. P.I. Brånemark, a professor at the University of Gothenburg (Sweden), is considered to be the pioneer of modern implantology.

In 1952, an orthopedic surgeon conducted a study on rabbits and found that titanium chambers placed in the fibula, structurally integrated into living bone, firmly fixed in the bone without rejection of the implants. The bone actually stuck to the surface of the titanium. He carried this idea into the field of dentistry as the concept of “osseointegration” or “a direct

structural and functional connection between ordered, living bone and the surface of a load-bearing implant[7]. Based on his implants, Brånemark developed a root-shaped two-stage threaded implant made of pure titanium, which was placed in patients in 1965[8]. Thanks to Dr. Per-Ingvar Brånemark, dental implants have improved over the years to become what they are today[9].

In the 1960s, doctors Roberts and Roberts developed the ramus blade endosseous implant[10].

In the 1967, Leonard Linkow developed the Ventplant implant. The blade implant is now recognized as an endosseous implant[10].



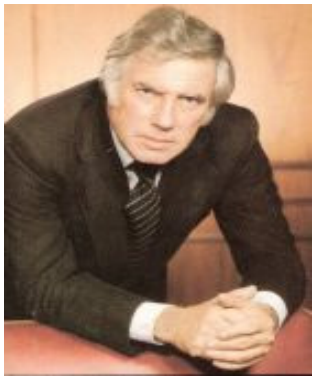


Fig. 2 Per-Ingvar Branemark Fig. 3 Leonard Linkow

In the early 1970s, Professor Andre Schroeder from the University of Bern (Switzerland) was able to demonstrate the first osseointegration on histological sections, was held preclinical and clinical studies to lay the foundation for successful osseointegration in dentistry[11].

From the 1970s to the 1980s, various companies introduced aluminum oxide implant designs, plasma sprayed titanium implants, and titanium aluminum vanadium alloy implants. However, commercially pure titanium has become the material of choice. One-piece implants have gradually evolved into two-piece implants to allow flexibility in the prosthesis.

The most recent dental implant innovations involve the use fluoride, antibiotics, growth factors and laminan.

Further innovations in implants dentistry have occurred in the decades since Dr. Branemark's discovery. New implant shapes have been used to ensure proper stability of the implant when in place. Many other types of implants were introduced after the Brånemark implant which included the ITI-sprayed implant, the Stryker implant, the IMZ implant and the Core-Vent implant

In addition, new oral surgery techniques have been developed in order to improve patient recovery and increase the stability of dental implants when they are in place. Over time in dental implant research, materials have evolved and restructured to provide the best choice of replacement teeth. As time marches on in dental implant study, the materials, forms, and surface coatings have been refined and restructured.

Today's implants have an extremely low failure rate. With proper treatment, reasonable surgical procedures and prosthetics, dental implants are a successful and long-lasting solution that also restore facial appearance.

2.

MATERIALS USED IN ORAL IMPLANTOLOGY

The development of dental implantology is based on modern achievements of materials science, biomechanics, physical chemistry, technology of plasma processing of bioactive and bioinert materials. Multiple materials are used in dental implantology.

The correct choice of implant biomaterial is a key factor in the long-term success of implants. Every clinician should have a thorough knowledge of the various biomaterials used for dental implants. The products remain often controversial for many practitioners and even some scientists. At one hand, there are the early adapters and convinced users, at the other hand there are uninformed and sometimes stubborn clinicians who only accept titanium as the material for the manufacture of dental implants.

Today, various biomaterials are created, and their surfaces are modified to get better results.

Before selecting an implant, clinicians must have detailed knowledge of the latest implant materials, aspects of their design, and properties for a successful treatment outcome.

Materials used in implantology must meet the following requirements[12]:

1. clinical-biological features characterized by the interaction of the implant with living tissue due to toxic, oncogenic, corrosive properties,
2. technological,
3. aesthetic.

Requirements for the materials used depend on the method of their application. Materials can contact both the external and internal environment of the body. More stringent requirements are imposed on materials in contact with the internal environment of the body.

The following materials are distinguished by the nature of interaction with the surrounding tissue[13]:

- biotolerant materials. metals, metal alloys, composite materials, plastics,
- bioinert materials. titanium (Ti), aluminum oxide (Al2O3),
- glass carbon etc.,
- bioactive materials- Ca10(PO4)6(OH)2, bioceramics and others.

From a chemical point of view, dental implants can be made from metals, ceramics, or polymers.

According to groups of materials used in implantology can be divided into biotolerant, bioinert, and bioactive, metallic and non-metallic[14].

Metal materials include alloyed steel, cobalt-chromium-molybdenum alloys, tantalum, titanium, zirconium and others.

Non-metallic materials include plastics, ceramic biological glass based on aluminum oxide, glass ceramics, ceramics based on calcium and phosphorus, hydroxyapatite and synthetic carbon materials.

Currently used implants are mainly made of titanium or zirconium and the design of the implant must match its physical properties.

Metals and alloys

Currently, implants made of metals and their alloys are widely used in implantology. This is largely due to their high mechanical strength, plasticity and ease of preparation. At the same time, there are certain problems caused by their corrosion resistance, compatibility with tissues, cyclic loads and changes in mechanical properties.

2.1 Titanium and Titanium alloys (Ti6Al4V)

Titanium is regarded as the "gold standard" for dental implant manufacturing[15,16]. It can be commercially pure or alloyed. The most common titanium alloy contains 6% aluminum and 4% vanadium. The material is heat treated to improve its strength, resulting in a low-density material that is resistant to corrosion and fatigue. The materials used to make dental implants can be categorized according to their chemical composition or the biological reactions they elicit during implantation.

Fig. 4 Titanium dental implant

Some patients prefer not to have any form of metal in their bodies, moreover there is little evidence to show an allergy to titanium. But it is possible that titanium may cause hypersensitivity in some patients which may play a role in implant failure. Allergy to titanium is rare, but it is a real possibility[17,18].

Allergic reactions to titanium are associated with the presence of ions formed because of implant corrosion, which can get inside or get on the mucous membrane[19,20].

The most common type of corrosion is galvanic, in which the destruction or displacement of the surface layer of titanium oxide occurs[21]. These ions can form complexes with native proteins and act as allergens, causing hypersensitivity reactions. Patients who have already been diagnosed with allergies to other metals will be more likely to be allergic to titanium. Titanium implants may have soft tissue recession in some situations; in such situations, an unaesthetic display of titanium gray occurs. Bioactivation by chemical or biophysical methods increases the surface energy of the fixture and then the wettability by removing the oxidized outer layers. At present, the implant market is still clearly titanium predominates (more than 95%).

Titanium is very strong, corrosion resistant, easily machined. At the same time, titanium's biological inertness, resistance to acids and bases are of great importance. Its protective function is determined by a layer of titanium oxide, which forms on the surface of cleanly treated titanium during contact with air, reaching a thickness of 2-10 nm. The oxide layer is composed of several oxides: TiO2, TiO, Ti2O3, Ti3O4[22].

Of all the known titanium alloys, titanium nickelide is the most important, which, along with the above-mentioned properties, has the property of thermomechanical memory.

Titanium hypersensitivity

There are different diagnostic tests to determine titanium hypersensitivity[23,24]. The aim is to determine if patients would profit from dermatological of laboratory tests if they are suspected to intolerance or hypersensitivity towards titanium. The latter seems to play a role in the growing manifestation of periimplantitis. A systematic literature search was performed on this topic, including randomized controlled trials, cohort studies and cases series. The implemented PICO design studied the effect of the insertion of titanium implants (I), on patients with and without metal allergy (P), compared to patients without dental implants or with ceramic implants (C) in terms of the development of a hypersensitivity reaction (O)[25].

Recommendations

I - Predictive epicutaneous test (ECT) for titanium hypersensitivity. An epicutaneous test is used in case of suspicion of allergy to substances that encounter the skin. Test material is placed in small chambers directly on the skin and is left untouched for 48 hours. The test is read after 72 hours, and the area is not washed until the test has been read. This test should not be used for titanium hypersensitivity because contact sensitization shows a different pathophysiology compared to allergy.

II - Predictive ECT for titanium hypersensitivity in patients with anamnestic allergic symptoms.

For the same reasons, this test should not be used in patients with a history of appropriate former diseases.

III - ECT in patients with clinical symptoms and suspected titanium hypersensitivity.

This test should also not be performed in patients with suspected clinical intolerance.

IV - Predictive lymphocyte transformation test (LLT) for titanium.

The lymphocyte transformation test (LTT) measures the proliferation of T cells to a drug in vitro - from which one concludes to a previous in vivo

reaction due to a sensitization. This test should not be used for this purpose since titanium intolerance is not considered as classical allergic reaction.

V - Predictive LLT for titanium in patients with anamnestic allergic symptoms also, for this indication, this specific test is not applicable.

VI - LTT in patients with clinical symptoms and suspected titanium hypersensitivity.

For patients, suspected with titanium intolerance, zirconia implants are the most evident alternative. The first set of guidelines described the optimal use of these ceramic implants in implant dentistry. The incidence of titanium allergy has a prevalence of 0.6%. Allergy to titanium in the medical literature is described in the form of urticaria, itching of the skin or mucous membranes, atopic dermatitis[26]. Although this is a rather low occurrence, the general allergy for metals is increasing to 10-15% worldwide. Since titanium implants are sometimes made of grade 5 titanium, aluminium and vanadium are included. Allergic reactions to vanadium and aluminium are common. To avoid this problem, the use of zirconium-dioxide implants can be considered. Allergy to zirconia has not been documented yet.

2.2 Zirconium

Zirconium is used since a shorter period, so its longevity has not yet been proven, and less is known about how it osseointegrates[27]. Zirconium is a material that can integrate with bone in the same way as titanium, and its use eliminates patients concerns towards allergies or sensitivity. Potential benefits of choosing zirconia include zero risk of corrosion and its use eliminates the possibility of metal shining through the gums or being exposed due to gum or bone recession. Zirconium is also not thermally conductive. For patients who have sensitivity or allergies to metals, zirconium can be a good option when used in the right clinical situation. Zirconium implant has a high biocompatibility and ability to withstand forces, and the color is close to the color of the tooth, which improves the aesthetic appearance of dental implants[28].

One of the advantages of zirconia implants is that its white color has advantages over metal implants in narrow ridges, avoiding the “black line” for titanium dental implants in patients with gingival and bone recession. Unlike titanium, zirconia is a bioceramic[29,30].

It has a higher survival rate and marginal bone loss when compared to titanium dental implants 10 or more years after implantation[31].

Fig. 5 Zirconium dental implant

Another advantage of using zirconia is its high corrosion resistance, as well as its low rates of infection and plaque formation. The metal analysis showed a statistically significant advantage of zirconia implants over titanium in terms of favorable response to alveolar bone. Zirconia surfaces provide better adhesion to epithelial cells than titanium surfaces[32].

Thus, due to its ideal physical, aesthetic and biological properties, zirconia can serve as a reliable and safe material for dental implants[33]. Titanium-zirconium alloys with a zirconium content of 13-17% (TiZr1317) have better mechanical properties[34].

Straumann has developed Roxolid to meet the requirements of implant dentists and it is 50% stronger than pure titanium[35]. Thin implants and implant components that can be subjected to high loads can be fabricated using TiZr1317 due to its better mechanical properties, provided the material exhibits the same good biocompatibility as pure titanium.

2.3 Bioceramics and composite materials

With the development of biomaterials science and industrial technology, there has been renewed interest in ceramics for dental applications. Over the last 15 years, various forms of ceramic coatings have been used on dental implants[36,37].

Ceramic is defined as an inorganic, non-metallic material, consisting of metal oxides, i.e., compounds of metal and oxygen. Ceramics have been used for surgical implants due to their inert behavior and good strength and physical properties such as minimal thermal and electrical conductivity.

Fig. 6 Ceramic dental implants

Some properties of ceramics, such as low ductility and brittleness, limit the use of ceramics. Ceramic dental implants represent an innovative and modern treatment option in dentistry[38]. Looking at the actual situation in implant dentistry, two materials can be distinguished to produce dental implants: titanium and ceramics. On titanium dental implants there are thousands of scientific peer reviewed articles; ranging from case studies to systematic reviews. The history on the use of ceramic implant materials has a complete other evolution. Sami Sandhaus dentist who in 1962 first developed a screw-shaped dental implant named Crystalline Bone Screw—CBS®[39]. This ceramic however was to brittle as dental implant material, causing multiple intra-bony fractures. These fractures are responsible for the bad name ceramic implants had for years.

Due to constant innovations, ceramic implants are experiencing a revival during the last decade[40].

FDA approval since 2007, and the ceramic material has been used to make dental implants in Europe since 1987.

These developments offer them material properties, soft tissue adaptations and osseointegration, comparable to those of the metal titanium. The aesthetic white color is an extra asset in thin biotype patients[41]. Not only we see a growing demand for metal-free restorations from biologically conscious patients, also more and more practitioners start to see the advantage of full ceramic oral rehabilitations. Moreover, patients with

proven (or even unproven) titanium hypersensitivity, insist more and more to be treated with complete metal-free prosthetic restorations.

2.4 Composition systems are very promising.

Among them, sieves - spodumene and lithium disilicate are often used. Implants with a metal base (titanium, its alloys (BTi-O, BTi-OO, Ti-BA1-4V, etc.)) and a coating of bioactive ceramics (tricalcium phosphate, glass ceramics with active components) have already become widespread[42]. Of all types of calcium-phosphorus ceramic materials made of CaO and P2O5, only tricalcium phosphate and tetracalcium phosphate are bioactive.

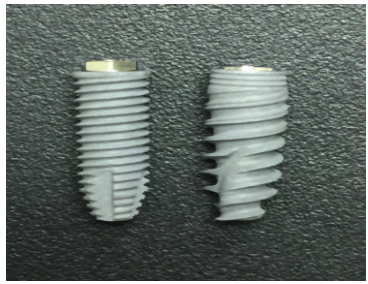


Fig. 7 Hydroxyapatite coating implants

Implants made of these two types of ceramic materials have high biocompatibility and osteointegration properties. Ca10(PO4)6(OH)2 is widely used in clinical practice[43]. Hydroxyapatite is present in the composition of mineral bone tissue. It has a crystalline structure. Calcium ions, released as a result of resorption of hydroxyapatite in tissues, have an anti-inflammatory effect, stimulate regeneration and mineralization of bone tissue. Phosphorus-containing groups have an anabolic effect, activating the processes of reactive regeneration. Numerous clinical observations have shown that hydroxyapatite is characterized by high biocompatibility, does not cause allergic reactions, does not have embryotoxic and mutagenic properties, regulates immunity and does not cause a lymphocytic inflammatory reaction[43]. For this reason, it is widely used in surgical stomatology and implantology.

2.5 Peek (Polyetheretherketone) as dental implants

The major beneficial property for peek is its low elastic modulus (3-4 GPa) being close to human bone , good resistance to degradation, lack of

toxicity, good chemical and sterilization resistance, lighter in weight, PEEK combines high strength with a relatively low Young's modulus which is closer to that of human bone than titanium[44,45]. This property may minimize the stress by distributing it in more physiological manner thus supporting bone formation around the implant and reducing osteolysis.

Fig. 8 Peek dental implants

3.

BONE GRAFT MATERIALS USED IN ORAL IMPLANTOLOGY

A variety of grafting materials are available for use in dental applications.[46, 47] By origin, the materials used for replacing bone tissue are divided into the following groups[48-50]:

1. autogenous (the patient is the donor),
2. allogeneic (material taken from another donor),
3. xenogenic (substance obtained from animal),
4. alloplastic (synthetic, including from natural materials, corals).

The ideal material for bone rehabilitation should possess the following characteristics: Osteogenic, osteoinductive and osteoconductive properties. According to another well-known classification based on the expression of the inductive potential, all materials used for the replacement of bone tissue can be divided into osteoinductive, osteoconductive, osteoneutral and those materials that provide targeted tissue regeneration[51,52].

In the group of osteoconductive implants, it is appropriate to include some non-resorbable materials, although in the original classification they are presented in the section of osteoneutral implants[53].

Osteoinduction (Urist, McLean 1952) is the property of the material to induce.

a) osteogenesis, b) cementogenesis, c) growth of periodontal ligament[54].

Osteoconduction (Urist et al., 1958) is the ability of the material to act as a passive matrix for new bone.

Allogeneic bone graft is taken from another person or can be taken from corpses[55].

3.1 Autografts

Autogenous bone grafts are the gold standard for restoration of bone defects among transplant materials, as they contain viable osteoblasts, have osteoinductive and osteoconductive properties[56,57].

Autogenous bone grafts are divided into:

1. extraoral: cranium, clavicle, ilium bone, fibula, rib,
2. intraoral: chin region, region of the external oblique line mandibular ramus, tuber region maxilla.

The most common donor area is the intraoral areas. Among the intraoral donor regions, the largest number of autotransplant can be obtained from the submental region, the region of the external oblique line, the mandibular ramus and tuber region maxilla[58,59].

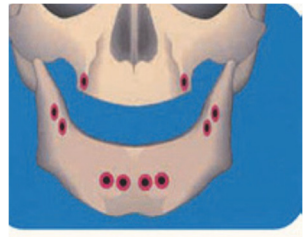
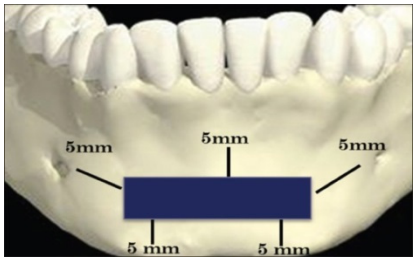


Fig. 9 Intraoral donor regions.



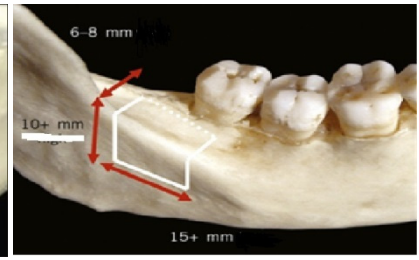


Fig. 10, 11 Methodology of obtaining an autotransplant from the chin region and the region of the external oblique line mandibula

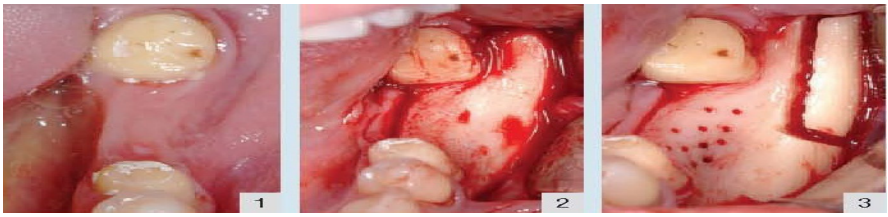


Fig. 12 Intraoral autotransplant from external oblique line mandibular

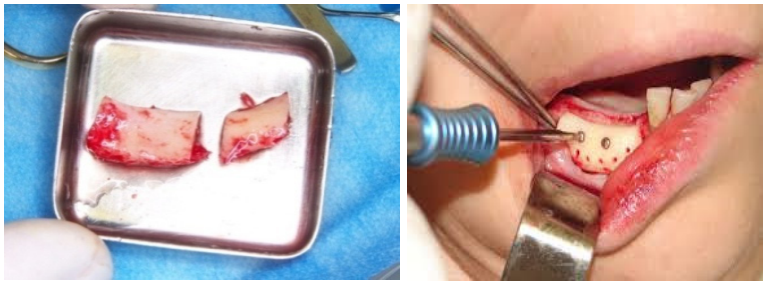


Fig. 13, 14 The taken autotransplant is placed in a sterile saline solution; before fixation, the recipient area of the mandibula is decortified and the autograft is tightly fixed with titanium screws

Autotransplant are mainly used to repair small bone defects, sometimes in combination with xenogenic and alloplastic bone substitutes and barrier membranes.

The most common extraoral donor area is ilium bone and fibula[60].

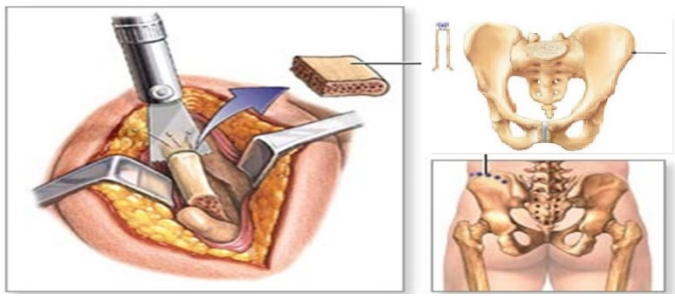


Fig. 15 Extraoral autotransplant from the ilium bone.

In 1989, Hidalgo became the first to report the transfer of fibular bone to reconstruct a segmental defect of the mandible[61]. Fibula is the most common donor site in both the vascularized and non-vascularized groups[62]. Simple anatomy and accessibility of the fibula caused the popularity of this transplant in reconstructions of the lower jaw. The bone is available with enough length to reconstruct any mandible defect. A 22 to 25 centimeters segment of fibula bone may be harvested in the adult patient, permitting reconstruction of near total mandibular defects with a single flap. During harvest, distally at least 5 cm of fibula should be left to prevent angle instability. Its characteristics such as the thick and long cortical bony component (average width is 2.5 cm 3 cm, thickness approximately1.5 cm) provide a good rigidity to withstand physiological stress during mastication[63,64].

However, harvesting an autogenous bone block is associated with the risk of donor site morbidity, postoperative pain, increased blood loss, and infections[65].

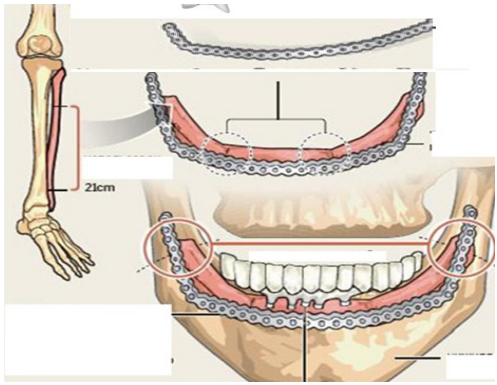


Fig. 16 Extraoral autotransplant from fibula.

3.2 Allograft

Along with the use of autogenous bone materials for the purpose of bone plastic, bone substitute materials of various origins are widely used. Allogeneic bone graft is taken from another person or can be taken from corpses[66]. These transplants undergo chemical treatment to prevent allergic reactions and immune rejection[67]. The most common method of processing allogeneic transplants is the method of freeze drying, lyophilization. To ensure safety, manufacturers prepare these vaccines

according to carefully developed protocols and after processing and sterilization store them in bone banks. The benefits of allogeneic bone blocks include unlimited supply, decreased operative trauma and blood loss, absence of donor site morbidity, and extremely low antigenic potential[68,69].

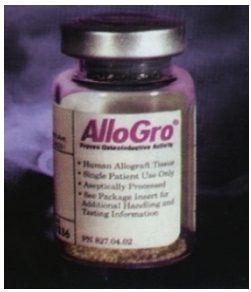


Fig. 17 Lyophilized allogeneic bone grafts

Cortical and spongy types of allogeneic bone grafts are produced in the form of pastes, powders, granules and blocks. They are applied to the atrophied areas of the jaw and perform two functions there. Firstly, they serve as a guide for bone formation, and secondly, they contribute to the formation of new bone in the bone matrix by means of osteoinductive proteins.

3.3 Xenograft

In the last decade, xenogen bone grafts have been successfully used in dental implantology and bone reconstructive surgery[70-72]. Xenogen bones are taken from animals, mainly bovine and pig bones, which can be lyophilized, demineralized and deproteinized. Inorganic bone matrix is obtained in two main ways. According to the first method, the removal of proteins and other organic substances is carried out using high temperature and water (Osteograph/N), according to the second method, using low temperature and chemical solvents (Bio-Oss)[73-76].

The first method is more efficient, since it allows you to remove 100% of the proteins and obtain material of animal origin that fully complies with the "Composition of inorganic bone substitutes used in surgery" standards.

Fig. 18 Xenogen bone grafts materials Bio-Oss

3.4 Alloplastic materials

Alloplastic materials include artificial bone substitute materials based on hydroxyapatite and titanium structures, microplates and splints.

Hydroxyapatite is a synthetic bone graft that is the most widely used of all synthetic materials due to its osteoconductive properties, hardness, and acceptability to bone. Tricalcium phosphate, currently used in combination with hydroxyapatite, has both osteoconductive and resorbable properties. The most common alloplastic material is a Hydroxyapatite (Osteograph/LD, Algipore)[77-79].

Fig. 19 Alloplastic materials in the form of block, granules, chips

3.5 Free Gum graft

A gum graft is a loose flap that is moved (transplanted) from one part of the mouth to another[80]. The indications for the use of free gingival grafting have now expanded considerably, and in addition to covering recession, it is also used to increase the volume of keratinized tissue, to improve edentulous tooth eruption, to increase keratinized tissue around implants, to cover wounds (e.g, post-extraction), etc[81-84].

Contraindications to vaccination can be due to both general health and local factors. Of the common health problems, here you should pay special attention to it problems that can cause significant bleeding from the donor site, such as high blood pressure or clotting problems The thickness of the tissue is determined by the purpose of the surgical intervention. If the amount of keratinized tissue increases, it can be 0.75-1 mm, and if the recession is closed, then preferably 1.5-2 mm. thickness A toothless tooth row and palate tissue can be used as a donor segment. A large volume of donor tissue can be taken from the palate.

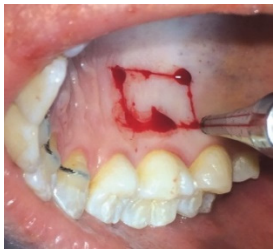


Fig. 20a. (left) Free Gum graft from palatinal region.
Fig. 20b. (right) Free Gum graft

It is not recommended to take a free gingival graft from the area of folds, since these folds are further expressed in the receiving area. Medially, you do not need to approach the middle line, because the gingival and connective tissues located here are thinner, there is no submucous fat cell, there is a possibility of exposing the bone. A significant part of the glandular and fatty tissue on the inner surface of the flap should be removed, trying not to thin out the received graft too much. Then the processed fabric is placed in the receiving zone, if necessary, it is finally formed and sewn. From the removal of the fabric to the completion of sewing, it is desirable to pass a maximum of 15 minutes, the fabric can be fixed with ordinary knots.

4.

GUIDED BONE REGENERATION (GBR)

Guided bone regeneration (GBR) is the most common technique in implantology for the treatment of bone defects, and the most important component of the GBR procedure is the use of barrier membranes[85-88].

The presence of bone is essential for safe and predictable implant placement, as sufficient bone is required to achieve the functional stability of the implant required to achieve osseointegration. Moreover, the goal of achieving adequate esthetic results requires an optimal three-dimensional position of the implant after the planned prosthetic reconstruction. The frequent presence of residual ridge defects, both in the horizontal and vertical dimensions, requires indications for bone augmentation procedures, either simultaneously with implant placement or as a step-by-step intervention.

These ridge changes may be different depending on the area of the affected jaw, as well as the functional and aesthetic requirements of the patient may differ, which requires an individual assessment of the possible need for bone augmentation procedures. Therefore, the existing bone ridge must be carefully assessed clinically and mainly through a three-dimensional radiological assessment using modern CBCT (cone beam computed tomography) technologies. Changes in the anatomy of the residual alveolar process may be a consequence of the underlying pathology that caused the loss of the tooth (trauma, chronic / acute infections or severe periodontal disease). Even in the absence of overt pathological conditions, loss of mechanical function following tooth extraction or loss will result in severe atrophic changes in the residual alveolar process, which may limit the possibility of adequate implant placement.

Over the past two decades, tissue regeneration has become an alternative method of repairing and restoring the function of damaged tissues. This method is used either separately before implantation to restore bone volume, or simultaneously with implant placement to restore insufficient

bone volume. The biological film is placed in the surgical area in order to delineate the defect, protect the bone material and at the same time prevent the growth of neo-osteogenic cells in this area. The established membrane simultaneously creates a space between the bone and the connective tissue, where cells capable of ossification-precursors of the bone tissue, moving to the area of the defect, are transformed into osteoblasts and osteoclasts[89-91].

Regeneration of bone under biomembrane control consists in the separation of bone and epithelial tissues in order to prevent migration of epithelial and connective tissues to the area of damaged bone tissue after restoration of the latter by auto- or allograft[92].

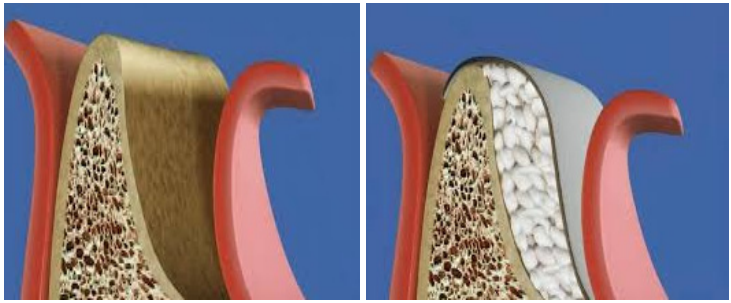


Fig. 21 Guided bone regeneration (GBR)

For the successful application of directed tissue regeneration, it is necessary to strictly observe a number of conditions.

1. In the area of the defect, a precise flap should be formed so that it completely covers the transplant material filling the defect.

2. Perform decortication of the defect walls in order to improve blood supply and increase the number of proliferating bone cells.

3. Create conditions for stabilization and fixation of the thrombus in the area of the defect, using various methods.

4. Place a membrane film in the surgical area to demarcate the defect, blood pressure in order to protect the ductus, simultaneously prohibiting the growth of non-osteogenic cells in that area.

5. Stabilize the membrane placed in the region of the defect in order to obtain the necessary shape and volume of the regenerated tissue. If necessary, the membrane is fixed by means of stabilizing screws.

4.1 Use of Barrier membranes in oral implantology

Barrier membranes are used in GBR procedures to act as biological and mechanical barriers against invading cells not involved in bone formation, such as epithelial cells, and to allow the migration of slower migrating bone-forming cells into defect sites[93-95]. As bone defects heal, there is competition between soft tissues and bone-forming cells for penetration into the area of surgical intervention. In general, soft tissue cells migrate much faster than bone-forming cells. Thus, a regeneration process occurs under the membrane, which includes angiogenesis and the migration of osteogenic cells. The initial blood clot after vascular ingrowth is replaced by braided bone, which later transforms into load-bearing lamellar bone. Ultimately, this contributes to the regeneration of hard and soft tissues. If a barrier membrane is not used, the lack of space will lead to soft tissue integration and bone growth failure.

Today, there are many different membrane materials that implantologists can use depending on the clinical situation.

Ideally, the membrane should be biocompatible so that there is no inflammation or interaction between the membrane and host tissue to avoid wound dehiscence or infection[96-99].

The membrane must retain the space needed for the bone regeneration process. Adequate membrane stiffness is paramount to conserve space and prevent defect collapse.

Barrier Membranes can be divided into two categories[100]:

1. Natural:
    a) Collagen,
    b) laminated preserved lyophilized bone (Lambone),
2. Synthetic
    a) Calcium sulfate,
    b) polymeric

Depending on whether the installed biofilms remain permanent or are removed, there is: non-resorbable and resorbable.

Non-resorbable membranes are bioinert and require a second surgical procedure for removal after bone regeneration is complete. Non-absorbable membranes exhibit superior biocompatibility, excellent mechanical strength and increased rigidity and generally provide more comfortable space retention than resorbable membranes. However, wound dehiscence is more common with non-resorbable membranes, and these membranes have the disadvantage of requiring reoperation, resulting in increased morbidity, cost, and patient discomfort. The most common types of non-resorbable membranes include polytetrafluoroethylene (PTFE) and titanium mesh[101-105].

Fig. 22 (left) Polytetrafluoroethylene (PTFE)
Fig. 23 (right) Titanium mesh.

Resorbable membranes are naturally biodegradable and have different resorption rates.

The advantage of resorbable membranes is that their removal does not require repeated surgical intervention, which reduces discomfort and pain for the patient[106-108]. However, the disadvantages of collagen include an unpredictable resorption time, which can adversely affect the volume of bone formation. Resorbable membranes derived from xenogeneic collagen for use in GBR procedures are the most popular membranes used in dental implantology today. Various types of resorbable membranes include collagen, pericardium, platelet-rich fibrin, and cell-free dermal matrix[109-111].

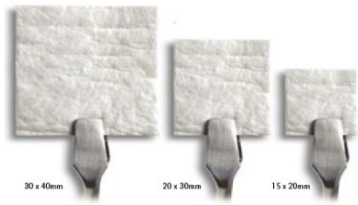


Fig. 24 (left) Xenogeneic collagen resorbable membrane
Fig. 25 (right) Resorbable membrane in blood