The Polytetrafluoroethylene (PTFE) and Collagen Membranes in Bone Grafting for Dental Implants

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Bone regeneration remains an important challenge for research trends in dentistry. In this study, the authors analyse the effect of the membrane composition for the results of bone grafting.They used in 30 cases, collagen and polytetrafluoroethylene membranes. The dehiscences was bigger in case with PTFE membranes.

Keywords: bone regeneration, bone grafting, collagen, polytetrafluoroethylene membranes

Bone regeneration remains an important challenge for research trends in dentistry.

Local methods of stimulating the bone consolidation can be: osteogenics, osteoconductive and osteoinductive.

Osteogenic methods include the use of natural materials like bone derivatives of the autologous bone marrow, autologous or allogeneic bone grafts, demineralized bone matrix.

The necessity to develop materials with accented morphoinductive abilities has led to be compiled numerous studies on the use of demineralized bone matrix.

The base material of the matrix is collagen, which has a reduced antigenic activity, is resistant to the action of tissular ferments and it is able to form complex components with biologically active substances.

Osteogenesis is the ability of osteoblasts within a transplant to produce bone neoformation

Osteoinduction - the influence of the bone morphogenetic proteins (BMP) upon the mesenchymal cells which reach the transplant through the neo-vessels; under the influence of BMP, the mesenchymal cells transform into bone-producing cells. The transplant acts like a structure that allows the support of neo-vessels from adjacent bone; the new bone is formed on this structure.

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The conditions for the bone regeneration were described by Murray since 1957 as follows: *a source of living bone cells around the defect, having a source of vascularity, with the wound stable from mechanical point of view. There must be created and maintained a space between the membranes and bone, while the soft tissues should be excluded from the above mentioned space*. The types of available graft material to treating such problems include essentially autologous bone (from the patient), allogeneic (from a donor) and demineralised bone matrix, as well as a wide range of synthetic bio-materials, such as ceramics, polymers and composites. Until recently, the use of autologous bone grafts has been the number one choice for depressed bone regeneration (table 1).

The addition implants are obtained from lyophilized bovine bone or from the own human bone/from bone banks, beta TCP, or extracts of seaweed/ coral.

The surgical membranes are biological barrier, prevents the proliferation of cells forming soft tissue inside the augmentation material and they are space maintainer [1,2].

MATERIALS	ORIGIN	USE
AUTOLOGOUS (autogenous)	grafting (from the same body)	teeth transplant teeth replanting
HOMOLOGOUS (ALLOGENEIC)	homoplastice (from other individual of the same species)	bones bank (cialitic conservation lyophilization
HETEROLOGOUS (XENOGENEIC)	heteroplasmie (from an individual from another species)	devitalized bone, deproteinised collagen, gelatin
ALLOPLASTIC	Alloplastic(synthetic substances)	metals ceramics plastic materials carbon

Table 1
CLASSIFICATION OF MATERIALS FOR AUGMENTATION FROM THE IMMUNOLOGICAL POINT OF VIEW

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Classification after the shape of material	Surgical membranes
• GRANULATED (BioOss, Cerasorb)	COLAGEN membranes
• BLOCKS (autologous bone, block BioOss)	POLYTETRAFLUOROETHYLENE membrane
• PASTES (Ostim)	
• KITS (Regenaform)	

Table 2
DIFFERENT TYPES OF GRAFT MATERIALS

Experimental part

The membranes are used in order to isolate an anatomical space to produce healing - invented in the '50s in neural reconstructions. Another reason for using membranes is that the fibroblasts produce inhibitors for osteoblasts. Also the soft tissue grows 10 times faster than bony tissue [3,4].

The sinuslift techniques are presented in table 4.

The Open Technique can be made in one step by augmentation + insertion, which is made during the same session, or in two steps, that is performed through augmentation + insertion, being achieved during two different sessions.

The advantages of the Internal Technique are: possibility to be made in patients with impaired general condition, even in cases of chronic sinusitis; it has a short surgical protocol and a reduced healing period.

The external sinuslift has several variables, and these are: addition material, the surface of implants and the used membranes. Referring to the external sinuslift, the xenografts are secure, available, and they remove accumulations, having an osteoinductive effect; they do not resorb, they do not interfere with regeneration and increase the density of graft. The purpose of the own bone is that of maturing the graft faster [5,6].

Membrane type	The material of which they are made	Examples of commercial products	
nonabsorbable	hybrid cellulose, latex	- latex (rubber dam material)	
	PTFE	- Gore-Tex Periodontal Material (W.L. Gore, SUA) - Gore-Tex Augmentation Material (W.L. Gore, SUA) – armată cu titan - TefGen (Oraltronics, SUA)	
	titanium foils, titanium nets, aluminum oxides,	- FRIOS BoneShield (Friatec, Germany) - titan-o-tec FOLIE (Pedrazzini, Germany) - SIS (SIS Systems, SUA) - Tiomesh (Tiolox Implants, Germany)	
absorbable	synthetic materials	polylactic acid in combination with esters of citric acid	-Guidor (Guidor AB, Suedia) -Atrisorb (Atrix Laboratoires, SUA)
		copolymers of glycolic and lactic acid	-Vicryl (Ethicon, Germany) -Resolut (W.L. Gore, SUA) -Resolut XT (W.L. Gore, SUA)
		calcium sulfate	-Capset (Lifecore Biomedical, SUA)
	natural materials	collagen (Type I and/or III)	-Bio-Gide (Geistlich AG, Elveția) -BioMend (Calcitek, SUA) -CollaCote, CollaTape (Calcitek, SUA) -Periogen (Collagen Corporation, SUA) -Paroguide (Collectica, SUA) -MSRII (INCOTP-ICPI, Romania)
		proteins of amelar matrix	-Emdogain (Biora, Suedia)
		dura mater	-no longer it is used as membrane material

Table 3
CLASSIFICATION OF THE MEMBRANES AFTER THE MATERIAL NATURE

1. Open Technique	-opening of the lateral wall of the sinus -lateral fenestration minimally invasive
2. Closed Technique	- Osteotomy

Table 4
CLASSIFICATION FOR ELEVATION TECHNIQUES OF THE SINUS FLOOR

During the intervention, the elevation of membrane is made up to the medial wall, beginning with augmentation of the front wall, the bone is inserted from two directions, the augmentation material is relatively dry, otherwise it slids distally. Finally, the membrane is inserted over the created window.

The perforation rate is 15-56%, on average 25%. The larger the perforation is, the stiffer/more rigid the membrane must be, the bigger the sinus is, the higher the rate of perforations grows (Bio-Gide can be adapted better/ not to repair membranes).

The demineralized bone matrix represents the organic substrate of the bone tissue, which is composed of collagen fibers type I and glucidoproteic base substrate. It was first proposed by N. Senn, in 1889, as an osteoinductive remedy. The bone matrix was obtained from compact bone, demineralized in hydrochloric acid solutin, after being kept in ethyl alcohol solution [7,8].

The positive results have enabled the author to implement them in the clinical practice in patients with bone defects. Over several years, while the proposed method was almost forgotten, the eminent scholar M. R. Urist appreciated this kind of graft very much. He studied and developed the contemporary methods used in the preparation of demineralized bone matrix with major osteoinductive capabilities[9]. The osteoinductive capabilities of the demineralized bone matrix were the subject of researches made by other scientists, having as aim the improving the osteoinductive capacity of biopreparation, using other preservation and preparation methods or modernizing the existing ones.

The man, as a multicellular organism, is composed of multiple types of differentiated cells. Their shape, capabilities, proteins expressed in each of them are different, even if they have the same origin - undifferentiated predecessors cells. In the mature body there may persist undifferentiated pluripotent cells, which have not yet been selected by the genetic differentiation program.

Continuous search for new osteostimulating preparations has led to the discovery of bone morphogenetic protein in the compact substance of the diaphyses of tubular bones (BMP - Bone morphogenetic protein)[9-12].

Multiple scientific studies have confirmed that in the interstitial tissue of the bone there is found a substance of proteic origin, called bone morphogenetic protein, able to stimulate the regenerative processes in the bone tissue, at the same time possessing the ability to stimulate its formation and in the extrascheletice tissues [13-15]. This ability was called ectopic induction osteogenesis [9]. The family of bone morphogenetic protein now includes 25 members, which have a variety of adjacent names of BMP, such as *growth and differentiation factors, osteogenic protein.* These proteins are subgrouped according to their amino-acid structure. OP-1 and BMP-7 were the first identified having osteoinductive properties and produced as recombined proteins[9]. The local inoculation mixed with collagen matrix results in regeneration of the bone defects resulting in a variety of bone segments, such as the long bones, craniofacial bones and vertebrae. RhBMP7 has been used to treat nonunion inveterate of the long bones in combination with surgical treatment, having good results [14-16].

The matrix represents a biological or synthetic complex, with certain resistance characteristics with a three-dimensional structure, in which the inoculated cells can grow.

The requirements for this type of matrix includ: the lack of cytotoxicity and adhesive properties which would facilitate installation, the attachment, proliferation and differentiation of the cells placed on its surface [17,18].

It does matter a lot the mechanical properties and accordance of characteristic needs of each region in which it is used. Another important property is biodegradation, which is achieved by common metabolic pathways.

For this study was selected 30 cases with bone graft, 15 cases with PTFE membranes and 15 cases with colagen membranes.

It used few ussualy surgical instruments with highly precision (fig.1c,d; 2c; 3a, b), PTFE membrane, colagen membranes and artificial bone graft.

All the subjects was selected between 45-65 years, clinically healthy. We excluded the patients that have a history of oral carcinoma, which radiotherapy was previously performed or other oral pathology events.

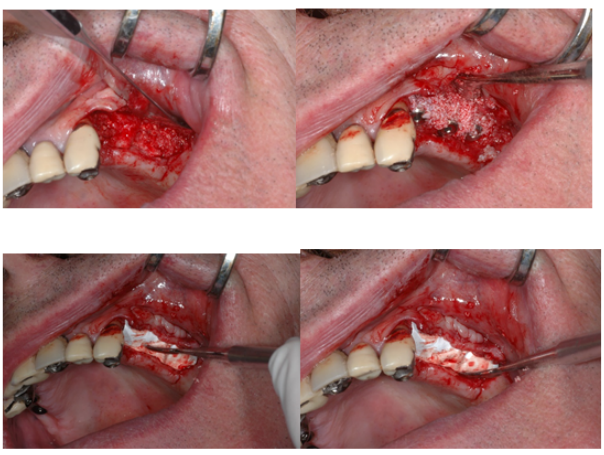

Fig. 1 a,b,c,d Clinical aspects with PTFE membrane insertion

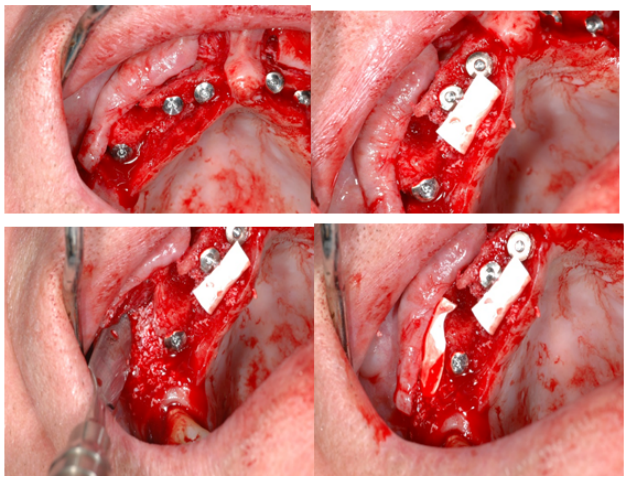

Fig.2 a, b, c, d Bone graft with colagen membrane in the frontal area

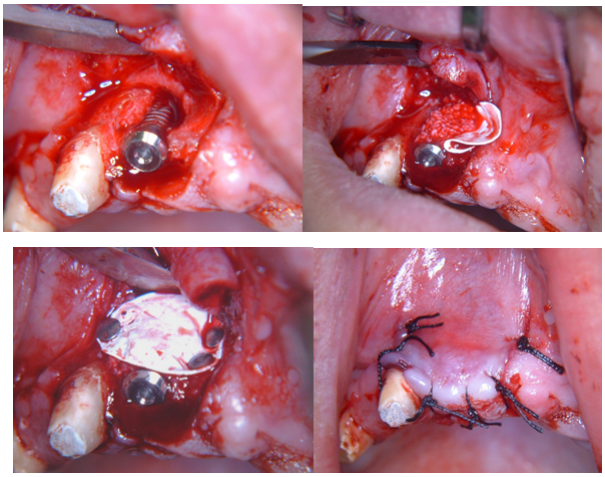

Fig 3 a, b, c, d PTFE membrane with pins in the lateral edentulous area

For measurement it used Digital Caliper (Stainless Hardened) (fig 6).

The mesure was made between the superior line of the palatinal and vestibular surgical flaps.

Results and discussions

In this study, the patients was continuous monitoring. The evaluation of cases was made at 2,4, and 6 month.

The results of dehiscences mesure it is represented in the table 5.

The cases with PTFE present dehiscence.

From the practicians point of view, the cases with PTFE membranes need a special suture technique. The soft tissues healing procces was better for the cases with colagen membranes.

The stability of the implants was similar and also, the confort of the patients was similar in all casses from our study.

Polytetrafluoroethylene (PTFE) is comprised of a carbon chain with two fluorine atoms for every carbon atom. The complete fluorination of the carbon chain, along with the strength of the carbon-to-fluorine bonds, makes PTFE highly stable. This stability results in a synthetic polymer that is non-resorbable, biologically inert and chemically non-reactive, and therefore an ideal material for many medical device applications. In addition to its long history in the field of guided tissue regeneration (GTR), PTFE has been used for over 30 years in cardiovascular applications such as suture, vascular grafts and heart valves [1].

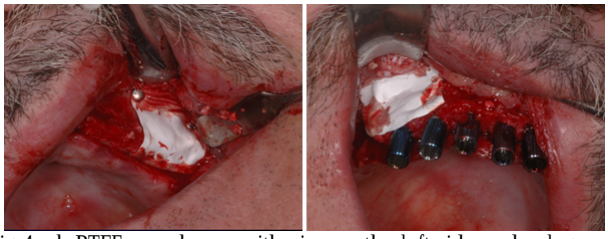

Fig 4 a,b PTFE membrane with pins on the left side and colagen membrane on the other side in the same edentulous area

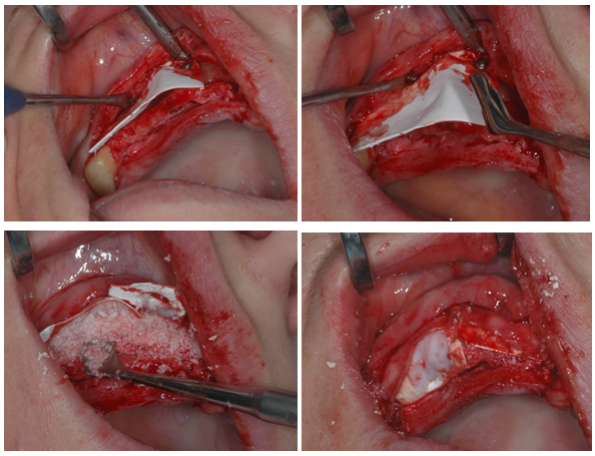

Fig.5 a,b,c,d Colagen membrane insertion

Fig.6a,b . Digital Caliper (Stainless Hardened) before and after measuremen

Table 5

Dehiscences in cases with PTFE membranes(mm)	Dehiscences in cases with collagen membrane(mm)
4.8	1
5.1	1.3
5.3	1.1
4.8	1.1
4.6	1
4.5	1.4
5	1.6
4.9	1.2
5.3	1.1
4.8	1.4
5.2	1.2
4.9	1.2
4.7	1.6
5.1	1
5.3	1.1

PTFE as a biomaterial differs in porosity based on the amount of expansion applied during manufacturing. Heating PTFE and then applying force expands the material's microstructure to make expanded PTFE (ePTFE). Under scanning electron microscopy, we see a network of dense nodes connected by fibrils. As the nodes and fibrils are expanded, the porosity of the material continues to increase [1, 19].

Collagen membranes have been used in Guided Tissue Regeneration (GTR) and Guided Bone Regeneration (GBR) for many years. The principle of these techniques is based on the placement of a barrier membrane for separation of slowly proliferating regenerative cell types, such as osteoblasts and periodontal cells, from fast proliferating epithelial and connective tissue cells, thus enabling a predictable regeneration of lost tissue [2].

Conclusions

In conclusion, we think that for best results in bone graft it must use a combined technique.That means a PTFE membrane first and a collagen membrane upper, in contact with soft tissue.

The collagen membrane enables the ingrowth of the periosteum thus offering more stability for the soft tissues while the ptfe membrane maintaine the barrier function for the whole period of healing.Without the use of the collagen membrane more dehicencies can appear because the ptfe membrane does not offer sufficient adhesion for the soft tissues. Membrane fixation is a must for both types.

Nevertheless, the future research should establishe and maybe generate the *ideal* barrier membrane.

References

1 .*** https://www.osteogenics.com/media/uploads/resourceDocs/123vqjb203hg.pdf

2. *** https://www.botiss.com/en/content/collagen-membranes-gbr-and-gtr-technique

3. *** https://www.osseonews.com/membranes-over-bone-grafts-is-this-really-necessary/

4. *** http://www.joionline.org/doi/full/10.1563/AAID-JOI-D-09-00121.1

5.MORGANO A. T., Functional Load in Oblique Bicortical Implants: Parasinusal Implants and Palatine Implants, Journal of Oral Implantology. 2013;39(4):467-474.

6.DIMITRIOU R , MATALIOTAKIS G , CALORI G M , AND GIANNOUDIS P V The role of barrier membranes for guided bone regeneration and restoration of large bone defects: current experimental and clinical evidence BMC Med. 2012; 10: 81 doi: 10.1186/1741-7015-10-81

7.DIMITRIOU R, JONES E, MCGONAGLE D, GIANNOUDIS PV. Bone regeneration: current concepts and future directions. BMC Med. 2011;9:66. doi: 10.1186/1741-7015-9-66.

8.MASQUELET AC, BEGUE T. The concept of induced membrane for reconstruction of long bone defects. Orthop Clin North Am. 2010;41:27–37. doi: 10.1016/j.ocl.2009.07.011.

9.URIST MR, STRATES BS. The classic: Bone morphogenetic protein Clin Orthop Relat Res. 2009 Dec;467(12):3051-62. doi: 10.1007/s11999-009-1068-3

10.MEINIG RP. Clinical use of resorbable polymeric membranes in the treatment of bone defects. Orthop Clin North Am. 2010;41:39–47. doi: 10.1016/j.ocl.2009.07.012.

11.RETZEPI M, DONOS N. Guided bone regeneration: biological principle and therapeutic applications.Clin Oral Implants Res. 2010;21:567–576. doi: 10.1111/j.1600-0501.2010.01922.x

12.GOTTLOW J. Guided tissue regeneration using bioresorbable and nonresorbable devices: initial healing and long-term results. J Periodontol. 1993;64(11 Suppl):1157–1165.

13.DAHLIN C, LINDE A, GOTTLOW J, NYMAN S. Healing of bone defects by guided tissue regeneration.Plast Reconstr Surg. 1988;81:672–676. doi: 10.1097/00006534-198805000-00004.

14.MCALLISTER BS, HAGHIGHAT K. Bone augmentation techniques. J Periodontol. 2007;78:377–396. doi: 10.1902/jop.2007.060048.

15.SCANTLEBURY TV. 1982-1992: a decade of technology development for guided tissue regeneration. J Periodontol. 1993;64(11 Suppl):1129–1137

16.GIELKENS PF, SCHORTINGHUIS J, DE JONG JR, PAANS AM, RUBEN JL, RAGHOEBAR GM, STEGENGA B, BOS RR. The influence of barrier membranes on autologous bone grafts. J Dent Res. 2008;87:1048–1052. doi: 10.1177/154405910808701107

17.NEEDLEMAN IG, WORTHINGTON HV, GIEDRYS-LEEPER E, TUCKER RJ. Guided tissue regeneration for periodontal infra-bony defects. Cochrane Database Syst Rev. 2006;2:CD001724.

18.UEYAMA Y, KOYAMA T, ISHIKAWA K, MANO T, OGAWA Y, NAGATSUKA H, SUZUKI K. Comparison of ready-made and self-setting alginate membranes used as a barrier membrane for guided bone regeneration. J Mater Sci Mater Med. 2006;17:281–288. doi: 10.1007/s10856-006-7315-1.

19.BECKER W, BECKER B, MCGUIRE M. Localized ridge augmentation using absorbable pins and e-PTFE barrier membranes: a new surgical technique. Case reports. Int J Periodont Restor Dent. 1994;14:48–61.

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