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Alveolar Bone Augmentation

Dimova Cena[1a], Papakoca Kiro[1b], Papakoca Velko[2]

University "Goce Delcev" – Stip, R. Macedonia,
[1-] Faculty of Medical Sciences, General Dentistry,
Department of Oral and Maxillofacial Surgery and Dental Implantology
[2-] PHO "Dent Estet" – Shtip, R. Macedonia
[a -] cena.dimova@ugd.edu.mk
[b –] kiro.papakoca@ugd.edu.mk

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Abstract

Bones and teeth are the only structureswithin the body where calciumandphosphate participate asfunctional pillars. Despite their mineralnature, both organs are vital and dynamic.
The aim was to remark the indications for *alveolar augmentation* after tooth extraction and prior the placement of endoosseous dental implants.

The autograft, allograft, alloplast, and xenograftmaterials all have reported success, alone or in combination,for particulate bone augmentation. Theparticulate autograft is the gold standard for mostcraniofacial bone grafting, including the treatmentof dental implant–related defects. Advantages of alveolar ridge augmentation with sufficient bone volume to adjust for uncompromised and esthetic implant placement, renders these procedures more than effective for majority of patients. Surgical reconstruction of the tissues and the procedure of ridge augmentation and subsequent placement of dental implant are necessary.

Introduction

Immediately after extraction the bony walls of the alveolus present significant resorption,the central part of the socket is partly filled up with woven bone and the extraction sitebecomes markedly reduced in size. Pietrokovski & Massler (1967) [1] and Schropp et al. (2003)[2] have shown that the edentulous site diminishes in all dimensions i.e. bucco-lingual, buccopalataland apico-coronal. At the same time, the soft tissues in the extraction site undergoadaptive changes that clinically may appear as deformations of the jaw [3].

In helth, the different structures of the alveolar process, the cortical and cancellousbone are constantly undergoing remodeling in response to functional forces acting on theteeth. Once teeth are lost, the attachment apparatus is destroyed, and the alveolar process,mainly the alveolar ridge, undergoes significant structural changes; these are referred to as*"disuse atrophy"* [3]

Alveolar ridge atrophy after loss of teeth occurs secondaryto advancing age, to deterioration of generalhealth, to systemic or metabolic diseases, and due toocclusion defects or to denture pressure.The condition causes serious problems for both thedentist and the patient. The toothless mandibular resorptionor the high muscular attachments caused by senileatrophy produces unsuitable conditions for total denture [4].

Resorption of the edentulous or partially edentulousalveolar ridge or bone loss due to periodontitisor trauma frequently compromises dental implantplacement in a prosthetically ideal position.Therefore,augmentation of an insufficient bone volume is oftenindicated prior to or in conjunction with implantplacement to attain predictable long-term functioningand an esthetic treatment outcome [5].

Ridge augmentation methods are therefore very importantdevelopments and have so far been promising especiallyin view of the fact that life is increasingly prolonged especiallyin economically developed countries and the incidenceof the disease is expected to further increase in

thefuture.Bones and teeth are the only structureswithin the body where calciumandphosphate participate asfunctional pillars. Despite their mineralnature, both organs are vital and dynamic [5].

According to Frost [4] the aims of alveolar ridge augmentationare:

1. to restore the function of the jaw in anterior, posterior,vertical and lateral directions,
2. to increase the bone tissue in cases where themandibula has atrophied,
3. to create and optimal support for dentures andbetter distribution of the jaw's functional forces,
4. to provide biologic acceptance of implants or transplants,
5. to rehabilitate the dentures for efficient functioningand to produce better facial esthetics.

There seems to be no uniformity of opinion howeveras to which of the available methods provide the bestanatomical and functional results. Among the producesproposed to restore the alveolar ridge, bone grafts werethe first to be popularized. Kruger [6] who favored thismethod recommended iliac grafts. Although costal graftscan perhaps better be adjusted to the mandibulor arch,there can occur 50% loss due to contraction. Theseresults are akin to those of Steinhouser and Obwegeser[6] who concluded that significant amount of atrophy anddefects are observed of the mandibula or on the maxillaafter bone grafting. Other studies have reported satisfactory results in generalfor treatment of atrophic ridge using hydroxyapatitewith lesser percentage of neural injuries [7]. Postoperativeridge resorption is observed only in 4-10% of cases, afigure which compares favorably with other proceduresaiming to correct alveolar ridge atrophy.

Principles of osteogenesis, osteoconduction,osteoinduction, osteointegration, osteopercepcion and osteopromotion

The principles of osteogenesis, osteoconduction,osteoinduction,osteointegration osteopercepcion and osteopromotioncan be used to optimize therapeuticapproaches to bone augumentation and regeneration.

- *Osteogenesis* - this term means that primitive, undifferentiatedand pluripotent cells are somehow stimulated todevelop into the bone-forming cell lineage. One proposeddefinition is the process by which osteogenesis is induced. Osteogenesishas been described as the direct transfer of vital cellsto the area that will regenerate new bone.
- *Osteoconduction* - the term means that bone grows on asurface. An osteoconductive surface is one that permitsbone growth on its surface or down into pores, channelsor pipes. Wilson-Hench in a report of Albrektsson [8] has suggested that osteoconductionis the process by which bone is directed so as toconform to a material’s surface. Osteoconductionembraces the principle of providing the spaceand a substratum for the cellular and biochemicalevents progressing to bone formation. The spacemaintenance requirement for many of the intraoralbone augmentation procedures allows the correctcells topopulate the regenerate zone.
- *Osteoinduction*embodies the principle of converting primitive, undifferentiated and pluripotential,mesenchymal-derived cells along an osteoblast pathwaywith the subsequent formation of bone. This term means that pluripotent cells are somehow stimulated to develop into the bone-forming cell lineage.This conceptwas established in 1965, with heterotopic ossicleformation induced by the glycoprotein family of morphogensknown as the bone morphogenetic proteins(BMPs). A bone graft material that is osteoconductive and osteoinductive will not only serve as a scaffold for currently existing osteoblasts but will also trigger the formation of new osteoblasts, theoretically promoting faster integration of the graft. The most widely studied type of osteoinductive cell mediators are bone morphogenetic proteins (BMPs) [8].
- *Osteointegration*- Brånemark [9] introduced the term "osseointegration" to describe this modality for stable fixation of titanium to bone tissue.Osteointegration was originally definedas a direct structural and functional connection between ordered living bone and the surface of a load-carrying implant [10]. It is now said that an implant is regarded as osseointegrated when there is no progressive relative movement between the implant and the bone with which it has

direct contact [11]. In practice, this means that in osseointegration there is an anchorage mechanism whereby nonvital components can be reliably and predictably incorporated into living bone and that this anchorage can persist under all normal conditions of loading [12].Osseointegration provides an attachment mechanism for the incorporation into living bone of nonvital components made of titanium. As a biological phenomenon it has been amply demonstrated and clinically tested, and is now widely accepted. The present range of clinical applications is:

- In the field of oral surgery - worldwide, more than 800,000 patients have been treated since 1965 until now with osseointegration dental reconstructions, according to Brånemark. The results indicate a clear superiority over conventional prosthodontics, with respect to long-term success rates [13];
- Facial prosthesis (extraoral applications of osseointegration include anchorage for craniofacial prostheses including ear, eye, and nose] and finger prosthesis etc.

- *Osseoperception* - is the term used to describe the ability by patients with osseointegrated fixtures to identify tactile thresholds transmitted through their prostheses. It is a phenomenon of importance in both dental and orthopaedic applications of osseointegration.The identification of osseoperception as a phenomenon of osseointegration was the result of work carried out in the dental sciences by Torgny Haraldson[14].
- *Osteopromotion* involves the enhancement of osteoinduction without the possession ofosteoinductive properties. For example, enamel matrix derivative has been shown toenhance the osteoinductive effect of demineralized freeze dried bone allograft (DFDBA), butwill not stimulate from the new bone growth alone [15]

Ridge augumentation and bone grafting

The placement of endosseous dental implants for prosthetic support requires adequate bone volume at the desired location. Defect morphology is an important consideration in selecting a method for ridge augmentation. Although iliac crest is used most often in major jaw reconstruction for implants, block grafts from the mandible have been used with favorable results for repair of smaller defects Autologous bone grafts are the gold standard in repair of alveolar atrophy and bone defects.[16]. Despite of this as they are the most predictable material, only a limited amount of autogenous bone canbe procured from intraoral sites which may not be sufficientfor complete fill of defects. Meanwhile, alloplasticmaterials, particularly bioactive glass, may represent apossible alternative to be mixed with autogenous bone forthe treatment of intrabony defects. Some histologicalstudies have shown that the use of bioactive glassinduces a significant increase in newly formed cementumand attachment and that apical downgrowth of thejunctional epithelium can be prevented. Resultsfrom clinical and histological studies also indicated thatbioactive glass is easy to handle, biocompatible, hashaemostatic properties, and osteoconductive as well aspotentially osteoinductive effects [17, 18, 19].

Bone augmentation techniques and material

Alveolar ridge deformities are classified according totheir morphology and severity. A classification foralveolarridgedefectshasbeendescribedtostandardizecommunication among clinicians in the selection andsequencing of reconstructive procedures designed toeliminate these defects:

- Iclass - defect has bucco-lingualloss of tissue with normal ridge height in an apicocoronal direction.
- II class - defect has apico-coronalloss of tissue with normal ridgewidth in a bucco-lingualdirection.
- III class- defecthasacombinationbucco-lingualand apico-coronal loss of tissue resulting in loss ofheight and width.

Critical-sized alveolar ridge defects in the horizontaland vertical dimensions may occur following toothloss, fractures, or pathologic processes. Such defectsmay compromise the ideal implant placement asprescribed prosthetically with an unfavorable outcome.

Bone augmentation techniques may be used for *theapplications of extraction socket defect grafting,horizontalridge augmentation, vertical ridge augmentatio*[5],*and sinus augmentation*[19]. Tomaximize the resultsfor each of these applications, a variety of differenttechniques is employed. They include particulategrafting, membrane use, block grafting, and distractionosteogenesis, either alone or in combination [5].

In the scientific literature bone augumentation technique are refered as: 1. Bone Augmentation with BarrierMembrane Technique; 2. Particulate Bone Grafting Technique; 3. Block Grafting Approaches; 4. Combination Approaches; 5. Ridge Expansion Techniques; 6. Future bone augmentation approaches likely (will usemolecular, cellular, and genetic tissue engineering technologies).

Horizontal and vertical ridge augmentation[5] were describedwith the use of a variety of different techniquesand materials. Although achieving comparableclinical outcomes for vertical ridge augmentation hasbeen more challenging, success was demonstratedwith the use of non-resorbable ePTFEmembranes withautograft, titaniummesh with particulate grafts,forced tooth eruption, autogenous block grafting,and distraction osteogenesis. [20].

Grafting materials [5, 19] were categorized in one ofthe following groups:1. No graft (coagulum); 2. Autograft block (extraoral or intraoral donor site); 3.Autograft particulate; 4. Autograft from bone trap; 5. Membrane alone (nonresorbable or resorbable); 6. Allograft (freeze-dried bone allograft [FDBA] ordemineralized freeze-dried bone allograft[DFDBA]); 7.Xenograft (demineralized bovine bone mineral[DBBM], algae-derived, or coral-derived); 8.Alloplast (hydroxyapatite [HA], _-tricalciumphosphate [TCP], bioglass, or calcium sulphate); 9. Combinations (autograft + allograft, autograft +xenograft, autograft + alloplast, allograft +xenograft, or allograft + alloplast).

Jansen et al. [5] has evaluated total of 2006 abstracts and 424 full-text articles. Studies with horizontal ridge augmentations were analysed as:*(1)* studies that reportedon the augmentation procedure itself, and *(2)* studies that evaluated implantsurvival in horizontally augmented alveolar ridges.Seventy-six studies with vertical ridge augmentationswere evaluated as full text. The efficiency of the augmentation procedure showed that 73% of the cases were without the need for additionalgrafting and the implant survival rates ranged from 95% to 100%(median 100%).

Socket Preservation Application - in the anterior maxilla, where the buccal plate often isextremely thin and friable, consistent bone resorptionis found after extraction.To minimize bone resorption,less traumatic extraction techniques with socketaugmentation, using a variety of particulate bonegraft materials with and without membrane barriers,were reported that demonstrated significantly reducedalveolar ridge dimensional changes associatedwith these preservation techniques.To preserve the extraction socket architecture andto accelerate the timeline to final implant restoration,the technique of immediate implant placement atthe time of extraction often is proposed.Immediate implantplacement was shown to have a failure rate of<5%, which is comparable to delayed placement[21]. Socket preservation helpsto maintain the alveolar architecture and significantly reduces the loss ofridge width and height following tooth removal [22].

If an autogenous bone transplant is too difficult to perform, other treatments such as*distraction osteogenesis* or fillings with various bone substitutes are thus generally performed.For bone regeneration, three conditions of proper scaffolds, efficient growth factors, andstem cells are needed. Bone substitutes are thought to be useful as proper scaffoldings [23].

Bone augmentation with barrierMembrane TechniqueThe concept of GBR was described first in 1959 whencell-occlusive membranes were employed for spinalfusions. The terms ‘‘guided bone regeneration’’and ‘‘guided tissue regeneration’’ (GTR) often areused synonymously and rather inappropriately. GTRdeals with the regeneration of the supporting periodontalapparatus, including

cementum, periodontalligament, and alveolar bone, whereas GBR refers tothe promotion of bone formation alone. GBR andGTR are based on the same principles [24, 25].

Conclusion

A large but heterogeneous body of literature wasavailable regarding augmentation of localized bonedefects in the alveolar ridges after including all levelsof clinical evidence except expert opinions.The major development in esthetic dentistry, and more so the introduction of implantdentistry, led to significant developments aimed to regenerate or restore bony defects andbone loss in the edentulous ridge. Most clinical efforts in the developments in boneaugmentation procedures are related to either simplifying clinical handling or influencing ofbiologic processes. Many techniques exist for effective bone augmentation.The approach largely is dependent on the extentof the defect and specific procedures to be performedfor the implant reconstruction. It is most appropriateto use an evidenced-based approach when a treatmentplan is being developed for bone augmentationcases.

References

[1] Pietrokovski, J. & Massler, M. (1967). Alveolar ridge resorption following tooth extraction.Journal of Prosthetic Dentistry 17, 21–27.

[2] Schropp, L., Wenzel, A., Kostopoulos, L. & Karring, T. (2003). Bone healing and soft tissuecontour changes following single-tooth extraction: a clinical and radiograhic 12-month prospective study. International Journal of Periodontics & Restorative Dentistry23, 313–323.

[3] Haim Tal, Zvi Artzi, Roni Kolerman, Ilan Beitlitum and Gal Goshen (2012). Augmentation and Preservation ofthe Alveolar Process and Alveolar Ridge of Bone, Bone Regeneration, Prof. Haim Tal (Ed.), ISBN: 978-953-51-0487-2, InTech, Available from: http://www.intechopen.com/books/bone-regeneration/augmentation-andpreservation-of-the-alveolar-process-and-alveolar-ridge-of-

[4] Uran N. Use of Block Hydroxyapitite Implantsin the Augmentation of Subalveolar Ridge.Journal of Islamic Academy of Sciences, 1989; 2:4, 289-290,

[5] Jensen SS., Terheyden H. Bone Augmentation Procedures in LocalizedDefects in the Alveolar Ridge:Clinical Results with Different Bone Graftsand Bone-Substitute Materials. Int J Oral Maxillofac Implants 2009; 24 (Suppl):218–236.

[6] Kruger GO: Textbook of Oral and Maxillofacial Surgery.1984; 106-163,.

[7] Boyne PJ, Rothstein SS, Guamer KI, Drobeck HP: Longterm study of hydroxyapatite implants in canine alveolar bone. J Oral Maxillofac Surg 1984; 42:589-594.

[8] Albrektsson T, Johansson C. Osteoinduction, osteoconduction and osseointegration, Eur Spine J (2001) 10:S96–S101.

[9] Brånemark R, Brånemark P-I, Rydevik B, Myers RR, Osseointegration in skeletal reconstruction and rehabilitation.Journal of rehabilitation research &development 2001; 38 (2)

[10] Brånemark P-I. Introductory remarks. In: Williams E, Rydevik B, Brånemark P-I, editors. Osseointegration from molecule to man. Institute for Applied Biotechnology, Proceedings of Interdisciplinary Conference, 1999 May 2; Göteborg, Sweden: Artisten.

[11] Brånemark P-I, Hansson BO, Adell R, Breine U, Lindström J, Hallén O, Öhman A. Osseointegrated implants in the treatment of the edentulous jaw. Stockholm: Almqvist and Wiksell; 1977. 132 pp.

[12] Brånemark P-I. Osseointegration and its experimental studies. J Prosthetic Dentistry 1983; 50:399-410.

[13] Worthington P. History, development, and current status of osseointegration as revealed by experience in craniomaxillofacial surgery. In: Brånemark P-I, Rydevik BL, Skalak R, editors. Osseointegration in skeletal reconstruction and joint replacement. Carol Stream, IL: Quintessence Publishing Co; 1997. p. 25-44.

[14] Esposito M, Hirsch JM, Lekholm U, Thornsen P. Biological factors contributing to failures of osseointegrated oral implants. (I). Success criteria and epidemiology. Eur J Oral Sci 1998; 106:527-51.
[15] Nguyen Ngoc Hung. Basic Knowledge of Bone Grafting, Bone Grafting, 2012. Dr Alessandro Zorzi (Ed.), ISBN: 978-953-51-0324-0, InTech, Available from:
http://www.intechopen.com/books/bone-grafting/basicknowledge-of-bone-grafting
[16]Precheur HV. Bone graft materials. DentClin North Am. 2007; 51, 729-746.
[17] Nevins ML, Camelo M, Nevins M, King CJ,Oringer RJ, Schenk RK, Fiorellini JP (2000)Human histologic evaluation of bioactive ceramicin the treatment of periodontal osseous defects. IntJ Periodontics Restorative Dent 2000; 20, 458-467.
[18] Brkovic BM, Prasad HS, Rohrer MD, Konandreas G, Agrogiannis G, Antunovic D, Sándor GK. Beta-tricalcium phosphate/type I collagen cones with or without a barrier membrane in human extraction socket healing: clinical, histologic, histomorphometric, and immunohistochemical evaluation. Clin Oral Investig 2012; 16 (2): 581-90.
[19] Galindo-Moreno P, Avila G, Fernández-Barbero JE, Mesa F, O'Valle-Ravassa F, Wang HL. Clinical and histologic comparison of two different composite grafts for sinus augmentation: a pilot clinical trial. Clin Oral Implants Res. 2008; 19, 755-759.
[20] Hjørting-Hansen E. Bone grafting to the jaws with special referenceto reconstructive preprosthetic surgery. A historicalreview. Mund Kiefer Gesichtschir 2002;6:6–14.
[21] Byrne Gerard. Socket preservation of implant sites. A critical summary of Ten Heggeler JMAG, Slot DE, Van der Weijden GA. Effect of socketpreservation therapies following tooth extraction in non-molar regions in humans: a systematicreview (published online ahead of print Nov. 22, 2010). Clin Oral Implants Res2011; 22(8):779-788..
[22]Dimova C. Socket Preservation Procedure after Tooth Extraction. Key Engineering Materials 2014; 587:325-330.
[23]Baker B, Gibbons S, M Woods M.Intra-alveolar distraction osteogenesis in preparation fordental implant placement combined with orthodontic/orthognathic surgical treatment: A case report. Australian Dental Journal 2003;48:(1):65-68.
[24] Llambés F, Silvestre FJ, Caffesse R.Vertical guided bone regenerationwith bioabsorbable barriers. J Periodontol 2007;78:2036–2042.
[25] De Boever AL, De Boever JA. Guided bone regenerationaround non-submerged implants in narrow alveolar ridges:Aprospective long-term clinical study. Clin Oral Implants Res2005;16:549–556.