When to indicate the autogenous bone grafts or bone substitutes in implant dentistry? Part II

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Physiology of the alveolar bone loss

One of the greatest and most constant challenges for professionals in Dentistry and more specifically for Implantodontists has been the recovery of edentulous regions after the loss of one or more teeth. Despite all visible progress in the prevention of caries and periodontal disease, tooth extraction is still a prevalent and mutilating treatment.

In the dental alveolus , the disposition of hydroxyapatite crystals and collagen fibers of bone depend on the traction or stretching of the periodontal fibers which cause an orientation of forces, adapting to the functional requirement of the periodontium. When a tooth is extracted, the force applied is over and the preexisting Haversian system becomes useless. The osteoclasts resorb this system, being followed by the deposition of a simpler new osteon which is in accordance to local pressure and strength system only.[8] The alveolar atrophy is continuous and irreversible, and its etiology is multifactorial, involving both local and systemic factors, including diet, facial morphology, hormonal disorders, osteoporosis and use of prostheses.[23]

Biology of the repair of autogenous block bone grafts in block

Bone reconstruction using autogenous bone grafts triggers a number of remarkable events which culminate in its incorporation and remodeling. The processes are conducted by principles of osteogenesis, osteoinduction and osteoconduction according to the structural nature of the graft.[3,4,7] After the consolidation of the graft, it is essential that minimal loss of the original volume occur and largest portion possible be replaced by vital bone.

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Autogenous bone grafts consist of a hard tissue matrix and a cellular component of osteoblasts and osteocytes. There may also be a medullary portion containing fat cells in stromal connective tissue, in addition to osteoblast progenitor cells express osteogenic activity by adequate stimulus.[19]

According to Hardesty et al[10] in 1990, there are many aspects that interfere in the process of repairing a autogenous bone graft. Macroscopic shape, revascularization, architectural differences, as well as the preparation of the receptor bed and rigid fixation of the graft should be considered as predictive values and therefore they need to be extensively researched and understood.

Different macroscopic shapes available for its application (in cortical, cancellous, corticocancellous blocks, in particles or as a macerated bone) result in different repair ways that are peculiar, with strong influence on the final outcome.[7,17]

In general, the shape is selected according to the indication of the graft. Reconstructions in height, thickness, or both require block grafts, preferably corticocancellous. The bone in particles obtained by grinding or scaling, is suitable for filling preexisting bone defects or surgically created store, such as in the case of maxilla sinus floor elevation.

The graft incorporation involves different stages, from initial inflammatory to complete remodeling. One of the first steps is the angiogenesis occurring in response to factors that promote proliferation and growth of blood capillaries.[2,19]

Revascularization is considered a critical aspect to a good final result of grafting procedures. It is observed that the vascular invasion has variable speed according to the shape and density of the graft. The literature is wide in stating that revascularization and consequently repair of cancellous bone differ essentially from that of cortical bone.[2,4,10,11,12,14,15,21] The constitution of cancellous bone, favored by large medullary spaces, has a first simultaneous osteogenic phase to vascular invasion which occurs on the grafted bone trabeculae. Only subsequently, nonvital osteoclastic bone resorption occurs. Instead, in the cortical bone, it is initially necessary to have osteoclastic resorption opening the path towards the blood vessels and osteogenic cells. This phenomenon was possible to confirm in the work of Paleckis,[16] given the occurrence of absorption channels with cell contents entering into the block graft, particularly within 14 days.

As a result, revascularization and resorption of membranous bone are slower when compared to those of endochondral bone. This aspect may be decisive for the choice of the donor area. If the bed is deficient in its vascularization, the endochondral graft should be the best choice.[20] However, Pinholt et al[21] demonstrated more intense revascularization in mandibular grafts (membranous origin) and iliac grafts (endochondral origin) than in cap and tibia, respectively, of membranous and endochondral origin, suggesting the medullary spaces of those first facilitated the process. With this, the authors ratified the importance of bone architecture in the revascularization process.

Bone formation is conducted by the surviving cells of the graft and the ability of the bone matrix in inducing osteogenic cell differentiation in the recipient area. Although the graft and bed have individual contributions to the process, the sum of their interactions determines the success or failure of the same.[4]

Certainly, the revascularization, remodeling and graft persistence processes are multifactorial as stated by

Lozano et al[12] and Gordh et al[9] and cannot be consisted by the alone mechanism.

The dense and slightly porous structure of the cortical block characterizes its repair by a first phase of osteoclastic resorption observed for an osteogenic period. The preexisting vascular channels are invaded by resorptive and extended cells following invasion of blood vessels and osteogenic cells.

In order to promote cellular transformation that produces new bone and consolidates graft, an appropriate recipient bed must be prepared to favor its revascularization. The rigid fixation eliminates graft micromovements and the graft juxtaposition eliminates dead spaces, favoring a solid interface.[5]

Regarding the surgical preparation of recipient bed, this is performed in order to approach the bone marrow to the recipient area (source of osteogenic cells and blood vessels) and graft. Prolo and Rodrigo,[22] in 1985, warned the need for careful preparation of the recipient bed, preferably with exposure of bone marrow, but without causing heating or cell destruction.

Alberius et al[1] demonstrated that bed perforation to favored the graft incorporation and a structural reinforcement of the bone marrow.

Gordh et al[9] performed perforations both in bed and graft. The procedure enabled the migration of recipient bone marrow cells to the graft, thus reducing the volume loss. Despite this and surprising to the authors, full consolidation occurred between the graft cortical surface and bed also cortical, including in the absence of perforation.

Carvalho et al[5] showed that the preparation for bed by decorticalization or perforations, influenced positively on graft integration, unlike to which occurred when the bed was not prepared, in which resulted in fibrous union.

The volume loss is not linear and is more dramatic in the first weeks. The rigid fixation would exert its influence in the initial phases. The same authors inferred that, once the graft becomes adhered to the bed, the fixation type is no longer important.

It is assumed that the rigid fixation by plaques and screws maintains the intimate contact between the graft and bed, thus eliminating dead spaces.[5] It also prevents micro-movements, providing the delicate capillary proliferation from the interface to the graft, ensuring the indispensable supply of nutrients and oxygen to a region in the repair process.

Biology of the repair of autogenous bone grafts in particle form

According to Perri De Carvalho and Okamoto,[18] alveolar repair may be considered in four fundamental phases: Cell proliferation, development of connective tissue, maturation of connective tissue and bone differentiation or mineralization. The repair process begins immediately after tooth extraction. The blood clot is gradually invaded by preexisting fibroblasts and adventitious cell differentiation, both present in the remaining of the periodontal ligament that remains attached to the alveolar walls. Then the newly formed connective tissue exhibits a large amount of cells, notably fibroblasts, and newly formed capillaries. As it increases the amount of collagen fibers and decreases the number of cells and blood vessels, the connective tissue is in the maturation phase. Then, near the alveolar walls and from the bottom of the alveolus, the osteoblasts, originate from cells called osteoprogenitors, deposit the organic matrix, forming osteoid tissue. When this tissue becomes calcified, bone trabeculae is formed.

Pallensen et al,[17] in 2002, demonstrated that small particles are also rapidly absorbed, with higher simultaneous bone apposition than in the use of larger particles. The authors stated that the small size increases the contact surface to the tissue that involves it.

If the absorption speed of the particles obtained by scaling can support their rapid replacement due to their small size, on the other hand, it can adversely influence on the final volume of the graft. The fact should warn on the possibility of volume decrease for this graft type while its clinical application, especially in the use for sinus grafts.

Luppino[13] and Coradazzi[6] reported favorable course in repairing bone cavities filled with powdered bone particles, bone scraps or macerated bone, collected during milling. The presence of such particles, in the authors' opinion, was related to a higher new bone formation. Coradazzi[6] stated that the resorption of cortical bone particles, rich in BMP, would have good osteoinductive capacity.

As with block grafts, the bed preparation for particle grafts can facilitate the repair and serve as a starting point to the new bone formation.

Bone defects: Etiology and clinical consequences

In addition to the bone remodeling that occurs after tooth loss, there is often the presence of maxillary and mandibular bone defects which include the need for autogenous bone graft in the prosthetic-surgical planning.

Bone defects can be classified as congenital and acquired. The congenital bone defects are found in subjects since birth and can cause other problems, such as cleft patients who usually have many disorders like phonetic, esthetic, muscle positioning, psychological among others.

The acquired defects are usually caused by trauma, pathological processes, alveolar resorption after root fractures and even implant extraction.

Among the pathological processes of high importance for bone losses are those caused by periodontal disease and periapical abscesses. When they are not correctly treated, these processes cause a rapid osteolytic process generating large defects which need to be rebuilt for rehabilitation. In such cases, besides removing the cause, there is a need to restore the balance between bacterial virulence/host resistance for intervention in the area.

In addition to these, there are pathological processes of tumoral origin, mostly osteolytic processes, and they require safety margin. Depending on their aggressiveness, resection of the maxilla or mandible portion can be necessary.

The most aggressive losses observed are defects caused by trauma. The dentoalveolar trauma, mainly in the upper anterior teeth, generates significant bone defects when the teeth suffer avulsion and fracture of the buccal bone plate. There are more severe cases in which the alveolar process is fractured, thus affecting the buccal and lingual plates that can be absorbed if there is no adequate immobilization of the segment and/or nutrition during bone consolidation phase.

Implants that do not present prosthetic solutions due to inadequate positioning or fractures may be indicated for extraction. When extracting osseointegrated implants, it is necessary to extract the buccal bone plate, similar to the alveolectomies, causing bone defects in the alveolar ridges which need to be rebuilt for later rehabilitation.

As clinical consequences of alveolar resorption and bone defects, it may be: Thin ridge, concavities, loss in the contour of alveolar process, pneumatization of the maxillary sinus, and in cases of prolonged tooth extraction in which the antagonistic arch consists of natural teeth, it is often found flaccid mucosa.

Conclusion of biological aspects for grafts

- The autogenous bone grafts in a block shape should be indicated for the reconstruction of resorbed alveolar processes, both in thickness and height.
- Whereas the recipient bed should be prepared and the bone block fixed, the autogenous bone grafts present in the initial phases a biological sequence of devitalization, resorption and revascularization from the recipient bed.
- The autogenous bone grafts have a short phase of osteogenesis and, subsequently, more prolonged phases of osteoinduction and osteoconduction, the latter being more durable in the cortical grafts.
- The bone grafts in particle shape should be indicated to fill bone defects and cavities, as well as alveoli that show remaining bone walls.
- Using bone in particle shape, the bone repair comprises the resorption of small particles and incorporation of larger particles.

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