Original Article

HISTOLOGICAL ASPECTS OF AUTOLOGOUS BONE UNDER BONE LAMINA

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ABSTRACT

Autologous bone appears to be the most predictable and successful material available. The main problem concerning its use is its availability, but with autologous bone, there are no immunologic reactions or risks of disease transmission. The authors present a histological study of autologous bone used in ridge augmentation associated with bone lamina. Twenty patients participated in this study, and all gave their informed consent. In all patients, autologous bone was obtained during implant bed preparation in association with bone lamina in lateral and vertical ridge augmentation procedures. After 12 months, a small biopsy of the regenerated tissues was carried out. Histologically, almost all particles of autologous bone were surrounded by newly formed bone; all particles had been surrounded by new bone or undergoing remodeling. In conclusion, we observed that autologous bone used in ridge augmentation procedures under bone lamina membranes presented excellent osteoconductive properties: all the particles were surrounded by newly formed bone.

KEYWORDS: *autologous bone, bone lamina, bone regeneration, remodeling*

INTRODUCTION

Insufficient bone amount of bone is one of the most significant clinical challenges in dental implantology (1). Alveolar distraction osteogenesis, guided bone regeneration (GBR), and onlay grafting have been described to augment the horizontal and vertical bone volume (2). Trauma, surgery for tumors, or periodontal pathologies cause resorption of the alveolar process or, in severe cases, resorption of native bone may produce insufficient bone volume or unfavorable vertical, transverse, and/or sagittal inter-arch relationships for dental implant placement (3).

Various graft materials have been effectively used for bone regeneration, including xenografts, alloplasts, and allografts, but autologous bone is considered a gold standard. Autologous bone (AB) grafting is the gold-standard technique and appears to be the best type of graft used in bone regeneration (4), and is the most predictable and successful material

Received: 13 February 2024
Accepted: 20 March 2024

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available (5-8). In implant surgery, the reported benefits of AB graft include accelerated wound healing and the regeneration of new bone and soft tissue following tissue injury because it contains viable osteogenic cells, intrinsic growth factors, and a scaffold that collectively promotes new bone formation (9). However, autologous bone graft can present various disadvantages, including limited grafted bone and procedure time. Moreover, a year after the regenerative procedure, bone reabsorption happens in 40% (10).

Usually, the intraoral area is the main site of autologous bone donation, including maxillary tuberosity, mandibular symphysis, and ascending ramus of the mandible. Also, the iliac crest graft and calvarial graft have been used in major surgeries because of the large amount of donated bone (11). The autologous harvested bone contains cortical bone and cancellous bone. Cancellous bone is rapidly revascularized, and this type of bone is resorbed and replaced by creeping substitution, while cortical bone appears to be revascularized very slowly (12).

The main problems concerning the use of autologous bone are its availability (13), infections, a limited amount of donor bone tissue, the need for a second surgery site for bone graft harvest, bleeding, and chronic pain. For this reason, many other types of materials have been used as substitutes for autologous bone (2, 13-15).

However, autologous bone remains the gold standard in bone regeneration due to its osteogenic, osteoinductive, and osteoconductive properties (16), growth factors, and the fact that it does not cause immunogenic reactions (17). Autologous bones are classified according to their intraoral or extraoral origin and endochondral or membranous according to their embryologic origin. In implantology, the most frequently used intraoral donor sites are the chin and body or ramus of the mandible; the main disadvantage is their high number of postoperative complications (18, 19).

The present study aimed to perform a histologic study in man to analyze the healing features and remodeling patterns of autologous bone used under bone lamina membranes in ridge augmentation procedures.

MATERIALS AND METHODS

Twenty patients participated in this study (mean age 48; range 32 to 72). All gave their informed consent. In all patients, autologous bone was obtained during implant bed preparation in association with Bone Lamina (OsteoBiol by Tecnoss, Italy) in lateral and vertical ridge augmentation procedures (Fig. 1, 2).

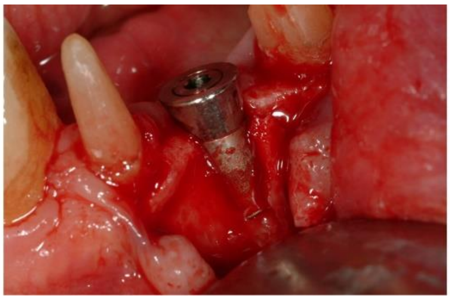

Fig. 1. *Vestibular bone defect.*

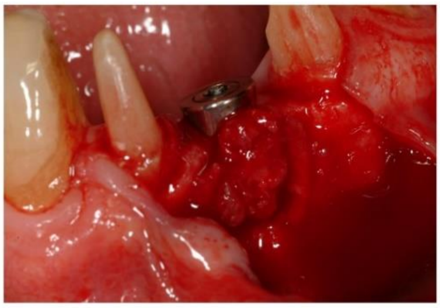

Fig. 2. *Bone defect treated with autologous bone before placement of the bone lamina.*

After 12 months, a small biopsy of the regenerated tissues was carried out at implant insertion. The specimens were retrieved, washed in saline solution, and immediately fixed in 4% paraformaldehyde and 0.1% glutaraldehyde in 0.15 M cacodylate buffer al 4°C and pH 7.4 to be processed for histology. The specimens were processed to obtain thin ground sections with the Precise 1 Automated System (Assing, Rome, Italy) (20). The specimens were dehydrated in an ascending series of alcohol rinses and embedded in a glycolmethacrylate resin (Technovit 7200 VLC, Kulzer, Germany). After polymerization, the specimens were sectioned with a high-precision diamond disc at about 150 μm and ground down to about 30 μm. The slides were stained with basic fuchsin, toluidine blue, and von Kossa. The histochemical analysis of acid and alkaline phosphatases was carried out according to a previously described protocol (21).

RESULTS

In many histological samples, it was possible to see that almost all particles of autologous bone were surrounded by newly formed bone. In some fields, it was possible to see that this newly formed bone was lined by a rim of osteoblasts that was positive for alkaline phosphatase. No osteoclasts or macrophages positive to acid phosphatase were present. A resorption phenomenon was present. In many areas, it was possible to observe the presence of compact, mature cortical bone that could be easily differentiated from the newly formed bone. The grafted bone presented different structure and maturation features from the regenerated bone: it had a lesser affinity for dyes and a basic fuchsin-positive, highly stained line, similar to the cementing lines, divided the grafted from the regenerated bone (Fig. 3).

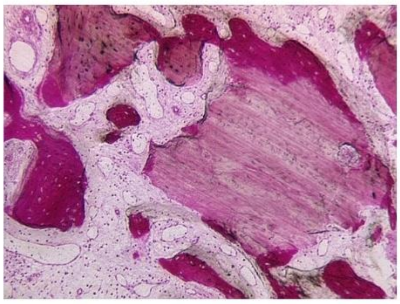

Fig. 3. *Autologous bone is easily recognized due to its lesser staining affinity than newly formed bone. Basic fuchsin-toluidine blue 100 X.*

These lines had higher staining than the cementing lines observed in normal bone. The biological fluid colonized the bone plate, which was also present, and in several areas, it was in direct contact with the new bone.

DISCUSSION

The present study shows that all particles of autologous bone were always surrounded by newly-formed bone, and several areas showed a resorption process. The underlying cellular mechanisms that trigger graft resorption remain to be elucidated. In the present study, we show graft resorption could plausibly be compared to bone resorption during physiological remodeling (22). Much remains elusive with regard to the underlying cellular mechanisms that trigger graft resorption. The old or damaged bone is resorbed by osteoclast during bone remodeling. This is a desirable effect because resorption is coupled with bone formation during physiological bone remodeling.

Autogenous bone is currently the only osteogenic material available (23). The biology and biomechanics of bone healing are complex and currently considered that successful bone healing requires the presence of viable osteogenic cells and appropriate connective tissue matrix, adequate vascularity, the presence of multiple growth factors that have both temporal and particular specificity within the fracture site, and appropriate degree of mechanical stability (24). Viable bone cells have been found in borings collected from implant cavities (25).

Autogenous bone from the iliac crest appears to be the best material for sinus-lift procedures (24), treatment of dehiscences and fenestrations around dental implants (24), and vertical ridge augmentation around dental implants (3). Autologous bone is inert, does not produce immunologic reactions, is replaced by osteoclastic resorption and bone formation, presents cell viability and a decreased time for revascularization, resorption, and replacement, and has no risks of disease transmission (26).

Our histological results show a very high osteoconductivity of the autologous bone: all the particles were always surrounded by newly formed bone, and the latter was firmly attached to the former (27, 28). It was possible to find a regular cement line at the interface between the autologous and the newly formed bone (28). These lines occasionally had a crenated appearance, which osteoclastic resorption could explain this phenomena before bone formation. The bone regeneration with autologous bone had the most significant bone regeneration (26). Cortical bone becomes revascularized much slower than cancellous bone (26, 28).

The cortical portion is revascularized slowly through the Haversian system and remodeled by cortical bone-modeling units (28). Allografts, on the other hand, are replaced slowly. There is a host immune response, and the failure of all forms of allografts is significantly higher than that of autografts (26). Autologous bone can be mixed with platelet concentrates to improve bone healing (29).

CONCLUSIONS

In conclusion, we observed that autologous bone used in ridge augmentation procedures under bone lamina membranes was excellently osteoconductive: all the particles were surrounded by newly formed bone.

ACKNOWLEDGMENTS

A special acknowledgment and thanks to Dr Francesco Tricca for his assistance with the morphological data.

REFERENCES

1. Malchiodi L, Scarano A, Quaranta M, Piattelli A. Rigid fixation using titanium mesh in edentulous ridge expansion for horizontal ridge augmentation in the maxilla. *Int J Oral Maxillofac Implants.* 1998;13(5):701-705.
2. Simion M, Dahlin C, Trisi P, Piattelli A. Qualitative and quantitative comparative study on different filling materials used in bone tissue regeneration: a controlled clinical study. *Int J Periodontics Restorative Dent.* 1994;14(3):198-215.
3. Scarano A, Carinci F, Assenza B, Piattelli M, Murmura G, Piattelli A. Vertical ridge augmentation of the atrophic posterior mandible using an inlay technique with a xenograft without miniscrews and miniplates: case series. *Clin Oral Implants Res.* 2011;22(10):1125-1130. doi:https://doi.org/10.1111/j.1600-0501.2010.02083.x
4. Becker W, Dahlin C, Becker BE, et al. The use of e-PTFE barrier membranes for bone promotion around titanium implants placed into extraction sockets: a prospective multicenter study. *Int J Oral Maxillofac Implants.* 1994;9(1):31-40.
5. Triplett RG, Schow SR. Autologous bone grafts and endosseous implants: complementary techniques. *J Oral Maxillofac Surg.* 1996;54(4):486-494. doi:https://doi.org/10.1016/s0278-2391(96)90126-3
6. Bell RB, Blakey GH, White RP, Hillebrand DG, Molina A. Staged reconstruction of the severely atrophic mandible with autogenous bone graft and endosteal implants. *J Oral Maxillofac Surg.* 2002;60(10):1135-1141. doi:https://doi.org/10.1053/joms.2002.34986
7. Sethi A, Kaus T. Ridge augmentation using mandibular block bone grafts: preliminary results of an ongoing prospective study. *Int J Oral Maxillofac Implants.* 2001;16(3):378-388.
8. Behneke A, Behneke N, d'Hoedt B. Treatment of peri-implantitis defects with autogenous bone grafts: six-month to 3-year results of a prospective study in 17 patients. *Int J Oral Maxillofac Implants.* 2000;15(1):125-138.
9. Chen X, Wang H, Wang Y, Shi Y, Wang Z. Enhanced osteogenesis by addition of cancellous bone chips at xenogenic bone augmentation: In vitro and in vivo experiments. *Clin Oral Implants Res.* 2023;34(1):42-55. doi:https://doi.org/10.1111/clr.14017
10. Stricker A, Jacobs R, Maes F, Fluegge T, Vach K, Fleiner J. Resorption of retromolar bone grafts after alveolar ridge augmentation-volumetric changes after 12 months assessed by CBCT analysis. *Int J Implant Dent.* 2021;7(1):7. doi:https://doi.org/10.1186/s40729-020-00285-9
11. Valentini V, Cassoni A, Marianetti TM, Romano F, Terenzi V, Iannetti G. Reconstruction of craniofacial bony defects using autogenous bone grafts: a retrospective study on 233 patients. *J Craniofac Surg.* 2007;18(4):953-958. doi:https://doi.org/10.1097/scs.0b013e3180690123
12. OT J. Guided bone graft augmentation. *Guid Bone Regen Implant Dent.* 1994;235–264.
13. Simion M, Trisi P, Piattelli A. Vertical ridge augmentation using a membrane technique associated with osseointegrated implants. *Int J Periodontics Restorative Dent.* 1994;14(6):496-511.
14. Simion M, Trisi P, Piattelli A. GBR with an e-PTFE membrane associated with DFDBA: histologic and histochemical analysis in a human implant retrieved after 4 years of loading. *Int J Periodontics Restorative Dent.* 1996;16(4):338-347.
15. Camelo M, Nevins ML, Lynch SE, Schenk RK, Simion M, Nevins M. Periodontal regeneration with an autogenous bone-Bio-Oss composite graft and a Bio-Gide membrane. *Int J Periodontics Restorative Dent.* 2001;21(2):109-119.
16. Schwarz N, Schlag G, Thurnher M, Eschberger J, Dinges HP, Redl H. Fresh autogeneic, frozen allogeneic, and decalcified allogeneic bone grafts in dogs. *J Bone Joint Surg Br.* 1991;73(5):787-790. doi:https://doi.org/10.1302/0301-620X.73B5.1894667
17. Clarke B. Normal bone anatomy and physiology. *Clin J Am Soc Nephrol.* 2008;3 Suppl 3(Suppl 3):S131-139. doi:https://doi.org/10.2215/CJN.04151206
18. Inchingolo AM, Patano A, Di Pede C, et al. Autologous Tooth Graft: Innovative Biomaterial for Bone Regeneration. Tooth Transformer((R)) and the Role of Microbiota in Regenerative Dentistry. A Systematic Review. *J Funct Biomater.* 2023;14(3):doi:https://doi.org/10.3390/jfb14030132

19. Inchingolo AD, Inchingolo AM, Bordea IR, et al. The Effectiveness of Osseodensification Drilling Protocol for Implant Site Osteotomy: A Systematic Review of the Literature and Meta-Analysis. *Materials (Basel).* 2021;14(5):doi:https://doi.org/10.3390/ma14051147
20. Scarano A, Quaranta M, Piattelli A. Bone sectioning using the precise 1 automated cutting system. *Handb Histol Methods Bone Cartil.* 2003;265-269.
21. Borges FL, Dias RO, Piattelli A, et al. Simultaneous sinus membrane elevation and dental implant placement without bone graft: a 6-month follow-up study. *J Periodontol.* 2011;82(3):403-412. doi:https://doi.org/10.1902/jop.2010.100343
22. Andersen TL, Abdelgawad ME, Kristensen HB, et al. Understanding coupling between bone resorption and formation: are reversal cells the missing link? *Am J Pathol.* 2013;183(1):235-246. doi:https://doi.org/10.1016/j.ajpath.2013.03.006
23. Misch CE, Dietsh F. Bone-grafting materials in implant dentistry. *Implant Dent.* 1993;2(3):158-167. doi:https://doi.org/10.1097/00008505-199309000-00003
24. Wheeler SL, Holmes RE, Calhoun CJ. Six-year clinical and histologic study of sinus-lift grafts. *Int J Oral Maxillofac Implants.* 1996;11(1):26-34.
25. Lauer G, Schili W. Collected Implant Cavity Borings Used as Peri-Implant Osseous Augmentation Material. *Int J Oral Maxillofac Implants.* 1994;9
26. Becker W, Becker BE, Polizzi G, Bergstrom C. Autogenous Bone Grafting of Bone Defects Adjacent to Implants Placed Into Immediate Extraction Sockets in Patients: A Prospective Study. *Int J Oral Maxillofac Implants.* . 1994;9(4):
27. Schenk R. Bone regeneration: biologic basis. *Guid Bone Regen Implant Dent.* 1994;
28. Buser D, Sennerby L, De Bruyn H. Modern implant dentistry based on osseointegration: 50 years of progress, current trends and open questions. *Periodontol 2000.* 2017;73(1):7-21. doi:https://doi.org/10.1111/prd.12185
29. Ucer C, Khan RS. Alveolar Ridge Preservation with Autologous Platelet-Rich Fibrin (PRF): Case Reports and the Rationale. *Dent J (Basel).* 2023;11(10):doi:https://doi.org/10.3390/dj11100244