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Systematic Review Paper
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# Are there specific indications for the different alveolar bone augmentation procedures for implant placement? A systematic review

**I. Milinkovic, L. Cordaro**
Department of Periodontology and Prosthodontics, Eastman Dental Hospital, Rome, Italy

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*Abstract.* Bone resorption following tooth loss often interferes with dental implant placement in a desired position, and requires additional bone augmentation procedures. Many techniques have been described to augment and reconstruct alveolar ridge width and height. The aim of this study was to systemically review whether there is evidence to provide indications for the various bone augmentation procedures based on defect dimension and type. An electronic search of the Medline database and Cochrane library, complemented by a manual search, was performed. Inclusion criteria for partial edentulism were: clinical trials on bone augmentation procedures in preparation or at the time of implant placement, reporting preoperative and postoperative dimensions of the ridge. For edentulous patients, studies were included when providing the data on ridge and defect description, or the amount of augmentation achieved. The search yielded 53 publications for partially edentulous patients and 15 publications for edentulous patients. The literature provides evidence that dehiscence and fenestrations can be treated successfully with guided bone regeneration (GBR) at the time of implant placement (mean implant survival rate (MISR) 92.2%, mean complication rate (MCR) 4.99%). In partially edentulous ridges, when a horizontal defect is present, procedures such as staged GBR (MISR 100%, MCR 11.9%), bone block grafts (MISR 98.4%, MCR 6.3%), and ridge expansion/splitting (MISR 97.4%, MCR 6.8%) have proved to be effective. Vertical defects can be treated with simultaneous and staged GBR (MISR 98.9%, MCR 13.1% and MISR 100%, MCR 6.95%, respectively), bone block grafts (MISR 96.3%, MCR 8.1%), and distraction osteogenesis (MISR 98.2%, MCR 22.4%). In edentulous patients, there is evidence that bone block grafts can be used (MISR 87.75%), and that Le Fort I osteotomies can be applied (MISR 87.9%), but associated with a high complication rate. The objective of extracting specific indications for each procedure could not be fully achieved due to the heterogeneity of the studies available. Further studies on bone

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augmentation procedures should report precise preoperative and postoperative measurements to enable a more exact analysis of the augmentation procedure, as well as to provide the clinician with the rationale for choosing the most indicated surgical approach.

Key words: alveolar bone augmentation; indications; dental implants; systematic review.

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The treatment of partial and total edentulism with dental implants has become a routine treatment modality in contemporary dental practice. Nevertheless, tooth loss is frequently associated with subsequent bone loss, often resulting in inadequate bone dimensions for dental implant placement in a prosthetically ideal position.[1,2,3] Alveolar ridge resorption in partially and totally edentulous patients may interfere with the safe and correct positioning and placement of implants. When ridge resorption occurs, bone augmentation is essential to guarantee adequate bone volume, to provide patients with proper inter-arch dimensions, and to assure a satisfactory aesthetic result.

Numerous reconstruction procedures have been proposed to increase alveolar bone dimensions, both vertically and horizontally, in order to obtain a sufficient ridge volume for adequate implant placement and prosthodontic rehabilitation.[4–6] These techniques include: (1) guided bone regeneration (GBR); (2) bone block grafts; (3) distraction osteogenesis (DO); (4) ridge splitting or expansion; (5) osteotomies of the ridge or the jaws; and (6) combinations of the above.

Several materials may be used in the aforementioned procedures, including autografts, allografts, xenografts, and alloplasts, as well as different barrier membranes or osteosynthesis materials.

In some cases, bone augmentation procedures can be performed simultaneously with implant insertion, whereas in other clinical situations a healing period of the reconstructed ridge is needed, requiring a delayed, non-simultaneous implant placement. The long-term goal of both one-stage and two-stage augmentation procedures is the stability of the augmented bone volume, allowing adequate function and optimal aesthetics, as expressed by implant survival, bone stability, and soft tissue stability.

Hence numerous combinations of techniques and materials may be used and have been described in the literature.[4–6]

Usually a surgical technique should be chosen in relation to the anatomical baseline situation, the expected outcome based on scientific evidence, and the expected complication rate, as well as the expected success rate of the treatment with a given technique. It is not yet clear which procedure is an adequate choice for each particular clinical situation, providing satisfactory and stable bone dimension increase, long-term implant survival and stability, and a competent prosthetic rehabilitation.

The objective of the present review was to explore, based on current publications, whether it is possible to extract clinical indications for the various bone augmentation procedures based on defect type and dimensions.

Some clinical situations, such as immediate placement of implants in extraction sockets and sinus floor elevation, were not analyzed in the present review. Both clinical procedures have been addressed in numerous review papers and the indications have been thoroughly discussed.[4,7–13]

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) were adopted throughout the process of the present systematic review.[14]

The focused question was adapted using the PICO criteria: ''In patients with inadequate ridge dimensions requiring dental implant treatment, which would be the preferred bone augmentation procedure for each clinical situation?'' (Table 1).

*Table 1*. PICO criteria for the systematic review.

| | |
|---|---|
| Population (P) | Patients who underwent bone augmentation procedures during preparation or at the time of implant placement |
| Intervention (I) | Horizontal and vertical bone augmentation procedures for partially edentulous patients, bone augmentation procedures in edentulous patients |
| Comparison (C) | Lack of indications for different bone augmentation procedures |
| Outcome (O) | Mean amount of augmentation, implant survival rate in the augmented bone, and occurrence of complications |
| Focused question | In patients with inadequate ridge dimensions requiring dental implant treatment, which would be the preferred bone augmentation procedure for each clinical situation? |

## Materials and methods

### Search strategy

A critical review of the literature was conducted to select pertinent full-length articles published in English. The most recent electronic search was undertaken on 1 June 2012.

The electronic Medline (PubMed) and Cochrane Library search covered all human clinical trials conducted from 1990 to 2012 in which the above-mentioned bone augmentation procedures were performed. Additionally, a hand search of journals included the following: *Clinical Oral Implants Research*, *Clinical Implant Dentistry and Related Research*, *Journal of Oral Implantology*, *International Journal of Oral and Maxillofacial Implants*, *International Journal of Periodontics and Restorative Dentistry*, *Journal of Oral and Maxillofacial Surgery*, *International Journal of Oral and Maxillofacial Surgery*, *Clinical Oral Investigations*, *Implant Dentistry*, *Journal of Periodontology*, *Journal of Clinical Periodontology*, *Journal of Craniofacial Surgery*, *Journal of Oral Rehabilitation*, *Journal of Prosthetic Dentistry*, and *Oral Surgery*, *Oral Medicine*, *Oral Pathology*, *Oral Radiology*, *and Endodontology*. Only publications in English on bone augmentation procedures were included in this systematic review.

### Search terms

A combination of the following search terms was utilized: bone atrophy, bone loss, alveolar ridge bone loss, alveolar ridge deficiency, fenestration, dehiscence, horizontal defect, vertical defect, preprosthetic surgery, bone augmentation, horizontal bone augmentation, vertical bone augmentation, GBR, resorbable membrane, non-resorbable membrane, autogenous bone graft, allograft, xenograft, alloplastic, distraction osteogenesis,