EDITOR's OPINION

https://doi.org/10.5125/jkaoms.2020.46.5.361
pISSN 2234-7550 · eISSN 2234-5930

Guided bone regeneration

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Abstract (J Korean Assoc Oral Maxillofac Surg 2020;46:361-366)

Guided bone regeneration (GBR) is a surgical procedure that utilizes bone grafts with barrier membranes to reconstruct small defects around dental implants. This procedure is commonly deployed on dehiscence or fenestration defects ≥2 mm, and mixing with autogenous bone is recommended on larger defects. Tension-free primary closure is a critical factor to prevent wound dehiscence, which is critical cause of GBR failure. A barrier membrane should be rigidly fixed without mobility. If the barrier is exposed, closed monitoring should be utilized to prevent secondary infection.

Key words: Bone, Wound, Membrane

[paper submitted 2020. 9. 10 / accepted 2020. 9. 14]

I. Introduction

Guided bone regeneration (GBR) is a bone graft procedure that uses a covering barrier membrane to block soft tissue invasion. Some scholars argue that GBR should be strictly defined as those cases using a barrier membrane. In general, however, any bone graft technique for repairing bone defects around a dental implant is called GBR. What are the key indications for GBR? Should every bony dehiscence around an implant be treated with GBR? It is important to clearly understand the indications of GBR in clinical implant dentistry. The need for GBR is determined by type and size of remaining bone wall. For example, when implants are placed immediately after tooth extraction, bone healing will be successfully achieved without GBR if all surrounding bony walls are intact. On the other hand, the necessity of GBR increases as loss of bony wall increases. Briefly, GBR should be performed in cases of large defect or loss of bony wall. In cases of small defect, on the contrary, the prognosis may be better without bone graft[1]. A slight dehiscence (<2 mm) on the buccal side after implantation does not require GBR if the implant is secure with good primary stability[2].

II. Principles of GBR

Wang and Boyapati[3] suggested the PASS principle (P: primary closure, A: angiogenesis, S: space maintenance, S: stability) for successful GBR. The authors agree with this principle. Primary closure should be performed to prevent wound dehiscence as it can cause GBR failure due to increased risk of complications such as infection. An excellent blood supply at the recipient site can help achieve successful bone healing. In addition, the space should be secured during bone healing, with stabilization of the bone graft and barrier membrane.

III. Necessity of Barrier Membranes

Some research showed that use of a membrane did not affect the clinical outcomes if the clinician followed the principles of bone grafting. In particular, Gielkens et al.[4] reported that the periosteum could function as a useful barrier membrane with osteogenic property. There has been controversy

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whether the barrier membrane benefits include reduced bone resorption[5]. The barrier membrane should be used in consideration of the clinical situation. The authors suggest that use of a barrier membrane is advantageous in cases of large bony defect and greater amount of bone grafts.

IV. Resorbable vs Non-Resorbable Membrane

Each of the two membrane types (resorbable and non-resorbable) has its own pros and cons. The type of membrane does not affect the clinical outcome if the clinician carefully follows the principles of GBR[5-8]. Decomposition materials, generated during resorbable membrane resorption, may interfere with new bone formation and mechanical stability as a barrier membrane[9]. The resorbable membrane is not suitable for vertical bone augmentation because of its low rigidity and stability. However, the resorbable membrane has an advantage of resisting infection after wound dehiscence and maintaining space supported by grafting material[10,11]. The non-resorbable membrane has an excellent space maintenance property and predictable bone formation ability, although there is a high risk of infection with wound dehiscence[12,13]. Various resorbable and non-resorbable membranes have been used in implant dentistry. In particular, crosslinking and non-crosslinking materials are widely used for resorbable collagen membranes, while expanded-polytetrafluoroethylene (e-PTFE) and high-density polytetrafluoroethylene (d-PTFE) are widely used for non-resorbable membranes. Although each product demonstrates its own characteristic, the clinical results were not significantly affected different by membrane type[14-16].

The types of resorbable membranes include collagen membranes, DynaMatrix extracellular membrane, acellular dermal matrix, polylactide/polyglycolide/N-methyl-2-pyrrolidone, and polyglactin 910[16-22]. Most non-resorbable membranes used include titanium mesh and polytetrafluoroethylene (PTFE) membrane[13,23,24]. The titanium meshes have been widely used in vertical and horizontal ridge applications because of their excellent stabilization and relatively good resistance to infection. To enhance bone formation capacity, a resorbable membrane is frequently applied to compensate for large pores in the titanium mesh[13,25]. A customized titanium mesh has been recently developed that is pre-bent according to various defect shapes and designed for easy handling and fixation[26,27]. In the future, tissue engineering research will be actively conducted to develop a functional barrier membrane that can induce direct bone regeneration. Prior studies are quite extensive and include topics, for example, of a barrier membrane containing bone substitutes such as hydroxyapatite, growth factors/stem cells, organic/inorganic nanocompositions, and nanostructures[28,29].

V. Bone Graft Materials

High-quality allogeneic graft materials have osteoinductive and osteoconductive healing potential, if they are manufactured from a proven tissue bank. On the other hand, poor-quality allografts have not only a low bone healing potential but can promote infection and immune rejection. To achieve successful GBR, bone substitutes should be selected with high demineralized bone matrix content and mechanical stability. In addition, proper application of the barrier membrane is needed[30-32]. Xenografts and alloplastic bone substitutes have only osteoconductive healing potential and a slow resorption rate, which indicate an excellent space maintenance effect with volumetric stability[33].

To overcome the disadvantages of autologous bone graft such as a large donor defect and high resorption rate, many clinicians have mixed such grafts with autologous bone and bone substitutes. These mixtures have showed excellent bone healing capacity with bone resorption if the mixture can secure stability via a barrier membrane. In addition, mixture with autologous bone facilitates rapid bone union and healing of bone substitutes[34-36]. The autologous bone can be collected by implant drilling as bone dust or harvested by bone scarper, trephine burr, micro-saw, and bone rongeur on adjacent bone, bony protuberance, torus, maxillary tuberosity, and mandibular ramus[37]. For effective reconstruction of severe bony dehiscence around a dental implant, the autologous bone should cover the implant, and xenografts or alloplastic bone substitutes are implanted above the autograft, covering the barrier membrane[38,39].

VI. GBR and Implant Placement: Simultaneous vs Delayed

If the implant can be secured to achieve primary stability, the clinical results are not affected by the timing of implant placement after GBR. However, in the case of poor primary stability due to severe bone defect, it is safe to provide a sufficient healing period between GBR and implant placement[40,41].

VII. Cortical Bone Perforation

The purpose of cortical bone perforation is to improve bone healing by enhancing blood supply to the graft as in the decertification concept[42]. Danesh-Sani et al.[43] reported that larger cortical bone perforated holes results in greater new bone formation in the grafted site. However, some research reported controversial experimental results that cortical perforations did not improve bone healing or increase the amount of new bone matrix[44]. The authors suggest that cortical perforation is not necessary on the maxilla, as it is dominantly composed of cancellous bone with sufficient blood supply. Furthermore, we recommended performing cortical perforation in the mandible, consisting of thick cortical bone.

VIII. Non-Submerged GBR

For proper bony healing after GBR, intimate primary closure is one of the general principles. When wound dehiscence occurs, many complications follow, such as infection, bone loss, and poor wound healing. However, non-submerged GBR is a bone graft procedure to repair surrounding defects after transmucosal implant placement with intentional exposure of the upper portion of the implants and with primary gingival closure. It is controversial whether stable bone healing can be achieved with the non-submerged GBR. Recently, some researchers reported the effectiveness of the non-submerged GBR[45-47]. Primary stability of the implant is essential to achieve successful outcomes of the non-submerged GBR, and an intimate primary closure that covers the resorbable membrane also is important to achieve stable clinical outcomes.

IX. Complications

Wound dehiscence and membrane exposure, which are the most common complications after GBR, could lead to postoperative infection, inadequate bony healing, and loss of graft materials. The causes of wound dehiscence are inadequate flap design, soft tissue tension, excessive graft material, trauma due to temporary denture, mastication, or tooth brushing. Upon membrane exposure, the amount of bone formation is reduced by seven-fold compared to a case without exposure. If GBR is performed to repair a dehiscence defect around the upper part of the implant, unsatisfactory bone healing often will be observed because the bone graft substitutes move toward the implant apex[48-50]. To prevent bone substitute migration, many clinicians apply an additional membrane fixation method with membrane holding suture, bone pin or screw, and L-shape soft block bone directly on the dehiscence defect area[50-52].

X. Clinical outcome of GBR

The long-term prognosis of implants with GBR is controversial[52]. Some studies reported higher marginal bone loss on implants with GBR compared to those without GBR[53,54]. Hämmerle et al.[55], Fiorellini et al.[56], and Nakajima et al.[57] reported that the prognosis of implants with GBR was not significantly different compared to that without GBR. However, Zitzmann et al.[58] suggested that GBR should be performed on bone dehiscence defects >2 mm because there was a mean bone loss of about 2 mm after GBR. The authors agree with Zitzmann et al.'s opinion[58] that a criterion for GBR is a bony defect greater than 2 mm.

XI. Summary

To achieve successful GBR, the authors emphasize the following principles.

1) Adequate case selection and accurate evaluation of bony defects.

2) Maintenance of excellent blood supply.

3) Tension-free primary wound closure.

4) Stable membrane fixation.

5) Sufficient healing period: At least six months, and a longer healing period (≥ nine months) is recommended for larger defects.

6) If possible, mixing with autogenous bone can shorten the healing period and enhance new bone quality.

7) Special consideration should be taken in an aesthetic area or a scar region (where a previous surgery failed).

8) The experience and technique of the operator are important factors.

9) On large defects, it is safe to perform GBR first and place the implant second.

10) Infection management: Preventing infection is of utmost importance. If an infection occurs, early treatment should be performed, such as incision and drainage with antibiotics.

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Authors' Contributions

Y.K.K. participated in the literature review and wrote the primary manuscript. J.K.K. participated in the literature review and wrote the final manuscript.

Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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How to cite this article: Kim YK, Ku JK. Guided bone regeneration. J Korean Assoc Oral Maxillofac Surg 2020;46:361-366. https://doi.org/10.5125/jkaoms.2020.46.5.361