Contributing Factors to Bone Graft Loss in Guided Bone Regeneration: A Case Report

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Objectives Guided bone regeneration (GBR) is one of the most commonly used techniques for alveolar ridge augmentation. With the increasing demand for implant treatments and ridge augmentation, the prevalence of GBR complications has also increased. Herein, we discuss the factors affecting particulate graft integration in the GBR technique, and describe re-treatment of a failed site.

Case GBR with particulate xenograft bone material was performed in a systemically healthy young female. After 6 months, the re-entry surgery revealed failed graft integration despite the clinically normal appearance of the site, and uneventful healing period. The failed site was re-treated successfully with cortical tenting technique, and re-entry revealed integrated graft after 5 months from the second surgery.

Conclusion In addition to the PASS principle to achieve successful results in GBR, the graft particle properties, compaction force of the graft particles, defect characteristics, and waiting time for graft maturation are some of the factors that may affect the results of GBR. Cortical tenting could be a predictable technique for subsequent grafting in failed GBR sites.

Keywords Bone Regeneration; Graft Survival

Introduction

Optimal survival and success rate in implant therapy are related to several factors. The concept of "restoration-driven implant placement" was introduced to optimize both survival and success rate. It basically depends on the bone volume, and residual bone volume is a major factor that may be compromised by post-extraction socket events. [1-3] The external dimensions of the alveolar ridge decrease following tooth extraction.[3] Several augmentation techniques have been developed to reconstruct the alveolar ridge. Among these approaches, guided bone regeneration (GBR) is one of the most common techniques with favorable and reproducible results.[4] The basis of this technique is using particulate bone material with membrane to maintain biological space for bone regeneration and prevent the migration of unwanted non-osteogenic cells into the bone defects. In other words, bone is "guided" into the desired region by using bone grafts and barrier membranes and excluding the epithelial and connective tissue cells. [5]

Blood clot formation occurs in the space created by membrane and bone materials in the first 24 hours. In early stages, blood clot is removed, and initial formation of granulation tissue occurs. Angiogenesis and vascular circulation in the granulation tissue are the key factors in osteoid formation and subsequent mineralization to woven bone.[6] Finally, mature lamellar bone is formed by the remodeling process of woven bone. [7]

Although GBR has shown to be highly successful, some complications may occur. In a recent systematic review that evaluated the sequelae of surgical complications in horizontal GBR, the complications were categorized based on 2 factors namely onset (early/late), and magnitude (minor/major). They concluded that minor wound dehiscence is the most common post-surgical complication that may lead to early or late membrane exposure, graft contamination, infection, and partial/total loss of the graft.[1] The main focus of similar studies is on the membrane exposure and wound dehiscence of the grafted sites and the related consequences. [8, 9]

Even if the wound is apparently stable and the healing period is uneventful, it would not guarantee a successful bone grafting procedure. Consolidation and incorporation are two main events in the block graft healing procedure. Incorporation is determined by histocompatibility between the host and graft. Consolidation enables the formation of a scaffold framework for initiation of the osteoconductive phase of the healing process. Any disturbance in these phases may lead to graft failure and necessitate additional grafting procedures.[10, 11]

The aim of this study was to evaluate the factors affecting particulate graft integration phase in the GBR technique, and describe management of a failed site with the cortical tenting technique.

Case Report

A young non-smoker systemically healthy female presented requiring replacement of the lost maxillary right premolars. After clinical and radiographic examinations (Figure 1a-d), a concave horizontal defect was detected (Figure 1e-f). The decided treatment plan included GBR with xenograft accompanied by screw "tent-pole" technique. Because of the reduced mesiodistal dimension, we decided to insert an implant in the second premolar site

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and use a cantilever pontic in the first premolar site.

Surgical procedure

Preoperative chlorhexidine rinse was performed for 2 minutes. Infiltration of 2% lidocaine with 1:100,000 epinephrine was done to achieve local anesthesia. A crestal incision and a vertical releasing incision distal to the first molar were made. Decortication was done, and an 8-mm screw was fixed into the site with minimum bone width (Figure 1g-h). A thin xenogeneic collagen membrane (Dentium, Korea) was fixed with two small pins in the apical portion (Figure 1i). Particulate xenograft (Small granules, 150 - 1000 μm, InterOss, SigmaGraft) was mixed with about 10% autogenous bone harvested from the adjacent area by bone scraper, and placed in the defect site (Figure 1j). As a double-layer technique, first collagen membrane (Dentium, Korea) was placed over the graft and another membrane (Allograft, Regen) covered the first one (Figure 1k). A periosteal releasing incision was made for flap advancement. Passive primary closure over the graft was obtained with horizontal mattress and interrupted sutures (4-0 nylon) (Figure 1l). During flap reflection, a small perforation in the mesio-apical portion occurred, and

closure was achieved with 5-0 nylon interrupted sutures. Amoxicillin 500 mg, q8h for 7 days and chlorhexidine rinse, q12h for 7 days were prescribed. After 6 months, the grafted site was uncovered and it was noticed that graft integration had failed (Figure 2a-b). All particles and the screw were removed (Figure 2c). A thin cortical plate was harvested from the retromolar region and screwed into the site (Figure 2d). Particulate allograft (Cortico-Cancellous mineralized freeze dried bone granules, 500 - 1000 μm, Regen) was applied in the gap between the cortical plate and the recipient site and also over the plate (Figure 2e). A thin xenograft collagen membrane (Tutopatch Tissue Matrix) was fixed, and flap closure was achieved by horizontal mattress and interrupted sutures (4-0 nylon) (Figure 2f-g). After 5 months, the site was uncovered again (Figure 3a). Graft integration was successful (Figure 3b-c). Screws were removed and dental implant (4 x 10 mm, Biotem) was placed in the desired position (Figure 3d-e). Due to the adequate primary stability, gingival former was tightened on the fixture, and the flap was sutured (Figure 3f). Finally, the prosthetic phase was scheduled for 3 months later.
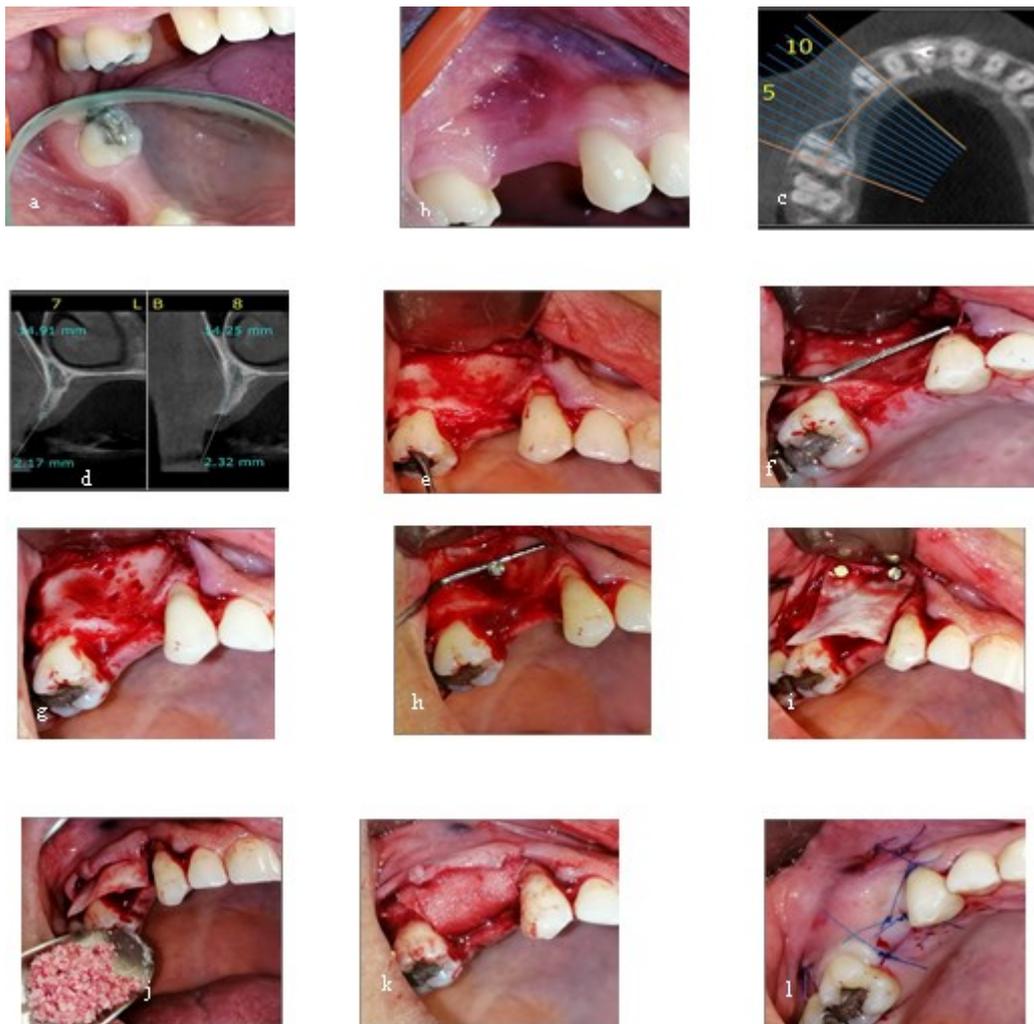

Figure 1- Clinical and radiographic views of the treatment procedure in the first surgery
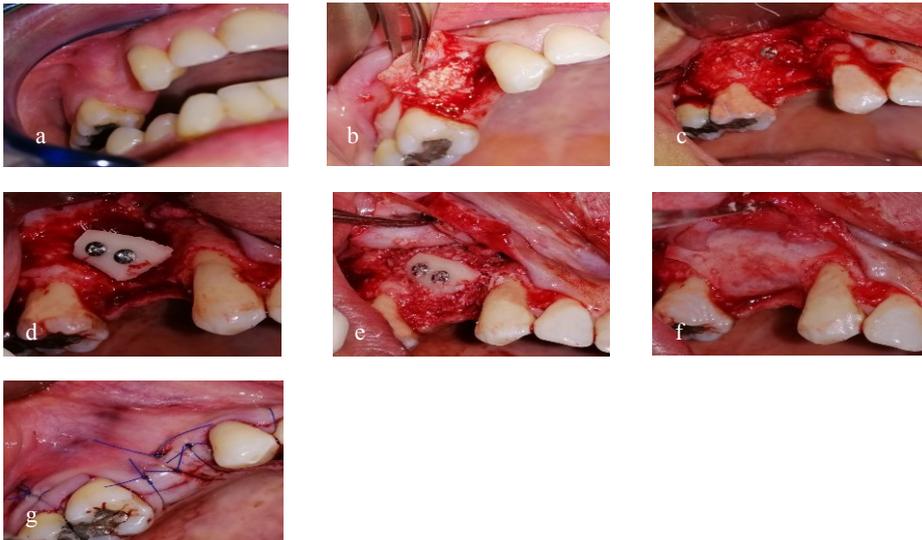
Figure 2- Clinical views of re-treatment procedure in the second surgery

Figure 3- Clinical views of screw removal and implant insertion procedure in the third surgery

Figure 4- Restorative phase

Discussion

The "PASS" principle was introduced in 2006 to ensure predictability of bone regeneration procedures. Prediction of ridge augmentation results in clinical experiences is often hard.[5, 12] Achieving primary soft tissue closure (P), angiogenesis, clot isolation and protection (A), space maintenance (S), and management of postoperative forces to provide wound stability (S), taken together represent the "PASS" principle, and these are the known biological factors affecting the results of GBR.[5, 13-16] The effect of different systemic conditions have also been proven in implant therapy.[17] In this case, we had primary closure without wound dehiscence during the healing period (P). Also, angiogenesis was induced by decortication (A). We used a screw to preserve the created space for the xenogeneic material and also to serve as a scaffold (S). Also, the patient was instructed to control postoperative forces to provide wound stability (S). Although we followed the "PASS" principle, graft integration failed after 6 months. When the wound appears to be well healed but the graft fails, we should search for other reasons.

Successful transplantation, according to the old definition, requires two main stages: incorporation and consolidation.[10, 11] Graft Integration is equivalent to these terms in particulate grafts. According to the literature, graft

particle properties including size, morphology, pore size and porosity, compaction forces on the particles during surgery, defect properties, and waiting time for graft maturation are some influential factors other than the "PASS" principle which might have been less considered.[12, 18-20]

Particulate grafts are osteoconductive, and act as a scaffold that enables the ingrowth of vessels, osteoblasts, and stem cells, so the graft integration occurs.[10] Osteoconductive properties of a scaffold are related to the void space between the particles. By a standard compaction force, micromovements of graft particles are decreased without any adverse effect on sprouting of blood capillaries into the pores.[21, 22] However, both over-compaction and under-compaction forces might impair bone formation and consequently graft consolidation.[19, 23, 24] A high compression force may fracture the brittle particles and thereby reduce the void space for sprouting of new blood capillaries.[23] On the other hand, a low compression force could result in smaller surface area of biomaterial for cell apposition. Larger void spaces between the particles could also allow micromovements that may hinder regeneration in favor of fibrous tissue formation.[25, 26] In this case, under-compaction of the bone grafts might have affected the results.

Waiting time is a major consideration specially in non-autogenous graft materials. Graft failure may occur in the early phase or the late phase. Graft loss could be partial or complete. It has been shown that in 26.6% of the cases treated with particulate bone grafts, additional augmentation is needed.[27] If soft tissue covers the membrane for a significant period of time (up to 6-8 months), bone regeneration is predictable.[5] Xenograft materials have low resorption rate and could impact healing of the grafted site. On the other hand, osteogenic potential of defect influences the GBR outcomes when using non-autogenous graft materials. It has been well established that defect size and morphology are related to the osteogenic potential because of their effect on blood supply and osteoblastic cell requirements. low volume of cancellous bone at the recipient site negatively affects blood flow, graft nutrition, and of course mesenchymal sources.[28, 29] In this case, we waited 6 months after the first surgery, but as we used about 10% of autogenous bone in combination with xenograft, and as the osteogenic potential of defect was poor due to low volume of cancellous bone, it would be better to wait for more than 6 months. Combination of more autogenous graft with xenograft can shorten the healing period.[30, 31]

In our case, the basic "PASS" principle was followed. However, as mentioned earlier, some additional reasons might have compromised the results. Material selection and adequate autogenous combination, regeneration capacity of the defect, magnitude of compaction force on the graft particles, and waiting time for graft maturity, are some possible reasons that may affect graft consolidation.

When complete failure of bone graft occurs, it is not recommended to do the same procedure again.[32] Due to the failure and prolongation of treatment procedure, it is better to choose a technique with the shortest healing time. Autogenous bone graft is still the gold standard in grafting techniques, and has faster resorption rate, but as we know, it is associated with higher level of pain and morbidity for the patient.[30, 31, 33-36] In this case, we decided to re-graft the area with autogenous bone.

Cortical tenting is a grafting technique, which is used in small to large bone defects. In this technique, a cortical plate harvested often from the mandible acts as a shell for space creation/maintenance and prevents soft tissue collapse over the bone graft material. It also prevents bone graft micro-movements during the healing phase.[37,39] In this case, an autogenous cortical plate was fixed on the defect and surrounded the underlying particulate bone graft material to prevent the negative effect of soft tissue contraction on graft materials. Autogenous cortical plate has osteogenic and osteoinductive potential compared with xenograft material. Bone morphogenetic proteins released from the autogenous bone graft act as osteoinductive signals, and induce the transformation of undifferentiated mesenchymal stem cells to osteoblasts.[12, 38]

In comparison with the onlay block graft, cortical autogenous tenting requires smaller amount of bone to be harvested and thus has lower patient morbidity.[39] Also, the reduced amount of graft size, minimal flap advancement, and tension free wound closure are more likely to occur; thus, the periosteal integration and blood circulation may be less compromised.

In this case, using the "cortical tenting" technique with a small piece of cortical plate made the management of previously failed GBR feasible, and the result was ideal.

Conclusion

Several factors may lead to late graft failure despite the normal appearance of the wound during the healing procedure. Aside from the PASS principle, the graft particle properties, compaction force on graft particles, defect morphology, and waiting time for graft maturation are some factors that may affect the results. In case of complete graft loss, it is recommended not to do the same procedure again. Cortical tenting can be a predictable technique for re-grafting with good soft tissue maintenance results.

Due to the lack of a comprehensive study regarding decision making to treat complete graft loss in the GBR technique, it is suggested to document the GBR failures and report the selected re-treatment procedures by the clinicians.

Conflict of Interest

No Conflict of Interest Declared ∎

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