Predictable and sustainable preprosthetic surgery: The crossroads of bone metabolism, molecular biology, and biomaterials

Because the deficiency of alveolar bone volume is a critical problem in various interventions for missing teeth, many attempts have been made to augment alveolar bone as a preprosthetic surgical treatment [1]. Basically, four principles have been used in combination or alone to augment bone volume:

1. Osteoconduction; uses grafting materials to serve as scaffolds for new bone growth.
2. Guided bone regeneration (GBR); allows selective bone tissue growth into a space protected by barrier membranes.
3. Bone splitting or distraction osteogenesis; enables new bone formation by surgically induced bone fracture.
4. Osteoinduction; uses appropriate growth factors that modulate cells to promote new bone formation.

Among these principles, osteoconduction and GBR are frequently used and well documented for the treatment of localized bone defects in the jaws, probably because of simplicity of use while allowing the placement of dental implants in areas with bony defects and/or insufficient bone volume. With regard to osteoconduction, the choice of grafting materials is the key to achieving a predictable clinical outcome. In general, autogenous bone is thought to be the gold standard, and it has many advantages over the alternatives. However, it needs to be harvested from a donor site, which means more invasive surgery and higher morbidity. Therefore several osteoconductive synthetic biomaterials (alloplasts) have been developed and frequently used as graft materials.

GBR uses barrier membranes to protect the bone augmentation site from nonosteogenic tissue in growth. However, several human clinical trials of GBR have proved that membrane-protected bone regeneration takes considerable time to reach the desired clinical outcome. For clinical applications, a prolonged healing period of 6 or more months is a problem. The big issue of GBR might be the barrier membrane itself. The periosteum has an osteogenic function, and it is responsible for forming new bone as a result of injury. A Volkmann’s canal is one that allows the transmission of blood vessels (or capillaries) from the periosteum into the bone. The barrier membrane is useful for protecting a bone-forming space; from a different point of view, however, the barrier membrane actually separates bone from the periosteum to obstruct bone maturation.

In this issue, Rakhmatia et al. reviewed current barrier membranes [2], focusing especially on titanium mesh applications for GBR. The review reports that titanium mesh maintains space more predictably, even in cases with large bone cavities, and resists collapsing better than other membranes. In my opinion, the advantage of titanium mesh is not only its mechanical properties, but also its high porosity, which allows appropriate passages to be provided between bone and the periosteum.

Nevertheless, no practical approach is currently available to shorten the healing period of GBR. One promising method to accelerate bone regeneration is the use of cytokines to stimulate bone cell proliferation and differentiation.

In this respect, several studies have been published in recent years with regard to osteoinduction. Akagawa et al. reported in the Journal of Prosthodontic Research (JPR) [3] that the use of locally applied slow-degradation-type basic fibroblast growth factor (FGF) – a gelatin hydrogel complex – may accelerate early-stage bone regeneration around fenestrated implants. In general, basic FGF (bFGF; the same as FGF-2) is a major cytokine found in various body tissues and is characterized by its capacity to stimulate the proliferation and differentiation of a wide variety of mesodermal and neuroectodermal cells. From the results of animal studies, not only have Bone Morphogenic Proteins (BMPs) been shown to induce tremendous bone growth in many animal and some human clinical studies, but also bFGF might be a strong candidate for enhancing bone formation in the treatment site.

In the future, the use of regenerative medicine, especially stem cell technology in dentistry, could be the most noteworthy strategy of the regeneration of missing oral tissues. In vol. 56, issues 3 and 4, of JPR, Egusa et al. have published a series of comprehensive review papers that covered a wide range of topics about stem cell technology in dentistry [4,5]. In these reviews, the authors clearly stated that in the field of prosthodontics, especially in the clinic, material-based reconstruction without...
major surgical procedures was the main approach to treatment; however, emerging stem cell technologies and the requirements of alveolar ridge augmentation associated with implant dentistry have expanded the clinical concept to include stem-cell-based regeneration.

But we must admit that there may still be an ever-present danger of postoperative resorption of augmented bone. To our regret, this unfavorable phenomenon is not preventable at present. We should soon achieve a breakthrough to make outcomes of preprosthetic surgery more predictable and more sustainable.

References


