The future of bone augmentation

A number of factors have been identified as being important for the long-term success of dental implants and implant-supported prostheses. One crucial prerequisite is sufficient bone volume at the site for implant placement. Adequate available bone can be defined as the ability to place an implant of the preferred size in the planned position for aesthetics, prosthetic support and long-term function. When bone volume is insufficient, bone augmentation methods should be considered.

Although bone substitutes are effective for managing bone deficiencies within the bone contour, as can be done with socket and sinus bone grafting, for example, they lack the regenerative capacity to treat vertical bone deficiencies outside the bone contour. At present, autogenous bone remains the gold standard of grafting materials. It has superior biological properties and forms more bone at an earlier stage than bone substitutes[1]. In the future, the need for autogenous bone harvesting may be reduced by using tissue engineering principles to recapitulate the body's processes of bone repair and regeneration. The tissue engineering triad combines a scaffold, growth factors and cells to produce new bone tissue.

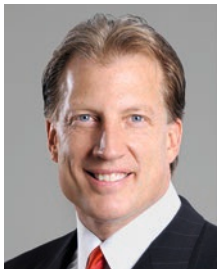
Using CBCT, implant planning software and computer-aided design (CAD), technicians can plan dental implants virtually to determine the volume of bone augmentation. Computer-aided manufacturing (CAM) can be employed to fabricate custom bone blocks from allogeneic sources or alloplastic materials. Another option is to use CAD technology to design a customised titanium mesh. This mesh is created using CAM by direct metal laser sintering. The advantages of customised scaffolds are reduced surgical time and greater stability, which decreases micromovement of the graft. Although the cost is higher, these advantages justify the added expense.

At present, two recombinant human (rh) growth factors are used in dentistry for bone regeneration: bone morphogenetic protein-2 (rhBMP-2) and platelet-derived growth factor-BB (rhPDGF-BB). For horizontal and vertical bone augmentation, rhBMP-2 has been used primarily with titanium mesh. Although randomised clinical trials on rhBMP-2 have reported outcomes similar to those of autogenous bone, the majority of publications are case reports or series[2]. To date, there is limited evidence that the use of rhPDGF-BB for bone augmentation improves outcomes[3]; however, PDGF plays an integral role in directing early wound healing, so its effect on bone regeneration may be to enhance soft tissue healing and graft incorporation. These exogenous growth factors are delivered in supraphysiological doses at the time of surgery and diminish rather quickly thereafter. This timing does not mimic the normal release of native growth factors, so methods to delay and sustain the output will be needed in future.

Bone marrow aspirates containing osteocompetent cells can be added to a scaffold, such as particulate bone substitutes. Cell-based therapies have been used to repair maxillofacial bone defects, for example alveolar clefts and continuity defects; however, there is low-level evidence that using mesenchymal stem cells can enhance bone gain for crest augmentation[4]. The issues posed by cell-based therapies include a lower yield of stem cells in adults and cell viability with transplantation. Governmental regulations prohibit the clinical use of laboratory cell cultures to expand cell populations and the technology involved is cost prohibitive for routine use.

Combining a customised scaffold with a bioactive protein, such as rhBMP-2, and mesenchymal stem cells may provide results that rival autogenous bone graft without the morbidity caused by bone harvesting. Future research will undoubtedly overcome some of the obstacles that prevent the translation of tissue engineering approaches into routine clinical practice. Better understanding

of cellular and molecular mechanisms is required to determine the optimal combination of components needed for the predictable and feasible regeneration of bone[5]. Until this is achieved, surgeons should consider the advantages and disadvantages of each material and technique for the clinical situation and select the approach with manageable costs, low morbidity and the greatest chance of success.



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