Editorial Real-Time Assessment of Osseous Tissue Changes After Guided Bone Regeneration

Guided bone regeneration (GBR) is a scientific breakthrough that has brought about a paradigm shift in osseous tissue regeneration.[1,2] In line with the principles of guided tissue regeneration,[3] GBR is aimed at selective repopulation of an osseous defect with osteogenic precursor cells and thereby new bone formation within the defect.[4] Although GBR is an accepted therapeutic modality, researchers are interested in its innate dynamics in real time. To investigate this, a replicable physiologic bone regeneration model that allows for longitudinal assessment is needed.[5] Experimental bone defect models are suitable for defect creation, graft implantation, regeneration analysis, and subsequent extrapolation of findings for clinical bone repair and regeneration.[6–8] Scientific advances in the field of computed tomography have led to the development of microcomputed tomography (microCT), which provides a platform for rapid, noninvasive assessment of bone regeneration in small animal models.[9,10]

MicroCT has evolved as a key technology in the field of bone research, wherein large amounts of two- and three-dimensional (2D and 3D) data combined with analytical software enable highly sensitive and specific quantitative and qualitative assessment of bone tissues in real time.[11–14] Moreover, microCT results are proven to be correlated to histologic and histometric measurements of mineralized tissues such as teeth and bone.[15–17] In the series of studies with accompanying video presented in this issue, sequential changes occurring upon osseous regeneration have been evaluated in real time in an experimental rat calvarial defect model using a SkyScan 1176 microCT scanner (Bruker). The rat calvarial bone defect model has been used in several previous reported studies and is of great translational significance.[8,18–21] Furthermore, it enables longitudinal in vivo assessment of osseous changes within the regenerated defect.[13] Several osseous regenerative techniques in combination with adjunct growth factors, bone morphogenetic proteins, and bone marrow–derived mesenchymal stem cells, in the presence or absence of resorbable barrier collagen membranes, have been evaluated. For each regenerative technique, the peak period of new bone formation and maximal bone density have been qualitatively and quantitatively assessed using in vivo microCT. These findings provide a new outlook on new bone formation and its mineralization characteristics in the field of GBR. Interestingly, these studies have also pioneered documenting the qualitative and quantitative resorption characteristics of different mineralized bone grafts and substitutes under various regenerative circumstances.

MicroCT technology possesses several advantages that make it a valuable investigative tool in bone assessment research. Some of these advantages are as follows:

1. It permits direct 3D measurement of samples instead of 2D measurement in histologic evaluations.
2. Fast measurement can be accomplished in a completely noninvasive manner, allowing the samples to be used for other tests, such as histology or mechanical testing.
3. It allows analysis of a larger volume of interest compared with 2D histology.
4. Near-exact representations of bone can be obtained with the high-quality scan and segmentation technique.
5. It permits early detection of changes in bone mineral density, which cannot be identified using conventional 2D methodologies such as histology.

The included studies held a great advantage in that the same animal was studied over time, providing a strong understanding of the behavioral changes in the biomaterials that would differ among animals using a non-real-time methodology.

These studies also report the findings of histologic and biomechanical assessments not only to

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validate the microCT findings of GBR but also to provide scientific evidence of new bone formation, its volume, its mineral density, and its physical properties when using different osseous regenerative protocols. The hardness and elastic modulus of even minute quantities of new bone formed following GBR have been assessed using nanobiomechanics with the help of Hysitron TI 750 Ubi.[20,21] Knowledge about osseous regeneration dynamics acts as a key to selecting and timing the ideal regenerative protocol for management of bone defects. There is no doubt that the findings of these studies provide a new perspective on how and when new bone is formed and how long it takes to mineralize and achieve sufficient physical properties using different regenerative protocols. These results shall enable researchers and clinicians to identify ideal osseous regenerative protocols for application in a wide array of clinical scenarios.

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