Vertical Bone Augmentation Using Bone Marrow–Derived Stem Cells: An *In Vivo* Study in the Rabbit Calvaria

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Purpose: *To evaluate the bone regeneration capacity of bone marrow–derived stem cells (BMSCs) in vertical guided augmentation of bone tissue.*

Material and Methods: *The calvaria of 20 rabbits were vertically augmented with autogenous bone graft (ABG); collagen/beta-tricalcium phosphate (β-TCP) linked scaffold transplanted with 15 × 10⁴ BMSCs; or scaffold alone (control). The augmentation materials were covered with stainless steel domes. BMSCs were isolated with Ficoll-Paque technique and applied directly without* in vitro *expansion. The newly formed bone was evaluated using radiodensitometric, histomorphometric, histological, and micro computed tomographic (micro-CT) analyses after a 12-week healing period. The data excluding micro-CT assessments were compared statistically.*

Results: *Radiodensitometric and bone volume parameters demonstrated increased bone formation in both BMSC group and ABG group compared with control group ($P < 0.01$), but difference between the BMSC and ABG groups was not significant ($P > 0.05$). The mean histological scores for the BMSC, ABG, and control groups were 7.44 ± 1.03, 8.44 ± 0.81, and 6.00 ± 1.10, respectively, indicating significant difference among the groups ($P < 0.05$).*

Conclusion: *BMSCs delivered with a collagen/β-TCP linked scaffold can provide improved new bone formation that is comparable with autogenous bone block graft through vertical guided bone regeneration technique. (Implant Dent 2015;0:1–9)*

Key Words: stem cell, vertical bone augmentation, bone regeneration, rabbit, calvarium

Augmentation of the edentulous alveolar ridges in the vertical direction is considered as one of the most challenging surgical interventions in implant dentistry.[1] Current techniques used for vertical bone augmentation are usually associated with a high complication rate and inconsistent results.[2] It has been claimed that this low success rate is mainly because of inadequate supply of the osteoprogenitor cells and limited blood supply.[3] Thus, among all the various graft materials, autogenous bone grafts (ABGs) still remain as the gold standard graft material, despite their significant disadvantages for example, need of a donor site.[4] Alternative graft materials and techniques that could replicate osteogenic features of ABGs have been studied in many animal and clinical studies.

Bone marrow–derived stem cells (BMSCs) are progenitor cells of the skeletal tissue components such as bone, cartilage, and the hematopoiesis-supporting stroma. They have the ability to differentiate into osteogenic, neural, and myogenic cells.[5,6] Mesenchymal stem cells (MSCs), which are the main stromal cells residing in the bone marrow, may contribute to bone formation directly by differentiating into osteoblasts or indirectly by releasing growth factors, proteins, and cytokines that take part in the bone regeneration process.[3] There are 3 minimum criteria to define the MSC. First, the cells must be plastic adherent, when maintained in standard conditions; second, expressions CD105, CD73, and CD90 surface molecules must be confirmed; and third, the MSCs must differentiate to adipocytes, osteoblasts, and chondroblasts *in vitro*.[7] The CD34

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