Autologous Bone Graft Obtained from the Iliac Crest and Cervical Vertebrae of the Same Patient Exhibit Similar Molecular and Structural Characteristics

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INTRODUCTION: Anterior cervical discectomy and fusion (ACDF) is one of the most common cervical spine procedures. Autologous bone graft (autograft) from the iliac crest (IC) is considered the historical gold standard for ACDF procedures because the tissue has osteoconductive, osteoinductive, and osteogenic properties; however, the required secondary surgical site is associated with both short- and long-term complications. To mitigate IC harvest site complications, the use of an adjacent cervical vertebral body as an alternative donor site has been previously identified. While successful fusion has been demonstrated clinically for this site in previous studies, a comparative assessment of the osteoinductive and osteoconductive properties of cervical vertebral tissue compared to the IC has not been investigated. Therefore, the purpose of this study is to compare the molecular and cellular characteristics of autograft from the IC and cervical vertebrae.

METHODS: A prospective study was performed on twelve consecutive skeletally mature patients undergoing ACDF, from whom autograft material was harvested from both the inferior cervical vertebrae and iliac crest. Portions of each autograft sample were assessed using 1) quantitative reverse transcriptase-polymerase chain reaction (qRT-PCR) and 2) micro-computed tomography (micro-CT) imaging to quantify and compare the osteogenic gene expression and bone morphological properties of both tissues, respectively. For qRT-PCR, tissue from both sites was digested and RNA was extracted prior to assessment of the following genes: mitochondrial membrane ATP synthase F (1)F(0) Complex V (ATP5F1), alkaline phosphatase (ALP), Bone Morphogenetic Protein 2 (BMP-2), vascular endothelial growth factor A (VEGFA), runt-related transcription factor 2 (RUNX2), and tumor necrosis factor superfamily member 11 (TNFSF11). The expression level of each target gene was calculated relative to that of ATP5F1 (housekeeping gene) in each sample. For the micro-CT analysis, imaging was performed using a Bruker SkyScan 1172 (60 kV, 167 mA, 17µm voxel size). Images were reconstructed and then post-processed in 3D Slicer and ImageJ to determine the bone morphological properties of each graft. Otsu's method was utilized to isolate bone tissue from background. Bone volume fraction (BV/TV), trabecular thickness (Tb.Th), trabecular separation (Tb.S), and bone surface to bone volume ratio (BS/BV) were then determined. Differences between the two groups were identified using student t-tests for qRT-PCR data and paired t-tests for micro-CT data. Significance was defined as 0.01 using Bonferroni correction to account for multiple exploratory comparisons.

RESULTS: A total of twelve patients, of which eight were female and four were male with a mean age of 53.9 ± 6.9 years, consented to participate and were enrolled in this study. Six patients had a history of tobacco use. Macroscopically, the iliac crest autografts were larger and more intact compared to the smaller, fragmented local inferior cervical vertebral bone. The qRT-PCR analysis of the bone autografts revealed no differences in ALP, BMP2, RUNX2, VEGFA, and TNFSF11 expression between the cervical vertebrae and iliac crest ($p > 0.01$). Finally, micro-CT analysis of the cervical vertebrae and iliac crest autografts showed no statistically significant differences between groups for BV/TV, Tb.Th, Tb.S, and BS/BV ($p > 0.01$).

DISCUSSION AND CONCLUSION: This study provides the first direct comparison between cervical vertebral bone and iliac crest based on micro-CT and qRT-PCR analysis from same donor bone samples. Given the lack of significant differences in gene expression and morphometric properties between bone from the cervical vertebrae and those for bone harvested from the iliac crest, the cervical vertebrae continue to represent an alternative source of autologous bone graft.