Morphological Comparison of Iliac Crest and Cervical Spine Bone Grafts for ACDF

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INTRODUCTION: Autologous bone graft (autograft) from the iliac crest is the gold standard for anterior cervical discectomy and fusion (ACDF). However, the use of iliac crest autograft requires a second surgical incision, which can contribute to higher morbidity. A novel ACDF technique has been developed using bone autograft from adjacent cervical vertebrae, eliminating the need for a second surgical incision [1]. While this site yielded a uniform osseous fusion in a previous, prospectively collected case series, the morphology of the cervical vertebral autograft tissue remains undetermined [2]. These structural and material properties impact mechanical support and the osteogenic properties of the graft. The purpose of this study is to compare the morphology of autologous iliac crest and adjacent cervical vertebrae bone grafts obtained during an ACDF at the tissue level to identify if microstructural equivalence exists between the bone graft donor site.

METHODS: Ten consecutive patients undergoing standard of care ACDF provided informed consent prior to participation in this Ethics Committee approved study. Autograft samples from both cervical vertebrae and iliac crest were excised using a 15-guage trephine needle and a 4 mm osteotome, respectively, and subjected to micro-computed tomography (microCT) imaging (Bruker SkyScan 1172, 60 kV, 167 mA, 17μm voxel size; Fig. 1). Images were reconstructed and then post-processed in 3D Slicer to determine the bone morphological and densitometric properties of each graft. Otsu's method was utilized to isolate bone tissue from background. Bone volume fraction (BV/TV), trabecular thickness (Tb.Th), and bone surface to bone volume ratio (BS/BV) were then determined. Python was utilized to generate a convex hull mask for the total volume used in the bone morphometric calculations using 3D Slicer and BoneJ2 (Fiji). Wilcoxon signed rank tests were used to identify mean differences in bone morphometric properties between the two sites. Statistical analysis was performed using R version 4.2.2.

RESULTS SECTION: Patient demographics and morphometric data are reported in Table 1. Macroscopically, the iliac crest autografts were larger and more intact compared to the smaller, fragmented local inferior cervical vertebral bone. On average, the sample obtained from the iliac crest was 5.222 mm^3 larger than from the cervical vertebra of the same patient. The autografts from the iliac crest had trends for greater mean difference in BS/BV (3.565%, p=0.076) and lower mean difference in Tb.Th (0.05820 mm, $p = 0.2754$) compared to those of the cervical vertebra. However, these differences were not significant.

DISCUSSION: Bone from the cervical vertebrae and iliac crest differed in volume and concavity macroscopically; meanwhile, the morphological measures did not significantly differ between the two harvest sites in trabecular or bone surface characteristics. Limitations of the study include the limited volume of cervical spine graft material compared to the IC, attributed to the lack of standardized surgical biopsy tooling for the cervical vertebra. Analysis of cadaveric cervical and IC autografts, excised using the same tools, may provide greater certainty in the equivalence of the microstructure of these two autografts. Further assessment of the transcriptional profile for genes known to act in bone repair and formation should also be evaluated to assess the viability of the cervical vertebrae as an alternative autograft. Given the current findings and positive clinical outcomes in pilot studies, autograft harvested from the inferior cervical vertebral body represents a potential alternative source of autologous bone graft for ACDF.

SIGNIFICANCE/CLINICAL RELEVANCE: This study provides the first direct structural comparison between cervical vertebral bone and iliac crest based on microCT analysis from same donor bone samples. The clinical relevance lies in demonstration of how these two harvest sites have similar structural features, thus potentially eliminating the need for a second surgical incision in 1-2 level ACDF procedures.

REFERENCES: [1] Walterscheid et al., *Geriatric Orthopaedic Surgery & Rehabilitation*, 2017. [2] O'Neill et al., *Global Spine Journal*, 2020.

ACKNOWLEDGEMENTS: This work has been supported by a Carilion Clinic Research Acceleration Program (RAP) 2023 grant and the National Center for Advancing Translational Science of the National Institutes of Health Award UL1TR003015/ KL2TR003016.

IMAGES AND TABLES

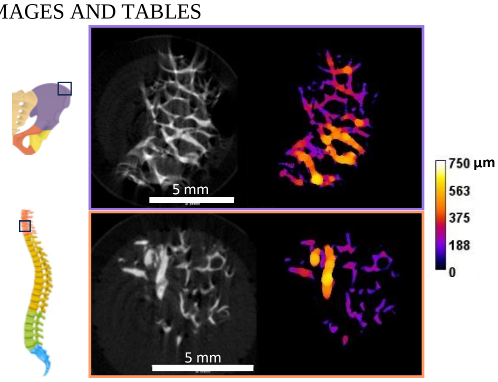

Figure 1. MicroCT images and Tb.Th (μm) heat maps from cervical spine (top) and iliac crest (bottom) from a single donor.

Table 1. The patient demographics and bone morphometric calculations for the ACDF surgery and the iliac crest and cervical spine grafts.

Demographics

Age (yrs)	*Sex (M/F)*	*BMI*	*Smoke (Y:N)*
53.6 [38-62]	3/7	28.7	4:6

Morphometrics

Graft	*BV/TV (%)*	*Tb.Th (mm)*	*BS/BV (%)*	*Volume (mm^3)*
Hip	21.5±3.63	0.276±0.083	21.56±4.69	29.97±31.78
Spine	25.3±6.45	0.334±0.071	18.00±4.08	24.75±10.00