Body Composition–Driven Changes in Infrapatellar Fat Pad Composition: Implementing Bioimpedance-Guided Risk Assessment in Total Knee Arthroplasty

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Introduction: The infrapatellar (Hoffa's) fat pad (IFP) is a metabolically active periarticular structure that supports load distribution, patellar tracking, and synovial fluid dynamics of the knee joint. Although mechanisms remain unclear, pathologic changes in the IFP have been linked to pain and osteoarthritis progression. Further, alterations in the balance of adipose tissue and fibrotic collagen in the IFP have been theorized to affect knee joint integrity and function. Because periarticular tissue quality and composition influence postoperative healing and surgical outcomes, characterizing IFP composition may provide insight into patient-specific risks associated with poor tissue quality such as impaired wound healing, infection, and poor suture integrity. This study analyzed fibrotic composition of the IFP in patients undergoing primary total knee arthroplasty (TKA) and evaluated its relationship with body composition metrics, aiming to identify factors with potential relevance for preoperative assessment and outcome prediction.

Methods: This study was approved by the University of Iowa Institutional Review Board, and informed consent was obtained from all participants. Infrapatellar fat pads, routinely excised during primary TKA, were collected from seventeen patients (9 male, 8 female) undergoing primary TKA. Ages ranged from 43–77 years, BMI from 24.7–51.7 (mean 38.3). Intraoperatively, the fat pad was removed with electrocautery and handed directly to a research team member for dissection. A central 3×2×1 cm section was excised to avoid electrocautery artifact, with superior and anterior aspects marked for consistent orientation during fixation and histologic processing. Samples were paraffin-embedded, coronally sectioned, and stained with hematoxylin and eosin (H&E) for general histological evaluation and Masson's trichrome to quantify fibrosis. Fibrosis was measured using ImageJ standardized color deconvolution thresholds to isolate collagen staining. Preoperative body composition was assessed using InBody bioimpedance scans, including BMI, fat mass, percent body fat, extracellular water to total body water ratio (ECW/TBW), and related measures. Fibrosis values and body composition metrics were compared to identify potential associations with periarticular tissue quality. The Wilcoxon rank-sum test was used to compare InBody metrics, operative limb-specific metrics, and fibrosis marker (Trichrome Area %) by age group (< 60 vs ≥ 60 years) and severe obesity status (BMI < 40 vs ≥ 40 kg/m²). Spearman's correlation was used to assess associations between Trichrome Area % and age, BMI, InBody metrics, and operative limb-specific metrics.

Results: Trichrome analysis revealed fibrosis ranging from 0.8–54% of tissue area, demonstrating wide interpatient variability. Fibrosis did not significantly correlate with BMI, age, or surgical laterality. Stratification by obesity class showed that severely obese patients (BMI ≥40) had significantly higher operative limb ECW/TBW while whole-body and contralateral limb ECW/TBW was not significantly different. No clear association was observed between fibrosis percentage and systemic body composition measures, though fibrosis remained a central feature of tissue heterogeneity.

Discussion: These findings emphasize two themes. First, fibrosis within the IFP is highly variable and not readily explained by systemic factors such as age or BMI, pointing toward localized or patient-specific remodeling processes independent of aging or systemic adiposity. Second, body composition analysis highlighted clear differences in operative limb ECW/TBW between severely obese and non-severely obese patients, suggesting that obesity may predispose to compromised periarticular tissue quality through mechanisms such as localized edema, altered extracellular matrix balance, or impaired lymphatic fluid homeostasis. While IFP fibrosis alone was not predictive of systemic body composition, bioimpedance-derived measures, particularly limb-specific ECW/TBW, may serve as reliable indicators of tissue vulnerability. Together, these data suggest that bioimpedance could complement standard demographic metrics in preoperative evaluation, offering a practical means of identifying patients at higher risk for wound complications or delayed recovery. Future directions include immunohistochemical staining for CD31 and CD45 to evaluate vascular and lymphatic changes, respectively, as well as prospective follow-up to track postoperative complications such as periprosthetic joint infection (PJI), revision procedures, and postoperative pain. Expansion to larger patient cohorts will further clarify the predictive utility of fibrosis heterogeneity and limb-specific ECW/TBW.

Clinical Significance: This study provides foundational insight into the relationship between periarticular tissue composition and body composition, suggesting a practical role for preoperative bioimpedance analysis in patient evaluation. Assessing localized fluid imbalance alongside tissue fibrosis may allow surgeons to identify patients at higher risk for complications such as impaired wound healing, infection, or poor suture integrity. By moving beyond traditional reliance on BMI or chronological age and instead leveraging quantitative measures of hydration and extracellular matrix status, clinicians may be better able to anticipate which patients are most vulnerable to poor postoperative recovery. Incorporating bioimpedance-derived metrics into routine orthopedic assessment therefore holds the potential not only to guide surgical planning and perioperative management, but also to inform broader efforts toward personalized, precision-based approaches in musculoskeletal care that directly link tissue quality with clinical outcomes.