A Prospective Study on the Relationship Between Mechanical Tension and Scar Cosmesis After Total Knee Arthroplasty

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Introduction

Total knee arthroplasty (TKA) is a widely performed and highly effective surgical intervention for patients with advanced symptomatic knee joint disease, most commonly due to osteoarthritis. While the procedure reliably improves pain, mobility, and quality of life, less attention has been paid to the aesthetic outcome of the surgical scar. This is a factor that can significantly influence patient satisfaction, particularly in younger, or more active individuals. Prior research suggests that increased mechanical tension during wound healing is a key driver of hypertrophic, or widened, scar formation.[1] However, there is a gap in the literature regarding how patient-specific mechanical forces, such as those generated by body habitus or soft tissue tension, affect scar cosmesis following TKA.

Objective and Significance

Is increased mechanical tension of the knee correlated with wider scars and less favorable scar appearance following TKA? Identifying such a relationship may highlight modifiable risk factors to improve postoperative aesthetic outcomes and overall patient satisfaction.

Knowledge Gap

- The mechanobiology of scar formation has been well established in dermatologic and burn literature, however the relevance has not been systematically evaluated in orthopaedic incisions, particularly those subjected to large dynamic forces such as the knee.
- No studies have sought to assess the regional, quantitative evaluation of scar mechanical tension across various aspects of the TKA incision and its relationship to scar morphology.

Methods

Design: Single-provider, single institution prospective Cohort, with patients assessed at 2 weeks, 3 months, and 6 months postoperatively
Population: Patients undergoing primary TKA
Variables Collected: Width of scar 4 inches above and below the patella as well as at the patella; Anterior knee soft tissue density as measured by lateral radiograph; BMI; Thigh circumference 4 inches above the patella.
Outcomes Measured: Patient satisfaction assessed with e-surveys
Analysis: Multivariable Regression and hierarchical modeling using SAS 9.4

Literature

Studies consistently demonstrate that mechanical tension is a critical determinant of scar formation, as excessive tensile forces activate fibroblasts and disrupt collagen alignment, resulting in hypertrophic or widened scars[1]. Mechano-transduction pathways, including TGF-β/Smad and YAP/TAZ signaling, convert external stress into cellular responses that promote fibrosis[7,8]. Reducing wound tension through incision design or tension-relieving techniques has been shown to improve scar appearance[2].

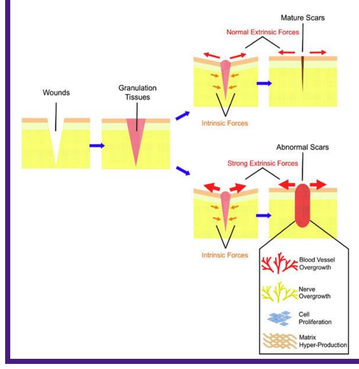

Figure 1: *Relationship between intrinsic and extrinsic forces in scar formation. The native balance between intrinsic and extrinsic forces is essential for mature scar formation. Demonstrated is the imbalance in these forces leading to abnormal scar formation. Excessive external forces lead to heightened cellular proliferation and angiogenesis (Ogawa, 2011, adapted).*

Hypothesized Results

Patients with greater anterior knee soft tissue thickness, larger thigh circumference, and higher BMI will demonstrate increased postoperative scar width.[1,2,4]

- Higher soft-tissue tension above the patella is expected to correlate with wider scars in that region compared with below the patella.
- Body habitus (BMI and soft-tissue density) will serve as independent predictors of less favorable scar appearance.
- Findings may identify modifiable biomechanical factors affecting wound healing and cosmesis following TKA.

Discussion and Limitations

Our study seeks to clarify whether increased mechanical correlates with unfavorable scar outcomes following TKA. Prior literature has identified mechanical tension as a key factor in hypertrophic and widened scar formation.[1,2] If our hypothesis is confirmed, this may provide surgeons with modifiable patient-specific risk factors to target, such as perioperative counseling, wound closure techniques, or adjunctive therapies aimed at reducing wound tension. Limitations include the single-center design and relatively small sample size, which may limit generalizability. Furthermore, scar cosmesis is multifactorial, influenced not only by tension but also by genetics, comorbidities (e.g., diabetes, smoking), and surgical technique. Finally, scar assessment is partially subjective despite standardized photography and ruler-based measurements, which could introduce measurement bias.

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