ON THE POTENTIAL ROLE OF THE COLLATERAL LIGAMENTS STRAIN RATIO FROM VARUS – VALGUS TESTING AS A PREDICTOR OF KNEE ARTHROPLASTY OUTCOME

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INTRODUCTION

The role of soft tissue balancing in optimizing functional outcome and patient satisfaction after total knee arthroplasty surgery is gaining interest. This is due in part to the inability of other surgical parameters such as alignment to demonstrate excellent functional outcomes [6], despite sophisticated navigation systems. Consistent soft tissue balancing has been aided by novel technologies that can quantify loads across the joint at the time of surgery [4,8]. Based on free body diagram theory, compressive load equilibrium should be correlated with ligamentous equilibrium between the medial and lateral collateral ligaments. The authors propose to use the Collateral Ligaments Strain Ratio (CLSR) as a functional tool to quantify and track the effectuated surgical change in laxity of the medial and lateral collateral ligaments and correlate this ratio to validated functional scores and patient reported outcomes. The relationship with intra-operative balancing of compartmental loads can then be scrutinized. The benefits of varus-valgus balancing within 2^{o} include increased range of motion [7], whereas pressure imbalance between the medial and lateral joint compartments has been linked to condylar liftoff and abnormal kinematics post-TKA [9].

METHODS

The study is a prospective IRB approved clinical study with three cohorts of 50 patients each: (1) a surgical prospective study group with ligamentous testing pre-operatively, at 4 weeks, 3 months and 6 months post-operatively; (2) a matched control group of non-operated high function patients; (3) a matched control group of high function knee arthroplasty recipients. The intra-operative balance is achieved by means of an instrumented tibial tray using principles developed by the authors (8) (OrthoSensor,Inc). The pre and post-operative testing of the CLSR is performed using a validated Smart Knee Brace developed by the authors and previously reported [1]. The output variables consist of the maximum angular change of the knee in the coronal plane at 10 degrees of flexion produced by a controlled torque application in the varus and valgus (VV) directions. This creates measureable strain on the lateral and medial collateral ligaments, which is reported as a ratio (CLSR). The New Knee Society Score is used to track outcomes. The applied varus and valgus moment was standardized to 10Nm with a handheld wireless dynamometer.

RESULTS

Pre-operative scatter graphs demonstrate a wide distribution of absolute VV values, reflecting the spectrum of pathological states. The relative distribution of strain after surgery trends towards consolidation. The median CLSR is 0.55 with a SD of 0.20 at 4 weeks post-operative. This asymmetrical value indicates a shift toward a tighter medial side as noted in the non-operated cohort. Columnar scatter graphs demonstrate post-operative clustering similar to that

reported by the authors for kinetic loads after soft tissue balancing [3]. The overall displacement values range from 0 -4 degrees.

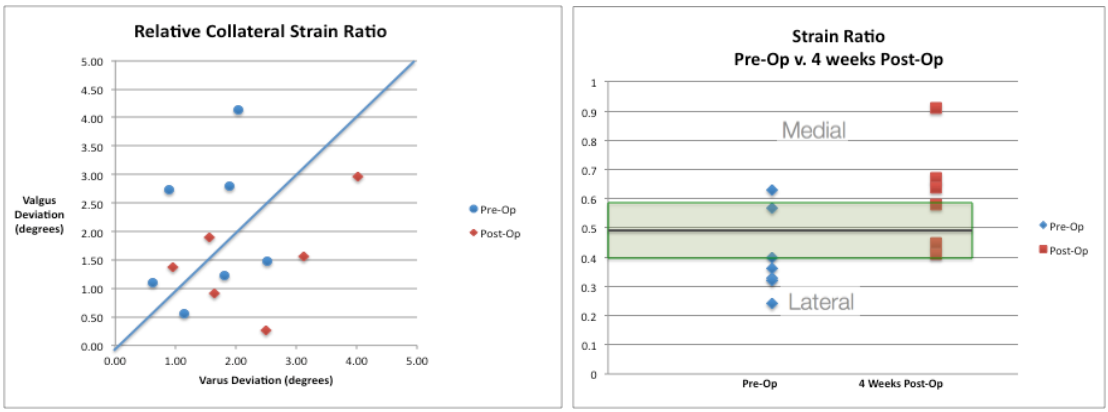

Figure 1: Relative Collateral Strain Distribution before and after TKR surgical balancing

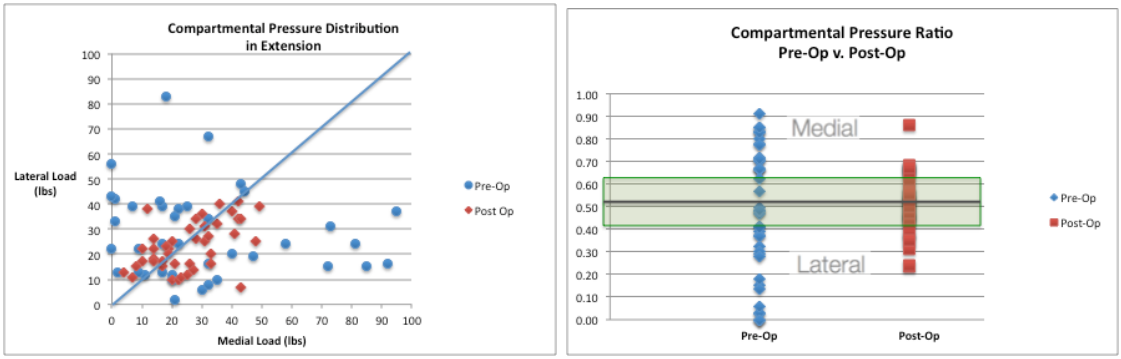

Figure 2: Relative Load Distribution before and after TKR surgical balancing

DISCUSSION

The angular changes under standard torque appear to correlate with previously reported linear displacement values [3]. The shifting towards a tighter medial side may naturally be a systematic error on the part of the single surgeon involved. The final patient reported outcomes would then serve as the validation test. Past studies do indicate a shift toward a tighter medial side in healthy older individuals, with an average CLSR in extension and flexion of 0.55 [5].

Success in achieving soft tissue balancing of the knee at the time of arthroplasty surgery may be predicted by a defined collateral ligament strain ratio under controlled VV testing. This study demonstrates clustering of the strain ratio in slight medial tightness with a range of absolute angular displacements of 0-4 degrees.

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