HOW ACCURATELY CAN KNEES BE BALANCED DURING TOTAL KNEE REPLACEMENT SURGERY? EVALUATION OF COMMON SURGICAL BALANCING CORRECTIONS

Patrick A Meere MD, CM; Svenja Schneider, Ilya Borukhov, Peter S Walker PhD

Department of Orthopaedic Surgery, New York University-Hospital for Joint Diseases
301 East 17th Street, New York, NY 10003, USA

INTRODUCTION

The main principles behind restoring optimal function in a total knee replacement (TKR) surgery are creating aligned bone cuts, along with proper soft tissue balance throughout flexion (Whiteside 2002). Balancing of the soft tissue has been shown in previous studies to have advantages such as greater post-operative patient satisfaction and better clinical outcome (Unitt 2008, Matsuda 2005, Winemaker 2002). Balancing can be achieved through small changes in bone cuts, soft-tissue releases, changes in component size, and rotation of the tibial component (Walker et al, 2014). Until recently, balancing was based on the surgeon's feel and use of spacer blocks or distractors, which was heavily dependent on experience and did not provide quantitative balancing data. In this study, we describe a method for quantifying balancing throughout the flexion range using an instrumented tibial trial (OrthoSensor, Inc, Dania, FL), which provides numerical intraoperative balancing data. This method has been linked to greater postoperative patient satisfaction (Gutske 2014). Notwithstanding this technological advance, the process of achieving balance is still complex and often time-consuming. In this study, we describe a method for quantifying balancing throughout the flexion range and quantify the effect of different surgical corrections on balancing. In this way, we determined how accurately balancing could be achieved within the practical time frame of a surgical procedure and how many surgical corrections were generally necessary when using an instrumented tibial trial.

METHODS

Data was obtained from 80 primary procedures using a PCL-retaining device. Initial bone cuts were made using navigation. Instrumented tibial trials were used to measure the contact forces and locations on the lateral and medial sides. These forces were generated by the pre-tensions in the collaterals supplemented by the PCL and the capsule. Video/audio recordings were made of all aspects of the surgeries. After performing bone cuts and removing osteophytes, the correct tibial insert thickness was determined using the Sag Test. The rotation of the insert was corrected by observing the contacts through the full range of flexion. The initial balancing was recorded after performing the Heel Push test. This was documented as lateral and medial contact forces as a function of flexion. The data was expressed as medial/total force ratio (total=medial + lateral), with 0.5 being equal lateral and medial forces. Surgical corrections specific to the obtained imbalance pattern were carried out, based on previous research (Walker et al, 2014). The Heel Push Test recording of load distribution was repeated after each correction and at final balancing. The load distribution was expressed as a scatter graph of lateral v. medial compartmental loads (Figure 1)

RESULTS

The initial balancing before correction showed that although the average ratio was 0.52+/-0.27 from 0-90 degrees, the data was scattered between 0.0 (lateral force only) and 1.0 (medial force only). The most common surgical corrections used to achieve balancing were: soft-tissue releases (49), changes in tibial insert thickness (27), bone adjustments (15), tibial rotational adjustments (7).

In 84% of the cases, 0-2 corrections were needed to obtain balancing (Range: 0-5). Balancing created an efficient clustering of the medial/total ratios about the 50% balanced value. 80% of the cases in early flexion (0-30 degrees) were balanced within 15% of the balanced state (79 % for 30-60 deg of flexion, 77% for 60-90 deg of flexion). The mean ratio for all flexion angles was 0.52 with standard deviation 0f 0.16. The average total force on the condyles from 0-90 degrees was 290.5+/-166.8 Newtons (65.3+/-37.5 lbs) initially and 215.3+/-86.3 Newtons (48.4+/-19.4 lbs) after balancing.

DISCUSSION

By following a predetermined surgical correction algorithm, accurate balancing was achieved in the majority of cases within 0-2 surgical corrections. These included bone cuts and soft tissue releases. The clinical use of one strategy versus another can be determined by the amplitude of the intercompartmental load differential. Generally, load differentials in excess of 40 lbs dictate a bony trim, or joint plane inclination change, whereas smaller differentials can be handled by soft tissue releases. Because of the natural population variance in ligament stiffness there was no reference value for total contact force values. Clinically, the most important range for balancing was early flexion. Although a perfect load symmetry (0.5 ratio) might be intuitively desirable, the higher value of 0.52 may be concordant with the published varus / valgus ratio of 0.55, in healthy individuals (Heeserbeek 2008). A subsequent study is now underway to determine the effect of balancing on functional outcome and patient satisfaction scores.

CONCLUSION

Knees can be balanced within 15% of a mean value of 0.52 (medial load/total load) in 80 % of cases using less than 2 surgical corrections

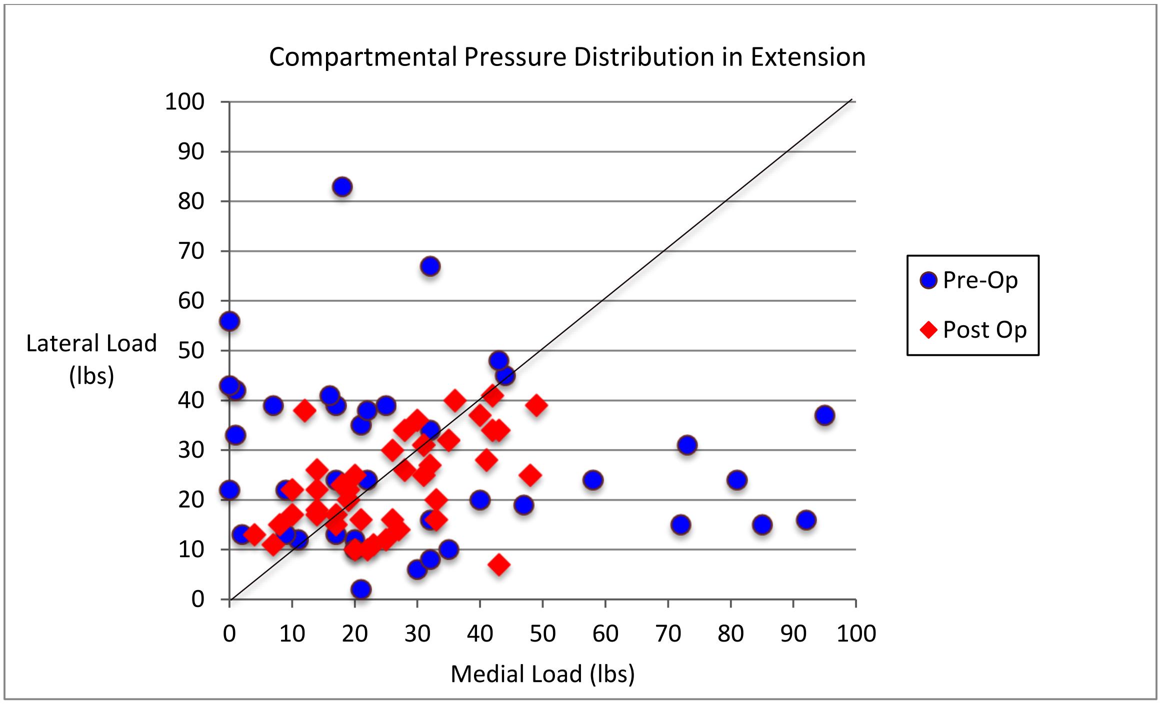

Figure 1. Scatter graph of inter-compartmental load distributions

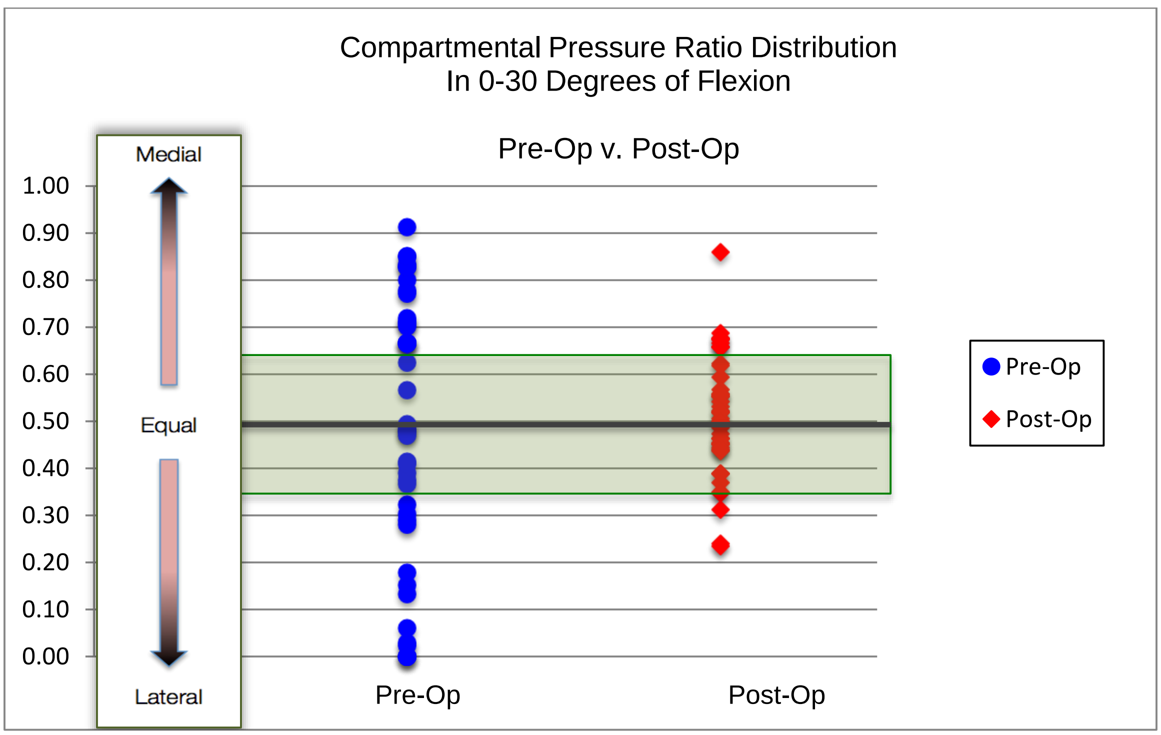

Fig. 2 Compartmental Pressure Ratio Distribution in Early Flexion before and after Balancing

REFERENCES

Gutske KA, Golladay GJ, Roche MW, Jerry GJ, Elson LC, Anderson CR, Increased satisfaction after total knee replacement using sensor-guided technology, The Bone and Joint Journal, 96-B (10), pp: 1333-1338, 2014.

Heesterbeek PJC, Verdonshot N, Wymenga AB, *In vivo* knee laxity in flexion and extension: A radiographic study in 30 older healthy subjects, The Knee, 15 (1), pp: 45-49, 2008.

Matsuda Y, Ishii Y, Noguchi H, Ishii R, Varus-valgus balance and range of movement after total knee arthroplasty, The Journal of Bone and Joint Surgery, 87-B, pp: 804-808, 2005.

Unitt L, Sambatakakis A, Johnstone D, Briggs TWR, Balancer Study Group, The Journal of Bone and Joint Surgery [Br], 90(2), pp: 159-165, 2008.

Walker PS, Meere PA, Bell CP. Effects of surgical variables in balancing of total knee replacements using an instrumented tibial trial. Knee. 2014 Jan;21(1):156-61.

Whiteside LA, Ligament balancing in total knee arthroplasty: an instructional manual, Berlin: Springer, 2004.

Winemaker MJ, Perfect balance in total knee arthroplasty, The Journal of Arthroplasty, 17 (1), pp: 2-10, 2002.

DISCLOSURES

Borukhov I: Nothing to disclose

Meere PA: OrthoSensor: Consulting, royalties, ownership, institutional support (non-restrictive)

Schneider SM: Nothing to disclose

Walker PS: OrthoSensor: Consulting, institutional support (non-restrictive)
Zimmer: Consulting, Royalties
Editorial Board: The Knee