

## The Use of Sensor Technology allowing Implant Salvage in Selected Cases of Revision Total Knee Arthroplasty: A Two-Case Retrospective Case Series

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### Abstract

Costly revision total knee arthroplasty continues to place an increased burden on the United States healthcare system. In light of highly variable revision rates between medical centers, new sanctions have been placed on reimbursement strategy, from the Centers for Medicare and Medicaid, that will financial penalize healthcare providers for unplanned patient readmissions before 90-days following surgery. For the benefit of both patient and healthcare provider, and in effort to reduce unplanned readmissions, new technology has been developed to provide surgeons with objective feedback during surgery. In this case study, the surgeon uses a new, wireless sensor to guide revision procedures and to mitigate unnecessary component exchange. Patients report marked increases in WOMAC, KSS, and range of motion. Use of the wireless sensor shows that implant salvage is possible, guiding surgeons to specific abnormalities.

**Keywords:** *Revisio; Total Knee Arthroplasty; Intraoperative Sensors*

### Introduction

The revision burden associated with total knee arthroplasty (TKA) is projected to reach a staggering 13 billion dollars, annually [3,4,5]. Complications reported by TKA recipients include: pain (44% overall), sensation of instability (21% reason for revision), and joint stiffness (17% reason for revision); problems that may be attributed to soft-tissue imbalance [6,7,8]. One of the possible reasons for the substantial prevalence of such complications is the traditional subjectivity associated with defining intraoperative soft-tissue balance [9].

The use of pressure sensors imbedded in tibial trial liners is proving an efficient method for soft tissue envelope calibration and rebalancing at the time of TKA [2]. When used in a revision case of a compatible implant, it may prevent the need for the exchange of all components. It is also critical that such methods are developed to diagnose specific problems during revision TKA, thereby facilitating surgical correction and implant salvage when feasible. Therefore, the purpose of this consecutive, two-patient case series was to test the efficacy of using intraoperative sensing technology to effectively guide revision surgery in patients with chronic instability.

### Methods

A case series of two patients is presented. The inclusion criteria for this series were:

1. Satisfactory radiographic alignment
2. Suspected soft tissue imbalance in the coronal plane

In both cases the contingency plan consisted of a revision total knee arthroplasty (rev TKA) with partial or total revision of the metallic components. The revision TKA surgery technique focused on balance restoration through critical analysis of pressure mapping technique of tibio-femoral contact point loads in the functional range. All contact point loading was measured and relayed via disposable microsensor technology (Ortho Sensor Inc., Dania Beach, FL). Loading values and contact point location were projected onto a graphic

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user interface, whereby dynamic kinetics were evaluated, in real-time, by the surgeon. “Balance” was defined as any mediolateral loading differential of less than 15 lbs., as previously reported in literature [10, 11]. Preoperative and post-operative functional scores along with clinical findings were prospectively documented.

### Results

#### Case 1

**Patient:** 57 year old female, 18 months after a primary total knee arthroplasty.

**Clinical Presentation:** Persistent pain, swelling and instability. Inability to stand, walk or perform stairs without significant pain and stiffness. No improvement despite diligent and supervised physiotherapy for over a year. Complains of inability to fully stretch. Positive antalgic gait with 10 degrees lack of extension contracture, further passive flexion range up to 95 degrees. Positive chronic effusion and periarticular swelling. No gross opening during varus or valgus stress test. Negative sag, less than 2 mm anterior draw in flexion. Radiographs show a satisfactory alignment and sizing with no evidence of malrotation (Figure 1).



Figure 1:

**Intended Plan:** Open arthrotomy, lysis of adhesions, probable femoral revision with distal femoral recession to regain flexion/extension balance.

**Operative Findings:** At the time of surgery pressure mapping identified the dominant instability as excessive medial tightness in extension with an excessively high pressure differential: 82 lbs. medially vs. 23 lbs. laterally (Figure 2). The medial and lateral pressures in flexion were tensioned appropriately (Figure 3). Pie-crusting of the posterior medial collateral ligamentous fibers selectively corrected the coronal imbalance and restored complete extension. Simple liner thickness then sufficed to restore pressure balance. The resultant pressures in supported extension were 36 lbs. medially vs. 32lbs laterally and in flexion (90 degrees) 10 lbs. medially vs. 13 lbs. laterally (Figures 4-5). The intra-operative PROM measured 0-123 degrees. The metallic implant components were preserved.

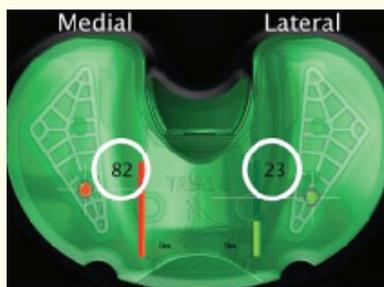
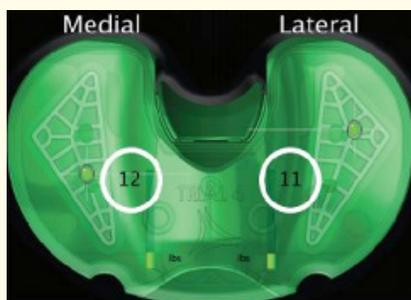


Figure 2: (in extension)

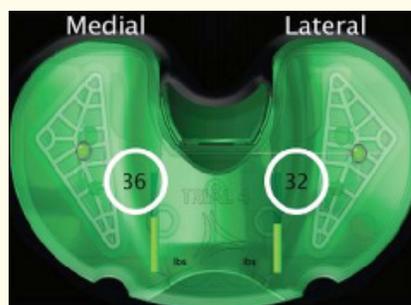
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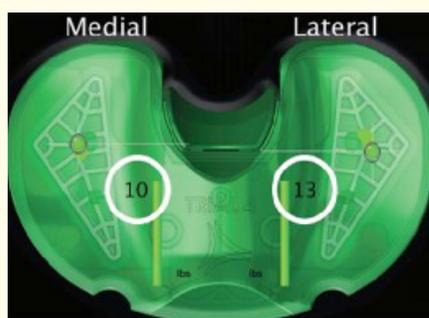
**Post-operative Course:** The WOMAC scores improved from 46.2 (pre-op) to 86.2 at 6 weeks and 88.6 at 8 months postoperatively. The total Knee Society Score (KSS) improved from 70 points (pre-op) to 169 points at 8 months. The KSS pain and function separately improved from 25 to 89 points and 45 to 80 points respectively. The passive range of motion (PROM) improved from 10-90 degrees (pre-op) to 0-122 and 0-127 for the same post-op intervals. The improved range was preserved to date.



*Figure 3: (in flexion)*



*Figure 4: (in extension)*



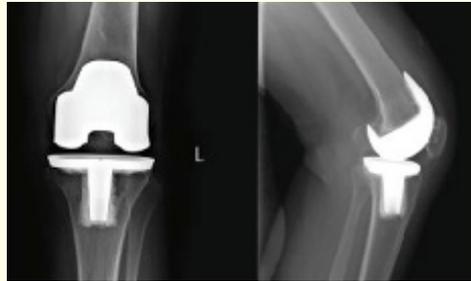
*Figure 5: (in flexion)*

### Case 2

**Patient:** 77-year-old female with recent MCL injury on 10-year-old left TKR.

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**Clinical Presentation:** Three months of instability, persistent pain diffusely in the left knee after sustaining an accidental fall in a department store. Prior to this the clinical function was good and there was no radiological evidence of wear on her posterior stabilized left knee total knee arthroplasty performed over 10 years ago (Figure 6). Subsequent to the fall with hypervalgus and forceful flexion, the patient developed recurrent and persistent instability of the left knee. Physical exam confirmed a grade II laxity of the medial collateral ligament with dull point tenderness at the femoral insertion point. There was associated multidirectional instability, recurrent effusion, synovitis and periarticular tissue edema. The PROM was -3 to 107. The valgus stress test at 10 degrees of flexion showed 5 mm medial opening with a soft endpoint. On varus stress the lateral joint opened by 3 mm. The anterior drawer test showed anterior translation by 4 mm (grade 2). The posterior draw was stopped by the post.



*Figure 6*

**Intended Plan:** The patient was indicated for a left knee open arthrotomy, synovectomy, and lysis of adhesions, possible primary medial collateral ligament repair, probable augmentation of tibial liner with soft tissue recalibration with the use of pressure mapping technology, possible full revision to a Total Stabilized TKA based on medial opening stability and ability to generate sufficient and functional contact resting pressures.

**Operative Findings:** The patient was found to have the anticipated diffuse synovitis secondary to chronic multidirectional instability. The MCL was found to be plastically deformed by approximately 10% but with very good residual elasticity. There was no evidence of mechanical dissociation of the implants. The patient was found to have significant patella baja with arthrofibrosis of the infrapatellar ligament. Compartmental tibial load pressure mapping indicated insufficient load on the medial side, reflecting the known traumatic laxity of the medial collateral ligament in extension (Figure 7). To increase the contact pressure to an acceptable level, a liner thickness augmentation is required. This however caused overstuffing of the lateral compartment in extension (Figure 8). This was then corrected by a rim coronary ligament release (Arcuate plus 3 mm of the lateral Iliotibial band insertion up to Gerdy's tubercle) on the lateral side and final liner thickness augmentation by 5 mm. The coronal pressure balance was thus optimized to less than 10 pounds differential in extension and in flexion (Figure 9-10). The above pathway pertains to static loads.

Dynamic load evaluation through a varus/valgus maneuver (at 10 degrees of flexion) can produce pressure differentials that reflect the tension in the ligaments opposite to the direction of the applied force. Varus loading with 25 N force created a 20 lbs. load differential on the medial compartment, representing the tightness of the lateral collateral ligament. Valgus loading with the same 25 N force generated a 17 lbs. load differential, confirming the sufficient resiliency of the MCL. This ligamentous stability was deemed to be very acceptable and preferable to a full revision to a TS component

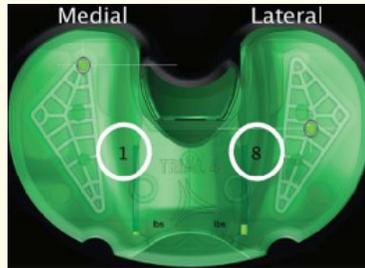


Figure 7: (in extension)

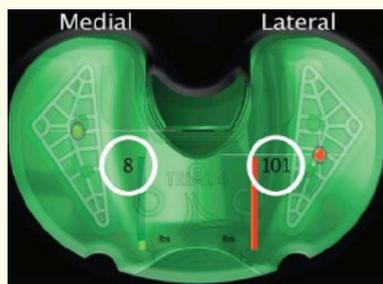


Figure 8: (in extension)

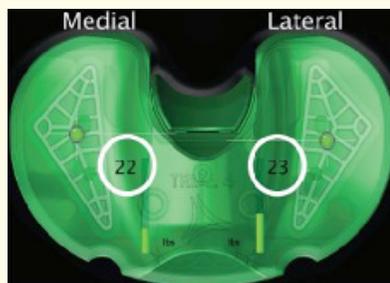


Figure 9: (in extension)

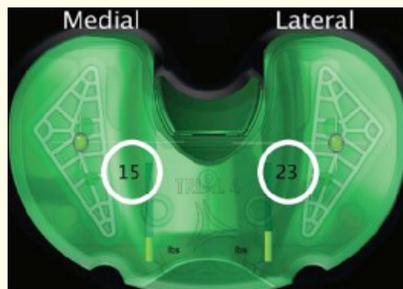


Figure 10: (in flexion)

**Post-Operative Course:** Discharged on post-operative day (POD) 2. Single cane on POD 10. Unassisted ambulation by POD 20 with walking tolerance of 6 blocks, no assist on stairs. Post-operative exam at 21 days reveals minimal pain or tenderness. Medial opening on valgus stress of less than 3 mm. PROM: -3 to 112 degrees. The WOMAC score improved from 47.7 (pre-op) to 84.8 at 6 weeks.

### Discussion

In this short case series, two patients presented with chronic instability, pain, and effusion in an established TKA joint. All asymmetric loading was confirmed and corrected through the use of the intraoperative sensor system. The initial operative plan for both cases indicated a potential need for exchange of metal components. However, digital guidance provided by the sensor system obviated the need for the surgeon to exchange any metal components, thereby avoiding patient morbidities and excess cost associated with revision surgery.

In Case I, the patient presented with coronal soft tissue imbalance, driven by excessive tension in the posterior medial collateral ligament fibers. In such cases, pressure mapping sensor technology helps the surgeon to define the specific deficiency and probable best correction. In many revision cases, the imbalance is coronal rather than sagittal. Thus, implant salvage may be feasible, sparing the patient the morbidity associated with a complete revision of all TKA components.

In Case II, the decision to convert an unstable TKA after a serious MCL injury relied on the subjective impression of medial joint line opening and shearing upon valgus stress testing. The adjunct use of sensor technology in this case allowed for quantified evidence of the morbid imbalance and assisted in the performance of titrated release of the relatively tighter contralateral ligament and capsule upon liner thickness augmentation. Finally, the response to physiological loading of the collateral ligaments showed symmetrical  $\Delta P$ 's (rapid pressure differentials during the load impulse application and recoil). This confirmed the restoration of functional stability to the joint. Of note was the fact that the implant salvaged in this case was of a different manufacturer than that for which the sensor was design. Nonetheless, undersizing by one size allowed for a good fit and translational stability for compression load testing purposes.

This small case series provides promising results for the efficacy of using intraoperative sensor technology during revision cases requiring the correction of instability. Further case studies and longer follow-up will need to be obtained to understand long-term outcomes.

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