Wearable Sensors and Machine Learning to Set Functional Expectations for Total Knee Arthroplasty

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Disclosures: Jennifer S. Polus (N), C. Thomas Appleton (AbbVie, Amgen, BMS, Celgene, Fresenius Kabi, Gilead, Janssen, Merck, Novartis, Pfizer, Hoffmann-La Roche, Sandoz, Sanofi Genzyme, and UCB), Edward M. Vasarhelyi (DePuy, Hip Innovation Tech, Microport, Smith & Nephew, Stryker, Zimmer), Steven A. MacDonald (Canadian Orthopaedic Association, CurvaFix, DePuy, Hip Innovation Tech, International Hip Society, JointVue, PSI, Smith & Nephew, Stryker, Zimmer), Brent A. Lanting (DePuy, Smith & Nephew, Stryker, Zimmer), Matthew G. Teeter (Canadian Orthopaedic Research Society, Canadian RSA Network, International Society for Technology in Arthroplasty)

INTRODUCTION: Total knee arthroplasty (TKA) is the only viable treatment for end-stage osteoarthritis, however, 20% of patients consistently report being dissatisfied with the outcome of their procedure. Patient dissatisfaction has been linked to unmet expectations of functional recovery. One way to potentially improve patient satisfaction is to counsel patients on what they can expect of their personal recovery. Our group has developed a tool to predict whether a patient is more likely to meaningfully improve on (responder) or keep (maintainer) their level of preoperative function after undergoing surgery. The purpose of this study is to assess the impact providing patients with a personal functional prediction has on their satisfaction and investigate relationships between patient satisfaction and functional recovery.

METHODS: Patients (n=50) undergoing primary TKA provide consent for this ethics approved study and are recruited to participate. Patients are randomized to either receive the prediction of their functional recovery or to have surgery as normal. Preoperatively, patients perform the timed-up-and-go (TUG) walking test while instrumented with wearable sensors (Figure 1). Using the data collected from the wearable sensor system, the machine learning classifier predicts whether each patient is a functional responder or maintainer. Patients repeat the TUG test again at three-months and one-year postoperatively to track functional recovery. Prediction accuracy is evaluated by assessing whether each patient improved in total TUG time by the minimum clinically important difference (MCID = 2.27 seconds) from pre-operation to post-operation. Patients also complete the Knee Society Score (KSS) questionnaires to address their expectations and satisfaction with their knee. Questionnaire scores are compared between patients who received a prediction and those who had surgery as normal.

RESULTS SECTION: Patient recruitment and follow-up are ongoing. Thus far, 37 patients have consented to participate and 36 have undergone TKA. Patients were randomized to either receive their functional prediction (n=17) or have surgery with no knowledge of their prediction (n=19). Three patients were predicted to be “responders” and the remaining 33 were predicted to be “maintainers”. So far, n=19 patients have completed their three-month follow-up and n=13 patients have completed their one-year follow-up. At three-months, one predicted responder improved on their pre-operative function by 2.25 seconds and three predicted maintainers improved on their preoperative TUG times by more than 2.27 seconds, a clinically important difference that would make them responders. By one-year, another predicted maintainer improved on their preoperative TUG times by more than 2.27 seconds, which would make them a responder. The current performance accuracy at three-months post-operations is 78.9% (15/19 correct predictions), in line with the trained and validated algorithm used that had an accuracy of 76%. Preliminary analysis shows no difference in mean KSS expectation and satisfaction scores preoperatively and at three-months between patient groups ($p>0.05$).

DISCUSSION: Patient dissatisfaction following TKA is widespread and costly. This ongoing study is the first to evaluate an objective tool that utilizes wearable sensors and machine learning to help patients manage preoperative expectations of functional recovery. The algorithm is performing as expected, with a bias towards setting a lower expectation to ensure satisfaction with functional outcomes. As recruitment continues, the relationship between satisfaction, expectations, and functional ability will be further investigated and related to other patient outcomes.

SIGNIFICANCE/CLINICAL RELEVANCE: Managing patient expectations with respect to functional recovery has been a difficult area to address and this work utilizes the potential of wearable sensors and machine learning techniques to help personalize care for patients.

FIGURES:

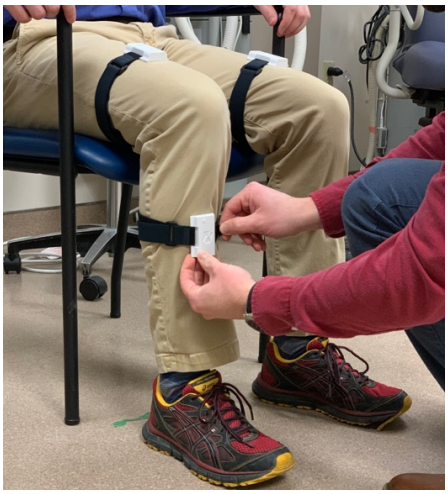

Figure 1: Wearable sensor placement above and below each knee during the instrumented TUG test.