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Validation of a Patient Outcome Prediction Tool Relative to Surgeon Predictions of Patient Outcome in Total Knee Arthroplasty

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Abstract

A key goal of all TKA alignment strategies is to achieve joint balance. This study aims to compare the alignments achieved by preoperatively planning to a novel distracted joint gap protocol to common alignment strategies as well as to the alignment of a healthy non-arthritic population.

A retrospective study comprised of 145 knees was performed. A long-leg supine CT scan, weightbearing AP knee X-ray and two distracted knee X-rays (one each in extension and flexion, making use of an ankle weight to open the joint) were taken pre-operatively. This imaging was used to perform segmentation, landmarking and 3D-to-2D registration. The medial and lateral joint gaps were determined in extension and flexion.

The mean weightbearing, KA planned and distracted joint planned HKA were 4.7° (±5.9°) varus, 0.3° (±3.2°) varus, and 2.2° (±3.5°) varus. This compares to a healthy adult HKA of 1.3° (±2.3°) varus. A patient level comparison between the planned KA and distracted joint HKA found that the coronal angles of the two alignments are within 3° of each other for 64% patients, within 3-5° for 26% of patients and greater than 5° for the remaining 10% of patients.

Of those compared, the planned distracted HKA was the closest to the constitutional varus HKA of a healthy population. Patient level analysis highlighted the fundamental differences between the planned KA and joint distracted alignments. By considering both hard and soft tissue, the planned joint distracted alignment allows for a more holistic foundation for pre-operative surgical planning for a given patient.

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1 Introduction

The current decision-making process when evaluating whether a patient is suitable for a Total Knee Arthroplasty (TKA) involves a combination of patient reported symptoms, clinical examination findings and radiological criteria[1]. Both the patient's expected outcome from the surgery (as assessed by the surgeon) as well as diagnostic need for the surgery must be considered. However, there is a lack of consensus amongst surgeons about the eligibility criteria for a TKA, which has the potential to result in inappropriate recipients receiving a TKA[2]. Although existing patient outcome prediction tools have been validated against actual patient reported outcomes[3-6], none are validated directly against the predictions of surgeon. This study aims to investigate ability of the Patient Expectation Management (PEM) tool, an artificially intelligent predictive tool, relative to surgeon predictions of patient outcome.

2 Methods

A retrospective study comprised of 138 patients totaling 145 operated knees (7 bilateral) was performed. All patients were recruited from a single experienced orthopaedic surgeon between March 2020 and March 2021. A long-leg supine CT scan, weightbearing AP knee X-ray and two distracted knee X-rays (one each in extension and flexion, making use of an ankle weight to open the joint) were taken pre-operatively. Segmentation and landmarking of the CT scans were performed. The output bone models were then registered onto the 3 different X-rays via 3D-to-2D registration, and the medial and lateral joint gaps were determined in extension and flexion. An algorithm corrected for geometrically determined osteophyte tenting of ligaments and a surgical plan to fill the expected gaps formed. Statistical analysis was performed in R Studio v1.3.1903. This retrospective analysis was approved by the Bellberry Human Research Ethics Committee (study number 2012-03-710 A prospective study was performed involving 89 patients totalling 100 operated knees (11 bilateral) recruited from 4 experienced TKA surgeons between May 2018 and September 2019. Pre-operative KOOS and 12-month post-operative KOOS were obtained for all patients. All patients were surveyed using the PEM tool prior to surgeon consultation. The tool assessed the patient's current pain state and provided a prediction for the patient's post-operative pain outcome on a 100-point scale. After the surgeon consultation but prior to seeing the PEM results, the surgeon noted their understanding of the patient's current pain levels and also predicted the patient's post-operative pain level on the same 100-point scale.

3 Results

Average age of patients was 70.22 ± 6.65 years and 56% (56) of the joints were of a female patient. The reported change in patient pain outcome for patients predicted to experience a significant improvement (change in KOOS Pain score ≥ 40) according to the PEM tool was 40.9 ± 13.0, compared to 21.9 ± 22.7 for patients predicted to experience an insignificant improvement ($p < 0.001$). The reported change in patient pain outcome for patients predicted to experience a significant improvement according to surgeons was 51.2 ± 23.2, compared to 50.0 ± 15.6 for patients predicted to experience an insignificant improvement (not statistically significant). Overall, the predicted change in pain outcome by the PEM tool and surgeon group were 31.4 ± 20.7 and 50.6 ± 19.7, respectively ($p = 0.003$).

4 Discussion

The PEM tool was able to predict significant improvements in patient pain outcomes more accurately than surgeons. This may in part be due to the more conservative predictions by the tool relative to surgeons as well as the nature of the KOOS Pain score, both of which may contribute to the creation of a 'ceiling effect' on the surgeons' predictions. Prior literature has found that surgeon expectations of patient recovery and outcome are generally more conservative than the expectation of patients themselves[7-9].

Due to the accuracy of the PEM tool relative to surgeons as established in this study and findings in its prior validation[3], the PEM tool can be implemented as an assistive tool for patient selection and also has potential to assist in patient expectation management, both of which can positively impact post-operative patient reported outcomes.

References

1. Adie, H., Harris, I., Chuan, A., Lewis, P. & Naylor, J.M. (2019). Selecting and optimising patients for total knee arthroplasty. Medical Journal of Australia, 210(3), 135–141.
2. Riddle, D. L., Perera, R. A., Jiranek, W. A., & Dumenci, L. (2015). Using surgical appropriateness criteria to examine outcomes of total knee arthroplasty in a United States sample. Arthritis care & research, 67(3), 349-357.
3. Twiggs, W., Wakelin, E. A., Fritsch, B. A., Liu, D. W., Solomon, M. I., Parker, D. A., Klasan, A. & Miles, B. P. (2019). Clinical and Statistical Validation of a Probabilistic Prediction Tool of Total Knee Arthroplasty Outcome. The Journal of Arthroplasty, 34(11), 2624–2631.
4. Lungu, E., Desmeules, F., Dionne, C.E., Belzile, E. L. & Pascal-Andre, V. (2014). Prediction of poor outcomes six months following total knee arthroplasty in patients awaiting surgery. BMC Musculoskeletal Disorders 15, 299 (2014).
5. Van Onsem, S., Van Der Straeten, C., Arnout, N., Deprez, P., Van Damme, G., & Victor, J. (2016). A new prediction model for patient satisfaction after total knee arthroplasty. The Journal of arthroplasty, 31(12), 2660-2667.
6. Sanchez-Santos, M. T., Garriga, C., Judge, A., Batra, R. N., Price, A. J., Liddle, A. D., Javaid, M. K., Cooper, C., Murray, W. & Arden, N. K. (2018). Development and validation of a clinical prediction model for patient-reported pain and function after primary total knee replacement surgery. Scientific reports, 8(1), 1-9.
7. Ghomrawi, H. M., Franco Ferrando, N., Mandl, L. A., Do, H., Noor, N., & Gonzalez Della Valle, A. (2011). How Often are Patient and Surgeon Recovery Expectations for Total Joint Arthroplasty Aligned? Results of a Pilot Study. HSS journal : the musculoskeletal journal of Hospital for Special Surgery, 7(3), 229–234.
8. Ghomrawi, H. M., Mancuso, C. A., Westrich, G. H., Marx, R. G., Mushlin, A. I., & Expectations Discordance Study Group. (2013). Discordance in TKA expectations between patients and surgeons. Clinical Orthopaedics and Related Research®, 471(1), 175-180.

9. Koenen, P., Bäthis, H., Schneider, M. M., Fröhlich, M., Bouillon, B., & Shafizadeh, S. (2014). How do we face patients' expectations in joint arthroplasty?. Archives of orthopaedic and trauma surgery, 134(7), 925-931

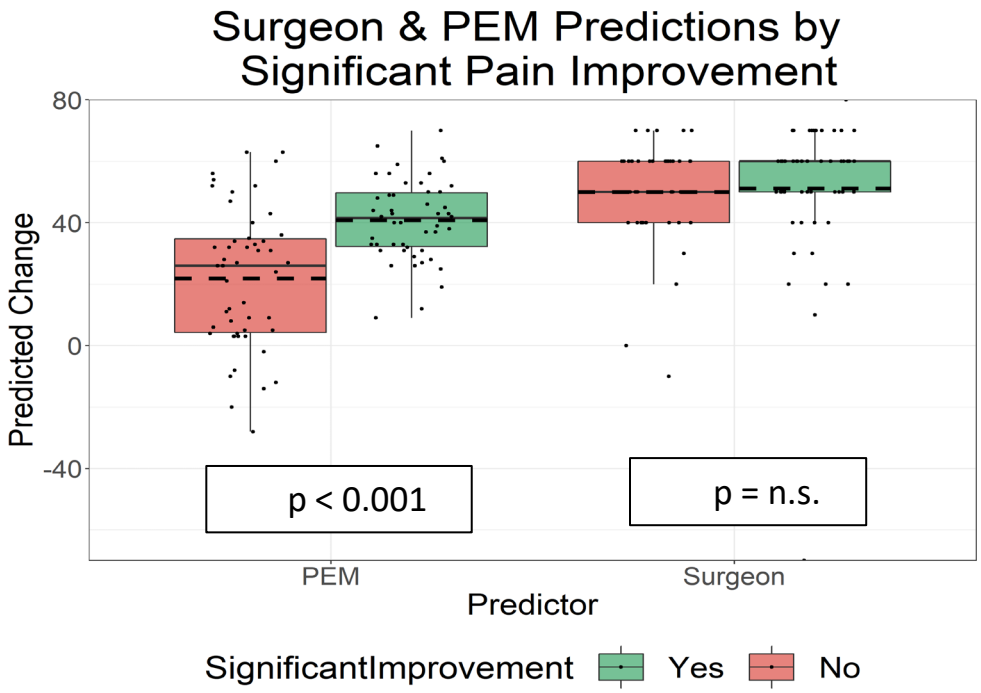

Figure 1. Box plot comparing Surgeon and PEM predictions of change in patient reported KOOS Pain outcome. The results for each predictor have been split by whether the patients experienced a significant improvement in pain outcome of greater than or equal to 40.

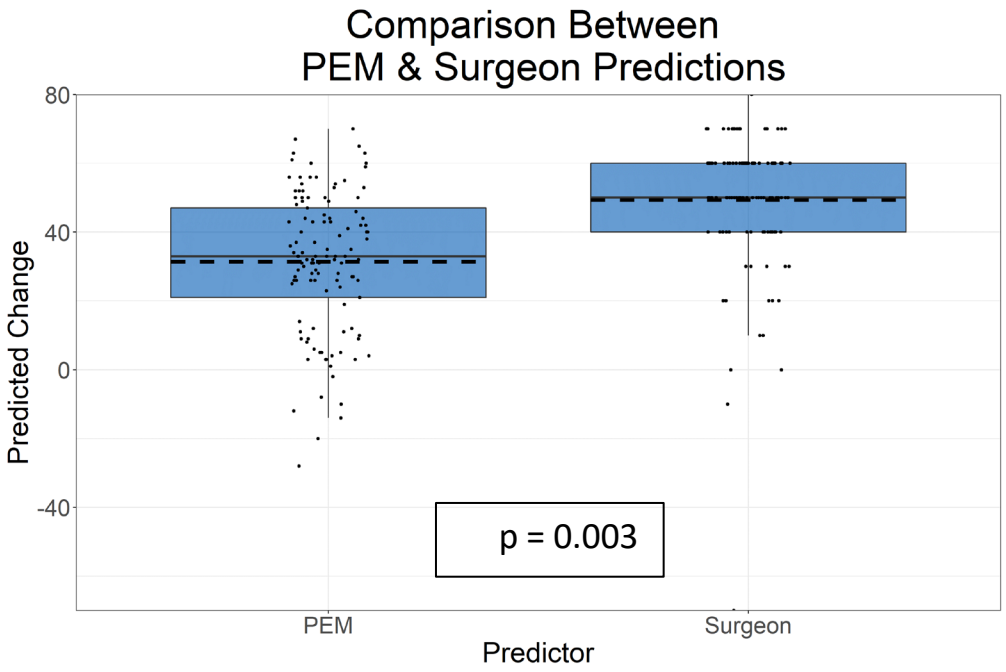

Figure 2. Box plot comparing the PEM and Surgeon predicted change in patient pain outcome. It is evident that the PEM predictions are relatively more conservative than those of the surgeons.