EPiC Series in Health Sciences

Volume 6, 2024, Pages 82–85

Proceedings of The 22nd Annual Meeting of the International Society for Computer Assisted Orthopaedic Surgery

Novel Patellofemoral Ligament Modelling to Detect Anterior Knee Pain After Total Knee Arthroplasty

Andrew Shimmin[1], Ishaan Jagota[2], Brett Fritsch[3], David Parker[3], Joshua Twiggs[2], Brad Miles[2]

[1] Melbourne Orthopaedic Group, Melbourne, Australia, 2360 Med Care, Sydney, Australia

[2] 360 Med Care, Sydney, Australia

[3] Sydney Orthopaedic Research Institute, Sydney, Australia

ishaan.jagota@360med.care

Abstract

Up to 35% of total knee arthroplasty (TKA) patients experience short term anterior knee pain (AKP) and up to 20% of non-revised knees experience anterior knee pain in the long term. Patellofemoral pain is the primary cause of AKP and accounts for over 8% of revision TKA procedures in Australia. This study introduces a geometric patellofemoral ligament analysis model which was used to differentiate between patients with and without post-operative anterior knee pain.

All patients received pre- and post-operative CT scans and lateral flexed radiograph. The CT scans were segmented and landmarked before being registered to the flexed radiographs. The antero-posterior (AP) of the medial and lateral patellar edge relative to the medial and lateral femoral epicondyles were measured pre-operatively, post-operatively as well as the difference between the two states. These measurements were analysed for their impacts on patient outcome using the Kujala score.

Both medial and lateral antero-posterior patellofemoral offsets had statistically significant, moderate inverse correlations with the overall Kujala score. However, no statistically significant relationship was observed between the post-operative Kujala score and the pre-operative AP offsets or the change in AP offset between the pre- and post-operative states.

The results suggest that a higher medial or lateral post-operative patellofemoral AP offset, potentially due to the overstuffing of the patellofemoral joint, may result in inferior patient outcomes and residual AKP. Overall, it is imperative to consider the possible causes of post-operative AKP and models should be developed to inform surgeons in a clinical setting.

1 Introduction

Up to 35% of total knee arthroplasty (TKA) patients experience short term anterior knee pain (AKP)[1] and up to 20% of non-revised knees experience anterior knee pain in the long term[2]. Patellofemoral pain is the primary cause of anterior knee pain and accounts for over 8% of revision TKA procedures in Australia[3]. Since the patellofemoral joint is understudied, it is imperative to understand some factors that may prevent the occurrence of AKP. Although computational modelling can be powerful in its ability to provide predictive and patient specific analysis, there are limited models to provide insight on the patellofemoral joint. This study introduces a geometric patello-femoral ligament analysis model which was used to differentiate between patients with and without post-operative anterior knee pain.

2 Methods

A lateral flexed knee radiograph and bilateral long-leg supine CT scan were obtained for each patient pre-operatively and post-operatively. The CT scans were segmented and landmarked before being registered to the flexed position as per the radiographs. A geometric convex hull algorithm was developed, which calculated the length of the medial and lateral patellofemoral ligaments as well as the antero-posterior (AP) offset of the medial and lateral patella relative to the medial and lateral femoral epicondyles, respectively. These distances and change in pre- to post-operative distances were calculated and analysed for their impacts on patient outcome using the Kujala score. The Kujala score was selected as it has been previously validated to differentiate between healthy subjects and those experiencing anterior knee pain and patellofemoral instability. A sample of 20 patients was selected for analysis, of which 10 had a high Kujala score (≥89) and 10 had low Kujala scores (≤80). The workflow of the image processing and anatomical measurements process is displayed in Figure 1.

3 Results

Both medial and lateral antero-posterior patellofemoral offsets had statistically significant, moderate inverse correlations with the overall Kujala score. These were -0.54 (p-value = 0.01) and -0.49 (p-value = 0.03), respectively. However, no statistically significant relationship was observed between the post-operative Kujala score and the pre-operative AP offsets or the change in AP offset between the pre- and post-operative states. The results are outlined in Table 1.

4 Discussion

The results suggest that a higher medial or lateral post-operative patellofemoral AP offset, potentially due to the overstuffing of the patellofemoral joint, may result in inferior patient outcomes and residual AKP. This is contrary to existing literature which has been unable to identify relationships between patellofemoral overstuffing and patient outcome and AKP[4, 5]. Although the data indicates that the difference in AP offset between the pre- and post-operative states did not influence the patient's outcome as per the Kujala score, this finding may be limited by the small

sample size. Overall, it is imperative to consider the possible causes of post-operative anterior knee pain and models should be developed to inform surgeons in a clinical setting.

The patellofemoral joint is relatively understudied with limited literature to provide guidance to clinicians on component positioning. The development of a clinically applicable model may assist surgeons during their decision-making process when planning the positioning of the femoral and patellar prostheses during TKA with the key goal of enhancing patient outcomes.

References

1. Morteza Meftah, Amar S. Ranawat, and Chitranjan S. Ranawat, “The Natural History of Anterior Knee Pain in 2 Posterior-Stabilized, Modular Total Knee Arthroplasty Designs,” The Journal of Arthroplasty 26, no. 8 (December 2011): 1145–48, https://doi.org/10.1016/j.arth.2010.12.013.
2. Boonchna Pongcharoen, Thanasak Yakampor, and Keerati Charoencholvanish, “Patellar Tracking and Anterior Knee Pain Are Similar After Medial Parapatellar and Midvastus Approaches in Minimally Invasive TKA,” Clinical Orthopaedics & Related Research 471, no. 5 (May 2013): 1654–60, https://doi.org/10.1007/s11999-012-2778-5.
3. Australian Orthopaedic Association National Joint Replacement Registry (AOANJRR). Hip, Knee & Shoulder Arthroplasty: 2022 Annual Report, Adelaide; AOA, 2022: 1-487
4. Beldman, Mark, Stefan JM Breugem, and Hans-Peter W. van Jonbergen. "Overstuffing in total knee replacement: no effect on clinical outcomes or anterior knee pain." International Orthopaedics 39.5 (2015): 887-891.
5. Kemp, Mark A., et al. "Does overstuffing of the patellofemoral joint in total knee arthroplasty have a significant effect on postoperative outcomes?." The Knee 25.5 (2018): 874-881.

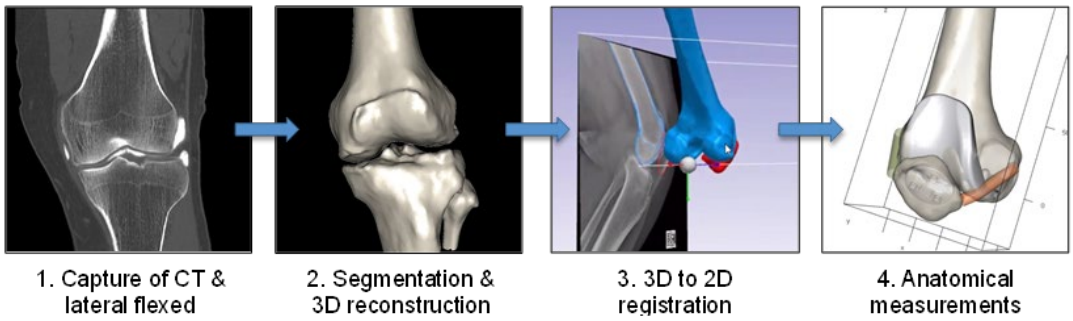

Figure 1. *Anatomical measurement process involves 1. Capture of long-leg lower-limb CT scans and lateral flexed radiographs. 2. The CT scans are then segmented and landmarked followed by 3. Registration of 3D bone models to the radiographs. 4. These reconstructions are used to take anatomical measures and determine the position patellofemoral offsets. Steps 1-4 were performed pre-operatively and post-operatively before statistical analysis was performed to investigate any relationships between the anatomical measurements and PROMs.*

Table 1. *Correlations between the medial and lateral antero-posterior offsets in different states and the post-operative Kujala score. A P-value of < 0.05 was considered to be statistically significant. * Denotes statistical significance.*

Antero-posterior Offset		Correlation	P-Value
Pre-operative	Medial	-0.25	0.37
	Lateral	-0.33	0.16
Post-operative	Medial	-0.54	0.01*
	Lateral	-0.49	0.03*
Change from Pre- to Post-operative State	Medial	0.13	0.59
	Lateral	0.18	0.45