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KNEE BIOMECHANICS TWO MONTHS AFTER TOTAL KNEE ARTHROPLASTY

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INTRODUCTION

Total knee arthroplasty (TKA) is the most common treatment for end-stage knee OA, with approximately 500,000 procedures performed each year in the United States. Several studies have examined the long-term effects of TKA on the biomechanics of the operated knee and have found that most patients still demonstrate poor gait patterns that are similar to their gait patterns preoperatively [1]. Most of these abnormalities have been found in the sagittal plane. Specifically, there is limited knee flexion-extension range of motion postoperatively as well as poor flexion-extension moments. Studies have related these findings to "stiff knee" muscle activation patterns due to habits developed preoperatively, as well as proprioceptive deficiency, instability and quadriceps weakness leading to a "quadriceps avoidance gait" [1]. In the frontal plane, researchers have found that KAM is improved at 6 months after surgery, but slowly regresses back to higher, preoperative levels after 1 year [2]. In the long-term, KAM is not significantly different from preoperative levels. This finding is noteworthy since high KAM may result in prosthetic degradation and failure in the long term.

There is a lack of information on the biomechanical postoperative results of surgery in the period earlier than six months, as well as adequate comparisons to gait patterns preoperatively. The purpose of the present study was to determine if gait patterns of the knee are improved in the early postoperative period. This would help determine what, if any, changes can be made to therapy protocols to prevent regression to preoperative gait levels with time. Furthermore, outcomes were examined across different knee prosthetics to determine if differences exist between prosthetic types.

METHODS

Fifty patients were examined before and two months after TKA. Patients underwent a 3D gait analysis using the Vicon Motion Analysis system (Oxford Metrics Ltd., Oxford, UK). Patients completed a VAS scale for pain and functional tests. Knee prosthetics included either PCL-retaining or PCL sacrificing, and custom fit design or not.

RESULTS AND DISCUSSION

Results are presented in Table 1. Knee flexion-extension range of motion decreased significantly by 22% ($p<0.001$). Knee flexion angle and moment did not change significantly postoperatively ($p=0.231$ and 0.169, respectively) (Figure 1). Knee extension angle, moment and impulse were significantly worse postoperatively than preoperatively (all $p<0.01$), and extension impulse showed a significant positive correlation of 0.4 with BMI ($p<0.05$) (Figure 1).

Peak knee varus angle during gait showed a significant reduction and improvement of 3.1° postoperatively ($p=0.001$) (Figure 2a). After surgery, first and second peak KAM decreased to 71% and 77% of preoperative values (Figure 2), respectively (both $p=0.001$), and knee adduction impulse decreased by 30% postoperatively ($p<0.001$) (Table 1) and VAS pain scores decreased by 21% ($p<0.001$).

Spatiotemporal parameters and functional tests did not yet show significant improvements by two months. No significant differences were found between outcomes in patients undergoing PCL retaining TKA or PCL sacrificing TKA, or between patients undergoing custom fit TKA and those not. Changes were consistent across BMI, age, gender and pain scores.

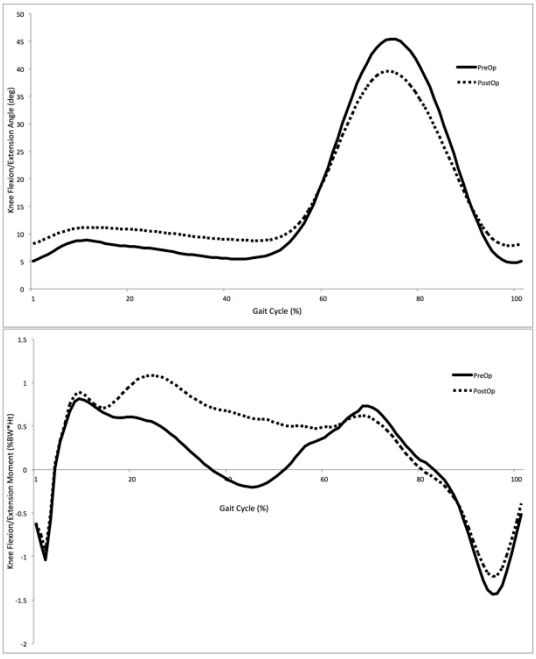

Figure 1: Knee flexion/extension angle (a) and moment (b) before and after TKA.

Table 1:

Parameter	PreOp	2 Month PostOp	Sig.
Spatiotemporal			
Walking speed (m/s)	0.78±0.22	0.72±0.21	P=0.069
Step length normalized to leg length	0.56±0.12	0.54±0.12	P=0.294
Single limb support (%GC)	33.6±5.1	32.8±5.0	P=0.368
Kinematic and Kinetic			
Peak Flexion Angle in Stance (deg.)	10.2±7.3	12.2±6.4	P=0.071
Peak Extension Angle in Stance (deg.)	4.5±6.7	7.9±6.3	P=0.005**
Peak Flexion Angle in Swing (deg.)	47.3±10.6	41.2±9.0	P=0.001**
Range of motion (deg)	42.9±10.3	33.4±8.7	P<0.001**
Peak Flexion Moment (%BW*Ht)	1.4±1.1	1.6±1.3	P=0.231
Flexion Impulse	28.7±26.3	35.4±31.5	P=0.169
Peak Extension Moment (%BW*Ht)	-1.0±1.3	-0.32±0.89	P<0.001**
Extension Impulse	-25.6±31.3	-11.3±19.8	P<0.001**
Peak varus angle (deg.)	4.5±8.4	1.4±5.3	P=0.001**
Varus angle range of motion (deg.)	4.2±2.8	3.0±2.0	P=0.007**
Peak adduction moment 1 (%BW*Ht)	3.1±1.5	2.2±0.81	P<0.001**
Peak adduction moment 2 (%BW*Ht)	2.6±1.4	2.0±0.86	P=0.001**
Adduction impulse	120.1±60.0	84.4±36.2	P<0.001**
Symptoms and Function			
VAS Pain Scale	7.2±2.0	5.7±2.0	P<0.001**
Timed-Up-Go Test (min)	12.4±3.3	12.1±2.5	P=0.544
6 Minute Walk Test (min)	330.7±102.9	304.9±95.8	P=0.102

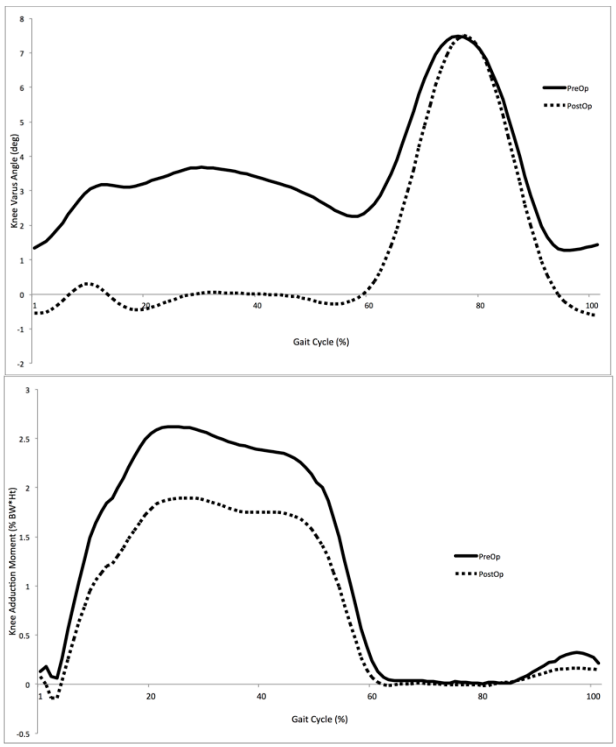

Figure 2: Ensemble average curves from all subjects showing the knee varus angle (a) and knee adduction moment (b) before and after total knee arthroplasty.

CONCLUSIONS

Knee biomechanics in the sagittal plane worsen significantly in the early postoperative period after TKA. TKA results in high improvement in kinematic and kinetic parameters in the frontal plane early in postoperative recovery. The results also suggest that there is an absence of differences between types of knee prostheses. When compared to the findings of previous studies, the results suggest that early after surgery, TKA patients will show decreased, improved KAM, but these improvements are slowly lost over the first and second year postoperatively. When considering long-term postoperative studies, these results suggest that the knee biomechanics of gait in the sagittal plane will improve with time, but they will not reach the levels of function of healthy individuals. This highlights the importance of early intervention postoperatively aimed at maintaining the low levels of KAM and joint loading. This may help reduce the risk of prosthetic failure and surgical revision in the long-term.

REFERENCES

1. McClelland JA, et al., *Knee*. **14**: 253-263, 2007.
2. Orishimo KF, et al., *CORR*. **470**:1171-1176, 2012.