ISAKOS

International Society of Arthroscopy, Knee Surgery and Orthopaedic Sports Medicine

11th Biennial ISAKOS Congress • June 4-8, 2017 • Shanghai, China

Paper #225

Knee Biomechanics After Replacement Surgery (Kbars) – Kinematic and Electromyographic Comparison of Posterior-Stabilised, Cruciate-Retaining and Medial-Pivot Designs During Locomotion

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Summary:
Comparative knee biomechanics and muscle activity in three implant designs

Abstract:
Background
Despite the promising clinical outcomes of the medial-pivot knee design reported to-date, fundamental questions regarding the in-vivo functional behaviour of the implant remain. That is, whether medial-pivot knees reliably replicate tibiofemoral kinematics during locomotion that is more normal than existing implants, and what relationship any improvement in the kinematic profile has with neuromuscular patterns. The existing literature is limited by small sample sizes and insufficient statistical analysis to address these questions. The purpose of this study was to determine whether the tibiofemoral motion and electromyographic activity of the knee extensors and flexors differs in patients with a medial pivot implant, compared to those with cruciate-retaining or posterior-stabilised designs, during locomotion.

Methods:
A cohort of patients (N = 72) that had undergone TKA a minimum of 12months prior were recruited to the study. The cohort was split into 3 groups based on implant type: medial-pivot (MP), posterior-stabilised (PS) and cruciate-retaining (CR). Motion capture with a high-speed optoelectronic system (200Hz, Vicon Bonita/Nexus, USA) and surface electromyography with wireless sensors (Delsys Trigno, USA) was recorded from the rectus femoris, vastus lateralis, vastus medialis, biceps femoris and medial hamstrings, with maximal voluntary isometric contractions performed for signal normalisation. Three-dimensional modelling was performed of knee motion in three-dimensions during a step-ascent task onto an 18cm high block. EMG signal amplitude was expressed relative to MVC (%) and cocontraction indices calculated between knee extensor and flexor pairs (BF-RF, BF-VL, MH-VM). All data were normalized to 0-100% of the weight acceptance phase (contralateral toe-off to contact). Medians with 95% confidence intervals were generated for each dependent variable to allow for between-group comparisons.

Results:
Preliminary analysis (N = 12) revealed that all patients displayed internal rotation with knee extension during the step ascent movement, and no significant difference ($P > 0.05$) in the amount of rotation between the MP (5.5°, 4.7 – 9.4), PS (5.3°, 4.4 – 6.2) and CR (4.5°, 2.5 – 5.8) knees. However, the MP knees displayed significantly ($P<0.01$) lower knee extensor activation to achieve the step-ascent than the CR group.

Conclusions:
These findings suggest that patients with all knee implant types are not strictly limited to producing the traditional screw-home mechanism, as previously reported comparing mobile- fixed-bearing (FB) TKA. The present findings also

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contrast a previous study on the MP design that reported initial external tibial rotation followed by internal rotation during a step-up task under fluoroscopy (Miyazaki et al., 2011). The present findings suggest that the MP design does not necessarily encourage greater range of rotational movement during locomotion. Ongoing analysis will confirm these initial findings and examine the hypothesis that the MP design provides a more stable knee that elicits more efficient neuromuscular patterns.