ACL PRESERVING TOTAL KNEE ARTHROPLASTY CAN IMPROVE KNEE STABILITY

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Introduction

Total knee arthroplasty (TKA) is a successful treatment for arthritis of the knee; eliminating pain and typically having a long term survivorship rate of greater than 90%. Despite these good clinical outcomes, dissatisfaction rates among patients can be as high as 20% [Carr, 2012]. The anterior cruciate ligament (ACL) and posterior cruciate ligament (PCL) and the combined ligament function is not adequately mimicked by conventional TKAs, causing instability and an unnatural feeling in the replaced knee which can result in reduced patient confidence, mobility and function. The aim of this study was to assess the surgical feasibility and mechanical performance of a novel TKA which retains the ACL in cases where the ligament is not too severely diseased, and incorporates an ACL reconstruction in cases where the native ACL is not viable. A cadaver study was performed with a prototype design and instrumentation to compare the tibiofemoral kinematics and stability of knees in 4 states: intact; ACL and PCL preserving TKA; conventional TKA (ACL sacrificed); and a PCL preserving TKA with a synthetic ACL. Design modifications were made to the implant and a second round of cadaver testing was conducted.

Methods

Thirteen fresh-frozen cadaver knees were used in 2 cadaveric studies: 9 knees were used in the first study; the remaining 4 were used to test the updated design. A previously developed test method and bespoke kinematics testing rig were used for this study [Kondo, 2011]. The intact knee was initially tested with only a 400 N central quadriceps force and then with various drawer forces and torques applied. When the intact measurements were complete, the bicruciate-preserving TKA was implanted. The test regime was then repeated with the knee in 3 further states: (1) TKA with intact ACL; (2) TKA with resected ACL and (3) TKA with synthetic ACL. The loads and torques used were 50% greater than those used in previous work in order to amplify any differences between the knee states. Tibiofemoral motions between 0° and 110° flexion were recorded using an optical tracking system.

Results

In the first round of cadaver testing, the surgical feasibility of implanting an ACL-retaining TKA and a TKA with a reconstructed ACL was proven. It was shown that anterior laxity was more closely mimicked with the ACL-retaining TKA and the synthetic ACL TKA, than with the conventional TKA. Anterior laxity with the conventional TKA was significantly larger than in the natural knee ($P=0.004$). However, avulsion fracture of the remaining tibial spine was a recurring problem, particularly near full extension. For the second round of testing, the metal tibial tray and UHMWPE inserts were both redesigned with a view to addressing this problem. For the 4 knees that were tested, only 1 experienced a fracture and in the remaining three knees the, ACL-retaining TKA exhibited similar anterior laxity levels to that of the intact knee ($P>0.05$).

Discussion

The concept of a bi-cruciate retaining TKA (either with the native or synthetic ACL) was tested in the first cadaver session and was shown to be a valid approach to restoring pre-osteoarthritic knee stability. However, during this session it became apparent that the bi-cruciate retaining TKA design was altering the native ACL forces and causing the bony eminence on the tibia to fracture in extension. A newly designed tibial plate was manufactured and tested in the second cadaver session and there were fewer problems with balancing the knee, which led to fewer fractures. Further work is now being carried out on the tibial tray and instrumentation to ensure that the knee is properly balanced in flexion and extension and to allow the most natural function in terms of knee kinematics and ligament tensions.

References

Carr, A.J., et al., The Lancet. 379:1331-40, 2012
Kondo, E., et al., AJSM, 39:279-288, 2011.