Does a multi-radius total knee arthroplasty knee function similar to a healthy knee? (A case study)

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Introduction

Currently little is known regarding muscle activation of the knee joint muscles used during the performance of a functional movement for a limb with a multi-radii total knee arthroplasty (MR-TKA). Compared to the normal knee that has only one flexion/extension (F/E) axis located at the trans-epicondylar line (Hollister et al. 1993, Churchill et al. 1998), an MR-TKA has at least two F/E axes, hence more than two radii. For the MR-TKA (S-7000™, Howmedica-Osteonics, Inc.) of this study, the transition from the first F/E axis to the second axis occurs approximately between 30º to 45º of knee flexion. The differences in length of the two radii of rotation of an MR-TKA may cause an abrupt discontinuity in the tension of knee medio-lateral connective tissue during F/E, e.g., collateral ligaments. We surmise that the transition from the longer to the shorter radius of rotation of the MR-TKA may partly explain a common complaint among TKA patients that medio-lateral instability occurs during mid-flexion, e.g., when climbing stairs or rising from a chair. In addition, the locations of the F/E axes of the MR-TKA are anterior to the epicondylar line. Thus, with a shorter quadriceps moment arm, to create equivalent knee extensor muscle torque, the MR-TKA would have to generate more muscle force. Therefore, the purpose of this case study is to determine if the MR-TKA limb functions similar to the non-TKA (N-TKA) limb during the sit to stand (STS) movement.

Methods

The three participants (mean age = 64 yr.; range of post-op time = 4 to 5 yr.) who had a unilateral MR-TKA (S-7000™, Howmedica-Osteonics, Inc.) were prescreened for health and functional status by the surgical group who performed the TKA operations. An 8-channel BTS TELEMG™ system (1000 Hz, bandpass filter: 3 - 600 Hz) was used to collect EMG for the varus medialis (VM), biceps femoris (BF), and the soleus (SOL) muscles for both legs.

Participants performed three trials of the STS while EMG and knee angular data were collected for both legs. RMS EMG (normalized to isometric MVC) was calculated for every 10º interval from 60º to 30º of knee flexion. No statistical analysis was conducted because of the small sample size.

Results

Figures 1, 2 and 3 show the mean RMS EMG of VM, VL and BF.

For the RMS EMG of the MR-TKA limb compared to the N-TKA limb,
(1) VM exhibited greater magnitudes of EMG during 60º to 30º of knee flexion.
(2) BF exhibited less EMG from 50º to 30º of knee flexion.
(3) SOL demonstrated greater EMG for two out of three participants during 50º to 40º of knee flexion.
Discussion

The greater TKA SOL EMG than that of the N-TKA knee exhibited by two participants from 50° to 40° of knee flexion may enhance anterio-posterior knee stability. Dorr et al. (1988) indicated that the SOL muscle of a TKA limb might substitute for the posterior cruciate ligament when sacrificed to stabilized the tibia during a stair descending movement. However, we surmised that the posterior shear force acting on the proximal tibial epiphysis generated by the SOL might assist the anterior cruciate ligament and the hamstring muscles to counteract the anterior shear produced by the quadriceps. Furthermore, the SOL could control tibial stability by producing axial compressive force that pulls the tibia down, thereby stabilizing the tibia about the ankle joint.

In this study, the MR-TKA limb of the participants exhibited less BF and greater VM EMG activity than their N-TKA limb during 50° to 30° and 60° to 30° of knee flexion, respectively. One possible explanation is that the TKA knee extensor: flexor moment arm ratio was less than that of the N-TKA limb. This would require less hamstring force and/or increased quadriceps activity of the TKA limb relative to that of the N-TKA limb to produce the desired net muscle moment. Moreover, the TKA limb may also use the BF to partially compensate for the lack of the anterior cruciate ligament.

References


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