INTRODUCTION

Unicompartmental knee replacements (UKR) are used occasionally to treat knee OA that is confined to either the medial or lateral plateau of the knee, but total knee replacements (TKR), that replace the entire knee joint, are much more common. Advocates of UKR point to a more physiologically functioning joint due to the preservation of both cruciate ligaments, the unaffected opposite compartment and patellofemoral joint, and the removal of minimal bone stock (O'Connor and Goodfellow, 1991; Marmor 1994). The variable success with UKR suggests that the mechanics of implantation and patient selection may be more critical in this procedure than in the TKR (Rand 1996). It is difficult to diagnose unicompartmental OA based on a clinical examination that includes a radiograph of the joint. The final decision to use a UKR is based on direct observation of the joint at the time of surgery. The objective of this study was to determine if pre-operative gait patterns could predict which patients selected for UKR actually received a UKR or a TKR.

METHODS

Twenty-two patients with painful, disabling osteoarthritis of one or both knees were referred to outpatient clinics of two Kingston, Ontario, Canada hospitals for surgical treatment with Zimmer Miller-Galante™ unicompartmental knee prosthesis. Informed consent was obtained from all subjects according to IRB guidelines. All 22 patients were initially diagnosed clinically with unicompartmental knee OA of the medial side, and prescribed to receive unicompartmental knee replacements (UKR). At the time of surgery, ten of the 22 UKR candidates presented more extensive degenerative changes to the lateral compartment of the knee than anticipated and received total knee replacements (TKR).

Three components of knee joint angles, moments and forces were calculated with the QGait gait analysis system (Costigan, 1992) resulting in 9 gait waveforms per subject. The following 4 gait parameters were also considered: velocity, stride length, stance percentage, and stance time. For each subject, the static Hip Knee Ankle (HKA) angle, the standing knee flexion angle, and the medial and lateral condyle joint spaces were measured with QPR, a standardized x-ray technique (Siu, 1991). Body Mass Index (BMI) was also calculated. The full gait cycle data of the 9 waveform gait measures and the 4 constants were simultaneously included in a principal component analysis (PCA). This multivariate statistical technique was used to extract the major features of variation in the original gait data. A subset of features that cumulatively explained at least 90% of the original data variation was retained. A backwards elimination stepwise discrimination procedure was employed to determine the subset of retained features that optimally separated the normal and OA groups of PC scores. A linear discriminant function was defined as a linear combination of the discriminatory features identified with the stepwise procedure. The discriminant function (i) represented the optimal boundary of separation between the two groups of PC scores and (ii) provided the discrimination power of each feature. The most discriminatory PCs were interpreted in terms of the relative contribution of each of the 9 waveforms and 5 constants, and the relative importance of each percentage of the gait cycle.

RESULTS

A stepwise discriminant procedure identified 5 features that optimally separated the UKR group from the TKR group. The misclassification rate was 0%. That is, the discriminant function completely separated the UKR and TKR patients based on their pre-operative data (Figure 1). The most discriminatory feature represented an early swing phase difference in the knee longitudinal rotation moments. Larger internal rotation moments during early swing were associated with the UKR group. The second most discriminatory feature was a multidimensional alignment feature related to the knee adduction moment, the mediolateral joint force, and the hip-knee-ankle angle.

DISCUSSION

The UKR and TKR groups were indistinguishable visibly, clinically, and radiographically, yet the pattern recognition technique employed in this analysis identified features that completely separated the two groups. This indicates that the technique was powerful enough to detect subtle gait pattern differences.

The most discriminatory feature in the gait data had the largest contribution from the longitudinal rotation moment at the knee. Smaller moments were associated with the TKR group. This difference may be attributed to differences in the knee ligament integrity of the two groups. To receive a UKR the patient must have an intact, functional, anterior cruciate ligament. The anterior cruciate ligament produces a moment that restrains the longitudinal rotation moment developed at the knee (Blankenvoort and Huiskes, 1996). With a lack of ligament strength to balance the external moment, TKR patients may employ other gait mechanisms to avoid large longitudinal rotation moments.

The second most discriminatory feature emphasized alignment related gait measures such as the abduction moment, the mediolateral joint force, and the radiographic hip-knee-ankle angle. These measures have been associated with knee OA severity (Hurwitz et al. 2002) which is consistent with the fact that the TKR group would have more severe knee OA. The TKR group had larger adduction moments, larger mediolateral joint forces, and more varus hip-knee-ankle angle.

Further clinical investigation into the biomechanical differences between the pre-operative groups could lead to more accurate diagnosis of unicompartmental knee OA as well as further understanding of the pathomechanics of knee OA.

REFERENCES