GAIT AFTER UNILATERAL TOTAL KNEE ARTHROPLASTY: FRONTAL PLANE ANALYSIS

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INTRODUCTION

Total knee Arthroplasty (TKA) is a common surgical procedure for end stage osteoarthritis (OA). After unilateral TKA, OA progresses in a non-random fashion in which the side contralateral to the operated knee is more likely to show the progression of the disease more than the operated side [1]. This laterality in disease progression suggests that mechanical factors might be involved in the disease progression. Patients after TKA present with altered gait mechanics that either developed after surgery or retained from pre-surgery patterns. The altered gait mechanics may alter the loading on the contralateral side and predispose it to disease progression. The external knee adduction moment is the best predictor of OA progression and can be used as indirect measure of loading in the medial tibiofemoral compartment [2]. Based on that, examining the frontal plane mechanics is important in understanding loading in both limbs in subjects after TKA. The first aim of this study was to compare frontal plane kinematics and kinetics of the operated and non-operated knee in two groups, 6 months and 1 year after unilateral TKA. The second aim of this study was compare the mechanics of both sides in patients with TKA to a healthy control group.

METHODS

Thirty one subjects 6 months after unilateral TKA (10 women, Age 70.03± 7.6y, BMI 31.5±6.3) and forty four subjects 1 year after unilateral TKA (21 women, Age 63.25± 12.4y, BMI 30.5± 4.5) were recruited. The healthy control group consists of 20 subjects (11 women, Age 62.6± 6.5y, BMI 28.8± 5.1) who reported no knee pain or injury. All subjects signed informed consent forms prior to participation. Gait analysis was performed using a three dimensional, 8-camera motion capture system (VICON, Oxford Metrics, London, England) synchronized with two Bertec force platforms (Bertec Corp., Worthington, OH, USA). Spherical retro-reflective markers were placed bilaterally on anatomical landmarks and rigid thermoplastic shells with at least 3 markers were secured on the lower leg and thigh and pelvis. Subjects practiced walking until reaching a constant self-selected speed. The collected trials fell within 5% of the practiced speed with clear contact of only one foot on each force plate. Seven walking trials were collected for each subject and the mean of these trials was used in the analysis. Frontal plane knee joint angles were calculated using rigid body analysis and Euler angles. Joint moments were calculated using inverse dynamics and were expressed as external moments normalized to body mass and height using Visual 3D software (C-motion, Inc, Rockville, MD). Knee adduction impulse was calculated by integrating the knee adduction moment curve during stance phase. Spatial and temporal parameters of gait were also calculated. For the control group, the data of both sides were averaged and the average was used in the analysis. A two-way mixed model analysis of variance (time x side) was used to examine within subjects (operated versus non-operated) and between subjects (6 months versus 1 year) differences in patients with TKA. The operated and non-operated knees of TKA group (6 months and 1 year subjects grouped together) were compared independently with the control group using independent t-test. All statistical analyses were performed with SPSS 16. Significance level was set at 0.05.

RESULTS AND DISCUSSION

Kinematics, kinetics, and temporo-spatial parameters were examined (Table 1). Peak knee adduction moment (PKAM), and knee angle at PKAM showed no time by side interaction, no time effect, but effect of side was significant (P<0.05) with the non-operated knee being more adducted and having larger moment than the operated knee. Knee adduction impulse and stance time showed no
time by side interaction, no effect of side, but effect of time was significant (P<0.03) with the 6 months group having higher impulse and longer stance time. The 6 months group had higher impulse compared to the 1 year group because they spend more time in stance. The operated and non-operated knees have similar impulse but the non-operated knee have higher PKAM suggesting higher loading.

Comparing TKA group to the control group revealed no difference between both the operated and non-operated limbs and controls in knee angle at PKAM, knee adduction impulse, and stance time (P>0.05). The control group had longer step length compared to operated (P=0.006) and non-operated knee (P=0.001) of the TKA group. The control group PKAM was not different from the non-operated limb (P=0.094), but it was higher than operated limb (P=0.001) (Fig.1). Because the control group walked faster than the TKA group (P=0.001), we reanalyzed the PKAM data using one way ANCOVA using speed as a covariate. When controlled for speed, the non-operated knee PKAM was still not different from that of the control group (P=0.57), while the PKAM of the operated knee approached significantly lower values than that of the control group (P=0.056). Looking at the loading of the non-operated knee compared to healthy controls, the data suggests that both groups experience the same total exposure to the adduction moment, as indicated by the impulse data, and the same peak amplitude of the adduction moment. On the other hand, subjects with TKA walked with shorter step length compared to the control group. With shorter step length, TKA group will take more steps to cover the same distance compared to the control group. With increasing the number of steps, the exposure of the TKA group to repetitive loading will increase compared to the control group. The higher repetitive loading of the non-operated knee might explain the predictable progression of OA in that limb. PKAM and impulse data should be interpreted cautiously when there are differences in temporo-spatial parameters.

Figure 1. Average knee adduction moment curve.

REFERENCES


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Table 1: Gait parameters [mean (standard deviation)]; adduction angle is +ve; external adduction moment is -ve.

<table>
<thead>
<tr>
<th>Variable</th>
<th>TKA 6mo Operated</th>
<th>TKA 6mo Non-operated</th>
<th>TKA 1 year Operated</th>
<th>TKA 1 year Non-operated</th>
<th>Control Operated</th>
<th>Control Non-operated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knee Angle (degree)</td>
<td>-0.14 (4.03)</td>
<td>2.65 (5.25)</td>
<td>0.58 (4.55)</td>
<td>2.7 (4.98)</td>
<td>2.26 (4.46)</td>
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<tr>
<td>PKAM (Nm/kg*m)</td>
<td>-0.26 (0.13)</td>
<td>-0.32 (0.14)</td>
<td>-0.28 (0.11)</td>
<td>-0.32 (0.15)</td>
<td>-0.37 (0.14)</td>
<td></td>
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<tr>
<td>Impulse ((Nm/kg*m)*s)</td>
<td>-0.11 (0.05)</td>
<td>-0.12 (0.05)</td>
<td>-0.09 (0.4)</td>
<td>-0.1 (0.05)</td>
<td>-0.12 (0.04)</td>
<td></td>
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<tr>
<td>Stance time (second)</td>
<td>0.7 (0.07)</td>
<td>0.7 (0.07)</td>
<td>0.66 (0.06)</td>
<td>0.66 (0.05)</td>
<td>0.65 (0.06)</td>
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<tr>
<td>Step length (meter)</td>
<td>0.69 (0.08)</td>
<td>0.68 (0.08)</td>
<td>0.69 (0.06)</td>
<td>0.68 (0.06)</td>
<td>0.74 (0.07)</td>
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<tr>
<td>Walking speed (m/s)</td>
<td>1.27 (0.19)</td>
<td>1.31 (0.13)</td>
<td>1.43 (0.14)</td>
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