



Joint kinematics following bi-compartmental knee replacement during daily life motor tasks

J. Leffler^a, L. Scheys^{b,*}, T. Planté-Bordeneuve^c, B. Callewaert^d, L. Labey^b, J. Bellemans^c, A. Franz^a

^a Klinik für Orthopädie und Sporttraumatologie, St. Marien-Krankenhaus, Kampenstraße 51, 57072 Siegen, Germany

^b European Centre for Knee Research, Smith & Nephew, Technologielaan 11 Bis, 3001 Leuven, Belgium

^c Department of Orthopaedic Surgery, University Hospital Leuven campus, Pellenberg, Weligerveld 1, 3212 Lubbeek, Belgium

^d Clinical Motion Analysis Laboratory, University Hospital Pellenberg, Katholieke Universiteit Leuven, Belgium

ARTICLE INFO

Article history:

Received 28 April 2011

Received in revised form 8 April 2012

Accepted 17 April 2012

Keywords:

Bi-compartmental knee replacement

Knee joint kinematics

Stair climbing

Squatting

Turning tasks

ABSTRACT

In many cases knee osteoarthritis leads to total knee replacement surgery (TKR) even if the lateral compartment is not involved. More recently, a bicompartamental knee replacement system (BKR) (Journey Deuce, Smith & Nephew Inc., Memphis, TN, USA) has been developed that only replaces the medial tibiofemoral and the patellofemoral compartments, thus preserving both cruciate ligaments with its associated benefits. However information on the effect of BKR on in vivo knee joint kinematics is not widely available in the literature.

Therefore, this study analyzed full three-dimensional knee joint kinematics in 10 postoperative BKR-subjects for a broad spectrum of relevant daily life activities: walking, walking followed by a cross-over or sidestep turn, step ascent and descent, mild squatting and chair rise. We analyzed to what extent normal knee motion is regained through comparison with their non-involved limb as well as a group of matched controls. Furthermore, coefficients of multiple correlation were calculated to assess the consistency of knee joint kinematics both within and between subject groups.

This analysis demonstrated that, despite the presence of differences indicative for retention of pre-operative motion patterns and/or remaining compensations, knee joint kinematics in BKR limbs replicate, for a large range of daily-life motor tasks, the kinematics of the contra-lateral non-affected limbs and healthy controls to a similar extent as they are replicated within both these control groups.

© 2012 Elsevier B.V. All rights reserved.

1. Introduction

Knee osteoarthritis (KOA) is one of the most common degenerative joint diseases [1,2]. The gait pattern of KOA patients typically shows increased knee adduction moments leading to increased loading of the medial knee compartment [3–5] and therefore a higher prevalence of cartilage damage at the medial compartment, the patellofemoral compartment or a combination of both [1,6].

In many cases KOA leads to total knee replacement (TKR) surgery although the lateral compartment is not involved. In contrast, uni-compartmental knee replacement (UKR) only replaces the medial compartment while retaining the lateral compartment and the cruciate ligaments. In the literature, this is reported to lead to improved proprioception and more natural

knee kinematics after surgery [7,8]. Nevertheless, when strictly adhering to selection criteria, only a low percentage of KOA patients would be eligible for UKA [9]. More recently, a bicompartamental knee replacement system (BKR) (Journey Deuce, Smith & Nephew Inc., Memphis, TN, USA) has been developed that only replaces the medial tibiofemoral and patellofemoral compartments. This system also preserves both cruciate ligaments with its associated benefits [10–13].

A recent study on knee joint mechanics in eight patients with BKR [14] showed that they still demonstrate some compensatory mechanisms but largely exhibit normal kinematics and kinetics. While knee mechanics of UKR and TKR patients have been extensively studied [5], more information on the effect of BKR on in vivo knee joint kinematics is, to the authors' knowledge, not yet available in the literature.

Therefore, the purpose of the presented study was to examine full three-dimensional knee joint kinematics in patients with BKR for a broader spectrum of relevant daily life activities: walking, walking followed by cross-over or sidestep turns, step ascent and descent, mild squatting and chair rise. Through comparison with their non-involved limb as well as a group of matched controls, we

* Corresponding author. Tel.: +32 016 30 14 32; fax: +32 016 30 14 11; mobile: +32 0475 95 69 80.

E-mail addresses: lennart.scheys@smith-nephew.com, lennartscheys@hotmail.com (L. Scheys).

analyzed to what extent normal knee motion is regained following BKR in a group of 10 patients. We hypothesized to find similar results for walking as in the study of Wang et al. [14], but an increased presence of compensatory mechanisms and retention of the pathologic motion pattern for motor tasks associated with higher knee joint loading (e.g. squatting and chair rise). Furthermore, as knee replacement specifically aims at correcting knee alignment in the coronal and axial plane [15], we expected to also find effects on out-of-sagittal plane knee joint kinematics.

2. Materials and methods

2.1. Sample characteristics

Upon ethical approval, ten patients participated in this study after giving informed consent (Appendix 1). Following a diagnosis of localized osteoarthritis in the medial and the patello-femoral compartment with an intact lateral compartment and normal functioning cruciate ligaments, each patient received a Journey Deuce bicompartamental knee replacement (Smith & Nephew Inc., Memphis, TN, USA) at least one year prior to this study. Furthermore, in all patients the non-operated side was screened by the treating surgeon to exclude the presence of any comorbidity that might negatively affect their functional performance during the analyzed motor tasks. As a reference, side-matched kinematic data of a group of 10 control subjects was selected out of the gait lab's normal reference database aiming for subjects that best match each individual patients' sex, age, height and BMI. A physiotherapist performed an additional screening of the control subjects to exclude any condition that could affect their functional performance.

2.2. Motion capture

Kinematic data were obtained using a fourteen camera MX40 motion capture system (Vicon, Oxford, UK) tracking the 3D positions of 23 retro-reflective spherical markers. A single well-trained physiotherapist fixed the markers onto the skin of the lower limbs and trunk according to the Helen-Hayes marker protocol. Although alternative, functional or image-based methods exist for subject-specific joint axis calibration, a Knee Alignment Device (KAD) [16] was used to identify the axis about which tibiofemoral flexion/extension is calculated. As mal-alignment of the knee flexion axis results in crosstalk between sagittal and coronal knee motion [17], the KAD position producing minimal excursion of knee abduction-adduction during the swing phase of walking was selected out of three trials.

Foot contacts were detected with two forceplates collecting at 1000 Hz (Advanced Mechanical Technology, Inc, Watertown, MA, USA). Workstation and Polygon software (Vicon, Oxford, UK) were used to identify motor task events and to derive the kinematics from the acquired data [17–19].

2.3. Motor tasks

Each subject was asked to perform seven different motor tasks, with three repetitions each:

1. Walking: walk straight ahead on a level floor at self-selected speed.
2. Walk and crossover turn: while walking forward, perform a 90° crossover turn, with the pivoting leg over a forceplate, as in [20].
3. Walk and sidestep turn: while walking forward, perform a 90° sidestep turn, with the pivoting leg over a forceplate, as in [20].
4. Step Ascent: step onto and over a 20 cm high step placed over a forceplate, as in [21], and continue straight ahead. The step length and width were 30 cm × 45 cm. Subjects started with toes 20 cm away from the step.
5. Step descent: descend from the same step as in 4 onto the force plate, and continue walking straight ahead.
6. Chair rise: without assistance of the upper limbs, rise from a sitting position into an up-right, full standing position, with feet over separate force plates. Subjects adjusted their own seat height for comfort, starting with approximately 90° knee flexion.
7. Mild squat: squat down to less than 90° knee flexion with both feet over separate force plates, with minimal exertion, and rise back up. Heels can rise off the floor.

For the patient group, both the involved and the non-involved limb were analyzed, while for the control group only one out of both sides was analyzed.

2.4. Data analysis and reduction

Data was extracted using Workstation software (version 5.2.9, Vicon, Oxford, UK) and the Plug-in-Gait model (Vicon, Oxford, UK) [22] following Woltring filtering (MSE = 15). Cycles for gait related tasks (walking and ascent/descent tasks) were time-normalized from initial contact (IC) to IC. CR-cycles were time-

normalized from the moment the upper body began to lean forward till maximal knee extension. Squat cycles were defined between times of maximal knee extension. Further processing of the data was performed in custom-build software (Matlab 7.12.0, The MathWorks, Natick, MA). For each task, corresponding kinematics curves were grouped together in three categories: patient – involved side, patient – non-involved side, controls. Furthermore a set of kinematic and spatio-temporal parameters was calculated [23].

A non-parametric Mann–Whitney *U* test was automatically performed at every percentage of the normalized motion cycles to detect systematic differences between the patients' involved sides and the control group. As a secondary control, non-parametric Wilcoxon signed rank tests were performed comparing between the patients' non-involved and involved sides. Significance level was set for both tests at 0.05, with a Bonferroni correction adjusting for the three repetitions of each motor task. Using the same setup, spatio-temporal parameters were analyzed statistically.

Finally, to analyze and interpret the kinematic consistency between the patient's operated side and their non-operated side as well as controls, both within- and between-group coefficients of multiple correlation (CMC) [18] were calculated. In case of poor kinematic consistency between the operated side and both reference groups, combining kinematic curves from both groups would decrease the homogeneity and therefore result in between-group CMC having lower values than the corresponding within-group CMC [24,25].

3. Results

3.1. Temporal findings

Except for mild squat, post-op subjects systematically performed all motor tasks at a lower cadence when compared to healthy controls, leading to $18.0 \pm 6.9\%$ longer cycle times (Table 1). Furthermore, a shortened stance phase was found at the patients' involved side for walking and step ascent when compared to their non-involved side. Contrastingly, it was prolonged for walking followed by a sidestep when compared to controls (Table 1).

3.2. Kinematic findings

3.2.1. Sagittal plane

When compared to controls (Fig. 1), we found a decreased range of motion (ROM) at the involved side for the stance phases of walking, walking followed by a sidestep and step descent. Although knee flexion during initial contact and loading response was in general very similar with only step descent showing a statistically significant reduction, the change in ROM was mainly caused by decreased (peak) knee extension at mid stance. For walking these effects resulted in a statistically significant increase of the average flexion angle during stance of 2.68° (Table 2).

Table 1

Overview for the different groups of motion cycle times (in s) (top) and timing of foot off, expressed as a percentage of the gait cycle. Significant differences are marked in black text ($p < 0.05/3$).

	Cycle time (s)			% diff
	Controls		Involved side	
Walking	1.00 ± 0.08	<	1.12 ± 0.07	12.0
Walking + cross over	1.50 ± 0.27	<	1.81 ± 0.35	20.7
Walking + sidestep	1.36 ± 0.22	<	1.63 ± 0.25	19.9
Step ascent	1.56 ± 0.28	<	1.74 ± 0.16	11.5
Step descent	1.11 ± 0.12	<	1.22 ± 0.11	10.0
Chair rise	1.30 ± 0.32	<	1.65 ± 0.35	26.9
Mild squat	2.38 ± 0.73		2.98 ± 1.12	25.2
	% cycle at foot off			
	Controls		Involved side	Non-involved side
Walking	59.83% ± 1.64		60.37% ± 1.63	< 61.17% ± 1.49
Walking + cross over	66.07% ± 4.38		68.37% ± 5.20	69.87% ± 4.13
Walking + sidestep	60.87% ± 2.91	<	64.93% ± 3.86	65.37% ± 3.78
Step ascent	70.60% ± 3.15		69.80% ± 2.37	< 71.83% ± 2.66
Step descent	60.83% ± 2.93		62.40% ± 2.94	62.10% ± 3.20

Download English Version:

<https://daneshyari.com/en/article/6207798>

Download Persian Version:

<https://daneshyari.com/article/6207798>

[Daneshyari.com](https://daneshyari.com)