Gait analysis of fixed bearing and mobile bearing total knee prostheses during walking: Do mobile bearings offer functional advantages?

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Key words: Gait, fixed bearing, mobile bearing, total knee replacement, biomechanics

Level of evidence: Level II

Background: Limited previous findings have detailed biomechanical advantages following implantation with mobile bearing (MB) prostheses after total knee replacement (TKR) surgery during walking. The aim of this study was to compare three dimensional spatiotemporal, kinematic, and kinetic parameters during walking to examine whether MBs offer functional advantages over fixed bearing (FB) designs.

Methods: Sixteen patients undergoing primary unilateral TKR surgery were randomised to receive either a FB (n=8) or MB (n=8) total knee prosthesis. Eight age and gender matched controls underwent the same protocol on one occasion. A 12 camera Vicon system integrated with four force plates was used. Patients were tested pre-surgery and nine months post-surgery.

Results: No significant differences between FB and MB groups were found at any time point in the spatiotemporal parameters. The MB group was found to have a significantly reduced frontal plane knee range of motion (ROM) at pre-surgery than the FB group (FB=14.92±4.02°; MB=8.87±4.82°), with the difference not observed post-surgery. No further significant kinematic or kinetic differences were observed between FB and MB groups. Fixed bearing and MB groups both displayed spatiotemporal, kinematic, and kinetic differences when compared to controls. Fixed bearing and MB groups differed from controls in six and five parameters at nine months post-surgery, respectively.

Conclusions: No functional advantages were found in knees implanted with MB prostheses during walking, with both groups indicative of similar differences when compared to normal knee biomechanics following prosthesis implantation.

Introduction

In total knee replacement (TKR) surgery, mobile bearing (MB) prostheses facilitate planar rotation about the vertical axis of the tibia [1] and [2], with a view to reducing sub-surface stress through dual surface articulation at both the superior and inferior surfaces of a polyethylene insert [3] and [4]. Dual surface articulation promotes load sharing between the relative displacements of the tibial and femoral components, dissipating knee moments and shear forces to the surrounding soft tissues in a similar manner to the normal knee [5].

Many theoretical benefits of the MB design, including the improvement in kinematics [5], have yet to be substantiated, with numerous authors documenting no improvements in outcomes when compared to fixed bearing (FB) designs [6], [7], [8], [9] and [10]. The majority of studies comparing FB and MB prostheses have used questionnaire based outcome measures that have been shown to be less sensitive than gait analyses when detecting changes in gait [11]. Gait analysis has been previously used to measure functional outcome following TKR surgery [12], with current systems able to calculate the biomechanics about the knee to a high degree of accuracy, establishing gait analysis as an important tool in the clinical management of knee problems [13].

Previous findings have been inconclusive in the comparison of FB and MB prostheses by means of gait analysis, with four previous authors assessing walking [14], [15], [16] and [17]. The differences in study design, instrumentation, and methods between the studies make it difficult to extract meaningful conclusions. Mockel et al. [16] and Kramers-de Quervain et al. [17] presented results in favour of MB prostheses [5] that warrant further investigation. Mockel et al. [16] found increased stance phase knee flexion in MB knees (14.1°) when compared to FB knees (10.8°), an indication of a more effective shock-absorbing mechanism during loading response [22].

Kramers-de Quervain et al. [17] detailed greater maximum knee flexion during the swing phase of gait in MB knees (52.4 ± 7.56°) when compared to FB knees (47.1 ± 4.74°) in bilaterally implanted TKR patients. A greater maximum knee flexion during swing demonstrates an improved ability for limb advancement and foot-clearance [18], in addition to increasing overall range of motion (ROM) which is an important determinant of functional activity following TKR surgery [19]. The aim of this study was to substantiate these previous limited findings of functional improvement in knees implanted with MB total knee prostheses during walking by means of three dimensional gait analysis.

Patients

Ethical approval was granted by an NHS Regional Ethics Committee. Nineteen patients with late stage primary knee osteoarthritis (OA) were recruited after giving written informed consent for participation. Patients were randomised to receive a FB (Sigma® Fixed Bearing Knee System, DePuy International, Leeds, UK) or MB (Sigma® Rotating Platform Knee System, DePuy International, Leeds, UK) total knee prosthesis. In contrast to a rotating platform where the femoral–tibial bearing surfaces are in substantial conformity from 0 to 60° of flexion, the MB knees in this study use the same multiradius femoral component and hence the femoral–tibial bearing is not in conformity.

Eight patients, five males and three females, received a FB prosthesis and had a mean age of 59.3 ± 8.8 years, height of 1.66 ± 0.09 m, mass of 87.85 ± 16.06 kg, body mass index (BMI) of 31.93 ± 4.86 kg/m^2, and pre-surgery Oxford Knee Score (OKS) of 39 ± 7.64. Eight patients, five males and three females, received a MB prosthesis and had a mean age of 59.6 ± 7.7 years, height of 1.7 ± 0.09 m, mass of 91.21 ± 12.43 kg, BMI of 31.92 ± 6.8 kg/m^2, and pre-surgery OKS of 37.42 ± 5.32. Inclusion criteria were patients between 45 and 80 years of age. Patients were excluded if they had previous hip or knee replacement surgery, gross ligament instability, valgus/varus displacement of ≥ 20°, significant infection of the knee joint post-surgery, or any other significant unrelated lower limb injury or chronic condition that was deemed to have the potential to affect ambulation. Both FB and MB prostheses were posterior cruciate ligament sacrificing, posterior stabilised, and had the patella resurfaced in all cases. One senior orthopaedic surgeon (DK) performed all of the procedures.

Eight age and gender matched asymptomatic participants, five males and three females, who had a mean age of 60.5 ± 7 years, height of 1.67 ± 0.12 m, mass of 72.58 ± 9.43 kg, and BMI of 26.06 ± 1.21 kg/m^2 were recruited as a control group. Table 1 details the demographic and anthropometric parameters of the FB, MB and control groups.

Method

Gait analysis

A 12 camera (T20, Vicon, Oxford, UK) three dimensional motion analysis system (Vicon MX, Oxford, UK) was calibrated through a standard dynamic protocol, exhibiting an image error of < 0.2 mm. Participants had their height and mass taken, along with bilateral leg length, and knee and ankle widths in order to fit the participant's specific dimensions to the lower body ‘Plug in Gait’ model (Vicon, Oxford, UK). Fourteen retroreflective markers (Ø = 14 mm) were placed bilaterally over the anterior superior iliac spine, posterior superior iliac spine, lateral distal third of the thigh, lateral distal third of the shank, lateral malleolus, heel on the calcaneus, and the head of the second metatarsal. Kinematic data were subsequently captured at 200 Hz into Vicon Nexus (1.7.1, Vicon, Oxford, UK).

Four force plates (OR6-7, AMTI, Watertown MA, USA) were embedded within a 7 m walkway and amplified into Nexus at a gain of 1000 (MiniAmp MSA-6, AMTI, Watertown MA, USA), with kinetic data captured at 1000 Hz. Two knee alignment devices ((KADs) Vicon, Oxford, UK) were then placed bilaterally over the medial and lateral epicondyles to independently define the alignment of the knee flexion/extension axis during static capture. These were removed during dynamic trials and two retroreflective markers (Ø = 14 mm) were placed bilaterally over the lateral epicondyles of the knee. The participants undertook a number of barefoot walking trials until three were collected in which the ipsilateral foot contacted a force plate during both initial contact and toe off. Patients were tested pre-surgery and nine months post-surgery.

Data analysis

Raw data were processed in Vicon Nexus by filling marker trajectory gaps using a Woltring quintic spline routine when the gaps were less than 10 frames [25]. Marker trajectories and kinetic data were filtered using a fourth order low pass Butterworth filter with zero lag. A cutoff frequency of 6 Hz and 300 Hz was used for marker trajectories and kinetic data, respectively. The processed data were imported into Polygon Authoring Tool (3.5.1, Vicon, Oxford, UK) to normalise the trials to gait cycle percentage. Moments were normalised to Newton metres per kilogramme of body mass. Discrete kinematic and kinetic variables of the affected knee were processed following data normalisation in Polygon Authoring Tool. Discrete parameters encompassing the maximum, minimum, and range were chosen over continuous waveforms as they have a greater potential to characterise knee gait patterns [20].

Statistical analysis

Normality of distribution was determined by calculating skewness and kurtosis in order to verify the assumptions of the ANOVA parametric tests in PASW Statistics (Version 18, Chicago, IL, USA). Skewness and kurtosis were converted to z-scores. The resultant z-score was indicative of a normal distribution if the magnitude was < 1.96 [21]. A one way repeated measures ANOVA was then undertaken to analyse differences between groups (FB, MB, control) at pre-surgery and nine months post-surgery. Sphericity was assumed if Mauchly's test was not significant ($p > 0.05$). In data where sphericity was not assumed, the violations were adjusted for by using the Greenhouse–Geisser correction. If the ANOVA was significant ($p < 0.05$), post-hoc pairwise comparisons using the Bonferroni method for the adjustment of multiple comparisons were undertaken.

Results

Axial plane kinematic and kinetic parameters were excluded from the results as no differences were found between all groups.

Spatiotemporal

At pre-surgery, reductions were found in the FB group when compared to controls in stride length ($F_{1.46,\ 26.28} = 12.51$; $p < 0.05$) and gait velocity ($F_{1.33,\ 23.92} = 33.18$; $p < 0.05$) (Table 2). Similar findings were apparent in the MB group with a reduction in gait velocity ($F_{1.33,\ 23.92} = 33.18$; $p < 0.05$) and cadence ($F_{1.46,\ 26.21} = 12.72$; $p < 0.05$), and an increase in stride time ($F_{1.27,\ 22.83} = 10.97$; $p < 0.05$) when compared to controls. No significant differences were observed between FB and MB groups.

The FB group walked with reduced stride length ($F_{1.46,\ 26.28} = 12.51$; $p < 0.05$), gait velocity ($F_{1.33,\ 23.92} = 33.18$; $p < 0.05$), and stride time ($F_{1.27,\ 22.83} = 10.97$; $p < 0.05$) when compared to controls at nine months post-surgery. The MB group derived reductions in cadence ($F_{1.46,\ 26.21} = 12.72$; $p < 0.05$) and gait velocity ($F_{1.33,\ 23.92} = 33.18$;$p < 0.05$). No significant differences were observed between FB and MB groups.

Knee kinematic

Reductions were found across both FB ($F_{2,\ 38} = 22.9$; $p < 0.05$) and MB ($F_{2,\ 38} = 22.9$; $p < 0.05$) groups in sagittal ROM when compared to controls at pre-surgery (Table 3). The MB group was found to exhibit a reduced frontal knee

ROM compared to controls ($F_{2, 38} = 9.04$; $p < 0.05$). The MB group was also found to walk with a reduced frontal knee ROM ($F_{2, 38} = 9.04$; $p < 0.05$) than the FB group (FB = 14.92 ± 4.02°; MB = 8.87 ± 4.82°).

The FB ($F_{1.36, 25.82} = 17.51$; $p < 0.05$) and MB ($F_{1.36, 25.82} = 17.51$; $p < 0.05$) groups walked with greater minimum knee flexion angles than controls at nine months post-surgery. The MB group also exhibited a significantly reduced sagittal knee ROM when compared to controls ($F_{2, 38} = 22.9$; $p < 0.05$). No significant differences were observed between FB and MB groups.

Knee kinetic

At pre-surgery, the MB group walked with a reduced maximum knee extension moment than controls ($F_{1.31, 23.49} = 10.95$; $p < 0.05$) (Table 4). This finding was replicated in the maximum knee flexion moment ($F_{2, 36} = 8.26$; $p < 0.05$), with a reduction observed when compared to controls. No significant differences were observed between FB and MB prostheses.

At nine months post-surgery, the FB group walked with a greater knee flexion angle at the incidence of the maximum knee extension moment ($F_{1.51, 27.24} = 7.8$; $p < 0.05$), in addition to a reduced maximum knee adduction moment compared to controls ($F_{1.3, 23.48} = 9.2$; $p < 0.05$). Significance was also reached in the MB group, with the patients walking with a reduced maximum knee adduction moment than controls ($F_{1.3, 23.48} = 9.2$; $p < 0.05$). No significant differences were observed between FB and MB groups.

Discussion

The aim of this study was to compare the three dimensional knee biomechanics of FB and MB total knee prostheses amid the limited previous findings of benefits of MB implanted knees during walking. Concurrent with the previous research [14], [15], [16] and [17], few biomechanical differences were found between FB and MB prostheses. The FB and MB groups could not be distinguished following an adequate period of rehabilitation at nine months post-surgery [12], [22] and [23], with no parameter reaching significance in the spatiotemporal, kinematic, and kinetic results.

The most important finding of the study was that there was no difference in the sagittal plane knee kinematics of the MB group when compared to the FB group. Differences have been previously reported between FB and MB prostheses in kinematic parameters during walking [16] and [17] that provide support for the hypothetical, but largely unsubstantiated, biomechanical advantages of the MB paradigm [5]. The normal knee permits axial rotation, with the lateral femoral condyle contacting anterior to the midline of the tibia in extension [24]. With progressive flexion, the lateral femoral condyle translates proportionally to a position that is posterior to the midline of the tibia. The proposed increase of sagittal knee ROM in MB knees is achieved through this femoral rollback during knee flexion and subsequent internal rotation of the tibia during knee extension [25], similar to the normal knee.

Mockel et al. [16] found that these mechanical advantages elicited a greater mean stance phase knee flexion in MB prostheses when compared to FBs. Further, Kramers de-Quervain et al. [17] detailed an increase in the maximum knee flexion of MB prostheses when compared to FBs. Unfortunately, no pre-operative data were presented for Kramers de-Quervain et al. [17], making it difficult to conclude that the post-surgery differences were representative of a true effect, as differences may have been apparent prior to implantation.

Despite the advantageous findings for MB prostheses, Sosio et al. [15] found no differences in knee flexion at heel contact, maximum knee flexion in stance, maximum knee extension in stance, and maximum knee flexion in swing between FB and MB groups. Tibesku et al. [14] found little mean differences in maximum and ROM in stance and swing, not exceeding that of the 0.5 standard deviation between groups, although the authors did not statistically compare FB and MB groups, but rather analysed the progression from pre-surgery to post-surgery.

A difference was observed at the pre-surgery time point in the current study, with the MB group found to walk with reduced frontal plane knee ROM compared to the FB group at pre-surgery, with both groups otherwise similar. Despite this finding, between-group similarity was compounded with the pre-surgery OKS, with no significant differences between groups (Table 1), and both groups indicative of 'moderate to severe osteoarthritis' (31–40) [26]. The difference in frontal plane ROM was not apparent following surgery, however, suggesting little meaningful difference following rehabilitation.

Although no differences were found between FB and MB groups, refuting the observations of Mockel et al. [16] and Kramers-de Quervain et al. [17], important differences were observed between the FB and MB groups when compared to the controls. Both FB and MB groups walked with a greater minimum knee flexion than controls following surgery, suggesting the presence of a flexion contracture [27]. An increase in knee flexion coupled with the reduction in gait velocity has been suggested to be an associate factor of a 'stiff knee' gait pattern [28].

Interestingly, the suggestion of a flexion contracture was not supported by the kinetic results, with no differences between FB and MB groups in the maximum knee flexion moment when compared to controls. Dorr et al. [29] suggested that reductions in the knee flexion moment are indicative of greater quadriceps and biceps femoris activity. It has been postulated that these mechanisms are adopted to reduce shear forces, or attributed to patterns developed prior to TKR surgery; however, this was not apparent in the current study.

Reductions were found in both FB and MB groups in the maximum knee adduction moment when compared to controls following surgery. Mechanically, reduced knee adduction moments suggest reduced loading of the medial compartment of the knee [1] and [30]. Reductions in ipsilateral knee loading may invoke greater loading in the contralateral knee, with an unequal loading ratio being an important risk factor for OA progression [31].

Fixed bearing and MB groups also walked slower than controls at pre-surgery and post-surgery time points. The FB group walked with a reduced stride length and increased stride time at post-surgery compared to controls, which was not observed in the MB group. The pre-surgery results suggest that the FB group had a reduced stride length prior to surgery, however, somewhat explaining the significant finding following surgery.

This study has a number of strengths. The addition of pre-surgery testing is imperative in validating post-surgery findings. Although useful, it is difficult to make informed clinical decisions from retrospectively designed studies due to the omission of pre-surgery analyses [15] and [17]. We also used the same implant manufacturer with the same femoral components, in addition to both prostheses being posterior stabilised with the patella resurfaced, limiting potential confounding factors. The predominant limitation of the current study is that of a small sample size, although comparable to the previous literature [15] and [17]. A power calculation was undertaken at the investigation outset, which suggested a total sample size of 21, inclusive of the FB, MB, and control groups. We are therefore confident that the results are of sufficient statistical power to distinguish a ‘medium’ effect among groups [32]. A further limitation is that the study only assessed walking. It is possible that MBs may offer advantages in activities requiring greater knee flexion where a FB prosthesis has a limited ability to rotate.

Our results suggest that MB prostheses do not offer any biomechanical advantages over FB designs during walking. Indeed, both groups showed findings indicative of a ‘stiff knee’ gait and decreased medial compartmental loading when compared to controls. Fixed bearing and MB prostheses both differed from controls in six and five parameters at post-surgery, respectively. This suggests that no prosthesis design exhibited conclusive superiority over another with regards to returning normal knee biomechanics.

Acknowledgements

The authors wish to thank De Puy International for providing funding for this study.

Conflict of interest statement

A grant was received from De Puy International providing funding for the study. De Puy International approved the concept and design of the research at the investigation outset, although the company did not have input into the analysis and interpretation of the data, or the decision to submit the work for publication.

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Table 1 – Demographic and anthropometric parameters of the fixed bearing (FB), mobile bearing (MB), and control group

	FB		MB		Control		ANOVA		FB - Control	MB - Control	FB - MB
	Mean	SD	Mean	SD	Mean	SD	*F*	*p*	Sig	Sig	Sig
n	8	-	8	-	8	-	-	-	-	-	-
Male	5	-	5	-	5	-	-	-	-	-	-
Female	3	-	3	-	3	-	-	-	-	-	-
Age (yrs)	59.3	8.8	59.6	7.7	60.5	7	0.046	p = 0.96	-	-	-
Height (m)	1.66	0.09	1.7	0.09	1.67	0.12	0.44	p = 0.65	-	-	-
Mass (kg)	87.85	16.06	91.21	12.43	72.58	9.43	4.73	*****	0.069	*****	0.86
BMI (kg/m^2)	31.92	6.8	31.92	6.8	26.06	1.21	3.86	*****	0.063	0.064	1
OKS (pre-surgery)	39	7.64	37.42	5.32	-	-	0.018	p = 0.89	-	-	-
OKS (three months post-surgery)	25.88	12.18	24.5	9.62	-	-	0.018	p = 0.89	-	-	-
OKS (nine months post-surgery)	19.57	5.65	21.14	9.53	-	-	0.018	p = 0.89	-	-	-

-'OKS' equates to 'Oxford Knee Score'; 'SD' to 'standard deviation'; '*' to 'significant at the 0.05 level'

Table 2 - Fixed bearing (FB), mobile bearing (MB), and control participant between group differences of spatiotemporal parameters at pre-surgery, three months post-surgery, and nine months post-surgery

		FB		MB		Control		ANOVA		FB - Control			MB - Control			FB - MB		
		Mean	SD	Mean	SD	Mean	SD	*F*	*p*	Mean dif	SE	*p*	Mean dif	SE	*p*	Mean dif	SE	*p*
Pre-surgery	Cadence (steps/min)	100.55	22.40	89.60	9.64	120.38	14.07	12.72	*	19.83	8.51	0.1	30.78	8.88	*	10.95	9.14	0.74
	Foot off (gait cycle %)	61.17	4.02	60.08	1.49	60.54	1.21	2.76	0.083	-	-	-	-	-	-	-	-	-
	Stride length (m)	1.05	0.15	1.13	0.20	1.30	0.10	12.51	*	0.24	0.078	*	0.17	0.08	0.16	0.077	0.08	1
	Stride time (s)	1.25	0.31	1.32	0.17	1.01	0.11	10.97	*	0.24	0.11	0.11	0.31	0.11	*	0.071	0.12	1
	Gait velocity (m/s)	0.89	0.26	0.87	0.20	1.29	0.11	33.18	*	0.4	0.1	*	0.43	0.11	*	0.021	0.11	1
Nine months post-surgery	Cadence (steps/min)	101.23	16.87	96.3	10.08	120.38	14.07	12.72	*	19.15	7.32	0.05	24.08	7.64	*	4.93	7.87	1
	Foot off (gait cycle %)	63.08	1.79	61.57	0.80	60.54	1.21	2.76	0.083	-	-	-	-	-	-	-	-	-
	Stride length (m)	1.11	0.13	1.23	0.09	1.30	0.10	12.51	*	0.18	0.056	*	0.071	0.06	0.71	0.11	0.06	0.23
	Stride time (s)	1.25	0.25	1.23	0.12	1.01	0.11	10.97	*	0.24	0.089	*	0.22	0.09	0.08	0.017	0.1	1
	Gait velocity (m/s)	1.01	0.21	1.00	0.12	1.29	0.11	33.18	*	0.28	0.08	*	0.29	0.08	*	0.01	0.09	1

'SD' equates to 'standard deviation'; 'Mean dif' to 'mean difference'; 'SE' to 'standard error'; '*' to 'significant at the 0.05 level'

Table 3 - Fixed bearing (FB), mobile bearing (MB), and control participant between group differences of knee kinematic parameters at pre-surgery, three months post-surgery, and nine months post-surgery

		FB		MB		Control		ANOVA		FB - Control			MB - Control			FB - MB		
		Mean	SD	Mean	SD	Mean	SD	*F*	*p*	Mean dif	SE	*p*	Mean dif	SE	*p*	Mean dif	SE	*p*
Pre-surgery	Min knee flexion (°)	12.90	10.24	13.18	10.50	6.18	3.16	17.51	*	6.72	4.38	0.42	7	4.38	0.38	0.27	4.52	1
	Max knee flexion (°)	54.75	10.67	54.77	9.85	64.16	2.74	2.99	0.06	-	-	-	-	-	-	-	-	-
	Sagittal knee ROM (°)	41.85	9.080	41.59	8.38	57.97	3.73	22.9	*	16.13	3.78	*	16.38	3.78	*	0.25	3.91	1
	Max knee abduction (°)	-6.53	14.09	-3.53	10.34	-7.11	7.58	1.98	0.17	-	-	-	-	-	-	-	-	-
	Max knee adduction (°)	8.39	13.53	5.34	11.70	7.41	5.83	4.85	*	0.97	5.51	1	2.07	5.51	1	3.05	5.70	1
	Frontal knee ROM (°)	14.92	4.02	8.87	4.82	14.52	3.39	9.04	*	0.39	2.11	1	5.66	2.11	*	6.05	2.18	*
Nine months post-surgery	Min knee flexion (°)	14.53	5.26	16.99	4.45	6.18	3.16	17.51	*	8.35	2.24	*	10.81	2.24	*	2.46	2.31	0.9
	Max knee flexion (°)	64.01	4.02	63.79	7.75	64.16	2.74	2.99	0.06	-	-	-	-	-	-	-	-	-
	Sagittal knee ROM (°)	49.48	6.62	46.79	9.41	57.97	3.73	22.9	*	8.5	3.55	0.08	11.18	3.55	*	2.68	3.66	1
	Max knee abduction (°)	-13.94	12.94	-11.08	6.57	-7.11	7.58	1.98	0.17	-	-	-	-	-	-	-	-	-
	Max knee adduction (°)	1.82	11.93	-1.64	4.89	7.41	5.83	4.85	*	5.59	4.17	0.59	9.06	4.17	0.13	3.47	4.31	1
	Frontal knee ROM (°)	15.77	7.03	9.43	2.22	14.52	3.39	9.04	*	1.25	2.40	1	5.09	2.40	0.14	6.34	2.47	0.06

‘SD’ equates to ‘standard deviation’; ‘Mean dif’ to ‘mean difference’; ‘SE’ to ‘standard error’; ‘*’ to ‘significant at the 0.05 level’

Table 4 - Fixed bearing (FB), mobile bearing (MB), and control participant between group differences of knee kinetic parameters at pre-surgery, three months post-surgery, and nine months post-surgery

		FB		MB		Control		ANOVA		FB - Control			MB - Control			FB - MB		
		Mean	SD	Mean	SD	Mean	SD	*F*	*p*	Mean dif	SE	*p*	Mean dif	SE	*p*	Mean dif	SE	*p*
Pre-surgery	Max knee ext. moment (Nm/kg)	-0.28	0.15	-0.25	0.043	-0.39	0.047	10.95	*	0.11	0.047	0.08	0.14	0.05	*	0.026	0.051	1
	Max knee flx. moment (Nm/kg)	0.54	0.35	0.49	0.29	0.96	0.30	8.26	*	0.42	0.16	0.05	0.47	0.17	*	0.048	0.17	1
	Knee flx at max ext. moment (°)	13.96	10.28	14.80	10.92	11.00	3.89	7.8	*	2.97	4.46	1	3.8	4.65	1	0.83	4.79	1
	Knee flx at max flx. moment (°)	26.73	11.59	24.38	8.79	25.52	5.57	0.4	0.61	-	-	-	-	-	-	-	-	-
	Max knee ab. moment (Nm/kg)	-0.13	0.19	-0.06	0.05	-0.11	0.04	0.03	0.98	-	-	-	-	-	-	-	-	-
	Max knee add. moment (Nm/kg)	0.44	0.13	0.40	0.17	0.46	0.13	9.2	*	0.019	0.073	1	0.058	0.076	1	0.039	0.078	1
Nine months post-surgery	Max knee ext. moment (Nm/kg)	-0.38	0.12	-0.34	0.097	-0.39	0.047	10.95	*	0.011	0.047	1	0.058	0.049	0.75	0.047	0.051	1
	Max knee flx. moment (Nm/kg)	0.75	0.40	0.73	0.25	0.96	0.30	8.26	*	0.21	0.17	0.67	0.24	0.18	0.59	0.022	0.18	1
	Knee flx at max ext. moment (°)	17.65	6.41	17.22	3.60	11.00	3.89	7.8	*	6.65	2.49	*	6.22	2.60	0.08	0.43	2.68	1
	Knee flx at max flx. moment (°)	27.92	9.50	22.20	4.95	25.52	5.57	0.4	0.61	-	-	-	-	-	-	-	-	-
	Max knee ab. moment (Nm/kg)	-0.10	0.04	-0.13	0.07	-0.11	0.04	0.03	0.98	-	-	-	-	-	-	-	-	-
	Max knee add. moment (Nm/kg)	0.30	0.08	0.26	0.11	0.46	0.13	9.2	*	0.16	0.056	*	0.19	0.059	*	0.038	0.061	1

'SD' equates to 'standard deviation'; 'Mean dif' to 'mean difference'; 'SE' to 'standard error'; '*' to 'significant at the 0.05 level'