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Gait kinetics of total hip replacement patients—A large scale, long-term follow-up study

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ABSTRACT

Background: It is not known if lower limb gait kinetics of total hip replacement (THR) patients reach normal levels at long term follow-up post-operatively.
Methods: Three-dimensional gait analysis was performed on 134 THR patients with identical implants 10-years post-operatively. Lower limb moments and powers were compared between different age strata (54–64 years, 65–69 years, 70–74 years, 75–79 years and over 80 years) and a normal elderly control group.
Results: Hip extensor moment and hip power generation were significantly reduced in all age groups compared to normal. External hip rotation moment was significantly reduced in all age groups, apart from the youngest group, compared to normal. However, in contrast to previous short term follow-up studies there was no significant difference in hip abduction moment between any of the age groups and the normal group.
Conclusion: This large cohort study shows that, at long term follow-up following THR, some hip joint kinetics (hip extensor and external rotation moments and hip power generation) do not reach normal levels, but that peak abduction moment is preserved. THR patients recovery could potentially benefit from intensive rehabilitation focusing on hip extension and external rotation in the post-operative, and perhaps preoperative, period.

1. Introduction

Total hip replacement (THR) is one of the most successful surgical procedures with over 80,000 performed annually in the UK and demand expected to increase [1,2]. THR provides effective pain relief and improved functional ability postoperatively [3]. Although gait patterns generally improve following THR they usually do not achieve levels comparable to normal age-matched subjects [4–10]. Previous studies of THR patients immediately postoperatively, or at short-term follow-up, report lower-limb moments and powers significantly different to controls [4,5] with peak hip abduction and external rotation moments significantly reduced [7,9–12]. This study aims to report age-stratified gait kinetics of a large cohort of THR patients receiving an identical implant at single institution 10-years post-operatively and compare moments and powers to elderly controls and across age-stratified groups.

2. Methods

2.1. Patient details and surgical procedure

All patients had unilateral THR surgery under the senior author (DEB) using an identical implant (Orthogensis custom X-press stem (DePuy International, Leeds, UK) and Elite cup (DePuy International, Leeds, UK)) using a posterior surgical approach at a single site between August 1992 and July 1996. Patients were recruited from routine 10-year review clinics. Exclusion criteria included other orthopaedic procedures (e.g. knee or ankle replacement), and lower limb pain. All replacements were primary arthroplasties (i.e. none were revision arthroplasties). The local Research Ethics Committee provided ethical approval (Reference number: 253/02) and all participants provided informed, written consent. Ten normal elderly subjects were tested as controls.

Three-dimensional lower limb gait analysis was captured at 120 Hz using a 6-camera Vicon 612 system. Anatomical landmarks associated with the Helen-Hayes model [13] were identified using 14 mm retro-reflective markers. Both THR patients and normal subjects walked at self-selected speed along a central walkway

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with a minimum of 3 trials captured and a single representative trial used for analysis. Gait events (i.e. heel contact, toe off) were determined using thresholding of ground reaction force data from instrumented force plates (AMTI, Watertown, MA).

2.2. Statistical analysis

Temporospatial variables were velocity, step length, double-support and stance phase duration. Kinetic variables were hip flexor/extensor, ab/adduction and internal/external rotation moments, knee flexor/extensor moment, ankle dorsi/plantarflexion moment and hip, knee and ankle powers. Differences between age-stratified groups were tested with one-way ANOVA and Tukey's test (variables with equal variance) or Tamhane's test (variables with unequal variance). A p-value < 0.05 was considered significant. Analysis was performed using SPSS 19.0 (IBM Corp, Armonk, NY).

3. Results

139 patients were recruited and reviewed at average 9.9 years post-operation (9.0–11.1 years). Due to excessive cross-talk between knee varus/valgus signal and knee flexion/extension signal five patients were excluded [14]. Patients were stratified in five age groups, 54–64, 65–69, 70–74, 75–79 and 80 years and over. Patient and normal elderly group details are shown in Table 1.

3.1. Temporospatial variables

All groups displayed reduced walking speed and step-length compared to normal, with the oldest group (Group 5) having significantly reduced walking speed and step-length compared to the youngest group (Group 1) (Table 2). Although double-support time was greater for all groups compared to normal, with greatest times for the oldest group, these differences were not significant (Table 2). Similarly, while stance-phase duration was greater for all groups relative to normal, with the greatest percentage (64.5%) for the oldest group, (60.9%), these differences were not significant.

3.2. Moments

All groups showed significantly reduced peak hip extensor moment (HE) compared to normal and Group 3 significantly less than Group 2. There was no difference in peak hip flexor moments in stance (HF1) or swing (HF2) between any group and normal. There was no difference in peak hip abductor moments (HA1 and HA2), between any group and normal. Peak external hip rotation moment was significantly reduced in all age groups, except the youngest group, compared to normal, with the oldest group having the lowest rotation moment (Fig. 1(a)–(c), Table 3). Although peak internal hip rotation moment was reduced for all groups compared to normal, these differences were not significant except for the youngest THR group. There was no significant difference in peak internal rotation moment between age groups.

Peak knee flexion moment was significantly reduced compared to normal for all groups except Group 2, with no difference between age groups. There was no significant difference in peak knee extension moment in mid-stance between any of the age groups and normal apart from the oldest group. Peak ankle dorsiflexion moment was significantly reduced compared to normal in Groups 3, 4 and 5 (Table 3, Fig. 1(e)).

3.3. Powers

All groups had significantly reduced hip power generation at late stance/push-off relative to normal (Fig. 2(a), Table 3) with no significant differences between groups. Although peak hip power absorption was reduced in all groups relative to normal, these differences were not significant, apart from the oldest group (Fig. 2(a), Table 3). Peak knee power absorption in early stance was significantly reduced for all groups except the youngest (Group 1). Peak knee power generation in stance was significantly reduced for groups 2, 4 and 5 compared to normal. Peak ankle power was significantly reduced for Groups 3, 4 and 5 compared to normal and for group 5 relative to groups 1 and 2 and group 4 relative to group 1 (Table 3).

4. Discussion

Previous studies report that, following THR, certain hip kinetics, such as hip abduction and external hip rotation moments and sagittal hip power generation, were significantly reduced compared to normal, while others, like hip extension moment, were not [4,5,7–12]. In our study hip extension moment was significantly reduced in all groups relative to normal with similar patterns across age groups and no difference between oldest and youngest groups. This contrasts with previous studies which report no difference in peak hip extension moment relative to normal. In a systematic review Kolk et al. reports that, in 9 of 11 studies, there was no difference in peak hip extension moment compared to normal [5] with only one study reporting significantly reduced hip extension moments [9]. Reduced hip extension moments exhibited by all age groups is probably due to reduced hip extension in stance, a key feature following hip replacement [6]. Gait patterns developed due to preoperative pain causes muscle shortening (e.g. hip flexors), and muscles atrophy (e.g. gluteals) [15] with associated impact on hip extensor function. It is possible that short-term improvement in hip extensor function occurs post-operatively with subsequent, longer term loss of function. However, it is more likely that lack of reports of reduced hip extensor moment following THR are due to study design characteristics (e.g. small sample size, multiple confounding factors etc.). Our study found hip extensor moment does not return to normal at long-term follow-up. This reinforces the need to improve hip extension during patient rehabilitation.

External rotation moment in late stance was significantly reduced in all THR groups, except the youngest group, compared to normal, with the oldest group having the lowest rotation moment (Fig. 1(c), Table 3). Reduced postoperative external rotation

Table 1
Patients details for the age-stratified groups and details of the normal elderly group tested.

Group	Age strata	Number of patients	Gender (M:F)	Age (years) [SD]	Period post-op
1	54–64	29	11:18	61.35 [3.10]	9.89 [0.40]
2	65–69	18	10:8	67.44 [1.32]	9.83 [0.30]
3	70–74	44	31:13	72.42 [1.37]	9.92 [0.42]
4	75–79	30	19:11	76.85 [1.34]	9.96 [0.31]
5	>80	13	5:8	84.06 [3.64]	10.01 [0.12]
Elderly Normal		10	6:4	64.0 [3.6]	n/a