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Original Article

Gait analysis and hip extensor function early post total hip replacement

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ABSTRACT

Objective: The purpose of this study was to systematically evaluate the sagittal kinematic and kinetic gait patterns in patients in this early post-operative period, to describe them and to better understand the deficiencies in that gait pattern that may help to develop targeted rehabilitation strategies.
Methods: This study evaluated early gait patterns in 10 patients with isolated unilateral hip osteoarthritis who were post-operative for total hip replacement. Kinetic and kinematic assessments – focusing on sagittal plane abnormalities – were performed at 2 weeks pre-operatively and 8 weeks post-operatively.
Results: Our results demonstrated that while clinical scoring for pain and functional ability significantly improved post-operatively, as did clinical assessment of range of motion passively, this did not translate to the degree of dynamic improvement in gait. Step length and stride length did not improve significantly. Lack of hip extension in terminal stance associated with excessive anterior pelvic tilt persisted and was associated with a worsening in hip extensor power post-operatively.
Conclusion: Based on our results, post-operative rehabilitation programmes should include extensor muscle exercises to increase power and to retain the operative gain in passive range of motion, which would help to improve gait patterns.

1. Introduction

Osteoarthritis (OA) of the hip causes alteration in normal kinematic patterns – particularly in the sagittal plane.[1,6,7,9] This may be primarily due to pain, a decreased range of motion because of contractures or a combination of both. Total hip replacement surgery (THR) is one of the most successful surgeries, and provides symptomatic relief for patients with painful osteoarthritis.[2–4] Despite this huge gain in functional ability and a subjective improvement in walking ability, gait patterns in patients undergoing THR improve, but rarely achieve normality.[5–7,10] Many gait analysis studies have shown that gait patterns remain abnormal in the long term and are comparable to pre-operative gait.[9,12,17–19] Foucher et al. demonstrated that pre-operative gait parameters were strong predictors of some post-operative gait parameters.[8] Range of motion was improved following THR, but in many cases remained less than normal. It is important to note that hip flexion contractures, with resultant loss of hip extension, have been shown to recur up to 1 year after total hip replacement, and is probably due to a combination of factors, e.g. persistent muscle weakness, scar tissue formation and learned gait patterns though the exact pathogenesis is unknown.[10,11,29] Recent outcome studies have shown that post-operative range of hip motion correlates strongly with functional outcome.[35,36] The purpose of this study was to systematically evaluate the sagittal kinematic and kinetic gait patterns in patients in this early post-operative period, to describe them and to better understand the deficiencies in that gait pattern that may help to develop targeted rehabilitation strategies.

2. Methods

2.1. Patient selection and procedure

Inclusion criteria for the study were patients with isolated unilateral painful hip osteoarthritis, with no significant medical problems (ASA grade I & II) who were awaiting a total hip replacement in Adelaide and Meath, incorporating the National Children's Hospital (AMNCH) Tallaght.[32,34] Exclusion criteria

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included patients with: contralateral hip pathology, contralateral hip replacement, knee pathology, neurological impairment of the lower limbs, leg length discrepancy in a lower limb segment other than the pathological hip and fixed spinal deformity, as these factors would all have an affect on gait independent of hip pathology. Case notes for all patients on the AMNCH waiting list were reviewed and all patients who met the inclusion/exclusion criteria were invited to participate. A cohort of ten patients were identified and contacted. Participation was voluntary, and informed consent was obtained in each case.

Patients were assessed 2 weeks pre-operatively and 8 weeks post-operatively over a 4-month period. A thorough clinical examination was conducted, using a goniometer to determine joint range of motion for all lower limb joints and presence of contractures. Manual muscle strength testing was also tested and documented (strength classified on the Medical Research Council Scale, graded 0 = no contraction to 5 = normal).[33] Radiological examination included AP pelvis X-ray to determine grade of OA using Kellgren and Lawrence scale, and CT scanography to accurately measure for any leg length discrepancy.[12] Self-assessment questionnaires were completed to give an objective measure of function – SF-36v2 and Harris Hip Score (HHS).[34]

Three-dimensional lower limb gait analysis was performed in the Gait Laboratory Central Remedial Clinic (CRC), Clontarf using 3 CODA MPX30 motion analysers (Charnwood Dynamics Limited, Leicestershire, England). Twenty-four surface mounts, consisting of markers in each three-dimensional plane (coded LEDs) were applied to the bony sites of each of the lower limbs, according to the Bell Hip model, which allows markers to be seen laterally.[13] Markers were applied by the same investigator pre- and post-operatively. The pre-calibrated system captures the infrared light signal sequence from these markers, at a frequency of 200 Hz as the patient walks on a 20 m walkway. Patients were requested to refrain from using analgesics on the day of the assessment. Static and dynamic foot forces were recorded using Kistler piezo-electric footplates, embedded in the walkway (Kistler Instruments Ltd.) and subsequent joint forces and moments were calculated using inverse dynamic equations. Kinematic and kinetic patterns of the pelvis, hip, knee and ankle joints of the lower limbs were therefore assessed. Measuring three successive gait cycles to improve the accuracy and objectivity of the measurements by ensuring reliability and determining repeatability for each patients specific gait pattern minimized variability in the group. Data from a single representative cycle was retrieved for each patient and results produced were intra-subject ensemble averages.

All patients had THR surgery performed through an antero-lateral approach with half receiving a cemented Charnley THR (*DePuy*™) and half an uncemented Plasma cup/Bicontact stems (*Braun Aesculap*™).

Post-operatively, the patients received focused orthopaedic physiotherapist and were also instructed on a home exercise programme to include joint ROM exercises and abductor muscle strengthening. The patients were reassessed clinically and radiologically and self-assessment forms were repeated. Gait analysis was repeated and the results compared to assess the changes in the kinematic and kinetic patterns following total hip replacement. The results were further compared to a database of age- and sex-matched controls.

2.2. Statistical analysis

Paired *t*-tests were used to test for differences between pre-operative and post-operative variables for the affected and unaffected limbs. Statistical analyses were performed using SPSS1 13.0. *P* values <0.05 were considered significant.

3. Results

3.1. Patient demographics

The mean age was 55.4 (43–71), M:F 1:1 and mean BMI 27.1 (range, 22.7–31.8). Nine out of ten patients had moderate/severe OA in their affected hip (Table 1). The ten patients fully completed all aspects of the study, and there were no post-operative complications that may have affected the results. Repeat post-operative assessments were performed at 8 weeks, and all patients were independently mobile at that stage. Post-operative leg length discrepancy ranged from −26 mm to +5 mm, with a mean of −2.5 mm.

3.2. Functional outcome scoring

Table 2 shows the functional scores. There was a statistically significant improvement in mean functional outcome based on physical component of SF-36v2 scoring, and for the components of pain, function and range on motion, but not deformity on Harris Hip Scoring.

3.3. Clinical range of motion

Pre-operatively, there was marked decreased range of motion in the affected hip of all patients (Table 3). Nine of the ten patients had a fixed flexion deformity (FFD) contracture pre-operatively. Mean −15° (−4° to −30°). In all patients post-operatively there was no fixed flexion contracture apparent on clinical examination, and all could achieve active hip extension to neutral, at least (Table 3). This improvement was statistically significant ($p = 0.0001$).

3.4. Temperospatial parameters

Pre-operatively the walking velocity, cadence and step length were all reduced, compared to normal ranges. Though there was

Table 1
Radiological grade of OA.

Kellgren & Lawrence grade	1	2	3	4
No of patients	1	1	6	2

Table 2
Mean functional scores.

	Pre-operative mean score	Post-operative mean score	Change in mean score	*P* value
SF-36 v2 – PCS[a]	35.05	50.06	15.01	<.001
SF-36 v2 – MCS[b]	49.7	55.67	5.97	.10
Harris Hip Score	60.71	89.9	29.2	<.001
Pain	23	43.2	20.2	<.001
Function	31.5	38.5	7	.002
Deformity	2.8	3.6	0.8	.17
Range of motion	3.31	4.58	1.27	.002

[a] Physical component score.
[b] Mental component score.

Table 3
Analysis of range of motion results affected hip.

	Pre-operative mean	Post-operative mean	*P* value
Hip extension (°)	−15.0	1.80	<.001
Hip flexion (°)	82.7	94.3	.002
Hip internal rotation in flexion (°)	1.7	10.6	<.001
Hip external rotation in flexion (°)	6.7	21.6	<.001
Hip abduction (°)	14.71	19.85	.05
Hip adduction (°)	6.01	15.20	<.001

$P < .05$ with 95% CI.