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The use of the Gait Deviation Index for the evaluation of participants following total hip arthroplasty: An explorative randomized trial

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ABSTRACT

Introduction: In this paper, the Gait Deviation Index (GDI) was used as a convenient method to evaluate pre-to-postoperative gait pattern changes after total hip arthroplasty and identify factors which might be predictive of outcome.
Design: Three-dimensional gait data from a randomized clinical trial was used to determine changes in gait quality in participants walking at self-selected speed. Upon completion of the first assessment, the participants were randomly assigned to either resurfacing hip arthroplasty or conventional hip arthroplasty. The outcome was changes in overall gait 'quality' measured with GDI during the 6-month post-surgery follow-up period.
Results: 38 participants with severe unilateral primary hip osteoarthritis took part in the trial. We found no difference in change scores between the two treatment groups; 1.9 [95%CI: −0.3 to 4.0] or between change scores for the non-operated and the operated limbs; 0.3 [95%CI: −2.3 to 1.7]. However, the score for the two groups (pooled data) improved after surgery by 4.4 [95%CI: 1.8–7.0]. The single level regression analysis identified the preoperative GDI score as a strong predictor of outcome ($p < 0.001$).
Conclusion: Six months after surgery, there was no additional effect of resurfacing hip arthroplasty on GDI scores compared with conventional hip arthroplasty. Participants with the most pathological preoperative gait pattern improved the most. The GDI increased, which indicates an overall improvement in gait pathology after surgery.
Trial registration: NCT01229293

1. Introduction

Osteoarthritis (OA) is the leading cause of disability in adults, and hip OA accounts for much of this burden. It causes pain, gait abnormalities, and functional impairments. The prevalence of hip OA (Kellgreen/Lawrence grade ≥2) was reported as high (20–27%) from the age 45 [1–3] and the estimates of the prevalence of symptomatic hip OA was 4–10% [1–3]. Age and sex-standardized incidence rates of radiographic OA in individuals aged ≥20 is 88 per 100.000 person years [3]. Both incidence and prevalence will increase in the coming years due to the aging of the population [4].

Total hip arthroplasty (THA) is a well-accepted treatment for severe hip OA, and it is considered as one of the most successful orthopedic procedures [5,6]. In the past half-century, there have been improvements in implant technologies. Despite these advances, debate remains as to the superiority of any prosthetic concept. The ideal concept would minimize postoperative pain; restore hip joint function and improve quality of life. In most clinical studies, function is evaluated using performance-based activities such as short and long distance walking and stair negotiation [7], or self-reported questionnaires [8]. Although, such measures provide information about function, they fail to provide insight into the mechanics of movement seen with use of three-dimensional gait analysis (3DGA).

The complexity and volume of data generated by 3DGA, however, presents challenges during interpretation. Isolated hip

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kinematics after surgery shows patients walk with reduced hip adduction and extension angles [9–11] but is the overall gait performance affected? Simplifying 3DGA into a single measure of overall gait 'quality' would be of great valuable in clinical practice and using kinematics across the entire stride would remove most of the subjectivity involved in choosing valid gait parameters. The Gait Deviation Index (GDI) has been proposed as a single score that summarizes the overall 'quality' of the patient's kinematics during gait [12,13]. The GDI compares nine kinematic variables of a subject's gait against those of a reference group; this requires kinematics from the pelvis and hip in all three planes, the knee and ankle in the sagittal plane and foot progression. In addition to being simple, a valid index should be able to judge the overall severity of a condition affecting gait, be able to detect progress (change pre- vs. post-treatment), and evaluate the outcome of an intervention prescribed to improve the gait pattern. GDI appear to be such a general measure of gait pathology across pathologies and interventions.

Most published studies on summary measures describe the origin and construction of the particular index [12–20]; only a limited number focus on practical and clinical use [21–25] including children with cerebral palsy [26,27]. Thus, the purpose of this study was to quantify pre-to-postoperative gait changes after two types of THA using GDI and identify factors which might be predictive of outcome.

2. Materials and methods

2.1. Design

This trial complied with CONSORT (Consolidated Standards of Reporting Trials) guidelines [28], and was designed as a prospective, blinded, parallel-group, superiority trial, with balanced randomization [1:1]. The present gait analysis data represent secondary outcomes measures from a randomized controlled trial [29].

2.2. Participants

Forty-three participants were recruited from the Department of Orthopedics, Odense University Hospital, Denmark and had surgery from April 2007 to March 2009. The inclusion and exclusion criteria are listed in Table 1. Participants were able to walk independently without walking aids, were clinically and radio graphically evaluated preoperatively and diagnosed with end-stage hip OA. The clinical evaluation involved assessing hip joint mobility, and asking the patients about their perceived level of pain (at rest and during activity). The radio graphical evaluation involved assessing the degree of joint space narrowing [30], subchondral sclerosis, cyst- and osteophyte formation. The indication to offer total hip replacement was determined by surgeons not involved in performing the actual surgical procedures and otherwise not involved in the present study. The primary indication for surgery was pain relief and restoration of function, with improvement in gait being a secondary benefit. Twenty age-matched, able-bodied adults were recruited from a sample of convenience to provide reference group kinematic data. The trial complied with the Helsinki Declaration and was approved by the local Ethical Committee. Informed consent was obtained prior to participation.

Table 1
In- and exclusion criteria for the participants in the study.

Inclusion criteria	Exclusion criteria
Primary OA	Osteoporosis (*T*-score < 2.5 SD of the average bone density in the lumbar spine or proximal femur)
Secondary OA due to mild dysplasia	Severe acetabulum dysplasia (AP center edge < 15°)
40–65 years	Femur anteversion > 25°
	Femoral head deformity
	BMI > 35
	Leg-length discrepancy > 1 cm
	Hip joint offset problems
	Earlier fracture of the ipsilateral proximal femur
	Rheumatoid arthritis
	Neuromuscular or vascular disease

OA, osteoarthritis; AP, anterior-posterior; BMI, body mass index.

2.3. Randomization

The participants were assigned to either resurfacing hip arthroplasty (RHA) or conventional hip arthroplasty (THA) based on lots drawing using sealed envelopes and block randomization.

2.4. Surgical procedure

The full technical details of the surgical procedures have been described previously [29]. In brief, a posterior-lateral approach was used by two senior consultant orthopedic surgeons specialized in hip surgery. The two surgeons had comparable experience levels and solid experience with each of the two procedures. To minimize systematic bias, both surgeons received extensive RHA training together at certified centers, operated 30+ patients using the RHA approach, all prior to the study initiation, and both surgeons performed an equal number of procedures in each treatment group during the study. The RHA participants received a high-carbon cobalt–chromium alloy head mean size 51.8 mm and cup mean size 58.1 mm (ASR®, DePuy). The cup was press-fitted while the femoral component (ASR®, DePuy) was cemented (SmartSet® GHV Bone Cement). THA participants received a 28-mm ceramic head (Ceramtec) on a titanium Bimetric stem (Biomet®) with a Mallory-Head cup and polyethylene liner (Biomet®).

2.5. Gait data collection

3DGA data was collected using a six-camera motion capture system (Vicon MX03, Oxford, UK), the Helen Hayes marker set and PluginGait [31,32]. The participants walked at a self-selected speed. Data from at least three left and right strides for each participant at each visit were collected. The able-bodied participants completed an identical capture protocol. Consecutive force plate strikes of the left and right foot were acquired where possible, but single foot strikes were also allowed. Only individuals with gait cycles identified as having valid kinematic and kinetic data were included in the analysis. A single individual, experienced in gait analysis, collected the data using standardized procedures and instructions. The potential impact of bias due to marker misplacement was minimized by having that same person collect the data at each of the three assessment time-points and in both groups.

2.6. Data processing

The GDI compares nine kinematic variables of a participant's gait against those of a reference group; this requires kinematics from the pelvis and hip in all three planes, the knee and ankle in the sagittal plane and foot progression [13]. A deviation score for each limb was calculated, using our reference group data and the electronic addendum provided with the GDI paper [13]. Initially, the scores for the able-bodied, walking at self-selected walking speed, were calculated. Subsequent to this, scores for the surgical treated were calculated against our reference data. Individual limb mean GDI scores were used in the analysis. A score close to 100 or