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Original article

The Effect of Hip Arthroplasty on Osteoarthritic Gait: A Blinded, Prospective and Controlled Gait Study at Fast Walking Speeds

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ABSTRACT

Background: Painful unilateral cox arthrosis results in excessive forces passing through the "good leg." The impact of hip arthroplasty on contralateral leg gait has not been fully explored. We measured patients gait before and after arthroplasty, to answer 3 questions: (1) Are peak forces for the good legs outside the normal range? (2) Does arthroplasty protect contralateral limbs by reducing peak forces? and (3) Does arthroplasty result in a more symmetric and normal gait at fast walking speeds?

Methods: This prospective, controlled study, assessed ground reaction forces before and 13 months (range, 6-21 months) after hip arthroplasty.

Results: Peak ground reaction force in contralateral hips fell (1.45-1.38 times body weight, $P = .04$), whereas symmetry index maximum weight acceptance improved postoperatively (12.2 ± 11 vs 1.3 ± 6, $P < .001$).

Conclusion: Although gait becomes more symmetrical, patients still experience higher peak loads than matched controls. These high forces may offer an explanation to the progression of arthrosis in lower limbs.

Osteoarthritis (OA) develops when the mechanical stresses exerted on joints exceed their ability to withstand and repair damage [1]. End-stage hip OA can now be effectively treated with arthroplasty; however, there is growing interest in research areas aiming to prevent or reverse early pathologic structural changes [2]. Weight loss is an effective way of reducing symptoms, and slowing the progression of OA, presumably by reducing the forces exerted across a joint [3]. Patients with OA in one limb are at risk of disease progression in the other limb exposed to compensatory high peak forces and asymmetrical walking patterns [4-6]. Indeed patients are more likely to develop OA in the "good" leg than in the ipsilateral knee OA after hip arthroplasty [5,7,8]. Weight loss has been shown to reduce OA symptoms, presumably from reducing the peak forces experienced through these affected joints [9]. Therefore, it may be reasonable to hypothesize that the high peak loads and asymmetrical gait patterns may also contribute to disease progression in the compensating leg. Opinion remains divided as to whether surgery reverses these gait changes [10-12]. However, previous gait studies have examined patients walking at slow speeds or failed to look at the peak forces on contralateral limbs [10-12].

Between-leg differences become more apparent with increasing speed, in postarthroplasty [13] and prearthroplasty subjects [14,15]. Restricting analysis to low speeds may therefore miss the real extent of any asymmetry and under-report the actual improvement in gait after surgery [10].

In this prospective, single-blinded controlled study, we investigated whether (1) peak forces for the good legs were outside the normal range? (2) arthroplasty protected contralateral limbs by reducing peak forces? and (3) arthroplasty resulted in a more symmetrical and normal gait pattern at fast walking speeds?

This work was performed at Imperial College London, Charing Cross Campus, UK.

One or more of the authors of this paper have disclosed potential or pertinent conflicts of interest, which may include receipt of payment, either direct or indirect, institutional support, or association with an entity in the biomedical field which may be perceived to have potential conflict of interest with this work. For full disclosure statements refer to http://dx.doi.org/10.1016/j.arth.2016.03.002.

Ethics: Ethical approval was sought and gained before commencement of the study. All subjects taking part gave written informed consent to take part in the study. The study procedures were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000.

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Material and Methods

Participant Inclusion/Exclusion Criteria

Ethical approval was sought and gained before the study. We prospectively identified patients with painful unilateral cox arthrosis who were deemed suitable for total hip arthroplasty from the operating waiting lists of one surgeon. Patients had unilateral hip pain with otherwise asymptomatic lower limbs. Patients were excluded if they could not walk unaided. There were 9 males and 8 females with an average age of 59 years (range of 32-73). Seventeen previously tested asymptomatic control subjects were also selected from a database. They were sex-matched and of similar ages (average age 54 years, range 33-83). The sample size calculation was performed based on a study, which successfully documented the impact of intervention on the affected hip [11].

Outcome Measures

Our primary outcome measure was maximum weight acceptance as the greatest peak forces are seen at this point during fast walking on flat ground [13]. Secondary outcome measures included gait symmetry index (SI) values for weight acceptance rate, maximum weight acceptance, midsupport, push-off rate, and maximum push-off force. Previous studies have suggested a plateau of gait recovery at 6 months after hip arthroplasty; hence, we used this as our minimum postoperative assessment time [11,16,17]. Assessment was taken in the month before surgery and at an average of 13 months postoperatively (range 6-21 months).

Arthroplasty Surgery

All surgical cases were carried out by the senior author using a posterior approach with a capsular and muscular interosseous repair. Three different implants were used, including the Furlong Evolution Hip, and Furlong HAC (Joint Replacement Instruments, Sheffield, England) and the Birmingham Hip Resurfacing (Smith and Nephew, Memphis, TN).

Equipment/Assessment

Subjects were tested using a treadmill instrumented with force plates beneath the tread (Kistler Gaitway; Kistler Instrument Corporation, Amherst, NY). Treadmills have been used previously as a gait assessment tool in patients with a variety of medical conditions and with postarthroplasty gait assessment [13,18-21]. They have also been validated as a reasonable alternative to overground gait analysis, while allowing assessment at faster walking speeds [22]. Gait data were normalized for weight and height using previously published and acceptable techniques [23]. Testing followed a 6-minute warm up at 4 km/h where subjects acclimatized themselves to the treadmill. This warm-up period has been shown to reduce gait data inconsistencies [13,21,24]. Assessment was performed with 2 trained blinded observers, using a standardized testing protocol, which began at 4 km/h and increased in 0.5-km/h increments until the patients self-determined top walking speed was reached. Top walking speed was defined as the maximum speed subjects could walk comfortably without pain or needing to run [13,21].

Theory and Calculation

All GRF data were appropriately body weight and/or height normalized to enable cross-group comparison [23]. A paired *t* test was used to compare peak forces before and after surgery.

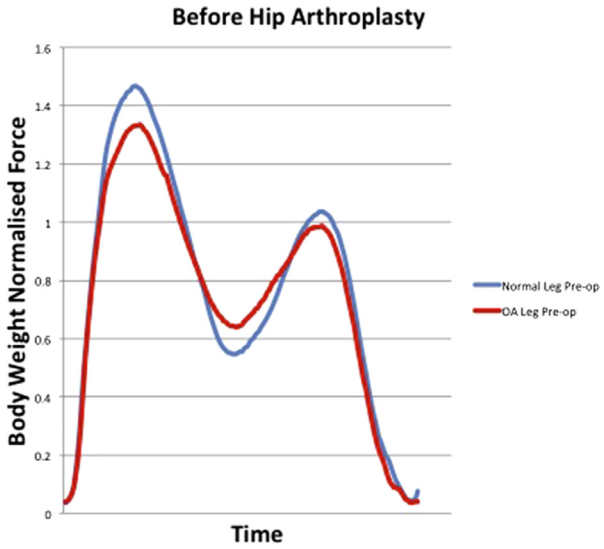

Fig. 1. Pre-operative ground reaction forces for OA and normal limbs.

Significance was judged at the 5% level. Gait data were examined at the fastest speed that subjects could walk before surgery and at the same speed postoperatively to allow a like for like comparison.

The SI was calculated using a previously described and accepted method [25,26].

$$\mathrm{SI} = \frac{(X_R - X_L) \times 100\%}{0.5(X_R + X_L)}$$

Values closer to zero indicated a tendency to greater symmetry. We compared presurgery and postsurgery SIs using a paired *t* test assessing for statistical significance at the 5% level.

To assess whether surgery resulted in a more "normal" gait, we compared presurgery and postsurgery SIs to that of an age- and sex-matched group of normal controls. Control group GRFs were sampled at 6 km/h to match the subject group average speed. As data were normally distributed, an independent sample *t* test was used to compare results between groups. Analysis was performed using IBM SPSS Statistics, version 21.

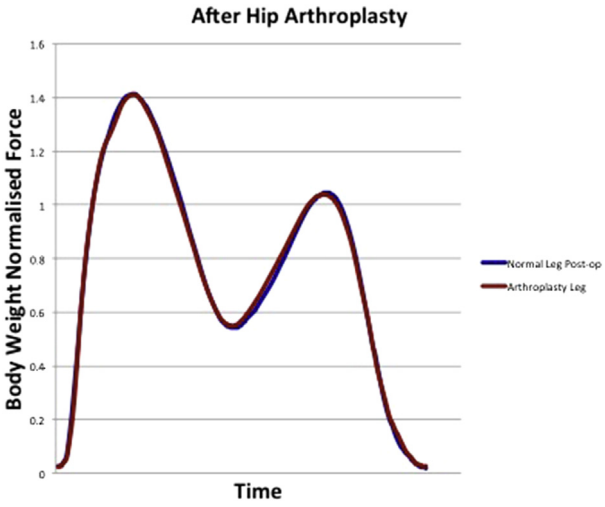

Fig. 2. Post-operative ground reaction forces for post arthroplasty and normal limbs.