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Preoperative leg-length inequality and hip osteoarthritis: a radiographic study of 100 consecutive arthroplasty patients

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Abstract *Objective:* To assess the leg-length inequality in patients with hip osteoarthritis (OA) and to evaluate a possible association between the length disparity and side of OA. *Design and patients:* Weight-bearing radiographs of 100 consecutive patients undergoing arthroplasty for primary OA were examined and measured for inequality of leg length, pelvic tilt and severity of OA. *Results:* The radiographic results showed that preoperatively OA occurred more frequently in the hip of the longer (84%) than the shorter (16%) leg. However, the development of OA did not show a linear relationship with the magnitude of

leg-length inequality. *Conclusion:* As hip OA occurred more frequently in the longer leg the authors speculate whether leg-length inequality might predispose to OA in the hip of the longer leg.

Keywords Leg-length discrepancy · Radiology · Hip joint · Osteoarthritis · Prevention

Introduction

Osteoarthritis (OA) has been categorised as primary (idiopathic) or secondary. Secondary OA refers to cases where some antecedent event such as a fracture, childhood disease or skeletal abnormality is recognised as a predisposing factor [1]. An extensive study by Solomon [2] has indicated that a large majority of cases previously thought to be primary OA of the hip are actually secondary to mild developmental abnormalities, which in the past have been overlooked or unrecognised.

Many hip joints degenerate for reasons that are primarily mechanical rather than biological [3]. A well-recognised cause of primary OA is a residual developmental dysplasia of the hip in adults causing a decreased contact area between the femoral head and acetabulum which increases the contact stress on articular cartilages of the joint. Aronson [4] found in 474 patients with severe OA

an underlying dysplasia of the hip in 43% that predisposed the hip to mechanical failure. An increased femoral anteversion in adults has also been demonstrated to be a predisposing factor for hip OA [5]. In a recent publication, Gantz et al. [6] proposed femoroacetabular impingement as a mechanism for the development of OA for many non-dysplastic hips, based on clinical experience and more than 600 surgical explorations of the hip allowing in situ inspection of the damage pattern.

Many opinions have been expressed both for and against the effect of a bilateral asymmetry in lower limb lengths for links with orthopaedic disorders, and the need for intervention to reduce the magnitude of the discrepancy. An association of OA of the hip joint with leg-length disparity has also been observed by the authors. To our knowledge, the current literature does not provide conclusive evidence with regard to leg-length inequality and its relationship with the development of hip joint OA.

This study was, therefore, undertaken to define whether patients with primary hip OA referred for an arthroplasty had a leg-length disparity and whether there was a correlation between the side of the longer leg and the side of hip surgery.

Patients and methods

From May 1998 to May 2000 a total of 691 hip arthroplasties were performed at the ORTON Orthopaedic Hospital, Helsinki, Finland. Of these, 383 were primary arthroplasties and 308 were revisions. For this study we examined the radiographs of all 383 who underwent primary arthroplasty for primary OA; patients with secondary OA due to hip dislocation, acetabular dysplasia (centre-edge angle of Wiberg [7] below 20°) or fractures of the hip, as well as patients with adductor contractions (muscle imbalance) and osteonecrosis of the femoral head, were excluded. Furthermore we excluded patients with earlier fractures, considerable injuries, surgery or arthroplasty in the extremities.

Thus, only patients with primary OA were included in this study and no other selection occurred. Of a series of 100 consecutive patients, 48 were men and 52 were women. The average age of the patients was 69 (range 38–88) years. The indications for arthroplasty were severe pain accompanied by considerable difficulties in performing normal daily activities.

Radiography

Preoperative radiographs were taken in the standing position with straight knees and with the body weight distributed equally on both legs. To ensure consistency of positioning a 15-cm-wide block was placed between the patient's feet [8]. The central X-ray beam was aimed at the symphysis pubis. The magnification factor of the radiographs was 1.2. For the measurements a vertical reference was obtained by using a plumb line. The difference between the length of the patient's legs and as well as the pelvic tilt were measured by either of the two radiologists (K.T., M.Y.).

Estimation of leg-length discrepancy was performed from the weight-bearing joint surfaces of the femoral heads regardless of whether the shape was preserved or flattened by collapse, and deviation in pelvic tilt was obtained from the lower margin of the sacroiliac joints (Fig. 1). In order to determine the accuracy of our leg length difference and pelvic tilt measurements we carried out an interobserver study in which both radiologists separately re-measured the radiographs of 25 patients for the leg-length difference and the pelvic tilt. Hip joint OA was evaluated on a three-point ordinal scale (1 = narrowed joint space; 2 = narrowed joint space and osteophytes, and 3 = narrowed joint space, osteophytes and severe joint deformation).

Results

In 39 patients the right leg was longer and in 42 the left leg was longer. Nineteen patients had no discernible leg-length difference. For 68 (84%) patients an arthroplasty was performed on the longer leg ($P=0.95$, confidence interval 74–90%). The mean difference in leg length in these patients was 7.5 mm and the standard deviation 4.7 mm. For 13 (16%) patients the operation was performed on the shorter leg ($P=0.95$, confidence interval



Fig. 1 Leg-length inequality (*LLI*) is measured from the weight-bearing surfaces of the femoral heads and the pelvic tilt (*PT*) from the inferior margin of the sacroiliac joints in relation to the horizon (*H*). There is severe osteoarthrosis in the left hip with narrowing of the superior joint space and flattening of the femoral head. In spite of foreshortening of the left femur the leg is still longer than the right one and the pelvis tilts to the right side

Table 1 Statistics for osteoarthrosis related to leg length

Leg	Degree of osteoarthrosis			
	0	1	2	3
Longer	1%	4%	30%	65%
Shorter	28%	42%	20%	10%

10–25%). The mean leg-length difference for these patients was 4.4 mm and the standard deviation 3.2 mm. The occurrence of severe OA was more common in the longer than in the shorter leg (Table 1). No correlation ($r=0.01$) between age and difference in leg-length was observed, and only a negligible correlation between difference in leg length and degree of OA ($r=0.22$ for the longer side and $r=-0.13$ for the shorter side). On the other hand, a significant correlation was found between the difference in leg length and pelvic tilt angle ($r=0.54$).

The average interobserver variability for leg-length difference was 0.8 mm and for pelvic tilt 0.9°.

The statistical method of logistic regression was applied, first to screen various candidate regressors, and then to test the only remaining regressor, the leg-length difference. Leg-length difference was found to be a significant predictor for the side of operation ($P=0.02$).

Discussion

On the basis of the preoperative weight-bearing radiographs of our 100 consecutive patients with primary hip OA we were able to conclude that OA occurs more frequently in the longer leg. Mahar et al. [9] postulated that

persons with a leg-length disparity have a tendency to shift weight-bearing to the longer limb. The same authors also stated that a leg-length discrepancy of as little as 10 mm might be biomechanically important. Friberg [10] reported that stress fractures occur more frequently in the longer limb. Already some 30 years ago Radin et al. [11] discussed the possibility that a decreased articulating surface in the hip joint would lead to increased weight-bearing pressure and hence increased stress on the cartilage and underlying bone, thus representing a possible biomechanical precursor of OA.

The effect of mild leg-length inequality on posture and gait has been the source of much debate and controversy. However, mild leg-length inequality has primarily been associated with two orthopaedic disorders: stress fractures in the limbs and low back pain [1]. Still the questions of when intervention is necessary and the optimal modality for correcting mild leg-length inequality remain controversial. Lack of consistent definition of leg-length inequality reflects the wide range of opinion regarding the problem of postoperative leg-length inequalities in total hip surgery [12].

In repeated radiographic assessments of leg-length inequality the mean accuracy has been reported to vary from 0.6 mm [13] to 1.5 mm [14]. In our interobserver study of the assessments of the leg-length difference and the pelvic tilt, the measurement agreements were considered good enough not to have any adverse effects on the results of this study.

The positioning of patients for a weight-bearing anteroposterior view of pelvis and hips is a routine procedure in our department and the repeatability is good. However, we cannot exclude the possibility that there were patients with difficulties in straightening their knees due to a slight varus, valgus or flexion deformity. None of the patients had undergone or was scheduled for any kind of knee or ankle surgery. Thus, a slight distortion or altered biomechanics of the leg were likely to be of chronic nature thus contributing to the leg-length difference and hip load.

Diagnosis of leg-length inequality is overlooked if the pelvis and hip radiographs are taken in a recumbent po-

sition. Pelvis and hip radiographic examinations are often carried out for various reasons and they should, where possible, be taken in standing position. In many orthopaedic centres lumbar spine radiographs are taken upright and in case of a considerable pelvic tilt, the hips joints and leg-length disparity are checked. Similarly, in young scoliosis patients it is the rule at the initial examination to check for a possible leg-length disparity.

In the present study we have found a positive association between a longer leg and hip OA. The results suggest that a leg-length difference may contribute to later development of hip OA. Proof of this would require young subjects with leg-length inequality to be followed up for several decades. It may be possible, if and when MRI can be conducted in the upright position, to conclude whether leg-length inequality really is a predisposing factor for hip OA. This would be of considerable importance, as identifying a risk factor is the first step to successful preventive measures. If leg-length inequality causes abnormal stresses to one limb, then the effect of shoe lifts is worth investigating as a cost-effective method for preventing some of the OA of the hip joint. A simple shoe lift has already been shown to provide symptomatic relief for patients with leg-length inequality [15].

The present study focused on patients who had already developed severe OA. Consequently, the present results cannot be considered valid per se for the general population. Nevertheless, it is possible that corrective measures for leg-length discrepancy could decrease the risk of the development of primary OA.

As severe OA may deform and flatten the femoral head and shorten the leg, the difference in leg length may have been even more pronounced at an earlier stage in many of our 100 patients. Thus, further imaging investigation at an earlier stage in the development process of OA should be conducted.

In conclusion, primary hip OA occurred more frequently in the longer leg of our arthroplasty patients and, in addition, the smaller the difference in leg length the less the amount of OA in the longer leg.

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