Osteoarthritis and Cartilage 21 (2013) 559–564

Osteoarthritis and Cartilage

Total hip replacement but not clinical osteoarthritis can be predicted by the shape of the hip: a prospective cohort study (CHECK)

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ARTICLE INFO

Article history:
Received 7 September 2012
Accepted 8 January 2013

Keywords:
Osteoarthritis
Hip
Morphology
Shape
Risk factor

SUMMARY

Objective: To investigate the association between baseline hip shape and both clinical hip osteoarthritis (OA) and total hip replacement (THR) at 5-year follow-up.
Design: Individuals from the Cohort Hip and Cohort Knee (CHECK) study, with early symptomatic OA, having standardized anteroposterior pelvic radiographs at baseline and 5-year follow-up ($n = 723$) were included. Hip shape on the radiographs was assessed using statistical shape modeling (SSM). Hips fulfilling the American College of Rheumatology (ACR) criteria at follow-up were classified as clinical OA. The association between each mode of shape variation and both outcome measures was calculated by Generalized Estimating Equations (GEE).
Results: The included individuals comprised 575 females and 148 males (mean age 55.9 ± 5.2 years). At baseline, 8% fulfilled the ACR criteria, 76% had no radiographic hip OA [Kellgren & Lawrence (K&L) = 0] and 24% had doubtful OA (K&L = 1). At follow-up, 147 hips (10.4%) fulfilled the ACR criteria and 35 hips (2.5%) had received THR. Five shape variants (modes) at baseline associated significantly with THR within 5 years. When combined in one GEE model, these shape variants resulted in a predictive power indicated by an area under the curve of 0.81. No shape variants associated with the presence of clinical OA at follow-up.
Conclusion: The shape of the hip as quantified by an SSM has a good predictive value for THR, whereas variation in shape cannot predict clinical OA. Minor shape variants may be used as a radiographic biomarker to predict the future risk of THR.

Introduction

Osteoarthritis (OA) is often present in multiple joints, but hip OA frequently occurs in isolation, suggesting that local factors are important in its development[1]. There is growing evidence that morphology of the hip joint is one such risk factor. Morphological abnormalities of the hip probably predispose to OA by an altered biomechanical behavior of the hip[2]. This seems plausible for hips with an evident non-optimal shape as seen in (congenital) hip dysplasia, Perthes disease, and slipped capital femoral epiphysis[3,4]. Recently however, the more prevalent cam-type deformities have also been recognized as a causative factor for end-stage OA, with a positive predictive value as high as 52%[5]. Thus, the morphology of the hip appears promising for prediction of hip OA before the actual onset of OA[6,7].

Obvious shape abnormalities are usually quantified by predefined measures such as the center-edge angle for dysplasia and the alpha angle for cam-type deformity. However, subtle morphological variation might also play an important role, but these are difficult to capture by predefined measures.

By using statistical shape modeling (SSM), a sophisticated technique which identifies independent shape variants, it is possible to quantitatively describe the total morphology of the hip[8,9]. An SSM describes all variation in shape that exists in the study population, and is therefore a method which can identify shapes 'at risk' for OA without any assumptions.

Hip OA is usually defined by clinical symptoms such as pain and decreased function, or radiographically by structural alterations as seen on radiographs. However, a poor association between clinical

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1063-4584/$ – see front matter
http://dx.doi.org/10.1016/j.joca.2013.01.005

and radiographic definitions for hip OA has been reported[10]. Previously, it has been shown in cross-sectional and case-control studies that subtle shape variants of the proximal femur associate with radiographic OA[6,9,11–13]. However, it is unknown whether hip shape associates with OA as defined by clinical criteria. Possibly, 'at risk' shapes are different for both definitions, as it has been shown that those shape variants that associated with radiographic hip OA were different from those that associated with pain[13].

We investigated whether minor shape variants of hips without definite radiographic signs of OA at baseline, can be predictive in people with first onset hip or knee pain for the development of hip OA after 5 years, as classified either by the American College of Rheumatology (ACR) criteria for clinical OA or by total hip replacement (THR).

Methods

Study cohort

All individuals were participants of the Cohort Hip and Cohort Knee (CHECK) cohort. CHECK is a nationwide prospective cohort study of 1002 individuals with early symptomatic OA of knee or hip. On entry, all participants had pain or stiffness of knee or hip and were aged 45–65 years; they had not yet consulted their general practitioner (GP) for these symptoms, or the first consultation was within 6 months before entry. Participants with a pathological condition other than early OA that could explain the symptoms were not included in the cohort [for hip: trauma, rheumatoid arthritis, congenital dysplasia, Perthes disease, subluxation, osteochondritis dissecans, fracture, septic arthritis, Kellgren & Lawrence (K&L) grade 4 or THR, previous hip surgery, and individuals having only symptoms of bursitis or tendinitis][13].

Radiographs, serum samples, and clinical examination were obtained from 11 (general and university) hospitals at baseline and at 5-year follow-up. Individuals were recruited either by GPs who were invited to refer eligible persons to one of those centers and by advertisements in local newspapers. The 723 of the 1002 individuals who had anteroposterior (AP) pelvic radiographs of sufficient quality obtained both at baseline and at 5-year follow-up were included [the mean standard deviation (SD) follow-up was 5.06 (0.17) years]. Of the initial 1002 individuals, 137 subjects did not have pelvic radiographs at both baseline and follow-up, of the remaining individuals, 124 subjects had AP hip instead of AP pelvic radiographs at baseline, and 18 subjects did not have radiographs of sufficient quality at baseline to add them to the SSM. Excluded individuals did not differ on any baseline characteristic from the included individuals. The study was approved by the medical ethics committees of all participating centers, and written informed consent was obtained from all participants.

Radiographs and SSM

Weight bearing AP pelvic radiographs were obtained according to a standardized protocol. Feet were positioned such that the medial side of the distal part of the first phalanx touched and a wedge was used to assure 15° internal rotation. The tube to film distance was 120 cm, and the beam was centered on the superior part of the pubic symphysis.

From these radiographs at baseline the shape of the proximal femur and pelvis was outlined using SSM software (ASM tool kit, Manchester University, Manchester, UK)[8]. The shape model was created by a set of 75 landmark points that were positioned along the surface of the bone in the image by three investigators, who were unaware of any clinical or radiographic outcomes. Each point is always positioned on the same anatomical landmark (e.g., most lateral point of greater trochanter, most distal point of ischial bone etc.) of the outline, to allow comparison between the shapes (Fig. 1). Principal component analysis was used to transform the set of points into an SSM, which consists of a number of modes that together describe the total variation in shape in the study population. Shape variants which are correlated are captured in one mode such that each single mode represents independent shape variants. Each mode is quantitatively described as the mean, which corresponds with 0, and the positive or negative deviation from the mean as expressed in the number of SDs[8].

To examine the inter-observer reliability of the modes obtained, the point set was positioned by each investigator in 24 randomly

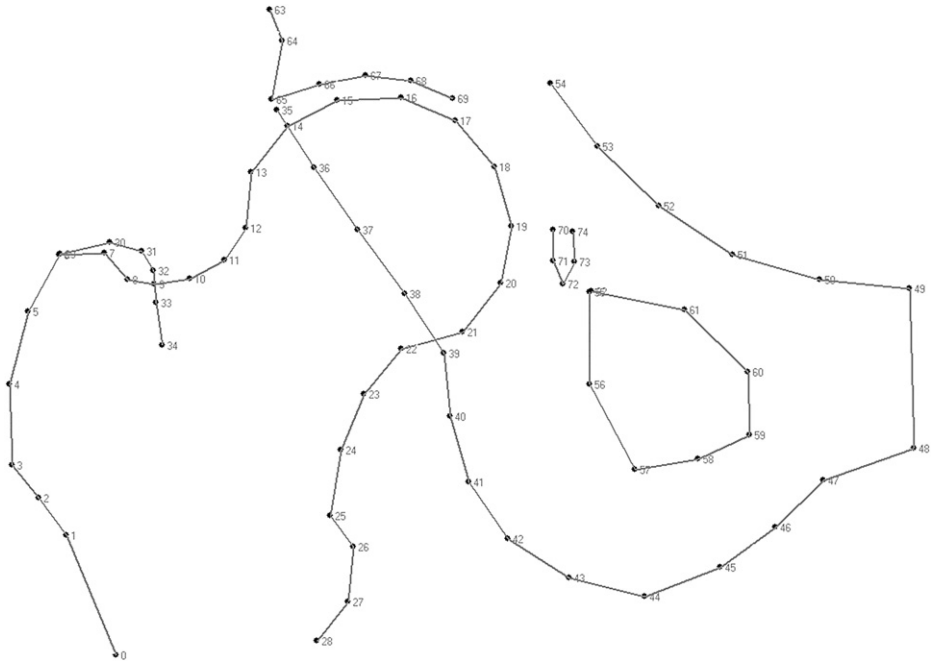

Fig. 1. The statistical shape model which consisted of 75 points.