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Factors associated with meniscal body extrusion on knee MRI in overweight and obese women

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SUMMARY

Objective: To determine factors associated with higher degree of meniscal body extrusion in overweight and obese women at high risk of knee osteoarthritis (OA).
Design: We used baseline data of the PRevention of knee Osteoarthritis in Overweight Females (PROOF) study, Netherlands, comprising overweight or obese women aged 50–60 years, free of clinical knee OA. All subjects completed a questionnaire on knee complaints and physical activity, underwent physical examination, radiography, and 1.5 T magnetic resonance imaging (MRI) of both knees. Using the mid-coronal MRI slice, one blinded observer measured tibial plateau width and meniscal body extrusion of both menisci in both knees. The association between baseline factors and meniscal extrusion, were analyzed with a random effects regression model. In addition, we used a fixed effect regression model for evaluation of knee-specific factors.
Results: Mean age of the included women ($n = 395$) was 55.7 years and mean body mass index (BMI) 32.4 kg/m^2. Of all knees, 23% had an absolute medial meniscus body extrusion ≥3.0 mm and 4% had lateral meniscus body extrusion ≥3.0 mm. In the multivariable model, the medial meniscus extrusion was increased by 0.44 mm (95% confidence interval [CI] 0.11, 0.77) when a medial meniscus tear was present, by 0.20 mm per 5 kg/m^2 (95% CI 0.05, 0.35) increase in BMI and by 0.25 in the presence of mild knee symptoms (95% CI 0.05 to 0.44). Kellgren–Lawrence (KL) grade ≥1 and tibia width were associated with increased both medial and lateral extrusion.
Conclusion: In women, ipsilateral meniscus tear and high BMI are factors associated with medial meniscus body extrusion.

Introduction

The menisci are two crescent-shaped fibrocartilaginous discs located medially and laterally between the surfaces of femur and tibia in the knee joint cavity. The menisci act to disperse the weight of the body, reduce shock and friction during movement and stabilize the knee joint[1,2]. If the integrity or normal position of meniscus is compromised, these functions may be negatively affected. Findings of meniscus tears or destruction on magnetic resonance imaging (MRI) of the knee are common in the general population and increase with increasing age[3,4]. Several reports show damage to the menisci is a strong risk factor for the occurrence and progression of knee osteoarthritis (OA)[5–7]. Further, if the outer margin of meniscal body (mid portion of meniscus) is markedly located outside the tibial joint margin, typically by 3 mm or more, this phenomenon is considered as meniscus extrusion[8,9].

Meniscus extrusion has been reported to be more prominent in women than men[10,11]. Knee OA is also more frequent in women after menopause than in men of corresponding age[12–14]. The

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gender propensity may be attributed to certain female physiological factors which may lead to increased laxity of certain knee structures such as collateral ligaments which serve as important attachment of the medial meniscus in particular[15,16]. Body mass index (BMI) has also been reported as a risk factor for the development of medial meniscal extrusion[17]. Obesity increases the load that needs to be transmitted by the menisci, which may also lead to meniscus extrusion. Among population without any signs of radiographic OA a previous study has suggested that female sex, incident meniscal tear, and higher baseline value of extrusion are risk factors for increased meniscal body extrusion[18].

In order to get a better understanding of factors associated with meniscus extrusion in women, and potentially better insight into the mechanisms involved in knee OA development, we studied a specific cohort of obese women OA. We paid attention to a number of pre-specified demographic and knee-specific characteristics such as age, BMI, presence of meniscus tear, menopause, knee alignment, the presence of Herberden's nodes, prior knee injury etc. which might be associated with meniscal body extrusion.

Methods

Study sample

Data of our study were obtained from baseline data of the PRevention of knee Osteoarthritis in Overweight Females (PROOF) study, Netherlands, which comprises 407 women with a BMI $\geq$27 kg/m^2, aged 50–60 years, free of clinical knee OA according to the clinical ACR criteria for knee OA[19]. However, some of the participants already had evidence of radiographic knee OA. The BMI cut-point of 27 kg/m^2 was chosen since there is a clear increase in OA incidence beyond this point[20]. All subjects completed a questionnaire on knee complaints and physical activity, underwent physical examination, radiography, and 1.5 T MRI of both knees. PROOF was originally designed to evaluate the effects of a diet, exercise program and glucosamine sulfate on the development of clinical knee OA. During the progress of reading images, we found that 12 subjects' MR images were incomplete (with only one sided knee images) or unreadable. Therefore, the final number of subjects analyzed was 395.

PROOF was approved by the ethics committee at the Erasmus University Medical Center Rotterdam, the Netherlands in 2005.

MRI protocol

MRIs of both knees were acquired at baseline on 1.5 T scanners The MRI protocol included coronal and sagittal non-fat suppressed proton density weighted sequences (slice thickness 3.0 mm/slice gap 0.3 mm), a coronal T2 weighted Spectral Presaturation by Inversion Recovery sequence (slice thickness 5.0 mm/slice gap 0.5 mm, TE 79 ms, TR 2550 ms, No. of slices 17, Matrix 448 $\times$ 358, No. of signals acquired 2, FOV 480 $\times$ 144, echo train length 7), an axial dual spin-echo sequence (slice thickness 4.5 mm/slice gap 0.5 mm, TE 14/100 ms, TR 3000 ms, No. of slices 19, Matrix 512 $\times$ 512, No. of signals acquired 1, FOV 160 $\times$ 160 mm, echo train length 5) and a sagittal 3D water selective sequence with fat saturation (slice thickness 1.5 mm, TE 6 ms, TR 19.5 ms, No. of slices 17, Matrix 384 $\times$ 384, No. of signals acquired 1, FOV 160 $\times$ 160 mm, echo train length 1).

MRI measurements

We used a two-dimensional quantitative measurement method of meniscal extrusion previously reported by several other investigators[6,8]. One observer (FZ), who was blinded to subject characteristics and clinical data, performed measures on both left and right knees on the baseline mid-coronal MR images. We refer 'mid-coronal' to the single slice visually presenting the greatest area of the medial tibial spine. Sometimes this was difficult to differentiate because two slices may depict a similar area of the tibial spine, in which case we used the slice which showed the greatest width of the tibial plateau. The observer measured tibial plateau width from the margin of the tibial plateau excluding any possible osteophytes, medial and lateral meniscus coronal width, and meniscal body extrusion to the closest 0.1 mm using Sante DICOM Editor (64-bit) software (Fig. 1). Thirty randomly selected knees were reassessed. Intra-observer reliability (intra-class correlation coefficient) and inter-observer reliability for the tibial plateau width, medial and lateral meniscus width, medial and lateral meniscal extrusion ranged from 0.69 to 0.98 and 0.62 to 0.96, respectively.

Meniscal tears were read by two trained readers (JR, PvdP) and one experienced musculoskeletal radiologist (EO) as part of MOAKS scoring system[21,22]. After extensive training, high to nearly perfect inter-observer reliability was reached[21].

Other covariates

BMI was defined as the body weight in kg divided by the square of the body height in meters. Both hands were examined for Heberden's nodes. Standardized semi-flexed posterior–anterior knee radiographs were taken, according to the MTP-protocol[23]. Knee radiographs were read by a trained reader, blinded to clinical measures, according to the Kellgren–Lawrence (KL) scale[24]. Medial anatomical knee alignment angle was assessed by digitally determining the angle between the line from the center of the tibial spine through the center of the femoral shaft at approximately 10 cm from the joint margin and the matching line through the tibia[25]. Isometric quadriceps muscle strength was measured as maximal isometric contraction in a supine position, using a hand-held dynamometer. This method has proven to be valid and reliable[26]. Date of birth and information on physical activity level[27], menopausal status, mild knee symptoms (defined as any knee complaints in the last year), and previous knee injury were ascertained by questionnaires.

Statistics

Our pre-specified hypothesized risk factors that we evaluated were: age (continuous), BMI (continuous), physical activity (continuous), menopause status (yes/no), presence of mild knee symptoms (yes/no), Heberden's nodes (yes/no), knee alignment

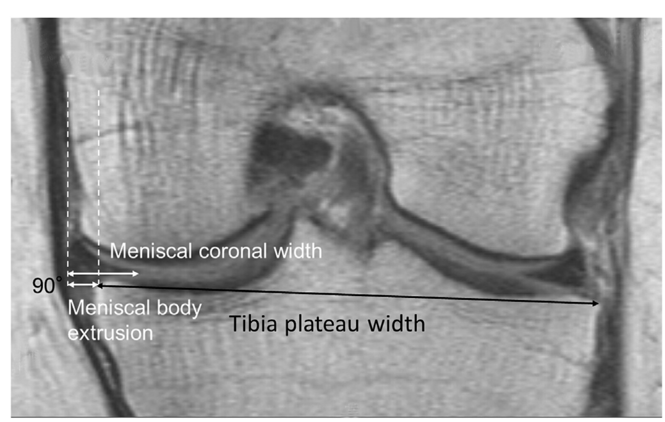

Fig. 1. Example of measurements on mid-coronal 1.5 T intermediate weighted knee magnetic resonance images using Sante DICOM Editor (the two dashed white vertical lines perpendicular to the tibial plateau mark the edge of the tibial plateau and the peripheral border of the meniscus body, respectively).