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The association between reduced knee joint proprioception and medial meniscal abnormalities using MRI in knee osteoarthritis: results from the Amsterdam osteoarthritis cohort

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SUMMARY

Background: Osteoarthritis (OA) of the knee is characterized by pain and activity limitations. In knee OA, proprioceptive accuracy is reduced and might be associated with pain and activity limitations. Although causes of reduced proprioceptive accuracy are divergent, medial meniscal abnormalities, which are highly prevalent in knee OA, have been suggested to play an important role. No study has focussed on the association between proprioceptive accuracy and meniscal abnormalities in knee OA.

Objective: To explore the association between reduced proprioceptive accuracy and medial meniscal abnormalities in a clinical sample of knee OA subjects.

Methods: Cross-sectional study in 105 subjects with knee OA. Knee proprioceptive accuracy was assessed by determining the joint motion detection threshold in the knee extension direction. The knee was imaged with a 3.0 T magnetic resonance (MR) scanner. Number of regions with medial meniscal abnormalities and the extent of abnormality in the anterior and posterior horn and body were scored according to the Boston-Leeds Osteoarthritis Knee Score (BLOKS) method. Multiple regression analyzes were used to examine whether reduced proprioceptive accuracy was associated with medial meniscal abnormalities in knee OA subjects.

Results: Mean proprioceptive accuracy was 2.9° ± 1.9°. Magnetic resonance imaging (MRI)-detected medial meniscal abnormalities were found in the anterior horn (78%), body (80%) and posterior horn (90%). Reduced proprioceptive accuracy was associated with both the number of regions with meniscal abnormalities ($P < 0.01$) and the extent of abnormality ($P = 0.02$). These associations were not confounded by muscle strength, joint laxity, pain, age, gender, body mass index (BMI) and duration of knee complaints.

Conclusion: This is the first study showing that reduced proprioceptive accuracy is associated with medial meniscal abnormalities in knee OA. The study highlights the importance of meniscal abnormalities in understanding reduced proprioceptive accuracy in persons with knee OA.

Introduction

Osteoarthritis (OA) of the knee involves many tissues, such as cartilage, bone, menisci and the synovial membrane[1–4]. Clinical characteristics of the disease are joint pain and activity limitations[5]. Reduced joint proprioceptive accuracy might be associated with pain and activity limitations[6–10]. Although causes of reduced joint

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proprioceptive accuracy are divergent, meniscal abnormalities have been suggested to play an important role[11–13]. As far as we are aware, the direct association between reduced knee joint proprioceptive accuracy and meniscal abnormalities has not yet been demonstrated in persons with knee OA.

Proprioceptive accuracy in knee OA is reduced and not well understood[9,10]. Key factors that may affect proprioceptive accuracy in knee OA are: impaired articular mechanoreceptors, muscle weakness through reduced γ-motor neuron activation with reduced muscle spindle sensitivity, OA-related inflammation and effusion, and concomitant abnormalities to the anterior cruciate ligament or meniscus[9,10].

Meniscal abnormalities (i.e., tears or maceration) have been found in up to 80% of knees with OA[2–4]. Meniscal abnormalities affect the load transmission of the knee in at least two ways: (1) through alteration of the morphology and anatomical structure of the meniscus, and (2) by impairing the mechanoreceptors of the knee[2,12]. Studies focusing on the mechanical properties of the menisci have found that the most substantive strains and the highest load (70%) are in the medial meniscus[14–16]. In the medial meniscus, the mechanoreceptors are located in the outer rim, which is firmly attached to the capsule and the coronary (collateral) ligaments, where mechanoreceptors are also found[17,18]. In contrast, the lateral meniscus is only attached to the coronary ligaments, not to the capsule and contains less mechanoreceptors[19]. Therefore, it could be expected that a medial meniscal abnormality might reduce the number of mechanoreceptors, as well as impair mechanoreceptor function, thereby affecting proprioceptive accuracy. This effect may be bi-directional. Reduced proprioceptive accuracy may lead to meniscal damage due to impaired neuromuscular control and thereby knee instability. Instability may increase the strains and load on the medial meniscus with a high risk for damage, leading to a self-perpetuating cycle[20]. The first step in studying this self-perpetuating cycle is by examining the relationship between proprioceptive accuracy and meniscal abnormality, which will improve knowledge regarding reduced proprioceptive accuracy. Therefore, the aim of this study was to explore the association between reduced proprioceptive accuracy and medial meniscal abnormality in a clinical sample of persons with knee OA.

Methods

Subjects

For the present study, participants were recruited from a randomized controlled trial (STABILITY-trial) from January 2010 to August 2011[21,22]. This trial was embedded in the Amsterdam osteoarthritis (AMS-OA) cohort, a cohort of subjects with OA of the knee and/or hip who are referred to a specialized clinic (Reade, Centre for Rehabilitation and Rheumatology, Amsterdam, The Netherlands)[21,22]. Inclusion criteria were clinical knee OA diagnosis according to the American College of Rheumatology criteria[23], age between 40 and 75 years, biomechanically assessed and/or self-reported knee instability and written informed consent[21,22]. Exclusion criteria were total knee arthroplasty, any form of arthritis other than OA, comorbidities affecting daily functioning, severe knee pain (numeric rating scale (NRS) $>$ 8) and contra-indication for magnetic resonance imaging (MRI) (e.g., pacemaker, claustrophobia). The study was approved by the Slotervaart Hospital/Reade, Institutional Review Board. All measurements were scheduled prior to the start of an exercise program

Knee joint proprioception

Proprioception was assessed in a knee joint motion detection task, expressed as the joint motion detection threshold. A device was used that provided knee angular displacement in extension and precise measurement of the angular displacement with a resolution of 0.1° (Fig. 1). This method of assessment has been described in previous studies[6,24]. The angular displacement between the starting position and the position at the instant of pushing a stop button was recorded. The threshold for detection of knee joint movement was defined as the difference, in degrees, between the actual onset of motion and the subject's detection of knee joint position change or motion. High joint motion detection threshold meant a great difference between the actual onset of motion and the subject's detection and expressed poor proprioceptive accuracy. The mean joint motion detection threshold from three measurements was used for analyzes. Intra class correlation coefficients (ICCs) for intra-rater reliability for the assessment of participants with and without OA by a single experienced tester were 0.91 and 0.86, respectively[24]. The within-rater minimal detectable difference (MDD) was 6.26° and the between-rater MDD was 5.90° respectively, in subjects with knee OA[24].

Magnetic resonance (MR) imaging

MRI scans were performed of the knee that was clinically diagnosed with knee OA (in unilateral knee OA) or of the knee with most severely affected daily activities (in bilateral knee OA). Knees were imaged by a 3 T whole body MR scanner (General Electric Medical Systems, Milwaukee, WI) using a phased array knee coil. The MRI examination included five sequences. The first sequence was a sagittal proton density-weighted turbo spin-echo with fat suppression (slice thickness 3 mm; interslice gap 0.3 mm; repetition time (TR) 3,480 ms; echo time (TE) 42 ms; turbo factor 8; matrix 384 × 256). The second sequence was a sagittal T1-weighted turbo spin-echo (slice thickness 3 mm; interslice gap

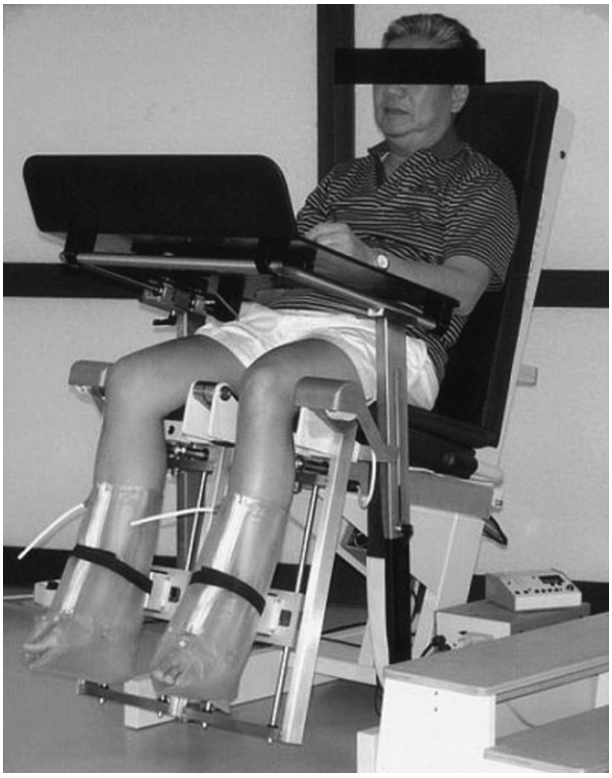

Fig. 1. Experimental setup for the assessment of knee joint proprioception, showing the measurement chair control mechanism, handheld button, air splints, and footrest (the moving component of the apparatus).