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Original Research Article

Evaluation of Medial Meniscal Thickness, Tear and Extrusion in Patients with and without Osteoarthritis of Knee

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Abstract:

Background: Osteoarthritis (OA) poses a global health burden, involving complex interactions of genetics, mechanical stress, and biochemical factors. The medial meniscus, vital for knee biomechanics, undergoes structural changes linked to OA. Despite insights into meniscal dynamics, understanding how these changes correlate with OA severity remains limited. Our cross-sectional study, utilizing advanced imaging like MRI, aimed to meticulously evaluate and compare medial meniscal features in cohorts with and without knee OA.

Methods: This cross-sectional study, spanning two years, assessed medial meniscal characteristics in individuals with and without knee osteoarthritis (OA) in North India. Participants, aged 18 years and older, were recruited from the Orthopaedics department. Clinical confirmation of knee OA utilized the Kellgren-Lawrence grading system. Exclusion criteria included knee surgery history, inflammatory joint diseases, recent significant knee trauma, and MRI contraindications. Clinical assessments, imaging with a 1.5 Tesla MRI scanner, and image analysis by blinded radiologists were conducted. Statistical analysis involved descriptive statistics, independent t-tests, Mann-Whitney U tests, and chi-square tests ($p < 0.05$).

Results: Our study revealed significant differences in medial meniscal characteristics between individuals with and without knee osteoarthritis (OA). Those with OA exhibited reduced medial meniscal thickness, higher prevalence of tears (53.7% vs. 42.6%), and increased extrusion (>50%) compared to the non-OA group. Additionally, femoral and tibial cartilage thickness showed significant differences between the groups. Age and gender distribution varied significantly. The study highlights distinct morphological variations in the medial meniscus associated with knee OA, emphasizing the importance of advanced imaging for a comprehensive assessment.

Conclusion: This study provides valuable insights into the radiological and demographic characteristics associated with knee osteoarthritis. The observed differences in medial meniscus thickness, cartilage thickness, and meniscal extrusion contribute to our understanding of OA-related changes in the knee joint.

Keywords: Osteoarthritis, Medial Meniscus, MRI, Knee Joint, Cartilage..

Introduction

Osteoarthritis (OA) stands as a pervasive and intricate musculoskeletal disorder, imposing a substantial global health burden [1]. The degenerative cascade of OA involves multifaceted interactions among genetic predisposition, mechanical stress, and biochemical factors, converging to inflict progressive damage to the knee joint's articular cartilage, synovium, and subchondral bone [2]. As a leading cause of pain, disability, and impaired quality of life, OA demands comprehensive investigation to unravel its complex pathogenesis and identify potential avenues for targeted intervention [3]. At the epicenter of knee joint biomechanics lie the menisci, particularly the medial meniscus, which serves as a critical shock absorber and load distributor [4,5]. The intricate interplay between the medial meniscus and knee OA has garnered substantial research interest, as structural alterations within this fibrocartilaginous structure could hold pivotal clues to the disease's onset and progression [6]. Existing literature has illuminated the dynamic role of the medial meniscus in knee joint function and highlighted its vulnerability to degenerative changes, such as alterations in thickness, tears, and extrusion [7,8,9]. However,

despite these insights, a nuanced understanding of how these morphological characteristics of the medial meniscus correlate with the presence and severity of knee OA remains a frontier in musculoskeletal research [10,11,12].

In this context, our cross-sectional study seeks to contribute to the existing body of knowledge by employing advanced imaging modalities, particularly magnetic resonance imaging (MRI), to meticulously evaluate and compare the medial meniscal thickness, tears, and extrusion in cohorts with and without knee OA. By incorporating a diverse patient population and considering influential demographic factors, we aimed to provide a comprehensive and nuanced exploration of the relationships between meniscal features and knee OA.

Materials and Methods

Study Design and Participants: This cross-sectional study was conducted to evaluate medial meniscal thickness, tears, and extrusion in individuals with and without knee osteoarthritis (OA) in the department of Orthopaedics at tertiary care enter of North India, for a period of 2 years during April 2021 to March 2023. Participants were recruited from OPD, and written informed consent was obtained from each participant prior to their inclusion in the study. The study cohort comprised individuals aged 18 years and older, with a specific focus on those with clinically confirmed knee osteoarthritis based on Kellgren-Lawrence grading on X-rays. Participants in the non-OA group were required to have no clinical or radiological evidence of knee osteoarthritis. Exclusion criteria included individuals with a history of knee surgery, inflammatory joint diseases (including rheumatoid arthritis), significant trauma to the knee within the last six months, and contraindications to MRI (including claustrophobia, metallic implants).

Clinical Assessments: All participants underwent a thorough clinical assessment, including a medical history review and physical examination. Diagnosis of knee osteoarthritis was established based on clinical symptoms, joint examination findings, and radiological evidence. The Kellgren-Lawrence grading system was employed for radiological assessment.

Imaging Protocol: Magnetic Resonance Imaging (MRI) was employed to assess medial meniscal characteristics. The MRI scans were conducted using a state-of-the-art 1.5 Tesla MRI scanner (Philips Ingenia, Siemens Magnetom) to ensure consistent and high-quality imaging across all participants. The imaging protocol included the acquisition of high-resolution proton density-weighted and T2-weighted images in multiple planes, including sagittal, coronal, and axial views. The use of multiple sequences allowed for a comprehensive evaluation of the medial meniscus and provided detailed anatomical information for accurate measurement and analysis. The sagittal plane allowed for a focused assessment of meniscal thickness, while the coronal and axial planes provided additional perspectives to identify and characterize meniscal tears and evaluate extrusion. For the proton density-weighted sequence, the echo time (TE) was set between 35-45 milliseconds, providing an optimal balance between signal intensity and contrast resolution. The repetition time (TR), crucial for effective relaxation of the proton spins, was carefully selected to 2000 milliseconds, ensuring adequate time for relaxation between radiofrequency pulses. The field of view (FOV) was defined as 16 square centimeters (cm^2), offering adequate coverage while maintaining spatial resolution.

Image Analysis: Image analysis was performed by two experienced musculoskeletal radiologists who were blinded to participants' clinical information. To ensure inter-observer reliability, a subset of images was randomly selected and independently analyzed by both radiologists, with subsequent comparison and resolution of any discrepancies through consensus. Medial meniscal thickness was measured at predetermined standardized locations on sagittal images using electronic calipers. The measurements were performed at the anterior horn, mid-body, and posterior horn, ensuring a comprehensive assessment of meniscal morphology. Meniscal tears were identified and classified based on established criteria, considering the tear location (anterior, middle, posterior) and type (horizontal, radial, complex). Extrusion of the medial meniscus was quantified by measuring the distance between the outermost margin of the meniscus and the tibial plateau on axial images. Demographic details collected included age, gender, body mass index (BMI), and relevant medical history.

Statistical Analysis: Statistical analysis was conducted using SPSS version 20.0, with significance set at $p < 0.05$. Descriptive statistics were used to summarize demographic data, and continuous variables were expressed as mean ± standard deviation. Group comparisons were performed using independent t-tests or Mann-Whitney U tests for continuous variables and chi-square tests for categorical variables.

Ethical Considerations: The study adhered to the principles outlined in the Declaration of Helsinki, and ethical approval was obtained from the Institutional Ethics Committee.

Results

A total of 132 cases and 136 controls were included in the analysis. Significant differences were observed in the distribution of age groups between

cases and controls (P < 0.0001). In the <40 years age group, 9.8% of cases and 25.7% of controls were present. The 40-49 years age group constituted 47.7% of cases and 63.9% of controls, while the 50-59 years age group comprised 31.9% of cases and 8.1% of controls. Participants aged 60 years or more accounted for 10.6% of cases and 2.3% of controls. Gender distribution also exhibited a statistically significant difference (P = 0.004), with 55.3% of cases and 72.1% of controls being male. Female participants constituted 44.7% of cases and 27.9% of controls. Regarding Body Mass Index (BMI), no significant difference was observed between cases and controls (25.23 ± 4.41 vs. 25.01 ± 4.52, P = 0.687)(Table 1).

Table 1: Baseline characteristics of the study participants

Variables	Cases (n=132)	Controls (n=136)	P value
	Frequency (%)/ Mean ± SD		
Age groups			
<40 years	13 (9.8)	35 (25.7)	<0.0001
40-49 years	63 (47.7)	87 (63.9)	
50-59 years	42 (31.9)	11 (8.1)	
60 years or more	14 (10.6)	3 (2.3)	
Gender			
Male	73 (55.3)	98 (72.1)	0.004
Female	59 (44.7)	38 (27.9)	
Body mass Index (kg/m^2)	25.23 ± 4.41	25.01 ± 4.52	0.687

The distribution of osteoarthritis grades, assessed using the Kellgren Lawrence scoring system, showed that the majority of cases exhibited grades 2 and 3 osteoarthritis, constituting 37.1% and 32.6%, respectively. Grade 1 osteoarthritis was observed in 11.4% of cases. Additionally, 18.9% of cases were classified with grade 4 osteoarthritis. These findings highlight the prevalence of moderate to severe osteoarthritic changes within the cases cohort (Table 2).

Table 2: Osteoarthritis grading based on Kellgren Lawrence scoring system among cases (n=132)

Osteoarthritis grade based on Kellgren Lawrence scoring system	Frequency	%
1	15	11.4
2	49	37.1
3	43	32.6
4	25	18.9

In Figure 1A, the image displays a second-grade extrusion of the medial meniscus body, revealing a single obliquely oriented tear in a horizontal fashion (indicated by an arrow). Additionally, observable are regions of cartilage damage in the medial tibiofemoral compartment (indicated by arrowheads). The vertical line serves as a reference for measuring extrusion in the coronal plane.In Figure 1A., the reference section is identified by the presence of the medial tibial spine (pointed out by an arrow) at its maximum volume. Vertical lines, drawn along the outer edge of the medial (M) and lateral (L) tibial plateaus while excluding osteophytes, serve as points of reference for evaluating meniscus body extrusion. No extrusion is evident in this particular image, denoting a grade 0 classification (Figure 1).

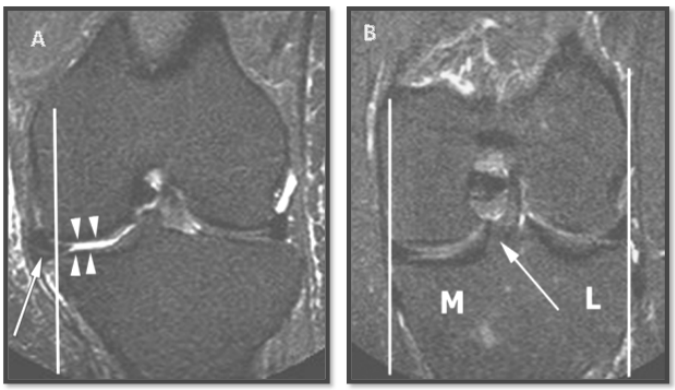

Figure 1: 1A. Second-grade extrusion of the medial meniscus body in cases. 1B. Zero-grade extrusion of the medial meniscus body in controls

Notable differences were observed in medial meniscus thickness across all segments, with cases exhibiting significantly reduced thickness compared to controls (Anterior horn: 3.84 ± 1.24 vs. 5.64 ± 1.28, P < 0.0001; Body: 3.46 ± 1.38 vs. 6.14 ± 1.71, P < 0.0001; Posterior horn: 3.42 ± 1.47 vs. 6.45 ± 1.32, P < 0.0001). Analysis of medial meniscus tear incidence showed no statistically significant difference between cases and controls (53.7% vs. 42.6%, P = 0.068). However, medial meniscus extrusion displayed a marked distinction, with cases more frequently exhibiting extrusions greater than 50% compared to controls (19.6% vs. 4.4%, P < 0.0001). Furthermore, cases demonstrated significantly reduced medial femoral cartilage thickness (1.73 ± 0.41 vs. 2.11 ± 0.56, P < 0.0001) and medial tibial cartilage thickness (1.75 ± 0.38 vs. 2.13 ± 0.57, P < 0.0001) compared to controls (Table 3).

Table 3: Radiological parameters of the medial meniscus among study participants

Radiological parameters	Cases (n=132)	Controls (n=136)	P values
	Frequency (%)/ Mean ± SD		
Medial meniscus thickness*			
Anterior horn	3.84 ± 1.24	5.64 ± 1.28	< 0.0001
Body	3.46 ± 1.38	6.14 ± 1.71	< 0.0001
Posterior horn	3.42 ± 1.47	6.45 ± 1.32	< 0.0001
Medial meniscus tear			
Yes	71 (53.7)	58 (42.6)	0.068
No	61 (46.3)	78 (57.4)	
Medial meniscus extrusion			
>50%	26 (19.6)	6 (4.4)	<0.0001
50% or less	52 (39.4)	22 (16.2)	
No	54 (41.0)	108 (76.4)	
Medial femoral cartilage thickness*	1.73 ± 0.41	2.11 ± 0.56	< 0.0001
Medial tibial cartilage thickness*	1.75 ± 0.38	2.13 ± 0.57	< 0.0001

*In millimetres

Discussion

The present study provides a comprehensive evaluation of radiological parameters and demographic characteristics in individuals with and without knee osteoarthritis (OA), shedding light on potential associations between these factors and medial meniscal characteristics. The findings reveal several noteworthy observations that contribute to the understanding of OA-related changes in the knee joint.

The observed differences in age distribution between cases and controls align with study by Blagojevic et al., indicating an increased prevalence of knee OA with advancing age [1]. Notably, our study demonstrates a significant association between age and the presence of knee OA, emphasizing the age-related nature of OA development. Additionally, the gender distribution disparity, with a higher percentage of males in the OA group, is consistent with study by Hwang et al., [13].

In our study, regarding Body Mass Index (BMI), no significant difference was observed between cases and controls (25.23 ± 4.41 vs. 25.01 ± 4.52, P = 0.687), but in the study by Grotle et al., elevated BMI was a well-established risk factor forincident knee OA [14]. The predominance of moderate (grades 2 and 3) osteoarthritis in the study population corresponds with the progressive nature of OA, with a substantial portion of individuals exhibiting moderate to severe joint changes. This aligns with the studies by Stehling et al., and Pan et al., andthe prevalence of grade 4 OA in our study warrants attention, suggesting a considerable proportion of individuals with advanced joint degeneration [8,9]. The observed reduction in medial meniscus thickness across all segments in individuals with knee OA is consistent with studies by Kawahara et al., Wenger et al., and Arno et al., associating meniscal thinning with OA progression [15,16,17]. This reduction may contribute to altered load distribution within the knee joint, potentially exacerbating OA-related changes. The significant decrease in medial femoral and tibial cartilage thickness among cases and it aligns with the studies by Hunter et al.,Wluka et al.,Saunders et al., Maschek et al., and Pelletier et al., which supports the concept of cartilage loss being a hallmark of OA [18,19,20,21,22].

The higher prevalence of medial meniscus extrusion (>50%) in cases compared to controls is in agreement with studies by Krych et al., Guermazi et al., Roemer et al., Teichtahl et al., Berthiaume et al., and Van der Voet, highlighting extrusion as a potential marker of meniscal degeneration and OA severity [4,23,24,25,26,27]. Extrusion may signify disruption of the meniscus–tibial plateau relationship, contributing to abnormal joint mechanics and further cartilage degeneration

[28,29,30]. The higher incidence of medial meniscus tears among cases as compared to controls aligns with studies byHare et al., Özdemir et al., Resorlu et al., and Jarraya et al., reporting a higher prevalence of meniscal tears in OA patients [31,32,33,34].

Limitations

While our research contributes valuable insights into the associations between radiological parameters, demographic characteristics, and knee osteoarthritis (OA), several limitations should be acknowledged. Firstly, the cross-sectional design restricts our ability to establish causality, and longitudinal studies are warranted to explore the temporal relationships between identified factors. Additionally, the study population's demographic composition may not be entirely representative of broader populations, limiting the generalizability of our findings.

The reliance on self-reported medical history and the absence of certain lifestyle factors may introduce information bias. The study's reliance on a single imaging modality (MRI) might limit a comprehensive assessment, and future investigations incorporating multiple imaging techniques could provide a more nuanced understanding of knee joint pathology. Lastly, while efforts were made to standardize imaging protocols, variations across different MRI scanners and field strengths may impact the consistency of radiological measurements. These limitations underscore the need for cautious interpretation of our findings and prompt avenues for further research to address these constraints.

Conclusion

This study provides valuable insights into the radiological and demographic characteristics associated with knee osteoarthritis. The observed differences in medial meniscus thickness, cartilage thickness, and meniscal extrusion contribute to our understanding of OA-related changes in the knee joint. However, the comparable incidence of meniscal tears raises questions about the interplay between meniscal pathology and OA. Future research with larger cohorts and longitudinal designs is warranted to validate these findings and explore the intricate relationships between demographic factors, radiological parameters, and the progression of knee osteoarthritis.

References

1. Blagojevic M, Jinks C, Jeffery A, Jordan KP. Risk factors for onset of osteoarthritis of the knee in older adults: a systematic review and meta-analysis. Osteoarthritis Cartilage. 2010;18:24-33
2. Goldring SR, Goldring MB. Bone and cartilage in osteoarthritis: is what's best for one good or bad for the other? Arthritis Res Ther. 2010;12:143.
3. Baum T, Joseph GB, Arulanandan A, et al. Association of magnetic resonance imaging-based knee cartilage T2 measurements and focal knee lesions with knee pain: data from the Osteoarthritis Initiative. Arthritis Care Res (Hoboken). 2012;64:248-55.
4. Guermazi A, Hayashi D, Jarraya M, et al. Medial posterior meniscal root tears are associated with development or worsening of medial tibiofemoral cartilage damage: the multicenter osteoarthritis study. Radiology. 2013;268:814-21.
5. Hussain ZB, Chahla J, Mandelbaum BR, Gomoll AH, LaPrade RF. The role of meniscal tears in spontaneous osteonecrosis of the knee: a systematic review of suspected etiology and a call to revisit nomenclature. Am J Sports Med. 2019;47:501-7.
6. Mosher TJ, Dardzinski BJ, Smith MB. Human articular cartilage: influence of aging and early symptomatic degeneration on the spatial variation of T2—preliminary findings at 3 T. Radiology. 2000;214:259-66.
7. Stehling C, Liebl H, Krug R, et al. Patellar cartilage: T2 values and morphologic abnormalities at 3.0-T MR imaging in relation to physical activity in asymptomatic subjects from the osteoarthritis initiative. Radiology. 2010;254:509-20.
8. Pan J, Pialat JB, Joseph T, et al. Knee cartilage T2 characteristics and evolution in relation to morphologic abnormalities detected at 3-T MR imaging: a longitudinal study of the normal control cohort from the Osteoarthritis Initiative. Radiology. 2011;261:507-15.
9. Liebl H, Joseph G, Nevitt MC, et al. Early T2 changes predict onset of radiographic knee osteoarthritis: data from the osteoarthritis initiative. Ann Rheum Dis. 2015;74:1353-9.
10. Joseph GB, Baum T, Alizai H, et al. Baseline mean and heterogeneity of MR cartilage T2 are associated with morphologic degeneration of cartilage, meniscus, and bone marrow over 3 years—data from the Osteoarthritis Initiative. Osteoarthritis Cartilage. 2012;20:727-35.
11. Raya JG, Dietrich O, Horng A, Weber J, Reiser MF, Glaser C. T2 measurement in articular cartilage: impact of the fitting method on accuracy and precision at low SNR. Magn Reson Med. 2010;63:181-93.
12. Peterfy CG, Schneider E, Nevitt M. The osteoarthritis initiative: report on the design rationale for the magnetic resonance imaging protocol for the knee. Osteoarthritis Cartilage. 2008;16:1433-41.
13. Hwang B, Kim S, Lee S, et al. Risk factors for medial meniscus posterior root tear. Am J Sports Med. 2012;40:1606-10.

14. Grotle M, Hagen KB, Natvig B, Dahl FA, Kvien TK. Obesity and osteoarthritis in knee, hip and/or hand: an epidemiological study in the general population with 10 years follow-up. BMC Musculoskelet Disord. 2008;9:132.
15. Kawahara T, Sasho T, Katsuragi J, Ohnishi T, Haneishi H. Relationship between knee osteoarthritis and meniscal shape in observation of Japanese patients by using magnetic resonance imaging. J Orthop Surg Res. 2017;12:97.
16. Wenger A, Wirth W, Hudelmaier M, et al. Meniscus body position, size, and shape in persons with and persons without radiographic knee osteoarthritis: Quantitative analyses of knee magnetic resonance images from the osteoarthritis initiative. Arthritis Rheum. 2013;65:1804-11.
17. Arno S, Walker P, Bell C, et al. Relation between cartilage volume and meniscal contact in medial osteoarthritis of the knee. Knee. 2012;19:896-901.
18. Hunter DJ, Zhang Y, Niu J, et al. Increase in bone marrow lesions associated with cartilage loss: a longitudinal magnetic resonance imaging study of knee osteoarthritis. Arthritis Rheum. 2006;54(5):1529-35.
19. Wluka AE, Stuckey S, Snaddon J, Cicuttini FM. The determinants of change in tibial cartilage volume in osteoarthritic knees. Arthritis Rheum. 2002;46:2065-72.
20. Saunders J, Ding C, Cicuttini F, Jones G. Radiographic osteoarthritis and pain are independent predictors of knee cartilage loss: A prospective study. Intern Med J. 2012;42:274-80.
21. Maschek S, Wirth W, Ladel C, Hellio Le Graverand MP, Eckstein F. Rates and sensitivity of knee cartilage thickness loss in specific central reading radiographic strata from the osteoarthritis initiative. Osteoarthritis Cartilage.2014;22:1550-3.
22. Pelletier JP, Raynauld JP, Berthiaume MJ, et al. Risk factors associated with the loss of cartilage volume on weightbearing areas in knee osteoarthritis patients assessed by quantitative magnetic resonance imaging: a longitudinal study. Arthritis Res Ther. 2007;9:R74.
23. Krych AJ, Johnson NR, Mohan R, et al. Arthritis progression on serial MRIs following diagnosis of medial meniscal posterior horn root tear. J Knee Surg. 2018;31:698-704.
24. Roemer FW, Zhang Y, Niu J, et al. Tibiofemoral joint osteoarthritis: risk factors for MR-depicted fast cartilage loss over a 30-month period in the multicenter osteoarthritis study. Radiology. 2009;252:772-80.
25. Teichtahl AJ, Cicuttini FM, Abram F, et al. Meniscal extrusion and bone marrow lesions are associated with incident and progressive knee osteoarthritis. Osteoarthritis Cartilage. 2017;25:1076-83.
26. Berthiaume MJ, Raynauld JP, Martel-Pelletier J, et al. Meniscal tear and extrusion are strongly associated with progression of symptomatic knee osteoarthritis as assessed by quantitative magnetic resonance imaging. Ann Rheum Dis. 2005;64:556-63.
27. Van der Voet JA, Runhaar J, van der Plas P, Vroegindeweij D, Oei EH, Bierma-Zeinstra SMA. Baseline meniscal extrusion associated with incident knee osteoarthritis after 30 months in overweight and obese women. Osteoarthritis Cartilage. 2017;25:1299-303.
28. Allaire R, Muriuki M, Gilbertson L, Harner CD. Biomechanical consequences of a tear of the posterior root of the medial meniscus. Similar to total meniscectomy. J Bone Joint Surg Am. 2008;90:1922-31.
29. Bhatia S, LaPrade CM, Ellman MB, LaPrade RF. Meniscal root tears: significance, diagnosis, and treatment. Am J Sports Med. 2014;42:3016-30.
30. Crema MD, Roemer FW, Felson DT, et al. Factors associated with meniscal extrusion in knees with or at risk for osteoarthritis: the Multicenter Osteoarthritis study. Radiology. 2012; 264:494-503.
31. Hare KB, Stefan Lohmander L, Kise NJ, Risberg MA, Roos EM. Middle-aged patients with an MRI-verified medial meniscal tear report symptoms commonly associated with knee osteoarthritis. Acta Orthop. 2017; 88:664-9.
32. Özdemir M, Turan A. Correlation between medial meniscal extrusion determined by dynamic ultrasound and magnetic resonance imaging findings of medial-type knee osteoarthritis in patients with knee pain. J Ultrasound Med. 2019; 38:2709-19.
33. Resorlu M, Doner D, Karatag O, Toprak CA. The relationship between chondromalacia patella, medial meniscal tear and medial periarticular bursitis in patients with osteoarthritis. Radiol Oncol. 2017; 51:401-6.
34. Jarraya M, Roemer FW, Englund M, et al. Meniscus morphology: Does tear type matter? A narrative review with focus on relevance for osteoarthritis research. Semin Arthritis Rheum. 2017; 46:552-61.