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Ali Guerhazi

Insights from Imaging on the Epidemiology and Pathophysiology of Osteoarthritis 539

David J. Hunter

This article highlights recent studies, particularly those with an emphasis on MR imaging, that are providing unique insights into the relation between structures identified on imaging and symptoms and disease genesis. It is becoming increasingly apparent that the subchondral bone, periosteum, periarticular ligaments, periarticular muscle spasm, synovium, and joint capsule are all richly innervated and are the likely source of nociception in osteoarthritis. It is also apparent that local tissue alterations in the bone and meniscus and alignment of the lower extremity are important in terms of disease genesis. This article represents the literature in that much of the focus and understanding is knee centric with less focus on the hip and hand.

Role of Alignment and Biomechanics in Osteoarthritis and Implications for Imaging 553

David J. Hunter and David R. Wilson

Osteoarthritis is widely believed to result from local mechanical factors acting within the context of systemic susceptibility. This article delineates current understanding of the etiopathogenesis of osteoarthritis and more specifically examines the critical role of biomechanics in disease pathogenesis. There are several ways that mechanical forces across the joint can be measured, including many that rely heavily on imaging methods. These are described and methods to advance the field are proposed.

Radiographic-Based Grading Methods and Radiographic Measurement of Joint Space Width in Osteoarthritis 567

Marie-Pierre Hellio Le Graverand, Steve Mazzuca, Jeff Duryea, and Alan Brett

Accurate and highly reproducible measurements of the rate of progression of osteoarthritis is crucial to assessing structural change, and requires adherence to exacting standards of positioning, which include specifications for flexion and rotation of the joint, and angulation of the x-ray beam. The progression of osteoarthritis traditionally has been measured using radiographic joint space width (JSW). Over the past two decades, numerous knee radiographic protocols have been developed with various levels of complexity and performance as they relate to detecting JSW loss (ie, joint space narrowing). Semiautomated software has been developed to improve the accuracy of JSW measurement over manual methods. JSW measurements include minimum JSW, mean JSW or joint space area and JSW at fixed locations.

Ultrasonography in Osteoarthritis 581

Helen I. Keen and Philip G. Conaghan

This article outlines the benefits of imaging osteoarthritis with ultrasonography and some of the limitations. Pathologic structures able to be identified in osteoarthritis

with ultrasonography are reviewed, with a focus on the validity of the technique. Common ultrasonographic abnormalities seen in osteoarthritis in specific joint regions are discussed. Finally, future research agendas are considered. With improving technology, accessibility of ultrasonography, increasing evidence regarding the validity, and use of ultrasonography in osteoarthritis mean that ultrasonography is likely increasingly used in the clinical trial setting and routine clinical practice to aid the diagnosis and management of osteoarthritis.

CT Arthrography, MR Arthrography, PET, and Scintigraphy in Osteoarthritis

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Patrick Omoumi, Gustavo A. Mercier, Frédéric Lecouvet, Paolo Simoni, and Bruno C. Vande Berg

CT arthrography and MR arthrography are accurate methods for the study of surface cartilage lesions and cartilage loss. They also provide information on subchondral bone and marrow changes, and ligaments and meniscal lesions that can be associated with osteoarthritis. Nuclear medicine also offers new insights in the assessment of the disease. This article discusses the strengths and limitations of CT arthrography and MR arthrography. It also highlights nuclear medicine methods that may be relevant to the study of osteoarthritis in research and clinical practice.

MR Imaging in Osteoarthritis: Hardware, Coils, and Sequences

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Thomas M. Link

Whole-organ assessment of a joint with osteoarthritis (OA) requires tailored MR imaging hardware and imaging protocols to diagnose and monitor degenerative disease of the cartilage, menisci, bone marrow, ligaments, and tendons. Image quality benefits from increased field strength, and 3.0-T MR imaging is used increasingly for assessing joints with OA. Dedicated surface coils are required for best visualization of joints affected by OA, and the use of multichannel phased-array coils with parallel imaging improves image quality and/or shortens acquisition times. Sequences that best show morphologic abnormalities of the whole joint include intermediate-weighted fast-spin echo sequences. Also quantitative sequences have been developed to assess cartilage volume and thickness and to analyze cartilage biochemical composition.

MR Imaging-Based Semiquantitative Assessment in Osteoarthritis

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Frank W. Roemer and Ali Guerhazi

Whole-organ semiquantitative (SQ) assessment by expert readers has become a powerful research tool in understanding the natural history of osteoarthritis (OA). SQ morphologic scoring has been applied to observational large cross-sectional and longitudinal epidemiologic studies in addition to interventional clinical trials. In comparison to quantitative and biochemical assessment of cartilage, SQ whole-organ scoring also analyzes additional joint structures that are potentially relevant as surrogate outcome measures for interventional approaches. Resources needed for SQ scoring rely on the MR imaging protocol, image quality, experience of the expert readers, method of documentation, and individual scoring system that is applied. This article discusses the different available OA whole-organ scoring systems, focusing on MR imaging of the knee, and also reviews alternative approaches.

Quantitative MR Imaging of Cartilage and Trabecular Bone in Osteoarthritis

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Felix Eckstein, Ali Guerhazi, and Frank W. Roemer

Whereas the strength of scoring systems in osteoarthritis (OA) lies in detecting local changes, involving small parts of the structures of interest (ie, cartilage lesions),

quantitative measures are powerful where minute changes occur homogeneously throughout large structures. Cartilage measurements at 1.5 or 3 Tesla are technically accurate, reproducible, and sensitive to change. The rate of change in knee OA was found to be 1% to 2% annually. Risk factors of cartilage loss include a high BMI, meniscal pathology, malalignment, advanced radiographic OA, bone marrow alterations, and focal cartilage lesions. MRI of articular tissues represents a potent tool in experimental, epidemiological and pharmacological intervention studies; however, it is only with the availability of disease modifying drugs that it will play a relevant role in clinical practice.

Measures of Molecular Composition and Structure in Osteoarthritis

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Deborah Burstein, Martha Gray, Tim Mosher, and Bernard Dardzinski

Osteoarthritis involves ongoing degradative and healing processes that occur at the molecular level in multiple tissues in the joint in response to a number of biochemical and mechanical factors. Understanding these dynamic processes before they affect the structural aspects of the joint motivates the need for metrics to better visualize the compositional and structural molecular aspects of the tissues *in vivo*. As reviewed here, most of the work to date in this regard has been focused on magnetic resonance imaging approaches for interrogating molecular features of cartilage, including T2 mapping, T1rho mapping, delayed gadolinium-enhanced magnetic resonance imaging of cartilage (dGEMRIC), and sodium imaging. Specific examples illustrate new opportunities and insights emerging from these methods.

MR Imaging of Intra- and Periarticular Soft Tissues and Subchondral Bone in Knee Osteoarthritis

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Michel D. Crema, Frank W. Roemer, Monica D. Marra, and Ali Guermazi

Osteoarthritis of the knee has to be considered a disease of the whole joint. Magnetic resonance imaging allows superior assessment of all joint tissues that may be involved in the disease process, such as the subchondral bone, synovium, ligaments, and periarticular soft tissues. Reliable MR imaging-based scoring systems are available to assess and quantify these structures and associated pathology. Cross-sectional and longitudinal evaluation has enabled us to understand their relevance in explaining pain and structural progression.

The Role of the Meniscus in Knee Osteoarthritis: a Cause or Consequence?

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Martin Englund, Ali Guermazi, and Stefan L. Lohmander

The menisci play a critical protective role for the knee joint through shock absorption and load distribution. Asymptomatic meniscal tears are common and are frequent incidental findings on knee MR imaging of the middle-aged or older patient. A meniscal tear can lead to knee osteoarthritis (OA), but knee OA can also lead to a spontaneous meniscal tear through breakdown and weakening of meniscal structure. A degenerative meniscal lesion in the middle-aged or older patient could suggest early stage knee OA and should be treated accordingly. Surgical resection of non-obstructive degenerate lesions may only remove evidence of the disorder while the OA and associated symptoms proceeds.

MR Imaging of Hip Osteoarthritis and Implications for Surgery

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Tallal C. Mamisch, Christoph Zilkens, Klaus A. Siebenrock, Bernd Bittersohl, Young-Jo Kim, and Stefan Werlen

Osteoarthritis of the hip joint is caused by a combination of intrinsic factors and extrinsic factors. Different surgical techniques are being performed to delay or halt

osteoarthritis. Success of salvage procedures of the hip depends on the existing cartilage and joint damage before surgery; the likelihood of therapy failure rises with advanced osteoarthritis. For imaging of intra-articular hip pathology, MR imaging represents the best technique because of its ability to directly visualize cartilage, superior soft tissue contrast, and the prospect of multidimensional imaging. This article gives an overview on the standard MR imaging techniques used for diagnosis of hip osteoarthritis and their implications for surgery.

Osteoarthritis of the Wrist and Hand, and Spine

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Antoine Feydy, Etienne Pluot, Henri Guerini, and Jean-Luc Drapé

Although osteoarthritis (OA) of the wrist and fingers is routinely diagnosed using plain film, a thorough assessment of cartilage injuries using CT-arthrography, MR imaging, or MR-arthrography remains necessary before any surgical procedure. MR imaging is ideally suited for delineating the presence, extent, and complications of degenerative spinal disease, including OA of the spine involving the disc space, vertebral endplates, facet joints, or supportive and surrounding soft tissues. Other imaging modalities such as CT, dynamic radiography, myelography, and discography may provide complimentary information in selected cases. This article focuses on imaging of OA of the wrist and hand and the lumbar spine, with an emphasis on current MR imaging grading systems available for the assessment of discovertebral lesions.

Imaging in Pre- and Post-operative Assessment in Joint Preserving and Replacing Surgery

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Adnan Sheikh and Mark Schweitzer

Within the recent years, advances in imaging technology have increased its applicability to diagnose musculoskeletal disease. The modification of imaging techniques and improved image quality has led to increased use of computed tomography and magnetic resonance imaging in the assessment of postoperative complications related to orthopedic procedures. This article discusses the indications, pre- and post-operative imaging findings and post-operative complications of knee and hip arthroplasty, articular cartilage repair and high tibial osteotomy.

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