



Role of imaging in surgical decision making in young knee osteoarthritis

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HIGHLIGHTS

- Prevalence of knee osteoarthritis is increasing in younger population.
- Surgical treatment of osteoarthritis at a younger age has its own challenges of need to return to higher levels of physical activity and longer life expectancy.
- Osteoarthritis is now considered a whole organ dynamic disease.
- Imaging plays an important role in decision making in treatment and management of osteoarthritis.

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ABSTRACT

Osteoarthritis is the most common form of knee arthritis, characterized by pain and discomfort from primarily articular cartilage wear. Traditionally in its end stage, it has been treated with total knee arthroplasty, a permanent process with a life span of ten to fifteen years and challenges with revision. With an increasing longevity and epidemic of obesity that the population is facing, naturally, we are seeing more and more patients with osteoarthritis at a younger age. This makes it imperative to extend the life of the native knee by conservative measures, injections of steroid, hyaluronic acid, or biologicals and finally a slew of surgical alternatives ranging from joint realignment to partial and total joint replacement. Besides the clinical presentation, decisions are made based on joint alignment, extent and degree of cartilage wear and the status of the subchondral bone. Imaging plays an invaluable role in surgical decision making. In this article, we will discuss how imaging is used in our practice during decision making for the management of the young osteoarthritic knee.

1. Article

1.1. What is OA?

Osteoarthritis (OA) is a progressive joint disease with significant burden on the public health and morbidity. The understanding of OA has significantly changed in the last few decades. Earlier it was considered predominantly a disease of the articular cartilage wear and tear but with advances in imaging especially MRI, it is now considered as a whole organ dynamic disease that involves cartilage, bone, synovium, ligaments, and muscles. It is caused by an imbalance between breakdown and repair of the joint tissues. It is not just cartilage thinning and adjoining bony changes but also includes synovial inflammation as well as ligament and meniscal damage [1]. Osteoarthritis is the more appropriate term as it is primarily a degenerative joint disease rather

than osteoarthritis which signifies an inflammatory disease [2].

The number of younger patients presenting with OA is increasing with increasing life expectancies, continuing physical careers, lifestyles into later life and rising obesity levels [3]. Traumatic injury also contributes to development of OA in young adults with meniscal and cruciate ligament injuries leading to instability and altered mechanics that significantly increase the risk of OA [4].

Defining the cut-off age for young OA is difficult, which may depend on not only chronological but also biologic age of the joint especially in athletes. Hence, decision making is based on the current physical and medical condition of a patient along with the potential/intended outcome, however below 55 years may be considered as young [5].

The patient can present with pain, disability, deformity, swelling and instability. Generally, patients present with activity related pain in early to intermediate OA [6–8]. It progresses to pain at rest and night pain

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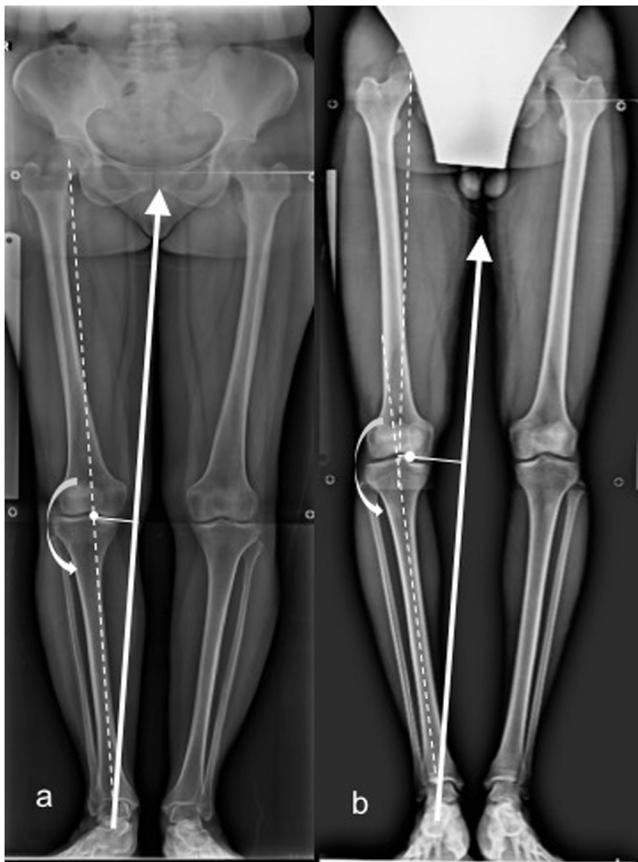


Fig. 1. Weight bearing lower limb scanogram a) neutral alignment depicts GRF passing medial to knee center of rotation with resultant small KAM and resultant concentration of compressive load on medial femorotibial compartment and b) varus deformity shows increase in KAM and compressive load on medial femorotibial compartment with increase in the perpendicular distance between GRF (thick line with arrow) and center of knee rotation. The dotted lines represent the mechanical axis of femur and tibia while the curved arrow depicts the KAM. This explains the biomechanics which can cause progressive OA. A lower limb is considered neutral if the angle between the mechanical axis of the femur (the line joining the femoral head center to femoral intercondylar notch center) and the mechanical axis of the tibia (the line joining ankle talus center to the center of the tibial spine) is 0° .

disturbing sleep-in advanced stage. Patients can also present with acute exacerbation associated with an osteophyte fracture or a meniscal tear. In early OA, there is early fatiguability that progresses to inability to walk longer distances or climb stairs or walk on uneven grounds that finally makes it difficult to manage day to day activities of living in severe OA. 90 % of Indian population has a varus knee attitude that becomes worse with progressive medial compartment OA leading to progressive varus deformity and ultimately knee subluxation in severe OA. On the other hand, patients who have a valgus knee attitude tend to progress to lateral compartment arthritis. This generally becomes symptomatic only in later stages of arthritis. Early OA presents with knee swelling only with unaccustomed activities such as squats and lunges and progresses to residual persistent knee swelling. Instability is less common.

1.2. Principles of management

a. Confirmation of osteoarthritis

When a young patient presents with knee pain, and clinical suspicion of OA/diffuse chondrogenic etiology is considered, the first step is usually to perform frontal weight bearing knee radiographs to assess the joint space as this is presumed to be reflective of articular

cartilage loss [9]. If one intends to intervene, then one should follow this up with an MRI as there are multiple confounding variables that may result in radiographic joint space narrowing which could be mistaken for cartilage loss but not actually be, such as meniscal tears/extrusion. Furthermore, even if there is cartilage loss, MRI help in identifying other causes of pain, such as a meniscus flap or loose body [10]. A clinical decision regarding the cause of pain is made.

b. Confirmation of cause of pain

It is important to assess whether the patient's presentation is that of osteoarthritis or acute exacerbation of osteoarthritis due to a subchondral insufficiency fracture, meniscal tear, fractured osteophyte or loose body. These entities may change the course of management from managing osteoarthritis to managing the entity specifically with arthroscopy.

c. Grading of OA

MRI helps to identify the size (percent of articular surface area) and depth (grade) of cartilage loss, which could together be termed as the "extent" of cartilage involvement for particular knee compartment. This has been discussed in detail later. This enables us to determine whether the compartment cartilage can be ignored as close to normal, salvageable by chondral surgery/realignment or needs to be replaced. Simultaneously, the articular cartilage in rest of the compartments is also assessed and a decision on which compartments can be spared, salvaged or replaced can be made.

d. Management of OA

The first line of management in OA is non-surgical [11], like physiotherapy, alignment correcting wedge insoles, bracing and exercise. Pharmacologic treatment like non-steroidal anti-inflammatory drugs and analgesics can be helpful. Disease modifying osteoarthritis drugs like glucosamine sulfate and chondroitin sulfate have also been tried with limited usefulness. Intra articular corticosteroid injection provides short term pain relief and are especially useful in acute exacerbations of OA. Viscosupplementation with hyaluronic acid which also has analgesic and anti-inflammatory effects are also used frequently [12]. Biological agents such as platelet rich plasma (PRP) and mesenchymal stem cells have been discussed and used without consistent success or guidelines.

These conservative therapies however do not correct the abnormal biomechanics which are considered the main causative factor for disease progression in OA [13]. The limited usefulness of these conservative therapies may also be due to the fact that they are instituted only late in the disease process.

Single compartment mild or moderate disease may be managed conservatively.

When conservative management fails, arthroscopy may provide relief in a small group of patients with meniscal tears or loose bodies.

If there is greater extent of cartilage involvement, decisions on realignment surgery versus partial or complete joint replacement are taken based on the compartments involved and the alignment/biomechanics of the knee. Compartment involvement is evident from MRI while alignment is determined by a standing scanogram. Scanograms help determine the biomechanics of the knee, discussed in detail in the following section. It provides mechanical axis and loading patterns in the knee as well as contribution of the femur or tibia to the angulation deformity subsequently allowing the surgeon to decide between performing a high tibial osteotomy or distal femoral osteotomy based on the medial proximal tibial and lateral distal femoral angles respectively.

If articular cartilage involvement is moderate and involves a single compartment, then realignment surgery may be indicated to further extend the life of the native knee. Total knee arthroplasty in younger individuals has its own challenges regarding implant durability due to increased physical demands and patients will outlive the implant with need for revision in future. Thus, the challenge for the orthopedician is to select the surgery which provides pain relief and return to function but also taking care not to compromise future surgery or revision



Fig. 2. Frontal radiograph of knee depicting (a) Grade 2, (b) Grade 3 and (c) Grade 4 medial femorotibial joint space narrowing as per Kellgren -Lawrence grading system.



Fig. 3. Frontal radiograph of both knees a) non weight bearing shows mild bilateral medial femorotibial compartment joint space narrowing in comparison to the b) weight bearing radiographs depict severe bilateral medial femorotibial compartment joint space narrowing.

surgery that may be inevitable with disease progression or prosthesis failure [5]. The decision is usually between a high tibial osteotomy and or distal femoral osteotomy depending on the contribution of each bone to the alignment abnormality. In some cases, a bipolar osteotomy may be performed to change the mechanical axis in both the coronal as well as the sagittal planes based on the pattern of articular cartilage wear.

If there is more extensive single compartment articular cartilage loss, where cartilage can no longer be salvaged or there is normal alignment and there is no significant role for realignment surgery in helping to spare residual cartilage, a unicompartmental arthroplasty may be considered.

If there is involvement of both femorotibial compartments, total knee arthroplasty is considered. Alignment abnormalities in this situation can be addressed by changing the alignment of the implants at the time of arthroplasty.

In the early/ initial stages of OA, especially in younger patients, small, isolated cartilage defects can be treated with microfracture, osteochondral allografts and autologous chondrocyte implantation. In microfracture, an arthroscopic awl is used to drill multiple small holes in the subchondral bone which leads to super clot formation. This provides

suitable environment for the pluripotential marrow stem cells to differentiate into fibrocartilaginous repair tissue that fills the original defect [14].

Mosaicplasty/ OATs involves transfer of cylindrical autologous osteochondral graft plugs from low-weight bearing areas like trochlea to the site of chondral defects along weight bearing femoral surface [15].

In autologous chondrocyte implantation, in the first step arthroscopy, cartilage is harvested which is then used to produce culture expanded autologous cartilage cells. These cartilage cells are then injected into the chondral defect under a patch of periosteum. [16].

2. Role of biomechanics in OA

Majority of patients present with a medial compartment OA with a varus deformity. The force applied to the knee joint depends upon the ground reaction force- GRF (which is indeed dependent upon patient weight) and the varus moment (VM) at the knee. The resultant vector is called as knee adduction moment (KAM) and is calculated by multiplying the above two parameters. This has been directly correlated with progression of OA. Obviously, in an overweight patient where the GRF is



Fig. 4. Frontal radiograph of the knee a) showing apparent joint space narrowing due to obliquity with oval shaped medial tibial articular surface and b) depicting normal joint space on correction of obliquity.



Fig. 5. (a) Frontal radiograph of knee depicting mild medial femorotibial joint space narrowing (b) coronal PD weighted MRI image of the same patient depicting extrusion of the medial meniscus with maintained articular cartilage also demonstrated on (c) Sagittal PD weighted MRI.

high, the adduction moment is higher. Weight loss hence has a significant role in controlling OA progression. Similarly, in a patient with varus deformity, the KAM is higher and will lead to a vicious circle of increasing varus deformity due to progressive OA that further worsens the deformity (Fig. 1). High tibial osteotomy as a realignment procedure is based on correcting this AM by correcting varus and stopping the vicious circle of varus OA [17,18].

Need for correction of abnormal joint mechanics and durability concerns of implant make realignment osteotomy such as a high tibial osteotomy a useful alternative in young active individuals. In HTO, the mechanical axis is redirected from the degenerated area of joint (medial compartment) to the relatively maintained area of joint. Normally the mechanical axis of the lower limbs passes just medial to the midline with 75 % of the load passing through the medial tibial plateau. Loads of almost twice the body's weight act on the femorotibial joints which

increase further on activities like climbing/ squatting and impact activities. In patients with varus deformity, HTO offloads the medial compartment and redirects the mechanical axis to relatively preserved lateral femorotibial joint. It provides pain relief and slows disease progression with good long term results but appropriate patient selection is very important. A patient with medial femorotibial OA and varus deformity with good range of motion and intact ligaments is the ideal candidate for HTO [19].

In young or middle-aged patients with valgus deformity and lateral compartment OA in patients, the varus DFO (distal femoral osteotomy) is an effective treatment [20].

Unicompartmental knee arthroplasty in which a single (usually) medial femorotibial compartment is replaced by implant has advantages over TKR with maintained bone stock and soft tissues as well as preserved gait pattern and mechanics. A prerequisite for unicompartmental

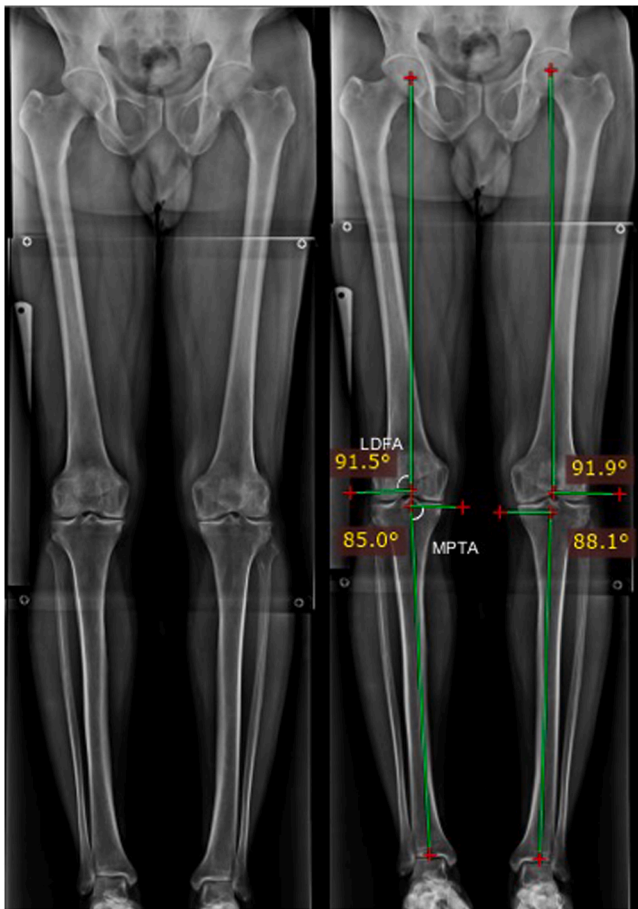


Fig. 6. (a) Weight bearing lower limb scanogram, (b) depicting the alignment with measurements of lateral distal femoral angle (LDFA) and medial proximal tibial angle (MPTA).

knee replacement is a well preserved lateral compartment, grade IV OA in medial compartment and a stable knee. A severe deformity may not be suitable for a unicompartamental knee replacement.

Results of TKR after modern HTO or UKR has same results as in an unoperated knee making these useful as the first line of surgical management in young individuals who will maintain active lifestyle for longer time and may need TKR in later stages of life.

3. Role of imaging

As emphasized, imaging helps us determine the cause of patient's symptoms, contribution of osteoarthritis to the cause of pain and extent of cartilage damage. Radiographs and MRI are the most commonly used imaging modalities.

3.1. Plain radiographs

have been considered the gold standard for morphologic assessment of OA and remain the mainstay of imaging. They are used in clinical practice to establish the diagnosis of OA and also to monitor disease progression. Joint space narrowing has been used as an indirect evidence of cartilage thinning. Joint space narrowing (JSN), osteophytes, subchondral sclerosis and cysts are seen in osteoarthritis.

Kellgren-Lawrence scale has been used to grade the severity of OA and monitor its progression in clinical trials.

Kellgren-Lawrence in 1957 described grading for OA on AP knee radiographs. (Fig. 2).

K-L Grade 0 - no JSN or reactive changes,

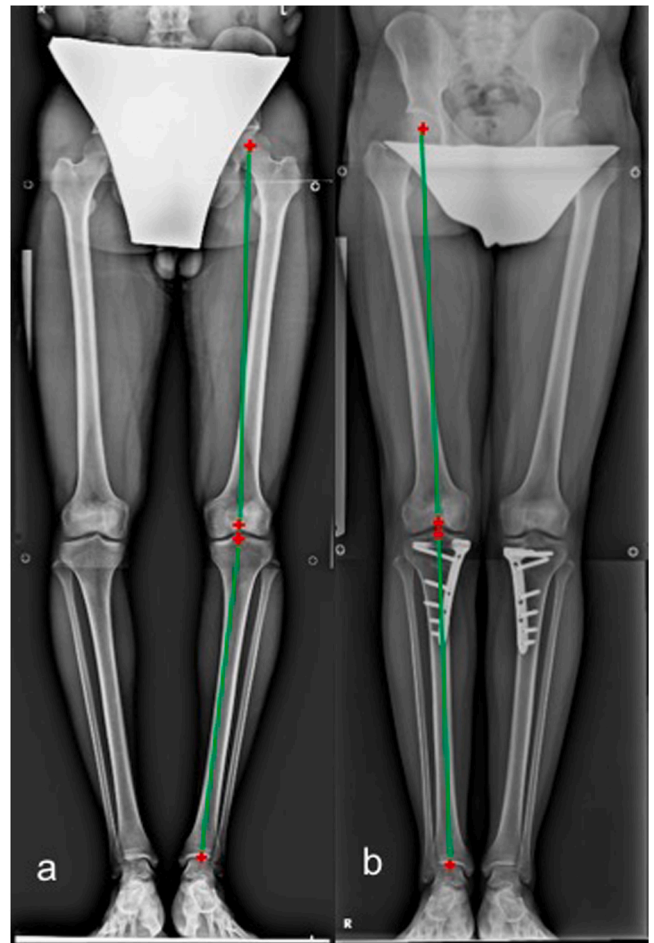


Fig. 7. Weight bearing lower limb scanogram (a) pre and (b) post high tibial osteotomy reveals post operative realignment with correction of the varus deformity.

Grade 1 - doubtful JSN, possible osteophytic lipping.

Grade 2 - possible JSN, definite osteophytes.

Grade 3- definite JSN, moderate osteophytes, some sclerosis, possible bone end deformity.

Grade 4- marked JSN, large osteophytes, severe sclerosis, definite bone end deformity [21].

Although K-L system has its own limitations, it remains widely used in clinical practice and research.

Osteoarthritis Research Society International (OARSI) atlas classification grades the joint space narrowing and osteophytes separately in each compartment of the knee [22].

Weight bearing AP knee radiographs in full extension are routinely used to evaluate OA (Fig. 3). There are several limitation with the radiographs. Angulation of knee and obliquity with the x ray beam not parallel to the joint space is a common limitation and may lead to artifactual JSN. (Fig. 4) Inability to reliably reproduce the joint space measurements is another limitation. Fluoroscopy to guide knee flexion to obtain alignment of the medial tibial plateau in relation to the horizontal x-ray beam may help overcome obliquity [23]. Lyon Schuss view, which is a fluoroscopically assisted view with knee in 25–30° flexion with anterior aspect of the hip, patella and tip of the great toe placed in contact with the vertical radiographic table provides satisfactory medial tibial plateau alignment [24]. But these are often difficult to implement in routine clinical practice. Comparison with the opposite knee radiographs also helps in objectively assessing the joint space narrowing.

Severe medial femorotibial joint space narrowing may lead to widening of the lateral joint space limiting the evaluation of lateral



Fig. 8. Coronal PD weighted MRI images depicting various patterns of chondral loss (a) medial femoral chondral loss (b) lateral femorotibial chondral loss and (c) medial as well as lateral femorotibial chondral loss with large peripheral osteophytes.

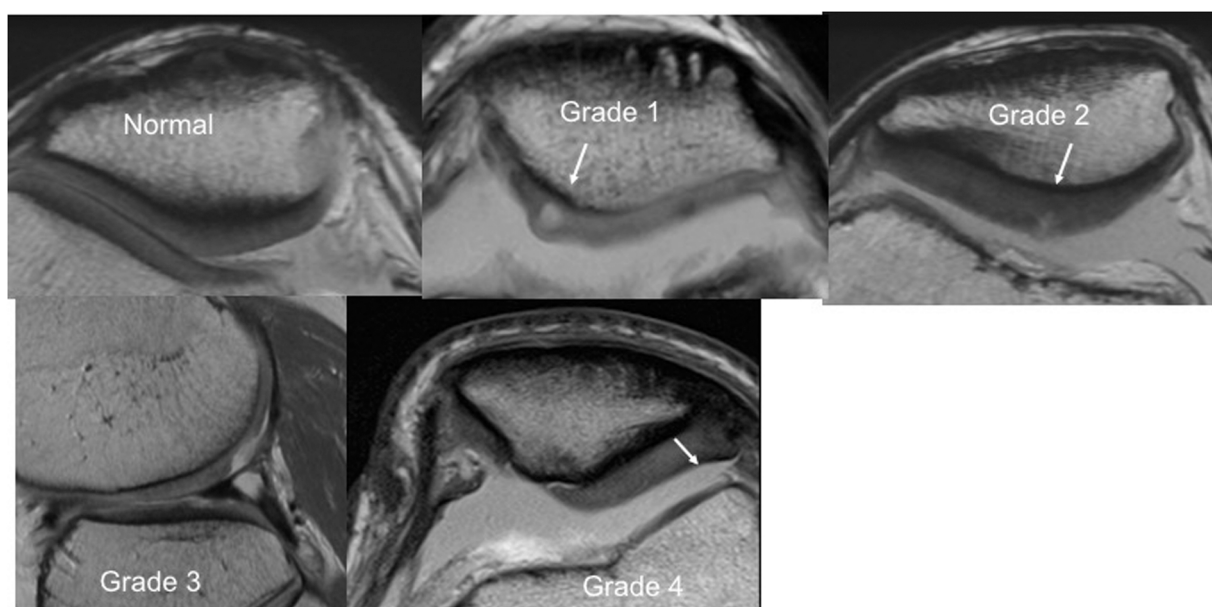


Fig. 9. Proton density images depicting modified Outerbridge grading of cartilage lesions.

compartment cartilage on radiographs [25].

Radiographs do not allow direct visualization of the cartilage and menisci, thus joint space narrowing due to other causes like meniscal extrusion may be mistaken for osteoarthritis (Fig. 5). Normal joint space does not exclude cartilage loss as by the time joint space narrowing becomes evident on radiographs, more than 10 % of the articular cartilage is usually already lost [26].

Thus plain radiograph, though limited in its ability to detect early OA should always be obtained. It can be useful to assess for loose bodies, alignment (varus or valgus), fractures/ stress fractures and osteochondral lesions.

3.2. Weight bearing limb scanograms

provide accurate assessment of the mechanical axis in loading conditions. This is very important in successful outcome of high tibial osteotomy in which precise alignment of mechanical axis of the lower limb is restored. Full length hip to ankle weight bearing scanogram has been found to be more reliable than computer navigation technique in restoration of the coronal limb alignment [27]. Lateral distal femoral angles and medial proximal tibial angles are measured on the scanogram and help the surgeon decide the plan of

management and type of surgery. The mechanical axis of femur is drawn by joining center of the femoral head to midpoint of a line tangential to the distal femoral condyles. The mechanical axis of tibia is obtained by joining the midpoint of line tangential the tibial plateau to the midpoint of the line along distal tibial articular surface tangential to ankle joint. Lateral distal femoral angle is the angle between the mechanical axis of femur and distal femoral articular surface while medial proximal tibial angle is the angle between the tibial mechanical axis and proximal tibial articular surface [28] (Figs. 6, 7)

3.3. MRI

With the paradigm shift in acceptance that OA is a disease of the whole joint, MRI has an important role to play as it can evaluate the cartilage, subchondral bone, menisci, ligaments, synovium, and periarticular soft tissues which are potential pain generators or structural issues that should be addressed when managing osteoarthritic symptoms.

Articular cartilage wear traditionally forms the core of present understanding of OA and MRI is the most accurate non-invasive method to

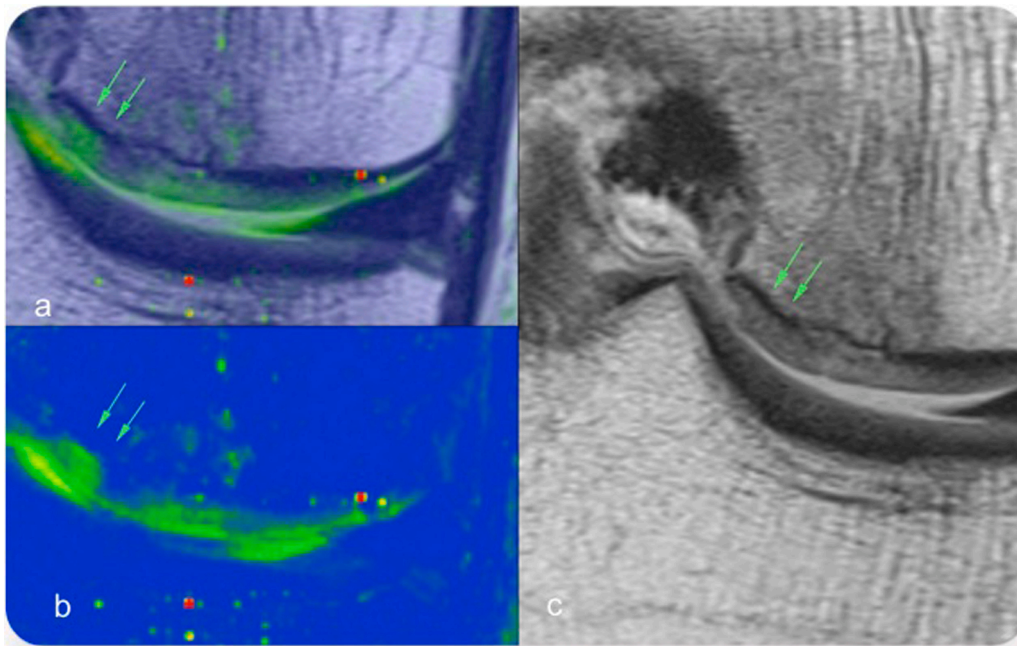


Fig. 10. T2 mapping (a & b) shows increase in T2 relaxation value along inner central weight bearing medial femoral cartilage with normal signal on proton density images (c) suggestive of chondral degeneration. The adjoining cartilage shows softening and fissuring on proton density images.

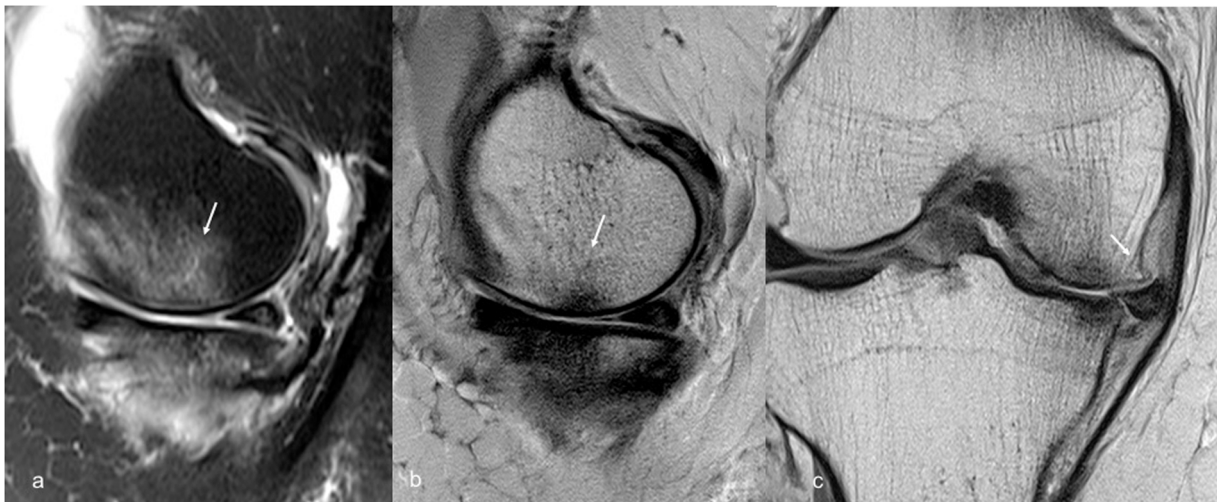


Fig. 11. a) Sagittal T2 fat suppressed image depicting moderate to marked subchondral medial femorotibial marrow edema, b) Sagittal PD and c) Coronal PD reveals diffuse advanced weight bearing medial femorotibial chondral loss with severe extrusion of the body segment of the medial meniscus on coronal images.

image the articular cartilage. MRI can be used to assess cartilage morphology (thickness, discrete defects, flaps) and ultrastructure (collagen orderliness and glycosaminoglycan content). It helps in quantifying the cartilage loss in the different compartments of the knee (Fig. 8).

Several sequences have been developed to evaluate the cartilage morphology. The main challenge lies in obtaining adequate contrast difference between the cartilage and subchondral bone as well as high spatial resolution in a thin structure along curved surface.

Two dimensional (2D) fast spin echo proton density sequences form the mainstay of morphologic imaging of the cartilage as they provide good contrast between the bright fluid and intermediate signal intensity cartilage, show good intrachondral detail and also allow evaluation of the other structures like menisci and ligaments. Their main drawback is partial volume averaging, anisotropic voxels, limited resolution, and image blurring. [9,29] Fat saturated T2 weighted images depict the

underlying marrow changes like edema and subchondral cystic changes.

3 dimensional (3D) T1 spoiled gradient recalled echo sequences provide high resolution images with good contrast between bright cartilage and dark fluid, bone, and muscle. They have a very high sensitivity of 93 % in detection of cartilage defects with good correlation with arthroscopy findings and have been considered the standard for quantitative morphologic cartilage assessment [30]. Disadvantages include longer scanning times, sensitivity to susceptibility artifacts and poor depiction of subchondral marrow abnormalities.

A number of other sequences like DESS (Double Echo Steady State), DEFT (Driven Equilibrium Fourier Transform) and 3D spin echo have also been used for evaluation of hyaline cartilage.

These sequences demonstrate chondral defects, fissures and delamination which are most commonly graded by the modification of the Outerbridge classification [31] (Fig. 9).

Grade 0 - Intact cartilage.

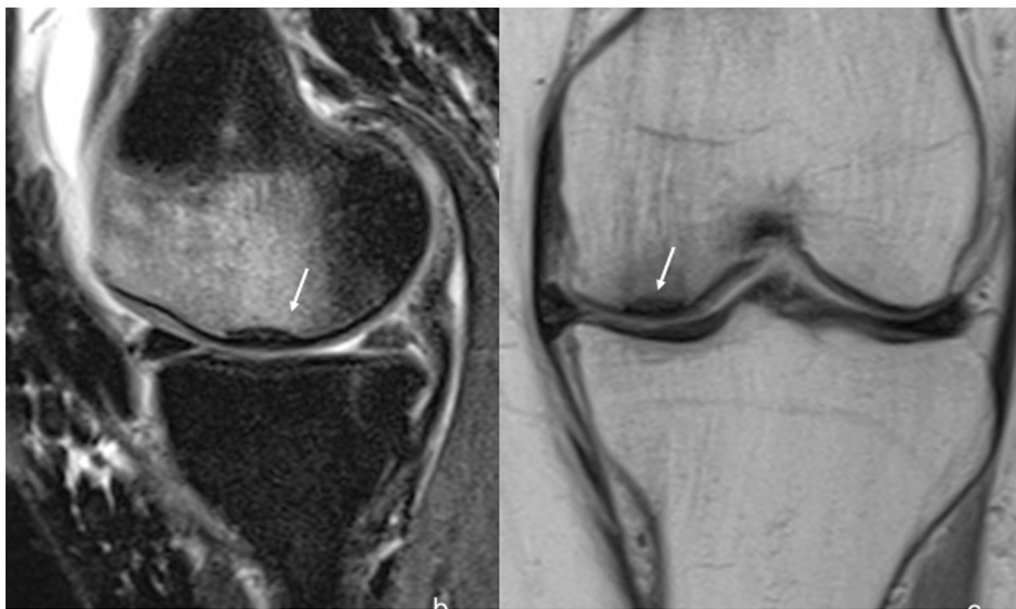


Fig. 12. a) Sagittal T2 fat suppressed, b) Coronal PD MRI images depicting moderate medial femoral subchondral marrow edema with subchondral insufficiency fracture but relatively maintained articular cartilage.

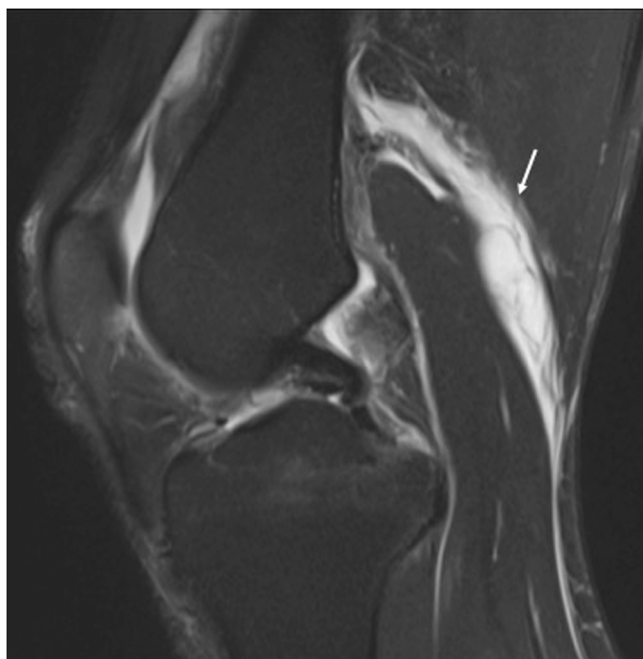


Fig. 13. Sagittal T2 fat suppressed image reveal ruptured Baker's cyst.

Grade 1 - Chondral softening or blistering with an intact surface.

Grade 2 - Shallow superficial ulceration, fibrillation, or fissuring involving less than 50% of the thickness of the articular surface.

Grade 3 - Deep ulceration, fibrillation, fissuring, or a chondral flap involving 50% or more of the articular cartilage thickness without exposure of subchondral bone.

Grade 4 - Full-thickness chondral loss with exposure of subchondral bone [32].

Semiquantitative MRI scoring methods like whole organ MRI score (WORMS), Boston-Leeds osteoarthritis score (BLOKS), Knee osteoarthritis scoring system (KOSS) and MRI osteoarthritis knee score (MOAKS) have been used in clinical trials and epidemiological studies.

These divide the knee into subregional compartments and evaluate cartilage, bone marrow lesions, osteophytes, menisci, synovitis and ligaments as well as periarticular popliteal cysts, bursae and loose bodies [33–36].

3.4. MRI of cartilage ultrastructure

Physiologic imaging of the articular cartilage images the chondral architecture and allows detection of cartilage degeneration prior to morphologic signal changes and defects. This will allow early diagnosis and treatment focused on prevention instead of palliation for late disease. The articular cartilage is made up of chondrocytes and an extracellular matrix. The extracellular matrix consists of highly organized collagen, water, negatively charged proteoglycans made of glycosaminoglycans and hyaluronic acid. Earliest changes of cartilage degeneration manifest as loss of glycosaminoglycans and increased water content [37]. This forms the basis of various methods for physiologic cartilage imaging like T2 mapping, Delayed gadolinium enhanced MRI, sodium and Rho imaging.

T2 mapping: The T2 relaxation times of articular cartilage reflect its water content and spatial collagen architecture. [38] A multiecho spin echo sequence is used followed by generation of gray scale or color map depicting the T2 relaxation. Increase in T2 relaxation time is seen with aging, activity as well as cartilage degeneration [39,40]. Aging is associated with asymptomatic diffuse increase in T2 values in the transitional zone of the articular cartilage while symptomatic damaged cartilage shows a focal increase in T2 [41]. (Fig. 10) Higher baseline T2 values in people with normal radiographs has been found to be useful in predicting the onset of radiographic OA [42].

Delayed gadolinium enhanced MR Imaging of the cartilage (dGEMRIC), Sodium MR Imaging and T1Rho imaging are the other modalities for ultrastructure imaging. However, in current clinical practice, these modalities are not routinely used except for T2 mapping.

Alterations in collagen and GAG content diffusely may play a role in implementing systemic chondroprotective medications such as chondroitin sulfate etc.

T2 mapping may be used to assess the cartilage adjacent to a discrete chondral lesion prior to cartilage repair procedures and also as a non-invasive method to assess the biochemical properties of the cartilage repair tissue following surgery [43].



Fig. 14. Sagittal and axial PD weighted MRI images show chondral bodies.

Approach to the young OA patient

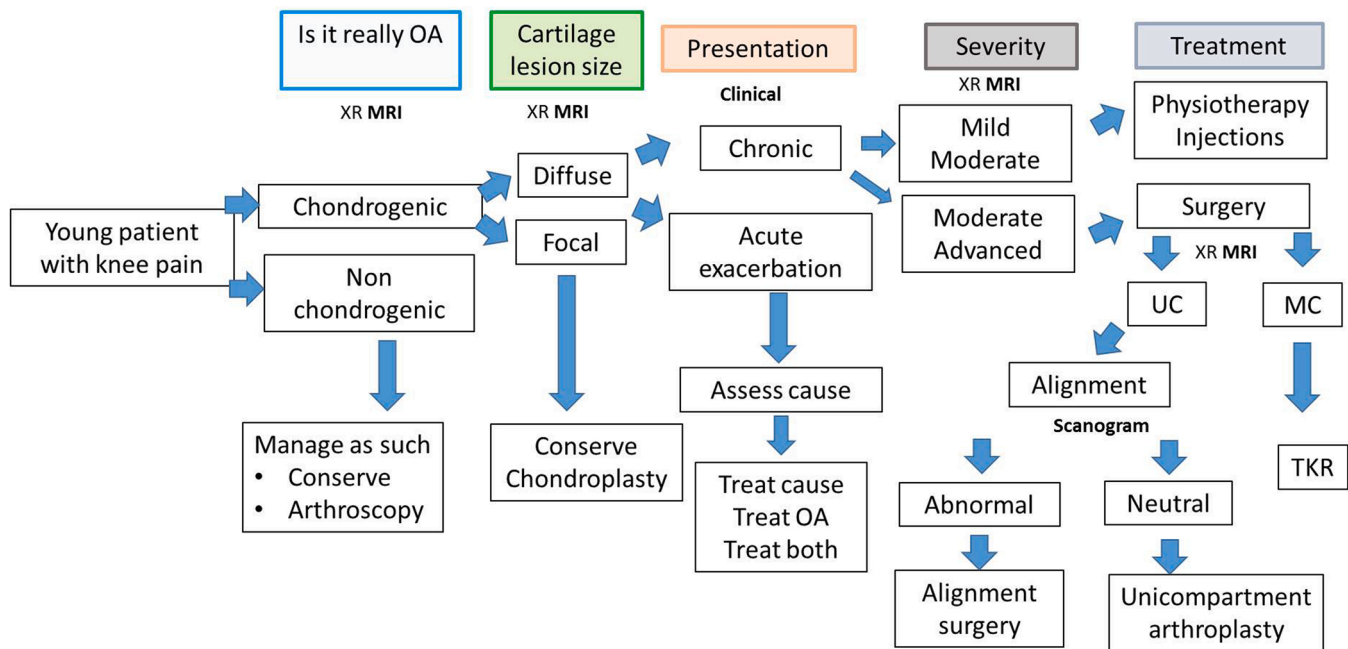


Fig. 15. Algorithm of role of imaging and its role in planning patient management in osteoarthritis. UC(unicompartmental), MC(multicompartmental), XR (radiographs), MRI (Magnetic resonance imaging).

Bone marrow edema patterns, subchondral cyst like lesions changes and bone attrition are demonstrated well on MRI. These relate to alteration in the subchondral trabecular architecture. Increase in the size of the bone marrow edema like lesions is associated with development of knee pain as well as increase in the cartilage loss [44,45]. (Fig. 11).

A common cause of acute exacerbation of OA is a subchondral insufficiency fracture. These are usually radiographically occult in early stages. They may occasionally occur in non-osteoarthritic knees due to underlying osteopenia/osteoporosis. Loss of the underlying subchondral support may lead to accelerated chondral loss [46]. These have previously been referred to as spontaneous osteonecrosis (SPONK) and our understanding of the same is still evolving [47]. Nevertheless, MRI is

extremely sensitive at detecting these as subchondral linear hypointense fracture line with disproportionate marrow edema (Fig. 12).

Another cause of acute exacerbation of osteoarthritis is the fractured osteophyte, which can be easily detected on MRI.

Untreated meniscal tear can lead to osteoarthritis but recent studies indicate that osteoarthritis may lead to spontaneous meniscal tear. Thus a degenerative meniscal tear in a middle aged or older patient could suggest an early osteoarthritis as MR visualized meniscal damage may be evident before chondral changes. MRI may show horizontal, flap or complex tears as well as meniscal maceration and destruction [48]. Meniscal extrusion can be seen on MRI and this may be seen as joint space narrowing on radiograph.

Parameniscal cysts can often be a cause of pain and these are identified easily on MRI.

Synovitis is not only secondary to osteoarthritis but may also play an important role in progression of cartilage loss. It may be reactive or inflammatory and can contribute to pain [49]. It is seen as synovial thickening and enhancement or alterations in Hoffa's fat pad signal.

MRI is excellent at identifying joint effusions, Baker's cysts and other fluid collections around the knee (Fig. 13). Baker's cysts and other bursae, if symptomatic can be aspirated and injected under ultrasound guidance for diagnostic and therapeutic purposes.

Intra articular bodies are occasionally seen. These could be embedded in synovium or when mobile may cause locking and more rapid progression of osteoarthritis. Chondral bodies are identified on MRI and are not visible on radiographs (Fig. 14).

Ligamentous laxity may have a role in development and progression of OA [50]. MRI can accurately demonstrate ligament tears. Fig. 15.

In a radiographically OA knee, the patient may present with acute exacerbations due to subchondral insufficiency fracture, fractured osteophyte, acute chondral delamination and ruptured or inflamed Baker's cyst. MRI can demonstrate these conditions and the bone marrow edema provides a clue to the cause of the acute pain.

Seiya Ota et al. have described MRI findings of cartilage damage, osteophytes, and bone marrow lesions, subchondral cysts, meniscal lesions were more common in women without any radiographic evidence of OA. Among these MRI findings, they found that synovitis was most strongly associated with knee pain and thus may be a therapeutic target in patients with knee OA [51].

Image guided interventions are a good option for diagnostics and therapeutics in osteoarthritis patients with multiple possible pain generators and can delay the need for surgery.

4. Conclusion

Imaging plays an important role in diagnosing and assessing the severity of OA. In young OA, imaging provides an algorithm that can be used to decide between the various therapeutic options and to plan the type of surgery. Our understanding of OA is still evolving and imaging is contributing significantly in understanding the pathophysiology as well as biomechanics of the disease process allowing early intervention.

CRedit authorship contribution statement

Malini Lawande: conceptualization, original draft preparation, visualization, **Aditya Daftary:** conceptualization, writing- review and editing, **Ankita Ahuja:** conceptualization, visualization, **Bhushan Sabnis:** conceptualization, writing- review and editing.

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