Conventional Magnetic Resonance Imaging versus Magnetic Resonance Arthrography in Evaluation of Ankle Impingement Syndromes

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ABSTRACT

Background: Bony and soft-tissue impingement syndromes are now increasingly being recognized as significant causes of chronic ankle pain.

Objective: To compare the diagnostic efficacy of MR arthrography with conventional MRI in evaluation of ankle impingement in correlation with clinical and arthroscopic findings.

Patients and methods: This study reviewed 23 patients who had preoperative MR imaging and MR arthrography and then underwent arthroscopy (as a gold standard), in the period from May 2019 till August 2021. The study is approved by the ethical committee of Faculty of Medicine of Assiut University.

Results: Conventional MRI and MR arthrography showed sensitivity, specificity, and an accuracy of 100.0% in diagnosing bony impingement. For diagnosing soft tissue impingement; MR arthrography was shown to be more superior to conventional MRI with a sensitivity of 88.2%, a specificity of 100.0%, and an accuracy of 94.4%.

Conclusion: MR arthrography is highly beneficial in diagnosing bony and soft impingement that expands the functionality of conventional MR imaging by taking advantage of the natural benefits of joint effusion.

Key wards: Ankle Arthroscopy, Impingement, MR arthrography, MR imaging.

Clinical trial: NCT03860922.

INTRODUCTION

Chronic ankle pain is a common clinical issue with a wide range of possible causes. Soft-tissue and osseous impingement syndromes are now increasingly recognized as a significant cause of chronic ankle pain[(1)].

In athletes, ankle impingement syndromes are a prevalent and serious source of post-traumatic morbidity [(2)]. It is defined as pathologic conditions resulting in chronic, painful restriction to movement at the tibiotalar articulation secondary to soft-tissue or osseous abnormalities, and can be classified according to its anatomic relationship to the tibiotalar joint as anterolateral, anterior, anteromedial, posteromedial, or posterior impingement [(3)].

The anterolateral impingement syndrome is caused by obstruction of the anterolateral gutter (ALG) or recess secondary to an inversion injury resulting in disruption of the syndesmotic and/or lateral collateral ligaments and capsule. Repetitive microtrauma and subclinical microinstability typically seen in young athletic patients may lead to soft-tissue abnormalities in the anterolateral gutter [(4)]. After an ankle sprain, ligamentous and capsular tearing, as well as the resulting microinstability and bleeding, can cause reactive synovial hyperplasia and scarring. In patients with advanced synovitis, the synovial tissue may become molded to the triangular shape of the anterolateral gutter [(5)].

In anterior impingement, direct microtrauma to the talus and tibia is considered as the aetiology. The natural course of this microtrauma is to form osseous spurs. This inflammatory reaction can irritate the capsule and trigger a synovial inflammatory response, which can cause pain and result in the creation of fibrous bands. These bands can help to minimize dorsiflexion [(6)].

The mechanism of anteromedial impingement is unknown, however it is most likely an uncommon complication of a supination (inversion) injury rather than a pronation (eversion) injury, as initially assumed. During the acute injury, the anterior tibiotalar ligament is damaged and subsequently thickens. Other suspected causal variables include osteophytes, synovitis, and fractures, in addition to ligament thickening. Recurrent microtrauma can cause bone spurs to grow along the talar neck, medial malleolus anterior edge, or anteromedial tibial plafond, limiting range of motion [(7)].

Plantar flexion, inversion, and internal rotation trauma are the most prevalent triggering injuries for posteromedial ankle impingement. This can lead to damage to the posterior tibiotalar ligament and associated synovitis, which can partially encase the posterior tibialis tendon (PTT), the flexor hallucis longus tendon or the flexor digitorum longus tendon [(8)].

The posterior talus is involved in the majority of posterior impingement disorders. Around the ages of 8–13, the secondary ossification centre of the posterolateral talus develops and then merges within a year. Non-fusion with os trigonum can occur in a small percentage of cases (about 7%) [(9)].

MRI is particularly suited for the evaluation of complex bone and soft-tissue anatomy of the ankle because of its superior soft-tissue contrast and the ability to image in multiple planes [(10)].

Conventional MR imaging can accurately detect and localize osteophytes and associated lesions. In addition, MR imaging provides an easy evaluation of

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any articular cartilage changes, ligamentous injury, and occult bony contusions [11].

Direct MR arthrography was proved to be superior to conventional MR imaging as it can utilizes the natural advantages gained from joint effusion. The contrast solution expands the joint capsule, highlights intraarticular structures, and leaks into abnormalities. It can detect cartilage damage intraarticular loose bodies and osteochondral talar lesions [12].

The aim of this study was to compare the diagnostic efficacy of MRI arthrography with conventional MRI in evaluation of ankle impingement in correlation with clinical and arthroscopic findings.

PATIENTS AND METHODS

This study included 23 patients referred from the outpatient of Orthopedics Department. The patients complained of chronic ankle pain with suspicious ankle impingement (limitation of motion, joint line tenderness or swelling and pain on activity) according to physical examination. Their age ranged from 19 up to 58 years (33.42 ± 9.72 year), all patients underwent MR imaging and MR arthrography at MRI Unit of Radiology Department of Assiut University Hospitals in the period from May 2019 till August 2021 then underwent arthroscopic evaluation (as a gold standard).

Patients with inflammatory or infective arthritis of ankle joint, neoplasm around ankle joint, and those with contraindications to MRI examination were excluded from this study.

MR imaging protocol:

MR imaging data were acquired with a 1.5 Tesla scanner (Gyroscan, achieva Philips Medical Systems, USA) with extremity coil around the ankle joint. Patients were placed in supine position with the ankle was in neutral position (feet first).

1) Conventional MRI:

The following MR sequences in ankle were obtained:

- **Sagittal T1 weighted spin echo sequence** with repetition time (TR)/echo time (TE) 642/20 msec. Images obtained with 3 mm section thickness, field of view (FOV) 130 mm and 308x246 acquisition matrix.
- **Sagittal T2 weighted spin echo sequence** with TR/TE 4635/100 msec. Images obtained with 3 mm thickness, slice gap 0.3 mm, field of view (FOV) 130 mm and 188x147 acquisition matrix.
- **Axial T2 weighted spin echo sequence** TR/TE 5837/100 msec. Images obtained with 3 mm thickness, slice gap 0.3 mm, field of view (FOV) 140 mm and 284x213 acquisition matrix.
- **Coronal T2 weighted spin echo sequence** TR/TE 5392/100 msec. Images obtained with 3 mm thickness, slice gap 0.3 mm, FOV 140 and 236x185 acquisition matrix.
- **Sagittal Short T1 inversion recovery (STIR)** TR/TE 3517/70 msec. Images obtained with 3 mm thickness, slice gap 0.3 mm, field of view (FOV) 140 mm and 176x140 acquisition matrix.

2) Direct MR arthrography:

A. Technique of injection:

- No specific preparation or medication before injection.
- All injections were performed on an outpatient basis with no sedation.

Injections were done under ultrasonography guidance using ultrasound (US) system (Philips Infinity G50, USA).

- Patients placed in supine position with the foot in slight planter flexion.
- Skin and transducer preparation and sterilization using alcohol 70% ensuring sterile environment.
- The ankle placed in neutral position.
- Skin puncture was performed at the anterior aspect of the ankle either immediately medial to the tibialis anterior tendon or medial to the tendon of the extensor hallucis longus.
- A 22-gauge needle was inserted into the identified site (in anterior joint space marked by lower tibia and upper edge of talus) and directed posterolaterally. On US, the needle was identified as linear mobile echogenic structure.
- 0.1 ml of gadolinium (Gadodiamode 287 mg) was diluted in 10 ml of saline and local anesthetic as (1 ml zylocaine).
- The mixture solution was injected into the joint space and flow smoothly usually 6-10 ml injected.
- Stop injection if the patient experienced severe pain or if high resistance were felt during the instillation of the solution to prevent capsular disruption.
- Put sterile gauze and adhesive dressing upon injection site.
- The injection procedure was tolerated by most of the patients and no major side effects were observed (as vasovagal attack). Contrast media extravasation was observed in two patients, but did not significantly affect the diagnostic quality of MR arthrography study.
- Then we prescribed antibiotic (velosef 500 oral), analgesics and anti-inflammatory (Brufen 500) for the patient to avoid joint infection.

B. MR Arthrography:

- Imaging was performed within 30 minutes after examination to avoid resorption of contrast material or loss of capsular distention.
- Sequences and planes: Axial, coronal and sagittal T1W fat-suppressed (SPIR) with TR/TE 638/15 msec. Images obtained with 3 mm section thickness and field of view (FOV) 150 mm.

Image assessment:

Conventional MRI findings were assessed and compared with MR arthrography findings. Ankle impingement syndromes are divided into bony and soft tissues lesions.

- Bony lesions include: osseous spurs in neck of talus and tibial plafond, os-trigonum, or intra-articular loose bodies. Associated bone marrow edema and/or soft tissue edema or flexor hallius longus tenosynovitis in posterior impingement.
- Soft tissue lesions include: capsular fibrosis or thickening, synovitis, chronic ligamentous injury with fibrosis around.

Arthroscopic procedures:

All patients then underwent arthroscopy, used as reference gold standard. It was performed within 2 months after imaging examination.

Ankle arthroscopic examinations were carried out under spinal or general anesthesia with a high thigh tourniquet. A 4 mm arthroscope was used for the surgery with a noninvasive ankle distractor. Sterile fluid flows into the joint to expand it and allow for better visualization. Various portals were used including anteromedial, anterolateral, posteromedial, posterolateral or central according to the pathology location (anterior or posterior) usually at least two portals were used. After completion of arthroscopy, the results of conventional MRI and MRA were compared with the operative findings.

Ethical consent:

An approval of the study was obtained from Assiut University Academic and Ethical Committee. Every patient signed an informed written consent for acceptance of participation in the study. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis

All statistical calculations was done using SPSS (Statistical package for the social sciences; SPSS Inc., Chicago, IL, USA) version 22. Cohen's kappa and weighted kappa statistics were calculated to evaluate the strength of agreement using the benchmarks of Landis and Koch. For conventional MRI and MRI arthrography findings, using arthroscopy as the gold standard, the sensitivity and specificity of the two imaging techniques were compared using Open Epi software. P-value is always 2 tailed set significant at 0.05 level.

RESULTS

Twenty three patients have impingement syndromes as suspected by physician, 6 from 23 (26.1%) suspected to have anterior impingement, 7 (30.4%) suspected to have posterior impingement, 5 (21.7%) suspected to have anterolateral impingement, 3 (13%) suspected to have anterolateral and posterior impingement, 1(4.3%) suspected to have anteromedial impingement and another 1(4.3%) suspected to have both anterior and posterior impingement. Conventional MRI detected 13 cases with bony impingement but, it could not detect any case with soft tissue impingement (the only case detected was false positive). While MR arthrography detected 13 cases with bony impingement, 3 cases with capsular fibrosis or thickening, 7 cases with Synovitis and 3 cases had ligamentus injury with peri-ligamentus fibrosis. Twenty three patients received arthroscopic intervention. Six patients had bony impingement, 10 patients had soft tissue impingement, and 7 cases had combined lesions according to the arthroscopic findings **(Table 1).**

Table (1): Summary of impingement by preoperative conventional MRI, MR arthrography and arthroscopy (n=23)

Type of lesion	Conventional MRI (pre-operative)	MR arthrography (pre-operative)	Arthroscopic findings
Bony	13	7	6
Soft tissue	1	9	10
Combined	0	6	7

The sensitivity, specificity, positive predictive value, and negative predictive value for bony and soft tissue impingement by conventional MRI and MR arthrography **(Table 2).**

Table (2): Sensitivity, specificity, positive predictive value, and negative predictive value for diagnosis of bony and soft tissue impingement by conventional MRI and MR arthrography versus the arthroscopic finding as a gold standard (n=23)

Diagnostic modalities	Sensitivity	Specificity	PPV	NPV	Accuracy
Bony impingement					
➢ Conventional MRI	100.0%	100.0%	100.0%	100.0%	100.0%
➢ MR arthrography	100.0%	100.0%	100.0%	100.0%	100.0%
Soft tissue impingement					
➢ Conventional MRI	5.9%	100.0%	100.0%	52.9%	54.3%
➢ MR arthrography	88.2%	100.0%	100.0%	90.0%	94.4%

Agreement between conventional MRI and MR arthrography versus the arthroscopic findings (gold standard) in the diagnosis of pathological entities in different bony and soft tissue impingement using Kappa degree of agreement was summarized in **(Tables 3, 4**).

Table (3): Agreement between conventional magnetic resonance imaging (MRI) and MR arthrography (perioperative) versus the operative finding in the diagnosis of pathological entities in different bony impingement (n=23)

Bony impingement		Arthroscopy		Kappa	P value
Conventional MRI		Yes	No		
• Os trigonum	Yes	10	0	1	**<0.001***
	No	0	13		
• Talar neck and tibial plafond bony spur	Yes	3	3	0.596	**0.002***
	No	0	17		
MRI Arthrography					
• Os trigonum	Yes	10	0	1	**<0.001***
	No	0	13		
• Talar neck and tibial plafond bony spur	Yes	3	2	0.701	**<0.001***
	No	0	18		

*: Significant

The discrepancy of diagnosis was observed between conventional MRI and arthroscopic findings was more apparent in diagnosis of soft tissue impingement namely for (capsular fibrosis or thickening, synovitis and ligamentous injury with periligamentous fibrosis) **(Table 4).**

Table (4): Agreement between conventional MRI and MRI arthrography (perioperative) versus the arthroscopic findings in the diagnosis of pathological entities in different soft tissue impingement (n=23).

Soft tissue impingement		Arthroscopy		Kappa	P value
Conventional MRI		Yes	No		
• Capsular fibrosis or thickening	Yes	---	---	0.000	1
	No	4	19		
• Synovitis	Yes	---	---	0.000	1
	No	9	14		
• Ligamentous injury with Periligamentous fibrosis	Yes	0	1	-0.075	0.639
	No	4	18		
MRI Arthrography					
• Capsular fibrosis or thickening	Yes	3	2	0.587	**0.004***
	No	1	17		
• Synovitis	Yes	7	1	0.721	**0.001***
	No	2	13		
• Ligamentous injury with periligamentous fibrosis	Yes	3	1	0.697	**0.001***
	No	1	18		

*: Significant

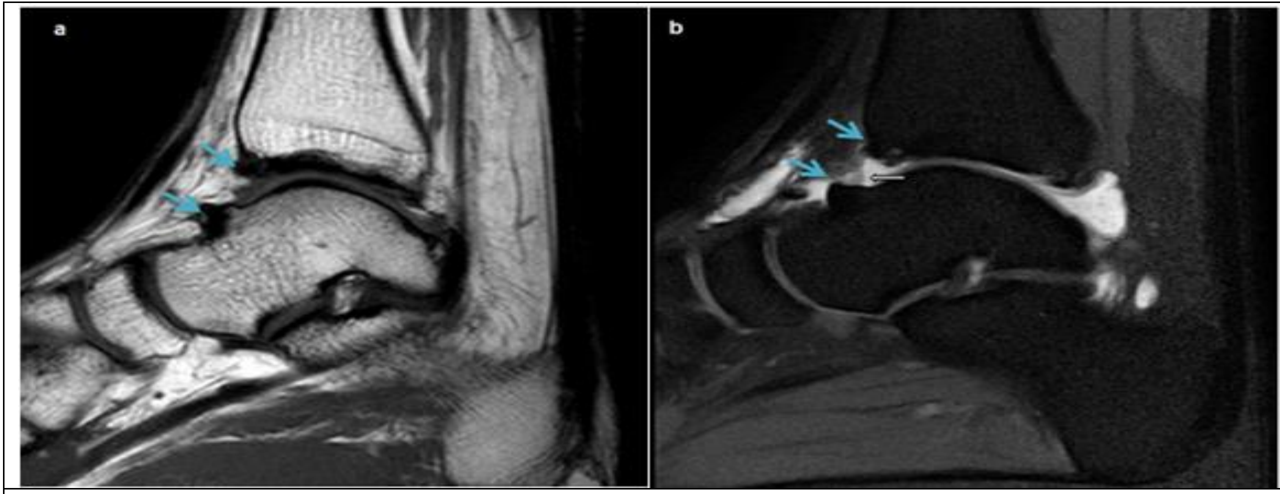


Figure (1): Male patient, 33 years old presented with chronic right ankle pain and limitation in dorsiflexion. (a) Sagittal T1 weighted spin echo conventional MRI shows anterior bony impingement in terms of tibial and talar neck spurs (kissing lesions) *(Blue arrows)*, (b) sagittal T1 SPIR MR arthrogram shows anterior bony and soft tissue impingement in terms of tibial and talar neck spurs (kissing lesions) *(Blue arrows)* and synovitis in anterior capsular recess *(white arrow)*. Arthroscopy revealed**:** Anterior bony and soft tissue impingement (Anterior tibial and talar spurs with anterior capsular recess synovitis).

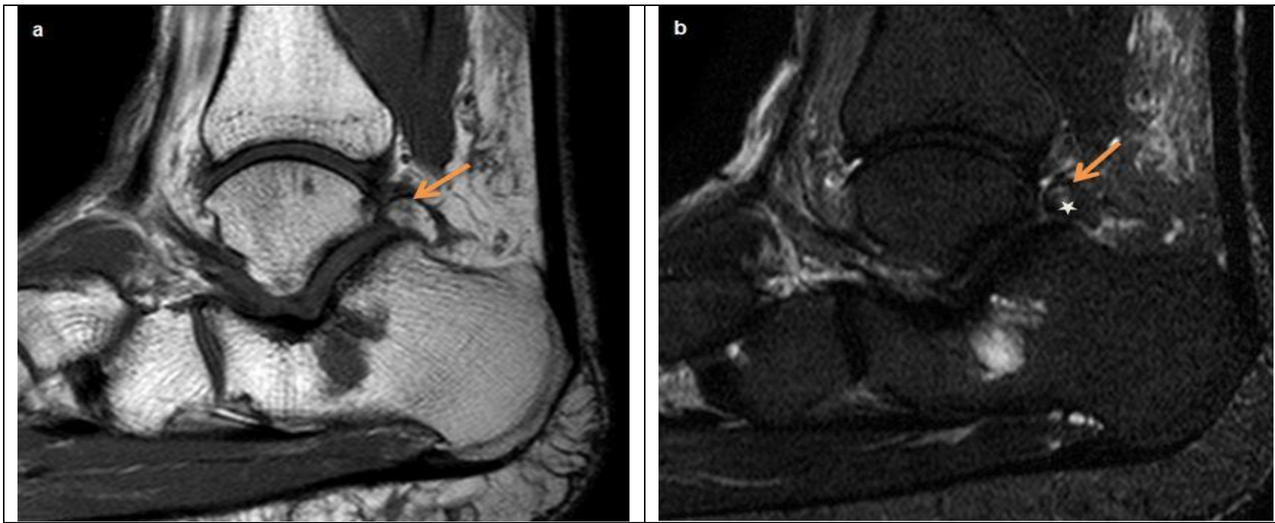


Figure (2): Male patient, 45 years old with chronic right ankle pain with history of old trauma and limitation in planter flexion. (a) Sagittal T1 weighted spin echo and (b) sagittal STIR conventional MRI show posterior bony impingement in terms of os trigonum *(orange arrow)* with bone marrow edema *(white star) in b*. (c) Sagittal T1 SPIR MR arthrogram shows posterior bony and soft tissue impingement in terms of os trigonum *(orange arrow)* with element of synovitis in posterior recess (thickening and irregularity of synovium) *(blue star)* which was confirmed by arthroscopy.

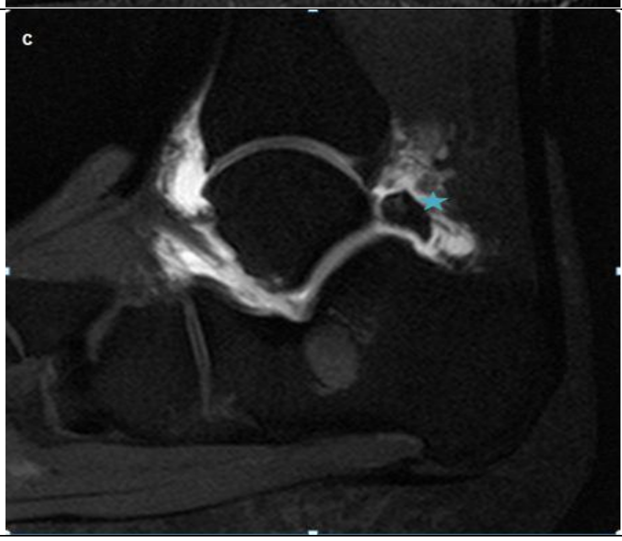
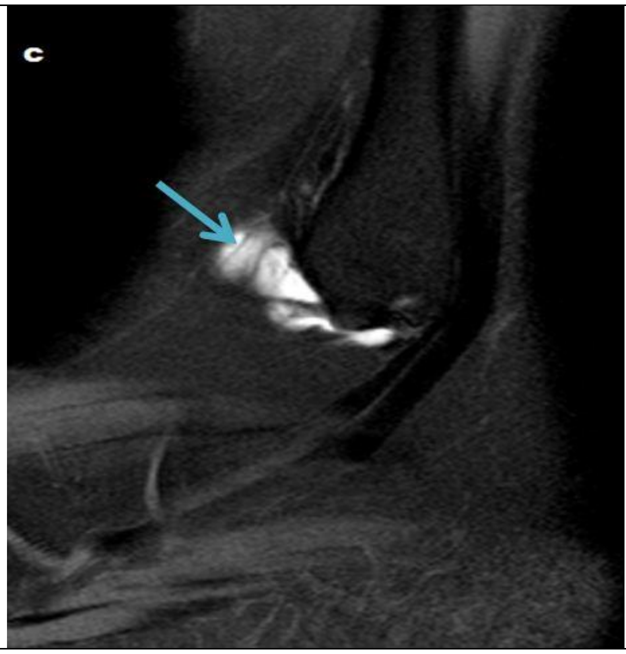


Figure (3): Female patient, 46 years old with chronic left ankle pain and limitation of movement (a), (b) axial T2 and sagittal STIR conventional MRI respectively (negative for impingement, no abnormalities in anterolateral gutter). (c) Sagittal T1 SPIR MR arthrogram shows capsular fibrosis in anterolateral gutter. Arthroscopy revealed arthrofibrosis in anterolateral gutter.



DISCUSSION

Imaging studies can show osseous and soft tissue lesions and anatomic variations that can help diagnose and treat impingement syndromes. MRI can be useful to determine the presence of soft tissue pathology that may be causing impingement. Furthermore, MRI allows the physician to rule out other potential differential diagnoses, including osteochondral lesions, loose bodies, and stress fractures [(13)]. The present study is a prospective observational study was done on 23 patients with chronic ankle pain and suspected clinically to have impingement syndromes. Mean age was 33.42 ± 9.72 year with range between 19 and 58 years. Majority (61.1%) of those patients was males. However; there is a lack of data evaluating whether patient sex plays any underlying role in ankle impingement or whether it affects treatment outcomes [(14)].

Our results found that bony impingement is more frequent (13 cases from 23) than soft tissue impingement. In agreement with the current study, **El-Zawawi *et al.***[(15)] concluded that posterior ankle impingement was the most commonly encountered entity (n = 34, 37.9%) and the os trigonum was the most common causal agent, accounting for 67.6% (n = 23 out of 34) of all cases. Also, **Özer and Yıldırım** [(16)] found that out of their studied patients, 21.6% of patients had os trigonum.

Our study is also supported by the study of **Bureau *et al.***[(17)] who reported that os trigonum is prevalent MRI finding of posterior ankle impingement syndrome (PAI). MRI clearly depicts the osseous and soft tissue abnormalities associated with PAI syndrome and is useful in the assessment of this condition.

The current study revealed that conventional MRI is able to detect all cases with bony impingement with sensitivity and specificity of 100%. In previously published study, assessment of conventional MRI for diagnosis of anterior impingement, **Ferkel *et al.*** **[18]** determined that MRI has a sensitivity of 83.3% and specificity of 78.6%.

Also conventional MR imaging accurately detects and localizes anterior tibiotalar spurs, and it is valuable in demonstrating coexisting lesions such as collateral ligament complex injury, osteochondral lesions of the talar dome, and intra-articular bodies **[2]**.

In our study conventional MRI failed to detected any case with soft tissue impingement. In agreement with our results, **Subhas *et al.*[19]** proved that conventional MRI had limited diagnostic yield in detection of soft tissue impingement. Also, **Jordan *et al.*[20]** reported that diagnostic ability of conventional MR imaging depends on the degree of joint distension, which may be limited by the presence or absence of joint effusion or contrast agent. Sensitivity and specificity vary greatly in the literature regarding ability of conventional MRI in soft tissue impingement.

In line with our study, studies (arthroscopic and radiologic) that investigated the value of conventional MR imaging have reported conflicting results in the assessment of patients with soft tissue impingement preoperatively. Sensitivity (39%–100%) and specificity (50%–100%) for detection of soft-tissue impingement varied widely **[21-23]**. Also, one study demonstrated that conventional MRI had a sensitivity of 89% for detecting synovitis, capsular thickening, scar and granulation tissue, although only 67% sensitivity and 78% specificity for detecting anterior tibial osteophytes **[11]**.

In disagreement with our study, **Duncan *et al.*[24]** concerning the usefulness of MRI in the diagnosis of soft tissue impingement of the ankle, the axial images were considered to be most helpful in making the diagnosis. Sensitivities ranged from 75.0% to 83.0%, whereas specificities ranged from 75.0% to 100.0%.

MR arthrography represents an excellent tool for diagnostic elucidation before arthroscopy, and a relevant finding is the absence of fluid in the recess between the soft tissues of the anterolateral region and the anterior fibular surface, because of the presence of adhesions and cicatricial tissue between the fibula and the joint capsule, preventing the fluid to enter the recess **[25]**.

In our study MR arthrography was able to detect all cases of bony impingement with sensitivity and specificity of 100%. **Robinson *et al.*** **[23]** stated that MR arthrography had 96% sensitivity and 97% specificity for diagnosis of bony impingement of the ankle. Also, **Haller *et al.*** **[11]** concluded that MR arthrography offers the opportunity of differentiation between extra- and intra-articular causes. Also, MR arthrography may facilitate the evaluation of patients with suspected bony ankle impingement in whom conventional MR imaging is not sufficient for obtaining an adequate diagnosis, and is thus useful for planning therapy **[26]**.

Our study also revealed that MR arthrography was accurately diagnosing cases with soft tissue impingement with sensitivity 88%, specificity 100% and accuracy 94.4%. In line with our results, **Cerezal *et al.*[26]** reported that MR arthrography is highly accurate in the assessment of soft tissue impingement with a sensitivity of 96%, specificity of 100%, and an accuracy of 100%. Also, in a prior study, MR-arthrography was found to be helpful in the detection of synovial tissue in the anterolateral aspect of the ankle joint that led to irregularity or nodularity of the soft tissues. This prior study also indicated that similar MR-imaging signs are found in patients without clinical symptoms of anterolateral impingement **[23]**.

CONCLUSION

For evaluating ankle disorders, using conventional MRI alone is not adequate for correctly detecting soft tissue impingement of the ankle joint. MR arthrography improves the sensitivity and the accuracy for capsular fibrosis or thickening, synovitis, and ligamentous injury with periligamentous fibrosis. It also helps in assessing coexisting pathologic lesions of ankle joints, especially impingement syndromes, and provides more accurate information for therapeutic decision making.

RECOMMENDATIONS

From this study we recommend that:

- To perform such study on large scale of patients in multiple centers to confirm the results.
- It's advisable to conduct comparative studies between different imaging modalities and MR arthrography as computed tomography and ultrasound in such conditions.
- MR arthrography is recommended in cases where conventional MR imaging is insufficient or inadequate for diagnosis or treatment planning.

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