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Femoroacetabular impingement in amateur athletes: The value of response to anaesthetic injection during hip MR arthrography

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ABSTRACT

Purpose: Femoroacetabular impingement (FAI) represents a common aetiology of hip pain. The purpose of the present study was to prospectively evaluate MR imaging findings and intra-articular block results in amateur athletes presenting with symptoms of FAI that were treated arthroscopically.

Material and Methods: During a five-year period (January 2014 to January 2019), 197 amateur athletes (116 male, 81 female, aged 18-54 years, mean age 33 years) presented with symptoms of hip pain and were referred with the possible diagnosis of FAI. After careful clinical evaluation 27 of them met the diagnostic criteria of FAI and were subsequently studied with direct MR Arthrography (MRA) in combination with intra-articular block. Patients were consequently treated by means of arthroscopy. MRA findings and Visual Analog Scale (VAS) scores pre and post intra-articular block were recorded and were analysed to verify the clinical suspicion of impingement.

Results: FAI was verified in all patients (27/27, 100%). Labral tears were depicted in 23 patients (85.2%) by arthroscopy. High sensitivity and specificity were recorded for MR arthrography regarding labral tears (96% and 85% respectively). Evaluation of intra-ar-

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ticular blocks showed high positive predictive value (PPV) and accuracy for the diagnosis of intra-articular pathology (PPV: 92%, accuracy: 96.5%). The mean pain scores pre and post intra-articular blocks were 8 and 2 respectively.

Conclusions: MR arthrography in combination with intra-articular block showed high sensitivity and specificity for the diagnosis of FAI syndrome.

KEY WORDS

Hip joint; Magnetic resonance arthrography; Acetabular labral tear; Femoroacetabular impingement; Anaesthetics, Local/administration & dosage

Introduction

Hip osteoarthritis is among the leading causes of functional incapacity and chronic disability [1, 2]. A number of different mechanic, traumatic, nutritional, and genetic factors have been implicated in hip arthritis [1, 2]. Even though it is perceived as a disease of the elderly, the detection of early osteoarthritic changes in the young athletic population has gained much attention [1, 2]. Currently, femoroacetabular impingement (FAI) has been proven a known aetiological risk factor for hip pain and early arthritis in the young adult [3, 4]. This syndrome is the result of abutment between the proximal femur and the acetabular rim [3, 4]. The abnormal contact during either normal or extensive range of motion may lead to both labral and cartilage tears and may progress to degenerative arthritis, especially if the underlying aetiology of impingement is left untreated [3-5]. Sports activities have been proven to accelerate the process of labral and cartilage degeneration and the role of imaging focuses in identifying the reason for early-onset internal derangement [6, 7].

Given the recent increase in the number of hip arthroscopies performed worldwide, reliable and reproducible radiologic evaluation of the joint is clinically important. There have been a number of studies to document correlation between the lesions seen in preoperative imaging and intraoperative findings [3-8]. These studies reveal that high field magnets with new improved sequences and techniques have increased the diagnostic accuracy of MRI [8]. The purpose of our study was to prospectively evaluate the value of adding intra-articular block in MRA studies for depicting arthroscopically proven labral tears. To the best of our knowledge, limited and sparse reports have examined the role of MRA together with intra-articular blocks in FAI evaluation.

Material and Methods

Study population

During a 5-year period (from January 2014 to January 2019), 197 amateur athletes (14 male, 20 female, aged 18-54 years, mean age 33 years) with hip pain were referred for clinical examination. After careful clinical evaluation 34 of them met the diagnostic criteria of FAI as presented in the following "Clinical Evaluation" paragraph and were subsequently studied with MRA in combination with intra-articular block. Seven patients were not treated surgically and thus were not included in the statistical analysis for MRA and intra-articular blocks, while 27 patients were consequently treated by means of arthroscopy. Inclusion criteria for our study were: (i) age >18 years, (ii) available arthroscopic report and (iii) clinical and MRA findings suggestive of FAI. Exclusion criteria included previous hip fracture or surgery. The study was approved by the Medical Ethics Committee of our institution (Democritus University of Thrace Medical Ethics Committee) and all participating patients signed an informed consent.

Clinical evaluation

All athletes were evaluated by a senior orthopaedic surgeon specialised in hip arthroscopy. The primary symptoms were motion-related or position-related pain in the hip or groin. Pain could also be felt in the back, buttock or thigh. Besides pain, patients could also describe clicking, catching, locking, stiffness, restricted range of motion or giving way. Hip impingement tests were used to reproduce the patient's typical pain. Standard clinical tests included FADIR (flexion adduction internal rotation), FABER (flexion abduction external rotation) and log-roll tests in all patients and the mean pain score was recorded for every patient prior to MRA [9].

After MRA with intra-articular block was performed, the same orthopaedic surgeon examined the patient with identical clinical tests and the new mean pain score was recorded within 30 min after injection. The same orthopaedic surgeon performed all arthroscopies.

Pain evaluation

A quantitative pain Visual Analog Scale (VAS) score ranging from 0 to 10 was used. Classification was as following: no pain (VAS=0), mild discomfort (VAS=1-3), moderate pain (VAS=4-7) and severe pain (VAS=8-10).

Procedure

Arthrography was performed under fluoroscopy by a senior musculoskeletal radiologist with 15 years of experience. The patient was placed supine on the fluoroscopic table, and the lower extremity was held in slight internal rotation. Strict sterile precautions were used. For minimising radiation exposure to the gonads, lead shielding and limited fluoroscopy were used. Using an anterior approach, a 12 cm-21 gauge needle was advanced intra-articularly. The intra-articular position of the needle was verified with 1 mL of iodinated contrast material. Manual and continuous traction to allow the fluid to enter into the central compartment of the joint was performed. The intra-articular block consisted of 4 mL of ropivacaine 2%. A mean volume of 14 mL (range 10-18 mL) of diluted gadolinium solution (dilution ratio=1:250) was injected. The solution was injected under fluoroscopic guidance. MR arthrograms were obtained within 20-30 min after injection.

Imaging protocol

MRA examinations were performed with a 1.5 Tesla MRI scanner (Siemens MAGNETOM® Avanto, Erlangen) and a flexible wraparound surface body coil was used in all cases. MR imaging protocol included fat-saturated T1w images in four imaging planes (axial, sagittal, coronal, and axial oblique planes) with the following parameters: TR/TE 597/13, matrix size 512×512, section thickness 3-4 mm, field of view 16 cm.

Radiologic measurements

We performed detailed measurements of known morphological parameters associated with FAI syndrome and then classified the patients according to the prevalence of CAM or PINCER findings.

Statistical analysis

Statistical analysis and calculations were carried out using the MedCalc version 10.1.2 statistical software. MRA findings and VAS scores were analysed according to arthroscopy. Sensitivity, specificity, positive predictive value (PPV) and accuracy were calculated for MRA regarding labral tears. Evaluation of intra-articular blocks' PPV and accuracy for the diagnosis of intra-articular pathology were also calculated. Pre and post injection of anaesthetic was evaluated using the paired t test. The Hip Outcome Score-Sports Subscale (HOS-SS) was used to evaluate clinical outcomes after arthroscopy treatment. Differences were considered statistically significant for a p value of less than 0.05.

Results

Male athletes were involved primarily in football (7/14, 50%), while female athletes in running (9/20, 45%). Mean duration of symptoms prior to examination was 12.1 months (range 3-48 months). The most frequently affected hip was that of the dominant right side (19/34, 58.9%).

The technical success of MRA combined with intra-articular block was 100% (34/34). No complications were recorded periprocedurally. Patients reported a mean pain value of 7.7 (range 7-10) prior to block and a mean pain value of 1.9 (range 0-4) post block. The value of t was calculated -22.71003. The value of p was <0.00001 and the result was considered statistically significant at p values <0.05.

Statistical analysis using Fisher's exact test showed a statistically significant difference between the two types of FAI in relation to gender (p_1=0.006<0.05). CAM type was seen more frequently in males, while PINCER type was depicted more commonly in females. There was no statistically significant difference between the two types of FAI in relation to age (p_2=0.3151>0.05). Statistical analysis using the Chi-Square test for multiple variables showed a statistically significant difference in relation to alpha angle α (p_3=0.0001<0.05). A pathologic alpha angle was seen exclusively in CAM type FAI.

Compared to arthroscopic findings our results were as following: FAI was verified in all patients (27/27, 100%). Labral tears were depicted in 23 patients (23/27, 85.2%). High sensitivity and specificity were recorded for MRA regarding labral tears (96% and 85% respectively). MRA showed a high PPV and accuracy for the diagnosis of labral tears (PPV: 95.7%, accuracy: 91%). Evaluation of

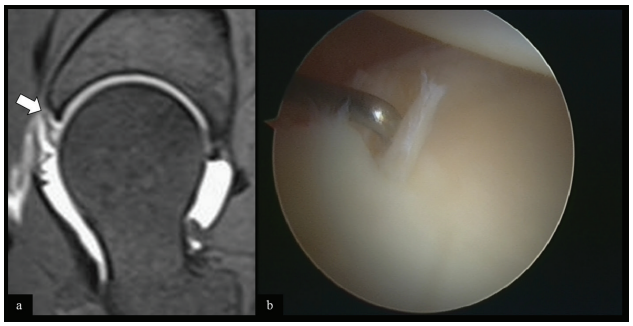


Fig. 1. *Labral tear.* ***a.*** *The axial oblique T1w fat saturated MR arthrographic image shows a labral tear (arrow) that was confirmed and treated arthroscopically with debridement (**b**).*

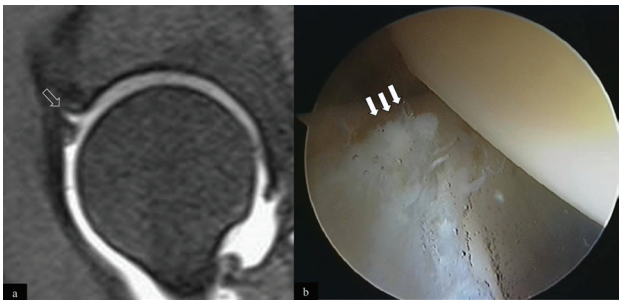


Fig. 2. *Labral tear with fraying.* ***a.*** *The sagittal T1w fat saturated MR arthrographic image demonstrates a labral tear (arrow). The findings were confirmed and corrected arthroscopically (arrows in **b**).*

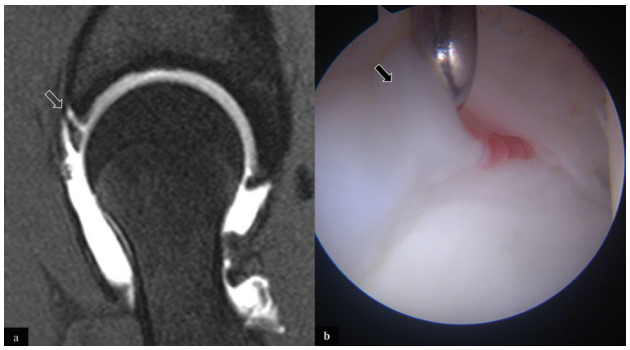


Fig. 3. *Labral tear with detachment.* ***a.*** *The axial oblique T1w fat saturated MR arthrographic image demonstrates a completely detached labral tear (arrow). The findings were verified and corrected arthroscopically (black arrow in **b**).*

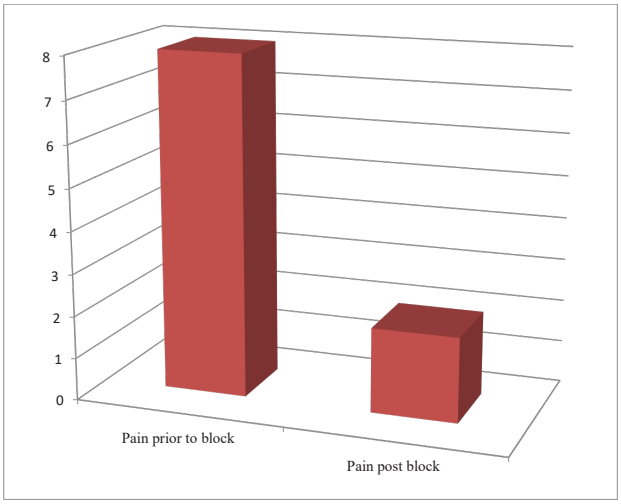
intra-articular blocks showed a high PPV and accuracy for the diagnosis of intra-articular pathology (PPV: 92%, accuracy: 96.5%) with a negative predictive value (NPV) of 100% and sensitivity of 100%. The HOS-SS showed a statistically significant improvement (p_4=0.0001<0.05) in all patients after arthroscopy treatment (mean HOS-SS was 36% prior to treatment and mean HOS-SS was 92% post treatment).

Results are shown in **Tables 1, 2, Graphs 1, 2** and examples are shown in **Figs. 1-3**.

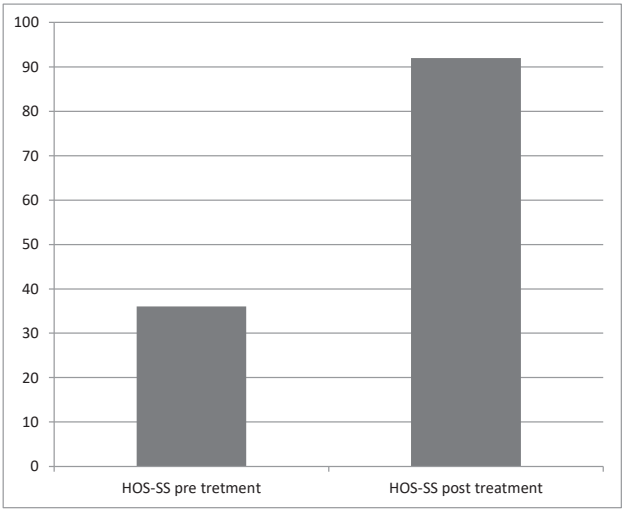
Discussion

FAI has a progressive course that necessitates early surgical intervention [10, 11]. Improvements in hip arthroscopy allow for joint preserving techniques with excellent outcomes [10-14]. In CAM-type, correction of the femoral head abnormality is the main goal and modern arthroscopic techniques allow femoral head-neck "bump" resection together with labral tear repair by debridement or reattachment. Conversely, in PINCER-type FAI correcting the acetabular morphology is the main target and acetabular rim trimming and reverse periacetabular osteotomy are currently the treatment of choice. Chondral damage restoration with clearance and micropuncture or chondrocyte graft techniques is also applied [10-15]. Early intervention may potentially prevent osteoarthritis progression, so the value of imaging is to identify the major anatomical factor of impingement in a time- and cost-effective manner. The role of imaging is in identifying subtle morphological changes that allow surgical interventions before the degenerative change are irreversible. Various cross sectional imaging signs and radiographic measurements aid in the diagnosis of FAI [16, 17]. However, radiologists should always bear in mind that the presence of abnormal values is by no means an indicator of symptoms, as there is a very high prevalence of borderline and pathologic measurements in asymptomatic individuals [16, 17]. FAI remains a clinical syndrome and imaging findings should be interpreted in the relevant clinical history. Similarly in our study we used a detailed orthopaedic evaluation prior to including patients in our protocol. In addition, radiologic measurements were proven useful for evaluation, but no significant differences were seen between the two types of FAI in relation to most of the variables tested.

Our findings are in accordance with previously reported literature results. Several studies that investigated the effectiveness of MRA in labral hip lesions have



Graph 1. *Mean pain scores prior and post intra-articular blocks.*



Graph 2. *Mean HOS-SS prior and post arthroscopic treatment.*

Table 1. Demographics of amateur athletes with CAM type of impingement

Patients	Age	Gender	Sport	Duration of symptoms (months)	Hip	Alpha (α) Angle
patient 1	52	F	RUNNING	18	R	65.4
patient 2	41	M	TENNIS	18	R	62
patient 3	27	M	FOOTBALL	4	R	61.3
patient 4	45	M	RUNNING	4	R	62.1
patient 5	43	F	RUNNING	20	R	71
patient 6	32	M	FOOTBALL	16	R	67.3
patient 7	27	M	FOOTBALL	13	R	70.1
patient 8	19	M	FOOTBALL	3	L	69.9
patient 9	26	M	MMA	7	L	64
patient 10	26	M	MMA	13	R	60.7
patient 11	19	M	FOOTBALL	7	L	64.4
patient 12	18	M	FOOTBALL	6	R	63

MMA: Mixed Martial Arts

produced similar results regarding sensitivity and specificity [18, 19]. MRI alone has been proven inadequate for visualising the acetabular labrum [18, 19]. Llopis et al. in their studies reported that MRI with hip traction was better but several researchers reported that MRI fails to detect small lesions and MRA is preferred, as the capsular distension obtained, depicts intra-articular details that are not visible with standard MRI [19]. Czerny et al. demonstrated that sensitivity and accuracy of MRI for non-distended joints were 30% and 36%, respective-

Table 2. Demographics of amateur athletes with PINCER type of impingement

Patients	Age	Gender	Sport	Duration of symptoms (months)	Hip	Lateral center edge Wiberg Angle
patient 1	52	F	DANCING	4	L	54.2
patient 2	18	F	WEIGHT LIFTING	6	L	43.8
patient 3	22	F	RUNNING	5	L	44.9
patient 4	45	F	RUNNING	6	R	47.2
patient 5	18	M	FOOTBALL	3	R	47.6
patient 6	44	M	BASKETBALL	22	L	41.4
patient 7	39	F	DANCING	7	L	45.5
patient 8	33	M	SKIING	5	R	44
patient 9	19	F	GYMNASTICS	6	R	42.6
patient 10	44	F	RUNNING	13	L	41.2
patient 11	29	F	DANCING	12	R	40.3
patient 12	18	F	GYMNASTICS	48	L	40.6
patient 13	58	F	RUNNING	30	R	41.5
patient 14	18	F	GYMNASTICS	5	R	44
patient 15	20	F	GYMNASTICS	6	L	42.4
patient 16	24	F	WEIGHT LIFTING	6	R	41.9
patient 17	48	F	RUNNING	24	R	42.4
patient 18	46	F	DANCING	8	L	40.1
patient 19	46	F	RUNNING	26	L	41.6
patient 20	19	M	SKIING	7	R	44.6
patient 21	57	F	DANCING	23	L	45.9
patient 22	29	F	RUNNING	12	L	44.1

ly, whilst sensitivity and accuracy rose up to 90% and 91% after capsular distention during MRA [20]. We also recorded high sensitivity and specificity for MRA regarding labral tears (97% and 84% respectively).

Although the role of imaging in the differential diagnosis of hip pathology is unequivocal, FAI poses a diagnostic difficulty because it depends on detecting subtle intra-articular pathology in a limited joint space with closely opposing articular surfaces. Imaging should always begin with a properly positioned AP pelvic radiograph together with a true lateral or frog lateral view of the symptomatic hip [16-20]. Subsequently, arthrographic protocols with either MRI or CT offer several advantages over plain CT and MRI studies [21, 22]. Knowledge of common anatomic locations and appearances of articular cartilage and labral lesions is necessary so that radiologists do not misinterpret these entities. Kheterpal et al. in their recent study examined the value of anaesthetic injection during hip MR arthrography (anaesthetic MRA) to differentiate between intra- and extra-articular pathology in patients

with hip pain [23]. They concluded that anaesthetic MRA can be used as an adjunct to define the origin of hip pain. In accordance to the aforementioned literature, we also observed that response to anaesthetic injection during hip MRA adds to the efficacy of the method in diagnosing intraarticular lesions such as symptomatic labral tears. The combined utilisation of anaesthetic injection could isolate patients with asymptomatic labral tears, thus increasing the specificity of MRA. Martin et al. in their study for diagnostic hip injections concluded that all labral tears identified on MR arthrograms may not be a major contributor to patient pain complaints and therefore the combination of both (MRA and intra-articular block) seems to increase the specificity of MRA [24].

Furthermore, regarding the added use of intra-articular block together with MRA, it has been shown that minimum volume of local anaesthetic is required for an effective local anaesthetisation of intra-articular structures [25, 26]. No risk of systemic toxicity was seen, as the major joints, such as hip, are devoid of major blood vessels and the risk of inadvertent injection into circulation is minimal, especially under guided instillation [25, 26]. In addition, anaesthesia of the small nerve endings in the joint does not require high-concentration of local anaesthetic, and the concentration of anaesthetic can be kept low within safe limits. Kehlet et al as well as McCarthy et al performed systematic review studies for the safety of use of intra-articular blocks in hip surgery [25, 26]. Our study is in accordance with their findings and the application of intra-articular anesthetisation together with MR arthrographic protocols seems to be a promising field of future research. Finally, there is some concern in the literature that large volume of analgesics in the joint may result to chondrolysis [27, 28]. There is minimal clinical evidence however, that chondrolysis may occur from a single injection [27, 28]. Jayaram et al. in their systematic review showed that ropivacaine at concentrations of 0.5% or less, as in our study, was found to have the least toxic effects [28].

We acknowledge a number of limitations in our study. Firstly, its relatively small number of patients. Our series was rather small, but arthroscopic comparison was available in all patients. The lack of additional orthopaedic surgeons for the pre-surgical joint evaluation and the subsequent arthroscopic identification of labral tears is a possible limitation, but this was a consecutive series of an experienced hip arthroscopy surgeon, which to some degree assures its consistency. An additional but inevitable limitation was our athletic population study group and the fact that selection bias might have been introduced when including patients. However, the athletes presented in a random way and to the best of our knowledge, a prospective study in amateur athletes for the combined use of MRA and intra-articular blocks with arthroscopic correlation has not been previously reported in the literature.

Conclusions

Our study strengthens the already popular use of MRA in clarifying the aetiology of hip pathology and signifies the fact that arthroscopy remains the gold standard of hip assessment. MR arthrography in combination with intra-articular block showed high sensitivity and specificity for the diagnosis of femoroacetabular impingement syndrome. Future research efforts are needed for the development and validation of evidence-based imaging protocols intended to better detect hip lesions in a time- and cost-effective manner. **R**

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Ethical approved

Democritus University of Thrace Medical Ethics Committee

Conflict of interest

The authors declared no conflicts of interest.

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