Original Article

Three-Grade Magnetic Resonance Imaging–Based Gluteus Medius and/or Minimus Tear Classification System Provides Excellent Inter-Rater Reliability

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Purpose: To develop a magnetic resonance imaging (MRI)-based classification system integrating tear characteristics including tear thickness (partial vs full) and tear retraction (less than or greater than 2 cm) for gluteus medius and/or minimus tears and to determine the inter-rater reliability of this MRI-based classification for gluteus medius and/or minimus tears. **Methods:** Patients who underwent primary endoscopic or open repair of gluteus medius and/or minimus tears between 2012 and 2022 were identified to be included in the review of 1.5-T MRI scans. One hundred MRI scans were randomized for review by 2 orthopaedic surgeons and evaluated for tear thickness (partial vs full), extent of retraction, and degree of fatty infiltration according to an applied Goutallier-Fuchs (G-F) classification. Tears were also graded according to the 3-grade MRI-based classification system as follows: grade 1, partial-thickness tears; grade 2, full-thickness tears with less than 2 cm of retraction; grade 3, full thickness with 2 cm or more retraction. Inter-rater reliability was calculated by absolute and relative agreement using Cohen's kappa (κ). Significance was defined by P value $<.05$. **Results:** In total, 221 patients were identified, and after application of exclusion criteria and randomization, 100 scans were evaluated. The 3-grade classification system demonstrated high absolute agreement (88%) comparable to the absolute agreement of the G-F classification (67%). The 3-grade classification system demonstrated substantial inter-rater reliability ($\kappa = 0.753$), whereas the G-F classification demonstrated moderate inter-rater reliability ($\kappa = 0.489$). **Conclusions:** The proposed 3-grade MRI-based classification system for gluteus medius and/or minimus tears demonstrated substantial inter-rater reliability, comparable with that of the applied G-F classification. **Clinical Relevance:** It is important to understand how gluteus medius and/or minimus tear characteristics impact postoperative outcomes. The 3-grade MRI-based classification incorporates tear thickness and amount of retraction that can complement previous classification systems to give the provider and patient more information when considering treatment options.

Gluteus medius and/or minimus tears have been increasingly recognized as a cause of lateral-sided hip pain in the older patient population.[1] Commonly, tears of the gluteus medius and minimus have been referred to as "rotator cuff tears of the hip," due to similarities of the gluteus medius and gluteus minimus tears to the supraspinatus and infraspinatus, respectively.[2,3] Gluteus medius and/or minimus tendinopathy encompasses a broad spectrum of tendon disease, including tendinosis as well as tears such as interstitial,

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partial-thickness, and full-thickness tears with or without retraction.[4] For patients with lateral-sided hip pain, nonoperative treatment modalities including activity modification, nonsteroidal anti-inflammatory drugs, and trochanteric bursa cortisone injections are the first line of treatment. When conservative treatment has failed to provide relief, operative intervention typically is recommended. Surgical options include endoscopic repair, open repair with or without augmentation, and tendon transfers.[5-9] Despite the numerous surgical options, the treatment algorithm for these conditions has largely come from anecdotal evidence and clinician preference, and more attention toward a systematized approach used for the identification of tears and their classification is necessary.[10-13]

One magnetic resonance imaging (MRI)-based classification system used for classifying gluteus medius and/or minimus tears is the Goutallier-Fuchs (G-F) classification system. Classically, this system has been used for assessment of fatty infiltration (FI) in rotator cuff pathology, with greater grades denoting greater FI, which have been shown to negatively impact patient outcomes following rotator cuff repair.[14,15] Bogunovic et al.[16] demonstrated that the G-F classification could be translated to assessment of FI in gluteus medius and/or minimus tears, with greater FI again demonstrating a negative influence on patient-reported outcomes following repair. Although the G-F classification system has shown to be predictive of patient-reported outcomes following repair,[17] there are likely other factors that influence outcomes following gluteus medius and/or minimus repairs. In rotator cuff literature, multiple studies have demonstrated that preoperative tendon retraction, specifically retraction greater than 2 cm, increases the risk of repair failure.[4,18] Wylie et al.[19] demonstrated that tears with greater retraction and greater FI demonstrated poorer postoperative outcomes. Therefore, a classification system that includes tear thickness and retraction is likely necessary to supplement previous MRI-based classifications to provide a more stepwise approach for the diagnosis and treatment of gluteus medius and/or minimus tears.

Another classification system for gluteus medius and/or minimus tears is the Milwaukee Classification, proposed by Davies et al.[20] from a retrospective review of 23 patients, and is based on MRI and intraoperative findings. This classification system used a musculoskeletal radiologist to interpret MRIs and assigns greater grades to tears involving a larger percentage of the total tendon footprint on sagittal imaging independent of tear retraction. Lall et al.[21] also proposed a classification system using a combination of physical examination, MRI, and endoscopic findings to characterize greater trochanteric pain syndrome. Although this classification system provides an extensive treatment algorithm with surgical technique and postoperative rehabilitation protocol for 6 different patient cohorts, neither study provides a stepwise algorithm for an orthopaedic surgeon to accurately grade the MRIs. Furthermore, neither classification system includes tear retraction, which has shown to influence clinical decision-making in gluteus medius and/or minimus repairs.

The purposes of this study were to develop an MRI-based classification system integrating tear characteristics including tear thickness (partial vs full) and tear retraction (less than or greater than 2 cm) for gluteus medius and/or minimus tears and to determine the inter-rater reliability of this MRI-based classification for gluteus medius and/or minimus tears. The authors hypothesized that the proposed MRI-based classification would have similar absolute and relative agreement to the established G-F classification.

Methods

Study Design

The following study was a retrospective case series examining MRI characteristics of gluteus medius and/or minimus tears. Following study approval from the institutional review board, the prospective database of the senior author (S.J.N) was queried to identify all patients who underwent primary open or endoscopic surgical intervention for gluteus medius and/or minimus tears from January 2012 to July 2022. Exclusion criteria were as follows: (1) age younger than 18 years old; (2) previous ipsilateral gluteus medius and/or minimus repair; (3) ipsilateral hip arthroplasty or ipsilateral hip resurfacing; (4) poor-quality MRI scan (ie, did not contain necessary sequences or tissue differentiation was difficult); (5) MRI obtained at an outside institution and unable to view; and (6) magnetic resonance arthrograms. To maintain consistency across MRI scans for inter-rater reliability statistics, only patients with available 1.5-Tesla (T) scans were included (Fig 1). Patients were indicated for surgery if they had not responded to preoperative conservative measures (ie, physical therapy, trochanteric corticosteroid injections, oral anti-inflammatories); if they had clinical-based diagnosis of a gluteus medius/minims tear such as hip abduction weakness, gait abnormality, and lateral-sided hip pain; and if they had MRI confirmation of a gluteus medius/minimus tear. Patient demographic data including age, sex, and body mass index were collected. Means and standard deviations for each demographic characteristic were calculated.

Three-Grade MRI-based Classification System

The proposed MRI-based classification system is composed of 3 grades, referred to as the "3-grade MRI-based classification," and is based on the authors' experiences with treatment decision-making and previous literature, which was reviewed by a musculoskeletal

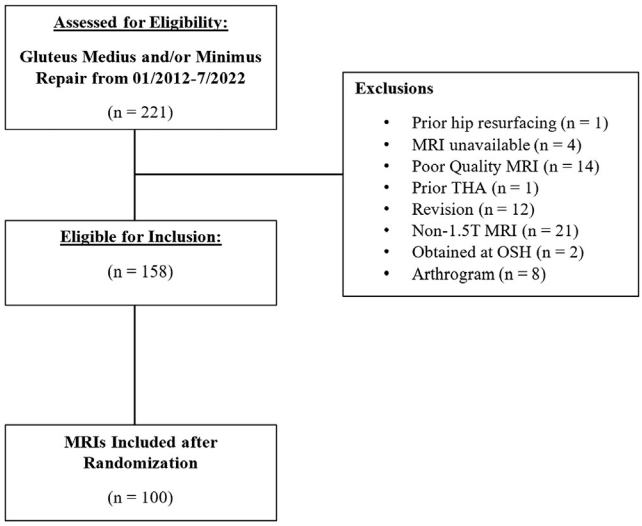

Fig 1. Consolidated Standards of Reporting Trials (CONSORT) diagram of patient selection methods. (MRI, magnetic resonance imaging; OSH, outside hospital; THA, total hip arthroscopy.)

radiologist (J.W.E). Grade 1 is defined as partial-thickness tears, grade 2 includes full-thickness tears with less than 2 centimeters of retraction, and grade 3 includes full-thickness tears with greater than 2 cm of retraction. Two centimeters of retraction was used as previous investigations in rotator cuff literature has demonstrated >2 cm retraction to have a greater risk of repair failure following arthroscopic intervention of the rotator cuff.[4,18] The axial T2-weighted MRI sequence is used to distinguish between partial- (grade 1) and full-thickness tears (grade 2 and 3). The sagittal T2-weighted MRI sequence is used to calculate maximum retraction and differentiate between grade 2 and grade 3.

Two orthopaedic surgeons (orthopaedic sports medicine fellows), surgeon 1 (R.B.B.) and surgeon 2 (S.A.) analyzed MRIs using Opal-Rad software (Konica Minolta Healthcare Americas, Inc., Wayne, NJ) to assess tear size, maximum length of tendon retraction and FI for all patients included in the study. Measurements were obtained independently while surgeon 1 was blinded to surgeon 2 measurements and vice versa. Images were then classified into the 3-grade MRI-based classification system.

Coronal Pelvis/Hip T2-Weighted Sequence

The clinician begins the assessment of gluteus medius and/or minimus tears at the anterior most slice on the coronal T2 hip of the affected side and moves posteriorly. The gluteus minimus tendon is assessed first as it inserts onto the anterior facet (blue) of the greater trochanter. The gluteus medius is then found slightly posteriorly inserting onto the lateral and posterosuperior facet (red) of the greater trochanter (Fig 2). The slice in which the lesser trochanter profile is most prominent will typically demonstrate the gluteus medius insertion. The clinician assesses the morphology of each tendon for continuity of the fibers with the footprint, as well as any fluid signal cranial to the tendon insertion.[11]

Axial Hip T2-Weighted Sequence

The gluteus medius and minimus muscle bellies are found proximally and followed distally until visualizing the musculotendinous junction using the axial hip T2-weighted sequence. As one continues to scroll distally, the surgeon will identify the gluteus medius tendon (red) inserting onto the posterosuperior and lateral facets and the gluteus minimus tendon (blue) inserting onto the anterior facet of the greater trochanter (Fig 3).[22] The following tendon characteristics are assessed on one slice: full-thickness versus partial-thickness tear and involvement of gluteus medius, gluteus minimus, or both. Full-thickness tears demonstrate fluid signal and complete discontinuity of gluteus medius and minimus tendons from their respective facets of the greater trochanter. In contrast, partial-thickness tears demonstrate intrinsic fluid signal within the tendon fibers with a component of the tendon fibers remaining attached to the greater trochanteric footprint. The clinician then confirms whether the tear is confined to the gluteus medius, gluteus minimus, or both while simultaneously comparing with the coronal T2 sequences.

Sagittal Hip T2-Weighted Sequence

Using the T2 sagittal imaging, the clinician begins evaluation of the gluteus medius and minimus with the lateral most slice and progresses medially. Tendon retraction is then assessed on the slice with the broadest footprint available. A line is drawn from the base of the footprint to the most retracted aspect of the tendon (Fig 4).

Three-Grade MRI-Based Classification System Examples

Examples of grade 1 (Fig 5), grade 2 (Fig 6), and grade 3 (Fig 7) tears are demonstrated.

Coronal Pelvis T1-Weighted Sequence

Attention is then turned to the T1 coronal pelvis to assess FI within the gluteus medius and minimus musculature. Starting anteriorly, the clinician evaluates posteriorly until identifying the slice with the best visualization of both the greater and lesser trochanters (Fig 8).[22] Tears are then graded using the G-F

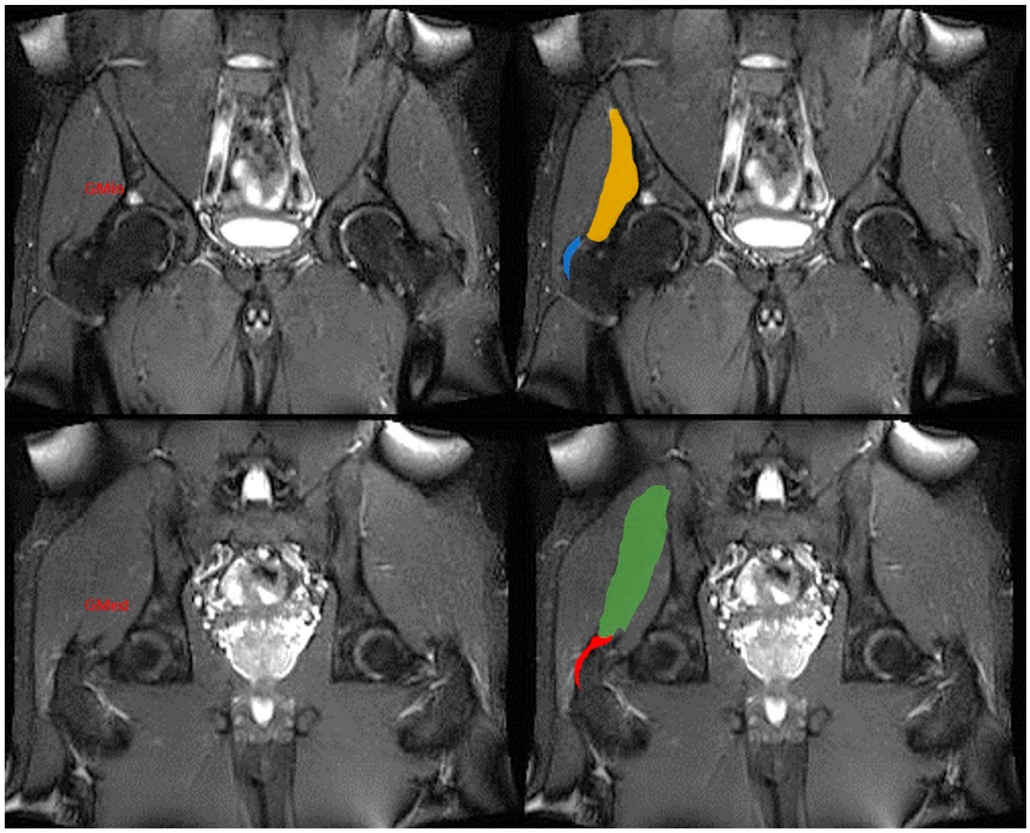

Fig 2. Coronal magnetic resonance imaging view of right-side gluteus minimus (top row) muscle belly (orange) and tendon insertion (blue) and gluteus medius (bottom row) muscle belly (green) and tendon insertion (red).

classification system based on percentage of FI as previously described by Bugonovic et al.[16]

Inter-Rater Agreement and Reliability

Inter-rater agreement was calculated using measures of absolute and relative agreement between the 2 orthopaedic surgeons by a third person (T.W.F.) not involved in MRI grading classification. Absolute agreement was reported using percent agreement. The percentage of scans with the same score assigned using measurements from each surgeon was divided by the total number of scans included in the study to give percentage of absolute agreement for the 3-grade MRI-based classification scores as well as G-F classification of FI.

Relative measures of agreement were reported as inter-rater reliability using Cohen's kappa (κ) statistic. Cohen's κ was calculated for the 3-grade classification and G-F classification scores, which was conducted using SPSS Statistics (IBM Corp., Armonk, NY). Resulting κ values were interpreted using the scale first proposed by Cohen: values ≤ 0 as indicating no agreement and 0.01-0.20 as none to slight, 0.21-0.40 as fair, 0.41-0.60 as moderate, 0.61-0.80 as substantial, and 0.81-1.00 as almost perfect agreement.[23,24]

An a priori power analysis was conducted to determine the optimal sample size for an inter-rater reliability analysis using the IRR package in R Studio (Boston, MA). The value of κ under the null hypothesis was set to 0.60 and the value of the true κ to be estimated was set to 0.91 with a desired power of 0.90 resulting in an optimal sample size of 25 patients in each classification. The null hypothesis was set to 0.60, as any κ value below this threshold would be considered inadequate agreement.[23] The true κ was set to 0.91m as any κ above 0.90 would be considered near-perfect agreement.[23] Thus, in attempts to obtain this optimal sample size for each group, 100 patients' MRIs from the eligible 158 were randomized and included in final review. Randomization was performed by assigning each patients' MRI a number by a random-number sequence generator. Then, the first consecutive hundred numbers (ie, patients' MRIs) were included in review.

Results

Patient Demographics

A total of 221 gluteus medius and/or minimus tears were assessed for eligibility. Of these, 158 were eligible for MRI review, of which 100 were randomly included

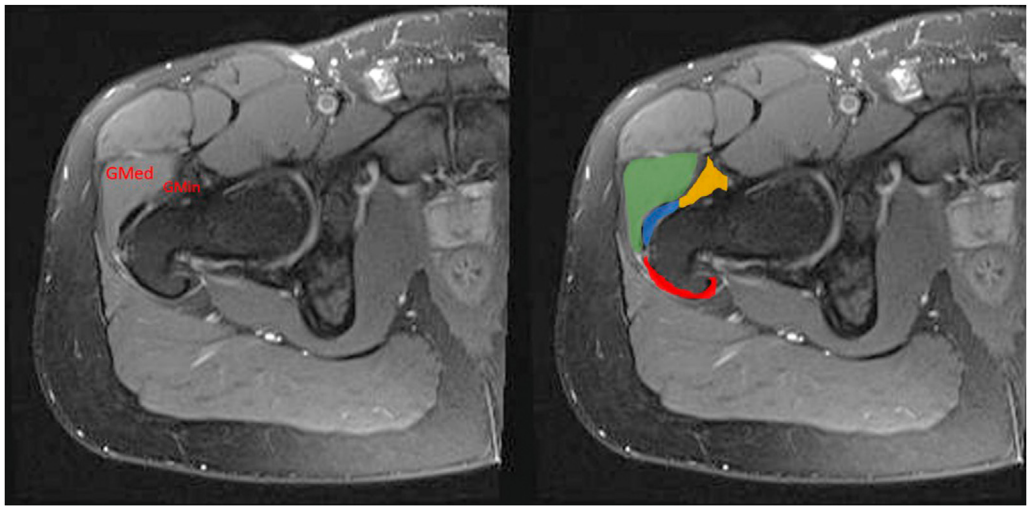

Fig 3. Axial magnetic resonance imaging of a right-sided gluteus minimus muscle belly (orange) and tendon insertion (blue) and the gluteus medius muscle belly (green) and tendon insertion (red).

in final analysis (Fig 1). A majority of the study population was female (93%) with an average age and body mass index of 61.0 ± 10.1 years and 28.2 ± 6.1, respectively (Table 1). Upon intraoperative assessment, the majority of included patients (71%) had tears involving both the gluteus medius and minimus.

Three-Grade MRI-based Classification System: Absolute Agreement

For the proposed 3-grade MRI-based classification system of gluteus medius/minimus tears, surgeon 1 and surgeon 2 agreed on 88 of 100 MRI scans for an absolute agreement of 88%. According to the G-F classification, the surgeons agreed on 67 scans for an absolute agreement of 67%. Regarding gluteus medius and/or minimus tendon involvement, the surgeons agreed on tendon involvement 84% of the time. When classifying tears by tear thickness (partial vs full thickness), the surgeons demonstrated an absolute agreement of 88% (Table 2). Full-thickness tears graded by surgeon 1 had an average maximum retraction of 2.1 ± 1.09 cm from the tendon footprint and full-thickness tears graded by surgeon 2 had an average maximum retraction of 2.03 ± 1.02 cm from the tendon footprint ($P = .629$). Of the tears that both surgeons agreed were full thickness (n = 24), they agreed 95.8% of the time when dichotomized to less than or greater than 2 cm of maximum retraction. Additionally, the average delta (surgeon 1-measured retraction − surgeon 2-measured retraction) for measured full-thickness tear retraction between surgeons was 0.3 ± 0.4 cm.

Inter-Rater Agreement and Reliability

There was substantial agreement between surgeons for the 3-grade classification system, with a Cohen's κ statistic of 0.753 ($P < .001$). Regarding the G-F classification, there was moderate agreement between surgeons, with a Cohen's κ statistic of 0.489 ($P < .001$).

Discussion

The most important finding of this study is that as demonstrated by the high absolute agreement (88%) and Cohen's κ of 0.753, the 3-grade classification system demonstrated substantial agreement between surgeons. The proposed 3-grade MRI-based classification system provides a stepwise method for the evaluation and classification of gluteus medius and minimus tears based on tear thickness and extent of retraction. Consistent with previous literature, the present study also exhibits that the G-F classification system demonstrates significant inter-rater reliability ($\kappa = 0.489$) between orthopaedic surgeons, similar to its usage within the rotator cuff literature. The authors accept the hypothesis that both classifications would demonstrate similar absolute and relative inter-rater reliability. Compared with other MRI classification systems, the proposed 3-grade MRI-based classification system may be used by orthopaedic surgeons to further incorporate tear thickness and retraction into their preoperative evaluation for gluteus medius/minimus tears.[16,22,25]

When comparing results of the current study to previous investigations of reliability using the G-F classification, the inter-rater reliability results demonstrated in this study were slightly lower than that previously reported. Previous studies have reported weighted κ values ranging from 0.59 to 0.93.[26-29] However, the Cohen's κ in this study was 0.489. The discrepancy in grading found within our investigation can likely be explained largely by variability in greater trochanter

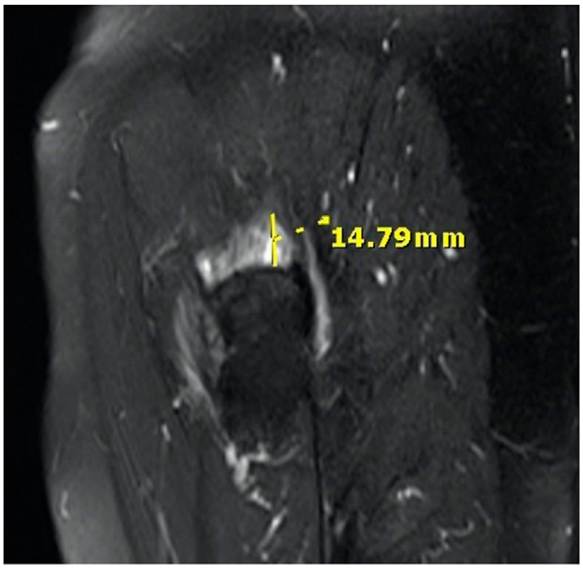

Fig 4. Sagittal T2-weighted magnetic resonance imaging of the right hip demonstrating how to measure maximum retraction using (a) the slice with the broadest footprint available and (b) a line drawn from the base of the footprint to the most retracted aspect of the tendon.

anatomy between patients. The ability to accurately assess individual patient anatomy is limited by patient body habitus, positioning, slice angle, and thickness of particular MRI sequences. Concomitant pathology such as trochanteric bursitis may also distort the evaluation of necessary MRI needed for accurate classification of tears. However, the high absolute and relative agreement between surgeons in this study when using the 3-grade classification system was comparable to the well-established G-F classification discussed in previous literature.[26-29] Thus, the proposed classification may be used to supplement previous classifications, like the G-F classification, to provide additional information to the surgeon and patient.

Bogunovic et al.[16] were the first to propose a gluteus medius/minimus tear classification system using the G-F classification system. The study demonstrated that the degree of FI plays a significant role in outcomes following repair and can be used by clinicians to counsel patients on likelihood of a successful outcome following surgery. Looney et al.[17] furthered this notion through a systematic review of the four largest case series assessing outcomes following gluteus medius and/or minimus repair and found increasing FI to be associated with significantly less improvement in patient reported outcomes following repair. Therefore, some surgeons have elected to augment repairs with human dermal allograft for tears with significant FI with promising early results.[14,30] Although the G-F classification system for gluteus medius and/or minimus tears has shown to be predictive of outcomes, more information on gluteus medius/minimus tear thickness and retraction, as used in the 3-grade classification, may be necessary for informed clinical decision-making and surgical planning.

In the shoulder literature, multiple studies have demonstrated that preoperative tendon retraction, particularly retraction >2 cm, increases the risk of repair failure following arthroscopic rotator cuff repair.[4,18] Furthermore, Wylie et al.[19] found that more retracted tears with increasing FI were less likely to heal and ultimately lead to poorer patient-reported outcomes. Patients with larger, retracted tears and increased FI have also demonstrated greater rates of postoperative pain and narcotic use.[31] Within the current hip literature, tear characteristics other than FI have influenced treatment modalities in multiple studies.[16,32,33] Therefore, a classification system like the 3-grade MRI-based classification that further

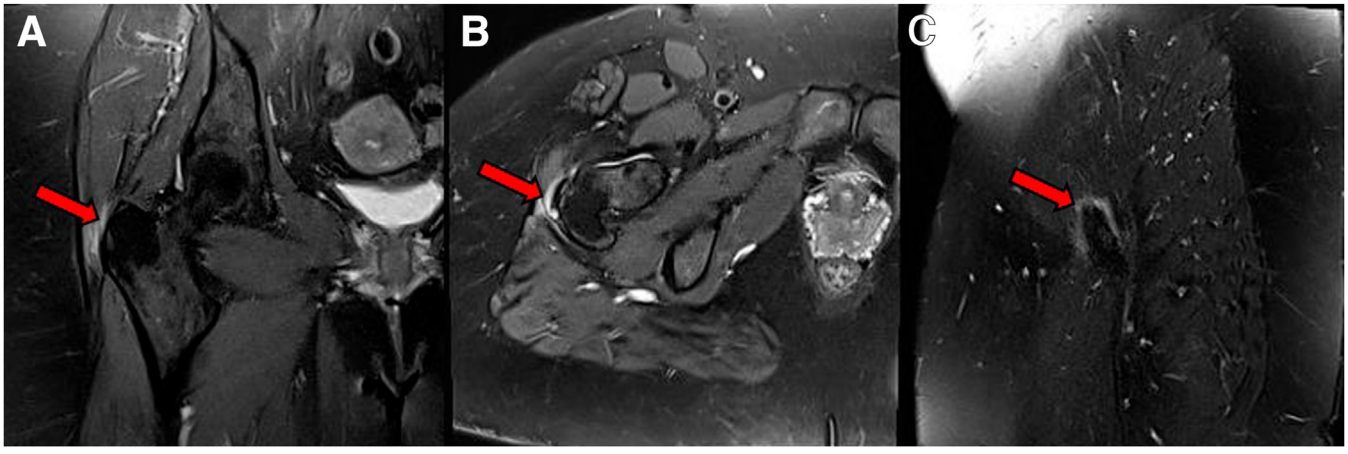

Fig 5. Representative magnetic resonance images of a right-sided gluteus minimus grade 1 partial- thickness tear (indicated by red arrow) shown in (A) coronal, (B) axial, and (C) sagittal planes.

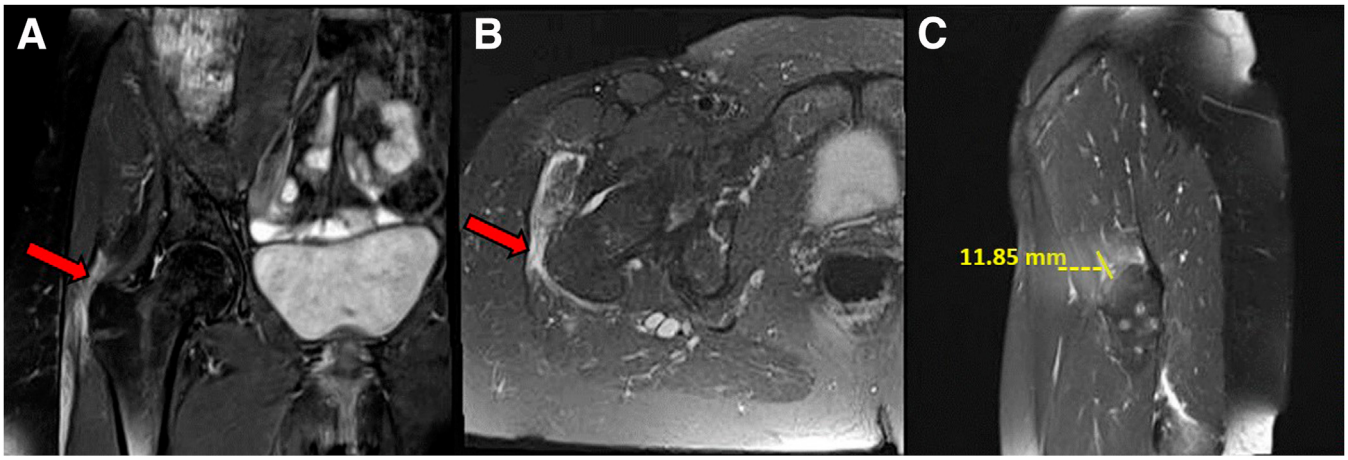

Fig 6. Representative magnetic resonance images of both a right-sided gluteus medius and minimus grade 2 full-thickness tear (indicated by red arrow) with <2 cm retraction shown in (A) coronal, (B) axial, and (C) sagittal planes (yellow retraction measurement of 11.85 mm).

implements both tear thickness and extent of retraction is useful to supplement the G-F classification and provide a more step-wise approach to the diagnosis and treatment gluteus medius and/or minimus tears. Further studies evaluating the impact of the 3-grade MRI-based classification on clinical outcomes will be beneficial to determine its clinical utility.

Although the Milwaukee classification system, an MRI-based classification system for gluteus medius and/or minimus tears, is commonly cited in research when describing tear characteristics, the classification uses a musculoskeletal radiologist, which further failed to perform any inter-rater reliability between the radiologist and an orthopaedic surgeon. Therefore, the classification may not be an accurate, generalizable, and easily reproducible tool for orthopaedic surgeons to use in clinical practice.[20] Furthermore, tendon retraction was not included in the Milwaukee classification and, and as previously mentioned, is likely an important preoperative factor to include in a classification system, as it has shown to negatively influence outcomes following rotator cuff repair.[34] The degree of retraction likely implies a degree of chronicity to the tear, which may influence treatment success.

The classification system proposed by Lall et al.[21] used a combination of physical examination, MRI, and endoscopic findings to separate gluteus medius and/or minimus tears into 6 types, which provided an algorithm with protocols for both surgical technique and postoperative rehabilitation. Although the classification

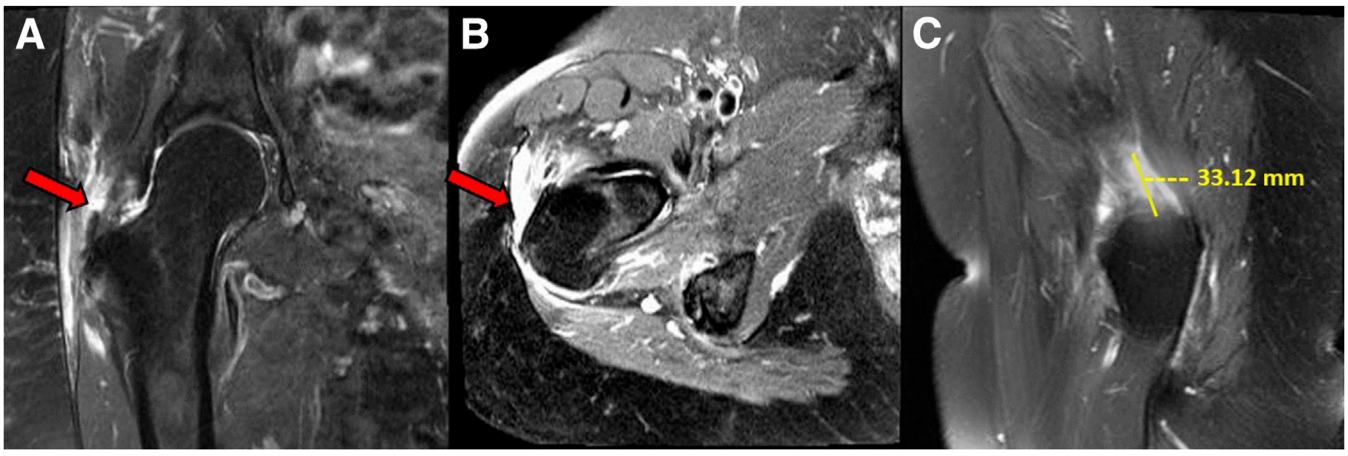

Fig 7. Representative magnetic resonance images of both a right-sided gluteus medius and minimus Grade 3 full thickness tear (indicated by red arrow) with >2-cm retraction shown in (A) coronal, (B) axial, and (C) sagittal planes (yellow retraction measurement of 33.12 mm).

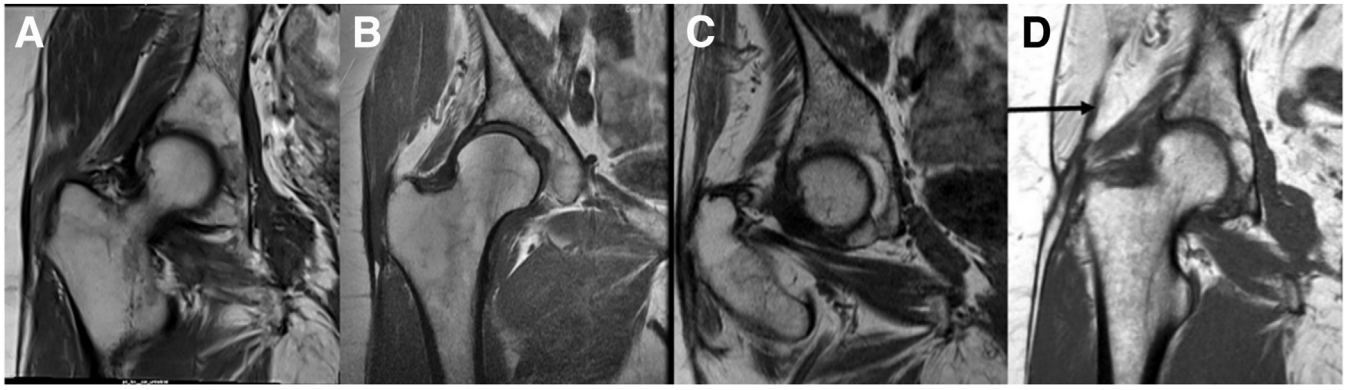

Fig 8. Goutallier-Fuchs (G-F) classification of muscle fatty infiltration of a right-sided gluteus medius and minimus with representative (A) grade I fatty infiltration, (B) grade II, (C) grade III, and (D) grade IV with severe fatty infiltration of the gluteus medius indicated by the black arrow.

system is comprehensive and extensive, the classification system does not demonstrate a step-wise approach for orthopaedic surgeons to assess this pathology using MRI or provide evidence that this classification is a reliable method for the assessment of these tears. Furthermore, the classification system's utility was limited to a cohort treated endoscopically and therefore, the generalizability to all gluteus medius/minimus tears, specifically those requiring an open approach, is not known. The 3-grade classification addresses these limitations by including a step-wise approach to use the classification and can be applied to a variety of tears treated via open and endoscopic approaches, improving the generalizability.

As the diagnosis and surgical treatment of gluteus medius and/or minimus tears becomes increasingly common, the 3-grade MRI-based classification system was designed to improve homogeneity of studied results and has shown substantial inter-rater reliability between orthopaedic surgeons. The present study provides orthopaedic surgeons with a method to accurately diagnose and discuss surgical options for patients with gluteus medius and/or minimus pathology both clinically and in research. Future studies are necessary to determine the clinical relevance regarding how the MRI-based classification system influences treatment decision-making and patient outcomes.

Table 1. Patient Demographic and Preoperative Radiographic Characteristics

N	100
Age, y	61.0 ± 10.1
Sex	
Female	93 (93%)
Male	7 (7%)
BMI	28.2 ± 6.1
Tears	
Gluteus medius only	23 (23%)
Gluteus minimus only	6 (6%)
Both gluteus medius and minimus	71 (71%)

NOTE. Continuous variables are represented as mean ± standard deviation. Categorical variables are represented as count (% percentage).

BMI, body mass index.

Limitations

This study is not without limitations. First, in order to accurately assess and classify gluteus medius tears, a quality 1.5-T MRI scanner must be used. Therefore, lower-quality MRIs obtained at outside institutions were excluded from the present study due to an inability to accurately classify tears into the 3-grade classification system. This may limit the generalizability of the classification system to clinicians in areas without readily accessible 1.5-T MRI scanners. Second, inherent to the designs of the 3-grade and G-F classifications, the simpler 3-grade classification will likely have greater agreement than a more complex one like the G-F classification, which uses 4 grades. Third, this study introduces a stepwise approach via MRI to grade gluteus medius/minimus tears based on thickness and retraction. However, further investigation is needed to determine how these tear characteristics relate to clinical outcomes. Fourth, correlations between the proposed MRI classification and objective intraoperative findings were not able to be made, as the majority of operative notes did not have the amount of retraction and, therefore, classification using the 3-grade system could not be made. Fifth, all patients included in this cohort eventually underwent surgical repair and, therefore, the classification may not be generalizable to patients not undergoing repair. Finally, the study reports data from surgical procedures performed by a single, fellowship-trained sports medicine surgeon with advanced training and experience in hip arthroscopy practicing at a high-volume practice, and, consequently, the study's results may not be generalizable to surgeons with different levels of training.

Table 2. Three-Grade MRI classifications by Surgeon

	Surgeon 1	Surgeon 2	Absolute Agreement
Novel MRI classification			88%
Grade 1	69	71	
Grade 2	16	14	
Grade 3	15	15	
G-F classification			67%
Grade 1	40	33	
Grade 2	38	52	
Grade 3	16	9	
Grade 4	5	6	
Tendon involvement			84%
Gluteus minimus	6	4	
Gluteus medius	18	16	
Both	76	80	
Tear size			88%
Partial thickness	70	81	
Full thickness	30	29	

G-F, Goutallier-Fuchs; MRI, magnetic resonance imaging.

Conclusions

The proposed 3-grade MRI-based classification system for gluteus medius and/or minimus tears demonstrated substantial inter-rater reliability, comparable with that of the applied G-F classification.

References

1. Chandrasekaran S, Gui C, Hutchinson MR, Lodhia P, Suarez-Ahedo C, Domb BG. Outcomes of endoscopic gluteus medius repair: Study of thirty-four patients with minimum two-year follow-up. *J Bone Joint Surg Am* 2015;97:1340-1347.
2. Bunker TD, Esler CN, Leach WJ. Rotator-cuff tear of the hip. *J Bone Joint Surg Br* 1997;79:618-620.
3. Kagan A. Rotator cuff tears of the hip. *Clin Orthop* 1999;(368):135-140.
4. Strauss EJ, Nho SJ, Kelly BT. Greater trochanteric pain syndrome. *Sports Med Arthrosc Rev* 2010;18:113-119.
5. Perets I, Mansor Y, Yuen LC, Chen AW, Chaharbakhshi EO, Domb BG. Endoscopic gluteus medius repair with concomitant arthroscopy for labral tears: A case series with minimum 5-year outcomes. *Arthroscopy* 2017;33:2159-2167.
6. Whiteside LA. Surgical technique: Gluteus maximus and tensor fascia lata transfer for primary deficiency of the abductors of the hip. *Clin Orthop* 2014;472:645-653.
7. Rao BM, Kamal TT, Vafaye J, Taylor L. Surgical repair of hip abductors. A new technique using Graft Jacket allograft acellular human dermal matrix. *Int Orthop* 2012;36:2049-2053.
8. Suppauksorn S, Nwachukwu BU, Beck EC, Okoroha KR, Nho SJ. Superior gluteal reconstruction for severe hip abductor deficiency. *Arthrosc Tech* 2019;8:e1255-e1261.
9. Whiteside LA. Surgical technique: Transfer of the anterior portion of the gluteus maximus muscle for abductor deficiency of the hip. *Clin Orthop* 2012;470:503-510.
10. Hartigan DE, Perets I, Walsh JP, Domb BG. Imaging of abductor tears: Stepwise technique for accurate diagnosis. *Arthrosc Tech* 2017;6:e1523-e1527.
11. Cvitanic O, Henzie G, Skezas N, Lyons J, Minter J. MRI diagnosis of tears of the hip abductor tendons (gluteus medius and gluteus minimus). *AJR Am J Roentgenol* 2004;182:137-143.
12. Makridis KG, Lequesne M, Bard H, Djian P. Clinical and MRI results in 67 patients operated for gluteus medius and minimus tendon tears with a median follow-up of 4.6 years. *Orthop Traumatol Surg Res* 2014;100:849-853.
13. Ebert JR, Brogan K, Janes GC. A prospective 2-year clinical evaluation of augmented hip abductor tendon repair. *Orthop J Sports Med* 2020;8:2325967119897881.
14. Shin YK, Ryu KN, Park JS, Jin W, Park SY, Yoon YC. Predictive factors of retear in patients with repaired rotator cuff tear on shoulder MRI. *AJR Am J Roentgenol* 2018;210:134-141.
15. Somerson JS, Hsu JE, Gorbaty JD, Gee AO. Classifications in brief: Goutallier classification of fatty infiltration of the rotator cuff musculature. *Clin Orthop* 2016;474:1328-1332.
16. Bogunovic L, Lee SX, Haro MS, et al. Application of the Goutallier/Fuchs rotator cuff classification to the evaluation of hip abductor tendon tears and the clinical correlation with outcome after repair. *Arthroscopy* 2015;31:2145-2151.
17. Looney AM, Bodendorfer BM, Donaldson ST, Browning RB, Chahla JA, Nho SJ. Influence of fatty infiltration on hip abductor repair outcomes: A systematic review and meta-analysis. *Am J Sports Med* 2022;50:2568-2580.
18. Park JS, Park HJ, Kim SH, Oh JH. Prognostic factors affecting rotator cuff healing after arthroscopic repair in small to medium-sized tears. *Am J Sports Med* 2015;43:2386-2392.
19. Wylie JD, Baran S, Granger EK, Tashjian RZ. A comprehensive evaluation of factors affecting healing, range of motion, strength, and patient-reported outcomes after arthroscopic rotator cuff repair. *Orthop J Sports Med* 2018;6:2325967117750104.
20. Davies JF, Stiehl JB, Davies JA, Geiger PB. Surgical treatment of hip abductor tendon tears. *J Bone Joint Surg Am* 2013;95:1420-1425.
21. Lall AC, Schwarzman GR, Battaglia MR, Chen SL, Maldonado DR, Domb BG. Greater trochanteric pain syndrome: An intraoperative endoscopic classification system with pearls to surgical techniques and rehabilitation protocols. *Arthrosc Tech* 2019;8:e889-e903.
22. Hartigan DE, Perets I, Ho SW, Walsh JP, Yuen LC, Domb BG. Endoscopic repair of partial-thickness undersurface tears of the abductor tendon: Clinical outcomes with minimum 2-year follow-up. *Arthroscopy* 2018;34:1193-1199.
23. McHugh ML. Interrater reliability: The kappa statistic. *Biochem Medica* 2012;22:276-282.
24. *A Coefficient of Agreement for Nominal Scales - Jacob Cohen* 1960. https://journals.sagepub.com/doi/abs/10.1177/001316446002000104?journalCode=epma. Accessed November 21, 2022.

25. Naimark M, Trinh T, Robbins C, et al. Effect of muscle quality on operative and nonoperative treatment of rotator cuff tears. *Orthop J Sports Med* 2019;7:2325967119863010.
26. Schiefer M, Mendonça R, Magnanini MM, et al. Intraobserver and interobserver agreement of Goutallier classification applied to magnetic resonance images. *J Shoulder Elbow Surg* 2015;24:1314-1321.
27. Rulewicz GJ, Beaty S, Hawkins RJ, Kissenberth MJ. Supraspinatus atrophy as a predictor of rotator cuff tear size: An MRI study utilizing the tangent sign. *J Shoulder Elbow Surg* 2013;22:e6-10.
28. Wall LB, Teefey SA, Middleton WD, et al. Diagnostic performance and reliability of ultrasonography for fatty degeneration of the rotator cuff muscles. *J Bone Joint Surg Am* 2012;94:e83.
29. Oh JH, Kim SH, Choi JA, Kim Y, Oh CH. Reliability of the grading system for fatty degeneration of rotator cuff muscles. *Clin Orthop* 2010;468:1558-1564.
30. Porat S, Nottage WM, Fouse MN. Repair of partial thickness rotator cuff tears: A retrospective review with minimum two-year follow-up. *J Shoulder Elbow Surg* 2008;17:729-731.
31. Misir A, Uzun E, Kizkapan TB, Ozcamdalli M, Sekban H, Guney A. Factors affecting prolonged postoperative pain and analgesic use after arthroscopic full-thickness rotator cuff repair. *Orthop J Sports Med* 2021;9:23259671211012410.
32. Levy DM, Bogunovic L, Grzybowski JS, Kuhns BD, Bush-Joseph CA, Nho SJ. All-endoscopic single-row repair of full-thickness gluteus medius tears. *Arthrosc Tech* 2016;5:e1-6.
33. Thaunat M, de Saint Vincent B, Caron E, Ingale PS. A comparison of outcomes after endoscopic repair of partial- versus full-thickness tears of the gluteus medius tendon. *Arthroscopy* 2021;37:2465-2472.
34. Meyer DC, Wieser K, Farshad M, Gerber C. Retraction of supraspinatus muscle and tendon as predictors of success of rotator cuff repair. *Am J Sports Med* 2012;40:2242-2247.