ORIGINAL ARTICLE

CiSE
Clinics in Shoulder and Elbow

Clinics in Shoulder and Elbow Vol. 20, No. 1, March, 2017
https://doi.org/10.5397/cise.2017.20.1.30

Isolated Ruptures of the Infraspinatus: Clinical Characteristics and Outcomes

Kwang Yeol Lee, Sae Hoon Kim, Joo Han Oh

Department of Orthopaedic Surgery, Seoul National University Bundang Hospital, Seongnam, Korea

Background: Isolated infraspinatus tear is very rare and clinical features are not as well known, therefore the purpose of this study was to evaluate clinical characteristics and outcomes of isolated infraspinatus tear that authors experienced.
Methods: Authors reviewed 288 cases of full-thickness rotator cuff tear involving infraspinatus between 2010 and 2015, and retrospectively analyzed six cases of isolated infraspinatus tear. Perioperative clinical characteristics, postoperative functional outcomes of 6 months were investigated. Functional evaluation included visual analogue scale (VAS), range of motions, American Shoulder and Elbow Surgeons (ASES) score, and Constant score.
Results: Calcific tendinitis was accompanied in 4 cases (66.7%). Three of them received steroid injection or aspiration or extracorporeal shockwave therapy. Mean preoperative pain VAS was 7.1 (range, 5–9), and mean postoperative pain VAS at 6 months later was 1.6 (range, 0–5). Preoperative muscle strength by isokinetic muscle performance test showed 52% deficit of abduction and 37.6% deficit of external rotation. All 6 patients had arthroscopic repair of the infraspinatus tendon. All the patients at the 6 months follow-up exhibited clinical improvement in the Constant score (67.8 [range, 45–77] to 89.3 [range, 81–100], $p=0.029$), and ASES score (52.3 [range, 30–77] to 90.0 [range, 80–100], $p=0.002$). There was no healing failure on imaging.
Conclusions: Isolated infraspinatus tendon tear was frequently accompanied by calcific tendinitis, but pathophysiologic relationship should need more study. To rule out neurogenic etiology, magnetic resonance imaging and electromyography would be helpful. Arthroscopic infraspinatus tendon repair and supraspinatus debridement showed relatively good result in painful shoulder.
(Clin Shoulder Elbow 2017;20(1):30-36)

Key Words: Isolated infraspinatus tear; Calcific tendinitis; Suprascapular nerve palsy; Fatty degeneration

Introduction

The rotator cuff is composed of the supraspinatus, the infraspinatus, the subscapularis, and the teres minor. Each muscle cooperates with one another, together contributing to the stability of the glenohumeral joint. Functionally, the supraspinatus is known not only to initiate abduction but also to act throughout the range of abduction of the shoulder. And the subscapularis and the teres minor are known to act throughout the range of external rotation of the shoulder.[1-3] Cuff tears are the most common lesions of the shoulder, among which tears of the supraspinatus tendon at the greater tuberosity are the most prevalent.[4] But because a substantial portion of the infraspinatus tendon is also inserted into the greater tuberosity, the infraspinatus is expected to contribute to abduction of the shoulder to some extent. Therefore, cuff tears occurring at the greater tuberosity may be closely associated with the infraspinatus at a higher rate than was previously thought. In support of this, a recent study has proposed a novel anatomical and functional perspective of the insertion anatomy of the cuff into the greater tuberosity, and related studies have been performed to support these findings.[5,6] For instance, Kato et al.[7] described the infraspinatus

Received December 10, 2015. **Revised** August 7, 2016. **Accepted** August 7, 2016.

Correspondence to: Kwang Yeol Lee
Department of Orthopaedic Surgery, Seoul National University Bundang Hospital, 82 Gumi-ro 173beon-gil, Bundang-gu, Seongnam 13620, Korea
Tel: +82-31-787-7197, **Fax:** +82-31-787-4056, **E-mail:** sorimky@hanmail.net
IRB approval (No. B-1701/379-111).

Financial support: None. **Conflict of interests:** None.

pISSN 2383-8337
eISSN 2288-8721

tendon in terms of the direction of fibrosis: the oblique component and the transverse component. Using their method to divide the infraspinatus muscle into four compartments, Matsuki et al.[8] found that the superior compartment was associated with around half the tears of the anterior infraspinatus whereas the inferior compartment was associated with half the tears of the posterior infraspinatus.

Compared to the plethora of studies reported on the infraspinatus muscle, those that have investigated isolated infraspinatus tears are very few in numbers. Most studies on isolated infraspinatus injuries are related to instances of denervation, such as the Parsonage-Turner syndrome[9,10] and suprascapular nerve entrapment.[11] Although the compression of the nerve during suprascapular nerve entrapment is the most common cause of paralabral ganglion, other etiological causes such as tumors or vascular malformation are also likely.[12,13] Studies of isolated infraspinatus injuries that are independent of any nerve injury are very rare; none have been reported in the Korean literature so far. Lunn et al.[14] have reported 19 cases of isolated infraspinatus tears that are absent of any nerve injury. To this end, we investigated the following parameters in 6 patients with isolated infraspinatus tears lacking a neurological background: 1) pathological features of isolated infraspinatus tears; 2) and the clinical characteristics and outcomes after arthroscopic repair.

Methods

Of the 1,755 patients who had received a cuff repair from February 2010, we selected a total of 288 patients who had an all-thickness tear of the infraspinatus muscle. And among them, we enrolled 6 patients who had an isolated all-thickness tear of the infraspinatus muscle into our study. We diagnosed the tears through preoperative magnetic resonance imaging (MRI) and intraoperative arthroscopic findings and defined an isolated infraspinatus tear as an all-thickness tear of the infraspinatus alone without a combined all-thickness tear of any another cuff muscle.[14] Our definition of an isolated tear, therefore, included tears that were combined with partial tears of another cuff region.

Discriminating the supraspinatus muscle from the infraspinatus muscle by insertion anatomy alone is difficult. In this study, we defined and diagnosed an isolated tear as one involving the infraspinatus tendon only when the tendon in concern could be traced to the belly of the infraspinatus muscle on MRI and to the scapular spine arthroscopically, in a way that is clearly distinct from the supraspinatus tendon. In other words, we included only patients who had an all-thickness tear that was at least 2.0–2.5 cm away from the biceps (Fig. 1). None of the patients enrolled into our study had a bilateral injury, and 4 of the 6 patients had the injury on the dominant shoulder as opposed to

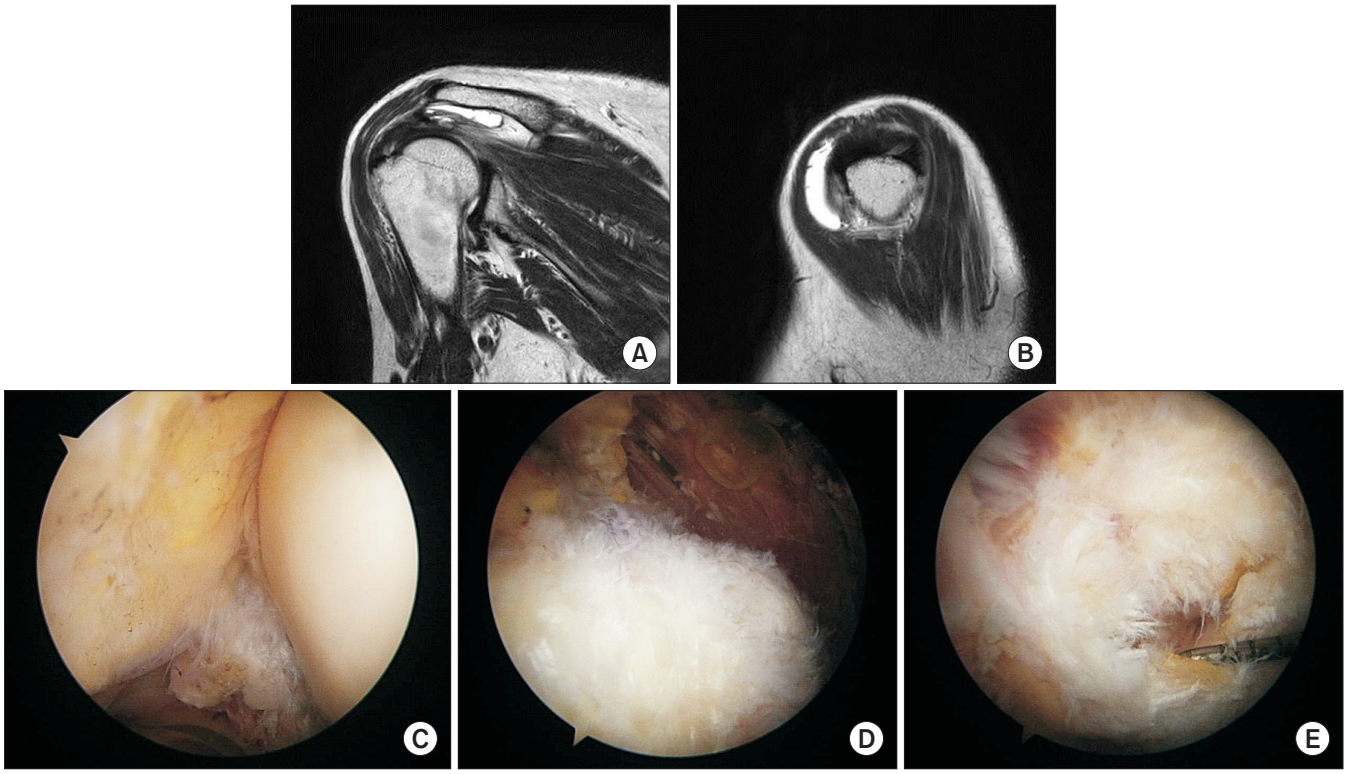

Fig. 1. (A, B) Preoperative magnetic resonance imaging of a 70-year-old female patient (ID-1) suggests concealed interstitial delamination at the anterior infraspinatus tendon. The intraoperative, arthroscopic findings revealed an articular-sided partial tear of the supraspinatus tendon (C, D) and a full thickness tear of the infraspinatus tendon (E).

the non-dominant shoulder. The patients had an average age of 58.7 years at the time of operation (range, 53–70 years). And our patient sample consisted of 1 male patient and 5 female patients. Except for a single taxi driver, the patients in general were engaged in very low levels of labor, let alone in any overhead sports. All patients received preoperative physical examination and one patient received an electromyography (ID-2). The average period between the onset of symptoms and diagnosis was 39.6 months (range, 10–36 months), and the average follow-up period was 13.7 months (range, 6–43 months) (Table 1).

Patients were evaluated preoperatively using radiographic imaging tools such as MRI and x-ray and isokinetic muscle performance tests. We performed an arthroscopic cuff repair for the infraspinatus and an acromioplasty on all patients. With regards to the fraying of the supraspinatus muscle, we carried out debridement only. We assessed clinical outcomes by comparing the preoperative and 6-month follow-up values of pain visual analogue scale (PVAS), active range of motions (ROMs), and functional scores such as the American Shoulder and Elbow Surgeons (ASES) score and the Constant score. Postoperatively, we performed ultrasonography at the 3- and 6-month follow-ups and MRI at the 1-year follow-up in order to assess for retears.

For all statistical analyses, we used the IBM SPSS software ver. 22.0 (IBM Co., Armonk, NY, USA). To compare the pre- and postoperative outcome values, we used a paired t-test. Statistical significance was set to a *p*-value of less than 0.05.

Results

Among our patients, only one had a trauma-induced symptom (ID-2), which had begun a year previous to hospital admission and had exacerbated after a traction injury that was incurred whilst lifting a heavy item 6 months previous to the admission. All the patients were symptomatic for pain, and the average PVAS was 7.1 (range, 5–9). Preoperatively, the average ROMs of the patients was 152° for anterior flexion (140°–160°), 50° for external rotation (range, 20°–70°), and T10 for internal rotation at the back (T6–T12). We found that tenderness was presented in 3 patients around the greater tuberosity but in none around the posterior joint. Four patients had preoperative calcific tendinitis for which 3 had received the following regimens of conservative management within a year before being admitted to our hospital for surgical treatment: fluoroscopy-guided aspiration and two steroid injections, 9 months preoperatively (ID-

Table 1. Patient Demographic Data

Patient ID	Sex	Age (yr)	Dominant hand	Sx onset	Calcification	Previous treatment	Trauma history	F/U duration (mo)	Preop-ROM (FF-ER-IRaB)	Pain VAS
1	F	70	Y	3 YA	N	N	N	8	140-40-T12	7
2	F	59	Y	1 YA	Y	N	Y*	7	160-70-T8	7
3	F	54	N	10 MA	Y	Aspiration 1 Injection 2†	N	43	150-50-T6	6.5
4	M	54	Y	2 YA	N	N	N	13	150-20-T12	5
5	F	62	N	10 YA	Y	ESWT 3 Injection 3†	N	6	160-70-T9	8
6	F	53	Y	2 YA	Y	ESWT 3	N	6	150-70-12	9

Sx: symptoms, F/U: follow-up, Preop-ROM: preoperative range of motion, FF: forward flexion, ER: external rotation, IRaB: internal rotation at back, VAS: visual analogue scale, F: female, M: male, Y: yes, N: no, YA: years ago, MA: months ago, ESWT: extracorporeal shockwave therapy.
*Traction injury. †Steroid injection on the shoulder joint.

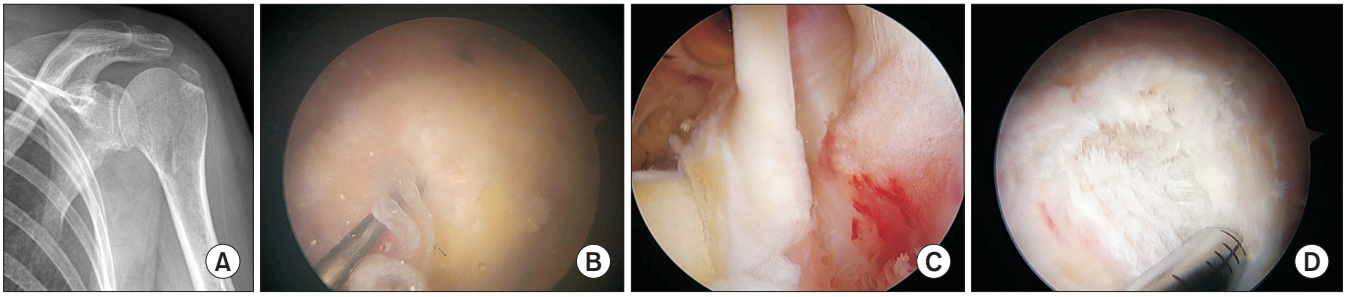

Fig. 2. (A) Preoperative anteroposterior radiograph of a 62-year-old female patient (ID-5) suggests calcification on the greater tuberosity of the left humerus. Arthroscopic view from the posterior portal shows calcification of the infraspinatus over the greater tuberosity (B), and a 'cherry spot' lesion (C). (D) Poor tissue quality of the infraspinatus tendon may have resulted from having received three times of extracorporeal shockwave therapy and injections.

3); 3 sessions of extracorporeal shockwave therapy (ESWT) with parallel steroid injections, 2 months preoperatively (ID-5) (Fig. 2); and 3 sessions of ESWT alone, 3 months preoperatively (ID-6) (Table 1).

Using preoperative isokinetic muscle performance tests, we found that in relation to the contralateral arm the affected arms of the patients showed an average 52.7% of abduction (range, 35.7%–100%) and an average 37.6% of external rotation (range, 3.2%–100%). We did not observe a Hornblower sign or an external lag sign in any of the patients but observed positive findings for the Jobe's impingement test in 5 patients. Although no abnormal findings were found after physical examination, our findings suggested the presence of fatty degeneration with a severity corresponding to a Goutallier grade 4 lesion in the infraspinatus muscle of one patient. We carried out an EMG in this patient but found that she had normal EMG findings (Fig. 3A). None of the preoperative x-rays among our patients were suggestive of glenohumeral arthritis or a reduced acromio-humeral distance. Putative entities of mass, especially those denoting cysts in suprascapular notches, were not found on any of the preoperative MRIs. We used the Goutallier grading system to classify fatty degeneration in the infraspinatus muscle on the basis of sagittal MRI images. Our patients were classified into the following Goutallier grades: two grade 1, two grade 2, one grade 4, and one grade 0. Preoperatively, we diagnosed the following supraspinatus lesions through MRI and arthroscopy: three cases of tendinitis; chronic interstitial delamination (CID); and 20% and 30% low grade partial tears. For partial tears, we carried out debridement. The average PVAS at the 6-month follow-up was 1.6 (range, 0–5), and the average ROM was 142° for anterior flexion (range, 110°–170°), 53° for external rotation (range, 30°–70°), and T11 for internal rotation at back (range, T9–L5) (Table 2). We found that the Constant score improved from a preoperative average of 67.8 (range, 45–77) to a postoperative average of 89.3 (range, 81–100) by the 6-month follow-up (p=0.029). And the ASES score improved from a preoperative average of 52.3 (range, 30–77) to postoperative average of 90.0 (range, 80–100) (p=0.002) (Table 3). None of the postoperative follow-up ultra-

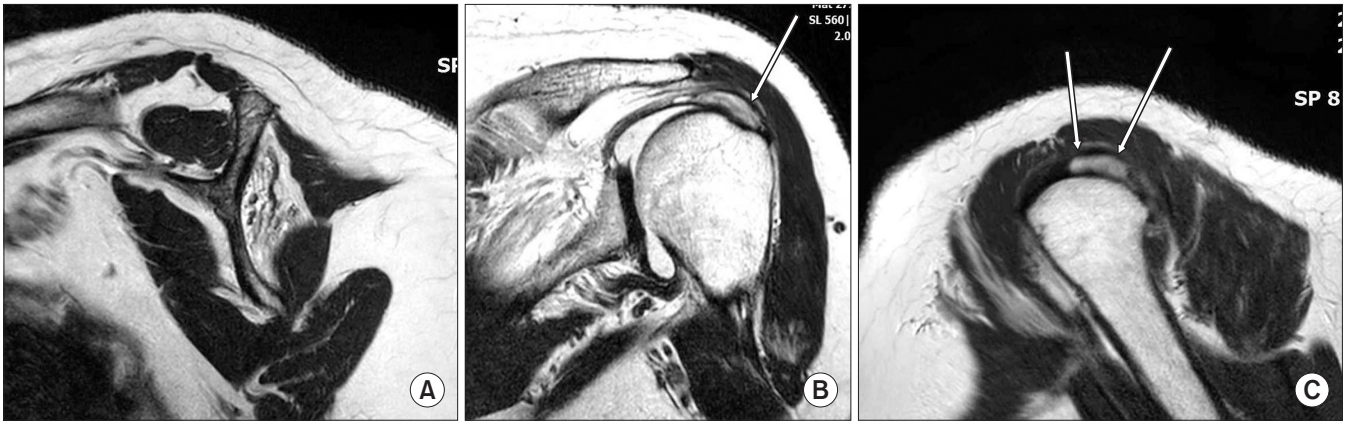

Fig. 3. (A) Signs of severe, isolated fatty degeneration of Goutallier stage 4 severity on the infraspinatus muscle a 59-year-old female patient (ID-2). (B, C) Arrows show isolated infraspinatus tear. An electromyography was performed to rule out possibilities of nerve injury no definitive findings for neurologic lesions were found. We found no evidence for cysts or masses, especially around the suprascapular notch and the spinoglenoid notch.

Table 2. Patient's Clinical Feature and Outcomes

Patient ID	IMPT (AB-ER-IR)*	IST tear size (Ret×AP cm)	SST	Goutallier stage (SST-IST-Tm-SSc)	Postop-ROM (FF-ER-IRaB)	Postoperative pain VAS	Retear
1	43.4-3.2-44.3	2.0×0.8	aPT	2-1-1-2	135-65-L5	5	N
2	47.0-64.7-4.2	1.5×1.5	IDN	1-4-0-1	135-45-L1	5	N
3	100-100-100	1.0×1.0	bPT	1-2-0-1	110-30-T11	1	N
4	41.0-32.5-5.7	0.7×0.8	TP	1-1-0-0	170-70-T10	0	N
5	44.8-4.3-19.3	1.3×1.0	TP	1-2-0-1	150-70-T9	2	N
6	39.7-20.7-36.2	1.5×0.8	TP	0-0-0-0	150-60-T9	1	N

IMPT: isokinetic muscle performance test, AB: abduction, ER: external rotation, IR: internal rotation, IST: infraspinatus, Ret: retraction, AP: anterior to posterior, SST: supraspinatus, Tm: teres minor, SSc: subscapularis, Postop-ROM: postoperative (3 months) range of motion, FF: forward flexion, IRaB: internal rotation at back, VAS: visual analogue scale, aPT: articular side partial tear, IDN: interstitial delamination, bPT: bursal side partial tear, TP: tendinopathy, N: no.
*Deficit (%) of muscle power compared with contralateral shoulder.

Table 3. Patient's Functional Outcomes

Patient ID	Constant score		ASES score	
	Preoperative	Postoperative*	Preoperative	Postoperative*
1	70	90	47	80
2	73	82	30	92
3	45	100	50	100
4	77	88	75	100
5	70	81	35	80
6	72	95	77	88
Mean	67.8	89.3	52.3	90.0
p-value	0.029		0.002	

ASES: American Shoulder and Elbow Surgeons.
*6 month later.

sound, computed tomography, or MRI findings showed signs of retears.

Discussion

In this study, we investigated the clinical characteristics of isolated infraspinatus tears and the clinical outcomes after its arthroscopic repair. As isolated infraspinatus tears are a relatively rare condition, they have not been reported in the literature often. The limited number of previous studies that have investigated isolated infraspinatus injuries have shown that they are in general caused by nerve injury such as denervation. Unlike previous studies, we investigated isolated infraspinatus tears that are independent of any nerve injuries.

The exact causes of isolated infraspinatus tears or of infraspinatus muscle atrophy have not yet been determined. Infraspinatus tears have been shown to generally occur in combination with tears of the supraspinatus muscles. Furthermore, the extent of the infraspinatus tear has been shown to be closely associated with that of the supraspinatus tear.[15,16] Although none of our sample of patients had concomitant all-thickness tears of the supraspinatus, the following comobidities were observed: 3 cases of calcific tendinitis, a case of CID, a case of articular partial tear, and a case of bursal side partial tear. According to a recent anatomical study, the insertion of supraspinatus tendon into the greater tuberosity was found to be much smaller than that of the infraspinatus muscle than previously thought. So it is plausible that previously diagnosed isolated supraspinatus tears may have inadvertently included tears of the infraspinatus muscle[6] meaning that many isolated infraspinatus tears may have been misdiagnosed as a supraspinatus tear or as a combined tear. In this study, we diagnosed infraspinatus tears as a case of isolated tears only when they could be traced from the belly of the infraspinatus muscle through MRI and from the scapular spine arthroscopically in a way that is clearly distinct from the supraspinatus. In other words, we enrolled patients with all-thickness tears that were at least 2.0–2.5 cm away from the biceps. We took these precautions to avoid overlooking infraspinatus tears with vague insertion anatomy that is difficult to differentiate from supraspinatus tendon insertions.

Causes of isolated infraspinatus injuries reported in the literature include secondary changes brought about by suprascapular nerve palsy, which is induced when the suprascapular notch or the spinoglenoid notch impinge on the nerve.[17-19] The incidence of infraspinatus tears that is secondary to nerve injury has been shown to be especially high among athletes involved in overhead activities such as volleyball or baseball.[20,21] Because atrophy of the muscles can be induced by tears or by nerve injuries, the two etiologies require differentiation to avoid misdiagnosing or neglecting the conditions. We assessed the patients' preoperative MRIs and found that no masses suggestive of impingement around the suprascapular nerve were found. Neither did we find any neurological symptoms upon physical examination and consultation nor abnormal EMG findings in the one patient who received an additional EMG test. Thus, we excluded the possibility of an etiology relating to nerve injury in any of the patients.

Interestingly, we found a relatively high incidence of calcific tendinitis among our patients with isolated infraspinatus injuries. Our findings are similar to those reported by Lunn et al.[14] showing that around 68.4% of patients with isolated infraspinatus injuries (13/19) have calcific tendinitis; this is comparable to the respective value observed in our study (66.7%). These findings imply a putative role for calcific tendinitis in isolated injuries of the infraspinatus muscle. Regarding this subject, Lunn et al.[14] suggested that the injuries may be attributed to the post insult therapies for calcific tendinitis such as steroid injections and needling rather than the pathophysiology of calcific tendinitis per se. In line with their suggestions, we saw that 3 of the 4 patients who had calcific tendinitis had had needling, aspiration, ESWT, steroid injections, and etc. previous to arthroscopic repair of the infraspinatus tears. Although more conclusive evidence is required to support this hypothesis, we suggest that these factors may contribute to the pathogenesis of isolated infraspinatus tears. Our arthroscopic findings also revealed poor quality of the tendon tissues in these patients (Fig. 2D).

We did not observe an association between infraspinatus tears and calcific tendinitis or history of trauma. We enrolled patients with all-thickness tears of the infraspinatus, of which there were 5 interstitial delamination tears and one tear that was relatively small in size; began principally from the articular side; and had a moderate retraction.

Atrophy and fatty degeneration of the rotator cuff are regarded as critical prognostic factors after cuff repairs.[22-25] But these findings are usually based on studies that have investigated supraspinatus muscles and not infraspinatus muscles. In this

study, we found that our patients had more severe fatty degeneration in the infraspinatus muscle than in the supraspinatus muscle, measured in terms of Goutallier grading (1.7 vs. 1.0). In a recent study by Seo et al.[26] that analyzed as two sections the fatty degeneration in the infraspinatus of 152 patients with cuff tears (the superior region and the inferior region), they found that fatty degeneration in the superior infraspinatus muscle was significantly associated suboptimal abduction strength and fatty degeneration in the lower infraspinatus muscle was significantly associated with external rotation and abduction. Further, previous reports have shown that infraspinatus tears induce acute and severe atrophy of the infraspinatus muscle, during which edema and acute fatty infiltration often occur.[14,27]

In Lunn et al.'s study,[14] they found that the lesions of 5 patients (among 19 patients with isolated infraspinatus tears) who received a cuff repair had progressed to severe fatty infiltration postoperatively, instead of showing a functional improvement. Since then, Lunn et al.[14] preferentially chose to perform conservative management over surgical treatment in subsequent patients. Yet conservative management is far from the ideal treatment modality because Lunn et al.[14] found that chronic weakness during external rotation and recalcitrant pain and discomfiture were still evident in these patients despite conservative management. In another study that investigated the infraspinatus muscle in overhead athletes, they found a prevalence of 30% of infraspinatus muscle atrophy; the clinical outcomes regarding the surgical treatment of these 9 athletes remains to be seen.[21] In this study we carried out surgical treatment on all six symptomatic patients presenting with pain and functional defect and found that in all patients pain resolved and functional outcomes improved postoperatively.

Although our study deserves merit in that it has investigated the relatively rare isolated infraspinatus injuries, it comes with limitations. Because the follow-up period was generally very short, only a few patients were evaluated through to the one-year follow-up, meaning that changes in fatty degeneration cannot be assessed meaningfully on the basis of our findings alone. Further, the restricted amount of studies on this rare lesion does not lend to a systematic or an objective study on the clinical characteristics or on the pathogenesis of isolated infraspinatus tears. These limitations may be overcome by subsequent studies that include a greater number of cases and have longer follow-up periods.

Conclusion

On the basis of medical history and of findings of our examination, we analyzed the clinical outcomes and the clinical characteristics of patients with the rare isolated infraspinatus tears. Interestingly, we observed a tendency for isolated infraspinatus tears to occur in combination with calcific tendinitis, although further studies are required to delineate the etiological role, if any, of calcific tendinitis in infraspinatus tears. We suggest that the diagnosis of isolated infraspinatus tears requires ruling out a background of neurological etiology during diagnostic x-ray and MRI and carrying out an EMG, if necessary. We also found that the arthroscopic repair of the infraspinatus tears was associated with comparatively favorable clinical outcomes.

References

1. Colachis SC Jr, Strohm BR, Brechner VL. Effects of axillary nerve block on muscle force in the upper extremity. Arch Phys Med Rehabil. 1969;50(11):647-54.
2. Colachis SC Jr, Strohm BR. Effect of suprascauular and axillary nerve blocks on muscle force in upper extremity. Arch Phys Med Rehabil. 1971;52(1):22-9.
3. Inman VT, Saunders JB, Abbott LC. Observations of the function of the shoulder joint. 1944. Clin Orthop Relat Res. 1996;(330):3-12.
4. Gartsman GM, Khan M, Hammerman SM. Arthroscopic repair of full-thickness tears of the rotator cuff. J Bone Joint Surg Am. 1998;80(6):832-40.
5. Mochizuki T, Sugaya H, Uomizu M, et al. Humeral insertion of the supraspinatus and infraspinatus. New anatomical findings regarding the footprint of the rotator cuff. J Bone Joint Surg Am. 2008;90(5):962-9.
6. Mochizuki T, Sugaya H, Uomizu M, et al. Humeral insertion of the supraspinatus and infraspinatus. New anatomical findings regarding the footprint of the rotator cuff. Surgical technique. J Bone Joint Surg Am. 2009;91 Suppl 2 Pt 1:1-7.
7. Kato A, Nimura A, Yamaguchi K, Mochizuki T, Sugaya H, Akita K. An anatomical study of the transverse part of the infraspinatus muscle that is closely related with the supraspinatus muscle. Surg Radiol Anat. 2012;34(3):257-65.
8. Matsuki K, Sugaya H, Watanabe A, et al. Infraspinatus muscle atrophy as a function of the sagittal extent of rotator cuff tears. Orthopedics. 2010;33(5). doi: 10.3928/01477447-20100329-08.
9. Bredella MA, Tirman PF, Fritz RC, Wischer TK, Stork A, Genant HK. Denervation syndromes of the shoulder girdle: MR imaging with electrophysiologic correlation. Skeletal Radiol. 1999;28(10):567-72.
10. Helms CA, Martinez S, Speer KP. Acute brachial neuritis (Parsonage-Turner syndrome): MR imaging appearance: report of three cases. Radiology. 1998;207(1):255-9.
11. Ludig T, Walter F, Chapuis D, Molé D, Roland J, Blum A. MR imaging evaluation of suprascapular nerve entrapment. Eur Radiol. 2001;11(11):2161-9.
12. Carroll KW, Helms CA, Otte MT, Moellken SM, Fritz R. Enlarged spinoglenoid notch veins causing suprascapular nerve compression. Skeletal Radiol. 2003;32(2):72-7.

13. Fritz RC, Helms CA, Steinbach LS, Genant HK. Suprascapular nerve entrapment: evaluation with MR imaging. Radiology. 1992;182(2):437-44.
14. Lunn JV, Castellanos-Rosas J, Tavernier T, Barthélémy R, Walch G. A novel lesion of the infraspinatus characterized by musculotendinous disruption, edema, and late fatty infiltration. J Shoulder Elbow Surg. 2008;17(4):546-53.
15. Cheung S, Dillon E, Tham SC, et al. The presence of fatty infiltration in the infraspinatus: its relation with the condition of the supraspinatus tendon. Arthroscopy. 2011;27(4):463-70.
16. Yao L, Mehta U. Infraspinatus muscle atrophy: implications? Radiology. 2003;226(1):161-4.
17. Boykin RE, Friedman DJ, Higgins LD, Warner JJ. Suprascapular neuropathy. J Bone Joint Surg Am. 2010;92(13):2348-64.
18. Kim SH, Koh YG, Sung CH, Moon HK, Park YS. Iatrogenic suprascapular nerve injury after repair of type II SLAP lesion. Arthroscopy. 2010;26(7):1005-8.
19. Sergides NN, Nikolopoulos DD, Boukoros E, Papagiannopoulos G. Arthroscopic decompression of an entrapped suprascapular nerve due to an ossified superior transverse scapular ligament: a case report. Cases J. 2009;2:8200.
20. Cummins CA, Messer TM, Schafer MF. Infraspinatus muscle atrophy in professional baseball players. Am J Sports Med. 2004;32(1):116-20.
21. Lajtai G, Pfirrmann CW, Aitzetmüller G, Pirkl C, Gerber C, Jost B. The shoulders of professional beach volleyball players: high prevalence of infraspinatus muscle atrophy. Am J Sports Med. 2009;37(7):1375-83.
22. Mellado JM, Calmet J, Olona M, et al. Surgically repaired massive rotator cuff tears: MRI of tendon integrity, muscle fatty degeneration, and muscle atrophy correlated with intraoperative and clinical findings. AJR Am J Roentgenol. 2005;184(5):1456-63.
23. Liem D, Lichtenberg S, Magosch P, Habermeyer P. Magnetic resonance imaging of arthroscopic supraspinatus tendon repair. J Bone Joint Surg Am. 2007;89(8):1770-6.
24. Sugihara T, Nakagawa T, Tsuchiya M, Ishizuki M. Prediction of primary reparability of massive tears of the rotator cuff on preoperative magnetic resonance imaging. J Shoulder Elbow Surg. 2003;12(3):222-5.
25. Gladstone JN, Bishop JY, Lo IK, Flatow EL. Fatty infiltration and atrophy of the rotator cuff do not improve after rotator cuff repair and correlate with poor functional outcome. Am J Sports Med. 2007;35(5):719-28.
26. Seo JB, Yoo JS, Jang HS, Kim JS. Correlation of clinical symptoms and function with fatty degeneration of infraspinatus in rotator cuff tear. Knee Surg Sports Traumatol Arthrosc. 2015;23(5):1481-8.
27. Walch G, Nové-Josserand L, Liotard JP, Noël E. Musculotendinous infraspinatus ruptures: an overview. Orthop Traumatol Surg Res. 2009;95(7):463-70.