High-Grade Articular, Bursal, and Intratendinous Partial-Thickness Rotator Cuff Tears: A Retrospective Study Comparing Functional Outcomes After Completion and Repair

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Abstract

We conducted a study to assess the impact of tear location on functional outcomes in high-grade partial-thickness rotator cuff tears (PTRCTs) after arthroscopic completion and repair.

Retrospectively, we evaluated the preoperative and postoperative findings of 60 patients who underwent arthroscopic completion and repair of Ellman grade 3 partial-thickness tears of the supraspinatus. The 60 patients were grouped by tear subtype (20 articular, 20 bursal, 20 intratendinous) as identified by preoperative imaging and confirmed at time of surgery.

After surgery, the 3 subtypes showed similar significant ($P < .001$) improvements in American Shoulder and Elbow Surgeons scores (articular, 46.9, 85.1; bursal, 44.3, 80.3; intratendinous, 43.6, 86.1), Constant scores (articular, 54.3, 79.4; bursal, 49.9, 75.0; intratendinous, 56.8, 80.9), and visual analog scale scores (articular, 5.1, 1.2; bursal, 5.8, 1.6; intratendinous, 6.0, 1.2).

Our study findings validate use of the current algorithm for Ellman grade 3 PTRCTs of the supraspinatus and advocate their completion and repair, regardless of tear location.

The Ellman[1] classification of partial-thickness rotator cuff tears (PTRCTs) is based on tear location or subtype (A, articular; B, bursal; C, intratendinous) and tear depth (grade 1, <3 mm; grade 2, 3-6 mm; grade 3, >6 mm). Ruotolo and colleagues[2] reported that the medial-lateral insertion width of the supraspinatus averaged 12.1 mm, and most authors have indicated that tear depth of 6 mm or more represents 50% tendon thickness. Therefore, Ellman grade 3 tears are considered high-grade (>50% thickness).

Advancements in shoulder arthroscopy, imaging modalities, and clinical research have helped refine our understanding of PTRCTs. Classic teaching based on the retrospective study by Weber[3] calls for simple débridement of low-grade (<50%) tears and repair of tears thicker than 50%. According to this standard, Ellman grade 1 and 2 tears should be débrided and grade 3 tears repaired. However, Cordasco and colleagues[4] provided evidence supporting an algorithm reformation based on tear location. In their study, results of simple débridement were significantly worse for Ellman grade 2B PTRCTs than for 2A tears, suggesting low-grade bursal tears should also be repaired. Although their study supported a change in operative management for grade 2 tears, to our knowledge no one has investigated the need for differing surgical treatments for grade 3 subtypes based on tear location.

Several studies have demonstrated the efficacy of arthroscopic completion and repair for high-grade PTRCTs of the supraspinatus.[5-7] Although all these studies addressed articular- and bursal-sided tears, there has been relative silence with respect

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to the intratendinous subtype. One explanation is that these tears, given their interstitial nature, pose diagnostic challenges. Histologic research has also shown that they can exist in combination with other tears.[8] Despite such challenges, these tears are well documented. They were identified in the seminal study by Ellman[1] and were the most common PTRCTs encountered in a well-known cadaveric study (N = 249).[9,10] More recently, in 2011, a radiologic study using magnetic resonance arthrography found that 33.8% of PTRCTs were intratendinous (N = 68).[11] That study also documented the case of a nonoperatively treated intratendinous tear that progressed to a full-thickness tear within about 6 months.[11] Given these facts, it was important for the current PTRCT debate to include an intratendinous group when investigating treatment algorithms for grade 3 tears. Although results of the present study may continue reformation of the 50% algorithm, we hypothesized that arthroscopic completion and repair of all grade 3 PTRCTs will be equally effective, regardless of tear location.

Materials and Methods

After obtaining Institutional Review Board approval for this study, we retrospectively reviewed the operative reports of a fellowship-trained shoulder surgeon for the period 2008–2010. Patients who underwent arthroscopic completion and repair of a supraspinatus tendon PTRCT were identified. Preoperative identification of PTRCT was made on the basis of physical examination and magnetic resonance imaging (MRI) findings (**Figures 1–3**). For inclusion, MRI findings were compared with intraoperative findings to confirm tear location. For intratendinous tears, MRI typically displays signal changes within the tendon without extension to the articular or bursal surfaces. These scans were then used to help locate the intratendinous tear during surgery. Nakagawa and colleagues[12] reported a similar approach. Patients with concomitant shoulder procedures (eg, superior labral débridement, subacromial decompression) were included. Surgery was indicated in cases of failed nonoperative management consisting of physical therapy (PT), use of oral nonsteroidal anti-inflammatory drugs, and, in some cases, local steroid injection. PT consisted of a 6- or 8-week formal program that included strengthening and stretching exercises and home exercise instruction. Local steroid injection consisted of 3 cc of lidocaine 1% without epinephrine and 1 to 4 mg of dexamethasone administered to the subacromial space.

Patients with low-grade PTRCTs of the supraspinatus, identified at time of arthroscopy, were excluded, as were patients with tears that extended into other rotator cuff tendons and patients with previous rotator cuff repair, glenohumeral instability, or adhesive capsulitis.

During the initial appointment, each patient completed a standard questionnaire that included standardized subjective scales evaluating pain and function. A fellowship-trained surgeon then took the patient's history and performed a physical examination. Postoperative clinical outcome was determined at a minimum of 12 months. Clinical outcomes were assessed with 3 validated outcome measures: visual analog scale (VAS) score,

Figure 1. Coronal magnetic resonance imaging of grade 3 articular-sided partial-thickness rotator cuff tear.

Figure 2. Coronal magnetic resonance imaging of grade 3 bursal-sided partial-thickness rotator cuff tear.

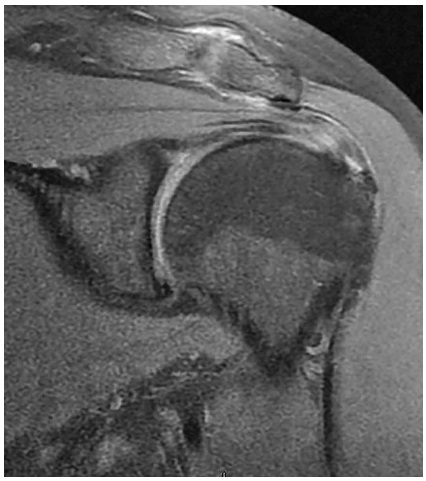

Figure 3. Coronal magnetic resonance imaging of grade 3 intratendinous partial-thickness rotator cuff tear.

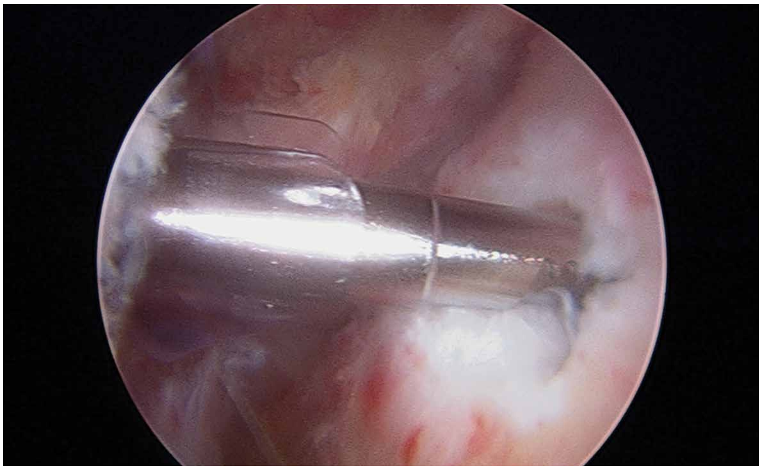

Figure 4. Arthroscopic shaver is used to débride bursal fibers until it falls into intratendinous tear.

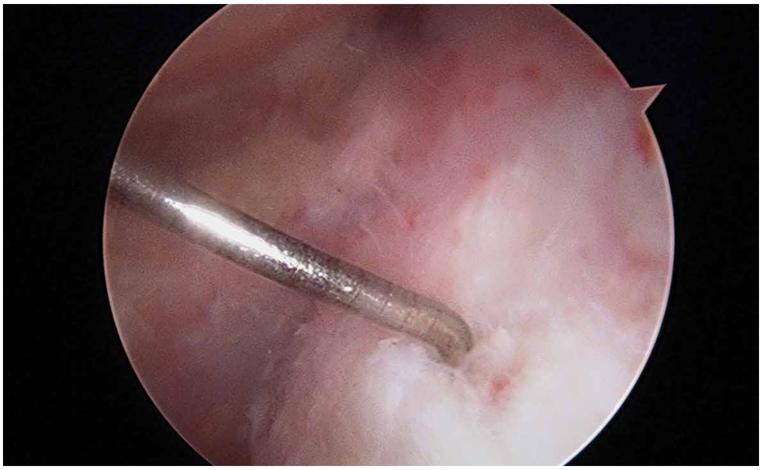

Figure 5. Three-mm bent arm of arthroscopic probe is inserted into intratendinous partial-thickness rotator cuff tear to assess tear depth.

American Shoulder and Elbow Surgeons (ASES) score, and Constant score.

Surgical Procedure and Rehabilitation

All procedures were performed with the patient under general anesthesia with or without an interscalene block. The patient was positioned in the upright beach-chair position. Diagnostic arthroscopy was used to assess the rotator cuff and associated pathologic conditions. If impingement was noted, subacromial decompression was performed. An acromioplasty was limited to removal of osteophytic bone. Distal clavicle excision and biceps tenotomy or tenodesis were performed if preoperative evaluation warranted these procedures.

The rotator cuff was assessed from the articular and bursal sides. For articular PTRCTs, a tagging suture was used to identify the lesion from the bursal side. Bursal-sided tears were probed to assess thinning of the tendon and determine tear grade. If preoperative MRI findings suggested an intratendinous tear, a probe was used to confirm thinning of the tendon. An arthroscopic shaver was then carefully used to débride the capsule on either side of the tendon at the location of the suspected tear. The shaver inevitably penetrated the capsule and entered the tear, where any degenerative tissue was further débrided (**Figure 4**). Tear depth and percentage for all tear locations were determined with the aid of a calibrated arthroscopic probe with a 3-mm bent arm after débridement of degenerative tissue was complete (**Figure 5**). Removal of frayed tendon before depth determination is a method recommended in the literature.[2] The operative indication for completion and repair was a tear exceeding 50% tendon thickness, satisfying Ellman's grade 3 criteria. All PTRCTs in this study were then converted to full-thickness tears.

After the PTRCT was completed to full thickness, the rotator cuff footprint on the greater tuberosity was débrided to bleeding cortical bone. Depending on tear length, 1 or 2 Bio-Corkscrew absorbable suture anchors (Arthrex) with 2 No. 2 FiberWire sutures (Arthrex) were then placed in the tuberosity 3 to 5 mm lateral to the articular margin. An arthroscopic suture passer was used to move the 2 sutures through the rotator cuff, such that one was placed in the horizontal mattress and the other was placed in a simple fashion deep to the horizontal mattress. The sutures were then tied with a modified Roeder knot.

A standardized postoperative protocol was used for all patients starting within the first week after surgery. Passive range of motion (ROM) was performed for the first 6 weeks after surgery and was advanced to include active ROM from 6 to 8 weeks after surgery. Strengthening was initiated 8 weeks after surgery.

Statistical Analysis

Power analysis demonstrated that a sample size of 20 in each group was adequate for detecting a medium to large effect size with 80% power. Wilcoxon signed rank test was used to compare the preoperative and postoperative scores for each outcome measure, and analysis of variance (ANOVA) was used to compare the amount of improvement for each of the 3 PTRCT subtypes. Paired *t* test was used to compare preoperative and postoperative ROM values, and unpaired *t* tests were used to determine the impact of corticosteroid injections and preoperative PT. For statistical analysis, patients were divided into 2 groups (yes, no) regarding injections and 2 groups (yes, no) regarding PT. Last, multiple linear regression analyses were performed for each outcome measure to determine the impact of potential confounders. Covariates included symptom duration, etiology, age, injection, PT, tear location, percentage of tendon torn (medial-lateral), and tear length (anterior-posterior). $P < .05$ was considered significant.

Results

Patient Sample and Demographics

Sixty-seven patients underwent arthroscopic repair of a PTRCT—22 grade 3A, 23 grade 3B, and 22 grade 3C. In each of the 3 groups, 20 patients returned for end-of-healing evaluation. Thus, the study population consisted of 60 patients (60 shoulders). The 7 patients who did not return for end-of-healing evaluation or who could not be contacted were excluded from the study.

Table 1 summarizes the key patient demographics. Of the 60 patients, 35 were men and 25 were women. Mean age at time of surgery was 47.43 years (range, 29-66 years). There were no throwing athletes in the study population. The dominant shoulder was involved in 32 (53%) of the 60 cases. Mean (SD) time from symptom onset to surgery was 14.23 (10.08) months. There was little variance among the articular, bursal, and intratendinous means with respect to age (50.4, 45.15, and 46.75 years, respectively) and time from symptom onset to surgery (13.4, 13.55, and 15.75 months, respectively). Mechanism of injury was traumatic (eg, motor vehicle crash, pulling, pushing, fall) in 32 cases and insidious in 28 cases. Forty patients (66.67%) had received at least 1 injection before surgery; mean time from injection to surgery was 4.36 months. Of the 46 patients (76.67%) who underwent a preoperative PT regimen, 32 (69.57%) completed 6 to 8 weeks of PT, and the other 14 completed either a 4-week program or a program lasting longer than 8 weeks. Mean time from completion of PT to surgery was 4.16 months.

Range of Motion

The sample as a whole exhibited statistically significant improvement in active ROM (**Table 2**). Mean forward flexion improved from 138° to 157° ($P < .0001$), mean external rotation improved from 67° to 71° ($P = .0119$), mean abduction improved from 135° to 157° ($P < .0001$), and mean internal rotation improved from the 12th to the 7th thoracic vertebra ($P < .0003$). There was significant improvement in all planes of motion in each tear location group, exception for the bursal and intratendinous groups in external rotation, which exhibited mean increases of only 3.5° ($P = .3142$) and 1° ($P = .6347$), respectively.

Operative Findings

Operative findings included mean tear thickness of 74% for the sample as a whole and mean anterior-to-posterior tear length of 10.7 mm overall. There was very little variance among the articular, bursal, and intratendinous means with respect to percentage of tear thickness (78.3%, 75.0%, and 68.8%, respectively) and anterior-to-posterior tear thickness (11.5 mm, 11.4 mm, and 9.1 mm, respectively). Each of the 6 tears (3 bursal, 2 articular, 1 intratendinous) that were longer than 15 mm required 2 anchors. Fifty-nine repairs (98%) involved subacromial decompression, 38 (63%) involved acromioclavicular resection, 18 (30%) involved débridement of the superior labrum

Table 1. **Patient Demographics**[a]

	Age, y		Sex		Hand Dominance		Operative Side		Etiology		Time from Onset to Surgery, mo			
Group	**Mean**	**SD**	**F**	**M**	**R**	**L**	**R**	**L**	**Traumatic**	**Insidious**	**Mean**	**SD**	**Local Steroid Injection**	**Physical Therapy**
Articular	50.4	10.78	9	11	19	1	12	8	9	11	13.4	10.93	12	12
Bursal	45.15	7.17	10	10	16	4	10	10	12	8	13.55	8.79	13	16
Intratendinous	46.75	8.71	6	14	19	1	10	10	11	9	15.75	10.74	15	18
All	47.43	8.12	25	35	54	6	32	28	32	28	14.23	10.08	40	46

[a]Except where noted otherwise, all data are numbers of patients.

anterior-to-posterior (SLAP), and 12 (20%) involved biceps tenodesis/tenotomy.

Outcome Measures

In the study population as a whole, and in all 3 tear subtypes, postoperative improvement in VAS, ASES, and Constant scores was statistically significant (**Table 3**). Postoperative VAS scores were improved by 3.9 points in the 3A group, by 4.2 points in the 3B group, and by 4.8 points in the 3C group. ASES scores were improved by 38.2 points in the 3A group, by 36.0 points in the 3B group, and by 42.5 points in the 3C group. Constant scores were improved by 25.1 points in the 3A group, by 25.1 points in the 3B group, and by 24.1 points in the 3C group. ANOVA revealed no significant difference in preoperative-to-postoperative improvement among the 3 PTRCT subtypes (VAS scores, *P* = .5258; ASES scores, *P* = .4950; Constant scores, *P* = .9524).

Multiple linear regression analyses showed that etiology, symptom duration, and steroid injection were the primary predictors of each outcome. After the other variables were adjusted for, injection (vs noninjection) seemed to be associated with more improvement in ASES (*P* = .0061), VAS (*P* = .020), and Constant (*P* = .067) scores. Insidious (vs traumatic) etiology was significantly associated with more improvement in ASES scores (*P* = .033) and VAS scores (*P* = .014) but not Constant scores (*P* = .50). Longer time from symptom onset to surgery was associated with less improvement, though the coefficient was not statistically significant in any of the models at *P* = .05. The other possible covariates had no significant impact on outcomes.

Complications

There were no intraoperative or postoperative complications, and there were no incidents of recurrent rotator cuff tear or postoperative stiffness.

Discussion

We investigated the effectiveness of arthroscopic completion and repair of Ellman grade 3 PTRCTs by comparing the functional outcomes for each

Table 2. **Range-of-Motion Improvements, Analyzed With Paired *t* Test**

	Range of Motion							
	Forward Flexion		External Rotation		Internal Rotation (Vertebral Levels)		Abduction	
Group	Mean	*P*	Mean	*P*	Mean	*P*	Mean	*P*
Articular	12.50°	.0266	10.75°	.0181	1.05	.0194	14.75°	.0196
Bursal	24.75°	.0027	3.5°	.3142	1.45	.0654	23.25°	.0080
Intratendinous	12°	.0017	1°	.6347	1.4	.0456	15.75°	.0004
All	16.42°	<.0001	5.08°	.0119	1.3	.0003	17.92°	<.0001

Table 3. **Preoperative and Postoperative Mean Outcome Scores, Tested With Wilcoxon Signed Rank Test**

		Visual Analog Scale			ASES			Constant Score		
Group	n	Preop	Postop	*P*	Preop	Postop	*P*	Preop	Postop	*P*
Articular	20	5.1	1.2	.00013	46.9	85.1	<.0001	54.3	79.4	<.0001
Bursal	20	5.8	1.6	.00019	44.3	80.3	.00011	49.9	75	<.0001
Intratendinous	20	6.0	1.2	.00014	43.6	86.1	<.0001	56.8	80.9	<.0001
All	60	5.6	1.3	<.0001	45.0	83.8	<.0001	53.7	78.4	<.0001

Abbreviation: ASES, American Shoulder and Elbow Surgeons.

subtype. Although several studies have analyzed results of PTRCT repair, they all either omitted intratendinous tears or were not grade-specific. In a systematic review, Strauss and colleagues[13] discussed 4 PTRCT outcome studies[4,6,14,15] in which only articular- and bursal-sided tears were addressed. Of these studies, only 1 (Kamath and colleagues[6]) focused on grade 3 lesions, and the number of bursal tears was insufficient for comparison with the articular tear group. Cordasco and colleagues[4] limited their study to grade 1 and 2 tears but did not include intratendinous lesions.

In other research, Itoi and Tabata[16] distinguished among the 3 subtypes but did not measure grade. As we did in our study, Deutsch[5] focused on grade 3 lesions and used the completion-and-repair method, but he did not include intratendinous tears. Porat and colleagues[17] reviewed grade 3 completion-and-repair results but did not compare them by subtype. Last, Uchiyama and colleagues[18] reported strong outcomes for intratendinous tears but did not measure grade and used various surgical methods.

These studies have made important contributions to the ongoing PTRCT discussion, but debate about appropriate operative management persists. To limit the influence of external variables and provide the most exhaustive evidence regarding current PTRCT treatment algorithms, we designed the present study to consider outcomes with all 3 Ellman subtypes, only grade 3 lesions of the supraspinatus, only 1 surgical method, and consistent techniques of only 1 fellowship-trained shoulder surgeon.

Results of this chart review confirmed the findings of other grade 3 PTRCT repair studies. For instance, Koh and colleagues[15] reported excellent results of 38 grade 3B PTRCTs completed to full thickness and repaired. Specifically, their mean ASES and Constant scores improved 34.1 and 23.7 points, respectively. These results are similar to our ASES and Constant score improvements—38.9 and 24.7 points for the group as a whole and 36 and 25.1 points for the grade 3B cohort. In addition, our ASES scores are nearly identical to the preoperative (46.1) and postoperative (82.1) ASES scores found by Kamath and colleagues.[6] Although the mean ASES and VAS score improvements reported by Deutsch[5] (51 and 5.7 points, respectively) were slightly better than ours, these results are still comparable and support completion and repair.

Although results of the study by Cordasco and colleagues[4] support differing surgical treatments of grade 2 tears based on location, the present findings support the established 50% algorithm for all 3 high-grade PTRCTs. The completion-and-repair method not only produced significant improvements for each PTRCT subtype, but, importantly, there was no significant difference among those outcomes. Unlike previous results for grade 2 tears, the present results confirmed the established algorithm for grade 3 tears.

Our multiple linear regression analyses suggested that etiology, longer duration of symptoms, and steroid injections each had a strong impact on outcomes. The literature on these preoperative factors is often conflicting, and our results continue the trend. For instance, in a study of acute rotator cuff tears, Petersen and Murphy[19] studied acute rotator cuff tears and also found tear size had no significant effect on functional outcomes. However, contrary to our findings, they did not find symptom duration to be a significant predictor of results. Also contrary to our findings, Oh and colleagues[20] found age and tear size to be significant influences on outcomes for full-thickness tears. The strong correlation of preoperative steroid injection and better outcomes is novel and warrants further investigation.

In this study, we investigated the effectiveness of the completion-and-repair method in treating Ellman grade 3 PTRCTs. Although our findings validate this surgical technique, we acknowledge alternative approaches to high-grade PTRCTs. For instance, the transtendon method, which does not convert PTRCTs to full thickness, has also shown good clinical outcomes.[21-23] In fact, the preoperative and postoperative VAS measures used in our study are nearly identical to those used in an Ellman grade 3A transtendon repair study.[1] However, we agree with Porat and colleagues[17] that the remaining, intact cuff material of PTRCTs is degenerative and may result in poor fixation, increased pain, or retear. In addition, nonoperative treatment typically is attempted before surgery, though little evidence is reported for success specifically in high-grade PTRCTs. One study found that 91% of PTRCT patients were still satisfied 4 years after nonoperative treatment, but it was noted that many of the tears were low-grade.[24] To continue an evidence-based discussion on the more effective treatment, we invite advocates of alternative approaches to conduct a similar study on all 3 Ellman grade 3 subtypes.

Study Limitations

Concomitant procedures were not uniform among all patients and therefore may have affected some outcome measurements. Subacromial decompression was nearly universal, as it was performed for surgical visualization in 98% of patients. The additional procedures were also deemed necessary based on the preoperative assessment and arthroscopic findings. Although these procedures may have influenced outcome measurements, similar studies regularly include them as well.[5-7,17] Our minimum 12-month follow-up could be considered a restriction, as other studies have cited a 2-year follow-up threshold.[5-7] However, Strauss and colleagues[13] endorsed a 12-month standard in their systematic review. Last, about 10% (7/67) of our initial patients were lost to follow-up; this percentage, however, is comparable to what has been reported in other PTRCT studies.[4-6,14,15,21,22]

Conclusion

Our study findings validate use of the current algorithm for Ellman grade 3 PTRCTs of the supraspinatus and advocate their completion and repair, regardless of tear location.

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References

1. Ellman H. Diagnosis and treatment of incomplete rotator cuff tears. *Clin Orthop Relat Res*. 1990;(254):64-74.
2. Ruotolo C, Fow JE, Nottage WM. The supraspinatus footprint: an anatomic study of the supraspinatus insertion. *Arthroscopy*. 2004;20(3):246-249.
3. Weber SC. Arthroscopic debridement and acromioplasty versus mini-open repair in the treatment of significant partial-thickness rotator cuff tears. *Arthroscopy*. 1999;15(2):126-131.
4. Cordasco FA, Backer M, Craig EV, Klein D, Warren RF. The partial-thickness rotator cuff tear: is acromioplasty without repair sufficient? *Am J Sports Med*. 2002;30(2):257-260.
5. Deutsch A. Arthroscopic repair of partial-thickness tears of the rotator cuff. *J Shoulder Elbow Surg*. 2007;16(2):193-201.
6. Kamath G, Galatz LM, Keener JD, Teefey S, Middleton W, Yamaguchi K. Tendon integrity and functional outcome after arthroscopic repair of high-grade partial-thickness supraspinatus tears. *J Bone Joint Surg Am*. 2009;91(5):1055-1062.
7. Park JY, Yoo MJ, Kim MH. Comparison of surgical outcome between bursal and articular partial thickness rotator cuff tears. *Orthopedics*. 2003;26(4):387-390.
8. Fukuda H, Hamada K, Nakajima T, Tomonaga A. Pathology and pathogenesis of the intratendinous tearing of the rotator cuff viewed from en bloc histologic sections. *Clin Orthop Relat Res*. 1994;(304):60-67.
9. Fukuda H, Mikasa M, Yamanaka K. Incomplete thickness rotator cuff tears diagnosed by subacromial bursography. *Clin Orthop Relat Res*. 1987;(223):51-58.
10. Yamanaka K, Fukuda H, Hamada K, Mikasa M. Incomplete thickness tears of the rotator cuff [abstract]. *Orthop Surg Traumatol (Toyko)*. 1983;26:713.
11. Schaeffeler C, Mueller D, Kirchhoff C, Wolf P, Rummeny EJ, Woertler K. Tears at the rotator cuff footprint: prevalence and imaging characteristics in 305 MR arthrograms of the shoulder. *Eur Radiol*. 2011;21(7):1477-1484.
12. Nakagawa S, Yoneda M, Mizuno N, Hayashida K, Mae T, Take Y. Throwing shoulder injury involving the anterior rotator cuff: concealed tears not as uncommon as previously thought. *Arthroscopy*. 2006;22(12):1298-1303.
13. Strauss EJ, Salata MJ, Kercher J, et al. Multimedia article. The arthroscopic management of partial-thickness rotator cuff tears: a systematic review of the literature. *Arthroscopy*. 2011;27(4):568-580.
14. Kartus J, Kartus C, Rostgard-Christensen L, Sernert N, Read J, Perko M. Long-term clinical and ultrasound evaluation after arthroscopic acromioplasty in patients with partial rotator cuff tears. *Arthroscopy*. 2006;22(1):44-49.
15. Koh KH, Shon MS, Lim TK, Yoo JC. Clinical and magnetic resonance imaging results of arthroscopic full-layer repair of bursal-side partial-thickness rotator cuff tears. *Am J Sports Med*. 2011;39(8):1660-1667.
16. Itoi E, Tabata S. Incomplete rotator cuff tears. Results of operative treatment. *Clin Orthop Relat Res*. 1992;(284):128-135.
17. 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(5):729-731.
18. Uchiyama Y, Hamada K, Khruekarnchana P, et al. Surgical treatment of confirmed intratendinous rotator cuff tears: retrospective analysis after an average of eight years of follow-up. *J Shoulder Elbow Surg*. 2010;19(6):837-846.
19. Petersen SA, Murphy TP. The timing of rotator cuff repair for the restoration of function. *J Shoulder Elbow Surg*. 2011;20(1):62-68.
20. Oh JH, Kim SH, Ji HM, Jo KH, Bin SW, Gong HS. Prognostic factors affecting anatomic outcome of rotator cuff repair and correlation with functional outcome. *Arthroscopy*. 2009;25(1):30-39.
21. Castagna A, Delle Rose G, Conti M, Snyder SJ, Borroni M, Garofalo R. Predictive factors of subtle residual shoulder symptoms after transtendinous arthroscopic cuff repair: a clinical study. *Am J Sports Med*. 2009;37(1):103-108.
22. Castricini R, Panfoli N, Nittoli R, Spurio S, Pirani O. Transtendon arthroscopic repair of partial-thickness, articular surface tears of the supraspinatus: results at 2 years. *Chir Organi Mov*. 2009;93(suppl 1):S49-S54.
23. Spencer EE Jr. Partial-thickness articular surface rotator cuff tears: an all-inside repair technique. *Clin Orthop Relat Res*. 2010;468(6):1514-1520.
24. Denkers M, Pletsch K, Boorman R, Hollinshead R, Lo IKY. Partial thickness rotator cuff tears: observe or operative. In: Proceedings of the American Academy of Orthopaedic Surgeons Annual Meeting; February 2012; San Francisco, CA.