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ARTHROSCOPY AND SPORTS MEDICINE

Functional outcomes and repair integrity after arthroscopic repair of partial articular supraspinatus tendon avulsion

Roberto Castricini[1] · Francesco La Camera[2] · Marco De Gori[3] · Nicola Orlando[1] · Massimo De Benedetto[1] · Olimpio Galasso[2] · Giorgio Gasparini[2]

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Abstract

Introduction Partial-thickness rotator cuff tears are a common cause of shoulder pain and disability. Arthroscopic repair is an effective treatment for partial articular supraspinatus tendon avulsion (PASTA) lesions, and transtendon repair and completion of the tear and repair are the surgical techniques commonly used to treat such lesions. Our aim was to retrospectively evaluate the minimum 24-month clinical and radiological results of PASTA.

Materials and methods Patients suffering from PASTA lesion who underwent arthroscopic repair with a minimum 24-month follow-up were included in this study. The Constant and Murley score (CMS) was used to assess the patients' functionality pre- and postoperatively. The postoperative patient assessment included the simple shoulder test (SST). Postoperative tendon integrity was evaluated by ultrasound examination.

Results 151 patients (153 shoulders) were retrospectively evaluated 73.9 (24–142) months after a completion–repair (94 cases) or transtendon repair (59 cases) of a PASTA lesion. The CMS significantly improved from 47.7 (22–63) preoperatively to 84.2 (62–100) postoperatively ($p < 0.001$). The mean postoperative SST score was 10.1 (5–12), and 95% of patients were satisfied with the surgery. No significant differences were noted between the two techniques in terms of postoperative CMS, SST score and satisfaction. Seventy-four and 43 cases treated with completion and repair and transtendon repair, respectively, performed ultrasound examination 66.1 (24–142) months after surgery. The overall retear rate was 13.7%, supraspinatus retears were observed in ten shoulder subjected to completion and repair (13.5%) and six shoulders subjected to transtendon repair (13.9%), and no significant differences were noted between the two techniques as for CMS ($p = 0.896$), SST ($p = 0.973$), satisfaction ($p = 0.621$) and retear ($p = 0.999$). Males and younger patients had a higher postoperative CMS (p values < 0.001), and SST score ($p < 0.001$ and $p = 0.038$, respectively).

Conclusions Arthroscopic repair of PASTA lesion achieves high rates of repair integrity regardless of repair type and high levels of functional recovery and patient satisfaction 6 years after surgery.

Keywords Partial-thickness rotator cuff tear · PASTA lesion · Transtendon repair · Completion and repair · Ultrasound

✉ Olimpio Galasso
galasso@unicz.it

Roberto Castricini
robertocastricini@gmail.com

Francesco La Camera
lacameradoc@gmail.com

Marco De Gori
madegori@hotmail.it

Nicola Orlando
orlandnic@gmail.com

Massimo De Benedetto
massimodebenedetto@gmail.com

Giorgio Gasparini
gasparini@unicz.it

[1] Department of Orthopaedic and Trauma Surgery, Villa Maria Cecilia Hospital, Cotignola, Italy

[2] Department of Orthopaedic and Trauma Surgery, "Magna Græcia" University, Mater Domini" University Hospital, V.le Europa, (loc. Germaneto), 88100 Catanzaro, Italy

[3] Department of Orthopaedic and Trauma Surgery Alessandria, SS. Antonio and Biagio and Cesare Arrigo" Hospital, Alessandria, Italy

Introduction

Partial-thickness rotator cuff tears are a common cause of shoulder pain and disability. First described by Codman in 1934 as "rim rents" [1], such lesions were subsequently classified by Ellman on the basis of the anatomical location (articular, bursal or intratendinous) and the size of the tear (i.e., grade 1, < 3 mm; grade 2, 3–6 mm; grade 3, > 6 mm) [2]. Although the actual incidence of partial tears is unknown, they seem to be more frequent than full-thickness tears. The supraspinatus is the most involved injured tendon, and articular-sided tears are more represented than bursal and intratendinous lesions [3]. In this regard, Snyder introduced the term PASTA (partial articular supraspinatus tendon avulsion) to better recognize this particular lesion [4]. Surgical treatment of PASTA lesions is usually indicated in cases of failure of non-operative treatment or involvement of at least 50% of the tendon thickness [3, 5, 6], to improve function, relieve pain, and prevent progression and enlargement of the tear.

Different surgical strategies have been described to treat PASTA lesions. While acromioplasty and rotator cuff debridement do not seem to be effective in preventing progression of the tear [7], arthroscopic surgical repair with either a transtendon technique [8] or repair after completion of the tear [9] has shown good to excellent results in terms of clinical outcome, repair integrity and patient satisfaction; however, debate still exists regarding the best technique for repairing the PASTA lesions [10]. To date, only two studies with very small sample sizes of 15 [11] and 20 [12] patients provide long-term results (i.e., 13.5 and 6 years, respectively) after arthroscopic transtendon repair of PASTA lesions.

The purpose of our study was to retrospectively evaluate the minimum 24-month clinical and radiological results of arthroscopic repair of PASTA lesions. Our hypotheses were that (1) significant clinical improvement may be achieved with surgery, as measured by the Constant and Murley score (CMS) [13], (2) demographic, clinical or radiological characteristics of patients may affect the clinical and radiological outcomes and (3) arthroscopic transtendon repair provides better functional outcomes and a lower retear rate compared to completion and repair.

Methods

Study group

The study protocol of this retrospective study was approved by the local ethical committee. Patients that underwent arthroscopic repair for PASTA lesions from January 2003 to December 2014 were included in the study. Informed consent was obtained from all individual participants included the study. The inclusion criteria were: (1) a symptomatic PASTA lesion documented by preoperative magnetic resonance imaging (MRI) and confirmed by arthroscopy as Ellman's grade 2 or 3; (2) failure of conservative treatment for at least 3 months, including one course of physical therapy for at least 4 weeks, and one course of non-steroidal anti-inflammatory drugs or analgesic administration [14]; (3) a minimum 24-month follow-up. The exclusion criteria were: (1) intra articular or subacromial steroid injection administration; (2) previous shoulder surgery; (3) concomitant glenohumeral or acromioclavicular osteoarthritis; (4) subscapularis tear; and (5) Bankart lesions. In the absence of an evidence-based selection, the choice between transtendon repair and completion and repair was performed based on the surgeon's preference.

Surgical procedures

All surgeries were performed by a single senior surgeon (RC). All patients received an interscalene block and were placed in the lateral decubitus position with the arm under longitudinal traction. A routine arthroscopic evaluation was performed through standard arthroscopic portals (anterior, lateral, and posterior). The PASTA lesion was identified and assessed with a marked probe. The partial tear was then debrided and repaired with either a conversion to a full-thickness tear or an in situ transtendon repair. One double-loaded or triple-loaded metallic suture anchor was used for the single-row repair of the tendon to bone (Fastin® or Healix® RC, DePuy Mitek, Raynham, MA, USA; TwinfixTi, Smith & Nephew, Andover, MA, USA); mattress suture configuration was used for both repair techniques.

Postoperative protocol

Postoperatively, the arm was placed in a 15° abduction sling for 3 weeks; hand, wrist, and elbow mobilizations were allowed immediately. The sling was then removed, and passive and assisted exercises in forward flexion and external rotation were initiated. Strengthening exercises were restricted until 6 weeks after the surgical procedure. Three months after the operation, patients were allowed to engage in light physical sports activities. Return to heavy manual work and overhead activities were allowed at least 6 months after surgery.

Patient evaluation

A shoulder X-ray and MRI assessment were performed preoperatively in all patients. Thorough physical examinations before surgery and at the last follow-up visit were performed in all patients using a standardized data sheet. Preoperatively and postoperatively, the CMS [11] was measured in all patients. Strength measurement for the CMS was performed in abduction in the scapular plane and quantified using a digital dynamometer (Myometer 500 N; Atlantech Medical Devices, Nottingham, UK). The postoperative patient assessment also included the Italian adaptation and validation of the simple shoulder test (SST) [15]. Patients were asked to rate their satisfaction on the results of the surgical procedure on a previously described four-point-based scale (i.e., excellent satisfaction, good satisfaction, fair satisfaction and dissatisfaction) [16]. Patients were contacted and invited back for ultrasound examination. Orthopedic shoulder surgeons trained in shoulder musculoskeletal imaging determined the integrity of the repaired rotator cuff by ultrasound. Ultrasonographic evaluation was performed in duplicates by two authors who were unaware of the patients' clinical characteristics. Cohen's Kappa coefficient for intra-observer and inter-observer reliability of evaluation was >0.8 in both cases. A consensus decision on the evaluation was reached in a final common readout. Integrity of the tendons was graded as intact, fully or partially teared, as previously described [17]. Imaging was acquired using a Toshiba Xario 100 Scanner (Toshiba America Medical Systems, Inc., 2441 Michelle Drive, Tustin, CA 92780) with an 8-MHz linear array transducer. All the patients gave informed consent for participation in this retrospective study.

Statistical analysis

Descriptive statistics were used to describe continuous variables, and proportions were employed for categorical variables. Student's t test and the χ^2 test were used to evaluate the significance of differences. Models of univariate linear regression analysis were created to test the effect of patient age at surgery, gender, preoperative CMS, concomitant surgical procedures and length of follow-up on postoperative CMS, postoperative SST, retear and patient satisfaction. IBM SPSS Statistics 21.0.0.1 software (IBM Corp, Armonk, NY, USA) was used for the database construction and the statistical analysis. A two-tailed p value of <0.05 was considered significant.

Results

A total of 192 consecutive patients fulfilled the inclusion criteria. Thirty-nine (20.3%) patients were lost to follow-up, and 2 (1%) died prior to the final evaluation, leaving 151 patients (153 shoulders) included in the study. The follow-up rate, therefore, was 78.6%. There were 77 males (51%) and 74 females (49%), averaging 49.2 (22–76) years at surgery. Completion and repair was performed in 94 cases (61.4%) and in situ transtendon repair in 59 cases (38.6%). Other concomitant pathological conditions were evaluated. The long head of the biceps tendon was treated in 41 cases (26.8%) for instability or tendinopathy with tenotomy (21) or tenotomy followed by tenodesis (20). A SLAP lesion was detected in 26 cases (17%) and treated with tenotomy followed by tenodesis (16), tenotomy (8), debridement (1), and anchor repair (1). An acromioplasty was performed in 87 cases (56.9%) when a type II or III acromion was noted.

After a mean follow-up of 73.9 (24–142) months, the CMS significantly improved from 47.7 (range 22–63) preoperatively to 84.2 (62–100) postoperatively ($p<0.001$), thus reaching a mean CMS improvement of 36.4 (16–64), being in all cases above the minimal clinically important difference (MCID) of 10.4 points, which is the previously detected threshold for the CMS in patients with rotator cuff tear [18]. Also all CMS domains significantly improved with surgery: the CMS domain for pain improved from 2.3 (0–5) to 14.1 (range 8–15); the CMS domain for activities improved from 11.6 (range 6–16) to 19.2 (range 12–20); the CMS domain for range of motion improved from 30.5 (range 12–40) to 37.9 (range 20–40); and the CMS domain for strength improved from 3.5 (range 1–12) to 12.8 (range 4–25) (for all, $p<0.001$). The postoperative SST score was 10.1 (5–12); 112 patients (74.2%) reported excellent satisfaction with the surgical procedure; 31 (20.5%), good satisfaction; 7 (4.6%), fair satisfaction; and 1 (0.7%), dissatisfaction.

We performed a subgroup analysis to test the influence of the two different surgical techniques on postoperative outcomes. Patients averaged 50.5 (24–69) years in the completion group and 47.2 (22–76) years in the transtendon group ($p=0.081$), and the mean preoperative CMS was 48.5 (27–63) in the completion group and 46.4 (22–61) in the transtendon group ($p=0.088$). The groups did not differ for

Table 1 Concomitant surgical procedures

Procedure	Completion and repair	Transtendon repair	p
Acromionplasty	59 (62.7%)	28 (47.5%)	0.182
LHB			
Tenotomy	15 (15.9%)	6 (10.1%)	
Tenodesis	10 (10.6%)	10 (16.9%)	0.368
SLAP			
Debridement	0 (0%)	1 (1.7%)	
Anchor repair	0 (0%)	1 (1.7%)	0.225
Tenotomy	7 (7.4%)	1 (1.7%)	
Tenodesis	9 (9.6%)	7 (11.9%)	

LHB long head of the biceps

Table 2 Clinical outcomes according to the repair technique

Outcome	Completion and repair	Transtendon repair	*p*
CMS	84.1 (62 to 100)	84.3 (68 to 98)	0.896
SST	10.1 (5 to 12)	10.1 (5 to 12)	0.973
Satisfaction			
Excellent	69 (74.2%)	43 (74.1%)	
Good	20 (21.5%)	11 (19%)	0.621
Fair	3 (3.2%)	4 (6.9%)	
Dissatisfaction	1 (1.1%)	0 (0%)	
Ultrasound findings			
Intact tendon	64 (86.5%)	37 (86%)	
Partial-thickness retear	8 (11.3%)	5 (11.7%)	0.999
Full-thickness retear	2 (2.7%)	1 (2.3%)	

CMS Constant and Murley score, *SST* simple shoulder test

Table 3 Clinical outcomes and satisfaction according to ultrasound findings at follow-up

Outcome	Intact tendon	Retear	*p*
CMS			
Total	85.6 (68–100)	78.6 (68–91)	**< 0.001**
Pain	14.2 (8–15)	13.5 (10–15)	0.215
Activities	19.4 (16–20)	18.2 (16–20)	**< 0.001**
ROM	38.1 (20–40)	37.4 (32–40)	0.252
Strength	13.6 (4–25)	9.6 (4–18)	**< 0.001**
SST	10.3 (5–12)	9.1 (5–11)	**0.003**
Satisfaction			
Excellent	81 (80.2%)	7 (43.8%)	
Good	17 (16.8%)	6 (37.5%)	**0.003**
Fair	3 (3%)	3 (18.7%)	

CMS Constant and Murley score, *ROM* range of motion, *SST* simple shoulder test

the concomitant surgical procedures (Table 1). As shown in Table 2, no significant differences were noted between the two techniques in terms of postoperative CMS, SST score, satisfaction and repair integrity at follow-up.

Seventy-four and 43 cases treated with completion and repair and transtendon repair, respectively, performed ultrasound examination of the shoulder. An intact rotator cuff was observed in 101 of the examined shoulders (86.3%) and a supraspinatus retear in 16 shoulders (13.7%). In detail, partial- and full-thickness rotator cuff tears were observed in 13 and 3 shoulders, respectively. Half (i.e., 3 out of 6) of the patients that referred only fair or not satisfaction with the surgery had a retear. As shown in Table 3, a lower postoperative CMS, SST score, and satisfaction were observed in patients with a retear compared with those with an intact tendon. Notably, the seven-point difference in the CMS between the intact tendon group and the retear group is below the MCID. Regression analysis revealed that males and younger patients had a higher postoperative CMS (p values < 0.001) and SST score ($p < 0.001$ and $p = 0.038$, respectively); concomitant long head of the biceps (LHB) procedures were associated with higher satisfaction ($p = 0.040$) and a higher preoperative CMS directly correlated with higher postoperative CMS ($p < 0.001$).

No postoperative complications were reported. None of the patients had revision surgery.

Discussion

Six years after arthroscopic repair of PASTA, patients showed significant improvement of functional outcomes, a low postoperative retear rate and 95% of satisfaction rate. To the best of our knowledge, the current study involves the largest series of patients addressing the results of arthroscopic repair of PASTA lesions (Table 4). A significant improvement of the CMS from 47.7 to 84.5 was obtained 6 years after arthroscopic repair of the PASTA lesions. Previously published series [19, 20] with a similar study design and a shorter follow-up detected a higher postoperative CMS: Castricini et al. [20] showed a mean improvement from 44.4 to 91.6 at 33 months after surgery, and Castagna et al. [19] showed a mean improvement from 45.3 to 90.6 at 2.7 years after surgery. However, it should be considered that the discrepancy with our results is still below the MCID[17]. Consistently, 95% of our patients were satisfied with the surgery.

Tendon healing is a primary concern following surgical repair of rotator cuff tears. Although MRI is generally considered the gold standard for evaluating rotator cuff repairs [21], ultrasound is a valuable alternative for evaluating the rotator cuff integrity after a repair procedure [22]. Using a postoperative ultrasound evaluation, we detected a supraspinatus retear rate of 13.7% (both including partial and full-thickness tears), which is consistent with those of

Table 4 Clinical studies on arthroscopic PASTA repair

Author	Year	Study design	Cases	Surgical technique	Mean FU	Radiological evaluation	Retear rate	Clinical outcome scores	Complications
Castagna [19]	2009	Retrospective	54	Transtendon	2.7 years	N.a	N.r	CMS, UCLA score, VAS, SST	N.r
Castagna [31]	2015	Prospective comparative	74	Transtendon vs completion and repair	N.r	N.a	N.r	CMS	N.r
Castricini [20]	2009	Retrospective	33	Transtendon	33 months	MRI	0%	CMS	N.r
Chung [27]	2015	Cohort study	55	Completion and repair	28.4 months	CT	23.5%	CMS, UCLA score, ASES score, VAS	N.r
Deutsch [9]	2007	Retrospective	41	Completion and repair	38 months	N.a	N.r	ASES score	N.r
Franceschi [23]	2016	Prospective comparative	60	Transtendon vs completion and repair	38 months	MRI	3.3%	CMS, ASES score	Adhesive capsulitis 10%
Kamath [17]	2009	Retrospective	42	Completion and repair	N.r	US	12%	ASES score	Frozen shoulder 4.8%
Kim [24]	2013	Retrospective	32	Transtendon	N.r	MRI or US (at 7 months)	0%	CMS, UCLA score, ASES score	N.r
Ostrander [26]	2017	Retrospective	20	Transtendon	32.7 months	US	10%	CMS, UCLA score, VAS, SST	No postoperative complications
Ranalletta [8]	2016	Retrospective	80	Transtendon	62 months	N.a	N.r	UCLA score, ASES score, VAS	Adhesive capsulitis 6.2%
Shin [25]	2012	Prospective comparative	48	Transtendon vs completion and repair	31 months	MRI (at 6 months)	4.2%	CMS, ASES score	Adhesive capsulitis 10.4%
Stuart [11]	2013	Retrospective	15	Transtendon	13.5 years	N.a	N.r	UCLA score, SF-36	No postoperative complications
Vap [12]	2018	Retrospective	20	Transtendon	6 years	N.a	N.r	ASES score, QuickDASH, SF-12	No postoperative complications
Vinanti [30]	2016	Retrospective	100	Transtendon	37 months	N.a	N.r	UCLA score, SST, VAS	No postoperative complications

n.r. not reported, *n.a.* not applicable, *FU* follow-up, *MRI* magnetic resonance imaging, *CT* computed tomography, *US* ultrasound, *CMS* Constant and Murley score, *UCLA* University of California at Los Angeles, *VAS* visual analog scale, *ASES* American Shoulder and Elbow Surgeons, *DASH* disabilities of the arm shoulder and hand questionnaire, *SF* short form, *KSS* Korean shoulder score

the previous studies, with a shorter follow-up, ranging from 0 to 12% [17, 20, 23–26] using either ultrasound or MRI evaluations and lower than that reported by Chung et al. [27] (i.e., 23.5%) using a computed tomography arthrography evaluation. In contrast with Kamath et al. [17], who reported no significant difference in functional scores between the shoulders with an intact rotator cuff and those with a recurrent tear, we observed that the occurrence of a supraspinatus retear after the arthroscopic treatment of a PASTA lesion had a detrimental effect on the postoperative CMS, SST score, and satisfaction.

There remains no consensus on which is the best choice between arthroscopic transtendon repair and completion and repair techniques. Our findings showed that, even 6 years after surgery, completion of the PASTA lesion is not inferior to the transtendon repair in terms of functional outcomes, postoperative satisfaction and tendon integrity. A cadaveric analysis [28] that compared transtendon repair and completion and repair techniques revealed better biomechanical features for the transtendon repair technique over completion of the tear and repair in terms of higher ultimate tensile loads. Shin [25] observed a greater incidence of postoperative stiffness and a slower recovery in patients treated with transtendon repair compared with completion and repair, although no differences in CMS, visual analog scale score and American Shoulder and Elbow Surgeons (ASES) score were found

31 months following surgery. Six percent of patients were reported to have adhesive capsulitis after transtendon repair [8]; Huberty et al. [29] reported 5% of patients with adhesive capsulitis after transtendon repair that required an additional surgery to treat the postoperative stiffness. Postoperative stiffness was also observed by Vinanti et al. [30] in 18% of patients 3 months after transtendon repair.

A recent meta-analysis by Ono et al. [10], which summarized the results of the three prospective randomized trials [23, 25, 31] directly comparing completion and transtendon repair techniques, found no differences between the two techniques in terms of functional results, complication rate and repair integrity by MRI after a short- to mid-term follow-up. These findings together suggest that the biomechanical advantage of preserving the tendon integrity with in situ repair does not provide better functional results and healing rates compared with conversion to a full-thickness tear and repair. The return to sport activities after the arthroscopic repair of PASTA lesions was also investigated by Franceschi et al. [23], who failed to find differences between the two techniques with respect to the return to pre-injury sport activities. On the contrary, a study by Sun et al. [32] found a lower retear rate for transtendon technique. As far as we know, few data [12, 17, 32] are available in the current literature regarding possible outcome predictors following the arthroscopic repair of PASTA lesions. Although the effect of patient age at surgery on repair integrity has been stated [17], no data concerning the prediction of clinical outcomes have been previously provided for PASTA lesions. In the current study, we showed that better clinical outcomes, as measured with the CMS and the SST, should be expected in males. Female gender negatively affected CMS after full-thickness rotator cuff repair [33, 34]. This gender difference is likely to be secondary to factors independent of the operation [35, 36]. We found that younger patients had higher postoperative CMS. The role of patient age as a predictor of positive surgical outcome has already been reported in a short-term retrospective study [19]. On the other hand, in a small cohort of patients, Vap et al. [12] found no correlation between age and postoperative outcome.

We found that higher preoperative CMS is associated with higher postoperative CMS. Notably, a higher preoperative baseline outcome score was found to have a positive effect on ASES score after arthroscopic rotator cuff repair for full-thickness supraspinatus tendon tears [37]. In the current study, concomitant LHB procedures predicted a higher satisfaction with surgery.

Some limitations should be taken into account when interpreting the results of this study. The disadvantages of a retrospective study design and a 21% loss of patient to follow-up have to be considered. Although we were interested in exploring whether the repair technique (i.e., transtendon repair or completion and repair) could affect postoperative outcomes, the current study was not comparative in nature. However, the largest available series evaluating the functional outcomes after arthroscopic PASTA repair involved 100 patients, a single technique (i.e., transtendon) [30] and a 3-year follow-up (a smaller sample size with a shorter follow-up period when compared with the current study). Caution should be also exercised interpreting the association found between repair integrity and postoperative outcomes because of the small subset of patient population with a tendon retear. However, the largest series with imaging evaluation for repair integrity involves 60 patients and 38-month follow-up [23].

Use of ultrasound instead of MRI may represent a weakness of the study. However, MRI has limited accuracy for detecting PASTA lesion [38] and ultrasound is a reliable imaging modality for evaluating the rotator cuff integrity after a repair procedure [39], thus representing a viable alternative to MRI [40]. An additional limitation is that ultrasound scans were not performed by independent radiologist but by orthopedics trained in musculoskeletal ultrasonography that were involved in the primary care of the patients.

A significant number of patients received concomitant procedures at the moment of the index surgery, including acromionplasty and biceps tendon procedures that affected the clinical outcomes. However, it is challenging to evaluate a homogeneous cohort of patients who had isolated PASTA lesion.

Conclusion

Arthroscopic repair of PASTA lesion achieves high rates of repair integrity regardless of repair type and high levels of functional recovery and patient satisfaction 6 years after surgery.

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