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Long-term results after arthroscopic treatment of symptomatic Ellman grade 2 PASTA lesions

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Background: The purpose of this retrospective study was to evaluate the clinical and radiologic long-term results of medium-sized (Ellman grade 2) partial-thickness articular-sided supraspinatus tendon avulsion (PASTA) lesions treated arthroscopically.

Methods: Of 22 patients, 18 (82%) were available for follow-up evaluation after a mean of 15 ± 2 years (range, 12-17 years). The mean age at time of surgery was 55 ± 9 years (range, 35-66 years). The Constant score was used as the primary outcome instrument to evaluate shoulder function. Furthermore, the University of California–Los Angeles shoulder score, the American Shoulder and Elbow Surgeons score, and the Subjective Shoulder Value were collected. The patients' satisfaction with the outcome was investigated. Tendon integrity of the affected shoulder at final follow-up was assessed with magnetic resonance imaging or ultrasound in 89% of the cohort.

Results: Overall, 94% of the patients were very satisfied or satisfied with the outcome. The average Constant score of the affected shoulder was 78 ± 21 points; the University of California–Los Angeles score, 31 ± 7 points; the American Shoulder and Elbow Surgeons score, 85 ± 24 points; and the Subjective Shoulder Value, 83% ± 21%. Radiologic evaluation showed progression to a full-thickness rotator cuff tear in 6% (1/16), and 60% of the patients (6/10) showed persistent signs of partial tearing evaluated by magnetic resonance imaging.

Conclusion: At long-term follow-up, arthroscopic treatment of medium-sized PASTA lesions resulted in good clinical results together with a high satisfaction level of the patients.

Level of evidence: Level IV; Case Series; Treatment Study

Keywords: PASTA lesion; supraspinatus tendon; tear débridement; transtendon repair; magnetic resonance imaging; long-term results

This study was performed at the Department of Orthopaedics and Traumatology, Paracelsus Medical University, Salzburg, Austria.

Ethikkommission Land Salzburg approved this study (415-EP/73/594-2015). Written informed consent was obtained from all individuals participating in the study.

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Partial-thickness tears of the rotator cuff are primarily caused by intrinsic and extrinsic factors contributing to a strongly age-dependent prevalence.[17,20] Without specific treatment, Yamanaka and Matsumoto[28] demonstrated a tear enlargement in 50% of the patients, and 28% progressed to full-thickness tears within approximately 1 year. Conservative treatment has been established as first-line therapy for pain reduction and rotator cuff strengthening in symptomatic patients.[27] If nonoperative therapy fails, further surgical treatment is indicated. Various techniques, from tear débridement to tendon repair, have been described so far.[24-26]

The majority of symptomatic partial-thickness rotator cuff tears are partial-thickness articular-sided supraspinatus tendon avulsion (PASTA) lesions. Keeping in mind the multifactorial pathogenesis, pathomorphology, and patient-specific factors, current data recommend débridement of low-grade partial tears involving <50% of the tendon thickness (Ellman grades 1 and 2) and repair of extensive partial tears in which >50% of the tendon substance (Ellman grade 3) is affected, without any difference in repair techniques.[7,21] Nevertheless, these recommendations are mostly based on short-term and midterm outcome evaluations.[9] Furthermore, treatment algorithms fail to consider the variability in the width of the supraspinatus tendon footprint, ranging from 7 mm to 21 mm.[6,19] As a consequence, medium-sized PASTA lesions classified as grade 2 according to Ellman[7] with an exposed bone insertion of 3 mm to 6 mm may not necessarily equate to a tear extent of <50% in all patients.

Whereas only 1 study reported the long-term results after surgical tear débridement of grade 2 lesions with dissatisfying clinical and radiologic results,[14] limited studies investigating the long-term effect of tendon repair techniques exist.[2,24] The purpose of this study was to evaluate the clinical and radiologic long-term results in a homogeneous study cohort suffering from a grade 2 PASTA lesion that was treated arthroscopically. It was hypothesized that improvements in pain relief and shoulder function would be maintained at long-term follow-up and that transtendon repair would result in better outcomes compared with mere tear débridement.

Materials and methods

The institutional electronic shoulder database was retrospectively reviewed to identify all patients who underwent arthroscopic treatment of grade 2 PASTA lesions between 1998 and 2003.[7] We excluded all patients with previous operations on the affected shoulder, concomitant glenohumeral disease except for a lesion of the long head of the biceps tendon (LHBT), and overhead sport activities.

Thus, 22 patients meeting the inclusion criteria were enrolled for long-term follow-up in 2016. Of these, 4 patients (18%) lacked contact information and could not be reached, leaving 18 patients (82%) for final evaluation. The mean age at time of surgery was 55 ± 9 years (range, 35-66 years). There were 5 women (28%) and 13 men (72%). The dominant arm was affected in 11 patients (61%). All patients failed to respond to conservative treatment before surgical intervention, with a mean symptomatic interval before surgery of 10 ± 8 months (range, 3-13 months). The mean follow-up period was 15 ± 2 years (range, 12-17 years).

For further analysis, the study cohort was subdivided according to the arthroscopic procedure. Whether surgical tendon repair (group 1, n = 7 [39%]) or tear débridement (group 2, n = 11 [61%]) was carried out was based individually on the surgeons' preferences in treating grade 2 PASTA lesions. Baseline demographics of the 2 subgroups are listed in Table I.

Table I Baseline demographics

Variable	Baseline characteristics		*P* value*
	Group 1	Group 2	
	n = 7	n = 11	
Age at time of surgery (yr)	54 ± 10	56 ± 8	.724
Male sex	6 (86)	7 (64)	.316
Dominant arm	3 (43)	8 (73)	.322
Symptomatic interval (mo)	13 ± 9	8 ± 7	.345
Follow-up period (yr)	14 ± 2	16 ± 2	.064

Group 1, tendon repair; group 2, tear débridement.
Categorical variables are presented as number (%). Continuous variables are presented as mean ± standard deviation.
* Comparison of demographics between group 1 and group 2.

Surgical technique

All patients were treated in a single center by 2 highly specialized shoulder surgeons. The patients were placed in the beach chair position under general anesthesia. Diagnostic arthroscopy was performed to evaluate tear morphology and concomitant pathologic changes. After slight tendon débridement, the tear size was measured in the anteroposterior as well as in the mediolateral direction using a standardized probe.

Group 1 was treated with an arthroscopic transosseous repair technique primarily described by Tauber et al[24] in 2008. After tear débridement and preparation of the humeral footprint, a cannulated hollow needle (Rotator Cuff Bone Stitcher; Smith & Nephew, London, United Kingdom) was used to penetrate the tendon at its torn site. Under an intra-articular view with the scope, the hollow needle was then inserted into bone next to the humeral head cartilage. After perforation of the lateral cortex of the greater tuberosity, a nonabsorbable suture (No. 2 Ethibond Excel suture; Ethicon Inc., Somerville, NJ, USA) was inserted. To perform a transosseous mattress suture, a second tunnel was created posteriorly in an identical manner. The repair was finalized after knot tying at the lateral aspect of the greater tuberosity. Acromioplasty and an LHBT procedure were performed if necessary. The patient's arm was immobilized in a shoulder sling for 6 weeks postoperatively. Within this period, the affected shoulder was passively mobilized. At the beginning of the seventh week, active assisted exercises were permitted.

Arthroscopic tear débridement with concomitant acromioplasty was performed in group 2. After treatment of the LHBT, the soft tissue of the tendon footprint at the greater tuberosity was removed, and débridement of the tear was performed to remove frayed tendon fibers. After surgery, the affected arm was immobilized in a shoulder sling for 1 week. Active assisted exercises were allowed at the beginning of the second week.

Clinical and radiographic follow-up

Before final follow-up in 2016, preoperative functional shoulder data including active range of motion were registered. Furthermore, operative records of all patients were reviewed to determine exact tear morphology, LHBT procedure, and acromioplasty.

At final follow-up, all patients received standardized questionnaires. They were primarily asked to rate their satisfaction with the surgical outcome from 1 (not satisfied) to 5 (very satisfied). Failure of index surgery was defined as revision surgery within the follow-up period. The clinical assessment was performed in the outpatient clinic by the principal investigator who was not involved in the index surgical procedure. In addition to both bilateral active range of motion assessment with a goniometer and abduction strength investigation by use of an Isometer (IDO, Worcestershire, United Kingdom), the Constant score (CS) for both shoulders,[4] the University of California–Los Angeles (UCLA) shoulder score,[1] the American Shoulder and Elbow Surgeons (ASES) score,[18] and the Subjective Shoulder Value (SSV)[12] were obtained. A 10-point visual analog scale was used to assess pain intensity at final follow-up. Correlations between patients' characteristics and outcome scores were performed.

Radiologic evaluation of the affected shoulder included either magnetic resonance imaging (MRI; Ingenia 1.5T MR system; Philips, Amsterdam, The Netherlands) or ultrasound examination (11 MHz Logiq 400 Pro Series; General Electric, Fairfield, CT, USA) to assess tendon integrity at final follow-up. Ultrasound examination was used if MRI was contraindicated or refused.

Postoperative tendon integrity seen on MRI was classified into 5 types according to the Sugaya classification system[23]: type 1, sufficient thickness with homogeneously low intensity; type 2, sufficient thickness with partial high intensity; type 3, insufficient thickness without discontinuity; type 4, presence of a minor discontinuity; and type 5, presence of a major discontinuity.

Treatment failure was defined as either type 4 or type 5,[23] representing a full-thickness tear evaluated on coronal T2-weighted images or hypoechoic discontinuity on the long-axis section through the supraspinatus tendon with the transducer placed in the modified Crass position.[8] The analysis was performed by a skilled musculoskeletal radiologist who was blinded to clinical results.

Statistics

We used the SPSS software (version 21.0; IBM, Armonk, NY, USA) to perform statistical analysis. The Kolmogorov-Smirnov test was performed to assess normal distribution; to compare the preoperative and postoperative clinical parameters as well as the CS of the affected and nonaffected sides, the Wilcoxon test was used. Comparison between the subgroups was performed using the Mann-Whitney *U* test. Correlation was measured using the Pearson and Spearman correlation coefficient. The level of significance was set at the *P* value of $< .05$ (two sided).

Table II Preoperative and postoperative range of motion of the affected shoulder

Variable	Baseline	Follow-up	*P* value*
Flexion (°)			
Overall (n = 18)	145 ± 27	162 ± 25	.343
Group 1 (n = 7)	149 ± 18	170 ± 11	.201
Group 2 (n = 11)	145 ± 33	156 ± 31	.414
Abduction (°)			
Overall (n = 18)	138 ± 38	156 ± 33	.115
Group 1 (n = 7)	136 ± 39	164 ± 10	.109
Group 2 (n = 11)	139 ± 39	150 ± 41	.593
Internal rotation† (points)			
Overall (n = 18)	8 ± 1	8 ± 2	.672
Group 1 (n = 7)	8 ± 2	9 ± 1	.430
Group 2 (n = 11)	8 ± 1	7 ± 3	.141
External rotation (°)			
Overall (n = 18)	54 ± 12	62 ± 8	.401
Group 1 (n = 7)	52 ± 9	60 ± 6	.112
Group 2 (n = 11)	56 ± 14	58 ± 12	.711

Data are reported as mean ± standard deviation.
* Comparison of the outcome of the affected arm between baseline and final follow-up.
† Constant score points.

Table III Clinical outcomes at final follow-up

Outcomes score	Follow-up		*P* value
	Group 1	Group 2	
	n = 7	n = 11	
Constant score (points)	89 ± 5	72 ± 25	.047
Pain (points)	14 ± 2	12 ± 5	.589
ADL (points)	19 ± 1	17 ± 5	.590
ROM (points)	38 ± 2	32 ± 11	.091
Strength (points)	18 ± 4	10 ± 8	.040
UCLA score (points)	34 ± 2	29 ± 8	.117
ASES rotation score (points)	92 ± 11	81 ± 30	.746
VAS score (points)	0.7 ± 1.5	2.0 ± 3.4	.589
SSV (%)	86 ± 19	81 ± 23	.639

ADL, activity of daily living; *ROM*, range of motion; *UCLA*, University of California–Los Angeles; *ASES*, American Shoulder and Elbow Surgeons; *VAS*, visual analog scale; *SSV*, Subjective Shoulder Value.
Data are reported as mean ± standard deviation.

Results

Overall, no patient required revision surgery within the study period. No complication was reported. All patients except 1 (94%) were satisfied with the clinical outcome. Whereas 5 patients (71%) were very satisfied and 2 patients

Table IV Correlation of preoperative factors with clinical outcome scores at final follow-up

	CS		UCLA		ASES		SSV	
	CC (*R*)	*P* value	CC (*R*)	*P* value	CC (*R*)	*P* value	CC (*R*)	*P* value
Overall (n = 18)								
Age at time of surgery	−0.015	.952	−0.058	.818	−0.011	.966	0.009	.972
Symptomatic period before surgery	0.326	.256	0.194	.506	0.208	.475	0.023	.938
Follow-up period	−0.268	.283	−0.259	.300	−0.013	.958	0.008	.974
Subgroup 1 (n = 7)								
Age at time of surgery	0.241	.602	−0.432	.333	−0.142	.761	−0.107	.819
Symptomatic period before surgery	−0.415	.414	−0.544	.088	−0.603	.205	−0.617	.192
Follow-up period	0.293	.524	0.397	.377	0.277	.538	0.140	.765
Subgroup 2 (n = 11)								
Age at time of surgery	0.001	.998	0.065	.850	0.063	.855	0.109	.749
Symptomatic period before surgery	0.377	.357	0.335	.418	0.378	.356	0.391	.338
Follow-up period	−0.051	.881	−0.163	.631	0.157	.645	0.087	.800

CS, Constant score; *UCLA*, University of California–Los Angeles; *ASES*, American Shoulder and Elbow Surgeons; *SSV*, Subjective Shoulder Value; *CC*, correlation coefficient.

(29%) were satisfied in group 1, 8 patients (72%) in group 2 were very satisfied, 2 patients (19%) were satisfied, and 1 patient (9%) was unsatisfied ($P = .601$).

Arthroscopic features

Of the 18 patients enrolled in this study, all underwent concomitant acromioplasty and 2 patients (11%; group 1, n = 1; group 2, n = 1) underwent LHBT tenotomy because of poor tendon quality and partial tearing. The mean anterosuperior defect diameter was 1.1 ± 0.5 cm (range, 1.0-2.0 cm) without a significant difference between group 1 and group 2 (1.1 ± 0.3 cm vs. 1.2 ± 0.4 cm; $P = .420$).

Clinical findings

An improvement in active range of motion of the affected shoulder was found in all patients (Table II). There were no significant differences between group 1 and group 2 (flexion, $P = .536$; abduction, $P = .930$; internal rotation, $P = .061$; external rotation, $P = .536$). At final follow-up, an average CS of 78 ± 21 points (range, 18-98 points), UCLA score of 31 ± 7 points (range, 11-35 points), ASES score of 85 ± 24 points (range, 25-100 points), SSV of 83% ± 21% (range, 40%-100%), and pain level of 1.5 ± 2.8 points (range, 0.0-9.0 points) were noted. Comparing the postoperative CS, there was no significant difference between the affected shoulder (78 ± 21 points) and the nonaffected shoulder (77 ± 22 points; $P = .726$). Differences in clinical outcome scores between group 1 and group 2 are outlined in Table III, with significant differences in terms of both the total CS and its subgroup strength. No significant correlation was found between the age at time of surgery, the symptomatic period, or the follow-up period and clinical outcome scores (Table IV).

Radiologic results

At final follow-up, 16 patients (89%) had undergone radiologic examination; 2 patients (11%) refused radiologic evaluation completely. MRI of the affected shoulder was conducted in 10 patients (56%; group 1, n = 5; group 2, n = 5) and ultrasound assessment in 6 patients (33%; group 1, n = 2; group 1, n = 4). MRI was refused by 4 patients and contraindicated in 2 patients (conventional pacemaker, n = 1; claustrophobia, n = 1).

Overall, radiologic examination showed a full-thickness tear in 1 patient (6%) evaluated by ultrasound. This patient (female, 59 years old at index surgery, 17 years of follow-up) was treated with tear débridement combined with acromioplasty (group 2) and had the poorest clinical results with a CS of 18 points, UCLA score of 11 points, ASES score of 37 points, SSV of 40%, and visual analog scale score of 7 points.

Furthermore, 60% of the patients (group 1, 40%; group 2, 80%) showed persistent signs of partial tearing evaluated by MRI (Fig. 1). Further MRI results are summarized in Table V.

Discussion

The main finding of this retrospective study was that arthroscopic treatment of medium-sized PASTA lesions provided sustained pain relief and functional improvement at long-term follow-up. Whereas tendon repair resulted in significantly better outcomes as measured by the total CS compared with tear débridement, no further difference in any other outcome measures was found. Although signs of partial tendon lesions were found in almost half of the patients, treatment failure was rare. To the best of our

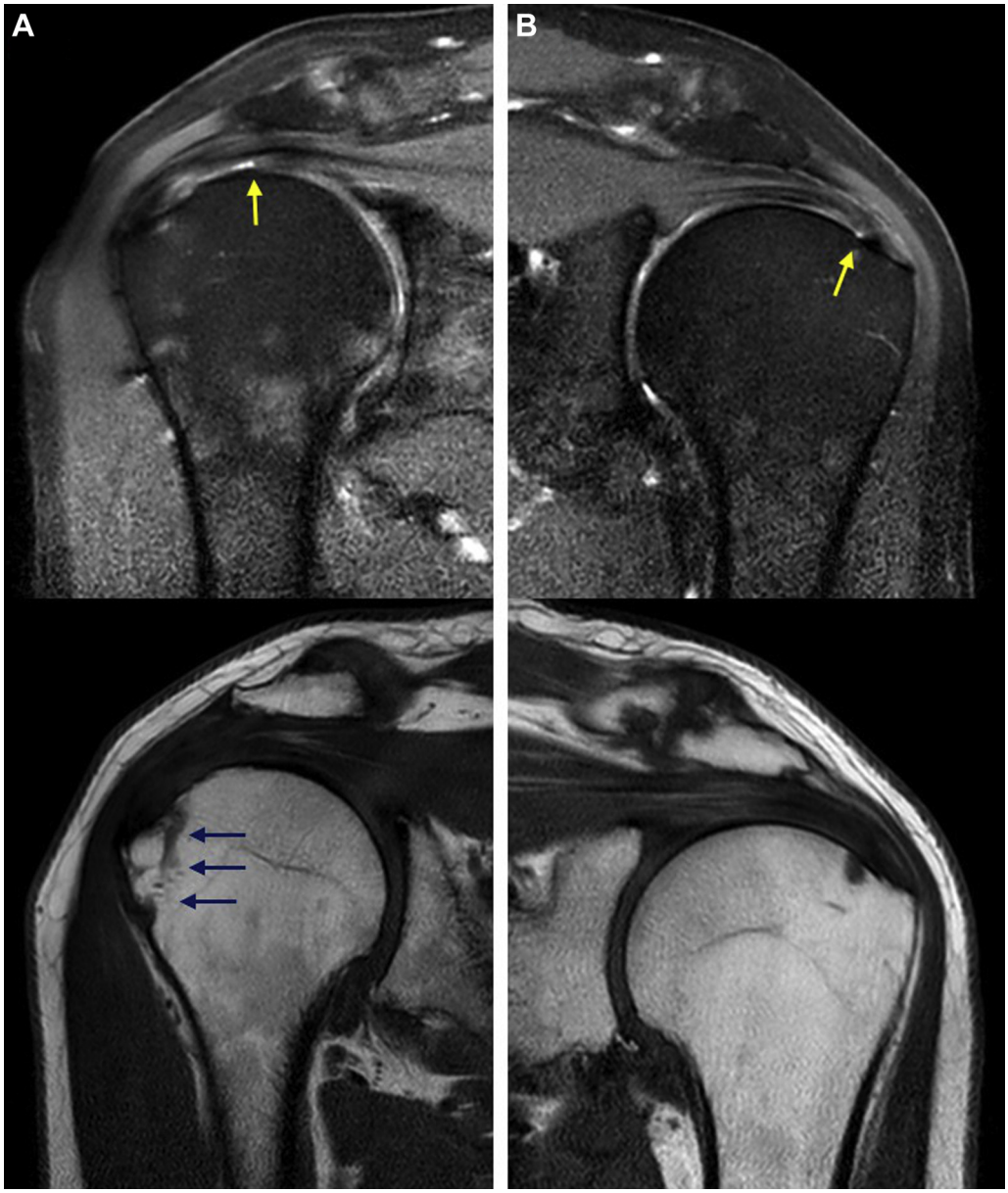

Figure 1 Magnetic resonance imaging at final follow-up. (**A**) Right shoulder. Coronal oblique T2-weighted image showing a partial retear of the articular layer (*yellow arrow*) with retraction to the apex of the humeral head. Transosseous tunnel (*blue arrows*) after rotator cuff repair is shown in the coronal oblique T1-weigthed image. (**B**) Left shoulder. Recurrent articular-sided tear of the supraspinatus tendon (*yellow arrow*) after arthroscopic tear débridement is revealed by coronal oblique T2-weighted images. A small cyst at the medial aspect of the tendon footprint is evident (T1-weighted image).

Table V Magnetic resonance imaging results according to the Sugaya classification

Sugaya classification[23]	Type 1	Type 2	Type 3	Type 4	Type 5
Study population (n)	1	3	6	0	0
Group 1 (n)	1	2	2	0	0
Group 2 (n)	0	1	4	0	0

knowledge, no study to date has directly compared the long-term effectiveness of 2 evidence-based arthroscopic procedures for medium-sized PASTA lesions.

Long-term results after surgical treatment of symptomatic partial-thickness rotator cuff tears are sparse. Thus, the current treatment algorithm is primarily based on retrospective case series reporting on short-term to midterm results.[9] As tendon lesions have a natural trend of increasing tear size,[28] long-term results are needed to specify individual treatment algorithms to minimize the risk of tear progression.

Whereas Liem et al[16] found a full-thickness tear in only 7% of the patients 5 years after tear débridement for grade 1 and grade 2 PASTA lesions, Kartus et al[14] reported a

failure rate of 35% 8 years postoperatively. The latter included both articular- and bursal-sided partial lesions, and therefore comparability is limited as treatment failure is dependent on initial tear morphology (bursal > articular).[5] Nevertheless, insufficient tendon tissue with signs of partial tearing was reported equally in almost two-thirds of the patients after mere tear débridement. It seems plausible that tear débridement was sufficient in the midterm follow-up but did not prevent further tendon degeneration of the rotator cuff. Correspondingly, we found areas of thinned tendons in 80% of the patients who did not undergo tendon repair. The rate of full-thickness tears was low, indicating some kind of healing within an early postoperative phase. Furthermore, patients with bursal-sided partial lesions were excluded from our study. Both histologic analyses and clinical studies have demonstrated decreased potential for tendon healing in bursal-sided tears compared with articular-sided tears.[10,15]

Tendon repair for partial rotator cuff tears was shown to result in successful clinical and radiologic results at short-term to midterm follow-up.[2,25] Furthermore, Stuart et al[22] described the results of 15 patients after arthroscopic transtendon anchor-based repair for high-grade PASTA lesions with a follow-up period of 12 to 15 years. Good clinical results were described, with only a traumatic repair failure in 1 patient 8 years after surgery. Their study was limited by the absence of postoperative imaging and its heterogeneous study population in terms of coexisting glenohumeral diseases. Similar clinical results were found in our study cohort after transosseous tendon repair for grade 2 PASTA lesions. Although no repair failure was demonstrated in our study cohort, signs of partial tearing were evident in 40% at final follow-up. This might be a result of natural age-related rotator cuff degeneration.[3]

Long-term studies have shown that an intact rotator cuff corresponds to a significant increase in abduction strength of the affected shoulder compared with a partial or complete retear of the supraspinatus tendon.[13] The subgroup analysis of this study found almost consistently better clinical results for tendon repair compared with tear débridement. Whereas most of the clinical measurements were not statistically significant at the long-term follow-up, the CS was significantly better in patients after tendon repair, which was mainly explained by the superiority in the strength assessment.

This study has some limitations. First, it is limited by the heterogeneous radiologic follow-up as both MRI and ultrasound examination were inconsistently used to evaluate tendon integrity. Nevertheless, ultrasound was demonstrated as sensitive and specific in the evaluation of recurrent rotator cuff tears.[11] Another limitation of this retrospective study is the small sample size. The fact that 2 shoulder surgeons performed the different surgical techniques might limit the comparability of the results. However, although not randomized, we were able to include a second treatment group with a consistent age distribution and follow-up period for comparison.

In general, the indication for arthroscopic tear débridement or tendon repair in grade 2 PASTA lesions has to be balanced against the individual risk of age- and pathomorphology-related tear progression. Further research will be necessary to definitely adopt a treatment algorithm for symptomatic PASTA lesions.

Conclusion

Arthroscopic treatment of medium-sized PASTA lesions resulted in good clinical outcomes in conjunction with a high satisfaction level of the patients at long-term follow-up.

Disclaimer

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