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SHOULDER

Clinical outcome and prognostic factors of revision arthroscopic rotator cuff tear repair

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Abstract
Purpose The aim of this study was to evaluate the clinical outcome of arthroscopic rotator cuff revision surgery in a cohort of patients and to identify prognostic factors for this procedure.
Methods Fifty-one consecutive patients undergoing revision arthroscopic rotator cuff repair were prospectively followed over a minimum period of one year. Radiologic findings and clinical data regarding primary and revision surgery were collected. Clinical evaluation was performed pre- and post-operatively by means of Constant Score and Simple Shoulder Test.
Results Median age at the time of revision surgery was 60 years (range 36–77 years). Median follow-up was 25 months (range 12–58 months). There were 17 men (33.3%) and 34 women (66.7%). The majority of the tears affected the supraspinatus tendon alone (51%) or both the supra- and infraspinatus tendons (35.3%). Significant improvements were seen in terms of active forward elevation, active external rotation, pain, Simple Shoulder Test score, Constant Score, and post-operative satisfaction—age, gender, and time to revision surgery did not show significant predictive value. A smaller tear size and pre-operative elevation greater than 90° were demonstrated to be independent prognostic factors for better outcome. However, the mean increase in Constant Score was not related to the size of the tear, range of motion, or age.
Conclusion The results of this study indicate that arthroscopic revision rotator cuff repair results in reliable improvement in shoulder function, pain, and satisfaction. Pre-operative active range of motion and tear size seem to determine final outcome. A similar increase in mean Constant Score can be achieved even in large tears in patients aged over 65 years.
Level of evidence IV.

Keywords Shoulder · Arthroscopy · Revision rotator cuff repair · Failure · Prognostic factors · Functional outcome

Introduction

Revision rotator cuff repair is a surgical challenge, and the literature contains scant information on outcomes. Although a number of series have reported excellent results in primary arthroscopic rotator cuff repair, published outcomes following revision surgery are generally reported to be less satisfactory [7, 8, 12, 14, 20, 23, 24].

The prognostic factors for primary rotator cuff surgery are well known. Indeed, we can predict surgical outcomes with some degree of accuracy based on patient age, size of the tear, and degree of fatty infiltration [3, 10, 16, 20, 21]. However, no prognostic factors have been established for revision surgery. While repair integrity is a well-known predictor of good shoulder function in primary and revision rotator cuff surgery [14, 18, 24], other factors may also play a key role. Efforts to draw conclusions from existing studies are hampered by issues such as small sample size, differences regarding surgical technique, heterogeneity of tear types, and methods of quantifying the outcome

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[9, 18, 23, 24]. The first published series of revision rotator cuff repair surgery involved open revision and did not use any validated shoulder score to describe their results [8, 9]. It was not until 2010 that Lo and Burkhart [19] published the first review of arthroscopic revision performed by a single surgeon. The authors noted significant improvements in UCLA scores and active motion elevation, with overall good to excellent results in 64% of procedures. Most reviews report consistent post-operative pain relief and a fair degree of functional gain. However, the majority lack data on previous functional status, thus making objective functional gain following revision rotator cuff surgery unknown.

The aim of this study was to evaluate the results of arthroscopic revision rotator cuff repair in patients for whom previous rotator cuff repair had failed and also to determine the prognostic factors affecting the outcome of revision surgery. Pre-operative and post-operative assessment was performed. As a result, the final functional outcome and the objective amount of improvement achieved were determined in each group included in the population.

Materials and methods

Inclusion/exclusion criteria

Fifty-one consecutive patients who underwent arthroscopic revision rotator cuff surgery by the senior author were prospectively followed up and evaluated for at least one year. The present study is a retrospective review of prospectively collected data. "As the study was explorative, a priori sample size calculation could not be performed, since there was no control group. The inclusion criteria were patients who had undergone arthroscopic or open rotator cuff repair and presented with clinical and structural failure as demonstrated on magnetic resonance imaging (MRI). Full thickness tears and partial thickness tears that were completed and repaired during surgery were included. Partial thickness tears involving less than 50% of the tendon were only debrided and were excluded from this investigation. Patients who underwent surgical revision for conditions other than rotator cuff re-tear were also excluded. All patients provided informed consent for participation.

Clinical assessment

A single blinded examiner evaluated all patients pre-operatively and post-operatively at 6 weeks, 6 months, and thereafter on a yearly basis except when the patient requested an earlier appointment. Demographic data and all relevant details from medical histories were recorded. In order to measure objective and subjective outcomes, Simple Shoulder Test score (SST) and Constant Score were used [6]. The result obtained was converted to the age- and sex-adjusted normative value (Adjusted Constant Score) as expressed by Katolik et al. [13]. Pain was recorded as the average amount of daily pain experienced by the subject and reported as none, mild, moderate, or severe. Subjective satisfaction was recorded on a visual analogue scale.

Radiologic assessment

Antero-posterior, true antero-posterior, scapular Y, and axillary view radiographs were obtained pre-operatively in standardized fashion, and the presence of rotator cuff tear arthropathy was assessed [26]. An MRI was obtained pre-operatively in all of the patients. A single musculoskeletal radiologist supervised all of the studies. The degree of fatty infiltration of the rotator cuff muscular masses was assessed as described by Fuchs et al. [11]. In the post-operative setting, however, an MRI was only requested in case of failure of clinical improvement.

Operative technique

The revision surgery was performed by the senior surgeon in all cases. All procedures were carried out arthroscopically in the beach-chair position. The procedure began with diagnostic assessment of the glenohumeral joint. Subsequently, subacromial bursectomy was performed, and the subacromial space was examined. Rotator cuff tears were assessed after bursectomy of the subacromial space but before debridement, and were classified based on size, thickness (full or partial), and number of tendons involved. The classification of DeOrio and Cofield [8] was followed to categorize the size of the tear. According to this system, the length of the greatest diameter was used to devise four categories of tears: small (1 cm or less), medium (1–3 cm), large (3–5 cm), or massive (>5 cm). Double-row repair was used to reconstruct the tear when possible, except for small tears, which were reconstructed using single row repair. Single row or margin convergence repair were used in massive tears if double-row repair was not possible due to severe retraction or poor tendon tissue quality. Interval slide or other techniques such as tissue augmentation or patches were not used. Additional procedures such as acromioplasty, biceps tenotomy or tenodesis, or acromioclavicular joint excision were performed when indicated. The acromioclavicular joint was considered to be arthritic where conventional radiographs or MRI studies evidenced subchondral sclerosis, bone marrow oedema, or osteophytes, though lateral clavicle resection was only performed if the patient was symptomatic as demonstrated by pain on palpation and the presence of a positive cross-arm test.

Post-operative and rehabilitation

Post-operatively, all shoulders in which repair surgery was performed were immobilized with a sling for a period of 4–6 weeks depending on the quality of the tissue and the strength of the repair. Patients were allowed to remove the sling periodically for self-care and for elbow, forearm, and wrist range of motion. They took part in a standardized rehabilitation protocol consisting of 4–6 weeks of shoulder immobilization allowing pendulum exercises and passive range of motion and then 6 weeks of active range of motion, followed by 12 weeks of rotator cuff strengthening and conditioning. Indications to return to work or resume sport activities were individualized on the basis of the specific requirements of each patient.

Statistical analysis

Categorical variables were described as rates (%) and measurable variables were expressed as mean (SD) or mean (range). Categorical variables were compared by the Pearson Chi-square test with continuity correction. A normality test of each variable using the Shapiro–Wilk test showed normal distribution of all continuous variables except for the SST score. Thus, all comparisons of these variables were based on parametric tests (paired and unpaired *t* tests). Comparisons affecting SST were performed using nonparametric statistical tests.

Correlations between quantitative variables were assessed using Pearson's correlation coefficient. Linear regression analysis was used to determine the independent variable affecting outcome. All statistical analyses were performed using the SPSS software package (version 15.0; SPSS, Chicago, IL), and $p < 0.05$ was considered statistically significant.

Results

The study group consisted of 51 patients. The median age at the time of the revision surgery was 60 years (range 36–77 years). In 78.4% of the patients, the right shoulder was involved and in 21.6% it was the left shoulder. All of the patients were right-handed. Four patients were diabetics, three had been diagnosed with fibromyalgia or depression, five of them were smokers and six were involved in a worker's compensation process. The median follow-up was 25 months (range 12–58).

With regard to previous surgeries, 49 patients had undergone arthroscopic rotator cuff repair, while open repair had been performed in two patients. The operation notes of the previous surgical procedures were reviewed to determine the surgical findings and technique (Table 1). Complete surgical data were not available in some of the 17 cases, in which the initial surgical intervention took place in other institutions.

Pre-operative assessment

The clinical presentation of the subjects was variable. The onset of the symptoms was linked to trauma in only seven of the cases. The remaining patients presented to the clinic with complaints of progressive pain and limited function. Data regarding pre-operative clinical evaluation is included in Table 2. The degree of fatty infiltration was recorded in 27 of the 51 patients. There were 19 patients without any sign of fatty infiltration on MRI, three patients showed grade I fatty infiltration, two patients grade III, and three patients grade IV. Osteoarthritis was detected in seven patients (13.7%).

Revision rotator cuff repair surgery

The median time from the previous surgery was 12 months (range 6–118). Data concerning surgical findings at revision procedure are included in Table 1. Two avulsed anchors were also identified and subsequently removed. An os acromiale was present in two cases (4.8%); one of them was a pre-acromion and was resected.

Clinical outcome

There were no perioperative surgical complications. One patient developed a superficial infection that healed with oral antibiotics. Data regarding clinical evaluation are included in Table 2.

In 14 patients with an unsatisfactory outcome (27%), repeat surgery was proposed, but only eight underwent further surgical treatment (15.7%). In five of these patients, a reverse arthroplasty was performed with a satisfactory outcome. For the remaining cases, in one patient, arthroscopic excision of the acromioclavicular joint was performed, producing satisfactory results. In another subject, arthroscopic biceps tenodesis was performed with a fair result. In the third patient with a re-tear, a third arthroscopic repair was performed with poor results due to a new failure of the reconstruction. Six patients with severe pain were referred to the pain clinic for further assessment.

Factors predicting functional outcome

Final functional results were compared between groups according to different pre-operative factors and surgical findings (Table 3). Age and gender did not show significant predictive value in the outcome of the revision repair. Based on the data available, we did not find any statistically

Table 1 Data regarding first and revision surgery findings and procedures

Surgical data	First surgery	*N*	Revision surgery	*N*
Tendons affected	SSP: 21 SSP/ISP: 15 SSP/ISP/SSC: 6 SSP/SSC: 2	44	SSP: 26 (51%) SSP/ISP: 18 (35.3%) SSP/ISP/SSC: 4 (7.8%) SSP/SSC: 2 (3.9%) ISP: 1 (2%)	51
Size of tear	Small: 7 Medium: 11 Large: 15 Massive: 12	45	Small: 12 (23.5%) Medium: 14 (27.5%) Large: 13 (25.5%) Massive: 12 (23.5%)	51
Type of repair	Simple suture: 31 Double row: 12	43	Simple suture: 34 (66.7%) Double row: 10 (19.6%) Margin convergence: 7 (13.7%)	51
Acromioplasty	Yes: 43 No: 3	46	Yes: 4 (7.8%) No/Previous: 47 (92.1%)	51
Long head of biceps tendon status and actions taken	None: 31 Tenotomy: 4 Tenodesis: 5	40	Intact: 23 (46.9%) Partial Tear: 8 (16.3%) Subluxated: 2 (4.1%) Absent: 18 (32.7%) Tenotomy/tenodesis: 9 (17.6%)	51
Acromioclavicular joint excision	Yes: 5 No: 41	46	Yes: 6 (11.8%) No: 45 (88.2%)	51

SSP Supraspinatus tendon, *ISP* Infraspinatus tendon, *SSC* Subscapularis tendon

Table 2 Comparisons made between pre-operative and post-operative functional data

Outcome	Pre-operative media (SD)	Post-operative (SD)	*p* value
Range of motion			
Forward elevation	96.6º (47.5)	135.6º (40.9)	<0.0001
External rotation	38.6º (22.2)	50.4º (25.3)	0.009
Constant Score (CS)	42.68 (25.2)	69.10 (28.1)	<0.0001
SST*	3.76 (11)*	7.58 (12)*	<0.0001
Pain scale (0, none; 1 mild; 2 moderate; 3 severe)	0 $N = 0$	*0* $N = 16$	<0.0001
	1 $N = 3$	1 $N = 15$	
	2 $N = 21$	2 $N = 8$	
	3 $N = 27$	3 $N = 12$	
VAS satisfaction	3.34 (2.4)	6.49 (SD 2.9)	<0.0001

* All continuous variables follow a normal distribution except for Simple Shoulder Test Score that has been expressed as mean and range

significant associations between degree of fatty atrophy and the final Constant Score. Time to perform revision surgery was also found not to be correlated with final Constant Score.

Final Constant Score was significantly higher ($p = 0.004$) for non-massive tears (75.4, SD 27.3) when compared to massive tears (48.8, SD 22.6). The mean increase in Constant Score depending on the size of the tear was calculated and compared. No statistically significant differences were found between groups ($p =$ n.s.) (Table 4). Comparisons between mean increase in Constant Score and age, sex, and pre-operative range of movement are included in Table 4.

Multivariate linear regression analysis initially included pre-operative pain, size, number of tendons involved, and pre-operative range of motion ($p < 0.05$). Pre-operative elevation (0.41) and size of the tear (−0.37) were proven to be independently associated with final Constant score.

Discussion

The most important finding of the present study is that arthroscopic revision rotator cuff repair is a safe procedure that produces satisfactory results in terms of pain decrease and improved range of motion. However, as previously

Table 3 Correlation of Final Constant Score with clinical and structural variables

	Average Constant Score (SD)	*p* value
Sex		
Male (*N*=17)	74.2 (22.1)	n.s.
Female (*N*=34)	66.6 (30.8)	
Pre-operative pain		
None-mild (*N*=24)	77.9 (24.7)	**0.03**
Moderate–intense (*N*=27)	61.3 (29.2)	
Age		
<65 (*N*=43)	67.8 (28.9)	n.s.
>65 (*N*=8)	76.3 (25.4)	
Elevation		
<90º (*N*=17)	54.4 (27.7)	**0.007**
>90º (*N*=17)	79 (21.4)	
External rotation		
<45º (*N*=13)	58.4 (25.4)	n.s.
>45º (*N*=8)	79.1 (19.4)	
Tear size		
1 (*N*=11)	80.5 (30.6)	**0.03**
2 (*N*=14)	76.1 (19.8)	
3 (*N*=13)	70.3 (32.2)	
4 (*N*=12)	48.8 (22.6)	
Tendons		
1 (*N*=26)	75.4 (27.3)	n.s.
>1 (*N*=24)	48.8 (22.6)	

Bold values indicate statiscally significant correlation between the Final Constant Score and clinical and structural variables *n.s.* non-significant

Table 4 Correlations for mean increase in Constant Score

	Change in Constant Score (mean and SD)	*p* value
Sex		
Male	25.7 (19.9)	ns
Female	23.8 (23.2)	
Age (yrs)		
<65	24.5 (22.3)	ns
>65	23.9 (22.7)	
Pre-operative external rotation		
<45º	29.6 (20.3)	ns
>45º	19.7 (20.2)	
Pre-operative forward elevation		
<90º	28.7 (21.9)	ns
<90º	21.9 (22.1)	
Revision surgery tear size		ns
Small	25.7 (23.4)	
Medium	27.8 (24.7)	
Large	21.0 (20.6)	
Massive	21.8 (20.6)	

n.s. non-significant

demonstrated, revision surgery produces poorer outcomes than primary repair [3, 9, 22, 24]. Initial reports involved open surgery and showed a moderate increase in shoulder function together with consistent pain relief in most cases. In these series, prognostic factors were technique-dependent and included deltoid detachment and the amount of acromioplasty performed [8, 9]. Djurasovic et al. reported their retrospective experience, which included 80 consecutive open cases. They found that 86% of the patients noted marked pain relief, with good to excellent results in 58%. However, one-third of the patients reported continued functional deficits [9].

Despite great advances in shoulder arthroscopy over the last decade, the results of revision rotator cuff surgery have lagged behind, and a high incidence of failure has been reported [1, 18, 23–25]. Controversy has surrounded the issue of whether or not the presence of a re-tear will determine the general outcome of the surgery, as many patients present with diminished pain and increased function despite re-tears [2, 5, 14]. While not entirely negating the important role of repair integrity, this could suggest that other factors can determine final outcome. As a result, efforts are now focused on identifying those subgroups of patients that could clearly benefit from revision surgery, as doing so would avoid unsatisfactory results and help in managing patients' expectations.

In this series, all interventions were performed arthroscopically, and complete anatomic repair was achieved in the majority. The supraspinatus and infraspinatus tendons were involved in more than half of the tears, and 59% of them were large and massive tears. There was a mean increase in forward elevation from 96.6° to 135.6° and a mean increase in external rotation from 38.6° to 50.4°. These results are comparable to previous studies in terms of functional outcome (i.e. shoulder function scores, pain assessment, and post-surgical subjective satisfaction) [4, 14, 15, 19]. Mean pre-operative forward elevation was below 100º, which is lower than other series; this may explain the fact that final outcome was lower as well, despite a 30° increase in this parameter [14, 19].

Many possible predictors of shoulder pain and function have been established for primary and revision rotator cuff surgery. Regarding epidemiologic data, no statistically significant correlations were found between final Constant Score or mean increase in Constant Score and sex or age in this study. Some authors have detected significantly worse results in females [4, 12, 17, 23]; however, in these studies an evaluation of sex- and age-adjusted Constant Score was not included, which can influence results. The influence of age on primary and revision rotator cuff surgery continues to be a point of controversy [24]. While Lädermann et al. [17] failed to find a statistically significant correlation between age and functional outcome, Keener et al.

[14] found age-related differences in repair integrity, with worse outcomes in patients aged 59 years versus patients aged 51 years. For their part, Chuang et al. [4] also found worse results in patients older than 70 years of age. In this group of patients, the median age at the time of the surgery was 60 years, which is consistent with the findings of similar series [4, 17]. The mean increase in Constant Score was 24.5 (SD 22.3) for patients under 65 years of age and 23.9 (SD 22.7) for patients over this age. This finding may have important clinical implications, since it implies that, in patients aged over 65 years with a failed rotator cuff repair, arthroscopic revision could be regarded as a valid alternative overall in the absence of rotator cuff arthropathy [12].

Pre-operative range of motion is a well-known predictor of functional outcome [12]. In our series, post-operative Constant Score was directly related to pre-operative forward elevation greater than 90º, which was shown to be an independent prognostic factor. Previous studies have also reported better results with pre-operative forward elevation above 136º [17] or abduction greater than 90º [23]. Though, in our study, the supraspinatus and infraspinatus tendons were involved in the majority of the tears, pre-operative external rotation may also have predictive value despite the fact that its prognostic role has not been studied so far. Our data suggest that pre-operative external rotation below 45º may be a negative prognostic factor in arthroscopic revision rotator cuff tear repair, though the differences found did not reach significance, likely due to small sample size.

As concerns surgical findings, the size of the tear has also been a concern when treating a re-tear of the rotator cuff [18]. The study by Piasecki et al. [23], for example, only included 7.4% of massive tears. Although they did not find any relation with the tear size, the authors do mention that small tears may be easier to repair. More recently, Lädermann et al. [17] did not find poorer results or a higher risk of re-intervention in massive tears as well as Shamsudin et al. [24]. Keener et al. [14], however, found a higher rate of repair integrity in tears affecting one tendon when compared to those affecting two or more. In our series, the size of the tear was significantly correlated with final Constant Score and was demonstrated to be an independent prognostic factor, and differences were significant when massive tears were compared with other types. However, when looking at mean increase in Constant Score, no differences were found between different tear sizes. This could indicate that patients with massive tears could also benefit from the surgery, although poorer final outcome should be expected [24]. The rate of failure after revision surgery was 27%, which is similar to reports by other authors [11, 22, 24].

Fatty atrophy is considered to be an important prognostic factor for revision rotator cuff tear repair [4, 20]. In our series, however, no statistically significant association was found between the degree of fatty atrophy and final functional outcome. This discrepancy could be explained by the fact that the degree of fatty infiltration in our patients was lower than that reported by others. Since some MRIs were performed at an outside institution, pre-operative fatty infiltration could not be investigated in some cases because the images obtained did not meet the requirements for evaluation of this condition according to the criteria of Fuchs et al. [11]. Additionally, this finding may be partially explained by the limited sample size used in our study.

The present study has some other limitations. The major limitation is that post-operative imaging follow-up was not performed routinely, but rather only in cases with a non-satisfactory result. As mentioned before, some authors have established associations between presence of structural failure and clinical outcome, and this is an important drawback in this investigation. Data regarding osteoarthritis, smoking habit, depression, fibromyalgia, diabetes, and involvement in worker's compensation claims accounted for a small number of patients. The fact that no association with these risk factors was found may have been due to the relatively small sample size. Thus, no solid conclusions can be drawn from this study concerning the prognostic value of these factors.

Conclusion

The findings of this study show significant improvement in pain and functional scores following arthroscopic revision rotator cuff repair. It appears that final clinical outcome is determined by pre-operative elevation and size of the tear. Age and gender did not show significant predictive value in the outcome of revision repair. However, no differences were found in mean increase in Constant Score as a function of age and tear size.

Compliance with ethical standards

Conflict of interest Authors declare that they have no conflict of interest.

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Ethical approval The Institutional Review Board of Hospital Universitario Fundación Jiménez Díaz (Universidad Autónoma de Madrid) approved the study (No. 06/2016).

Informed consent Informed consent was obtained in all patients.

References

1. Abrams JS (2010) Management of the failed rotator cuff surgery: causation and management. Sports Med Arthrosc 18(3):188–197

2. Anderson K, Boothby M, Aschenbrener D, van Holsbeeck M (2016) Outcome and structural integrity after arthroscopic rotator cuff repair using 2 rows of fixation: minimum 2-year follow-up. Am J Sports Med 34(12):1899–1905
3. Burkhart SS, Barth JR, Richards DP, Zlatkin MB, Larsen M (2007) Arthroscopic repair of massive rotator cuff tears with stage 3 and 4 fatty degeneration. Arthroscopy 23(4):347–354
4. Chuang MJ, Jancosko J, Nottage WM (2014) Clinical outcomes of single-row arthroscopic revision rotator cuff repair. Orthopedics 37:e692–e698
5. Cole BJ, McCarty LP, Kang RW, Alford W, Lewis PB, Hayden JK (2007) Arthroscopic rotator cuff repair: prospective functional outcome and repair integrity at minimum 2-year follow-up. J Shoulder Elbow Surg 16(5):579–585
6. Constant CR, Murley AH (1987) A clinical method of functional assessment of the shoulder. Clin Orthop Relat Res 214:160–164
7. Denard PJ, Burkhart SS (2011) Arthroscopic revision rotator cuff repair. J Am Acad Orthop Surg 19(11):657–666
8. DeOrio JK, Cofield RH (1984) Results of a second attempt at surgical repair of a failed initial rotator-cuff repair. J Bone Joint Surg Am 66(4):563–567
9. Djurasovic M, Marra G, Arroyo JS, Pollock RG, Flatow EL, Bigliani LU (2001) Revision rotator cuff repair: factors influencing results. J Bone Joint Surg Am 83-A(12):1849–1855
10. Dwyer R, Razmjou H, Holtby R (2015) Full thickness rotator cuff tears in patients younger than 55 years: clinical outcome of arthroscopic repair in comparison with older patients. Knee Surg Sports Traumatol Arthrosc 23(2):508–513
11. Fuchs B, Weishaupt D, Zanetti M, Hodler J, Gerber C (1999) Fatty degeneration of the muscles of the rotator cuff: assessment by computed tomography versus magnetic resonance imaging. J Shoulder Elbow Surg 8(6):599–605
12. Hartzler RU, Sperling JW, Schleck CD, Cofield RH (2013) Clinical and radiographic factors influencing the results of revision rotator cuff repair. Int J Shoulder Surg 7(2):41–45
13. Katolik LI, Romeo AA, Cole BJ, Verma NN, Hayden JK, Bach BR (2005) Normalization of the constant score. J Shoulder Elbow Surg 14(3):279–285
14. Keener JD, Wei AS, Kim HM, Paxton ES, Teefey SA, Galatz LM, Yamaguchi K (2010) Revision arthroscopic rotator cuff repair: repair integrity and clinical outcome. J Bone Joint Surg Am 92(3):590–598
15. Kowalsky MS, Keener JD (2011) Revision arthroscopic rotator cuff repair: repair integrity and clinical outcome: surgical technique. J Bone Joint Surg Am 93(Suppl 1):62–74
16. Kukkonen J, Kauko T, Virolainen P, Äärimaa V (2015) The effect of tear size on the treatment outcome of operatively treated rotator cuff tears. Knee Surg Sports Traumatol Arthrosc 23(2):567–572
17. Lädermann A, Denard PJ, Burkhart SS (2011) Midterm outcome of arthroscopic revision repair of massive and nonmassive rotator cuff tears. Arthroscopy 27(12):1620–1627
18. Lädermann A, Denard PJ, Burkhart SS (2016) Management of failed rotator cuff repair: a systematic review. J ISAKOS 1(1):32–37
19. Lo IK, Burkhart SS (2004) Arthroscopic revision of failed rotator cuff repairs: technique and results. Arthroscopy 20(3):250–267
20. Oh JH, Kim SH, Ji HM, Jo KH, Bin SW, Gong HS (2009) Prognostic factors affecting anatomic outcome of rotator cuff repair and correlation with functional outcome. Arthroscopy 25(1):30–39
21. Oh JH, Kim SH, Shin SH, Chung SW, Kim JY, Kim SH, Kim SJ (2011) Outcome of rotator cuff repair in large-to-massive tear with pseudoparalysis: a comparative study with propensity score matching. Am J Sports Med 39(7):1413–1420
22. Parnes N, DeFranco M, Wells JH, Higgins LD, Warner JJ (2013) Complications after arthroscopic revision rotator cuff repair. Arthroscopy 29(9):1479–1486
23. Piasecki DP, Verma NN, Nho SJ, Bhatia S, Boniquit N, Cole BJ et al (2010) Outcomes after arthroscopic revision rotator cuff repair. Am J Sports Med 38(1):40–46
24. Shamsudin A, Lam PH, Peters K, Rubenis I, Hackett L, Murrell G (2015) Revision versus primary arthroscopic rotator cuff repair: a 2-year analysis of outcomes in 360 patients. Am J Sports Med 43(3):557–564
25. Strauss EJ, McCormack RA, Onyekwelu I, Rokito AS (2012) Management of failed arthroscopic rotator cuff repair. J Am Acad Orthop Surg 20(5):301–309
26. Visotsky JL, Basamania C, Seebauer L, Rockwood CA, Jensen KL (2004) Cuff tear arthropathy: pathogenesis, classification, and algorithm for treatment. J Bone Joint Surg Am 86-A(Suppl 2):35–40