Clinical Outcome of Partial Repair of Irreparable Rotator Cuff Tears*

Resultado clínico do reparo parcial nas roturas irreparáveis do manguito rotador

Eduardo Angeli Malavolta[1] Luca Martinez[1] Mauro Emilio Conforto Gracitelli[1]
Jorge Henrique Assunção[1] Fernando Brandão Andrade-Silva[1] Arnaldo Amado Ferreira Neto[1]

[1] Shoulder and Elbow Group, Instituto de Ortopedia e Traumatologia, Hospital das Clínicas HCFMUSP, Faculdade de Medicina, Universidade de São Paulo, São Paulo, SP, Brazil

Address for correspondence Eduardo Angeli Malavolta, MD, PhD, Rua Dr. Ovídio Pires de Campos, 333, Cerqueira Cesar, São Paulo, SP, 05403-010, Brazil (e-mail: eduardomalavolta@gmail.com).

Rev Bras Ortop 2022;57(1):136–143.

Abstract

Objective To evaluate the functional outcome of patients who underwent partial arthroscopic repair of massive rotator cuff tears.

Methods Retrospective case series evaluating patients with massive rotator cuff tears who underwent partial arthroscopic repair. The primary outcome was the American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form (ASES) at 24 months. The secondary outcomes were the Modified-University of California at Los Angeles Shoulder Rating Scale (UCLA), and the following subdomains: satisfaction, active forward flexion and strength of forward flexion subdomains.

Results We evaluated 33 patients. The ASES scale evolved from 39.7 ± 19.6 to 77.6 ± 17.4 ($p < 0.001$). The UCLA scale evolved from 13.3 ± 5.5 to 27.9 ± 5.6 ($p < 0.001$). The satisfaction rate was 97%. The number of patients with active forward flexion $> 150°$ increased from 12 (36.4%) to 25 (75.8%) ($p = 0.002$). The number of patients with normal or good strength of forward flexion increased from 9 (27.3%) to 22 (66.7%) ($p = 0.015$).

Conclusion Partial repair of irreparable rotator cuff tears leads to significant improvement according to the ASES and UCLA scales.

Keywords
- rotator cuff
- arthroscopy
- shoulder
- evaluation of results of therapeutic interventions

Resumo

Objetivo Avaliar o resultado funcional de pacientes submetidos ao reparo parcial por via artroscópica de roturas extensas do manguito rotador.

Métodos Série de casos retrospectiva, avaliando pacientes com roturas extensas do manguito rotador submetidos ao reparo parcial por via artroscópica. O desfecho

* *Study performed at Instituto de Ortopedia e Traumatologia, Hospital das Clínicas HCFMUSP, Faculdade de Medicina, Universidade de São Paulo, São Paulo, SP, Brazil.*

received
March 5, 2020
accepted
July 6, 2020
published online
October 29, 2020

DOI https://doi.org/10.1055/s-0040-1716763.
ISSN 0102-3616.

Thieme Revinter Publicações Ltda., Rua do Matoso 170, Rio de Janeiro, RJ, CEP 20270-135, Brazil

primário foi a escala American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form (ASES, na sigla em inglês) aos 24 meses. Foram desfechos secundários a escala Modified-University of California at Los Angeles Shoulder Rating Scale (UCLA, na sigla em inglês), e seus subdomínios satisfação, flexão anterior ativa e força de flexão anterior ativa.

Resultados Avaliamos 33 pacientes. A escala da ASES evoluiu de $39,7 \pm 19,6$ para $77,6 \pm 17,4$ ($p < 0,001$). A escala da UCLA evoluiu de $13,3 \pm 5,5$ para $27,9 \pm 5,6$ ($p < 0,001$). A taxa de satisfação foi de 97%. O número de pacientes com flexão anterior ativa $> 150°$ passou de 12 (36,4%) para 25 (75,8%) ($p = 0,002$). O número de pacientes com força de flexão anterior ativa normal ou boa passou de 9 (27,3%) para 22 (66,7%) ($p = 0,015$).

Conclusão O reparo parcial nas roturas irreparáveis do manguito rotador leva a melhora significativa de acordo com as escalas da ASES e UCLA.

Palavras-chave
- manguito rotador
- artroscopia
- ombro
- avaliação de resultado de intervenções terapêuticas

Introduction

Rotator cuff tears affect 20% of the population and up to 50% of patients > 80 years old;[1] it accounts for 23% of the visits to a shoulder surgeon.[2] The number of rotator cuff repair surgeries in Brazil increased 238% from 2003 to 2015.[3]

The treatment of irreparable rotator cuff tears is challenging and controversial, with no consensus in the medical literature. Several surgical techniques are described, such as debridement, subacromial balloon, biceps tenotomy or tenodesis, partial repair, interposition grafting, upper capsule reconstruction, tendon transfer, and reverse arthroplasty[4]

In 1994, Burkhart[5] described the concept of functional rotator cuff tear characterized by anatomical failure with intact biomechanics. In the same year, Burkhart et al.[6] reported a series of 14 patients submitted to the partial repair of the rotator cuff. In this technique, the authors repaired lesion margins, restoring the force balance and the shoulder "suspension bridge" system, but not completely closing the defect. Active elevation increased from 91° to 150° and the Modified-University of California at Los Angeles Shoulder Rating Scale (UCLA) score increased from 10 to 28 points.

In a systematic review, Malahias et al.[7] demonstrated that the partial repair significantly improves strength and functional scores. Maillot et al.,[8] in a meta-analysis, found no difference between partial repair, complete repair, and reverse arthroplasty.

Although the arthroscopic partial repair technique was described 25 years ago, few papers discuss it. A systematic review from 2019 found only 11 studies with a minimum follow-up period of 12 months and functional assessment using standardized scales.[7]

The present study aimed to evaluate functional outcomes in patients submitted to the partial arthroscopic repair of extensive rotator cuff tears.

Methods

This is a retrospective case series with prospective data collection. Patients were operated on by 4 surgeons from the same institution, all effective members of the Brazilian Society of Shoulder and Elbow Surgery and with > 10 years of experience. The procedures were performed from 2013 to 2017.

The study included patients submitted to a partial repair of the rotator cuff using an arthroscopic approach. Subjects with glenohumeral arthrosis, instability or adhesive capsulitis were not included in the radiographic evaluation. Patients who were not submitted to pre- or postoperative clinical evaluation were excluded.

The present study was approved by the institutional Ethics Committee under the number 1142.

Outcomes

Outcomes included the American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form (ASES)[9] score (primary outcome) and the UCLA[10] score (secondary outcome) 1 week prior to surgery and 6, 12 and 24 months after the procedure.

Both scales were applied by a research assistant who did not take part in the study.

Analyzed variables

The following variables were analyzed:

Patient-related variables: age, gender, dominant side involvement, smoking status, diabetes, systemic arterial hypertension, hypothyroidism, rheumatoid arthritis, chronic use of corticosteroids, previous surgery and infiltration, work issues.

Lesion-related variables: the Fuchs et al.[11] classification for the supraspinatus, infraspinatus and subscapularis muscles was determined at a preoperative magnetic resonance imaging (MRI) scan. Other variables (retraction and extension of rotator cuff tear; tear and instability of the long head of the biceps; and presence of glenohumeral arthrosis) were determined at an intraoperative inspection. Retraction at the coronal plane was measured according to Boileau et al.[12] and classified as following: stage I (minimal retraction, lesion border lateral to the joint surface, usually with < 10 mm of retraction); stage II (moderate retraction,

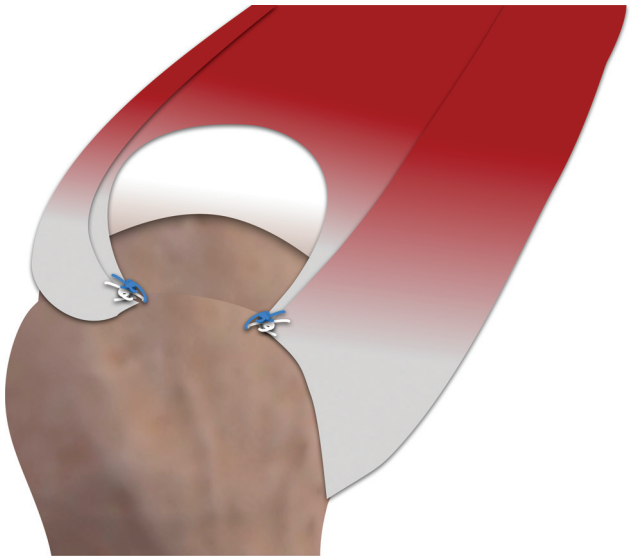

Fig. 1 Partial repair of the rotator cuff.

exposing the humeral head but not the glenoid cavity, usually with 10 to 30 mm of retraction); stage III (severe retraction, exposing the glenoid cavity, usually between 30 and 50 mm) and stage IV (massive tear, with medial retraction to the glenoid cavity).

Procedural variables: number of anchors used, acromioplasty and instrumentation at the long head of the biceps.

Intervention

The procedures were performed under general anesthesia with interscalene block. The patients were positioned in the beach chair position or in lateral recumbency at the surgeon's discretion. Conventional (posterior, anterior and lateral) portals were used, along with any additional required portals.

After detailed inspection and extensive bursectomy, lesion borders were pulled towards the bone bed with a grasper. If a complete repair was deemed impossible, tendon mobilization techniques, such as capsulotomy and rotator interval release, were employed. Margins were converged when required. Then, the tendon was repaired using a single row technique, including the subscapularis, when injured, and the posterosuperior portion of the rotator cuff (infraspinatus and supraspinatus muscles). The procedure was considered a partial repair when complete lesion repair was not feasible, and part of the exposed footprint remained.

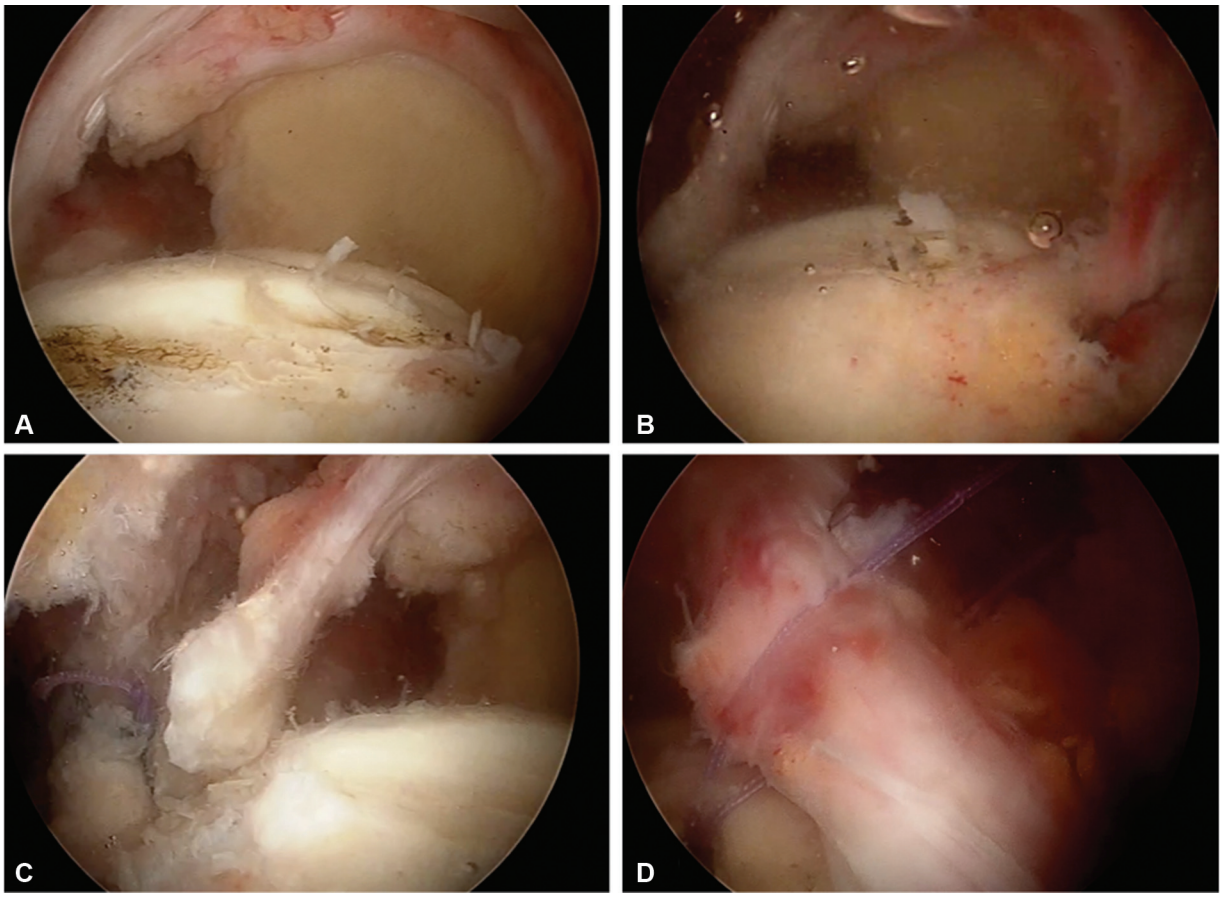

Fig. 2 Partial repair of the rotator cuff, arthroscopic view. (A) Before to the procedure; (B) After the procedure; (C) anterior margin (subscapularis) suture; (D) posterior margin (infraspinatus) suture.

►**Figure 1** shows a schematic representation of a partial repair, and ►**Figure 2** details one surgery from our case series.

Patients with partial tear or instability of the long head of the biceps were submitted to a tenodesis if they were < 65 years old or to a tenotomy if they were older. Acromioplasty was performed at the surgeon's discretion.

Rehabilitation

Patients were instructed to use a sling with an abdominal pad for 6 weeks, removing it only for bathing, and to perform elbow movements 3 times a day. Passive and active movements started 6 weeks after the procedure. Exercises to strengthen the rotator cuff and scapular stabilizing muscles started 12 weeks after the surgery. All patients were followed-up by a physiotherapist at the institution in presential visits twice a week, and oriented to perform daily exercises at home.

Statistical analysis

Continuous variables were assessed for normality using the Kolmogorov-Smirnov test and for homogeneity using the Levene test. Continuous variables are presented as mean, standard deviation (SD), median and interquartile range (IQR) and categorical variables are shown as absolute and percentage values. Functional outcomes according to the ASES and UCLA scores over different evaluation times were compared by the Friedman test with post-hoc Bonferroni adjustment. The UCLA subdomains (active anterior flexion and active anterior flexion strength) at the preoperative period and 24 months after surgery were compared using the Fisher test.

Data were analyzed using IBM SPSS Statistics for Windows, Version 21.0 (IBM Corp., Armonk, NY, USA), with a 5% significance level.

Results

During the evaluated period, 439 patients underwent surgery due to rotator cuff conditions. Those submitted to a complete repair of the rotator cuff (n = 385) or debridement (n = 12) were not included. Forty-two patients underwent a partial repair, but 9 were excluded due to the lack of a pre- or postoperative clinical evaluation; as such, the final sample for data analysis consisted of 33 patients.

The patients had, on average, 61.4 ± 7.3 years old at the time of surgery. Other general characteristics of the sample are shown in ►**Table 1**.

All patients presented a full-thickness tear in the entire length of the supraspinatus, mostly (54.5%) with retraction to the glenoid cavity. Infraspinatus tears affected 94% of the subjects, and 51% of the patients had a subscapularis full-thickness tear. Fatty degeneration was classified as Fuchs grade III in 33.3% of the patients for the supraspinatus, 27.3% for the infraspinatus and 6.1% for the subscapularis (►**Table 2**). ►**Table 3** shows the number of anchors used for the repair and additional procedures performed.

Table 1 General characteristics of the sample (patient-related variables)

	n	%
Gender		
Male	16	48.5
Female	17	51.5
Dominant side		
Yes	25	75.8
No	8	24.2
Smoking		
Smoker	2	6.1
Former smoker	6	18.2
No	25	75.8
Diabetes		
Yes	7	21.2
No	27	81.8
Systemic arterial hypertension		
Yes	14	42.4
No	19	57.6
Hypothyroidism		
Yes	4	12.1
No	29	87.9
Rheumatoid arthritis		
Yes	5	15.2
No	28	84.8
Chronic corticosteroid use		
Yes	1	3.0
No	32	97.0
Previous surgery		
Yes	2	6.1
No	31	93.9
Previous infiltration		
Yes	3	9.1
No	30	90.9
Work-related issues		
Yes	5	15.2
No	28	84.8

The ASES scores increased from 39.7 ± 19.6 in the preoperative period to 77.6 ± 17.4 at 24 months ($p < 0.001$). The UCLA scores also evolved favorably, increasing from 13.3 ± 5.5 to 27.9 ± 5.6 ($p < 0.001$). Both scores presented statistically significant improvements 6 months after surgery, as shown in ►**Table 4**.

Analysis of UCLA subdomains showed that 31 (94%), 31 (94%) and 32 (97%) of the patients were satisfied at 6, 12,

Table 2 General characteristics of the sample (lesion-related variables)

	n	%
Supraspinatus tear – Retraction		
Stage III	15	45.5
Stage IV	18	54.5
Fuchs classification (supraspinatus)		
Grade I	11	33.3
Grade II	11	33.3
Grade III	11	33.3
Infraspinatus tear – Extension		
Intact	2	6.1
Superior half	25	75.8
The entire tendon	6	18.2
Infraspinatus tear – Retraction		
Stage I	10	30.3
Stage II	6	18.2
Stage III	14	42.4
Stage IV	3	9.1
Fuchs classification (infraspinatus)		
Grade I	14	42.4
Grade II	10	30.3
Grade III	9	27.3
Subscapularis tear		
Intact	9	27.3
Partial, superior 1/3	7	21.2
Full-thickness, superior 1/3	6	18.2
Full-thickness, superior 2/3	8	24.2
The entire tendon	3	9.1
Fuchs classification (subscapularis)		
Grade I	23	69.7
Grade II	8	24.2
Grade III	2	6.1
Long head of the biceps tear		
Intact	15	45.5
Partial tear	14	42.4
Complete tear	4	12.1
Instability at the long head of the biceps		
Stable	11	33.3
Instable	9	27.3
Dislocation	10	30.3
Not applicable	3	9.1
Mild glenohumeral arthrosis		
Yes	5	15.2
No	28	84.8

Table 3 General characteristics of the sample (procedural variables)

	n	%
Supraspinatus or infraspinatus anchors		
1	10	30.3
2	17	51.5
≥ 3	6	18.2
Subscapularis anchors		
0	11	33.3
1	20	60.6
2	2	6.1
Acromioplasty		
Yes	9	27.3
No	24	72.7
long head of the biceps procedure		
None	9	27.3
Tenotomy	12	36.4
Tenodesis	12	36.4

Table 4 Pre- and postoperative functional evaluation

	Mean	Standard deviation	Median	IQR	*p-value*
UCLA					
Preoperative	13.3	5.5	12.7	7.5	$p < 0.001^*$
6 months	27.2	5.8	28.0	6.5	
12 months	28.1	6.4	29.0	7.0	
24 months	27.9	5.6	29.0	10.5	
ASES					
Preoperative	39.7	19.6	37.0	22.9	$p < 0.001^*$
6 months	69.6	21.2	73.3	31.5	
12 months	75.7	20.5	80.0	30.0	
24 months	77,6	17,4	83,8	27,6	

Abbreviations: ASES, American Shoulder and Elbow Surgeons Standardized Shoulder Assessment Form score; IQR, Interquartile range; UCLA, Modified-University of California at Los Angeles Shoulder Rating Scale.
*values from the Friedman test.
Post-hoc and Bonferroni analyses:
According to the UCLA scale, preoperative values differed from those obtained at 6, 12 and 24 months ($p < 0.001$). Further comparisons (6 × 12 months, 6 × 24 months, and 12 × 24 months) revealed no statistically significant difference ($p = 0.408$, 0.588, and 0.945, respectively).
According to the ASES score, preoperative values differed from those obtained at 6, 12 and 24 months ($p < 0.001$) and between 6 and 24 months ($p = 0.028$). Further comparisons (6 × 12 months, and 12 × 24 months) revealed no statistically significant difference ($p = 0.150$ and 0.426, respectively).

Table 5 Pre- and postoperative active anterior flexion

	Active anterior flexion				
	Preoperative		24 months		*p-value*
	n	%	*n*	%	
≥ 150°	12	36.4	25	75.8	0.002
120°-150°	11	33.3	1	3.0	
90°-120°	7	21.2	5	15.2	
45-90°	1	3.0	1	3.0	
<45°	2	6.1	1	3.0	

Table 6 Pre- and postoperative active anterior flexion force

	Active anterior flexion force				
	Preoperative		24 months		*p-value*
	n	%	*n*	%	
Grade 5 (Normal)	3	9.1	12	36.4	0.015
Grade 4 (Good)	6	18.2	10	30.3	
Grade 3 (Regular)	12	36.4	7	21.2	
Grade 2 (Poor)	6	18.2	3	9.1	
Grade 1 (Muscle contraction)	6	18.2	1	3.0	

and 24 months of follow-up, respectively. Active anterior flexion increased from an average of 2.8 to 3.9 points, and the number of patients with flexion > 150° increased from 12 (36.4%) to 25 (75.8%), with a statistically significant difference ($p = 0.002$) (►**Table 5**). Range of motion improved in 18 patients, worsened in 6 and was unaltered in 9. The average active anterior flexion strength increased from 3.9 to 4.5 points, and the number of patients with normal or good strength increased from 9 (27.3%) to 22 (66.7%), with a statistically significant difference ($p = 0.015$) (►**Table 6**).

Discussion

Our study revealed significant improvements in clinical scores. The ASES score increased from 39.7 to 77.6 points ($p < 0.001$) at 24 months, while the UCLA score increased from 13.3 to 27.9 points ($p < 0.001$), both with statistical significance and clinical relevance.[13] These outcomes are consistent with other papers evaluating the partial repair of the rotator cuff. Using the ASES score, Cuff et al.[14] observed an increase from 46.6 to 79.3 points, while Holtby et al.[15] detected an increase from 42.7 to 71.4 points. For the UCLA score, Burkhart et al.[6] demonstrated an increase from 9.8 to 27.6, whereas Franceschi et al.[16] reported an increase from 8.6 to 28.8. and Iagulli et al.[17] from 12.1 to 29.5. Authors using the Constant score reported preoperative values ranging from 36.3 to 45.9, and postoperative values ranging from 69.9 to 75.3.[15,18–21]

So far, there are no randomized studies comparing the main methods for irreparable rotator cuff tears treatment. In the absence of these studies, the comparison of case series using different therapeutic techniques is all that remains. An important caveat in this type of comparison is that populations may not be similar, resulting in selection bias. Compared with studies evaluating upper capsule reconstruction, our outcomes were inferior than those reported by Mihata et al.[22] and Burkhart et al.,[23] with ASES scores of 92.9 and 89 points, respectively. However, Pennington et al.,[24] Denard et al.,[25] and Hirahara et al.[26] reported ASES scores of 82, 77.5 and 70.7 points, respectively; such scores are similar to those obtained in our series. Reverse arthroplasty, another option for irreparable rotator cuff tears treatment, resulted in an average ASES score of 72.2 points and in a UCLA score of 26.9 points according to a systematic review by Petrillo et al.;[27] these data are also similar to those observed in our study. However, this review included patients with irreparable tears and rotator cuff arthropathy, who were also older when compared to our subjects. Maillot et al.,[8] in a meta-analysis involving 20 studies and 1,233 patients, compared different forms of treatment for large or extensive rotator cuff tears (conservative treatment, debridement, partial repair, complete repair, latissimus dorsi transfer, patches, platelet-rich plasma, and reverse arthroplasty). Latissimus dorsi transfer was the only treatment showing superiority over the others. Conservative treatment, partial repair, complete repair, and reverse arthroplasty had similar clinical outcomes.

In our series, 97% of the patients reported satisfaction with the procedure, a value higher than those reported by Cuff et al.[14] (82%) and Heuberer et al.[28] (86%). However, this value derived from a subdomain of the UCLA scale, and not from a specific question about satisfaction, which may justify the difference.

Active anterior flexion improved significantly in our series, and the percentage of patients with a range of motion ≥150° increased from 36.4 to 75.8%. This improvement is consistent with other reports.[6,16,21] Likewise, active anterior flexion strength showed a statistically significant improvement, with 66.7% of the patients with normal or good strength after the procedure, compared to 27.3% before surgery. Other authors have also demonstrated a strength improvement after partial repair of the rotator cuff.[6,15,16,19,20] It is worth mentioning that the arthroscopic repair of the rotator cuff is effective in reversing shoulder pseudoparalysis[29] and that the good outcomes from extensive tear repairs are sustained in the medium and long term.[30] However, it is important to highlight that these outcomes are not excellent, and 24.2% of the subjects could not raise their arms > 150°, and 33.3% still presented important weakness at the end of the follow-up period.

Our study has some limitations. It was retrospective and noncomparative. However, data were collected prospectively, which reduces measurement bias. In addition, a recent systematic review has shown that most studies on this topic

are indeed retrospective.[7] The sample of 33 patients may be considered small, but similar studies reported 14 to 73 partial repairs.[6,7] Anterior flexion strength does not reflect the whole biomechanics of the shoulder, and the measurement of abduction, lateral and medial rotation forces could add important information to the pre- and postoperative functional analysis. Strength, range of motion and satisfaction were assessed using subdomains from the UCLA scale, and not in a more detailed, objective manner, which can be a reason for bias. Finally, patients were not submitted to imaging tests after the repair. Malahias et al.[7] demonstrated that 49% of patients undergoing a partial repair have re-tears.

Our data show that the partial repair of the rotator cuff is successful in the treatment of extensive rotator cuff tears. The decision between different surgical options must consider the surgeons' experience and individual patient characteristics. Randomized studies are required to elucidate the best form of treatment for extensive and irreparable rotator cuff tears.

Conclusion

Partial repair of irreparable rotator cuff tears leads to significant improvement according to the ASES and UCLA scores, both in a statistically significant and clinically relevant way.

Financial Support
There was no financial support from public, commercial, or not-for-profit sources.

Conflict of Interests
The authors have no conflict of interests to declare.

References

1 Yamamoto A, Takagishi K, Osawa T, et al. Prevalence and risk factors of a rotator cuff tear in the general population. J Shoulder Elbow Surg 2010;19(01):116–120
2 Malavolta EA, Gracitelli MEC, Assunção JH, Pinto GMR, da Silveira AZF, Ferreira AA. Shoulder disorders in an outpatient clinic: an epidemiological study. Acta Ortop Bras 2017;25(03):78–80
3 Malavolta EA, Assunção JH, Beraldo RA, Pinto GMR, Gracitelli MEC, Ferreira Neto AA. Rotator cuff repair in the Brazilian Unified Health System: Brazilian trends from 2003 to 2015. Rev Bras Ortop 2017;52(04):501–505
4 Kooistra B, Gurnani N, Weening A, van den Bekerom M, van Deurzen D. Low level of evidence for all treatment modalities for irreparable posterosuperior rotator cuff tears. Knee Surg Sports Traumatol Arthrosc 2019;27(12):4038–4048
5 Burkhart SS. Reconciling the paradox of rotator cuff repair versus debridement: a unified biomechanical rationale for the treatment of rotator cuff tears. Arthroscopy 1994;10(01):4–19
6 Burkhart SS, Nottage WM, Ogilvie-Harris DJ, Kohn HS, Pachelli A. Partial repair of irreparable rotator cuff tears. Arthroscopy 1994; 10(04):363–370
7 Malahias MA, Kostretzis L, Chronopoulos E, Brilakis E, Avramidis G, Antonogiannakis E. Arthroscopic partial repair for massive rotator cuff tears: does it work? A systematic review. Sports Med Open 2019;5(01):13
8 Maillot C, Martellotto A, Demezon H, Harly E, Le Huec J-C. Multiple Treatment Comparisons for Large and Massive Rotator Cuff Tears: A Network Meta-analysis. Clin J Sport Med 2019;•••;. Doi: 10.1097/JSM.0000000000000786
9 Knaut LA, Moser ADL, Melo SdeA, Richards RR. Translation and cultural adaptation to the portuguese language of the American Shoulder and Elbow Surgeons Standardized Shoulder assessment form (ASES) for evaluation of shoulder function. Rev Bras Reumatol 2010;50(02):176–189
10 Oku EC, Andrade AP, Stadiniky SP, Carrera EF. Tradução e adaptação cultural do Modified-University of California at Los Angeles Shoulder Rating Scale para a língua portuguesa. Rev Bras Reumatol 2006;46(04):246–252
11 Fuchs B, Weishaupt D, Zanetti M, Hodler J, Gerber C. Fatty degeneration of the muscles of the rotator cuff: assessment by computed tomography versus magnetic resonance imaging. J Shoulder Elbow Surg 1999;8(06):599–605
12 Boileau P, Brassart N, Watkinson DJ, Carles M, Hatzidakis AM, Krishnan SG. Arthroscopic repair of full-thickness tears of the supraspinatus: does the tendon really heal? J Bone Joint Surg Am 2005;87(06):1229–1240
13 Cvetanovich GL, Gowd AK, Liu JN, et al. Establishing clinically significant outcome after arthroscopic rotator cuff repair. J Shoulder Elbow Surg 2019;28(05):939–948
14 Cuff DJ, Pupello DR, Santoni BG. Partial rotator cuff repair and biceps tenotomy for the treatment of patients with massive cuff tears and retained overhead elevation: midterm outcomes with a minimum 5 years of follow-up. J Shoulder Elbow Surg 2016;25 (11):1803–1809
15 Holtby R, Razmjou H. Relationship between clinical and surgical findings and reparability of large and massive rotator cuff tears: a longitudinal study. BMC Musculoskelet Disord 2014;15:180
16 Franceschi F, Papalia R, Vasta S, Leonardi F, Maffulli N, Denaro V. Surgical management of irreparable rotator cuff tears. Knee Surg Sports Traumatol Arthrosc 2015;23(02):494–501
17 Iagulli ND, Field LD, Hobgood ER, Ramsey JR, Savoie FH III. Comparison of partial versus complete arthroscopic repair of massive rotator cuff tears. Am J Sports Med 2012;40(05): 1022–1026
18 Berth A, Neumann W, Awiszus F, Pap G. Massive rotator cuff tears: functional outcome after debridement or arthroscopic partial repair. J Orthop Traumatol 2010;11(01):13–20
19 Godenèche A, Freychet B, Lanzetti RM, Clechet J, Carrillon Y, Saffarini M. Should massive rotator cuff tears be reconstructed even when only partially repairable? Knee Surg Sports Traumatol Arthrosc 2017;25(07):2164–2173
20 Kim SJ, Lee IS, Kim SH, Lee WY, Chun YM. Arthroscopic partial repair of irreparable large to massive rotator cuff tears. Arthroscopy 2012;28(06):761–768
21 Mori D, Funakoshi N, Yamashita F. Arthroscopic surgery of irreparable large or massive rotator cuff tears with low-grade fatty degeneration of the infraspinatus: patch autograft procedure versus partial repair procedure. Arthroscopy 2013;29(12):1911–1921
22 Mihata T, Lee TQ, Watanabe C, et al. Clinical results of arthroscopic superior capsule reconstruction for irreparable rotator cuff tears. Arthroscopy 2013;29(03):459–470
23 Burkhart SS, Hartzler RU. Superior Capsular Reconstruction Reverses Profound Pseudoparalysis in Patients With Irreparable Rotator Cuff Tears and Minimal or No Glenohumeral Arthritis. Arthroscopy 2019;35(01):22–28
24 Pennington WT, Bartz BA, Pauli JM, Walker CE, Schmidt W. Arthroscopic Superior Capsular Reconstruction With Acellular Dermal Allograft for the Treatment of Massive Irreparable Rotator Cuff Tears: Short-Term Clinical Outcomes and the Radiographic Parameter of Superior Capsular Distance. Arthroscopy 2018;34 (06):1764–1773
25 Denard PJ, Brady PC, Adams CR, Tokish JM, Burkhart SS. Preliminary Results of Arthroscopic Superior Capsule Reconstruction with Dermal Allograft. Arthroscopy 2018;34(01):93–99

26 Hirahara AM, Andersen WJ, Panero AJ. Superior Capsular Reconstruction: Clinical Outcomes After Minimum 2-Year Follow-Up. Am J Orthop 2017;46(06):266–278
27 Petrillo S, Longo UG, Papalia R, Denaro V. Reverse shoulder arthroplasty for massive irreparable rotator cuff tears and cuff tear arthropathy: a systematic review. Musculoskelet Surg 2017; 101(02):105–112
28 Heuberer PR, Kölblinger R, Buchleitner S, et al. Arthroscopic management of massive rotator cuff tears: an evaluation of debridement, complete, and partial repair with and without force couple restoration. Knee Surg Sports Traumatol Arthrosc 2016;24 (12):3828–3837
29 Miyazaki AN, Fregoneze M, Santos PD, et al. Avaliação funcional do reparo artroscópico da lesão do manguito rotador em pacientes com pseudoparalisia. Rev Bras Ortop 2014;49(02): 178–182
30 Miyazaki AN, Santos PD, da Silva LA, do Val Sella G, Checchia SL, Yonamine AM. Are the good functional results from arthroscopic repair of massive rotator cuff injuries maintained over the long term? Rev Bras Ortop 2015;51(01):40–44