Functional outcome of arthroscopic debridement for massive, irreparable rotator cuff tears

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Abstract. Background and aim of the work. Rotator cuff tears are a common cause of shoulder pain in the middle-aged population. The treatment of these lesions remains controversial and must be individualized on the basis of the type of patient, the clinical and anatomical picture. Arthroscopic debridement is indicated in painful massive tears, in the absence of severe functional impairment of the shoulder. The aim of this study is the evaluation of the short and medium term clinical results of this surgical procedure. Methods. We retrospectively assessed patients who underwent arthroscopic debridement surgery for massive rotator cuff injury in the period between January 2011 and December 2016 at our institution. A group of patients underwent a follow-up evaluation during which the Constant Score, Oxford Shoulder Score and NRS pain score were compiled. Those who were unable to attend the evaluation were assessed through a telephone questionnaire aimed at investigating pain and degree of satisfaction with the outcome of the treatment. Results. 93% of patients were satisfied with the results obtained, especially the decrease in pain, with an average NRS of 1.31 for patients undergoing the medical examination and 0.68 for patients contacted by telephone. The mean Constant score of the clinically evaluated patients was 75.6 ± sd, with a mean strength of 3.92 ± sd, while the mean value of the Oxford Shoulder Score was 16.8 ± sd. Conclusions. The study suggests that arthroscopic debridement is a viable therapeutic option for the surgical treatment of massive rotator cuff tears. The clinical results and patient satisfaction are conditioned by the preoperative functional status: an optimal outcome can be expected for painful shoulders with sufficiently preserved active mobility. A great advantage of arthroscopic debridement is the short and simple postoperative rehabilitation.

Key words: shoulder; massive rotator cuff tear; arthroscopic debridement.

Introduction

Rotator Cuff Tears (RCT) are a common source of pain and disability, especially in the elderly population (1). The management of patients affected by RCT includes several treatment options ranging from conservative methods to shoulder replacement. The treatment choice is influenced by different factors, that are related either to the lesion (size, location, pathogenesis, time of onset) or to the patient (age, clinical status, functional demands) (2–6).

In case of symptomatic small and medium RCT, surgical repair usually yields to good outcomes and patients’ satisfaction (7).

Conversely, massive RCT, are still a difficult and challenging problem (8). The definition of massive RCT varies in literature: in fact according to Cofield et al. (9, 10), a tear with antero-posterior or medio-lateral diameter ≥ 5 cm is considered massive, while Gerber et al. (11) defined massive a complete tear of
two or more tendons.

Rockwood and others defined irreparable tears as those that, because of their size and retraction, cannot be repaired primarily to their insertion onto the tuberosities despite conventional techniques of mobilization and soft-tissue releases (12).

According to Bedi et al (13) a massive RCT is considered irreparable if associated with cranial migration of the humeral head, and severe muscle atrophy and fatty infiltration.

The reported incidence of RCT varies from 5 to 40% and the prevalence increases with the age, reaching 50% in patients over 80 years old (14).

The real incidence of massive RCT is difficult to estimate (15), because they are often due to slow, degenerative process, associated with none or few symptoms; in fact several cadaveric and in vivo studies have shown that rates of asymptomatic rotator cuff tears increase proportionally with age, with 20% of patients in their 60s and up to 80% of patients over 80 years-old having tears (16).

However, given the insidious nature of rotator cuff disease, many patients do not seek treatment until considerable degeneration has occurred, presenting a formidable challenge to the surgeon (17).

In literature, several treatment modalities have been described for the management of massive RCT. Conservative therapies include non-steroidal anti-inflammatory drugs, local corticosteroids injections and rehabilitation programs to strengthen the deltoid and the residual cuff (18, 19). Surgical options include complete repair (interval slide or side to side technique), partial repair (20-23), superior capsular reconstruction (24-26), subacromial spacer (27-29), tendon transfer (30, 31), cuff debridement with or without tenotomy or tenodesis of the long head of the biceps (32-34), tuberoplasty, graft with or without biceps augmentation, shoulder hemiarthroplasty and total shoulder reverse arthroplasty (35-37).

The main goal of arthroscopic debridement is pain relief and improvement of shoulder motion secondary to discomfort reduction, while strength recovery is not to be expected (38). Therefore, this procedure is mainly indicated in older patients with massive/irreparable RCT, complaining of pain recalcitrant to conservative therapies, but not exhibiting severe restriction of active shoulder motion (8). Arthtoscopic debridement could be indicated even in some younger patients with massive, irreparable cuff tear that could prefer, at least initially, a less invasive treatment with quicker rehabilitation program just to achieve pain reduction.

The primary aim of this study is to assess the mid-term clinical outcome of arthroscopic debridement and tenotomy of the long head of the biceps for massive, irreparable RCT. The secondary aim is to evaluate if tear location (supero-posterior vs supero-anterior) influences the result.

Materials and methods

We retrospectively identified all consecutive patients who underwent arthroscopic debridement for massive, irreparable RCT between January 2011 and December 2016 at our institution consulting the surgical records. All the procedures were performed by the same surgeon. The study design protocol was approved by the Institutional Review Boards of Novara (Number of protocol 186/19) and it was conducted under the principles of the Declaration of Helsinki.

The diagnosis of massive, irreparable RCT was made through clinical examination and confirmed by MRI (Fig.1). Shoulder imaging was necessary to assess tear pattern and muscle condition. Tendon retraction and muscle fatty infiltration were evaluated using Patte and Goutallier (39) classifications, respectively. RCT were classified as massive when there was complete tear of two or more tendons and irreparable if fatty infiltration of tendons involved was at least III stage according to Goutallier (19).

Patients with a preoperative least active forward elevation of 90°, a reported pain ≥ 6/10 were included.

Patients who had previous surgery on the affected shoulder and those with radiographic signs of gleno-humeral arthropathy were excluded.

All operations were performed in beach-chair position and under regional (interscalene block) and general anesthesia. Tenotomy of the Long Head of the Biceps (LHB) was performed in case of its instability, degeneration or chronic synovitis. 

The success of this procedure was evaluated after 18 ± 12 months. The first aim was to evaluate the result.
sue was evaluated as well. If the tear was considered irreparable after this assessment, the debridement was carried out by removing debris and loose fragments of tendons, shaving their frayed edges and ablating the inflamed synovial tissue. Subacromial decompression was performed in patients that presented an acromion type II or III according to Bigliani (40) with an evident subacromial impingement of the supraspinatus tendon and consisted in the excision of subacromial spurs, with maintenance of the coracoacromial arch, in order to prevent antero-superior migration of the humeral head.

After surgery, the arm was kept in a sling to control postoperative pain. Passive and active mobilization was started immediately and continued until full motion was recovered.

At the time of this study, the patients were contacted for a follow up visit, in order to assess shoulder ROM and strength (Kg) in forward elevation and abduction by means of a dynamometer; the Constant-Murley score (CMS), Oxford Shoulder Score (OSS) and Numeric Rating scale (NRS) for pain were also recorded. Patients unable to attend the visit were asked to take part in a telephone interview, to inquire their postoperative history and collect the NRS for pain and the OSS. All included patients were assessed for satisfaction and classified in the following 4 degrees: very satisfied, satisfied, disappointed, dissatisfied.

Statistical analysis was performed with STATA software. Descriptive statistics were used to present patients’ characteristics. Normal distributed continuous variables were expressed as mean +/- standard deviation (SD), non-normal distributed continuous variables as median and range and categorical data with frequencies and percentages. The Chi-square or Fisher exact test was used for discrete variable association, while for continuous variables independent t tests and Mann-Whitney tests were used. The level of statistical significance was set at p value < 0,05 with a confidence interval of 95%.

Results

107 patients were eligible for our study. 34 could not collaborate with data collection, 2 died during the follow-up and 1 patient underwent reoperation: these patients were excluded from analysis. All the enrolled patients agreed to attend this study and signed an informed consent for the anonymous collection of their data.

At a mean follow up of 64 months (range 29-98 months) 70 patients were evaluated: 42 clinically, while 28 were investigated by telephone interview.

44 (63%) patients were men and 26 (37%) women. Their mean age at the time of surgery was 61,77 +/- 8,18 years; 48 (69%) patients were operated at the dominant arm, 22 (31%) at the non dominant arm. At the time of surgery, 11 (16%) patients were active smokers and 9 (13%) diabetic. Baseline patient’s characteristics are reported in Table 1.

The MRI evaluation revealed that supraspinatus tendon was torn in all patients, presenting grade 2 re-
traction according to Patte in 28 cases and grade 3 in 42; the infraspinatus tendon was involved in 45 cases, the subscapularis in 11 while in 4 cases the three tendons were torn. Severe fatty infiltration was found in all cases. In 10 shoulders the LHB was absent and in the remaining 60 LHB tenotomy was performed.

At the follow-up evaluation mean OSS was 16,8 +/- 6,4 (range 12-43); mean NRS value was 1,06 +/- 1,9 (range 0-8), in particular for patients that underwent clinical evaluation mean NRS was 1,31 and for patients investigated only by telephone the value was 0,68.

Mean CMS value was 75,6 +/- 10,5 (range 52,9-97), with a mean strength of 3,92 +/- 2,82 Kg.

With regard to the degree of satisfaction, 54 patients were very satisfied, 11 satisfied, 5 disappointed and none of the patients evaluated was dissatisfied.

No differences were encountered in clinical and functional mean +/-SD scores between postero- and antero-superior RCT: postero-superior CMS 76,25 +/-10,43, OSS 16,33 +/-6,92, NRS 0,95 +/-1,90, antero-superior CMS 76,57 +/-14,68, OSS 17,27 +/-5,25, NRS 1,18 +/-1,99. Statistical significance was
insufficient in all the aforementioned results with a p-value > 0.05 (Table 2).

Significant better results in terms of CMS were obtained in patients operated on the non dominant arm (81.6 +/- 3.88), compared to those operated on the dominant one (73.44 +/- 11.35)(p=0.0071), and in men compared to women, considering OSS (p=0.02) and CMS (p=0.002): men OSS 15.54 +/- 5.02, CMS 78.64 +/- 9.51, women OSS 19.04 +/- 7.95, CMS 67.92 +/- 9.28.

No significant differences were found between diabetic (CMS 68.18 +/- 12.79, OSS 19.22 +/- 6.72, NRS 2.33 +/- 2.55) and non diabetic patients (CMS 76.58 +/- 9.99, OSS 16.49 +/- 6.38, NRS 0.87 +/- 1.76) and between active smokers (CMS 68.64 +/- 10.26, OSS 20.82 +/- 2.80, NRS 2.36 +/- 2.90) and non smokers (CMS 76.51 +/- 10.36, OSS 16.10 +/- 5.56, NRS 0.81 +/- 1.60) (Table 3).

**Discussion**

Different treatment options have been proposed for massive RCT, but the ideal management is still controversial (41).

This kind of injury usually occurs in elderly patients, that can be totally asymptomatic without significant functional limitation; however, when RCT get symptomatic, patients complain about functional limitation.
impairment and pain that interferes with sleep and daily living activities (8). Conservative management should always be considered at first, with pain control and strengthening exercises.

If conservative treatment fails, surgery is indicated (12). Several treatment options are available, such as subacromial balloon spacer placement or tendon transfer. Subacromial balloon spacer is a good option mainly indicated for lower demand patients as shown in a recent systematic review (42). Tendon transfer could also be promising for cases in which rotator cuff tendons are ruptured and have retracted beyond surgical repair or those in which other attempts at surgical repair have failed (43).

Complete rotator cuff repair, if possible, can guarantee a better outcome (44), but in this kind of injury results of repair are inhomogeneous, because usually RCT is chronic, with high degree of retraction, characterized by friable tissue, muscle atrophy and high degree of fatty muscular infiltration. All these factors can easily lead to non consolidation of the lesion after repair (8).

According to many authors re-rupture after rotator cuff repair occur in 20-65% over time and this percentage increases with different factors such as age, tendon retraction, atrophy of rotator cuff muscles and fatty infiltration (11, 45).

Randelli et al.(46) in a recent study reported that at 10 years follow up 53,47% of previously repaired RCT was still intact at ultrasound examination and they found that re-rupture is related especially to RCT size at the time of surgery.

However, it’s important to appreciate that the presence of a persistent rotator cuff defect doesn’t necessarily imply a clinical failure and is compatible with a good postoperative result; in fact, even in elder patient the rate of re-tear increases, the functional requirements decrease and subjective satisfaction is reported, even without anatomical integrity of rotator cuff. The conversion of a symptomatic rotator cuff tear into an asymptomatic re-tear is not entirely clear, but probably is due to subacromial decompression, debridement and biceps tenotomy (47).

In patients with irreparable RCT, Rockwood et al. (12) performed debridement, evaluated clinical outcome at 6,5 years follow-up and reported a 83% pain reduction rate and the average mobility improved from

| Table 1: patients characteristics |
|----------------------------------|
| Gender                          |
| Male                            | 44 (67%) |
| Female                          | 26 (37%) |
| Age                             |
| Minimum                         | 51      |
| Maximum                         | 85      |
| Mean (± SD)                     | 67,2 (± 7,91) |
| Operated Side                   |
| Dominant                        | 48 (69%) |
| Non dominant                    | 22 (31%) |
| Smoking                         |
| Yes                             | 11 (16%) |
| No                              | 59 (84%) |
| Diabetes                        |
| Yes                             | 9 (13%)  |
| No                              | 61 (87%) |
| Classification                  |
| Posterosuperior                 | 45 (75%) |
| Anterosuperior                  | 11 (18%) |
| Antero and Posterosuperior      | 4 (7%)   |

| Table 2: postero-superior RCT vs antero-superior RCT |
|------------------------------------------------------|
| Postero-Superior Ret      | Antero-Superior Ret |
| CMS 76,25 +/-10,43        | 76,57 +/-14,68      |
| OSS 16,33 +/-6,92         | 17,27 +/-5,25       |
| NRS 0,95 +/-1,90          | 1,18 +/-1,99        |

| Table 3: results |
|------------------|
| CMS   | OSS   | NRS   |
| Operated Side   |
| Dominant arm    | 73,44 +/- 11,35 17,79 +/- 7,02 1,23 +/- 2,17 |
| Non dominant arm| 81,6 +/- 3,88 14,77 +/- 4,42 0,68 +/- 1,17 |
| Gender          |
| Male            | 78,64 +/- 9,51 15,54 +/- 5,02 0,84 +/- 1,60 |
| Female          | 67,92 +/- 9,28 19,04 +/- 7,95 1,42 +/- 2,37 |
| Diabetic        |
| Yes             | 68,18 +/- 12,79 19,22 +/- 6,72 2,33 +/- 2,55 |
| No              | 76,58 +/- 9,99 16,49 +/- 6,38 0,87 +/- 1,76 |
| Smoker          |
| Yes             | 68,64 +/- 10,26 20,82 +/- 2,80 2,36 +/- 2,90 |
| No              | 76,51 +/- 10,36 16,10 +/- 5,56 0,81 +/- 1,60 |
105 degrees of active elevation preoperatively to 140 degrees postoperatively.

Also Garstaman (48) reported good postoperative results after arthroscopic debridement: in particular average CMS improved from 31 points preoperatively to 52 points postoperatively.

Results of this study suggest that debridement can offer good results in terms of pain reduction and improvement of the range of motion; several authors reported good clinical results after arthroscopic debridement, but also worsening of the radiological condition, with a significant reduction of the acromiohumeral distance and progression to ostheoarthritis (32, 49, 50).

Berth et al (1) performed a prospective randomized study involving 42 patients with massive RCT, treated with debridement or partial repair of RCT and at 2 years follow-up they found good functional results in both groups, but better clinical outcome for those patients that underwent repair of the cuff tear, regardless of high rate of structural fail of the repair.

The primary goal of debridement is to eliminate possible sources of shoulder pain (38). The removal of rotator cuff unstable remnants and subacromial bursa, according to Burkhart et al. reduces mechanical irritation and inflammation (51).

The role of acromioplasty is controversial because it can weaken coracoacromial arch and cause, together with RCT, superior migration of humeral head (8, 49). Fenlin et al. (52) suggested that in these cases tuberculosis can be performed in order to restore acromiohumeral articulation, as we did in our case series.

Considering that in this kind of injury the LHB is an important source of pain, (38, 53) we performed tenotomy in all cases; Boileau et al. (32) in a series of patients with massive RCT performed arthroscopic biceps tenotomy or tenodesis and at a minimum follow-up of 2 years reported excellent results in terms of pain and dysfunction reduction and no difference between tenotomy and tenodesis groups. Moreover Walch et al. evaluated at a mean follow-up of 57 months, 307 patients that underwent arthroscopic biceps tenotomy for an irreparable RCT; the mean CMS increased from 48.4 points preoperatively to 67.6 points postoperatively, 87% of patients were satisfied or very satisfied with the result. They also performed radiographic examination that showed that acromiohumeral interval decreased by a mean of 1.3 mm during the follow-up period and that there wasn’t significant progression of glenohumeral arthritis. Acromioplasty guaranteed better subjective and objective results only in patients with an acromiohumeral distance greater than 6 mm. Muscle fatty infiltration had a negative influence on both the functional and radiographic results.

Collin et al. (41) suggested that a rotator cuff tear that involves the supraspinatus and the entire subscapularis is a risk factor for pseudoparalysis; nevertheless in our study no significant difference in terms of clinical outcome between antero and postero superior RCT was reported. This could be probably due to the fact that the lesion of subscapularis, in most patients, involved mainly the superior part of the tendon, which is associated with a better range of motion.

One of the main risk of arthroscopic debridement is the progression to eccentric ostheoarthritis that may occur few years after arthroscopic debridement. In this case there are two options: the patient is asymptomatic, not complaining pain or functional limitations, and in this case there are no further surgical indications, or the patient has a symptomatic arthritis; in this case there still is the chance for a reverse prosthesis implant.

Limitations of our study include the small sample size and the retrospective design with lack of preoperative data about shoulder pain and function, that didn’t allow a comparison with postoperative results; moreover, patients at follow up didn’t undergo radiological evaluation to assess the acromio-humeral distance and progression to ostheoarthritis.

**Conclusions**

Our study suggests that arthroscopic debridement of massive RCT can be a good surgical option in selected patients; in fact, according to our experience is indicated in elderly patients, with severe and constant pain, good remaining mobility, low expectations in terms of functionality. The short operation time, a low rate of complications and the possibility of a quicker rehabilitation program are also to be considered. Further studies with a longer follow-up are needed to evaluate the actual risks and benefits of debridement for massive rotator cuff tears over time.
Conflict of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article.

References

1. 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(1):13–20.
2. Ainsworth R, Lewis JS. Exercise therapy for the conservative management of full thickness tears of the rotator cuff: A systematic review. Br J Sports Med. 2007;41(4):200-10.
3. Alvarez CM, Litchfield R, Jackowski D, Griffin S, Kirkley A. A prospective, double-blind, randomized clinical trial comparing subacromial injection of betamethasone and xilocaine to xilocaine alone in chronic rotator cuff tendinosis. Am J Sports Med. 2005;33(2):255–62.
4. Wolf BR, Dunn WR, Wright RW. Indications for repair of full-thickness rotator cuff tears. Am J Sports Med 2007;35(6):1007-16.
5. Gohlke F, Rolf O, Böhm D. Open reconstruction of the rotator cuff. Orthopade. 2007;36(9):834-47.
6. Habermeyer P, Lehmann L, Lichtenberg S. Rotator cuff tears: diagnosis and therapy. Orthopade. 2000;29(3):196-208.
7. DeFranco MJ, Bershadsky B, Ciccone J, Yum JK, Iannotti JP. Functional outcome of arthroscopic rotator cuff repair: A correlation of anatomic and clinical results. J Shoulder Elb Surg. 2007;16(6):759–65.
8. Veado MA de C, Rodrigues AU. Functional Evaluation of Patients Who Have Undergone Arthroscopic Debridement To Treat Massive and Irreparable Tears of the Rotator Cuff. Rev Bras Ortop (English Ed [Internet]. 2010;45(5):426–31. Available from: http://dx.doi.org/10.1016/S2255-4971(15)30431-6
9. Cofield RH. Rotator cuff disease of the shoulder. J Bone Jt Surg. 1985; 67(6): 974-9.
10. Cofield RH. Subscapular muscle transposition for repair of chronic rotator cuff tears. Surg Gynecol Obstet. 1982; 154(5): 667-72.
11. Gerber C, Fuchs B, Hodler J. The results of repair of massive tears of the rotator cuff. J Bone Jt Surg - Ser A. 2000; 82(4): 505-15.
12. Rockwood CA, Williams GR, Burkhead WZ. Debridement of degenerative, irreparable lesions of the rotator cuff. J Bone Jt Surg - Ser A. 1995; 77(6): 857-66.
13. Bedi A, Dines J, Warren RF, Dines DM. Massive tears of the rotator cuff. J Bone Joint Surg - Series A. 2010; 92(9): 1894-908.
14. Oliva F, Osti L, Padulo J, Maffulli N. Epidemiology of the rotator cuff tears: a new incidence related to thyroid disease. Muscles Ligaments Tendons J. 2014 Jul;4(3):309–14.
15. Dines DM, Moynihan DP, Dines JS, McCann P. Irreparable rotator cuff tears: what to do and when to do it; the surgeon’s dilemma. Instr Course Lect. 2007;56:13–22.
16. Keener JD, Patterson BM, Orvets N, Chamberlain AM. Degenerative Rotator Cuff Tears: Refining Surgical Indications Based on Natural History Data. J Am Acad Orthop Surg. 2019 Mar;27(5):156–65.
17. Rothrauff BB, Pauroy T, Delski RE, Rodosky MW, Tuan RS, Musahl V. The rotator cuff organ: Integrating developmental biology, tissue engineering, and surgical considerations to treat chronic massive rotator cuff tears. Tissue Eng - Part B Rev. 2017;23(4):318–35.
18. Levy O, Mullett H, Roberts S, Copeland S. The role of anterior deltoid reeducation in patients with massive irreparable degenerative rotator cuff tears. J Shoulder Elb Surg. 2008;17(6):863-70.
19. Zingg PO, Jost B, Sukthankar A, Bühler M, Pfirrmann CWA, Gerber C. Clinical and structural outcomes of non-operative management of massive rotator cuff tears. J Bone Jt Surg - Ser A. 2007;89(9):1928-34.
20. Cuff DJ, Santoni BG, Pupello D. Partial rotator cuff repair and biceps tenotomy for the treatment of patients with massive cuff tears and retained overhead elevation: mid-term outcomes with a minimum 5 years of follow-up. J Shoulder Elb Surg. 2016;25(11):1803-09.
21. Durulde XA, Bair B. Massive rotator cuff tears: The result of partial rotator cuff repair. J Shoulder Elb Surg. 2005; 14(2): 121-7.
22. Franceschi F, Papalia R, Vasta S, Leonardi F, Maffulli N, Denaro V. Surgical management of irreparable rotator cuff tears. Knee Surg Sports Traumatol Arthros. 23(2):494-501.
23. Galasso O, Riccelli DA, De Gori M, De Benedetto M, Orlando N, Gasparini G, et al. Quality of Life and Functional Results of Arthroscopic Partial Repair of Irreparable Rotator Cuff Tears. Arthrosc - J Arthrosc Relat Surg. 2017;33(2):261-8.
24. Denard PJ, Brady PC, Adams CR, Tokish JM, Burkhart SS. Preliminary Results of Arthroscopic Superior Capsule Reconstruction with Dermal Allograft. Arthrosc - J Arthros Surg. 2018;34(1):93-9.
25. Lee SJ, Min YK. Can inadequate acromiohumeral distance improvement and poor posterior remnant tissue be the predictive factors of re-tear? Preliminary outcomes of arthroscopic superior capsular reconstruction. Knee Surgery, Sport Traumatol Arthros. 2018; 26(7): 2205-13.
26. Mihata T, Lee TQ, Watanabe C, Fukunishi K, Ohue M, Tsujimura T, et al. Clinical results of arthroscopic superior capsule reconstruction for irreparable rotator cuff tears. Arthros - J Arthros Surg. 2013; 29(3): 459-70.
27. Malahias MA, Brilakis E, Avramidis G, Antonogiannakis E. Satisfactory mid-term outcome of subacromial balloon spacer for the treatment of irreparable rotator cuff tears. Knee Surgery, Sport Traumatol Arthros. 2019; 27(12): 3890-6.
28. Piekkaa RSM, Bouman ICE, van Kampen PM, van Eijk F, Huijmsmans PE. Early promising outcome following arthroscopic implantation of the subacromial balloon spacer for treating massive rotator cuff tear. Musculoskelet Surg. 2018;
30. Elhassan BT, Wagner ER, Werthel JD. Outcome of lower trapezius transfer to reconstruct massive irreparable posterior-superior rotator cuff tear. J Shoulder Elb Surg, 2016; 25(8): 1346-53.

31. Gerber C. Latissimus dorsi transfer for the treatment of irrepairable tears of the rotator cuff. Clin Orthop Relat Res. 1992; (275): 152-60.

32. Boileau P, Baqué F, Valerio L, Ahrens P, Chuinard C, Trojani C. Isolated arthroscopic biceps tenotomy or tenodesis improves symptoms in patients with massive irreparable rotator cuff tears. J Bone Jt Surg - Ser A. 2007; 89(4): 747-57.

33. Liem D, Lengers N, Dedy N, Poetzl W, Steinbeck J, Marquardt B. Arthroscopic Debridement of Massive Irreparable Rotator Cuff Tears. Arthrosc - J Arthrosc Relat Surg. 2008; 24(7): 743-8.

34. Pander P, Siervevelt IN, Pecasse GABM, van Noort A. Irreparable rotator cuff tears: long-term follow-up, five to ten years, of arthroscopic debridement and tenodesis of the long head of the biceps. Int Orthop, 2018; 42(11): 2633-38.

35. Mulieri P, Dunning P, Klein S, Pupello D, Franken K. Reverse shoulder arthroplasty for the treatment of irreparable rotator cuff tear without glenohumeral arthritis. J Bone Jt Surg - Ser A. 2010; 92(15): 2544-56.

36. Ek ETH, Neukom L, Catanzaro S, Gerber C. Reverse total shoulder arthroplasty for massive irreparable rotator cuff tears in patients younger than 65 years old: Results after five to fifteen years. J Shoulder Elb Surg. 2013; 22(9): 1199-208.

37. Gerber C, Canonica S, Catanzaro S, Ernstbrunner L. Longitudinal observational study of reverse total shoulder arthroplasty for irreparable rotator cuff dysfunction: results after 15 years. J Shoulder Elb Surg. 2018; 27(5): 831-8.

38. Hawi N, Schmidthem U, Omar M, Stuebig T, Krettek C, Petri M, et al. Arthroscopic Debridement for Irreparable Rotator Cuff Tears. Open Orthop J. 2016;10(1):324-9.

39. Slabaugh MA, Friel NA, Karas V, Romeo AA, Verma NN, Cole BJ. Interobserver and intraobserver reliability of the goutallier classification using magnetic resonance imaging: Proposal of a simplified classification system to increase reliability. Am J Sports Med. 2012;40(8):1728-34.

40. Bigliani LU, Ticker JB, Flatow EL, Soslowsky LJ, Mow VC. The relationship of acromial architecture to rotator cuff disease. Clin Sports Med. 1991 Oct;10(4):823-38.

41. Collin P, Matsumura N, Lädermann A, Denard PJ, Walch G. Relationship between massive chronic rotator cuff tear pattern and loss of active shoulder range of motion. J Shoulder Elb Surg. 2014; 23(8): 1195-202.

42. Stewart RK, Kaplin L, Parada SA, Graves BR, Verma NN, Waterman BR. Outcomes of Subacromial Balloon Spacer Implantation for Massive and Irreparable Rotator Cuff Tears: A Systematic Review. Orthop J Sport Med. 2019;7(10):1-10.

43. Memon M, Kay J, Quick E, Simunovic N, Duong A, Henry P, et al. Arthroscopic-Assisted Lattissimus Dorsi Tendon Transfer for Massive Rotator Cuff Tears: A Systematic Review. Orthop J Sport Med. 2018;6(6):1-12.

44. Cucchi D, Menon A, Feroldi FM, Mazzoleni M, Santarsiero G, Nocerino E, et al. Rotator cuff integrity is correlated to superior functional results and slower osteoarthritis progression ten years after arthroscopic repair. Rev Chir Orthopédique Traumatol. 2018 Dec;104(8):S77.

45. Galatz LM, Griggs S, Cameron BD, Iannotti JP. Prospective longitudinal analysis of postoperative shoulder function: A ten-year follow-up study of full-thickness rotator cuff tears. J Bone Jt Surg - Ser A. 2001; 83(7): 1052-6.

46. Randelli PS, Menon A, Nocerino E, Aliprandi A, Feroldi FM, Mazzoleni MG, et al. Long-term Results of Arthroscopic Rotator Cuff Repair: Initial Tear Size Matters: A Prospective Study on Clinical and Radiological Results at a Minimum Follow-up of 10 Years. Am J Sports Med. 2019;47(11):2659-69.

47. Joseph P, Iannotti; Gerald R. Williams AMJDZ. Disorders of the Shoulder: Diagnosis and Management. 3rd ed. Iannotti, Joseph P; Gerald R. Williams J, editor. Baltimore, MD: Wolters Kluwer/Lippincott Williams & Wilkins; 2014.

48. Gartsman GM. Massive, irreparable tears of the rotator cuff: Results of operative debridement and subacromial decompression. J Bone Jt Surg - Ser A. 1997; 79(5): 715-21.

49. Scheibel M, Lichtenberg S, Habermeyer P. Reversed arthroscopic subacromial decompression for massive rotator cuff tears. J Shoulder Elb Surg. 2004; 13(3): 272-8.

50. Zvijac JE, Levy HJ, Lemak Lj. Arthroscopic subacromial decompression in the treatment of full thickness rotator cuff tears: A 3- to 6-year follow-up. Arthroscopy. 1994; 10(5): 518-23.

51. 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(1): 4-19.

52. Fenlin JM Jr, Chase JM, Rushton SA, Frieman BG. Tuberosity: creation of an acromiohumeral articulation—a treatment option for massive, irreparable rotator cuff tears. J Shoulder Elbow Surg 2002;11(2):136-142.

53. Walsh G, Edwards TB, Boulahia A, Nové-Josserand L, Neyton L, Szabo I. Arthroscopic tenotomy of the long head of the biceps in the treatment of rotator cuff tears: Clinical and radiographic results of 307 cases. J Shoulder Elb Surg. 2005; 14(3): 238-46.