

Carsten Braune · Ruediger von Eisenhart-Rothe  
Frederic Welsch · Matthias Teufel · Alwin Jaeger

## Mid-term results and quantitative comparison of postoperative shoulder function in traumatic and non-traumatic rotator cuff tears

Received: 25 September 2002 / Published online: 27 June 2003  
© Springer-Verlag 2003

**Abstract** *Introduction:* The objective of this study was to compare the postoperative range of motion (ROM) and patient satisfaction after surgical reconstruction of traumatic and non-traumatic rotator cuff tears. *Materials and methods:* The cases of 46 consecutive patients who underwent the same standardised surgical reconstruction and postoperative rehabilitation protocol between 1993 and 1998 were reviewed. Traumatic (group I,  $n=20$ , average age 34.2 years, range 15–49 years) and non-traumatic tears (group II,  $n=26$ , average age 54.1 years, range 50–68 years) formed the two study groups. Mean follow-up lasted 47.1 months (range 13–105 months) in group I and 41.4 months (range 11–94 months) in group II. Assessment included postoperative shoulder function with Constant and Murley's score and visual analogue scale (VAS). *Results:* Significantly ( $p=0.0019$ ) better results were observed in group I with an average of 94.1 points for Constant's score, compared with 75.3 points in group II. Postoperative shoulder function was not affected regarding full-thickness or partial tears ( $p=0.239$ ) in group I. VAS revealed an excellent or good result in all patients of group I ( $n=20$ ) and 50% of group II ( $n=13/26$ ). Quantitative comparison of postoperative ROM demonstrated significantly better results in forward flexion ( $p=0.013$ ), abduction ( $p=0.0019$ ) and external rotation ( $p=0.0042$ ) for group I. The remaining postoperative external rotation deficit for group II with a loss of 31% compared with group I ( $38.9^\circ$  vs  $56.6^\circ$ ) was statistically and clinically relevant. *Conclusion:* The results demonstrate that surgical reconstruction of traumatic and non-traumatic rotator cuff tears is a successful procedure. Comparison of both groups revealed significantly better postoperative results in the younger, traumatic collective.

**Keywords** Rotator cuff tear · Quantitative comparison of traumatic and non-traumatic tears · Postoperative shoulder function

### Introduction

The pathology and appearance of rotator cuff tears are closely related to increasing patient age and are caused, apart from anatomic entities, by a normal ageing process [12, 16, 22, 23]. Uthoff et al. reported in their cadaver study an incidence of 20% of full-thickness and 32% of partial tears at an average age of 59 years [27], Milgrom et al. found in their ultrasound-guided study an incidence of 11% in patients younger than 60 years, 50% in patients older than 70 years and 80% in patients older than 80 years [22]. Rickert et al. proved this in their biomechanical, fresh-frozen, human cadaver study and reported that the tensile strength and stiffness of the supraspinatus tendon decrease with age [26]. This biomechanical study evaluates for the first time the tensile strength and stiffness of intact, complete supraspinatus tendons.

Surprisingly, a 65-year-old specimen still demonstrated a weight-bearing supraspinatus tendon with a maximum of 900 N of tensile strength compared with 1400 N for a 40-year-old man [26]. This demonstrates a weight-bearing pattern for the supraspinatus tendon in elderly patients. Therefore, tears do not have to develop exclusively from degenerative alterations and may have a traumatic origin, with patients benefitting from surgical reconstruction. This suggests that the attitude that rotator cuff tears are an age-related, degenerative disease that does not require any surgical reconstruction should no longer be postulated or supported [13].

The literature reveals many results referring to the surgical outcome of rotator cuff tears in elderly patients [9, 10, 11, 14, 18]. Rotator cuff tears in patients younger than 40 years of age are extremely rare and reported infrequently [4, 16, 17, 25]. To our knowledge, objective data of a standardized comparison of both collectives is missing.

C. Braune (✉) · R. von Eisenhart-Rothe · F. Welsch · M. Teufel  
A. Jaeger  
Department of Orthopaedic and Trauma Surgery,  
University of Frankfurt am Main,  
Marienburgstrasse 2, 60528 Frankfurt am Main, Germany  
Tel.: +49-69-67050, Fax: +49-69-6705375,  
e-mail: c.braune@em.uni-frankfurt.de

The objective of this study is to compare the differences in outcome after surgical reconstruction of traumatic and non-traumatic rotator cuff tears. We hypothesized that in patients with non-traumatic tears, the postoperative range of motion and subjective satisfaction are inferior compared with traumatic tears.

## Patients and methods

A retrospective analysis was established of 46 consecutive patients with rotator cuff tears who underwent surgical repair between 1993 and 1998. Based on the aetiology of their rotator cuff tear, patients were divided into two study groups. Inclusion criteria for the traumatic origin of the lesion were related to the recommendations for diagnosis and legal assessment of traumatic rotator cuff tears of the German Association of Shoulder and Elbow Surgery [19]. Those criteria included no pre-existing shoulder pain or mal-function, complete, sudden loss of shoulder function, sharp trauma-related pain with correlated dead arm sign in combination with an adequate trauma mechanism such as passive forced external or internal rotation with abducted or adducted arm, passive ventral, medial or caudal traction, axial compression in cranioventral or ventromedial direction, and the combination of traumatic shoulder dislocation (group I,  $n=20$ ).

Additional information was provided by the intraoperative macroscopic tear shape. References for a traumatic origin were the isolated complete tear of the subscapularis muscle [6, 28] and luxation of the head of the long biceps tendon with a subsequent rotator interval lesion [6]. History of chronic shoulder pain and pre-existing shoulder malfunction, mechanical outlet impingement signs such as acromioclavicular joint arthritis or acromion traction osteophytes, patient age 50 years or older were used as exclusion criteria for a traumatic origin but inclusion criteria for a non-traumatic aetiopathology (group II,  $n=26$ ).

The patient's preoperative standard evaluation included clinical examination, standard X-ray shoulder assessment with a true anteroposterior (AP) and an outlet view [3]. Additionally, all patients underwent MRI for tear evaluation.

Intraoperative assessment included the size of the tear and its location followed by Bateman's [2] and Habermeyer's [12, 13] classification.

The surgical technique was performed in a standardized manner by the senior author. The anterolateral approach through the deltoid muscle included in the majority of cases an anterior inferior acromioplasty as described by Neer [23] in 1972. After blunt tendon mobilisation, surgical reconstruction followed an anatomic device. This included either tendon-to-bone refixation with transosseous sutures in McLaughlin's technique [21] or tendon-to-tendon repair in less severe cases with longitudinal intratendinous tear shape.

Average age at operation in group I was 34.2 years (range 15–49 years). Seven traumatic shoulder dislocations (35%) were observed, 2 of them additionally required a Bankart repair. Complete rotator cuff tears were observed in 10 patients (50%) and partial tears, either on the acromial or the articular surface, in another 10 (50%). Twelve patients (60%) received an anteroinferior acromioplasty. Mean follow-up was 47.1 months (range 13–105 months).

With an average age of 54.1 years (range 50–68 years) in group II, 25 patients (96.2%) sustained a complete rotator cuff tear, while 1 female patient had an acromial surface partial tear. An anteroinferior acromioplasty was required in 88.5% ( $n=23$ ) of this study group. Mean follow-up was 41.4 months (range 11–94 months).

General patient data concerning gender, affected dominant side, tear size and localisation, and surgical reconstruction technique performed are shown in Tables 1, 2, 3.

Standardised pre- and postoperative functional shoulder assessment followed Constant and Murley's [8] scoring system as recommended by the European Society for Shoulder and Elbow Surgery [10]. In order to enable an exact comparison of the postoperative range-of-motion (ROM) obtained and resulting shoulder

**Table 1** Summary of patient data referring to the selected study groups

	Group I ( $n=20$ )	Group II ( $n=26$ )
Full-thickness rotator cuff tears	10	25
Partial rotator cuff tears	10	1
Female/male	2/18	4/22
Mean age at operation (years)	34.2	54.1
Range (years)	15–49	50–68
Dominant arm	15	16
Mean follow-up (months)	47.1	41.4
Range (months)	13–105	11–94
Surgical reconstruction technique:		
Tendon-to-tendon	10	7
Tendon-to-bone	10	19

**Table 2** Rotator cuff tear size in full-thickness tears in both study groups [1]

	Bateman I	Bateman II	Bateman III	Bateman IV
Group I ( $n=10$ )	5	2	3	0
Group II ( $n=25$ )	4	7	10	4

function in both study groups, we differentiated the measured ROM and resulting scores into forward flexion, abduction and external rotation.

Postoperative rehabilitation in both study groups included a standardised physiotherapeutic treatment protocol with isometric muscle strengthening, passive forward flexion, individually pain-related, within the first 2 weeks after surgery. A limit of 90° of active movement in forward flexion and abduction was encouraged up to the 6th week after surgery. External rotation was limited to the neutral position and actively performed after 6 weeks together without any limitation in forward flexion and abduction.

Overall activity level and subjective functional assessment after the surgical rotator cuff repair were measured on a visual analogue scale (VAS). Patients rated themselves on a scale from 0 to 10 according to the parameters of pain and postoperative shoulder function compared with their preoperative status. Excellent subjective results were achieved with a score of 10 whereas poor and unsatisfactory results were noted for a score of 0.

Statistical analyses included the Wilcoxon-Mann-Whitney test for non-parametric data that allows the comparison of two groups with minimal ordinal scaled data.

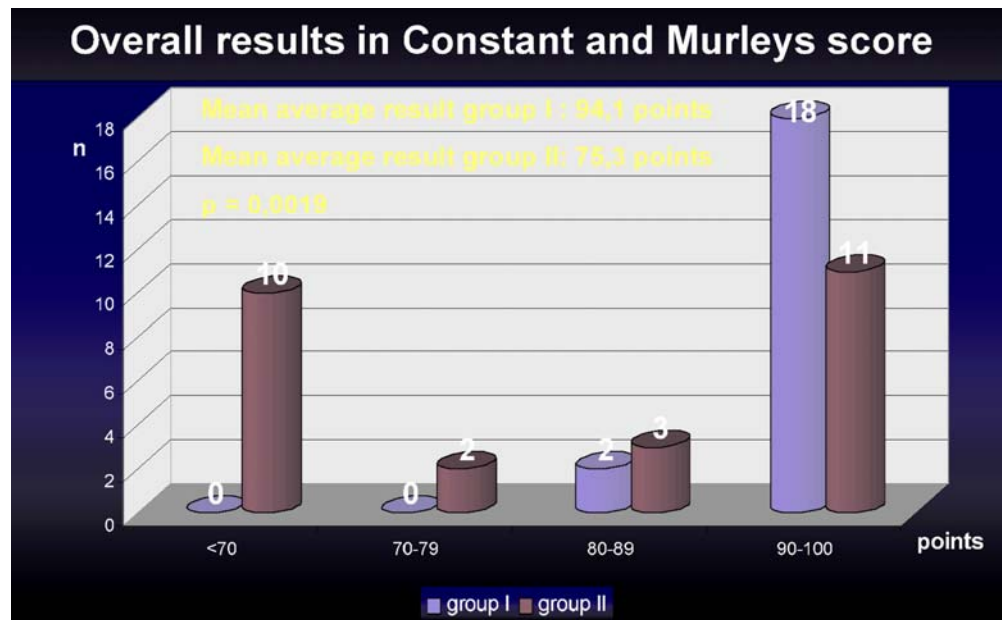
## Results

The assessment of the subjective functional outcome of rotator cuff reconstruction on VAS showed in group I values from 7 to 10 points in all cases ( $n=20$ ) with an overall good or excellent result.

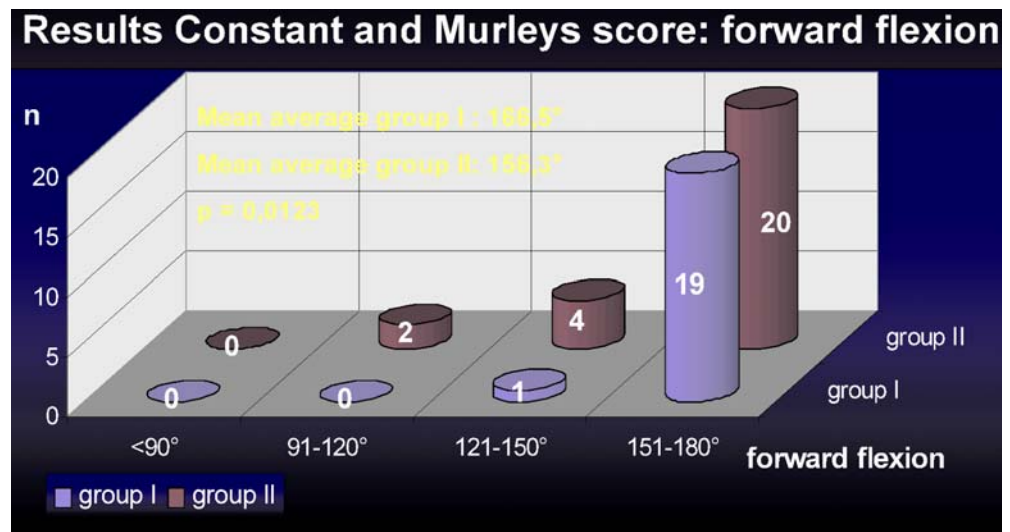
In group II, 50% ( $n=13$ ) of the patients obtained scores from 7 to 10 points, 26.9% ( $n=7$ ) from 5 to 6, and another 23.1% ( $n=6$ ) less than 5 points with an unsatisfactory result.

Complete evaluation of Constant and Murley's score showed an excellent postoperative result with an average of 94.1 points for the traumatic collective (group I). Eight-

**Fig. 1** Overall results with Constant and Murley's score demonstrate significantly better results for traumatic rotator cuff tears ( $p=0.0019$ ) with a mean average score of 94.1 points vs 75.3 points for the non-traumatic collective



**Fig. 2** With a mean of 166.5° in forward flexion, the postoperative range of motion was significantly better ( $p=0.013$ ) for group I



teen patients showed an excellent and 2 patients a good result. Statistical analysis revealed no significant differences in this collective ( $p=0.239$ ) regarding the comparison of full-thickness (average score of 95.9 points) with partial rotator cuff tears (average score 89.1 points).

With an average of 75.3 points, group II scored an overall objectively fair postoperative result with Constant and Murley's score. In this group 53.8% ( $n=14$ ) of the patients showed an excellent and good result, 7.7% ( $n=2$ ) a fair result, and 38.5% ( $n=10$ ) a poor result with a score of less than 70 points. According to this, comparison of Constant's score results showed an overall significantly better result for the traumatic collective ( $p=0.0019$ ) (Fig. 1).

Concerning forward flexion, group I achieved a mean of 166.5°. Comparison with group II showed 10° less for this collective, with a mean of 156.3°. Statistics revealed a significantly better result for group I ( $p=0.013$ ) (Fig. 2).

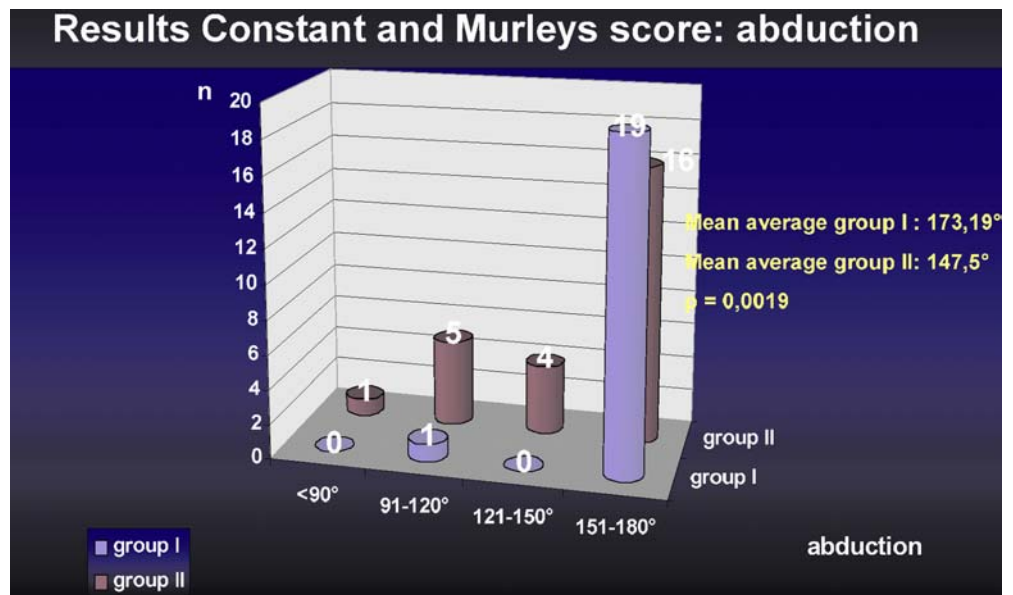
A highly significant difference ( $p=0.0019$ ) was observed for group I in postoperative abduction achieved compared with the postoperative result of group II. With an average better abduction of 25.6°, the postoperative average in abduction in group I was 173.1° compared with 147.5° in group II (Fig. 3).

Postoperative external rotation showed a mean of 56.6° in group I and 38.9° in group II. A significantly better external rotation ( $p=0.0042$ ) with an average remaining lack of 17.7° was observed for the non-traumatic collective (Fig. 4).

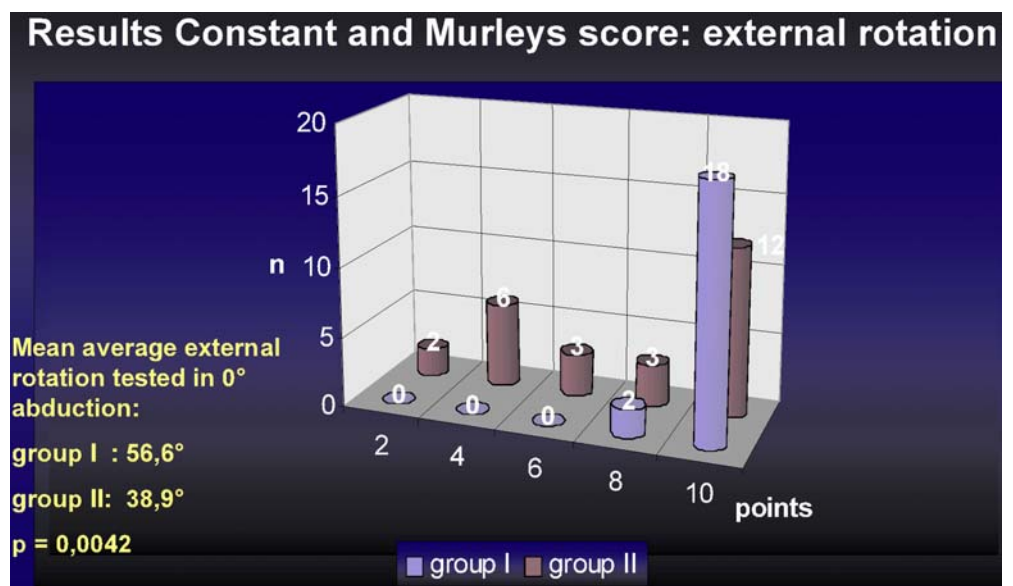
Correlating the remaining period of time between trauma or pain-related disease onset and surgery with the results of Constant's score, no significant differences ( $p=0.147$ ) were observed in either collective.

Evaluation of the patient's age at surgery with the subsequently resulting Constant's score showed no significant differences ( $p=0.0878$ ) for either study group.

**Fig. 3** Postoperative external rotation revealed a significantly better result ( $p=0.0042$ ) for the traumatic collective with an average remaining lack of external rotation of  $17.7^\circ$  for group II



**Fig. 4** Comparison of post-operative range of motion showed significantly better results in abduction for group I ( $173.1^\circ$  vs  $147.5^\circ$  for group II,  $p=0.0019$ )



## Discussion

The objective of this study was to compare the postoperative ROM and patient satisfaction after surgical reconstruction of traumatic and non-traumatic rotator cuff tears in a standardised trial. The results demonstrate that surgical rotator cuff reconstruction in the traumatic and younger collective produced better postoperative results. Constant's score results revealed a significantly better shoulder function ( $p=0.0019$ ) in these patients. Furthermore, quantitative analysis of the postoperative ROM revealed significantly better results. Comparison with non-traumatic cuff tears demonstrated the severest restriction of loss of motion in abduction followed by external rotation and forward flexion in this collective. Postoperative shoulder function was not influenced in traumatic tears by full-thickness or partial tears ( $p=0.239$ ).

As a matter of fact, the traumatic collective contained some incongruence in itself. With 7 additional traumatic shoulder dislocations, 2 of them undergoing a Bankart repair and capsuloplasty due to instability, partial and full-thickness tears, different pathologies were integrated. This partly explains the relatively high number of traumatic cuff tears. We accepted this incongruency for statistical reasons and had subsequently a less aggressive standardised postoperative rehabilitation protocol for all patients. Without any complications and a limitation of external rotation to the neutral position for 6 weeks, even patients with a Bankart repair could be mobilised within this rehabilitation pattern. With this restrictive, standardised protocol we tried to rationalise the incongruence of partial and full-thickness tears in combination with instability surgery compared with almost full-thickness tears in group II. Another fact that seems to compensate this inhomogeneity is the missing significant difference ( $p=0.239$ ) con-

cerning the postoperative result of Constant's score regarding full-thickness and partial rotator cuff tears. In our opinion, the obviously better tendon quality in the younger patients offered a better healing potential than in group II. The incongruency of age in both study groups is determined by the study design and cannot be influenced.

Our results show that rotator cuff surgery is limited by general physiological, age-related factors such as decreased tendon quality and limited blood perfusion [18], although Rickert et al.'s cadaver studies demonstrated a relatively high maximum of tensile strength for the supraspinatus tendon in a 65-year-old man [26].

Evaluation of the individual patient's satisfaction after surgery demonstrates an excellent result for the traumatic collective, with all patients having a score between 7 and 10 points. The postoperative average ROM was practically unlimited, enabling reintegration into daily working conditions. These results indicate the need for the surgical reconstruction of traumatic rotator cuff tears in patients younger than 50 years old. As a result, a predictive value for the expectation of a reasonable surgical result seems to be the traumatic aetiology of the rotator cuff tear itself. The recommendations for diagnosis and legal assessment of traumatic rotator cuff tears of the German Association of Shoulder and Elbow Surgery therefore offer a good modality for cuff tear evaluation.

Postoperative ROM and shoulder function demonstrated worse results for the non-traumatic collective. An overall average Constant's score of 75.3 points offers a fair outcome for this collective. Subjective patient satisfaction showed an overall acceptable result, with 77% of the patients having not less than 50% on VAS. The literature reveals no significantly better results in comparison with conservative management of rotator cuff tears. In this context, Wirth et al. [29] report 62% good or excellent and 38% poor results in their series of 60 patients, Hawkins and Dunlop [15] 68% satisfied and 32% unsatisfied results with a series of 33 patients, Bokor et al. [5] 56% satisfied and 44% unsatisfied results in their series of 53 patients, and Bartolozzi et al. [1] 70% good or excellent and 30% fair and poor results with their series of 136 patients.

Quantitative evaluation and comparison with the traumatic collective showed a significantly better shoulder function in forward flexion, abduction and external rotation for group I. Although significant, a loss of 14.8% in abduction and 6.1% in forward flexion does not seem to have a high clinical relevance for these patients. Considering the average loss of external rotation of 31% compared with the traumatic collective, a clinical relevance concerning a postoperative restriction in ROM for this collective has to be accepted.

Since Codman [7] first reported his results on surgical reconstruction of a ruptured supraspinatus tendon in 1911, many surgical techniques have been advocated and successfully introduced. Current concepts include a surgical refixation with the aim of a low tension repair including different mobilisation techniques and lysis of adhesions [12, 13, 17]. Refixation techniques vary from transosseous

suture refixation [12, 13, 24] to suture anchors [20] with acceptable results. As an established entity in middle-aged and elderly populations, surgical results and reconstruction devices in rotator cuff reconstruction concern this collective in general [2, 12, 13, 16, 22, 23, 27]. Although initially developed for an elderly population, these surgical devices also fulfil the criteria for a reasonable surgical result in younger patients. The overall excellent results for the traumatic group confirm this.

In conclusion, indications for surgical reconstruction have to follow strict criteria and represent an individual decision for each patient to enable an acceptable postoperative result for the patient and the surgeon. The choice of surgical or conservative treatment of non-traumatic rotator cuff tears has furthermore to consider, apart from the resulting postoperative ROM, that an intact rotator cuff is important to prevent cuff arthropathia [12, 13] and subsequent glenohumeral arthritis.

Our results demonstrate and support that surgical reconstruction of traumatic rotator cuff tears in patients younger than 50 years of age is a successful procedure that enables an adequate shoulder function. Quantitative comparison with non-traumatic tears showed significantly better results in Constant's score, forward flexion, abduction and external rotation. Evaluating the resulting clinical relevance of ROM and subjective satisfaction, non-traumatic cuff tears achieved a clinically relevant worse result in external rotation. Comparison with conservative treatment of non-traumatic tears does not provide better results for the patients. In conclusion, surgical reconstruction is advisable but has to follow strict individual devices to achieve an adequate result for the patient and the surgeon.

## References

1. Bartolozzi A, Andreychik D, Ahmand S (1994) Determinants of outcome in the treatment of rotator cuff disease. *Clin Orthop* 308:90–97
2. Bateman JA (1963) The diagnosis and treatment of rupture of the rotator cuff. *Surg Clin North Am* 43:1523–1530
3. Bigliani LU, Morrison DS, April EW (1982) The morphology of the acromion and its relationship to the rotator cuff tears. *Orthop Trans* 10:228
4. Bigliani LU, D'Alessandro DF, Duralde XA, McIlveen SJ (1989) Anterior acromioplasty for subacromial impingement in patients younger than 40 years of age. *Clin Orthop* 246:11–116
5. Bokor DJ, Hawkins RJ, Huckwell GH (1993) Results of non-operative management of full-thickness tears of the rotator cuff. *Clin Orthop* 294:103–110
6. Braune C, Gramlich H, Habermeyer P (2000) Intraoperative shape of rotator cuff tears in traumatic and non traumatic cases. *Unfallchirurg* 103:462–467
7. Codman EA (1911) Complete rupture of the supraspinatus tendon: operative treatment with report of two successful cases. *Boston Med Surg J* 164:708–710
8. Constant CR, Murley AHG (1987) A clinical method of functional assessment of the shoulder. *Clin Orthop* 214:160–164
9. Grondel RJ, Felix H, Filed LD, Jackson (2001) Rotator cuff repairs in patients 62 years of age or older. *J Shoulder Elbow Surg* 10:97–99
10. Gschwend N, Bloch HR, Bischof A (1991) Long term results of surgical management of rotator cuff rupture. *Orthopäde* 20: 255–261

11. Gupta R, Leggin BG, Iannotti P (1997) Results of surgical repair of full thickness tears of the rotator cuff. *Orthop Clin North Am* 2:241–248
12. Habermeyer P (1995) Rotatorenmanschette und lange Bizepssehne. In: Habermeyer P, Schweiberer L (eds) *Schulterchirurgie*, 2nd edn. Urban & Schwarzenberg, Munich, pp 185–213
13. Habermeyer P (1995) Open surgical therapy of the rotator cuff. *Orthopade* 24:512–528
14. Hattrup SJ (1995) Rotator cuff repair: relevance of patient age. *J Shoulder Elbow Surg* 4:95–100
15. Hawkins RH, Dunlop R (1995) Nonoperative treatment of rotator cuff tears. *Clin Orthop* 321:178–188
16. Hawkins RJ, Misamore GW, Hobeika PE (1985) Surgery for full thickness rotator cuff tears. *J Bone Joint Surg Am* 67:1349–1355
17. Hawkins RJ, Marin WD, Bonutti PM (1999) Surgical treatment of full-thickness rotator cuff tears in patients 40 years of age or younger. *J Shoulder Elbow Surg* 8:259–265
18. Iannotti JP (1994) Full thickness rotator cuff tears: factors affecting surgical outcome. *J Am Acad Orthop Surg* 2:87–95
19. Loew M, Habermeyer P, Wiedemann E, Rickert M, Gohlke F (2000) Recommendations for diagnosis and legal assessment of traumatic rotator cuff tears. *Unfallchirurg* 103:417–426
20. Machner A, Pap G, Mohrenweiser L, Neumann HW (2001) Comparison of two techniques for surgical repair of isolated supraspinatus rupture. A matched-pair study. *Unfallchirurg* 104:19–24
21. McLaughlin HL (1944) Lesions of the musculotendinous cuff of the shoulder: the exposure and treatment of tears with retraction. *J Bone Joint Surg* 26:31–54
22. Milgrom C, Schaffler M, Gilber S, Holsbeeck M van (1995) Rotator-cuff changes in asymptomatic adults. The effect of age, hand dominance and gender. *J Bone Joint Surg Br* 77:296–298
23. Neer CS II (1972) Anterior acromioplasty for the chronic impingement syndrome in the shoulder. *J Bone Joint Surg Am* 54:41–50
24. Neviasser RJ, Neviasser TJ (1985) Major rupture of the rotator cuff. In: Watson M (ed) *Practical shoulder surgery*. Grune & Stratton, London, pp 170–224
25. Norwood IA, Barrack R, Jacobson KE (1989) Clinical presentation of complete tears of the rotator cuff. *J Bone Joint Surg Am* 71:499–505
26. Rickert M, Georgousis H, Witzel U (1998) The native tensile strength of the supraspinatus tendon. A biomechanical study. *Unfallchirurg* 101:265–270
27. Uthoff HK, Lohr J, Sarkar K (1987) The pathogenesis of rotator cuff tear. In: Tkagishi N (ed) *The shoulder*. Prof Postgrad Serv, pp 211–212
28. Walch G (1993) Synthèse sur l'épidémiologie et l'étiologie des ruptures de la coiffe des rotateurs. *Journées Lyonnaises de l'épaule*, Lyon, 1–3 April, pp 256–266
29. Wirth MA, Basamania C, Rockwood Jr CA (1997) Nonoperative management of full-thickness tears of the rotator cuff. *Orthop Clin North Am* 28:59–67