Arch Orthop Trauma Surg (2000) 120:432–436

ORIGINAL ARTICLE

Michael Skutek · Reinhard W. Fremerey
Johannes Zeichen · Ulrich Bosch

Outcome analysis following open rotator cuff repair. Early effectiveness validated using four different shoulder assessment scales

Received: 4 October 1999

Abstract Evaluation of upper extremity function after reconstructive surgery is increasingly important both to predict outcome and for the control of cost-effectiveness. Three validated, self-administered shoulder questionnaires were applied prospectively in 23 otherwise healthy patients with rotator cuff deficiency and correlated to the Constant-Murley Shoulder Score and a visual analogue scale for satisfaction. Seven women and 16 men with combined tears of supraspinatus and infraspinatus (mean age 55.3 ± 10.5 years, r/l: 14/9, follow-up 57.8 ± 15.7 weeks) were gathered prospectively and evaluated pre- and postoperatively with the American Shoulder and Elbow Surgeons (ASES) Shoulder Index, the Simple Shoulder Test (SST) and the Disabilities of the Arm, Shoulder and Hand Module (DASH questionnaire). Additionally, a visual analogue scale for satisfaction was employed. All four scores and the visual analogue scale revealed improvement at a statistically significant level ($P < 0.01$) after surgery. All questionnaires showed a significant correlation with the Constant-Murley Shoulder Score (ASES: $r = 0.871$, $P < 0.01$; DASH: $r = –0.758$, $P < 0.01$, SST: $r = 0.494$, $P < 0.05$, Pearson's correlation coefficient). Taken together, all questionnaires were easy to apply, and reliable evaluation of shoulder function was possible with significant correlation to the Constant-Murley Shoulder Score postoperatively. The SST was easy to apply, and compound outcome analysis was possible with the ASES Shoulder Index and DASH questionnaire. The DASH scale was the most complex evaluation instrument. The Constant-Murley Shoulder Score comprises a physical examination, which is advantageous but restricts the application to the office. For postoperative assessment without the patient having to return to the clinic, the ASES Shoulder Index is preferred because of its good correlation to the Constant-Murley Shoulder Score ($r = 0.871$) and the visual analogue scale for satisfaction ($r = 0.762$).

M. Skutek · R. W. Fremerey · J. Zeichen · U. Bosch (✉)
Department of Trauma Surgery, Hannover Medical School,
Postbox 610180, D-30623 Hannover, Germany
e-mail: skutek@aol.com,
Tel.: +49-511-5322026, Fax: +49-511-5325877

Introduction

With growing attention being paid to efficiency and cost-effectiveness in health care, outcome evaluation is becoming increasingly important in musculoskeletal surgery of the upper limb. In the past few years, there has been a change in the musculoskeletal trauma literature from assessment of the radiographic appearance, motion of joints and hardware to more patient-oriented outcome analysis [6, 7, 18, 21, 22, 25, 26]. What patients really feel is of enormous interest not only for rehabilitation but also for the management strategy. By definition, the outcome should reflect all of the possible effects of a disease or intervention [6].

To minimise external influences such as the education level of the examiner and a lack of poorly evaluated scores with poor reliability, new outcome instruments are being developed. In addition to functional assessment and pain evaluation, parameters such as quality of life, satisfaction, level of ability to perform daily activities (disability) and of role function are included [19, 22]. Simple questions into disability instead of joint measurements allow more patient-oriented assessment.

As suggested, an outcome assessment should include patient-derived, health-oriented outcomes, combined with traditional clinical outcomes and patient satisfaction data [27]. In recent studies, questionnaires were evaluated regarding various shoulder problems, including impingement syndrome, osteoarthrosis, instability and humeral malunion [6, 21].

Concern has been expressed about correct assessment using different scoring systems for specific shoulder disorders [23]. To evaluate rotator cuff deficiencies, a common and severely disabling disorder, the application of three validated questionnaires was investigated in this study and compared to an established clinical outcome score [4, 9, 10]. We were especially interested to detect

items that might restrict their use for the selected topic. Additionally, we wanted to know whether there is a correlation to a visual analogue scale for satisfaction [27]. The three outcome assessment questionnaires were used prospectively to evaluate patients with rotator-cuff deficiency pre- and postoperatively but who were otherwise healthy. All of the questionnaires have been tested for various disorders previously [2, 6, 7, 9, 10, 14, 19, 20, 21].

Patients and methods

Between January 1996 and August 1997, 23 patients with combined tears of supraspinatus and infraspinatus underwent open repair. Thirteen had sustained a traumatic tear after a fall; 3 had suffered an anterior dislocation of the shoulder; 7 had a non-traumatic tear without adequate cause. All patients were otherwise completely healthy and had no concomitant lesions. The mean age of the 7 women and 16 men was 55.3 ± 10.5 years. In 14 patients the right and in 9 the left shoulder was involved. In 14 cases it was the dominant side. All patients had a full passive range of movement before surgery and no subluxation or rupture of the long head of biceps. No previous surgery had been done on the affected shoulder.

Preoperative diagnostics

Preoperatively, shoulder function and muscle power were assessed during a clinical examination. Anteroposterior and axillary roentgenographs were taken of all patient, and ultrasound was performed. An MRI was done for further assessment in terms of degeneration and size of the defect [28]. The indication for open repair was influenced by age, disability, functional impairment, and failed conservative therapy as well as size of the defect [16, 28].

Operative technique

Open repair was performed at a mean of 10.6 ± 7.9 months after trauma or the first onset of shoulder disability. All patients were operated in the beach chair position, using an anterolateral transdeltoidal approach. After acromioplasty according to Neer, the rotator cuff defect was classified according to Bateman [5] into grade I: < 1 cm; grade II: 1–3 cm; grade III: 3–5 cm and grade IV: > 5 cm. Using this classification, 9 patients had a grade II defect (n = 9, mean age 58 ± 10.8 years, r/l = 7/2), 7 grade III defect (n = 8, mean age 51.2 ± 9.1 years, r/l = 6/2) and 6 patients had grade IV massive rotator cuff defects (n = 6, mean age 58 ± 9 years, r/l = 3/3). Grade II and III defects were closed by suture after rotator cuff release [11, 12, 15]. For massive defects (grade IV) a deltoideus flap according to Augereau was performed [3]. In two patients with additional AC osteoarthrosis (1 post-traumatic, 1 idiopathic) a 'grande liberation' according to Patte was performed [15]. Postoperatively, the patients were immobilised in a Gilchrist dressing. In the first 6 weeks only passive and assisted motions of the involved shoulder were allowed. Additionally, an abduction pillow splint was applied. After 6 weeks active motion was started.

Outcome evaluation

Assessment of the shoulder function was performed preoperatively and at the latest follow-up. To exclude interrater variability, all investigations and evaluations of results were performed by one independent medical doctor who was not involved in the surgery or aftercare. Intrarater variability was neglected. Three recently validated shoulder self-assessment questionnaires were applied in this study: the ASES (Shoulder Index of the American Shoulder and Elbow Surgeons), the SST (Simple Shoulder Test) and the DASH questionnaire (Disabilities of the Arm, Shoulder and Hand Module) [6, 19, 21, 22, 26]. Additionally, the well-established Constant-Murley Shoulder Score was used as a reference scale [9, 10].

The self-evaluation section of the ASES Shoulder Index contains visual analogue scales for pain and instability and an activities of daily living (ADL) questionnaire. The ADL questionnaire is marked on a four-point ordinal scale that can be converted to a cumulative ADL Index. A shoulder score can be derived from the visual analogue scale for pain (50%) and the cumulative ADL Score (50%). The shoulder score is derived by the following formula: (10 – Visual analogue pain Score) × 5 + (Cumulative ADL Score*5/3) [22].

The SST consists of 12 questions concerning the function of the shoulder. In performing the 12 functions, patients have been shown to use the shoulder in a wide variety of positions, ranging from 60° of elevation in the 50° thoracic plane, to 120° of elevation near the coronal plane, to 70° of elevation in the 130° thoracic plane. It is designed for patient self-assessment and thus emphasises the patient's perspective. It is also practical (less patient time, less cost) to administer and offers the potential for periodic follow-up assessments without the patient having to return to the office [19, 21].

The DASH self-assessment form is part of the AAOS/COMSS (Council of Musculoskeletal Specialty Societies) outcome instruments. The core module is a complex evaluation instrument consisting of 30 function- and pain-related questions. Also role function and social activities are included. The maximum score in this section is 150 points. This raw score is transferred by the formula: raw score-30 (minimum score)/ 1.20 (score range) to the DASH function/symptom score. A value of zero means no disability (good function) and 100 reflects considerable disability [2, 17].

The results were compared with the Constant-Murley Shoulder Score [4, 9, 10]. Correlation and regression analysis was performed using SPSS. Assessment of shoulder function was performed preoperatively and at latest follow-up.

Results

No wound infections or nerve lesions were seen postoperatively. One patient received funds from the workman's compensation board and had a limited goal in rehabilitation. This patient belonged to group II and influenced the results in a negative sense.

Application of the ASES Shoulder Index, the SST and DASH questionnaire was easy, and all patients completed the forms without mistakes. The forms were completed in less than 5 min. The time needed to complete the Constant-Murley Shoulder Score was 10 min. An extra examiner, a goniometer and a spring balance were, however, needed.

The overall score results initially and at the time of follow-up are listed in Table 1. Compared with the preoperative findings, all scores improved postoperatively.

Statistical analysis

The difference between the preoperative findings and the score value at the time of follow-up represents the personal profit the patients obtain from the operation. A statistically significant difference was seen in all rating scales tested ($P < 0.01$, two-tailed t-test).

Table 1 Overall score results preoperatively and at latest follow-up. Differences are statistically significant using the two-tailed *t*-test ($P < 0.01$)

Score	Mean preop	Range preop	Mean postop	Range postop
Constant-Murley	26.04	± 09.38	64.56	± 15.04
ASES	33.94	± 15.92	71.91	± 16.83
DASH	49.58	± 08.45	21.62	± 12.98
SST	03.30	± 01.82	06.97	± 01.80
Visual analogue scale	40.22	± 16.68	78.26	± 17.49

Table 2 Correlation between Constant-Murley Shoulder Score (reference) and ASES Shoulder Index, DASH questionnaire, SST and the visual analogue scale. Pearson correlation coefficient

Score	Correlation	Significance level
ASES	$r = 0.871$	0.01
DASH	$r = -0.758$	0.01
SST	$r = 0.494$	0.05
Visual analogue scale	$r = 0.612$	0.01

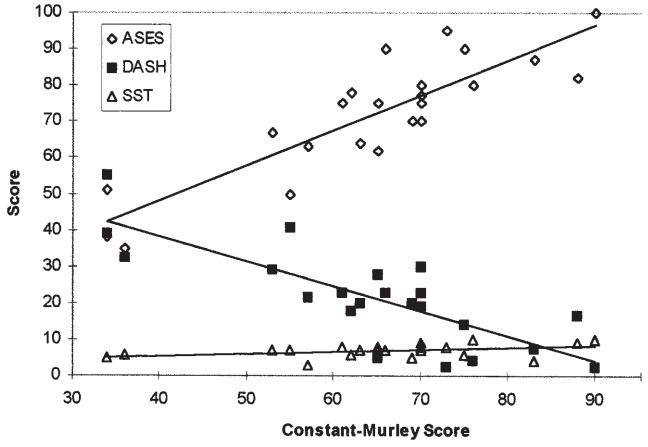

Fig. 1 Constant-Murley Shoulder Score results in relation to the ASES Shoulder Index, DASH questionnaire and SST. The correlation is statistically significant. Simple linear regression: ASES: $y = 0.9742x + 9.0156$; DASH: $y = -0.6829x + 65.711$; SST: $y = 0.059x + 3.1472$

The Constant-Murley Shoulder Score was used as a reference scale. All questionnaires were correlated with the Constant-Murley Shoulder Score (Table 2). A significant correlation was noted between the Constant-Murley Shoulder Score and the ASES ($P < 0.01$), DASH ($P < 0.01$) and SST ($P < 0.05$) at latest follow-up. The correlation with the visual analogue scale was statistically significant to the ASES ($P < 0.01$), Constant-Murley Shoulder Score ($P < 0.01$) and DASH questionnaire ($P < 0.05$). Initially, there was a significant correlation between the visual analogue scale and the ASES Shoulder Index ($P < 0.01$), but no significant correlation was noted ($P > 0.05$) in all three questionnaires.

Graphical evaluation of the Constant-Murley Shoulder Score in relation to the ASES, DASH and SST revealed linear regression in all three cases (Fig. 1). The significant correlation implicates a similar performance of the three questionnaires, compared to the Constant-Murley Shoulder Score.

Discussion

There is no doubt of the importance of outcome evaluation after musculoskeletal surgery [1, 6, 8, 10, 13, 14, 19, 21, 22, 24, 25, 26, 27]. However, the variety of different validated scores and questionnaires hinders making the right choice in daily clinical and research practice [7, 23]. Particularly after meticulous reconstructive surgery, a sensitive instrument is needed.

Along with classifications and the use of standardised therapeutic strategies, outcome evaluation comprises an important instrument for evaluating the success and effectiveness of operative treatment [1, 27]. It is used both to illustrate established management concepts and to evaluate new therapeutic strategies. With growing interest in health and health care, outcome analysis may determine which treatment and which circumstances ensure good results also for economic aspects [21, 22, 27]. This understanding should be central to planning the management and evaluating treatment effectiveness.

The traditional assessment of shoulder function has been performed by accurate measurements – such as range of motion and muscle power and pain – that reflect a local impact of a disorder. As a consequence, a number of shoulder scores were developed for use in clinical examinations. The measured findings were transformed to a score value. The Constant-Murley Shoulder Score, for example, transforms pain, ADL and range of motion in single and combined motions to a score value with a maximum of 100 points [4, 9, 10]. Although ADL are being considered to a certain extent, the assessment of measurements such as function and power is more important in this score. Because of the requirement of a clinical examination, the application is limited to the office.

Which new instruments do we have?

Per definition outcome should include all effects of a disease or intervention [1]. More recent scores evaluate not only ADL, but also parameters such as quality of life, ability to work and social activities [17, 18, 22]. In addition, some scores also include general health assessment to a greater or lesser extent [17]. All scores used in this study are specific shoulder assessment questionnaires, namely the DASH questionnaire, the ASES Shoulder Index and the SST [2, 17, 19, 21]. All are self-administered and to be used by clinicians in daily practice and as research tools. As all the patients were otherwise in good

general health, a general health survey such as Short Form-36 (SF-36) was not used [13, 14].

The ASES questionnaire meets the requirements of the American Association of Elbow and Shoulder Surgeons: easy to use, assessment of ADL, self-assessment with a visual analogue scale for accurate pain assessment [14, 22].

The DASH questionnaire is a complex evaluation instrument consisting of function- and pain-related questions. Also questions regarding role function and social activities are included [2, 17].

The SST is designed for patient self-assessment and emphasises the patient's perspective. Patients have been shown to use the shoulder in a wide variety of positions [21].

The findings in this study implicate that all of these self-administered evaluation instruments can be used either solely or in combination with a more function-orientated score such as the Constant-Murley Shoulder Score. The simple administration of the scores predestines them for use in the office and extraclinically for both clinical and research purposes. One advantage of self-assessment is that a clinical examination with the potential for intra- and interobserver error is not necessary.

Given the significant correlation to the Constant-Murley Shoulder Score, all scores may be used for outcome evaluation after rotator cuff reconstruction.

The ASES Shoulder Index performs in a similar way to the Constant-Murley Shoulder Score. As there is a significant correlation to both the Constant-Murley Shoulder Score and the visual analogue scale for satisfaction, this score is preferred for extraclinical outcome evaluation. However, in clinical practice the Constant-Murley Shoulder Score is used along with the ASES Shoulder Index.

Due to its large number of well-chosen and shoulder-specific questions, the DASH questionnaire provided the most accurate assessment. However, more time was needed for patients to complete the form and for medical staff personnel to evaluate it.

The SST was easy to administer and evaluate. No additional time is needed to collect the forms. Differentiation in comfort, level of activity, and power reveals high demands on shoulder performance in both single and combined motions. The strong preoperative overall impairment in grade 4 lesions was clearly expressed in this score (data not shown). Postoperative improvement was indicated as well. In contrast to the other scores, only a moderate correlation to the Constant-Murley Shoulder Score was noted.

Conclusions

A differential outcome evaluation was possible with the self-administered questionnaires used in this study. Compared with the Constant-Murley Shoulder Score, less time was needed for shoulder assessment. Also, an extra examiner with the risk of interrater errors was not necessary.

Despite a shift of balance to ADL, quality of life and pain relief, the self-administered outcome correlates well with the more objective findings in the reference scale. In broad clinical and extraclinical use, patient-related quality control is possible with the evaluated scores. Given its significant correlation to both the Constant-Murley Shoulder Score and the visual analogue scale for satisfaction, the ASES Shoulder Index is preferred for extraclinical outcome evaluation. However, in clinical practice, the Constant-Murley Shoulder Score is recommended in addition to the ASES Shoulder Index for the evaluation of rotator cuff deficiencies.

References

1. Amadio PC (1993) Outcomes measurements. J Bone Joint Surg Am 75: 1583–1584
2. Amadio PC (1997) Outcomes assessment in hand surgery. Clin Plast Surg 24: 191–194
3. Augereau B (1991) Reconstruction of massive rotator cuff rupture using deltoid muscle flap. Orthopade 20: 315–319
4. Bankes MJ, Crossman JE, Emery RJ (1998) A standard method of shoulder strength measurement for the Constant score with a spring balance. J Shoulder Elbow Surg 7: 116–121
5. Bateman JE (1963) The diagnosis and treatment of ruptures of the rotator cuff. Surg Clin North Am 43: 1523–1530
6. Beaton DE, Richards RR (1996) Measuring function of the shoulder. J Bone Joint Surg Am 78: 882–890
7. Beaton DE, Richards RR (1998) Assessing the reliability and responsiveness of 5 shoulder questionnaires. J Shoulder Elbow Surg 7: 565–572
8. Bosch U, Skutek M, Fremerey RW, Tscherne H (1998) The outcome after primary and secondary hemiarthroplasty in elderly patients with fractures of the proximal humerus. J Shoulder Elbow Surg 7: 479–484
9. Conboy VB, Morris RW, Kiss J, Carr AJ (1996) An evaluation of the Constant-Murley shoulder assessment. J Bone Joint Surg Br 78: 229–232
10. Constant CR, Murley AHG (1987) A clinical method for functional assessment of the shoulder. Clin Orthop 214: 160–164
11. Ellmann H (1990) Diagnosis and treatment of incomplete rotator cuff tears. Clin Orthop 254: 64–74
12. Gartsman GM, Milne JC (1995) Articular surface partial-thickness rotator cuff tears. J Shoulder Elbow Surg 4: 409–415
13. Gartsman GM, Brinkler MR, Khan M, Karahan M (1998) Self-assessment of general health status in patients with five common shoulder conditions. J Shoulder Elbow Surg 7: 228–237
14. Gartsman GM, Brinkler MR, Khan M (1998) Early effectiveness of arthroscopic repair for full-thickness tears of the rotator cuff: an outcome analysis. J Bone Joint Surg Am 80: 33–40
15. Habermeyer P, Schweiberer L (1996) Schulterchirurgie. Urban and Schwarzenberg, Munich
16. Hattrup SJ (1995) Rotator cuff repair: relevance of patient age. J Shoulder Elbow Surg 4: 95–100
17. Hudak PL, Amadio PC, Bombardier C (1996) Development of an upper extremity outcomes measure: the DASH (disabilities of the arm, shoulder and hand). The Upper Extremity Collaborative Group. Am J Ind Med 29: 602–608
18. L'Insalata JC, Warren RF, Cohen SB, Altchek DW, Peterson MG (1997) A self-administered questionnaire for assessment of symptoms and function of the shoulder. J Bone Joint Surg Am 79: 738–748
19. Lippit SB, Harryman DT, Matsen FA (1993) A practical tool for evaluation of function: the simple shoulder test. In: Matsen FA, Fu FH, Hawkins RJ (eds) The shoulder: a balance of mobility and stability. The American Academy of Orthopaedic Surgeons

20. Matsen FA, Smith KL, DeBartolo SE, Von Oesen G (1997) A comparison of patients with late-stage rheumatoid arthritis and osteoarthritis of the shoulder using self-assessed shoulder function and health status. Arthritis Care Res 10: 43–47
21. Matsen FA, Ziegler DW, DeBartolo SE (1997) Patient self assessment of health status and function in glenohumeral joint disease. J Shoulder Elbow Surg 4: 345–351
22. Richards RR, An KN, Bigliani LU, Friedmann RJ, Gartsmann GM, Gristina AG, Ianotti JP, Mow VC, Sidles JA, Zuckermann JD (1994) A standardized method for the assessment of shoulder function. J Shoulder Elbow Surg 3: 347–352
23. Romeo AA, Bach BRJ, O'Halloran KL (1996) Scoring systems for shoulder conditions. Am J Sports Med 24: 472–476
24. Rozencwaig R, Noort A van, Moskal MJ, Smith KL, Sidles JA, Matsen FA (1998) The correlation of comorbidity with function of the shoulder and health status of patients who have glenohumeral degenerative joint disease. J Bone Joint Surg Am 80: 1146–1153
25. Savoie FH3, Field LD, Jenkins RN (1995) Cost analysis of successful rotator cuff repair surgery: an outcome study. Comparison of gatekeeper system on surgical patients. Arthroscopy 11: 672–676
26. Soldatis JJ, Moseley JB, Etminan M (1997) Shoulder symptoms in healthy athletes: a comparison of scoring systems. J Shoulder Elbow Surg 6: 265–271
27. Swionkowski MF (1995) Outcomes measurements in orthopaedic trauma surgery. Injury 26: 653–657
28. Thomazeau H, Boukobza E, Morcet N, Chaperon J, Langlais F (1997) Prediction of rotator cuff repair results by magnetic resonance imaging. Clin Orthop 344: 275–283