

Deltoid muscular flap transfer for the treatment of irreparable rotator cuff tears

Justus Gille,¹ Joerg Suehwold,²
Arndt-Peter Schulz,¹ Benjamin Kienast,³
Andreas Unger,¹ Christian Jürgens³

¹Department of Trauma and Reconstructive Surgery, University of Schleswig-Holstein, Germany; ²Regio Clinics Wedel, Department of Trauma Surgery, Wedel, Germany; ³BG Trauma Hospital Hamburg, Germany

Abstract

The purpose of this study was to evaluate the outcome of deltoid muscle flap transfer for the treatment of irreparable rotator cuff tears. In a retrospective study 20 consecutive patients were evaluated. The index procedure took place between 2000 and 2003. Fifteen patients were male, mean age was 62 years. Inclusion criterion was a rotator cuff defect Bateman grade IV. Exclusion criteria were smaller defects, shoulder instability and fractures of the injured shoulder. An open reconstruction with acromioplasty and a pedicled delta flap was performed. Follow up period was mean 42 months. Follow-up included clinical examination, Magnetic Resonance Imaging (MRI) and the Constant and Simple (CS) shoulder tests. According to the Constant shoulder test the results were good in 13 patients, fair in 5 and unsatisfactory in 2. The pre-operative Constant Score improved from mean 25.7 points (± 5.3) to 72.3 (± 7.8) at follow-up. The mean values for the subcategories of CS increased significantly from 3.9 to 14.4 points for pain and from 4.2 to 15.9 points for activities daily routine ($p < 0.05$). The change in range of motion and strength were not significant ($p > 0.05$). Results of the Simple Shoulder Test showed a significant increase of the mean values from pre-operative 4.3 to 14.7 points post-operatively. MRI showed a subacromial covering of the defect in all cases, all flaps where intact on MRI but always the flap showed marked fatty degeneration. In conclusion, the delta flap is a simple method for the repair of large defects of the rotator cuff leading to satisfying medium results.

Introduction

Treatment of massive rotator cuff tears still presents a major challenge in shoulder surgery.

Rotator cuff tears mainly involve the supraspinatus tendon and usually occur after the age of 40 years.¹ The golden standard of treatment is surgery involving open refixation of the rotator cuff or nowadays even arthroscopic techniques.² A recent Cochrane review showed good evidence for functional outcomes in arthroscopic repairs being equivalent to open and mini-open repairs, with potentials for earlier recovery with open intervention.³ In massive rotator cuff tears, arthroscopic and open repair may be difficult due to the size of the defect, tendon retraction and muscular atrophy and fatty degeneration of the cuff remnant.⁴ Different surgical techniques are available to deal with the problem of massive rotator cuff tears, with variable indications and outcome. Among them are simple debridement and decompression,⁶ transposition of the subscapularis tendon or combined subscapularis and *teres minor* tendon transfer,⁶ deltoid flap reconstruction,^{7,8} *latissimus dorsi*⁹ and *pectoralis major*,¹⁰ closure with allografts, autografts¹¹ and synthetic graft material.¹² The variety of these procedures demonstrates the lack of consensus on the optimal treatment of massive rotator cuff tears. In massive rotator cuff tears, deltoid flap reconstruction has received attention as a salvage procedure and has proved to be an appropriate solution for improvement of pain and function in the shoulder. There are relatively few reports in international literature that have examined the functional outcome of the repair of massive rotator cuff tears with the use of deltoid flap. The results of this technique are controversial. The purpose of this article is to report our experience with the delta-muscle flap for the treatment of rotator cuff tears in a consecutive case series with a mean follow-up time of 42 months.

Materials and Methods

Inclusion criteria for the study were rotator cuff rupture of the supra- and infraspinatus tendon grade IV according to Bateman,¹³ fatty infiltration of the ruptured muscles of stage 3 and 4 according to Goutallier *et al.*¹⁴ and a chief complaint of weakness. Patients with partial tears or partial repairs, stiff shoulder and glenohumeral arthritis were excluded from the study. A pathological condition of the biceps was not an exclusion criterion while complete ruptures of the subscapularis tendon were excluded from the study. Prior to surgery, all patients received conservative treatment. When the patients were still unable to elevate their arm stretched above 90° after three months, due to mechanical reasons or pain inhibition, they were scheduled for surgery. After an initial arthroscopy an open conventional rotator cuff repair by means of simple suture was attempted in all patients. In all the

Correspondence: Justus Gille,
Department of Trauma and Reconstructive
Surgery, University of Schleswig-Holstein,
Germany. E-mail: justus_gille@usa.net

Key words: shoulder, rotator cuff, massive rotator cuff tear, deltoid muscle flap.

Received for publication: 23 June 2009.
Revision received: 17 July 2009.
Accepted for publication: 20 July 2009.

This work is licensed under a Creative Commons Attribution 3.0 License (by-nc 3.0)

©Copyright J. Gille *et al.*, 2009
Licensee PAGEPress, Italy
Orthopedic Reviews 2009; 1:e15
doi:10.4081/or.2009.e15

included patients, it was impossible to reattach the tendon edges to the greater tuberosity with the arm in less than 30° abduction.

Between January and June 2003, 20 patients with an irreparable rotator cuff tear were treated by two senior surgeons with deltoid flap transfer as a salvage procedure. One patient died due to cardiac arrest 11 months after shoulder surgery and 2 patients could not be recruited for the follow-up study. The mean follow-up was 42 months (25-74 months). All of the patients were right-handed and in all cases the dominant arm was affected. Fifteen patients were males and 5 females. The mean age of the patients was 62 years (53-82 years). Eleven patients could relate their symptoms to acute trauma. Four patients had an unsuccessful previous open rotator cuff repair with persistent disabling pain and limited function. All patients had pain and the perception of instability when the arm was placed either overhead or behind the plane of the body. Post-operative complications occurred in one individual, but was of no negative consequence after treatment (post-operative hematoma on the second post-operative day).

Pre-operative and post-operative function was assessed with active and passive movement of the arm in all planes and measured with a goniometer. Besides this, the Constant and Murley Score, as well as the Simple Shoulder Test, were performed.^{15,16} Overall activity level and subjective functional assessment after the surgical rotator cuff repair were measured on a visual analog scale (VAS).¹⁷ In 11 cases the follow-up examination included an imaging control with magnetic resonance imaging (MRI) of the treated shoulder.

All patients participating in the present study were educated in detail about the surgical technique and all alternative procedures with their advantages and disadvantages, and all participants chose to undergo the index surgical procedure. All patients signed informed consent to participate in follow-up examinations, including

magnetic resonance tomography. The analysis was carried out with the Statistical Package for the Social Sciences (SPSS 13.0, Chicago, IL, USA) for descriptive statistics with a level of significance at $p < 0.05$. The non-parametric Wilcoxon's signed rank test was used to analyze the data.

Operative technique

All operations were performed while the patient was under general anesthesia combined with a supplemental interscalene block in a beach chair position. The anterolateral approach through the deltoid muscle included, in the majority of cases, an anterior inferior acromioplasty as described by Neer in 1972.¹⁸ The bursa was excised together with any remnants of the cuff on the greater tuberosity and any osteophytes; the edges of the tear were debrided sparingly. While it was always easy to locate the proximal stump of the supraspinatus at the apex of the glenoid, the infraspinatus was usually in a higher position, as a result of the superior migration of the humeral head, and

had to be mobilized from the undersurface of the acromion. Sutures were then placed every 5mm and held in forceps; posteriorly, the teres minor was often completely displaced downwards behind the head of the humerus. Starting with the part of the deltoid muscle used for the approach (inverted L-shape), a flap was formed for the repair by anterior division in the line of the muscle fibers starting at the acromioclavicular joint. This distally based flap was then swung into the defect (Figure 1). If the deltoid was very thick, it was possible to create an anteromedial impingement at the tip of the coracoid process when suturing the anterior edge of the flap to the subscapularis. The sutures previously placed in the edges of the tear were passed through the flap edges and the knots tied one at a time, spreading the flap out over the head of the humerus, which was then separated from the arch of the acromion by this sheet of muscle (Figure 2). The subcutaneous and cutaneous layers were closed over a suction drain. The post-operative rehabilitation usually consisted of an abduction brace for 4-6 weeks. Initially a standardized physiotherapeutic treatment protocol with isometric muscle strengthening, passive forward flexion, individually pain

related, within the first 4-6 weeks after surgery, was followed by active rehabilitation. Exercises were also carried out at home under the supervision of a physiotherapist.

Results

The assessment of the subjective functional outcome of rotator cuff reconstruction on VAS showed values between 6 and 10 points in all cases with an overall good or excellent result. The mean pre-operative CS significantly increased from 25.7 (± 5.3) pre-operatively to 72.3 (± 7.8) points post-operatively, as shown in Figure 3. The mean values for the subcategories of CS increased significantly from 3.9 to 14.4 points for pain and from 4.2-15.9 points for daily routine activities ($p < 0.05$). The changes in range of motion and strength were not significant ($p > 0.05$). Results of the Simple Shoulder Test showed a significant increase of the mean values from pre-operative 4.3 to 14.7 points post-operatively. Concerning active forward flexion, no significant increase was shown for pre-operative (93.7 ± 32.1) to post-operative (98.3 ± 27.3) values. The mean active abduction increased with an average improved abduction of 12.5° . The mean internal rotation increased from 76.6 ± 18.3 to 78.1 ± 18.2 . In summary, the changes in range of motion were not statistically significant. In the post-operative MRI, almost all patients had an intact transferred deltoid muscle flap (Figure 4a). Three patients had an intact but very thin tendon, and in one case an avulsion of the deltoid muscle flap from the insertion side occurred (Figure 4b). There was congruity in the glenohumeral joint and there was no subluxation on the location of the center of the humeral head with respect to the midpoint of the glenoid. As mentioned above, one patient developed a post-operative hematoma on the second post-operative day. He underwent aspiration of the joint with negative cultures. There were no infections, wound healing or cosmetic problems.

Discussion

Emerging studies have clarified the complex process of rotator cuff degeneration. Acromial morphology in particular contributes to bursal sided cuff tears.¹⁹ More commonly, cuff tears are thought to begin on the articular side in the context of age-related degeneration and microtrauma.¹⁹ Inflammatory changes, oxidative stress, tissue remodeling and apoptosis are all important parts of this pathological process.²⁰ Massive tears of the rotator cuff have

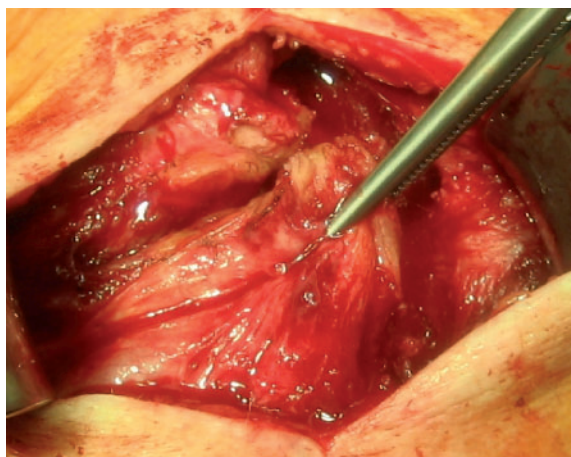


Figure 1. Intra-operative findings. Starting with the part of the deltoid muscle used for the approach (inverted L-shape), a flap was formed for the repair by anterior division in the line of the muscle fibers starting at the acromioclavicular joint. This distally based flap was swung into the defect.

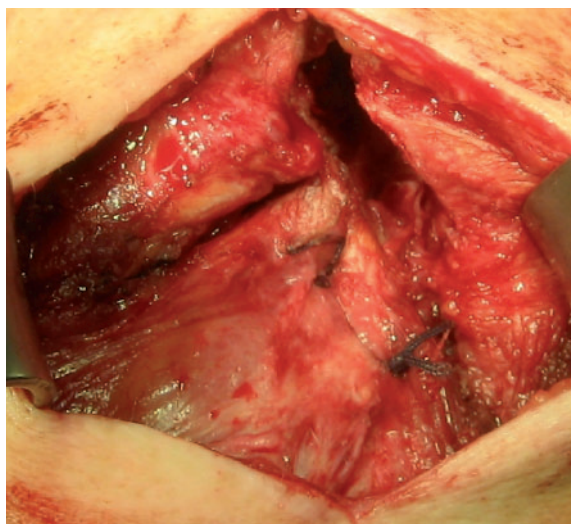


Figure 2. Intra-operative findings: the sutures previously placed in the edges of the tear were passed through the flap edges and the knots tied one at a time, spreading the flap out over the head of the humerus, which was then separated from the arch of the acromion by this sheet of muscle.

been anatomically defined as lesions that have a maximum diameter of more than 5 cm and functionally as lesions that involve two or more tendons.⁴ In massive rotator cuff tears, repair may be difficult due to the size of the defect, tendon retraction and muscular atrophy and fatty degeneration of the cuff remnant.⁴ Some authors report good results after conservative treatment.²¹ Different surgical techniques are available to deal with the problem of massive rotator cuff tears. The deltoid muscle flap transfer is an appealing method as it works synergistically with the infraspinatus and supraspinatus muscle, and because both the blood vessels and the nerve supply to the flap are preserved.²² The procedure interposes live tissue between the acromion and the proximal humerus forming a three-bellied muscle that opposes upward migration of the humeral head. The arthroscopic examination prior to the index procedure gave us the possibility of detecting pathologies of the humeroglenoidal joint, the biceps tendon and the rotator cuff. The vast majority of patients had an intact subscapularis muscle which provided additional stability to the glenohumeral joint. According to Gerber *et al.*, the subscapularis is critical to function in patients who have irreparable tears of the supraspinatus and infraspinatus.²³

Acromioplasty has been performed routinely in all shoulders in our study and this offers increased subacromial space, protection of the flap during the healing process, lessens post-operative pain and facilitates rehabilitation.^{18,24} In our opinion, the prevention of impingement of the cuff on the acromion is a critical element in the outcome of the surgery.

With a final global Constant Score of 62 points, the deltoid flap demonstrates its ability to produce better objective results than arthroscopic decompression of retracted tears.²⁵ Regarding arthroscopic debridement, longer-term data on humeral head migration and glenohumeral osteoarthritis are needed to determine the place of this procedure in the treatment of rotator cuff tears.²² Our data endorse the fact that tendon transfer has proven to be a valuable technique in young active patients.²⁶ Besides this, our results indicate that the deltoid muscle transfer is, even in elderly patients with degenerative massive cuff lesion, a reliable therapeutic alternative. This is in contrast with the literature reporting high rates of failure and re-rupture after surgical treatment of massive cuff lesions with autogenous grafts in both primary and revision surgery in elderly patients.²⁷ Watson reported clinical deterioration in patients older than 60 years of age.²⁸ We found no deterioration in the clinical findings of patients older than 60 years of age which we attribute to the fact that advanced age is usually associated with less stress, that demands decrease with age, that many recurrence defects are not detected on

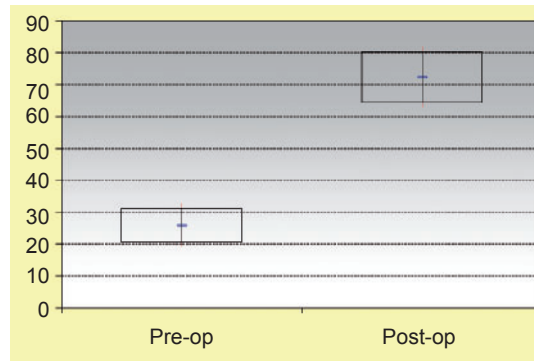


Figure 3. Box and Whisker plot of the clinical outcome evaluated by the Constant and Murley score. Scores are presented as medians; the ends of the boxes define the 25th and 75th centiles. The mean pre-operative CS significantly increased from 25.7 (± 5.3) pre-operatively to 72.3 (± 7.8) points post-operatively.

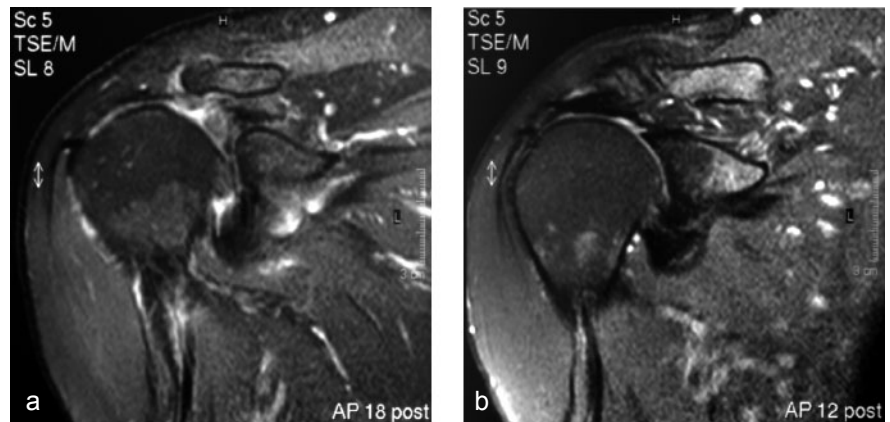


Figure 4. Post-operative magnetic resonance imaging. Almost all patients had an intact transferred deltoid muscle flap (a) and in one case an avulsion of the deltoid muscle flap from the insertion side occurred (b).

clinical examination, and that the subjective results may be quite good, as it has been reported before.² In our patient population a significant decrease of pain post-operatively, being the leading complaint pre-operatively, was noted. Our results are in accordance with the literature, reporting comparable results for the transposition of *latissimus dorsi*⁷ and *pectoralis major*¹⁰ in massive rotator cuff tears. In 16 patients with irreparable rotator cuff tears treated with latissimus dorsi flap reconstruction and re-evaluated after three years, Gerber *et al.* found a mean Constant Score of 67.5 with gains of 52% for flexion and 23% for external rotation.²⁹ Published data suggest that functional outcome after *latissimus dorsi* flap reconstruction may be similar to those recorded after deltoid flap transfer.³⁰ On the other hand, Le Huec *et al.* compared the results of 14 patients with a mean follow-up of 3.5 years after deltoid muscle flap transfer.³¹ Ten patients were very satisfied, 2 were satisfied and 2 disappointed. The authors conclude that this technique is a demanding procedure and results are no better than those obtained with arthroscopic subacromial decompression.³¹ This is in contrast with our results and may be based on the fact that the surgical technique described in this paper varies from that of the

previous report. As mentioned above, the range of motion did not increase significantly comparing pre-operative and follow-up data. This is in accordance with the literature, reporting good results on pain but no significant improvement in strength or motion.³²

In general, for measuring and evaluating the clinical outcome of a given treatment strategy, patient's satisfaction and improvement are most important and are best assessed by well-established clinical outcome-scores. The Constant and Murley Score, published in 1987, has been recommended by the European Society of Shoulder and Elbow Surgery.¹⁵ Generally, these scores represent an overall numerical score by combining findings from physical examination and patients' self report of functional limitations and disabilities.^{33,34} Like Gazielly *et al.*, we believe that the score may not be a reliable indicator of a tear or recurrent defect, probably because mobility, not typically reduced by a cuff defect, is weighted heavily in the CS score.³⁵ From the scientific point of view, additional detailed questions arise regarding measurable parameters like morphology and quality of the formed repair tissue as well as defect filling and graft integration. These issues can be addressed, for example, by non-invasive MRI techniques. In

our series, post-operative MRI showed an intact transferred deltoid muscle flap in almost all patients. A main limitation of the study is that not all patients underwent follow-up MRI investigation.

We acknowledge that the presented patient population is heterogenous, which reflects the situation of patients with an indication for deltoid muscle flap. Although patients' data were heterogenous, all rotator cuff tears were rated as Bateman IV. It is common that a patient population with massive rotator cuff tears presents with more than one isolated underlying pathology and thus needs more than one singular surgical procedure to address all them. In our series, concomitant surgical procedures were performed in 3 cases. Previous surgical procedures did not prove to negatively influence the follow-up results in our series. Studies show that results of a deltoid flap transfer are satisfactory over short- or medium-term follow-up for individuals who wished to return to work or for pain relief, with an improvement in the total function of the shoulder.⁹ This is in accordance with the current study. Shortcomings of the deltoid muscular flap are presented in long-term follow-up studies, where up to 50% were ruptured and osteoarthritis occurred in up to 70% of the shoulders.⁸

In conclusion, massive rotator cuff tears represent a separate and unique challenging entity of rotator cuff lesions based on differences of the mechanism of injury, clinical presentation, operative treatment and outcome. Deltoid muscle flap seems to be a reliable option for irreparable massive rotator cuff tears with regard to pain relief, function and stability of the glenohumeral joint in the short- or medium term.

References

- Cofield RH, Parvizi J, Hoffmeyer PJ, et al. Surgical repair of chronic rotator cuff tears. A prospective long-term study. *J Bone Joint Surg Am* 2001;83-A:71-7.
- Motycka T, Kriegleder B, Landsiedl F. Results of open repair of the rotator cuff—a long-term review of 79 shoulders. *Arch Orthop Trauma Surg* 2001;121:148-51.
- Coghlan JA, Buchbinder R, Green S, et al. Surgery for rotator cuff disease. *Cochrane Database Syst Rev* 2008;CD005619.
- Gavriilidis I, Kircher J, Magosch P, et al. Pectoralis major transfer for the treatment of irreparable anterosuperior rotator cuff tears. *Int Orthop* 2009 May 13. [Epub ahead of print].
- Miniaci A, MacLeod M. Transfer of the latissimus dorsi muscle after failed repair of a massive tear of the rotator cuff. A two to five-year review. *J Bone Joint Surg Am* 1999;81:1120-7.
- Costouros JG, Espinosa N, Schmid MR, et al. Teres minor integrity predicts outcome of latissimus dorsi tendon transfer for irreparable rotator cuff tears. *J Shoulder Elbow Surg* 2007;16:727-34.
- Habermeyer P, Magosch P, Rudolph T, et al. Transfer of the tendon of latissimus dorsi for the treatment of massive tears of the rotator cuff: a new single-incision technique. *J Bone Joint Surg Br* 2006;88:208-12.
- Lu XW, Verborgt O, Gazielly DF. Long-term outcomes after deltoid muscular flap transfer for irreparable rotator cuff tears. *J Shoulder Elbow Surg* 2008;17:732-7.
- Iannotti JP, Hennigan S, Herzog R, et al. Latissimus dorsi tendon transfer for irreparable posterosuperior rotator cuff tears. Factors affecting outcome. *J Bone Joint Surg Am* 2006;88:342-8.
- Samilson RL, Prieto V. Dislocation arthropathy of the shoulder. *J Bone Joint Surg Am* 1983;65:456-60.
- Cleeman E, Hazrati Y, Auerbach JD, et al. Latissimus dorsi tendon transfer for massive rotator cuff tears: a cadaveric study. *J Shoulder Elbow Surg* 2003;12:539-43.
- Magermans DJ, Chadwick EK, Veeger HE, et al. Biomechanical analysis of tendon transfers for massive rotator cuff tears. *Clin Biomech (Bristol, Avon)* 2004;19:350-7.
- Bateman JE. The diagnosis and treatment of ruptures of the rotator cuff. *Surg Clin North Am* 1963;43:1523-30.
- Goutallier D, Postel JM, Bernageau J, et al. Fatty muscle degeneration in cuff ruptures. Pre- and postoperative evaluation by CT scan. *Clin Orthop Relat Res* 1994;78-83.
- Nich C, Mutschler C, Vandenbussche E, et al. Long-term Clinical and MRI Results of Open Repair of the Supraspinatus Tendon. *Clin Orthop Relat Res* 2009 Jun 5. [Epub ahead of print].
- Mayerhoefer ME, Breitensteiner MJ, Wurnig C, et al. Shoulder impingement: relationship of clinical symptoms and imaging criteria. *Clin J Sport Med* 2009;19:83-9.
- Santamato A, Solfrizzi V, Panza F, et al. Short-term effects of high-intensity laser therapy versus ultrasound therapy in the treatment of people with subacromial impingement syndrome: a randomized clinical trial. *Phys Ther* 2009;89:643-52.
- Neer CS, 2nd. Anterior acromioplasty for the chronic impingement syndrome in the shoulder: a preliminary report. *J Bone Joint Surg Am* 1972;54:41-50.
- Yadav H, Nho S, Romeo A, et al. Rotator cuff tears: pathology and repair. *Knee Surg Sports Traumatol Arthrosc* 2009;17:409-21.
- Droge W. Oxidative stress and aging. *Adv Exp Med Biol* 2003;543:191-200.
- Ejnisman B, Andreoli CV, Soares BG, et al. Interventions for tears of the rotator cuff in adults. *Cochrane Database Syst Rev* 2004;CD002758.
- Vandenbussche E, Bensaida M, Mutschler C, et al. Massive tears of the rotator cuff treated with a deltoid flap. *Int Orthop* 2004;28:226-30.
- Gerber C, Krushell RJ. Isolated rupture of the tendon of the subscapularis muscle. Clinical features in 16 cases. *J Bone Joint Surg Br* 1991;73:389-94.
- Rockwood CA, Lyons FR. Shoulder impingement syndrome: diagnosis, radiographic evaluation, and treatment with a modified Neer acromioplasty. *J Bone Joint Surg Am* 1993;75:409-24.
- Gedouin JE, Katz D, Colmar M, et al. [Deltoid muscle flap for massive rotator cuff tears: 41 cases with a mean 7-year (minimum 5 year) follow-up]. *Rev Chir Orthop Reparatrice Appar Mot* 2002;88: 365-72.
- Audenaert E, Van Nuffel J, Schepens A, et al. Reconstruction of massive rotator cuff lesions with a synthetic interposition graft: a prospective study of 41 patients. *Knee Surg Sports Traumatol Arthrosc* 2006;14:360-4.
- Werner CM, Zingg PO, Lie D, et al. The biomechanical role of the subscapularis in latissimus dorsi transfer for the treatment of irreparable rotator cuff tears. *J Shoulder Elbow Surg* 2006;15:736-42.
- Watson M. Major ruptures of the rotator cuff. The results of surgical repair in 89 patients. *J Bone Joint Surg Br* 1985;67: 618-24.
- Gerber C. Latissimus dorsi transfer for the treatment of irreparable tears of the rotator cuff. *Clin Orthop Relat Res* 1992:152-60.
- Aoki M, Okamura K, Fukushima S, et al. Transfer of latissimus dorsi for irreparable rotator-cuff tears. *J Bone Joint Surg Br* 1996;78:761-6.
- Le Huec JC, Liquois F, Schaefferbecke T, et al. [Results of a series of deltoid flaps for the treatment of massive rotator cuff tears with an average follow-up of 3.5 years]. *Rev Chir Orthop Reparatrice Appar Mot* 1996;82:22-8.
- Ben Maitigue M, Bouaouaja G, Ben Chaabane T, et al. [Results of the deltoid flap for surgery of rotator cuff tears]. *Tunis Med* 2008;86:1066-9.
- Sgaglione NA, Del Pizzo W, Fox JM, et al. Critical analysis of knee ligament rating systems. *Am J Sports Med* 1995;23:660-7.
- Irrgang JJ, Ho H, Harner CD, et al. Use of the International Knee Documentation Committee guidelines to assess outcome following anterior cruciate ligament reconstruction. *Knee Surg Sports Traumatol Arthrosc* 1998;6:107-14.
- Gazielly DF, Gleyze P, Montagnon C. Functional and anatomical results after rotator cuff repair. *Clin Orthop Relat Res* 1994:43-53.