



Latissimus dorsi transfer : L'Episcopo versus Herzberg technique

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The purpose of this study was to compare the clinical results of two different techniques of latissimus dorsi transfer used in 28 patients, either a modified single incision mini-invasive Herzberg transfer (HT) or a combined latissimus dorsi and teres major transfer according to L'Episcopo (LE).

Twenty-eight patients fulfilled the inclusion criteria. Minimum follow-up was 24 months. Sixteen patients were treated with the Herzberg transfer (HT group) and 12 patients had the L'Episcopo technique (LE group).

The Constant score rose from 27.2 initially to 73.5 four years post-operatively in the LE group and from 32.2 to 76 three years and 3 months post-operatively in the HE group (statistically similar). The pre-operative acromiohumeral distance remained unchanged statistically. Radiological signs of osteoarthritis increased. Constant-Murley score, acromiohumeral distance and progression of rotator cuff tear arthropathy were not significantly different between the two groups.

Keywords : shoulder ; latissimus dorsi transfer ; rotator cuff ; osteoarthritis.

repairable rotator cuff tear is the involvement of the supra and infraspinatus, a third-degree retraction of the supraspinatus according to the Patte classification (29) and fatty degeneration of the infraspinatus in the sagittal and paracoronary slices. A massive rotator cuff tear does not necessarily have to be irreparable. Single muscular atrophy of the supraspinatus according to the Tomazeau classification (32) can often be treated by anatomic reconstruction (24).

Gerber was the first author to report on the technique of latissimus dorsi transfer (12). This technique is currently accepted as the gold standard in irreparable rotator cuff tears due to available data and material, the number of patients as well as the images generated in follow-up examinations (10,13). This technique has shown better clinical results in young, motivated patients desiring high functional restitution and in patients with an intact subscapularis tendon (10).

INTRODUCTION

Several studies have shown promising clinical and functional results in the treatment of symptomatic rotator cuff tears with latissimus dorsi transfer (10,14,22,27,28,34,36). Lesions involving at least two entire tendons are classified as massive rotator cuff tears. Our definition of a massive non-

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Alternatives are the Celli technique that mobilises and reattaches the M. teres major (6) and the modified L'Episcopo procedure. The latter technique, first performed by Sever *et al* (31) and later by L'Episcopo restored external rotation in patients with obstetrical plexus paralysis (2,26). The modified L'Episcopo technique was proven successful by Habermeyer in rotator cuff tears. He restored loss of external rotation in patients with massive postero-superior rotator cuff tears by transferring the common insertion of both latissimus dorsi and teres major from the medial side of the proximal humerus to a lateral site near the surgical neck (17). The aim of this technique is to restore the balance between internal and external rotation : it neglects the defect in the rotator cuff (17). This is an especially attractive option when the acromio-humeral gap measures less than 5 mm.

Herzberg recovered superior rotation and movement with a transfer of the latissimus dorsi to the infraspinatus insertion zone (20,30). This transfer can be completed through one incision. Preliminary results on clinical trials of the "single incision technique" have recently been published (16,24).

Contraindications to all of the above-listed procedures are associated irreparable subscapularis tears, deltoid palsy and advanced osteoarthritis.

The aim of this study was to compare the clinical, functional and radiological results of the Herzberg and L'Episcopo techniques with a minimum follow-up of 24 months.

PATIENTS AND METHODS

Fifty-two patients with irreparable, massive postero-superior rotator cuff tears were recruited from 2004 to 2009 in a prospective consecutive study and underwent a latissimus dorsi tendon transfer according to a modified Herzberg technique (n = 28) or L'Episcopo technique (n = 24). Twenty-eight patients fulfilled our inclusion criteria with a minimum follow-up of 24 months (43 +/- 10.6 mo) of whom 16 patients were treated by the Herzberg transfer (HT group : 6 male, 10 female, age : 61.9 +/- 10.6 ; FU 39 month, ranging from 30 to 58 months ; FU rate : 100%) and 12 patients by the L'Episcopo technique (LE group : 8 male, 4 female, age : 62.2 +/- 7.9 ; FU 52 months ranging from 26 to 62 months ; FU rate : 100%).

We examined classical symptoms for an average of 42 months (26-62 months) and included a total of eight previous operations : three cases of arthroscopic subacromial decompression and resection of the AC joint, two cases of tuberculoplasty with tenotomy of the long head of the biceps and three cases of rotator cuff reconstruction, including one patient who underwent two of the reconstructions mentioned above.

Pre-operative investigation included clinical examination and imaging with conventional x-rays, MRI and ultrasound. Twenty-four patients (11 in the HT group and 13 in the LE group) experienced a painful loss of joint function with a positive external rotation lag sign, as defined by the inability to keep the arm in a beforehand passively rotated position. All the patients complained of therapy-resistant pain at rest as well as during activity. Furthermore, a positive drop arm sign was seen in four patients who could not hold the passively positioned arm at 90° abduction. Another inclusion (criteria) was an intact subscapularis muscle, demonstrated both clinically and by means of MRI.

The decision either to perform the Herzberg technique or the L'Episcopo technique was made arbitrarily and independently of patient-specific characteristics without randomisation.

SURGICAL TECHNIQUES

Modified Herzberg technique (24)

Surgery was performed with the patient in a lateral decubitus position, and subsequently in a prone position (Fig. 1). The long head of the biceps (LBT) was arthroscopically sectioned when not done in an earlier procedure. The 5 cm incision started below the posterolateral edge of the acromion following the triceps for about 6-8 cm. The latissimus dorsi and teres major tendons were identified and sharply dissected from the humerus, with attention to the nearby radial nerve. When separation of latissimus dorsi and teres major was not possible, a combined transfer was done. The anatomical insertion of the infraspinatus was located under the posterior bundles of the deltoid muscle. A bony trough was prepared in abduction and external rotation at the anatomical insertion of the infraspinatus muscle and the tendons were fixed with suture anchors using Mersilene 2 and a Mason-Allen suture technique.



Fig. 1. — Patient in a prone position. The acromion, the inferior angle of the scapula and the surgical approach are marked with a felt-tipped pen.

L'Episcopo technique (14)

The patient was placed in lateral decubitus. An angled incision was made beginning from the posterior border of the deltoid muscle to the axillary fold according to Beauchamp *et al* (2) and further medial along the course of the latissimus dorsi muscle. The deltoid muscle was elevated to display the long head of the triceps and teres major muscle followed by exposure of the quadrangular space to identify the axillary nerve. Then the latissimus dorsi tendon was identified and the radial nerve was visualised in the triangular space (Fig. 2). The combined insertion of the latissimus dorsi and teres major tendons was sharply dissected from the humerus taking care not to injure the radial nerve. If necessary, the tendons were sutured together. A bony trough was prepared in abduction and external rotation at the lateral proximal humeral shaft, approximately 180° lateral to the anatomical insertion. After insertion of four suture anchors, the tendons were attached using 2 Mersilene sutures and a Mason-Allen suture technique.

Postoperative treatment

The upper limb was immobilised on an abduction pillow for three weeks and passive movement of the operated arm was restricted to 30° abduction, 30°



Fig. 2. — Radiograph after the L'Episcopo procedure with suture anchors in the humeral shaft.

flexion, 60° internal rotation and 0° neutral rotation. Range of motion was increased to 60° abduction, 90° flexion and 60° internal rotation after 3 weeks. At 6 weeks free range of motion was allowed dependent on patient's pain, with further mobilisation and careful strengthening after week seven.

Follow-up evaluation

Follow-up was performed after 42 months (range : 26-62 months ; n = 28) ; HE group : 39 mo (range : 30-58 ; n = 16), LE group : 52 mo (range : 26-62 mo ; n = 12). The patients were clinically evaluated using the normative age and gender related Constant and Murley scoring system according to Katolik *et al* (23).

Standard radiography was attempted including a true AP, outlet and axillary view. The acromio-humeral distance was measured on true AP view. The extent of glenohumeral osteoarthritis was evaluated according to Hamada *et al* (18). The integrity of the muscular flap was examined either by ultrasound or in 14 cases by MRI (Fig. 3).

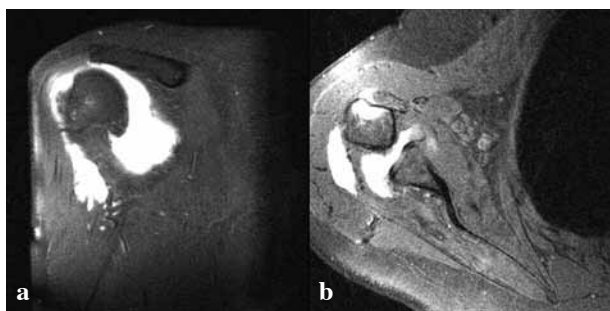


Fig. 3. — A post-op MRI in the coronal (a) and transverse (b) planes with suture anchors and the reinserted latissimus dorsi tendon.

Statistical Analysis

Statistical analysis was performed using SAS Version 9.2 (SAS Institute Inc., Cary, NC, USA). Pre- and post-operative non-parametric data from both groups were compared using the Wilcoxon signed-rank test. The comparison between the two groups was performed using the Mann-Whitney U test for independent samples.

The level of significance was set at $p < 0.05$.

RESULTS

The average operating time was 54 minutes (42-102 min).

The mean adjusted Constant-Murley score increased significantly ($p < 0.0001$) from 30.0% \pm 9.4% initially (range : 13.7% to 52.6%) to 75% \pm 25.5% (range : 32.5% to 117.1%) 43 \pm 10.6 months post-operatively. The patients showed a significant ($p < 0.0001$) improvement in pain, activities of daily living, active range of motion and power.

The implemented pain score ranging from 0 to 15 showed a significant improvement from a pre-operative average of 5.5 ± 1.8 to a post-operative average of 10.3 ± 4.3 . The evaluation of the range of motion showed a significant increase from 13.1 ± 4.5 to 28.7 ± 10.8 . Regarding the activities of daily living, the CS increased from 5.3 ± 2.6 to $14.6 \pm 5.0\%$. Table I shows there were no significant differences between both groups concerning all Constant score subgroups ($p > 0.1$).

Prior to surgery, 24/28 of the patients (85.7%) had a positive external rotation lag sign (LE group : pre-op $n = 11$, post-op $n = 3$; HE group : pre-op $n = 13$, post-op $n = 2$) still present post-operatively in 20.8% of patients after an average follow-up of 43 months and without a statistically significant difference between the groups. A positive drop arm sign present in 15.4% of the patients pre-operatively had resolved post-operatively in all cases. Between both groups, there were no significant differences.

Imaging analysis

Analysis of the pre-operative radiographs showed an acromiohumeral distance of 6.9 ± 2.8 mm which remained statistically unchanged ($p = 0.1155$) at 5.9 ± 2.7 mm (Table III). Radiological signs of osteoarthritis increased. Before surgery, 60.7% of the patients had no cuff tear arthropathy (Hamada grade 1), 28.6% a grade 2 and 10.7% a grade 3 according to the classification of Hamada. After surgery, the radiographs showed 52.0% grade 1, 24% grade 2 and 24% grade 3 ($p = 0.2842$) cuff tear arthropathy (Table IV ; Fig. 4). Differences between the groups are displayed in Table II. Nevertheless, the increase in osteoarthritis was not associated with a decline in shoulder function resulting in a persistent Constant score.

MRI ($n = 14$) showed consistent integrity of the latissimus dorsi and teres major flap at the 2 year follow-up examination. In one case a re-rupture of the reinserted Lat. dorsi tendon occurred and, in another, the suture anchor loosened on the second post-operative day requiring immediate reattachment with a transosseous fixation.

DISCUSSION

We compared the surgical outcome of two techniques of latissimus dorsi transfer.

Fatty infiltration of the rotator cuff muscles has been identified as a negative prognostic factor for the reparability of a massive cuff tear and the outcome after such a repair. The high failure rate associated with repairs of massive tears prompted the investigation of tendon transfers (3).

Table I. — The Constant score in both groups. An asterisk indicates statistical significance

	Adjusted Constant Score [%]	Pain	ADL	ROM	Power
Pre-operative LE	27.2 ± 5.8%	5.3 ± 1.2	5.1 ± 2.4	11.8 ± 2.8	0.2 ± 0.6
Post-op (48.3 mo) LE	73.5 ± 25.6%*	11.6 ± 3.6*	14.4 ± 5.2*	27.8 ± 10.8*	3.8 ± 2.9*
Pre-operative HT	32.2 ± 11.2%	5.6 ± 2.1	5.4 ± 2.8	14.0 ± 5.4	0.0 ± 0.0
Post-op (39 mo) HT	76.3 ± 26.3%*	9.3 ± 4.6*	14.8 ± 4.9*	29.4 ± 11.1*	4.4 ± 4.0

(ADL) : activities of daily living ; (ROM) : range of motion ; LE : L'Episcopo technique ; HT : Herzberg Transfer.

Table II. — Acromio-humeral distance. There were no statistically significant differences between pre- and post-op values or between groups

	AHD mm	Hamada grade 1%	Grade 2	Grade 3	Grade 4
Pre-operative LE	7.3 ± 3.3%	78.3	21.7	0	0
Post-op (48.3 mo) LE	5.7 ± 2.9	55.0	15.0	30.0	0
Pre-operative HT	6.9 ± 2.8%	66.7	33.0	0	0
Post-op (39 mo) HT	5.9 ± 2.7%	44.4	22.2	33.3	0

HD : acromiohumeral distance ; LE : L'Episcopo technique ; HT : Herzberg transfer.

Table III. — Decreases in the acromiohumeral distance without statistically significant differences between both groups

	Acromiohumeral distance pre-op	Acromiohumeral distance post-op
L'Episcopo group	7.3 mm	5.7 mm
Herzberg group	6.9 mm	5.9 mm
p-value	0.74	0.82

Table IV. — The distribution of pre- and post-op grading according to the Hamada *et al* classification (18)

	L'Episcopo pre-op	Herzberg pre-op	L'Episcopo post-op	Herzberg post-op
Grade 1	66.7%	56.3%	44.4%	56.3%
Grade 2	33.3%	25.0%	22.2%	25.0%
Grade 3	0%	18.8%	33.3%	18.8%
Grade 4	0%	0%	0%	0%
Grade 5	0%	0%	0%	0%

The method by Gerber *et al* is the most common technique and has become an established surgical option for unreconstructable, massive postero-superior rotator cuff tears. The first systematic post operative assessment was published in 1992 and showed preliminary clinical results in over 16 patients with a 33 month follow-up. The studies from Gerber's team showed good results, with an age-adapted CS of 75% (10,12,13).

Other working groups have also reported similar good results (8,9,22,23,27,34,36). Gerber *et al* published in 2006 the most extensive study so far by following 67 patients with 69 irreparable tears for 53 months post-operatively with a mean age and gender-matched Constant and Murley score of 55%, which increased to 73% at the end of the follow-up period (10).

Recently, similar results have been reported with single incision techniques (16,17,24). Habermeyer



Fig. 4. — The radiological progress of osteoarthritis from 2005 (a) to 2007 (b) to 2008 (c) to 2009 with osteoarthritis Hamada Grade 3 (d).

used the technique of L'Episcopo to regain external rotation for the treatment of massive postero-superior tears of the rotator cuff (17,14) and presented similar results after five years. In 2006, he published data on 14 patients treated with a modified latissimus dorsi transfer using a single incision technique (16).

Our experience with the Herzberg technique led to a minimally invasive modification, and results were comparable to the short-term results reported with other techniques (24). Our results did not show differences in the clinical outcome nor in progression of rotator cuff arthropathy.

Several authors have attempted to determine sensitive predictive factors able to influence the post-operative outcome. Iannotti *et al* found female sex, poor preoperative shoulder function, generalised muscle weakness and the absence of electrical activity of the transferred muscle at the time of follow-up to be negative predictive factors (21). It remains uncertain if the number of previous operations on the shoulder joint is a relevant factor. Warner and Pearson (34) as well as Irlenbusch *et al* (22) and Valenti *et al* (33) described inferior post-operative results in previously operated shoulders, whereas Miniaci and McLeod did not detect any differences in these groups (27). Moursy *et al* demonstrated inferior results of latissimus dorsi tendon transfers as revision procedures (28). Six of the 18 patients who underwent latissimus dorsi tendon transfer as a revision procedure had a persistent severe weakness of elevation, which is known to be a negative factor (28). Our study included eight pre-

viously operated patients prior to the latissimus dorsi transfer, a sample size too small to allow for a meaningful analysis. However, one ought to make a distinction between an arthroscopic tenotomy of the long head of the biceps (LHB) and an unsuccessful open operative reconstruction of the rotator cuff. Latissimus dorsi transfer should still be considered as a primary procedure when done after arthroscopic tenotomy of the LHB, subacromial decompression and/or cuff debridement, whereas it should be considered as a salvage reconstruction when done after failed rotator cuff repair. It is important to make this distinction.

Werner *et al* concentrated on the integrity of the subscapularis and stated that a positive outcome in clinical studies concerning massive tears requires a good function of this muscle (35). In our view an intact subscapularis tendon is a prerequisite in the indication for surgery. All patients included in this study showed an intact subscapularis muscle on preoperative MRI, and this was confirmed intra-operatively.

Other studies have focused on the teres minor muscle and have shown that this muscle's integrity is a predictive factor for a positive outcome (7). Moursy *et al* (28) confirmed the crucial role of teres minor integrity, as patients with extensive fatty infiltration of the teres minor muscle had poorer results. A further contraindication for latissimus dorsi tendon transfer is advanced osteoarthritis. In this case, reverse shoulder arthroplasty along with a latissimus dorsi and teres major tendon transfer as

performed by Gerber and Boileau (4,5,11) would be a better approach.

Several authors reported progression of glenohumeral osteoarthritis in 29 to 41% (1,8,10,28) irrespective of the surgical technique used.

Thirty percent of the patients in the L'Episcopo group and 33.3% in the Herzberg group had radiographs displaying a Stage III Hamada post-operatively. Whether or not these individuals will have diverging outcomes will be shown in time, however inferior results have not been reported so far. The progression of osteoarthritis is considered to be multifactorial and can also be explained through biochemical as well as biomechanical factors (25).

We did not note strength improvement after surgery, although the positive drop-arm sign, pre-operatively seen in 15.4% of the patients, was absent post-operatively in all. A single muscle transfer may not be sufficient to regain the strength in external rotation and elevation against resistance, even though the external rotation deficit and drop-arm sign are successfully diminished (24). A possible explanation of the lasting muscle weakness in post-operative examinations is that the transferred latissimus dorsi muscle cannot centre the humeral head in the shoulder joint as effectively as the rotator cuff muscles do. Therefore the deltoid muscle cannot exert its normal strength. Furthermore, Gumina *et al* showed that frequently the deltoid muscle is partly detached and possibly other techniques without detachment of the deltoid muscle should always be considered (15). We did not visualise the distal humeral deltoid insertion during transfer surgery and avoided axillary nerve injury with direct preparation towards the humeral shaft lateral to the long head of the triceps muscle tendon.

Our study shows that the results of latissimus dorsi transfer using both techniques are comparable with the results of the technique described initially by Gerber (10,11,12,13).

Surgery will find its typical indications in those patients in which conservative treatment has failed. Tendon transfer in demanding patients with irreparable massive tears should be considered with caution. Prosthetic replacement should be considered in patients with massive rotator cuff tears and advanced osteoarthritis (19).

Overall, the outcome of latissimus dorsi tendon transfer is influenced negatively by a number of associated factors, including subscapularis and teres minor deficiency, patient age, preoperative shoulder function, and a previous failed rotator cuff repair.

According to our data the surgical outcome is not dependent on the technique used.

REFERENCES

1. **Aoki M, Okamura K, Fukushima S, Takahashi T, Ogino T.** Transfer of latissimus dorsi for irreparable rotator-cuff tears. *J Bone Joint Surg* 1996 ; 78-B : 761-766.
2. **Beauchamp M, Beaton DE, Barnhill TA, Mackay M, Richards RR.** Functional outcome after the L'Episcopo procedure. *J Shoulder Elbow Surg* 1988 ; 7 : 90-96.
3. **Bedi A, Dines J, Warren RF, Dines DM.** Massive tears of the rotator cuff. *J Bone Joint Surg* 2010 ; 92-A : 1894-1908.
4. **Boileau P, Chuinard C, Roussanne Y, Neyton L, Trojani C.** Reverse shoulder arthroplasty combined with a modified latissimus dorsi and teres major tendon transfer for shoulder pseudoparalysis associated with dropping arm. *Clin Orthop Relat Res* 2008 ; 466 : 584-593.
5. **Boileau P, Chuinard C, Roussanne Y, Neyton L, Trojani C.** Modified latissimus dorsi and teres major transfer through a single delto-pectoral approach for external rotation deficit of the shoulder : as an isolated procedure or with a reverse arthroplasty. *J Shoulder Elbow Surg* 2007 ; 16 : 671-682.
6. **Celli L, Rovesta C, Marongiu MC, Manzieri S.** Transplantation of teres major muscle for infraspinatus muscle in irreparable rotator cuff tears. *J Shoulder Elbow Surg* 1998 ; 7 : 485-490.
7. **Costouros JG, Espinosa N, Schmid MR, Gerber C.** Teres minor integrity predicts outcome of latissimus dorsi tendon transfer for irreparable rotator cuff tears. *J Shoulder Elbow Surg* 2007 ; 16 : 727-734.
8. **Debeer P, De Smet L.** Outcome of latissimus dorsi transfer for irreparable rotator cuff tears. *Acta Orthop Belg* 2010 ; 76 : 449-455.
9. **Degreef I, Debeer P, Van Herck B et al.** Treatment of irreparable rotator cuff tears by latissimus dorsi muscle transfer. *Acta Orthop Belg* 2005 ; 71 : 667-671.
10. **Gerber C, Maquieira G, Espinosa N.** Latissimus dorsi transfer for the treatment of irreparable rotator cuff tears. *J Bone Joint Surg* 2006 ; 88-A : 113-120.
11. **Gerber C, Pennington SD, Lingenfelter EJ, Sukthankar A.** Reverse Delta-III total shoulder replacement combined with latissimus dorsi transfer. A preliminary report. *J Bone Joint Surg* 2007 ; 89-A : 940-947.
12. **Gerber C, Vinh TS, Hertel R, Hess CW.** Latissimus dorsi transfer for the treatment of massive tears of the rotator

- cuff. A preliminary report. *Clin Orthop Relat Res* 1988 ; 232 : 51-61.
13. **Gerber C.** Latissimus dorsi transfer for the treatment of irreparable tears of the rotator cuff. *Clin Orthop Relat Res* 1992 ; 275 : 152-160.
 14. **Gerhardt C, Lehmann L, Lichtenberg S, Magosch P, Habermeyer P.** Modified L'Episcopo tendon transfers for irreparable rotator cuff tears : 5-year follow-up. *Clin Orthop Relat Res* 2010 ; 468 :1572-1577.
 15. **Gumina S, Di Giorgio G, Perugia D, Postacchini F.** Deltoid detachment consequent to open surgical repair of massive rotator cuff tears. *Int Orthop* 2008 ; 32 : 81-84.
 16. **Habermeyer P, Magosch P, Rudolph T, Lichtenberg S, Liem D.** 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* 2006 ; 88-B : 208-212.
 17. **Habermeyer P, Magosch P, Lichtenberg S.** The modified L'Episcopo procedure to reconstruct massive rotator cuff tears- A prospective study. *AAOS Congress* 2002.
 18. **Hamada K, Fukuda H, Mikasa M, Kobayashi Y.** Roentgenographic findings in massive rotator cuff tears. A long-term observation. *Clin Orthop Relat Res* 1990 ; 254 : 92-96.
 19. **Handelberg F W.** Treatment options in full thickness rotator cuff tears. *Acta Orthop Belg* 2001 ; 67 ; 110-115.
 20. **Herzberg G, Urien JP, Dimnet J.** Potential excursion and relative tension of muscles in the shoulder girdle : relevance to tendon transfers. *J Shoulder Elbow Surg* 1999 ; 8 : 430-437.
 21. **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* 2006 ; 88-A : 342-348.
 22. **Irlenbusch U, Bendsdorf M, Gansen HK, Lorenz U.** [Latissimus dorsi transfer in case of irreparable rotator cuff tear--a comparative analysis of primary and failed rotator cuff surgery, in dependence of deficiency grade and additional lesions.] (in German). *Z Orthop Ihre Grenzgeb* 2003 ; 141 : 650-656.
 23. **Katolik LI, Romeo AA, Cole BJ et al.** Normalization of the Constant score. *J Shoulder Elbow Surg* 2005 ; 14 : 279-285.
 24. **Lehmann LJ, Mauerman E, Strube T, Laibacher K, Scharf HP.** Modified minimally invasive latissimus dorsi transfer in the treatment of massive rotator cuff tears : a two-year follow-up of 26 consecutive patients. *Int Orthop* 2010 ; 34 : 377-383.
 25. **Lehmann LJ, Schollmeyer A, Stoeve J, Scharf HP.** [Biochemical analysis of the synovial fluid of the shoulder joint in patients with and without rotator cuff tears.] (in German). *Z Orthop Unfall* 2010 ; 148 : 90-94.
 26. **L'Episcopo JB.** Tendon transplantation in obstetrical paralysis. *Am J Surg* 1934 ; 25 : 122-125.
 27. **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* 1999 ; 81-A : 1120-1127.
 28. **Moursy M, Tauber M, Forstner R, Koller H, Resch H.** Latissimus dorsi tendon transfer for irreparable rotator cuff tears : a modified technique to improve tendon transfer integrity : surgical technique. *J Bone Joint Surg* 2009 ; 92-A Suppl 1 : 226-239.
 29. **Patte D.** Classification of rotator cuff lesions. *Clin Orthop Relat Res* 1990 ; 254 : 81-86.
 30. **Schoierer O, Herzberg G, Berthonnaud E et al.** Anatomical basis of latissimus dorsi and teres major transfers in rotator cuff tear surgery with particular reference to the neurovascular pedicles. *Surg Radiol Anat* 2001 ; 23 : 75-80.
 31. **Sever J.** The results of a new operation for obstetrical paralysis. *J Orthop Surg* 1918 ; 16 : 248-257.
 32. **Thomazeau H, Rolland Y, Lucas C, Duval JM, Langlais F.** Atrophy of the supraspinatus belly. Assessment by MRI in 55 patients with rotator cuff pathology. *Acta Orthop Scand* 1996 ; 67 : 264-268.
 33. **Valenti P, Kalouche I, Diaz LC, Kaouar A, Kilinc A.** Results of latissimus dorsi tendon transfer in primary or salvage reconstruction of irreparable rotator cuff tears. *Orthop Traumatol Surg Res* 2010 ; 96 : 133-138.
 34. **Warner JJ, Parsons IMt.** Latissimus dorsi tendon transfer : a comparative analysis of primary and salvage reconstruction of massive, irreparable rotator cuff tears. *J Shoulder Elbow Surg* 2001 ; 10 : 514-521.
 35. **Werner CM, Zingg PO, Lie D, Jacob HA, Gerber C.** The biomechanical role of the subscapularis in latissimus dorsi transfer for the treatment of irreparable rotator cuff tears. *J Shoulder Elbow Surg* 2006 ; 15 : 736-742.
 36. **Zafra M, Carpintero P, Carrasco C.** Latissimus dorsi transfer for the treatment of massive tears of the rotator cuff. *Int Orthop* 2009 ; 33 : 457-462.