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PŮVODNÍ PRÁCE

Are there any Prognostic Prediction Parameters (PPPs) in the Treatment of the Massive Rotator Cuff Tear with Latissimus Dorsi Transfer?

Latissimus dorsi transfer in massiv rotator cuff tears

Existují prognostické prediktivní parametry (PPP) v léčbě masivní trhliny rotátorové manžety pomocí transferu musculus latissimus dorsi?

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ABSTRACT

PURPOSE OF THE STUDY

Especially in such complex salvage procedures as latissimus dorsi transfer for irreparable rotator cuff tears there is a need for valid prognostic prediction parameters. Parameters such as osteoarthritis, acromiohumeral distance, subscapularis, or teres minor insufficiency are controversial. The aim of this study is to present our data and to evaluate the literature regarding such parameters.

METHODS

Fifty-seven patients with a follow-up of 3 years (range, 18–72 months, n = 57) were selected for this study. Average age of patients at the time of surgery was 64.9 years. Patients were evaluated using the age and gender adjusted scoring system according to Constant and Murley score (CS). Standard radiography was attempted containing a true-ap, outlet, and axillary view. The acromio-humeral distance was measured in the true ap view. The grade of glenohumeral osteoarthritis and cuff tear arthropathy was detected using the classification of Hamada et al.

Differences in CS were compared for each of the PPP.

RESULTS

Mean Constant score increased significantly ($p < 0.0001$) 3 years postoperatively from initially 22.7 points to 66.0 points (adjusted CS 80.3%). We found a major difference in the Constant score in patients with or without previous surgery (80.4% vs, 65.2 %).

CONCLUSSION

Latissimus dorsi transfer is an excellent option in the treatment of irreparable postero-superior tears of the rotator cuff in well-selected patients. The literature remains ambiguous with regard to valid prognostic predictive parameters for complex salvage procedures, owing to the consistent use of small study samples. Thus, there is an overwhelming need for a multicenter study.

Key words: latissimus dorsi, rotator cuff tear, prognostic prediction parameter, shoulder.

INTRODUCTION

Patients with rotator cuff tears are often diagnosed late, so that – due to the size of the defect and the biology of the muscle – a reconstruction of the tendon without tension or mechanical stress is no longer possible. Particularly the loss of fibrocartilagenous and musculotendinous transition zone of the tendon leads to a substantial limitation of the healing potential after attempting an anatomical reconstruction (8, 13). The full thickness tear of at least two tendons of the rotator cuff with third-degree of the muscle belly retraction and its tendon according to Patte, a third-degree of muscle atrophy according to Thomazeau and an advanced fatty infiltration according to Goutallier (IV°) is defined as a non-reconstructable rotator cuff (12, 25). The attempt of surgical repair of these defects is rarely possible and usually accompanied by poor clinical outcome (4).

Based on the findings of Melis et al. (19, 20), rotator cuff repair should be performed before the appearance of fatty infiltration (Stage 2) and atrophy (positive tangent sign) in older patients when the tear involves multiple tendons.

Latisimus dorsi transfer is indicated in active patients with functional requirements who had combined major defects of the infra-and supraspinatus tendon that result in a non-compensable weakness of external rotation and abduction. For the surgical treatment of irreparable posterosuperior mass defects Gerber described in 1988 (10) the technique of latissimus dorsi transfer to center the humeral head and to improve the external rotation. From the time of that publication this technique of muscle tendon transfer of latissimus dorsi has been widely used and has exhibit very good clinical results. Due to the existing data material up to that time this procedure is evaluated currently as a gold standard for the treatment of massive irreparable posterosuperior defects of the rotator cuff (1, 7, 9). Influencing factors to the expected outcome are – according to literature – subscapularis and teres minor integrity, a pre-existing osteoarthritis, a pre-existing external rotation lag sign, a positive drop arm and a clinically bad pre-operative Constant score (2, 5, 27). Especially in complex salvage procedures like the latissimus dorsi transfer for non-reparable rotator cuff mass ruptures prognostic prediction parameters (PPPs) become an important preoperative decision support. The aim of our study was therefore to show the influence of all those parameters on the postoperative outcome after latissimus dorsi transfer, to compare these results with the literature.

MATERIALS AND METHODS

Between 2004 and 2012, 90 consecutive patients underwent transfer of the latissimus dorsi and / or teres major tendons according to the L´Episcopo or the Herzberg technique performed by a single surgeon (LJL). Surgery was performed as elaborated and described elsewhere (11, 18).

70 patients with a minimum follow up of 18 months were available for follow up. 13 patients were excluded because they could not be reached or decided not to participate in the study (FU rate 81%). The remaining group of patients (n: 57) consisted of 31women and 26 men.

The average age of patients at surgery was 64.9 years, ranging from 39 to 77 years. They exhibited the classical symptoms as pain, limitation of the range of motion and muscle weakness for an average of 15 months and included a total of 22 previous operations with 15 previous rotator cuff reconstructions and 7 previous arthroscopic acromioplasty and tenotomy of the long head of biceps.

The diagnosis of massive rotator cuff tear was based on clinical examination with evaluation of active ranges of motion, the external rotation lag sign and the horn blower sign. A radiological investigation by standardized X-ray examination in three planes was assessed to determine cranial migration of the humeral head and grade of osteoarthritis. MR Imaging was performed to evaluate the retraction of the cuff tear according to Patte (24) as well as the muscle atrophy using the classification of Thomazeau et al. (25). An intact subscapular and deltoid muscle was determined by clinical examination and MR Imaging. Prior to surgery all patients underwent an ineffective conservative treatment with physiotherapy and pain medication. The decision either to perform the Herzberg technique or the L'Episcopo technique was made independently of patient-specific characteristics without randomisation.

Surgical techniques

Modified Herzberg technique (18)

Surgery was performed with the patient in a lateral decubitus position, and subsequently in a prone position. The long head of the biceps (LBT) was arthroscopically sectioned when not done in an earlier procedure. The 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.

L'Episcopo technique (11)

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. (3) and further medial along the course of the latissimusdorsi 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. The combined insertion of the latissimusdorsi 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.

Post-operative rehabilitation

Immediately after surgery immobilisation was accomplished by an abduction pillow for the duration of 3 weeks. During this period passive mobilisation was restricted to 30° abduction, 30° flexion, 60° internal and 0° external rotation. The range of motion was increased to 60° abduction, 90° flexion and 60° internal rotation up to the end of week six. Pain depended a free range of motion was allowed with careful strengthening after the 7ths week when the passive mobilisation was free.

Follow up evaluation

All patients were examined postoperatively for a mean follow-up of 36 months (range: 18–72 months, n = 57). The patients were clinically evaluated using the age and gender adjusted scoring system according to Constant and Murley (17). Standard radiography was attempted containing a true-ap, an outlet and an axillary view.

The acromio-humeral distance was measured in the true ap view. The grade of glenohumeral osteoarthritis and cuff tear arthropathy was detected using the classification according to Hamada et al. (14). The integrity of the muscular flap was examined either by ultrasound or in the remaining patients who have residual complaints (n = 14) by an additional MRI.

Following possible parameters and influencing factors for an expected poor result were defined

- Acromiohumeral distance < 5 mm
- Pre-existing osteoarthritis > grad 2 according to Hamada
- Pos. external rotation sign and Horn blowers sign (insufficient teres minor muscle)
- Patient age > 60 years at the time of surgery
- Duration of symptoms > 6 months
- Revision surgery
- Surgical technique

Statistical analysis

We used SPSS version 19.0 (SPSS Inc., Chicago, Illinois). The level of significance was set at $p < 0.05$. Pre- and post-operative nonparametric data from both groups were compared using the Wilcoxon signed-rank test. Comparison between two groups (Constant score with or without a positive PPP) was performed using the Mann-Whitney U test for independent samples.

RESULTS

The mean Constant score increased significantly ($p < 0.05$) from initially 22.7 points (range 10 to 38 points) to 66.0 points (range 19.0 to 89 points; adjusted CS 80.3% range: 23.8–104.9%) at follow up. The patients showed a significant ($p < 0.05$) improvement in all qualities like pain, activities of daily living, active range of motion and strength of abduction. Last mentioned increased significantly from 0.1 point (range 0 to 2) to 6.2 points (range 0 to 15).

The implemented pain score ranging from 0 to 15 showed a significant improvement from a preoperative average of 5.2 (1–12) to postoperative average of 11 (1–15). The evaluation of the range of motion showed a significant increase from 11.9 (0–32) to 28.9 (2–40).

On average, forward flexion improved from 85° preoperatively to 140° at the time of follow-up, abduction improved from 80° to 135°. In regards to the activities of daily living the CS increased from 5.5 (0–12) to 14.0 (2–20) points.

Prior to surgery 48 patients had a positive external rotation lag sign, which could be demonstrated in 8 patients at follow up. Table 1 shows the results divided into the groups of the PPP and resulting statistically significant differences.

An analysis of the radiographs showed a pre-operatively acromiohumeral distance of 6.8 mm (range 2–15 mm) which decreased to 6.5 mm (range 0–14 mm); (p: n.s.). Before surgery the mean Hamada score was 1.5 (1–3). Averaged the arthropathy increased from initially to 1.7 at follow up. These changes over time were not significant. 52 of the 57 patients showed at follow up signs of a radiologically cuff tear arthropathy according to Hamada, 32 patients a grade 1, 15 patients a grade 2 and 5 a grade 3 according to the classification of Hamada. 5 Patients increased from a grade 1 to grade 2, 4 patients from grade 1 to grade 3 as well as 4 patients from grade 2 to grade 3.

MRI (n = 14) showed a consisting integrity of the latissimus dorsi and teres major flap at follow-up and in one case a rerupture of the reinserted lat. dorsi tendon.

In two cases the suture anchor failed on the second postoperative day. This was immediately reattached through transosseous refixation.

Two patients with increasing pain due to osteoarthritis were treated with an inverse prosthesis resp. hemiarthroplasty and based on "intention to treat" maintained in the study group.

DISCUSSION

Latissimus dorsi tendon transfer is a well-established reconstructive procedure for the treatment of such irreparable rotator cuff tears involving the supraspinatus and infraspinatus tendons. Several authors have tried to identify factors affecting the outcome.

Integrity of the subscapularis tendon is crucial for the best outcomes after LDT. Gerber et al. (9) were the first who observed a significant positive correlation between the integrity of the subscapularis tendon and the clinical outcome. Later on several authors (2, 9) focused on the relationship with the preoperative condition of the subscapularis and the clinical outcome. Aoki et al. showed

unsatisfactory results as Gerber and he did not recommend the LDT in case of SSC lesion. The only exception regarding the preoperative condition of SSC was reported from Miniaci et al. who did not consider absence of SSC as a contraindication (21).

Ianotti (15) came to the conclusion that a *preoperatively existing ROM* is a significant factor in determining the postoperative outcome, since the symptoms of the shoulder may even get worse through the transfer of an already weakened muscle. He found female sex, poor preoperative shoulder function, generalized muscle weakness, and the absence of electrical activity of the transferred muscle at the time of follow-up to be negative factors.

Fatty infiltration of the teres minor has been reported to play a key role in the outcome of latissimus dorsi tendon transfer. Costouros et al. reported that fatty infiltration of teres minor lower than or equal to stage 2 according to the system of Goutallier et al. was associated with a better postoperative Constant score (5). Moursy et al. confirmed the crucial role of teres minor integrity, as the patients with extensive fatty infiltration of the teres minor muscle had inferior results (23).

Debeer (6) found the mean Constant and Murley score in patients with no or mild osteoarthritis (stage 0–1) was 62.1 points whereas patients with moderate to severe osteoarthritis (stage 2–3) had a mean Constant and Murley score of 49.4 points. However , this difference was not statistically significant ($p = 0.13$). Patients who had an increase in the degree of osteoarthritis, had a lower mean Constant and Murley score as compared to the group with no change in the degree of osteoarthritis, but this was also not statistically significant ($p = 0.28$).

Miniaci and MacLeod (21) consider that transfer of the latissimus dorsi muscle *for salvage after a failed attempt at operative repair* of a massive defect of the rotator cuff is an effective procedure. Patients reported marked relief of pain and improvement of function.

Warner and Parsons (27) were the first who contradicted the results of Miniaci and MacLeod and reported that latissimus dorsi tendon transfer had better results when it was performed as a primary procedure than when it was done as a salvage procedure after failed rotator cuff repair.

They compared outcomes for 16 patients who underwent latissimus dorsi transfer as a salvage reconstruction for a failed prior rotator cuff repair with outcomes for 6 patients who underwent a primary reconstruction for an irreparable cuff defect.

Irlenbusch et al. (16) reported a continuous improvement in the Constant and Murley score during a 50-month period from 33 points initially to 71 points in patients undergoing latissimus dorsi transfer as a primary reconstruction.

Table 1. The results divided into the groups of the PPPs and resulting statistically significant differences

Influencing factor	**n**	**CS postop**	**Difference (p)**
Aro-lag sign (TM) +	**48**	**80.2**	**n.s**
Aro-lag sign -	**9**	**82.6**	
Influencing factor	**n**	**CS**	**p**
Arthrose H>2 +	**23**	**80.2**	**n.s.**
Arthose <H2	**34**	**74.8**	
Influencing factor	**n**	**CS**	**p**
Revision +	**17**	**65.2**	**0.43 n.s.**
Revision -	**40**	**80.4**	
Influencing factor	**n**	**CS**	**p**
AHA <5 mm	**24**	**76.4**	**n.s.**
AHA >5 mm	**33**	**83.3**	
Influencing factor	**n**	**CS**	**p**
Age >70 +	**16**	**80.9**	**n.s.**
Age <70/60	**41**	**75.5**	
Influencing factor	**n**	**CS**	**p**
Duration of symptoms >1 year	**24**	**75**	**n.s.**
Duration of symptoms <1 year	**33**	**80.4**	
Influencing factor	**n**	**CS**	**p**
Technique Herzberg	**31**	**80.3**	**n.s**
Technique L`Episcopo	**26**	**70.8**	
Influencing factor	**n**	**CS**	**p**
men	**30**	**72.8**	**n.s.**
woman	**27**	**80.9**	
Influencing Factor	**n**	**CS**	**p**
Etiology trauma	**21**	**75**	**n.s**
Etiology degeneration	**36**	**80.2**	

Table 2. Literature with difference in clinical outcome regarding the prognostic factor

Author/Year	N=	FU/m	CS overall pre to post-op	Prognostic factor	Difference CS p=
Gerber 2006[10]	69	53	55–73	**revision**	primary:70% vs revision: 79% n.s.
Warner 2001[31]	22	19		**revision**	primary: 37–69% vs. revision.: 36–52 % <0,05
Buchmann/Habermeyer 2009[33]	34			**revision**	primary:57–84% revision.: 51–73% p=0,03
Moursy2009[34]	42	47	41.9–69.3	**revision TM**	primary: 60,3% vs. revision: 76,2% <0,05
Irlenbusch 2003[23,32]	22 52	9 50,2	38–65,3 32–68	**revision**	primary.: 33–71 revision.: 31–60 P<0,009
Gerber[11]	16	33	73%	**SCP**	intact SCP: 82 % vs. SCP tear: 48 % p<0,05
Aoki 1996[14]	12	35.6	UCLA-score: 11.8–28.0	**SCP**	n.s.
Ianotti 2006[12]	14	24	PENN-score: 40–66	**praeop ROM**	
DeBeer 2010[26]	26	43,3	39–60	**osteoarthritis**	OA: 49.4 vs. no OA: 62.1 p=0,13
Costouros/Gerber 2007[15] Moursy	22	34	48 to 62	**teres minor**	intact TM: 67 vs TM tear: 53 p=0.015

Table 3. Literature without differences in clinical outcome regarding prognostic factor

Author/Year	N=	FU/m	CS overall pre to post-op	Prognostic factor	Differenz CS p=
Miniaci[25]	17	51	ULCA: 6.8 -16.4	**revision**	n.s.
Valenti 2010[30]	25	22	35.5–58	**revision**	n.s
Lehmann 2010[17]	26	24	20–56	**revision**	n.s
Gerhard and Lehmann[16]	20	24.7/60	46,5 → 72,5/68,2(2/5 y. postop.)	**osteoarthritis**	n.s.
Habermeyer 2006[35]	14	32	46.5 –74.6	**osteoarthritis**	n.s.
Moursy and Lehmann 2012	28	42	30–75	**insertion place**	n.s

Gerber et al. (9) documented worse ultimate outcomes after revision as compared with primary procedures but demonstrated nearly comparable increases in pain relief and function following revision and primary procedures. Thus, it appears that the procedure, if properly indicated, has the potential to improve symptoms comparably, independent of previous operations, at least if there is no longstanding severe pseudoparesis of elevation.

Moursy et al. (23) reported that the results of the latissimus dorsi tendon transfers that were done as revision procedures were inferior to the results of the primary procedures. The mean Constant score for the twenty-four patients treated with a primary operation was significantly better than that for the eighteen treated with a salvage procedure (76.2 compared with 60.3 points; $p < 0.05$). Possible reasons for this finding were the inferior preoperative shoulder function and the advanced age of the patients with a previous failed rotator cuff repair compared with the patients undergoing the tendon transfer as a primary procedure.

Valenti et al. (26) and Debeer et al. (6) did not find a significant difference between primary or revision repairs. All of these studies and various observations emphasize the multifactorial nature of the outcome of latissimus dorsi tendon transfer.

We found that the major difference in outcome for patients undergoing LDT was if it was done as a salvage or a primary procedure. Although the literature notes that this factor has a major role, our data does not prove a significance regarding that. The difference in outcome shows 80% improvement of Constant score for LDT as a primary procedure and 65% for LDT as a salvage procedure (Table 2 and 3).

The second major factor in our study was the difference in outcome regarding osteoarthritis. It is also plausible that patients with osteoarthritis more than Hamada 3 have poor CS due to the progression throughout the years and therefore deterioration in the mean outcome. A mean follow up of 3 years shows that there is no differences in the mean outcome between patients with and without osteoarthritis (Hamada II und III).

Regarding the surgical technique and the insertion point of the transferred tendon of latissimus dorsi, the only study which compares the influence of the used technique on the overall outcome was reported by Moursy et al. (22). They compared the results between two groups of LDT using Herzberg and L'Episcopo techniques and they reported a better mean outcome in the group of Herzberg technique, although it was not significant. The comparison between our results and that

which reported of other authors who are using the Gerber technique showed overall no significant difference.

Regarding the other influencing factors we could not also find any statistical significance differences. Surprisingly, patients over the age of 70 years have better CS (80.9%) than those under the age of 70 years (75.5%) . This fact was not reported by any other authors.

We believe that especially in salvage procedures, there is a serious need to define prognostic prediction parameters .

CONCLUSIONS

Although, latissimus dorsi transfer is an excellent option in the treatment of irreparable postero-superior tears of the rotator cuff in well-selected patients pain relief and a good range of motion can be expected after the transfer. However it remains difficult to determine in which patients this surgery can be predictably successful.

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