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TECHNICAL NOTE • SHOULDER - ARTHROSCOPY

Arthroscopic-assisted latissimus dorsi transfer for subscapularis deficiency

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Abstract Few salvage procedures have been described in case of irreparable subscapularis tear and with variable outcomes. Latissimus dorsi transfer has been widely proposed as a transfer for irreparable posterio-superior rotator cuff tear with good outcomes. The anatomic feasibility of the latissimus dorsi to reconstruct the antero-superior irreparable rotator cuff tear has been suggested, but no clinical study has ever been published. We hypothesized that it was possible to use an arthroscopic-assisted latissimus dorsi transfer to reconstruct the subscapularis function. Five patients were enrolled. A 5–7-cm axillary incision was performed to release the latissimus dorsi tendon from its humeral insertion, the teres major muscle and the apex of the scapula. Afterwards, under arthroscopic control, a 7-mm-diameter tunnel was drilled at the anterior and superior part of the humeral head with an oblique inferior and posterior direction. The tubularized latissimus dorsi tendon was introduced into the tunnel and fixed with a ZipLoop on the posterior humeral cortex. The authors show overall good experience with this technique.
Level of evidence Level IV-a, case series.

Keywords Latissimus · Transfer · Arthroscopy · Irreparable · Subscapularis · Transfer

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Introduction

Massive subscapularis (Sscp) tear leads to horizontal imbalance of the shoulder with pain and decrease of active internal rotation [1]. An associated supraspinatus (SS) tear leads to vertical imbalance with an antero-superior escape of the humeral head (HH) and to a decrease of active forward flexion [2]. There are only few Sscp reconstruction techniques that can reduce pain, recover internal rotation and stabilize this HH antero-superior escape. Reverse shoulder arthroplasty has been reported, but is not recommended in young and active patient without arthrosis. Pectoralis major (PM) transfer has been commonly proposed (clavicular or sternocostal part) with a route above or below the conjoined tendon with variable outcomes on pain and sometimes unsatisfactory active mobility recover and unsatisfactory stabilization of the HH with a persistent antero-superior escape [2–8]. To explain these disappointing PM transfer results, we hypothesized that this transfer did not respect one of the principles of a tendon transfer: a direction similar to the replaced tendon. Indeed, the PM originates anteriorly from the chest wall while the Sscp originates from the subscapularis scapula fossa posteriorly from the chest wall. Conversely, the LD originates from the posterior side of the chest wall with a similar direction compared to the Sscp. LD transfer has been widely proposed for irreparable posterio-superior rotator cuff treatment with good results either with an open or with an arthroscopic technique [9–12]. LD is an internal rotator and therefore synergistic with the Sscp. The anatomic feasibility of the latissimus dorsi to reconstruct the antero-superior irreparable rotator cuff tear has been suggested [13], but to our knowledge, no clinical study has been published so far. The purpose of this study was to describe a novel technique—arthroscopic-assisted LD transfer for

Sscp deficiency and—to give the preliminary results for our patients.

Materials and methods

Inclusion criteria for the study were irreparable Sscp tear or failed Sscp repair (re-tear) with stage-four Sscp fatty infiltration according to Goutallier [14]. There was a minimum of 12-month clinical and radiological follow-up. An exclusion criterion was eccentric arthritis with Hamada stage four or five [15].

Patient selection

Four men and one woman were enrolled prospectively and were operated on by the treating surgeon (JK). Previously, four out of five patients had been operated on for rotator cuff tear; the last one had been operated on for an anterior shoulder instability with an open Latarjet procedure. All five patients had shoulder pain and had a positive belly-press test (BPT), a normal active external rotation and a weak forward flexion. Plain X-rays showed neither arthritis nor significant static upward humeral head migration. MRI showed a stage-four fatty infiltration with a total and retracted to the level of the glenoid tear of both SS and Sscp. Details are presented in Tables 1 and 2.

Surgical technique (see video)

Step 1: Mini-invasive LD dissection

This step has been already described [11]. In the standard lateral decubitus position, a 4–7-cm incision (depending on patient anatomy) was performed at the anterior (axillary) border of the scapula. The first visible muscle was the LD. The LD neurovascular pedicle that penetrated the muscle mid-belly from its medial surface was identified and gently released with blunt dissection. The LD was separated from its fascial connections with the teres major (TM). The LD tendon could then be followed, released and tenotomized proximally from its humeral insertion at the tendon–bone transition zone. The distal LD muscle belly was released from the apex of the scapula.

Step 2: LD tendon harvesting

The LD tendon was tubularized using the ToggleLoc device with ZipLoop technology (Biomet, USA). In securing the tendon to the ZipLoop, the first suture was a Bunnell suture that prevents gap formation and secures the tendon. The second suture was tied in a Krackow fashion that provided a stiff and secure attachment to the tendon. We routinely obtained a 7-mm-diameter and a 7-cm-length tubularized tendon (Fig. 1). Three metal markers were placed at 2, 4 and 6 cm from the tip of the tendon to be able to analyse its position with a usual post-operative X-ray.

Step 3: Arthroscopic HH LD fixation

Three kilograms of traction was applied to the arm using a pulley system. Standard portals were used: posterior (soft point) for joint visualization and anterolateral portal for the instrumentation. Partial anterior subacromial, subdeltoid and Sscp footprint debridement were performed with a blunt stick, an alternating shaver blade and a 90°-tipped electro-cautery device. If the long head of the biceps was still present, a tenodesis was performed. The inferior surface of the coracoid process and the posterior surface of the conjoint tendon had to be controlled. Then, the arthroscope was switched through the

Table 1 Demographic results

No	Age	Sex	Side	PS	FI	Complication	BPT	SSV	FU	Constant	Metal markers
1 (JCN)	75	M	R	Cuff	4	Infection	Pre-op: + Review: +	Pre-op: 25 Review: 30	24	Pre-op: 32 Review: 36	Ruptured transfer
2 (CD)	67	F	R	Cuff	4	No	Pre-op: + Review: −	Pre-op: 15 Review: 65	22	Pre-op: 28 Review: 65	OK
3 (YP)	61	M	L	Cuff	4	Haematoma	Pre-op: + Review: −	Pre-op: 20 Review: 60	18	Pre-op: 35 Review: 58	OK
4 (JPC)	58	M	R	Cuff	4	No	Pre-op: + Review: ±	Pre-op: 25 Review: 70	13	Pre-op: 38 Review: 75	OK
5 (JB)	64	M	R	Latarjet	4	No	Pre-op: + Review: ±	Pre-op: 15 Review: 55	12	Pre-op: 24 Review: 60	OK

PS previous surgery, *BPT* belly-press test, *FI* Sscp fatty infiltration, *SSV* special shoulder value, *FU* follow-up (month)

Table 2 Detailed Constant score

	Pain pre/postop	ADL pre/postop	FF pre/postop	ABD pre/postop	ER pre/postop	IR pre/postop	Strength (kg) pre/postop	Total pre/postop
1	5/10	8/8	4/4	4/4	6/6	2/2	1/1	31/36
2	0/15	6/16	6/8	6/8	8/8	2/8	0/2	28/67
3	5/15	10/14	6/8	6/8	10/10	0/8	0/1	37/65
4	5/15	10/18	6/10	6/10	10/10	2/8	0/2	39/75
5	0/15	6/14	6/8	6/8	8/8	0/8	0/2	26/65

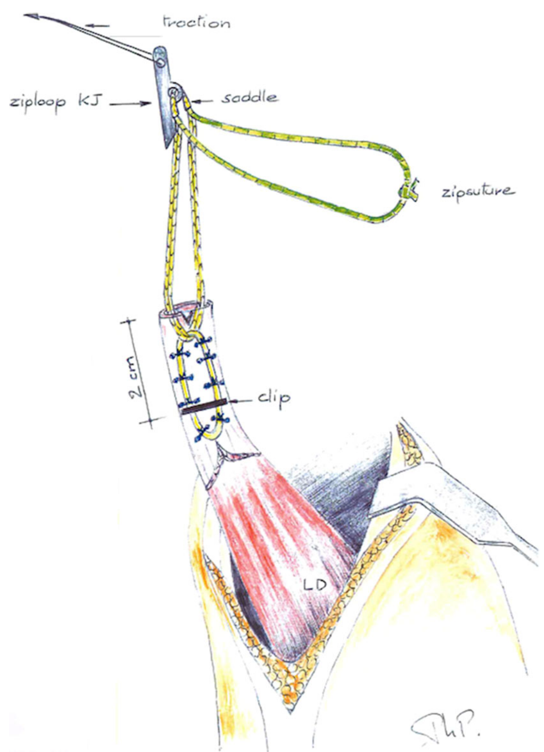

Fig. 1 LD tendon is tubularized using the ToggleLoc device with ZipLoop technology (Biomet, USA)

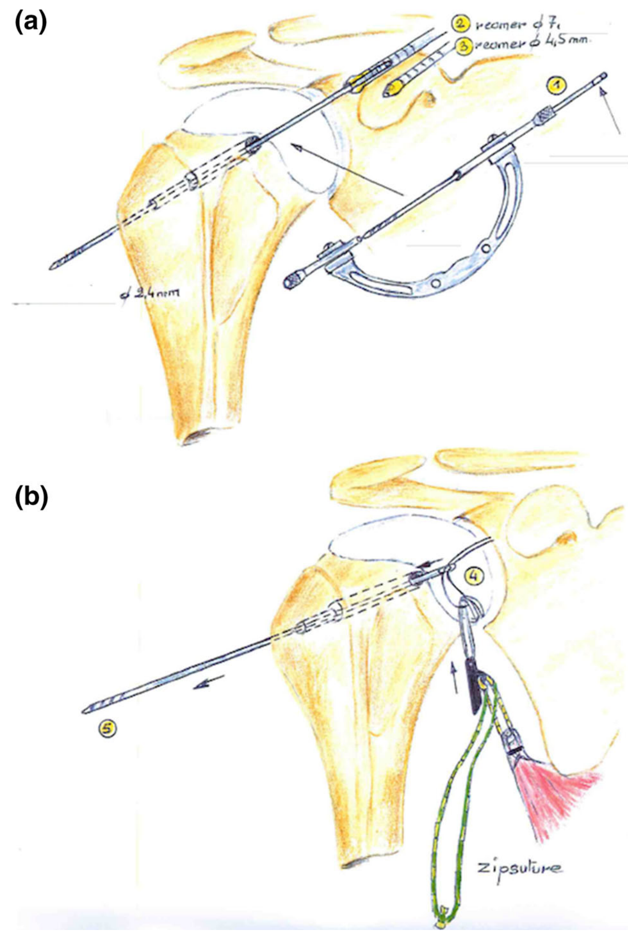

Fig. 2 **a**, **b** A 2.4-mm drill tip is introduced with the help of a specific guide. Careful drill through the posterior cortex over the guide pin with the ToggleLoc cannulated 4.5-mm drill is performed. A 7-mm cannulated drill is used to create a 3-cm-length tunnel, and a shuttle relay (No. 2 looped polyester suture) is introduced through this tunnel

anterolateral portal. A suture manipulator was introduced from an antero-superior portal in the newly anterior created space and retrieved through the axillary incision. The ZipLoop of the tubularized tendon was retrieved through this anterior space above the Sscp footprint, above the axillary nerve and laterally from the conjoint tendon.

Step 4: Drilling of the bone tunnel

The 30° arthroscope was transferred again into the posterior portal to control the antero-superior zone of the HH at the junction between the Sscp and SS footprints above the bicipital groove. The penetration point can be modified either anterior or posterior ("over the top") depending on the association with a supraspinatus tear. A 2.4-mm guiding pin was drilled through this area in a cranial-to-caudal and in an anterior-to-posterior direction (Fig. 2a) with the help of a specific guide. Careful drill through the posterior cortex over the guiding pin with the ToggleLoc cannulated 4.5-mm drill was performed as the axillary nerve locates

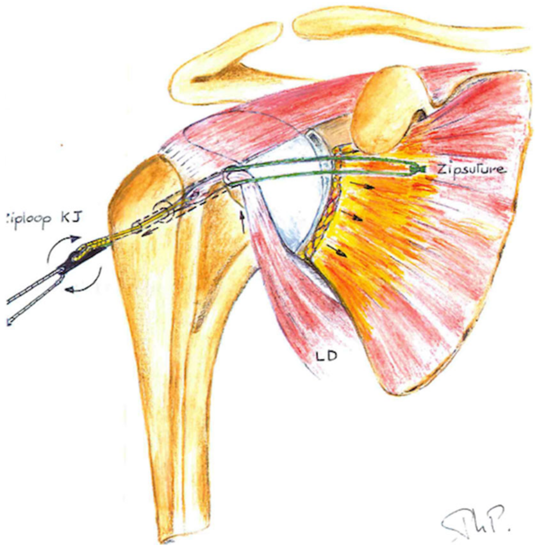

Fig. 3 Tension is placed on the sutures to flip/secure the button onto the posterior cortex; the zip strand is then tensioned and 3 cm of the tubularized LD tendon is seated into the tunnel

five centimetres under the acromion. A seven-millimetre cannulated drill (diameter of the tendon graft) was then used to create a three-centimetre-length tunnel, and a shuttle relay (No. 2 looped polyester suture) was inserted through this tunnel (Fig. 2b).

4/Passage of the button and tendon fixation

The ZipLoop was inserted into the tunnel through the posterior cortex using the shuttle relay and retrieved outside the skin at the posterior part of the arm. Tension was placed on the sutures to flip/secure the button onto the posterior cortex; the zip strand was then tensioned and three centimetres of the tubularized LD tendon was seated into the tunnel (Fig. 3); a probe was placed through the anterior portal to assist in graft passage (Fig. 4a, b).

Outcome assessment

Patients were evaluated at a minimum of 12 months postoperatively. We used the Constant score, the Simple Shoulder Test (SST) and the BPT to assess the patients clinically. We used standard radiographs for evaluation of metallic markers' position (Fig. 5).

Results

The results are summarized in Tables 1 and 2. All patients underwent an entirely arthroscopic humeral LD fixation procedure, with no conversion to open surgery. No intra-operative neurovascular lesions occurred. One haematoma and one

(a) (b)

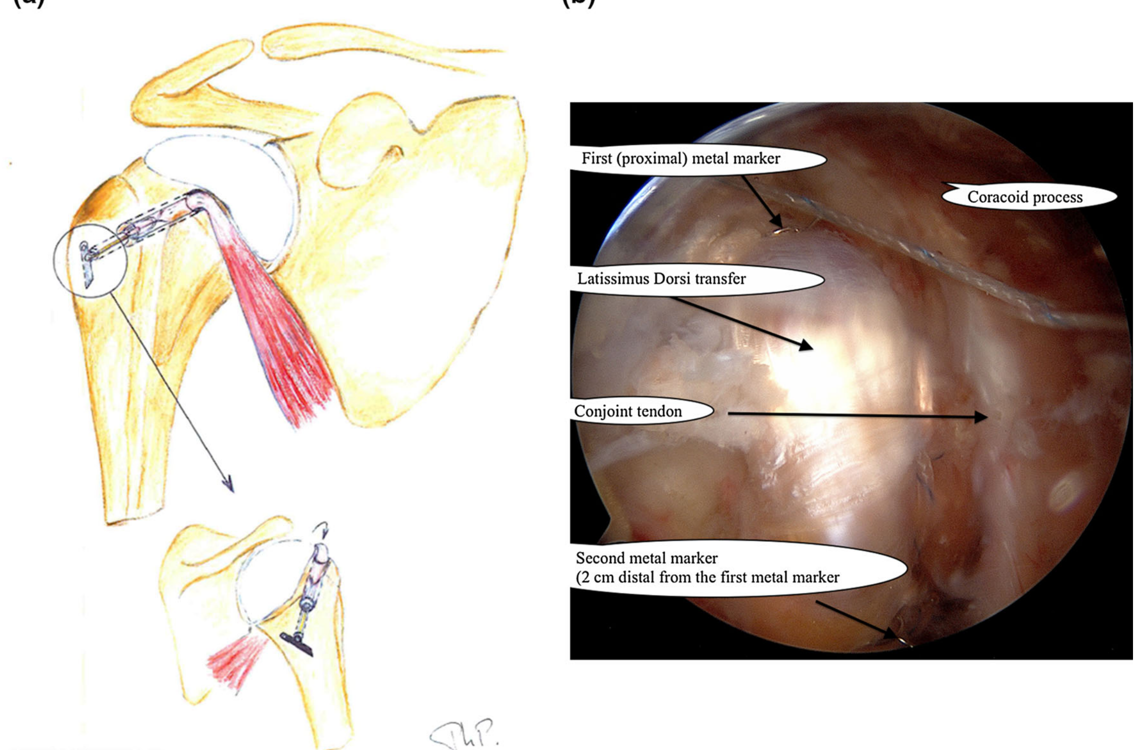

Fig. 4 **a** Final view (draw). **b** Arthroscopic final view with the latissimus dorsi onto the footprint of the Sscp. See the *proximal metal marker* at the entry of the tunnel proof that 2 cm of tendon is into the bone

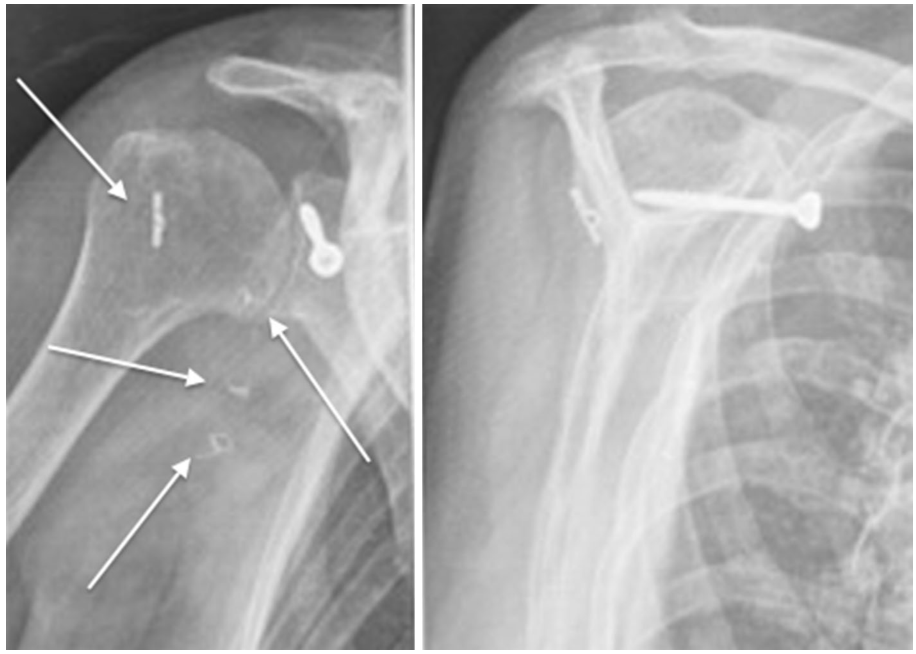

Fig. 5 Immediate post-operative X-ray showing the ZipLoop device locked onto the posterior aspect of the humeral head and the three *metal markers* at 2, 4 and 6 cm from the extremity of the transferred LD tendon

deep infection occurred. After a minimum of 12-month follow-up, neither any implant migrated nor any metal marker position modification occurred except for one patient that showed a ruptured transfer (infected patient). All patients but the one above mentioned could return to their normal previous daily living or recreational activities. Without the infected patient, the mean SSV score increased from 18.75 to 63.75 and the mean Constant score from 32.5 to 68. The belly-press test became progressively negative for four out of five patients. In no cases did a patient's outcome either deteriorate or remained unchanged.

Discussion

PM muscle originates from the anterior chest wall with its clavicular part and its sternocostal part. It is the most commonly used transfer for Sscp deficiency. Nevertheless, the line of pull of the PM is at a nearly 90° angle to the line of pull of the Sscp muscle fibres and does not comply with the principles of a tendon transfer whatever part of the muscle (either clavicular or sternocostal) or position (either above [4, 7, 16] or below [2, 5]) to the conjoined tendon is used. Up to now no technique has proved its superiority [17].

As opposed to the PM and following the basic principles of tendon transfer, the LD tendon transfer appears to replicate the line of pull of the Sscp muscle fibres almost anatomically. Indeed, the LD muscle originates as the Sscp posterior in relation to the chest wall and inserts onto the humerus close to the Sscp insertion with an oblique direction. Moreover, the LD is an internal rotator and therefore synergistic with the Sscp.

Elhassan [13] showed in a cadaveric study that the potential risk of nerve compression in this technique, including the axillary, the radial and the musculocutaneous nerves, is very low. We did not have any neurologic complication in our five cases.

This technique takes advantage of the tubularized tendon with a fixation that is stronger than anchors [18] and a tension muscle belly adjustment. Our short-term results support the notion that the BPT takes a 1-year post-operative period to become negative. The LD transfers were evaluated via standard X-ray to analyse metal marker position as MRI analysis remains difficult to analyse after LD transfer. As for our unique failure, we hypothesized that the infection compromised the transfer healing. This technique allows tension adjustment, and therefore, the transferred tendon is supposed to act as a dynamic transfer against the HH superior escape.

There are some limitations to be considered within this study such as the limited number of patients due to this novel technique described and to the longer follow-up that is required to consider it as successful and reproducible. Yet, to our knowledge, it is the first clinical study ever made so far.

Conclusion

The target population to be successfully treated with this technique could be the case of an irreparable Sscp (±SS) tear without any significant antero-superior static HH instability. Thus, it is thought that the technique mentioned above might be a possible alternative to the PM transfer.

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Compliance with ethical standards

Conflict of interest Author Jean Kany has received research grants from Company FH, has received a speaker honorarium from Company FH, Mitek and Tornier. Author Philippe Valenti has received research grants from Company FH, has received a speaker honorarium from Company FH and Biomet. Author Jean Grimberg has received research grants from Company Smith Nephew. Author Pierre Croutzet declares that he has no conflict of interest. Author Jean David Werthel declares that he has no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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