Mini Invasive Axillary Approach and Arthroscopic Humeral Head Interference Screw Fixation for Latissimus Dorsi Transfer in Massive and Irreparable Posterosuperior Rotator Cuff Tears

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Abstract: As the number of shoulder surgeries is increasing, the challenges of treating the massive and irreparable rotator cuff tears pose an operative challenge for the shoulder surgeons. The purpose of this study is to propose a new mini invasive axillary incision (5 cm) for harvesting latissimus dorsi (LD) tendon and arthroscopic-assisted interference screw fixation of the transfer on the humeral head for the treatment of massive and irreparable posterosuperior rotator cuff tears. We describe our technique. The incision is minimized with the help of ultrasound Doppler-guided identification of the LD pedicle preoperatively. This study also makes clear how to maintain the tension on the pedicle of the LD uniform before and after the fixation of the transfer. During our experience of 17 cases from November 2007 to July 2009, we had good-to-excellent results in patient satisfaction. The clinical outcomes were not indifferent from the other methods of fixation.

Key Words: latissimus dorsi transfer, massive irreparable posterosuperior cuff tear, iterative cuff tear, interferrence screw latissimus dorsi fixation, arthroscopic latissimus dorsi fixation, mini invasive axillary approach

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The incidence of the challenges for massive and irreparable rotator cuff tears is on the raise in the patients attending shoulder specialty centers for surgery. Some of these patients have already been operated by open or arthroscopic technique even before the age of 50 years. Gerber et al[1] is the first to publish the latissimus dorsi (LD) tendon transfer for the treatment of these massive irreparable rotator cuff tears. The LD flap is well known and widely used in other specialties such as breast reconstructions and paralytic shoulder owing to birth palsy in pediatric orthopedics.[2]

Gerber[3] and Gerber et al[4] discussed in detail regarding the indications and contraindications for the LD transfer. He concluded that when posterosuperior rotator cuff tears were associated with subscapularis tears, the LD transfer is contraindicated. Other authors[5–10] also confirmed bad results in case of subscapularis tears, deltoid anterior deficit, proximal migration of the humeral head, preoperative poor function of the shoulder, and as a salvage procedure. Whereas the patient selection plays an important role in success of this transfer, it remains a viable and effective option for younger patients with massive and irreparable rotator cuff tears.

Moreover, constantly great tuberosity is fragile owing to earlier surgery or lack of mechanical stimulus chronically by the absence of rotator cuff musculature. The technical difficulties of fixation of the LD transfer on to osteoporotic bone need to be studied in detail. Gerber et al[1] fixed the transfer to the subscapularis with transosseous sutures. Warner and Parson[6] fixed the transfer on to the greater tuberosity by transosseous sutures. Habermeyer et al,[11] Millett et al,[12] and Pearsall et al[13] prefer classic anchors for fixation of the transfer on to the great tuberosity.

We hypothesized that the reasons for failures of this transfer were not only owing to invasive and open surgery (new deltoid injury), but also owing to lack of adequate strong and stable fixation of the LD tendon on to the greater tuberosity. From the experience of the anterior cruciate ligament (ACL) reconstruction of the knee and from the work of Boileau et al[14] in the tenodesis of long head of biceps into the humeral head, we describe a new mini invasive technique for harvesting the LD tendon, new technique of fixation by tubularization, and interference screw (IFS) fixation into a bone tunnel made in the humeral head. This fixation initially carried out by open procedure now switched to arthroscopically assisted procedure as our experience increased and it was more advantageous. This procedure is a viable alternative to the existing techniques in the hands of surgeon who is skilled in arthroscopic management of shoulder pathology. The specific biomechanical study conducted under the guidance of Jean Grimberg (personal communication) has concluded that the IFS fixation of the LD transfer on the humeral head is equal or slightly better than the multiple anchor fixation technique. Various studies[15–22] have proven the superiority of IFS over the multiple anchors in tendon to bone fixations.

OPERATIVE TECHNIQUE

The patient is in lateral position with shoulder in 30 degrees abduction, slightly tilted toward the back, and a 3 kg traction. The operative position allows free wide access to the shoulder, entire scapula, and its apex as this transfer needs free movement of shoulder and arm. This position also allows easy shifting over from open axillary approach for LD tendon harvesting to shoulder arthroscopic fixation of the transfer. It is important at this point to mention that the LD muscle neurovascular pedicle enters from the medial and under surface of the muscle from about 10 cm from humeral insertion of the LD tendon and 2 cm from the lateral scapular border. The exact

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FIGURE 1. Preoperative ultrasound Doppler identification of the latissimus dorsi pedicule.

anatomic identification of the pedicle of the LD preoperatively gives an added advantage in minimizing the incision and unnecessary trauma to the pedicle while dissection. We had taken the advantage of the ultrasound Doppler for identification and marking of the pedicle preoperatively (see video Step 1 Supplemental Digital Content, http://links.lww.com/TSES/A1, and Fig. 1). The authors have taken the assistance of the anesthesiologists who are trained in ultrasound Doppler for their anesthetic blocks in identification of the LD pedicle (a 5-MHz probe is used to identify the triphasic waveform of the LD pedicle). An incision of about 5 cm is made along side of the axillary border of the scapula. This incision is 3 cm toward the humeral side and 2 cm toward the apex of the scapula from the earlier ultrasound Doppler assisted marking of the LD pedicle (see video Step 2 and Fig. 2). This gives the advantage of good visualization and safe dissection of the proximal tendinous insertion and easy blunt release of the LD muscle from the apex of the scapula. Centering of the incision on the pedicle makes it convenient for the dissection around the pedicle for maximum excursion and minimal tension on the transfer. In case of need, one can extend this incision toward axillary fold to facilitate the dissection in deep planes of pedicle. In this case, it is important to prevent retractile scar while extending the incision to the axillary skin.[5]

The first visible muscle is the LD. One should take advantage of the lax axillary skin fold in dissection (Figs. 3A–E).

FIGURE 2. Lateral position. A 5-cm incision is made just above the axillary edge of the scapula.

It is important to release subcutaneously till the apex of the scapula. Spending extra time in subcutaneous dissection is the key in minimizing the incision. The skin is lax and it is advantageous to pull in the direction of the dissection for better visualization. Once the pedicle of the LD is identified entering the belly of the muscle from medial side, it is important to release circumferentially around the pedicle to facilitate the transfer. It is basic to leave around (length of 4 to 5 cm) pedicle for smooth sliding of the pedicle. Some authors[23,24] described a nonfunctional transfer on electromyography probably because of insufficient release of pedicle (too much tension on the pedicle because of transfer).

After identification and release of the pedicle, one should follow the tendon of the LD by dissection along the axillary fold. At this point it is suitable to separate connective fibers between teres major (TM) and LD. Beck and Hoffer[25] describe the "double LD and TM transfer" because of deep muscle belly connections. Goldberg et al[26] showed only 50% connections between LD and TM. In our experience of more than 50 transfers, there is always a fatty delineation between these 2 muscles for separation. One must release fascial bands of tissue between muscular portion of LD and long head of triceps that are constant and represents Goldberg[26] dorsiepitrochlearis brachii of apes.

At this step it is important to look for the maximum length of the tendon. One has to internally rotate the shoulder and place a Howman retractor more proximally around the diaphysis. Then dissection can be done from the periosteum to gain additional 1 to 2 cm extra length of the tendon. Before tenotomy we advise to put 2 sutures 5 cm apart in the muscle belly centering the pedicle to simulate the maximum anatomic tension in abduction and external rotation (assuming that this position simulates the maximal anatomic tension on the tendon and also on the pedicle). The same tension (indicated indirectly by maintaining the same intersuture distance) on the pedicle will be maintained during the fixation of the transfer into the humeral head (see video Step 3 and Fig. 4). This technique acts as a good guide for the surgeon in maintaining the anatomic tension on the pedicle. We suggest to follow this step, as it is crucial for the pedicle to be functionally intact for the dynamic action of the transfer. To our knowledge, till date it is not clear to estimate the tolerable limits of tension on the LD pedicle during the surgery. Herzberg et al[27] and Schoierer et al[28] studied the excursion of the various musculotendinous units around the shoulder and made it clear that the LD muscle has the maximum excursion 33.7 cm.

Tenotomy is done from proximal (near the circumflex vessels) to distal. It is important to be cautious regarding close deep axillary vessels medially. After harvesting, the tendon is brought outside for tubularization (see video Step 4 and Figs. 5A, B). The tendon itself is a long and flat structure that can be tubularized like semitendinosus for ACL reconstruction. Golberg et al[26] showed that the average LD tendon is 7 cm long and 3.3 cm wide. Our experience also matches them. The average diameter after tubularization is about 7 mm and 7 cm length. It is easy now to release the muscle belly from the inconsistent fibrous bands beneath itself and the apex of the scapula by blunt dissection with gentle traction on the tubularized tendon. After complete successful release, it should be easy to pass finger all around the muscle belly without any difficulty. This gives good length for the tendon to be mobilized till the top of humeral head (see video Step 5). It is advisable to insert at least 3 cm of the tendon into the humeral head for better bone tendon healing similar to the ACL reconstruction. It is not advisable to give excessive

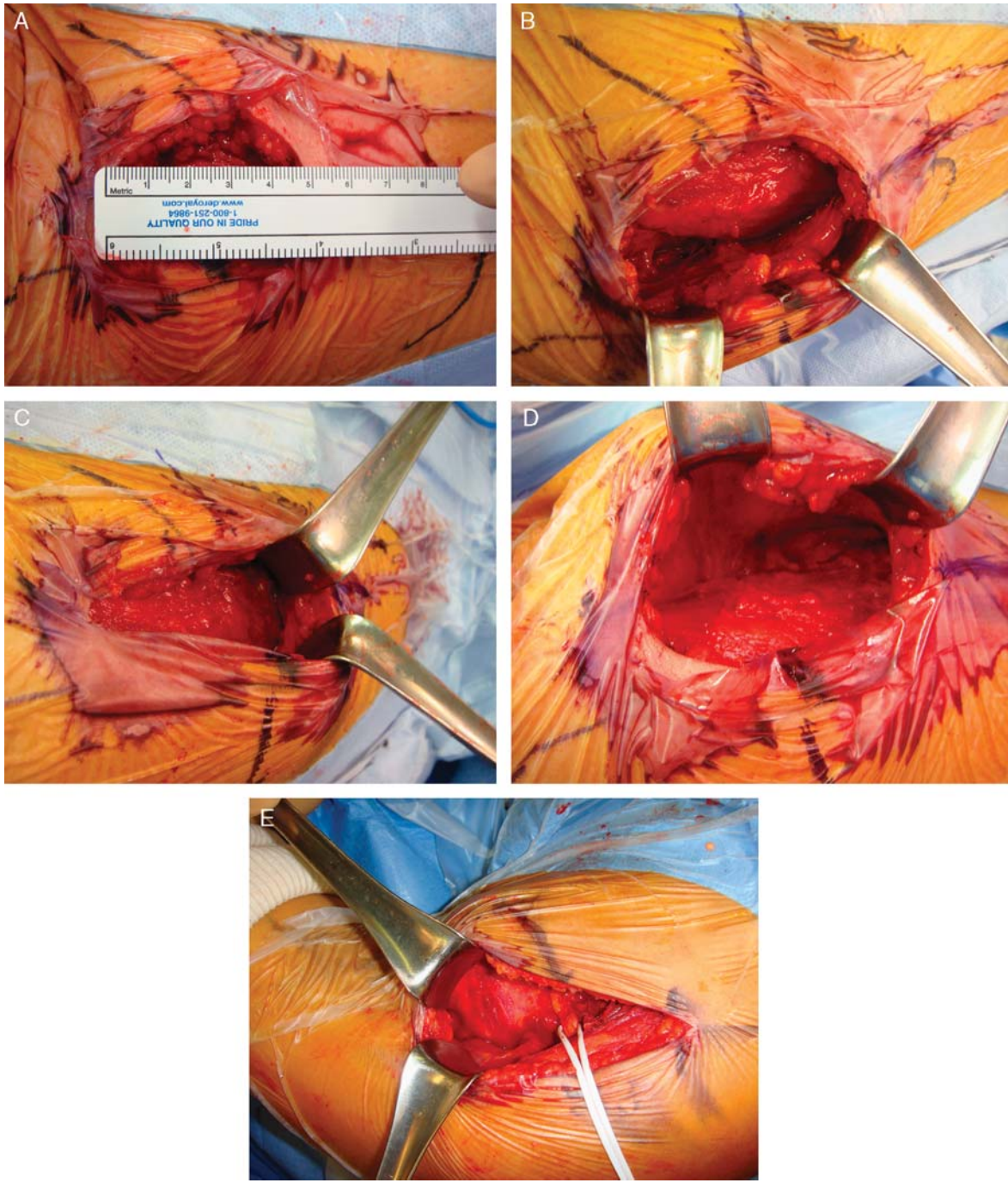

FIGURE 3. A–E, Lax axillary skin fold advantageous for subcutaneous dissection.

traction on the tendon and indirectly on the pedicle for gaining additional length into the humeral head, which is indicated by the increased intersuture distance on either side of the pedicle. The pedicle must remain without any impingement throughout the entire procedure.

The tendon is passed posterior to the triceps but anterior to deltoid as close as possible from the posterior surface of great tuberosity. This was carried out blindly without visualizing the tunnel to start with as in open procedure. As our experience increased we shifted to arthroscopically assisted tunnelization posterior to triceps and definitively anterior to deltoid as the tunnel was visualized (sometimes with Neviaser portal and with 70 degrees arthroscope as the large lateral acromion can block the vision) (see video Step 6, Step 7). Using the cannula will prove more advantageous at this step. In theory based on vectors of insertion and expected line of pull, if the tendon is fixed on the top of the humeral head near the junction of articular cartilage to pass above the center of rotation of the shoulder; this transfer will be effective in achieving external rotation and forward flexion. It will be also effective in humerus head lowering. If the transfer

FIGURE 4. Placement of 2 sutures on either side of the pedicle before tenotomy.

is fixed onto the posterior surface of the greater tuberosity, it should be effective in achieving external rotation but less forward flexion (see video Step 8).

We hypothesize that there are 2 different groups of patients with different requirements to decide for the site of fixation of the transfer on the humeral head, based on the theoretical assumption of the line of action of the transferred tendon.

Group 1: In case of complete supraspinatus, infraspinatus, and teres minor tears, we propose a posterior tuberosity fixation behind the humeral head center of rotation to increase external rotation and to have humeral head lowering effect.

Group 2: In case of complete supraspinatus and infraspinatus tear with intact teres minor, we propose an "over the top" LD fixation above the humeral head center of rotation to increase forward flexion and to induce a humeral head lowering effect.

Recently Zafra et al[29] published regarding the humeral head lowering effect of LD transfer and have concluded that there is radiologically significant humeral head lowering (3.2 mm average) owing to the tenodesis effect of the LD tendon.

The entry point is identified and 2-mm K-wire is drilled at 45 degrees angle to the humeral head in the direction of the bicipital groove. It is advisable to keep the arm in 30 degrees

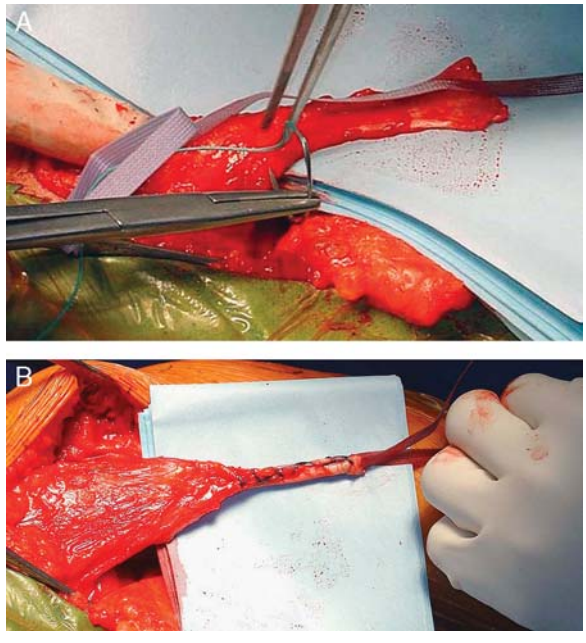

FIGURE 5. A and B, Tubularization of latissimus dorsi tendon.

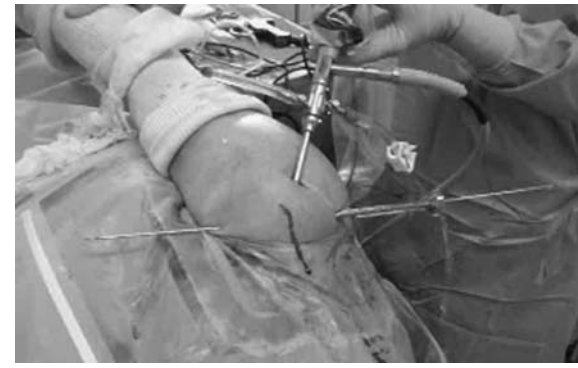

FIGURE 6. The K-wire cross the humeral head in the direction of the bicipital groove.

abduction in the scapular plan and 30 degrees external rotation during this step for the safe exit of the K-wire away from the anterior vital structures. It crosses the humeral head from posterior and superior to anterior and inferior (see video Step 9, Step 10, Fig. 6). A 7-mm tunnel is made around the K-wire. In our experience we found that it is advantageous to use a guide (similar or same as ACL guide) that can be useful to find the good exit for the tunnel placement (see video Step 9). We advise to put a second traction suture at the musculotendinous junction to facilitate the passage (Figs. 7–9). Before insertion of the IFS, it is advisable to make sure the distance between the 2 sutures placed on either side of the pedicle to remain 5 cm so that the same anatomic tension is maintained on the pedicle as before tenotomy (see video Step 11, Step 12). An IFS 2 mm larger than the drilled size is used for fixation. We have been using titanium or reabsorbable soft threaded IFSs. Our experience of IFS fixation was done by an open technique initially (about 30 procedures) and later by arthroscopy. Carrying out arthroscopy before harvesting the LD tendon in salvage procedures was not of much advantage. Carrying out arthroscopy before the LD tendon release in primary cases would be advantageous for better understanding and treating of the concomitant biceps tendon pathologies and also to confirm the intactness of subscapularis tendon. No fresh acromioplasty was done in any of the primary cases. Most of the salvage cases had already undergone an acromioplasty. The

FIGURE 7. Usage of 2 sutures for arthroscopic passage of the latissimus dorsi tendon through the humeral bone tunnel.

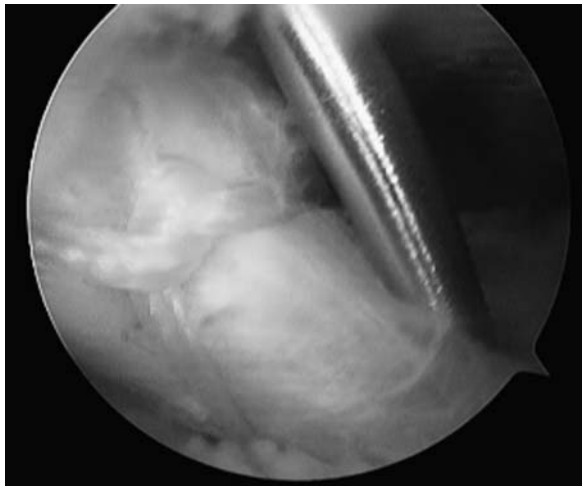

FIGURE 8. Intra-articular view of latissimus dorsi tubularized tendon with K-wire.

lateral position described earlier allows for both, open axillary approach for the harvesting of LD tendon and also for shoulder arthroscopic fixation of the transfer.

All the patients were immobilized for 6 weeks with a custom made 60 degrees abduction sling with immediate passive shoulder mobilization in all the directions except internal rotation. Active mobilization and muscle reeducation starts under the supervision of physiotherapist after 6 weeks. Patients are allowed for normal day-to-day activities after 3 months. All the patients were followed-up at regular intervals of 1, 3, 6, and 12 months regularly.

MATERIALS AND METHODS

During the period from November 2007 to June 2009, 17 cases were done with this arthroscopic technique. The site of fixation was on the top of greater tuberosity of humeral head for 16 patients and for 1 patient posterior of humeral head (for the patient whose indication was loss of active external rotation of the shoulder).

FIGURE 9. X-ray view of interference screw in the humeral head.

We were unable to do the first case arthroscopically, so we had to do a mini open technique (learning curve). One patient had a fracture of lateral cortex of the great tuberosity because of too lateral direction of this IFS. It was revised by mini open technique. There was 1 case of tendon rupture at 3 months of follow-up for which we had the opportunity to relook. We found that the rupture was at the junction of bone and the tendon entry and was fixed by multiple anchors. There was no loosening of the screw, which indirectly means that the IFS fixation was strong. This can be explained in the similar way as for the ACL ligamentization process, the graft is weak at 3 months owing to vascularization. We had no hematoma, infection, nor neurovascular complication. Follow-up ranges from 9 to 24 months with an average of 13.2 months. The clinical results were similar to the earlier studies (Table 1).

DISCUSSION

Management of posterosuperior massive and irreparable rotator cuff tears are still today a challenge, especially when the patients are young and around 50 years of age.

Gerber et al[1], Gerber[3,30] first described in 1988 a modified Phipps and Hoffer[2] procedure with a double incision, axillary, and superior transdeltoid. He introduced the LD transfer (with TM preservation) onto the top of the humeral head. Gerber stated that the transfer is contraindicated in subscapularis deficiencies. In the latest review, Gerber mentions that the LD transfer outcomes depend not on the tears of teres minor, but on the degree of fatty infiltration. Werner et al[31] with a cadaveric study showed significant differences not only in translation but also for rotation of the humeral head depending on subscapularis action.

Gerber's technique was used by Warner and Parson,[6] Miniaci and McLeod,[5] and Irlenbusch et al.[7,8] They confirmed the importance of patient selection, with poor results in case of subscapularis tear association, anterior deltoid lesions, or as a salvage procedure.

Recently, Habermeyer et al[11] introduced the concept of a single axillary incision and fixation of the transfer on posterior humeral head. Boileau et al[32] preaches for an "L'Episcopo modified procedure," also single incision to preserve anterior part of deltoid. He needed an anterior deltopectoral approach, but allowed partial section of pectoralis major.

Millett et al[12] first introduced the arthroscopic fixation of the LD transfer on the top of the humeral head by classic anchors to prevent weakness induced by a new invasive deltoid splitting open incisions.

We hypothesized that the reasons for failure of the earlier transfers were not only depended on the poor patient selection, but also on the strength of fixation of the tendon into the osteoporotic humeral head tuberosity.

Our goal since 2004 was to find a reliable and strong fixation system into this osteoporotic bone, able to resist against the LD tendon pull that carry out the upper limb mobilization. We adapted the initial Gerber et al[4] double incision technique by a tubularized LD tendon fixed onto the top of the humeral head with IFS technique. Biomechanical and clinical evidence is direct indication of IFS being the stronger and better fixation device in comparison with the other existing fixations in various bone tendon fixations.[15–22]

TABLE 1. Clinical Review

Sl. No.	Age (y)	Sex	No. Previous Surgeries	Indication Forward Flexion or External Rotation	Site of Fixation On Top or Posterior	Type of Fixation IFS/ Anchor	Follow-up (mo)	Arthroscopic Or Mini Open	Patient Satisfaction
1	56	M	1	Forward flexion	Top	IFS	12	Arthroscopic	Better
2	58	F	0	Forward flexion	Top	IFS	12	Arthroscopic	Good
3	66	F	1	Forward flexion	Top	IFS	22	Arthroscopic	Good
4	57	M	0	External rotation	Posterior	IFS	20	Arthroscopic	Excellent
5	64	M	0	Forward flexion	Top	IFS	9	Arthroscopic	Good
6	52	M	1	Forward flexion	Top	IFS	12	Arthroscopic	Good
7	66	M	1	Forward flexion	Top	IFS	10	Arthroscopic	Better
8*	58	F	1	Forward flexion	Top	IFS	10	Mini open	Better
9	55	F	1	Forward flexion	Top	IFS	9	Arthroscopic	Better
10	69	M	0	Forward flexion	Top	IFS	18	Arthroscopic	Good
11	65	F	0	Forward flexion	Top	IFS	9	Arthroscopic	Better
12	64	M	1	Forward flexion	Top	IFS	12	Arthroscopic	Better
13	68	M	1	Forward flexion	Top	IFS	10	Arthroscopic	Good
14	69	M	1	Forward flexion	Top	IFS	11	Arthroscopic	Good
15	61	M	0	Forward flexion	Top	IFS	9	Arthroscopic	Good
16†	32	F	5	Forward flexion	Top	IFS	15	Arthroscopic	Failure
17‡	49	M	1	Forward flexion	Top	IFS	24	Mini open	Good

F indicates female; IFS, interference screw; M, male.
*There was a fracture of lateral cortex of the great tuberosity (too lateral direction, revised by mini open technique).
†Tendon rupture at 3-month follow-up. Revision with arthroscopic multiple anchors fixations.
‡Unable to carry out arthroscopically as it was the first case (learning curve).

Jean Grimberg et al (personal communication) in specific biomechanical study compared the strength of fixation of IFS and multiple anchors fixation of the LD tendon into the humeral head and concluded that the IFS fixation is better than the multiple anchor fixation [statistically insignificant as the sample (6) was too small].

Our experience was first introduced in 2007 (SOFCOT, personal communication). Various authors[5–10] showed that multiples deltoid split were detrimental with regard to function and clinical results of the LD transfer. Millett first introduced the arthroscopic LD fixation. We developed a new technique of mini open axillary incision of 5 cm (in contrast to more than 20 cm described by earlier authors) with the help of ultrasound Doppler-guided preoperative identification of the LD pedicle. Taking advantage of the lax axillary fold, the dissection was carried out without much traction on the pedicle. This allows a good LD pedicle release, scapular apex control, and humeral diaphysis visualization for maximal length of LD tendon tenotomy with periosteum. Switching over from the classic open to an arthroscopic-assisted IFS fixation of the transferred LD tendon prevents new deltoid muscle splitting and improves the clinical outcomes as preservation of deltoid function remains the secret for the success of this surgery.

This transfer described currently does not avoid in 50% of the cases the proximal migration of the humeral head.[33,34] Tubularization and IFS LD fixation, proper selection of position for the bone tunnel, and anatomic muscle tension gives an immediate peroperative feeling of humeral head lowering effect. Zafra et al[29] have published that the average humeral head lowering effect was about 3.2 mm with the tenodesis effect of the LD on radiography. There is need for conducting further biomechanical studies to prove the implications of vector transmissions owing to this transfer and fixation.

CONCLUSIONS

This technique minimizes the axillary incision for LD tendon harvesting by preoperative ultrasound Doppler-guided identification of the pedicle, indirectly also minimizes the trauma on the LD pedicle during the dissection for its identification. This technique also prevents the damage to deltoid and pectoralis major. The precise anatomic maintenance of the tension of the musculotendinous unit is very important for the function of the transfer by avoiding excessive uncontrolled traction to achieve more tendon into the bone. Our hypothesis seems to hold good as the IFS fixation is strong fixation better than or similar to the earlier existing techniques of fixation. The site of fixation of the transfer on the humeral head is clarified and customized according to the preoperative requirement of the patient. The use of arthroscopy further makes the procedure less invasive and more precise regarding the deltoid protection and tunnel placement. The procedure achieves its goal of stable strong fixation and not to damage the already compromised deltoid sometimes owing to earlier surgeries. This makes the procedure a viable alternative to the existing techniques.

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