J Shoulder Elbow Surg (2014) 23, 1162-1170

ELSEVIER

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

Electromyographic activity after latissimus dorsi transfer: testing of coactivation as a simple tool to assess latissimus dorsi motor learning

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Background: The purpose of this study was to investigate coactivation (CoA) testing as a clinical tool to monitor motor learning after latissimus dorsi tendon transfer.
Methods: We evaluated 20 patients clinically with the American Shoulder and Elbow Surgeons (ASES) and University of California–Los Angeles (UCLA) outcomes scores, visual analog scale, active external rotation (aER), and isometric strength testing in abduction and external rotation. Measurements of aER were performed while the latissimus dorsi was activated in its new function of external rotation with concomitant activation (coactivation) of its native functions (adduction and extension). Bilateral surface electromyographic (EMG) activity was recorded during aER measurements and the strength testing procedure (EMG activity ratio: with/without CoA). Patients were divided into two groups (excellent/good vs fair/poor) according to the results of the ASES and UCLA scores.
Results: The mean follow-up was 57.8 ± 25.2 months. Subdivided by clinical scores, the superior outcome group lost aER with CoA, whereas the inferior outcome group gained aER (UCLA score: −2.2° ± 7.4° vs +4.3° ± 4.1°; $P = .031$). Patients with inferior outcomes in the ASES score showed higher latissimus dorsi EMG activity ratios ($P = .027$), suggesting an inadequate motor learning process. Isometric strength testing revealed that the latissimus dorsi transfer had significantly greater activity compared with the contralateral side (external rotation, $P = .008$; abduction, $P = .006$) but did not have comparable strength (external rotation, $P = .017$; abduction, $P = .009$).
Conclusions: Patients with inferior clinical results were more likely to be dependent on CoA to gain external rotation. Therefore, CoA testing may be used as a tool to evaluate the status of postoperative motor learning after latissimus dorsi transfer.
Level of evidence: Basic Science, Electromyography.

Keywords: Latissimus dorsi transfer; motor learning; coactivation testing; electromyography; isometric strength; muscle recruitment

Ethical Committee Approval (Ethikkommission der Fakultät für Medizin, Technische Universität München): No. 5635/12.

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1058-2746/$ - see front matter © 2014 Journal of Shoulder and Elbow Surgery Board of Trustees.
http://dx.doi.org/10.1016/j.jse.2013.11.005

Massive and irreparable rotator cuff tears are a challenging situation for orthopedic surgeons. Current treatment strategies include rotator cuff repairs with augmentation, tendon transfer techniques, and reverse shoulder arthroplasty. Reverse shoulder arthroplasty is typically reserved for less active and elderly patients, whereas latissimus dorsi transfer has become an established surgical treatment option for massive and irreparable posterosuperior rotator cuff tears in younger patients without glenohumeral osteoarthritis.[3,7,9-11,14,17,21-23]

Postoperative shoulder function and patient satisfaction after latissimus dorsi transfer have been reported to be variable, and the reasons for this remain only partially understood.[10,16,17,22,29] By transfer of the latissimus dorsi tendon from its native insertion to the greater tuberosity, biomechanical function changes from internal rotation and adduction to external rotation and abduction. Although some authors see the major effect of latissimus dorsi transfer in a soft tissue rebalancing of the glenohumeral joint (tenodesis effect), most studies reveal better clinical results and higher patient satisfaction if the transferred muscle shows electromyographic (EMG) activity in its new function.[2,11,12,16,17,29]

Werner et al[29] selected latissimus dorsi transfer patients with the best and the worst postoperative outcomes as assessed by Constant scores. They found that the patients in the better outcomes group had superior psychomotor skills and strong innervation of the transferred latissimus muscle.

To our knowledge, no simple clinical tool has yet been established to evaluate the muscle's ability to adapt to its new function. The purpose of this study was to investigate coinstantaneous activation (coactivation) of the latissimus dorsi in its new function, as an external rotator, and in its native function, as an extensor and adductor, for the purpose of creating a clinical tool to monitor motor learning in the postoperative setting. Furthermore, we evaluated the correlation of selective EMG activity of the transferred muscle and clinical outcome. We hypothesized that patients with inferior score outcomes would show an inadequate motor learning process and that coactivation (CoA) testing is a valuable tool to evaluate the status of postoperative motor learning after latissimus dorsi transfer.

Methods

Between 2003 and 2009, 29 consecutive patients (3 women and 26 men) underwent a latissimus dorsi tendon transfer at the Department of Orthopedic Sports Medicine, München. The indication for performing this procedure was a complete, irreparable posterosuperior rotator cuff lesion in younger patients with a primary complaint of a functional deficit rather than pain. Contraindications were advanced osteoarthritis, shoulder stiffness, and deltoid or subscapularis insufficiency. Preoperatively, all patients had a complete history, physical examination, and diagnostic imaging, including shoulder radiographs in 3 planes and magnetic resonance imaging.

Only patients with a follow-up of more than 24 months were included in the study. Exclusion criteria were a postoperative tear of the transferred tendon on ultrasound imaging, advanced osteoarthritis, shoulder stiffness, septic arthritis, and severe neurologic disorders. All patients were contacted by telephone and offered enrollment in the study.

Surgical technique

The latissimus dorsi tendon transfer was performed as described by Gerber et al.[9,11] An angulated dorsal incision was used for the latissimus dorsi approach. The muscle was sharply detached from its humeral insertion and mobilized by blunt dissection to provide sufficient excursion for transfer.

Through an anterolateral deltoid split approach, the torn rotator cuff was identified and mobilized, and the greater tuberosity insertion site was prepared for the tendon transfer. A space was then created between the rotator cuff and deltoid muscle, through which the latissimus dorsi tendon was passed and subsequently fixed to the supraspinatus and infraspinatus footprint at the greater tuberosity with titanium suture anchors (Arthrex, Naples, FL, USA) in a modified Mason-Allen suture technique. Anteriorly, the tendon was sutured to the superior edge of the subscapularis. Medially, the torn and retracted edges of the rotator cuff were sutured to the transferred tendon. If there was a partial or complete tear of the cranial subscapularis tendon, this was repaired with the same suture anchors.

Postoperatively, the arm was immobilized in a thorax abduction cast in 45° of abduction, 30° of flexion, and 0° of rotation for 6 weeks. Passive exercises were initiated in 45° of abduction and limited to 0° of internal rotation, with external rotation as tolerated. Abduction was allowed up to 90°. In week 4, active-assisted exercises were initiated, with gradual gain in range of motion after 6 weeks. Unlimited active range of motion was permitted from week 10 on.

Clinical outcome measures

Patients were evaluated by the American Shoulder and Elbow Surgeon (ASES) score and the University of California–Los Angeles (UCLA) shoulder rating scale.[1,27] Further clinical examination included a visual analog scale score for the average pain level (0 representing no pain and 10 representing maximal imaginable pain) and testing for external rotational lag sign.[24]

All patients were asked to report their overall satisfaction with the surgical outcome (satisfied vs nonsatisfied).

Diagnostic imaging

All preoperative magnetic resonance imaging scans were assessed for integrity and atrophy of the rotator cuff by 2 experienced orthopedic surgeons. The integrity of the subscapularis tendon was classified according to Fox and Romeo.[8] The posterosuperior rotator cuff lesions (supraspinatus and infraspinatus) were graded by the classification system of Goutallier for muscle atrophy and by the Patte system for tendon retraction.[13,26] The teres minor tendon was graded as intact, partially torn, or completely torn and was also assessed according to the Goutallier system for muscle atrophy.[13]