Anterior Glenohumeral Joint Stabilization in Tetraplegic Patients by Medializing the Anterior Head of Deltoid Muscle

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To improve control of the upper limb in high-level tetraplegic patients, the proximal shoulder must be the first consideration. Medialization of the anterior part of the deltoid muscle provides stabilization and is then an antagonist to the posterior deltoid when a pectoralis major palsy exists. It can also be performed in isolation in high-level tetraplegia even when there is little hope of distal extremity reconstruction to stabilize the shoulder. It also precedes the ability to restore elbow extension and perform further reconstructive hand surgery. We describe the surgical technique and report a clinical case. *(J Hand Surg Am. 2015;40(1):148–151. Copyright © 2015 by the American Society for Surgery of the Hand. All rights reserved.)*

Key words Tetraplegia, deltoid, elbow paralysis, tendon transfer, shoulder paralysis.

To restore more distal hand function in quadriplegic patients, muscular control and stability of the most proximal shoulder are first required. Furthermore, elbow extension is necessary before restoring hand function.

For anterior stabilization of the shoulder, we carry out a medializing transfer of the anterior fibers of the deltoid muscle. This transfer was first illustrated by Johnstone et al[1,2] in 1987, with excellent functional outcome. The patient reviewed in that study was classified as group 0, cutaneous negative, ocular positive, with pectoralis major deficit according to the Giens international classification.[3] Their surgical procedure involved medialization of the anterior fibers of the deltoid muscle. An increase in active range of motion of the shoulder was observed as well as a functional gain allowing eating, smoking, use of an electric wheelchair, and leisure activities (shooting) with the help of adaptive devices.[1]

Two surgical procedures published by Moberg[4] and Zancolli[5] described restoring elbow extension. They differed in the choice of donor muscle. The so-called Zancolli method uses the biceps brachii and the Moberg method uses the posterior deltoid muscle transferred to the distal insertion of the triceps brachii. This procedure was rendered more reliable by using polyester prosthetic reinforcement (Teissier and Marc, presented at the Fourth International Conference on Surgical Rehabilitation of the Upper Limb in Tetraplegia, 1995).

This transfer requires a competent clavicular head of the pectoralis major muscle to stabilize the glenohumeral complex during contraction of the posterior deltoid, now actively extending the elbow. In high-level tetraplegic patients (groups 0, 1, and 2 by the Giens classification[3]), the pectoralis major usually does not contribute to anterior stabilization of the shoulder. If the posterior deltoid is transferred in this case, active elbow extension will cause shoulder retropulsion, which shows that the absence of an

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anterior antagonist reduces effective force in elbow extension. The aim of this publication was to describe this surgical procedure, illustrated by a case report.

INDICATIONS

Patients classified as Giens group 0[3] can benefit from this procedure. It provides better control of upper limb positioning and greater independence. The pectoralis major is often dysfunctional in tetraplegic patients classified as group 0, 1, or 2. In high-level tetraplegia, even without restoring hand function, shoulder stabilization improves shoulder control and strength. This helps to improve patient transfer and upper limb positioning even with little hope of restoring hand function. This muscle transfer may also be indicated in cases of poor shoulder control and precedes restoration of more distal functions to elbow and wrist. This muscle transfer attempts to restore function of the pectoralis major: flexion and adduction of the shoulder while being an antagonist to shoulder extensors.

Restoring elbow extension is indicated in patients classified as Giens group 5 or lower. The triceps brachii is not functional in high-level tetraplegic patients classified as group 4 or lower and is inconstantly functional in intermediate-level tetraplegic patients in group 5. If the pectoralis major is not functional, anterior stabilization of the shoulder should be performed before deltoid-to-triceps transfer.

Medialization of the anterior deltoid head and restoration of active elbow extension can be performed either in 1 or 2 stages. In the latter case, there should be a 1-month interval between the 2 operations to allow the bone insertion to consolidate. The transfer requires muscle strength of at least 4/5 on the Medical Research Council scale.

CONTRAINDICATIONS

Contraindications are similar to those generally noted in upper limb tetraplegia surgery. Uncontrolled spasticity is a major contraindication. Patients must be informed about the surgical and rehabilitation procedure, and compliance must be ensured. We do not perform surgery on tetraplegic patients before 1 year after injury.

SURGICAL ANATOMY

The anterior head of the deltoid originates from the lateral part of the clavicle and forms the curve of the shoulder. It is located directly under the skin. Medially it is bordered by a triangular groove (trigonum deltopectorale) and the cephalic vein separates it from the pectoralis major. Its distal insertion on the humeral shaft lies next to the insertion of the pectoralis major. Therefore, after medialization of the anterior part of the deltoid, it lies parallel to the clavicular part of the pectoralis major muscle.

FIGURE 1: Dissection and isolation of the anterior head of deltoid (D). C, clavicle.

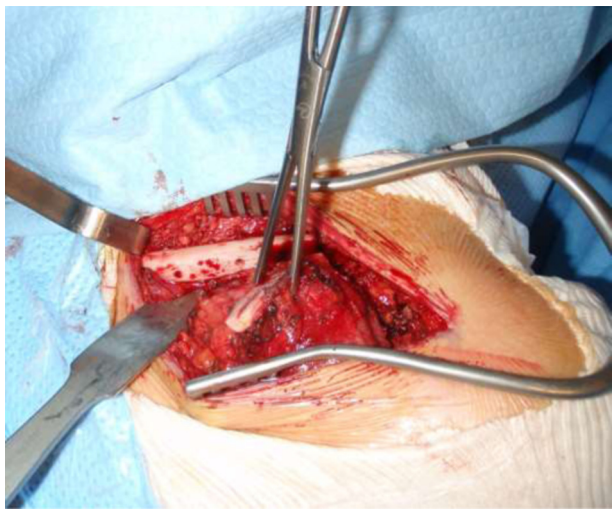

FIGURE 2: Anterior head of detoid with the bone graft detached. Preparation of the middle third of the clavicle.

PREOPERATIVE PLANNING

The deltoid is strengthened before the surgery because a muscle transfer reduces its strength by 1 point on the Medical Research Council scale.

TECHNIQUE

After general anesthesia is administered, we position the patient laterally, which allows both transfer of

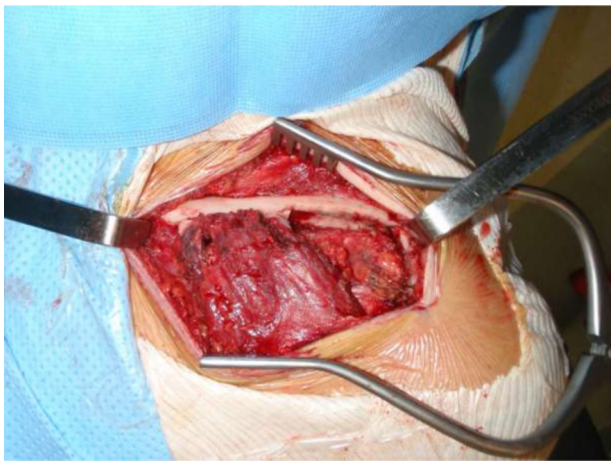

FIGURE 3: Bone graft fixation on the middle third of the clavicle with 2 screws and wire loops: final result.

FIGURE 4: Postoperative anterior x-ray showing clavicular bone graft held by 2 screws and wire loops.

TABLE 1. Preoperative and Postoperative Mesure d'Indépendence Fonctionnelle, Spinal Cord Independence Measure, Score de Capacités Motrices, and Strength Scores

Functional Evaluation	Before Surgery	After Surgery
Mesure d'Indépendence Fonctionnelle	66/126	70/126
Spinal Cord Independence Measure	27/100	30/100
Score de Capacités Motrices	104/233	161/233
Left neo-triceps strength, MRC scale	0/5	4/5

FIGURE 5: The transferred muscle. The shoulder's anterior stabilization is achieved by medialization of the anterior head of the deltoid.

the medialized deltoid and deltoid-to-triceps transfer in one step. The patient is draped with the entire shoulder and arm fully exposed. An S-shaped incision is made superficial to the middle and lateral third of the clavicle. The clavicle is exposed. We next locate the deltoid origin on the clavicle (Fig. 1). We use a sagittal saw to cut a cortical bone block from the clavicle, containing that portion of the clavicular head of the deltoid and encompassing one third of the clavicle thickness. The anterior head of the deltoid is freed and cleaved from the middle head of the deltoid. Then we clear the middle third of the clavicle of soft tissue (Fig. 2). The bone graft on the deltoid is medialized on the clavicle and positioned with a bone clamp forceps. Two holes are drilled at one-third intervals along the graft. The medialized bone graft together with muscle attachment is fixed with 2 3.5-mm screws and 2 wire loops, which are strong enough fixation to minimize the risk of disruption (Fig. 3). A drain is positioned and wound closure is accomplished.

If restoration of the elbow extension is also desired, the next step consists of deltoid-to-triceps transfer with the aid of a polyester prosthetic interposition. The posterior head of the deltoid is thereby transferred to the distal triceps brachii insertion according to the technique described by Moberg[4] and modified by Teissier and Marc (presented at the Fourth International Conference on Surgical Rehabilitation of the Upper Limb in Tetraplegia, 1995). An x-ray is obtained postoperatively (Fig. 4).

SURGICAL ALTERNATIVES

In the case of pectoralis major deficit, some authors prefer a biceps-to-triceps transfer to restore elbow extension.[3,6] However, we found that anterior shoulder

stabilization followed by deltoid-to-triceps transfer is a reliable, reproducible technique and provides substantial patient benefit.

REHABILITATION AND POSTOPERATIVE CARE

A thoraco-brachial orthosis (shoulder in 45° abduction, 45° antepulsion, and elbow in extension) should immobilize the upper limb for the first 4 weeks. However, passive shoulder mobilization should be started from day 1 to ensure normal motion range with regards to elevation, while retropulsion remains prohibited. Elbow flexion starts at 1 month after surgery and is increased 15°/wk.

If the triceps brachii is not transferred at the same time, postoperative immobilization is provided by a sling bandage for 4 weeks.

CLINICAL CASE

We report the case of a 22-year-old male patient with an incomplete C5 tetraplegia (right: C6 complete, C5 incomplete; left: C6 complete; American Spinal Injury Association A), who was injured during a dive accident in shallow water in July 2008. More than 1 year after the accident both upper limbs were classified as group 2, cutaneous (Cu) minus right, Cu positive left, and ocular positive. On both sides both the triceps brachii and the clavicular head of the pectoralis major were nonfunctional. Right-handed before the accident, this patient afterward principally used the left hand. He underwent a functional evaluation some weeks before the start of the surgical program (Table 1).

For the right upper limb, the surgical plan was limited to a biceps-to-triceps transfer following Zancolli's procedure. For the left upper limb, a multistep procedure was proposed: first, medialization of the anterior third of the deltoid, as described above; second, deltoid-to-triceps transfer using a polyester interposition; third, thumb stabilization (split tenodesis of the thumb interphalangeal joint, arthrodesis of the trapezometacarpal joint, and tenodesis of the extensor pollicis longus); and fourth, restoration of an active key grip, by brachioradialis-to-flexor pollicis longus transfer. After these procedures, at the time of discharge, functional values were assessed (Table 1, Fig. 5).

Follow-up x-ray showed consolidation of the bone graft on the clavicle. This patient had 2 upper limbs classified as Giens group 2. He underwent restoration of right elbow extension as well as improvement of left elbow extension. The patient was satisfied with the results, which increased strength and allowed better positioning control of the proximal limb (Fig. 5).

PEARLS AND PITFALLS

The bone graft must be strong enough to transfer without being fractured. The screw needs washers to avoid fragmentation of the bone graft. The bone graft must be less than one third of the clavicle thickness to prevent clavicular fracture.

COMPLICATIONS

Complications include those of any clavicle surgery: potential trauma to the subclavian artery and vein. The risk is small because the drill is positioned horizontally and not vertically on the clavicle.

DISCUSSION

The transfer presented here adds an additional procedure to classic surgical procedures. However, most patients reported that they would spend an additional 2 or 3 months in recovery to eventually become more independent.[7]

Limitations of this study are related to the type of the article. Because it is a technical note and a case report, it cannot provide results from a patient series. The senior author has performed 6 medializations of the anterior deltoid in 6 patients since 2001. The clinical results showed useful functional improvement.

This technical note proposes an additional procedure that can help hand surgeons in upper limb surgery for tetraplegic patients.

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