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MIPO of proximal humerus fractures through an anterolateral acromial approach. Is the axillary nerve at risk?

Josip Knežević[a,*], Mario Mihalj[b], Fabijan Čukelj[a], Arsen Ivanišević[a]

[a]University Hospital Split, Department of Orthopaedic Trauma, Spinčićeva 1, 21000 Split, Croatia
[b]University Hospital Split, Department of Neurology, Laboratory of Electromyoneurography, Spinčićeva 1, Croatia

KEYWORDS

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ABSTRACT

Purpose: It is known that shoulder surgery may cause iatrogenic injury to the axillary nerve as a serious complication, but there is little evidence to indicate whether the axillary nerve is at risk of injury during an anterolateral acromial approach for minimally-invasive plate osteosynthesis (MIPO) of proximal humerus fractures. We hypothesised that this surgical method is safe for the axillary nerve and would preserve it from iatrogenic injury.

Materials and methods: We conducted a prospective follow-up cohort study on 49 consecutive patients with proximal humerus fractures who were managed with MIPO through an anterolateral approach. All patients underwent standardised electroneurographic testing, with assessment of amplitudes of evoked compound muscle action potentials (CMAP) and distal motor latencies (DML) of the axillary nerves, pre- and post-operatively. Six weeks after injury, all patients underwent needle electromyographic (EMG) testing of anterior, middle, posterior deltoid, teres minor and paraspinal muscles for detecting abnormal muscle activity as a sign of acute denervation. After six months of physical rehabilitation, patients with axillary nerve injury underwent control electroneurographic testing to check the recovery of neurographic features (CMAP, DML). All nerve measurements were compared to reference values, and between right and left side.

Results: Five patients had a mild-to-moderate traumatic axillary nerve injury before surgery. There were no significant differences between amplitudes of CMAP ($p = 0.575$) and DML ($p = 0.857$) pre- and post-surgical procedure.

Conclusions: These results confirmed safety of this surgical method in the preservation of axillary nerve from iatrogenic injury, but the course of the axillary nerve must be kept in mind.

Introduction

Proximal humeral fracture is usually an osteoporotic fracture in women over the age of 70 years. As the population is aging, this type of fracture is becoming more common. The fractures are displaced in 50% of cases, requiring hospitalisation in at least one out of two cases and surgery was performed in one out of five [1].

As the elderly population becomes more physically active, there is an increased expectation of an improved quality of life.

Surgical options for treatment of these fractures are percutaneous Kirschner-wiring (K-wiring), ORIF with conventional or locking plates, intramedullary locking nails and shoulder prosthesis.

Fixation of proximal humeral fractures using polyaxial locking plates with minimally-invasive surgery (MIS) has been reported to provide stable osteosynthesis with a well-tolerated surgical procedure and good final results [2–10].

The deltapectoral approach is the standard for proximal humerus fractures [11]. This extensile approach causes additional soft tissue damage, retraction of the deltoid muscle with potential devascularisation of fracture fragments, and difficult visualisation of posteriorly-dislocated greater tuberosity fragments [12,13].

To prevent these problems, a minimally-invasive anterolateral approach through a split in the deltoid muscle is being progressively used. A disadvantage of this approach is the possibility of axillary nerve damage and paralysing the anterior part of the deltoid [3,14–19].

The aim of this prospective study was to evaluate and compare axillary nerve function before and after minimally-invasive plate osteosynthesis (MIPO) for proximal humerus fractures between the non-injured and injured shoulders.

* Corresponding author: Josip Knežević, MD, Department of Orthopaedic Trauma, University hospital Split, Spinčićeva 1, 21000 Split, Croatia, Tel: +385 21 556 487; Fax: +385 21 556 587.
E-mail: knez64@gmail.com

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Patients and methods

From February 2013 to November 2016, 49 patients (33 women, 16 men; average age 62 years, range 32–87 years) with dislocated proximal humeral fractures were managed with MIPO through an anterolateral approach in our institution.

According to the Neer classification system, there were 13 two-part, 25 three-part and 11 four-part fractures with dislocation (>1 cm or >45°) [20].

The fracture affected the dominant side in 43% of cases; 32 left and 17 right shoulders.

All patients with pre-existing nerve deficits before injury were excluded.

All surgical procedures were performed within one week of the injury by four experienced orthopaedic surgeons.

All patients signed a consent form preoperatively after being well informed.

Surgical technique

Under general anaesthesia, the anterolateral transdeltoid minimally-invasive surgical (MIS) approach was performed with the patient in the beach-chair position with abducted arm to relax the deltoid muscle. A fluoroscope was positioned on the contralateral side to enable visualisation of the proximal humerus in two axes. A five-hole Philos® Plate (De Puy Synthes®, Switzerland) with angle-stable screw fixation and radiolucent aiming device was used in all cases. Skin incision and deltoid raphe splitting was maximally 5 cm long from the tip of the acromion. After reduction with K-wires or non-absorbable sutures through the rotator cuff (particularly in weak bone), plate was slid underneath the deltoid muscle on the humerus shaft. The axillary nerve was never visualised, but rather protected with blunt periostal elevator or Langebeck retractor. Also, a stay suture was placed at the distal deltoid raphe to protect the axillary nerve from uncontrolled distal dissection. Fracture fixation with plate and locking screws was conducted as usual, with fixation in the head with four screws and fixation in the humeral shaft with three screws through stab incisions. One cortical screw was sometimes used as a reduction tool to correct humeral shaft valgus position. The final position of fracture fragments and plate with screws was checked under an image intensifier. Immediate postoperative active-assisted mobilisation was performed [7–10,15,17,21–26].

Electroneurography techniques and measurements

Nerve conduction studies were done using the Medelec Synergy electromyography (EMG) and EP system (software version 11, Oxford Instruments, Oxford, UK).

All patients underwent standardised electroneurographic testing, with full assessment of amplitudes of evoked compound muscle action potentials (CMAP, in mV) and distal motor latencies (DML, in ms) of the axillary nerves before and after surgical treatment.

All values were recorded bilaterally for side-to-side comparisons, and were measured according to laboratory routine, as previously described. The reference electrophysiological values were taken from accepted criteria and all nerve measurements were compared with reference values [27,28].

Clinical testing (early pre- and post-operative) of muscle strength was not conducted because of the impact of pain and fear of patients as well as possible damage to the axillary nerve due to the movement. Also, clinical testing of sensibility proved to be of low value because motor abnormalities of the axillary nerve were seldom accompanied by disturbances of sensibility.

Preoperative and early postoperative detection needle EMG (requires active muscle contraction and movement of limbs) was not done due to immobilisation of the injured limb and the possibility of further nerve damage due to movement. Moreover, spontaneous activity in muscle as a sign of acute nerve lesion can be detected 3–4 weeks after the injury. Therefore, all patients underwent a needle EMG examination of muscles about 5–6 weeks after injury (increased insertional activity, spontaneous activity, polyphasic, and impairment of recruitment at anterior, middle, posterior deltoid, and teres minor muscles). Also, at the same time, paraspinal muscles were examined (at the C4/5 and C5/6 levels) bilaterally to exclude possible acute radicular lesions (abnormal spontaneous activity, such as fibrillation, positive sharp waves), which could affect the size of CMAP amplitudes.

Methods

Axillary motor nerve conduction studies.

Room temperature was maintained at 26°C with air conditioning and skin temperature was maintained above 33°C. There was no need to heat the skin with a hairdryer. Skin temperature was controlled with a thermochromics thermometer – LCD strip – on the dorsum of the hands.

In the motor nerve conduction study, surface bipolar stimulating electrodes and recording bar electrodes with rectangular pads were used with a fixed distance between the cathode and anode of 23 mm, and with a wraparound ground electrode between them.

The gain was set at 2–5 mV per division. Stimulation duration was set at 200 μs. Sweep speed was set at 2–5 ms/division and frequency filter was set at 2–3 Hz for low and 10 kHz for high frequencies.

Most nerves require a current flow in the range of 30–60 mA to achieve supra-maximal stimulation. The current of the stimulator was initially set to zero, then gradually increased with successive stimuli (by 5–10 mA increments). A CMAP signal grew larger with the increasing stimulus strength. Current was increased to the point where CMAP no longer increased in size, from that point the current was increased by another 20% to ensure the supra-maximal stimulation.

The measured values were DML and CMAP. CMAP amplitude potentials were measured from peak to peak, i.e. from the highest to the lowest point of deflection of the action potential from the isoelectric line. The amplitude correlates with the number of nerve fibres.

The onset latency is the time in milliseconds from the stimulus artefact to the first negative deflection of CMAP.

The distance between the stimulation point and registration electrode was measured with an obstetric calliper (with the arm by the side) and fixed to 20 cm to interpret distal (onset) latency in a meaningful way.

The stimulating surface bipolar electrodes were placed at Erb's point (the cathode was placed slightly above the upper margin of the clavicle lateral to the clavicular head of the sternocleidomastoid muscle, the anode was superomedial). The registration surface electrodes for CMAPs of the axillary nerve were set over the most prominent portion of the middle deltoid muscle. The reference electrode was placed over the tendon insertion. The ground was placed over the acromion.

Statistical analysis

Results were expressed as mean ± SD. Preoperative DML and CMAP were compared between right and left sides using the Mann-Whitney U Test for independent samples. Pre- and post-operative DML and CMAP were tested using the Wilcoxon matched-pairs signed ranks test for dependent samples.

The level of significance was set at $P < 0.05$.

Results

Forty-four patients had normal CMAP amplitude and DML values, with no significant differences in axillary nerve values of DML and CMAP of injured and non-injured shoulders before surgery (Table 1).