J Shoulder Elbow Surg (2016) ■■, ■■–■■

ELSEVIER

Journal of Shoulder and Elbow Surgery

www.elsevier.com/locate/ymse

ORIGINAL ARTICLE

Axillary nerve lesions after open reduction and internal fixation of proximal humeral fractures through an extended lateral deltoid-split approach: electrophysiological findings

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Background: Axillary nerve injuries after shoulder surgery are rare. In most studies, the frequency of injury is usually determined using clinical examinations, but results from intraoperative neuromonitoring studies have revealed higher than expected rates. Few studies have investigated this topic. Our aim was to determine the frequency of axillary nerve lesions after open reduction and internal fixation of proximal humeral fractures by using electrophysiological assessments and to provide a review of the relevant literature.
Methods: This was a retrospective cohort study of 76 consecutive patients who received open reduction and internal fixation of a proximal humeral fracture using a locking plate through a deltoid-splitting approach. We performed a clinical and electrophysiological examination at a minimum follow-up time of 12 months. Functional results were assessed according to the Constant-Murley and Disabilities of the Arm, Shoulder and Hand scores. Electrophysiological examinations comprised electromyography, electroneurography, and motor and somatosensory evoked potentials. The main outcome was the frequency of axillary nerve lesions.
Results: Forty patients were monitored for an average of 28 months. The mean raw Constant-Murley score was 61 points, the age- and gender-adjusted score was 71%, and the mean Disabilities of the Arm, Shoulder and Hand score was 33 points. Neurapraxia occurred in 1 patient, axonotmesis with incomplete reinnervation occurred in 3, and complete reinnervation occurred in 3. The latter group was classified as having a temporary axillary nerve lesion.
Conclusions: The 10% rate of permanent axillary nerve lesions in our cohort is higher than expected based on the clinical examination. Electrophysiological assessment is therefore more appropriate to detect axillary nerve injuries.

The Ethical Committee of the Otto von Guericke University Magdeburg, Germany approved this study (No. 01_2009, Version 01, Ref. 144/09).

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http://dx.doi.org/10.1016/j.jse.2016.07.027

Level of evidence: Level IV; Case Series; Treatment Study

Keywords: Electrophysiology; fracture fixation; internal; neurophysiology; peripheral nerve injuries; postoperative complications; shoulder fractures

Proximal humeral fractures comprise 4% to 5% of all fractures.[28] They occur with an incidence of 95 per 100,000 persons annually.[3] This number has been continuously increasing because of increased life expectancy. Open reduction and internal fixation and shoulder arthroplasty are suitable procedures for treating humeral fractures, but the choice of procedure depends on the fracture morphology and patient characteristics.

Open reduction and internal fixation is possible through 2 approaches: the deltopectoral and the deltoid-splitting approach. The deltopectoral approach is generally accepted as the gold standard. Its main advantage is preserving the deltoid, with excellent possibility for distal extension and providing a good view of the humeral head. The deltoid-splitting approach is well established in rotator cuff surgery and reversed total shoulder arthroplasty.[24] However, the anterior branch of the axillary nerve perpendicularly crosses the incision in this approach. Therefore, injury to the nerve during surgical preparation is possible, and many surgeons avoid this approach because functional deficits of the deltoid cannot be excluded.

Although many cohort studies describe injuries to the axillary nerve as a complication of shoulder surgery, reliable data on the frequency of these lesions, as assessed by electrophysiology, are lacking. When we started our research, we identified 12 studies of axillary nerve lesions resulting from trauma or surgery that used electrophysiology to evaluate the nerve function.[4-6,9,11,12,25,26,29,35-37] Only 3 of these studies analyzed axillary nerve lesions solely caused by surgery, but they followed different surgical procedures (shoulder replacement,[26] open reduction and internal fixation,[12] and arthroscopy[11]). Data on axillary nerve injuries resulting from a specific surgical approach do not exist. We therefore aimed to electrophysiologically assess the frequency of axillary nerve lesions in patients who underwent open reduction and internal fixation of a proximal humeral fracture through an extended deltoid-splitting approach. The aim of the study was to detect the frequency of axillary nerve lesions and to provide a review of the relevant literature.

Materials and methods

Setting and patients

From January 2005 to December 2008, 76 patients underwent open reduction and internal fixation of a proximal humeral fracture through an extended deltoid-splitting approach at our level 1 trauma center. Four fellowship-trained surgeons performed all operations. Fracture fixation was achieved using a PHILOS plate (Synthes Inc., Umkirch, Germany.). All patients who fulfilled the inclusion criteria were eligible for the retrospective study. All patients provided informed consent that their statistics could be included in this study.

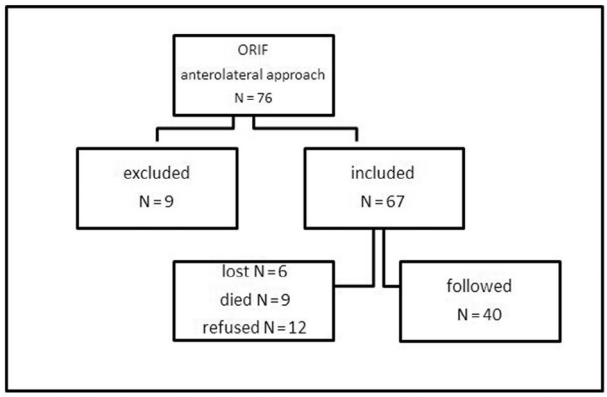

Figure 1 Patient allocation to the study groups. *ORIF*, open reduction and internal fixation.

Inclusion criteria were a proximal humeral fracture in which open reduction and internal fixation by a plate was indicated and no additional injury of the ipsilateral or contralateral arm existed. Excluded were patients with previous surgery in the same extremity, those with dementia or other severe mental disabilities, and those in whom electrophysiological examination was impossible because of permanent anticoagulation. Of 76 patients who were eligible for participation, 9 were excluded (concomitant injuries in 2, anticoagulation therapy in 2, dementia in 3, and previous surgery to the injured shoulder in 2). The minimum follow-up interval was at least 12 months. Of 67 patients who were invited for follow-up, 40 patients could be assessed for the final study because 9 patients had died, 12 refused to participate, and 6 could not be located (Fig. 1).

Fractures were classified according to Neer[27] with a modification of the original description. Fractures with a 5-mm gap and an angulation of 30° were considered displaced. Indications for plating were displaced 3- or 4-part fractures (group IV and V), fracture dislocation (group VI) in patients aged younger than 65 years, and 2-part fractures with shaft displacement (group III) if an open reduction was necessary because of severe varus displacement of the head.

We used the American Society of Anesthesiologists (ASA) score to evaluate the general medical condition of the patients. Sensation over the lateral upper arm was documented preoperatively. Preoperative electrophysiological examinations were not performed.

Approach and technique

The skin incision began at the anterolateral edge of the acromion and extended distally. The deltoid muscle was then dissected between the clavicular and acromial part within the avascular raphe. Detachment of the deltoid was strictly avoided. If detachment ac-