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Evaluation of axillary nerve integrity and shoulder functions in patients who underwent lateral deltoid splitting approach

Lateral deltoid splitting yaklaşım uygulanan hastalarda aksiller sinir bütünlüğünün ve omuz fonksiyonlarının değerlendirilmesi

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Abstract

Aim: The most common complication of the Lateral deltoid splitting approach (LDSA), which is used in the shoulder area, especially for posterior extension fractures and other soft tissue pathologies, is axillary nerve injury. Determining the frequency of nerve injuries that may occur after LDSA is decisive for the applicability of this approach. Therefore, in our study, we aimed to evaluate the axillary nerve integrity and shoulder functions in patients who underwent LDSA.

Methods: In this prospective cohort study, 55 patients who were operated with LDSA for proximal humerus fractures between February 2015 and July 2018 were evaluated. Among these patients, 35 were selected and included in the study. Six months later Electrophysiological tests (Electroneuromyelography – ENMG) and Constant Shoulder Score (CSS) were used for evaluation of each operated and non-operated shoulder. CSS difference between the operated and non-operated sides was graded as mild (11-20 point), moderate (21-30) and severe (>30).

Results: Mean age of the group was 66 (9) years. Twenty-five patients were female and 10 were male. Mean follow-up time was 4 (1) years. Mean latencies of axillary nerve were 4.6 (1.8) msn, 3.7 (0.54) msn and mean amplitudes of axillary nerve were 6.6 (2.21) mV, 8.4 (2.80) mV in the operated and non-operated shoulders, respectively. There was no statically significant difference between the operated and non-operated sides according to latency and amplitude (latency P=0.25, amplitude P=0.16). Mean CSS of the patients were 28.7. CSS of 12 patients were severe (mean: 39.08), 18 patients, moderate (mean 25.4) and 5 patients, mild (mean 16). There was no statically significant correlation between CSS and axillary nerve latency / amplitude (P= 0.62, r=0.267 / P=0.98, r=-0.339). Fracture type and CSS showed a statically significant correlation (P=0.032, r=0.829).

Conclusion: This study revealed that LDSA provides wide and versatile fracture control without compromising the deltoid muscle functions and axillary nerve, especially in fractures extending to the posterior part of the proximal humerus.

Keywords: Proximal humeral fractures, Deltoid-splitting approach, Nerve crush, Electromyography

Öz

Amaç: Omuz bölgesinin özellikle posterior uzanımlı kırıklarında ve diğer yumuşak doku patolojilerinde uygulanmakta olan Lateral deltoid splitting yaklaşım (LDSY)'ın en bilinen komplikasyonu aksiller sinir yaralanmasıdır. LDSY sonrası oluşabilecek sinir yaralanmalarının sıklığını belirlemek bu yaklaşımın uygulanabilirliği açısından belirleyicidir. Bu nedenle çalışmamızda, LDSY uygulanan vakalarda aksiller sinir bütünlüğünü ve omuz fonksiyonlarını değerlendirmek amaçlanmıştır.

Yöntemler: Prospektif kohort tipteki bu çalışmada Şubat 2015-Temmuz 2018 tarihleri arasında proksimal humerus kırığı nedeniyle LDSA uygulanarak opere edilen 55 hastanın verileri incelendi. Bu hastalar arasından seçilen 35 hasta çalışmaya alındı. Altı ay sonra tüm hastaların opere edilen ve edilmeyen omuzları elektrofizyolojik testler (Elektronöromiyelografi - ENMG) ve Constant Omuz Skoru (CSS) ile karşılaştırmalı olarak değerlendirildi. Opere edilen ve edilmeyen omuzların CSS farkları hafif (11-20), orta (21-30), şiddetli (>30) olarak derecelendirildi.

Bulgular: Hastaların yaş ortalaması 66(9) idi. Hastaların 25'i kadın, 10'u erkek hasta idi. Ortalama takip süresi 4(1) yıl idi. Opere olan ve olmayan omuz bölgelerinde yapılan ENMG incelemelerinde aksiller sinirin ortalama latansı sırasıyla 4,6(1,8) msn, 3,7(0,54) msn ve ortalama amplitude'u sırasıyla 6,6(2,21) mV, 8,4(2,80) mV idi. Latans ve amplitude değerlerine göre ameliyat edilen ve ameliyat edilmeyen taraflar arasında istatistiksel olarak anlamlı bir fark saptanmadı (latans P=0,25, amplitude P=0,16). Hastaların ortalama CSS skoru 28,7 idi. CSS'in 12 hastada şiddetli (ortalama: 39,08), 18 hastada orta (ortalama 25,4) ve 5 hastada hafif (ortalama 16) olduğu saptandı. CSS ve aksiller sinir latans / amplitude değerleri arasında istatistiksel olarak anlamlı bir korelasyon saptanmadı (P=0,62, r=0,267 / P=0,98, r=-0,339). Kırık tipi ve CSS arasında ise istatistiksel olarak anlamlı korelasyon olduğu görüldü (P=0,032, r=0,829).

Sonuç: Bu çalışma sonucunda, LDSA'nın aksiller sinir'e ve omuz fonksiyonlarına zarar vermeden özellikle proksimal humerusun arka kısmına uzanan kırıklarda geniş ve çok yönlü kırık kontrolü sağladığı saptanmıştır.

Anahtar kelimeler: Proksimal humerus kırıkları, Deltoid-splitting yaklaşım, Sinir yaralanması, Elektromiyografi

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Introduction

Nowadays, proximal humerus fractures have become the most widespread problem of the aging population. Preserving blood supply and neurologic innervation of the shoulder region are the challenging issues about fracture surgery. The deltopectoral approach is most used to fixate proximal humerus fractures [1]. However, some authors have argued that this approach involves extensive soft tissue dissection and muscle retraction to gain adequate exposure to the lateral aspect of the humerus [2,3]. Additionally, the amount of dissection is thought to further contribute to the devascularization of proximal humerus fractures at the time of internal fixation [4,5]. Especially proximal humerus fractures which extend to the posterior part of humeral head need more lateral exposure. For this reason, lateral deltoid splitting approach (LDSA) is described as an alternative, especially for proximal humeral fractures extending to the lateral and posterior parts of the humeral head. It has also been used for other shoulder region pathologies, such as impingement syndrome or rotator cuff tears [6]. The main complication of this approach is axillary nerve injury, which is widely recognized [2,7].

Axillary nerve originates from the posterior cord of the brachial plexus at the level of the axilla in the posterior division of the upper trunk. It carries nerve fibers from C5 and C6. The axillary nerve travels with the posterior circumflex humeral artery and vein through the quadrangular space which is formed by teres minor, teres major, long head of triceps and medial border of humerus. It gives anterior and lateral branches to enter and innervate the deltoid muscle after it travels around the humerus. This route of the axillary nerve runs transversely 5-7 cm distal to the edge of the acromion from the posterior to anterior [8].

LDSA is a useful approach, especially in posteriorly extending proximal humerus fractures, but it is limited by the position of the axillary nerve. The aim of this study is to evaluate axillary nerve integrity and shoulder function after proximal humeral fracture surgery using LDSA.

Materials and methods

In this prospective cohort study, the records of 55 patients who were operated for proximal humerus fracture between February 2015 – July 2018 were evaluated. Among these, 35 patients were selected according to inclusion criteria, which comprised being operated for proximal humerus fractures with LDSA, having the proximal humerus anatomic plate used for fracture fixation and having passed minimum 6 months after surgery. The study was approved by the ethics committee of Maltepe University Faculty of Medicine on 08.05.2020 (No:2020/900/24).

Surgical technique

For preoperative planning, axillary nerve route and bony landmarks were determined with a marker. A skin incision was made beginning at the anterolateral tip of the acromion extending distally approximately 5 cm (Figure 1).

The skin, subcutaneous tissue, fascia, and deltoid muscle were sharply dissected, and the greater tuberosity was exposed. The axillary nerve was not fully exposed, but identified and protected (Figure 2).

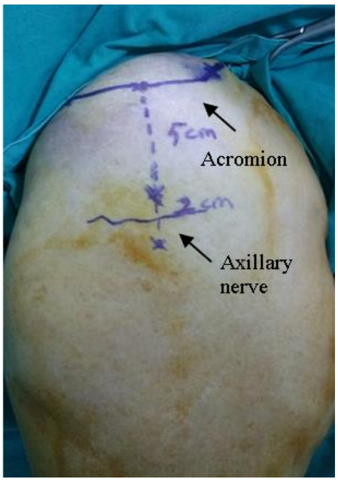

Figure 1: Preoperative planning

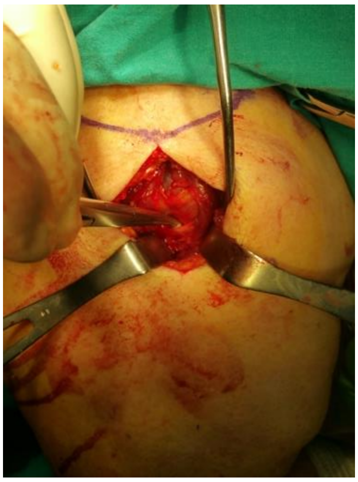

Figure 2: Intraoperative limited axillary nerve exposure

Fracture parts were fixed with proximal humerus anatomic plate and screws (Proximal humerus anatomic plate, Truemed, Istanbul, Turkey). After fixation, axillary nerve integrity was checked (Figure 3) and the wound was closed.

Figure 3: Checking axillary nerve integrity after fracture fixation

Evaluation of the patients

Physical and electrophysiological examination of the shoulder and Constant Shoulder Score (CSS) were used to evaluate axillary nerve integrity and functional status of the shoulder joint. Physical examination including inspection, palpation and touching sensation of the deltoid muscle was performed for investigation of atrophy and hypoesthesia of the shoulder. For the electrophysiological evaluation of the axillary nerve, electroneuromyography (ENMG) was performed on both upper limbs, earliest at the 6th postoperative month. In ENMG examination, axillary motor nerve’s latency and amplitude were recorded on the operated and non-operated sides. An active electrode was placed in the middle of deltoid muscle; a reference electrode was placed over the acromion. Supramaximal stimulation was given at Erb’s point. In needle electromyography, the electrode was inserted into the belly of deltoid muscle (Nihon Kohden Neuropack, Tokyo, Japan). Functional status of the operated shoulder was evaluated with CSS, which was performed to both healthy and operated sides. Difference of the scores were graded as > 30: severe, 21-30: moderate, 11-20: mild and <11: normal [9].

Statistical analysis

SPSS 25.0 statistics program was used for statistical analysis of results. Frequency analysis was used for demographic data. Bilateral latency and amplitude values of the axillary nerve were compared with student-t test. CSS, latency, and amplitude values of the axillary nerve were compared with correlation analysis. ANOVA test was used to compare CSS groups and latency – amplitude values. A P-value <0.05 was considered statically significant.

Results

Mean age of the patients was 66(9) years. Twenty-five patients were females and 10 patients were males. Mean follow-up time was 4(1) years. According Neer classification, 10 patients had surgical neck fractures (group III), 19 patients had a 3-part fracture (13 group IV, 4 group V, and 2 group VI), and 6 patients had a 4-part fracture (4 group IV, 2 group VI) (Table 1). In physical examination, none of the patients had deltoid atrophy or hypoesthesia at the lateral side of the shoulder. Mean latency and amplitude were 4.6(1.8) msn and 6.6(2.21) mV, respectively, on the operated side and 3.7(0.54) msn and 8.4(2.80) mV on the non-operated side, the difference between which were insignificant (latency P=0.25, amplitude P=0.16). There were no denervation potentials in needle electromyography, neither on the operated side nor on the non-operated sides (Table 2).

Mean CSS of all patients was 28.7. 12 patients were in bad condition (mean 39.08), 18 patients were in fair condition (mean 25.4), and 5 patients were in good condition (mean 16) at the last control visit. According to the correlation analysis, axillary nerve latency was prolonged and amplitude was low in patients with high CSS but there was no statically significant correlation between CSS and axillary nerve latency / amplitudes (P=0.62, r=0.267 / P=0.98, r=-0.339).When CSS groups were compared, there was no statically significant difference between groups with regards to EMG parameters (P=0.084). Correlation analysis between CSS and fracture type revealed that there was a negative correlation between functional scores and comminution of the fracture which means functional scores were bad or fair for more fragmented fractures (P=0.032, r=0.829).

Table 1: Demographics of the patients

Demographics	n
Mean age (min. – max.)	66.7 (53 - 79)
Gender (W/M) (n)	25 / 10
Mean follow-up (min. – max.) (year)	4.8 (3 – 7)
Side of humerus fracture (R / L)	19 / 16
Neer Classification	
Surgical Neck Fracture	10 (group III)
3-part fracture	19 (13 group IV, 4 group V, 2 group VI)
4-part fracture	6 (4 group IV, 2 group VI)

Min: minimum, max: maximum, W: woman, M: men, R: right, L: left

Table 2: The electrophysiological evaluation of axillary nerve

ENMG parameters	Operated side	Non-operated side	*P*-value
Mean latency (msn) (SD)	4.6 (1.8)	3.7 (0.54)	0.25
Mean amplitude (mV) (SD)	6.6 (2.21)	8.4 (2.8)	0.16

ENMG: Electroneuromyography, msn: millisecond, mV: millivolt, SD: standard deviation

Discussion

The deltopectoral approach is the most used approach in the shoulder region [10]. However, in some cases, LDSA may be preferred due to characteristics of the pathology and necessity of extended approach. The main complication of the LDSA is iatrogenic axillary nerve injury [11]. In this study, we evaluated the patients who were operated for proximal humerus fracture with LDSA with regards to axillary nerve integrity and shoulder functions. The results revealed that LDSA is a safe method for axillary nerve injury with careful dissection and fracture fixation. Additionally, functional scores of the shoulder joint were dependent to severity of the fracture.

One of the major upper extremity fractures is proximal humerus fracture and surgical treatment is usually necessary for comminuted fractures. The deltopectoral approach is well known and more commonly used for proximal humerus fractures. It has a relatively low complication rate and enhances exposure for fracture fixation, but deltopectoral approach may be insufficient for some comminuted and posterior extended fractures [11]. Some complications were defined for this exposure in these fractures [4,12]. Extended dissection to reach posterior part of humeral head may cause more disruption of the integrity of periosteum. Additionally, reduction of displaced greater tuberosity may become difficult with the deltopectoral approach. Deltoid muscle retraction during this approach may cause dysfunction of the muscle [13].

LDSA can solve this problem and provide more control on extreme fractures for fixing the posterior part of humeral head [14]. Especially for posteriorly extending proximal humerus fractures, LDSA can provide adequate exposure with a smaller incision than the deltopectoral approach. It affects postoperative functional outcomes of the shoulder joint [14, 15]. Isiklar et al. [16] demonstrated that constant scores in patients operated with LDSA were significantly better than patients who were operated using the deltopectoral approach at an earlier time. Additionally, this approach preserves periosteal blood supply by adequate exposure with limited incision. Despite these benefits, branches of axillary nerve are in danger due to its proximity to the surgical field, and iatrogenic axillary nerve injury is the main complication. Cheung et al. [17] investigated axillary nerve placement with a cadaver study and revealed that the axillary nerve lies about 5 cm distal from the mid-acromion. The risky area for axillary nerve is between 5 cm to 9 cm from mid-acromion.

Axillary nerve injury and shoulder functions after fixation of proximal humerus fracture were evaluated in many studies [15,18]. Khan et al. [15] reported that none of patients had an axillary nerve injury after lateral deltoid splitting approach with shoulder strap incision. In their surgical technique, axillary nerve is visualized and protected during fixation. Laflamme et al. [18] also reported that axillary nerve injury was not seen in their case series who were operated due to proximal humerus fractures with 2 different incisions, using mini open lateral deltoid splitting approach. They did not visualize the axillary nerve. In our study, postoperative 6th month ENMG results revealed that there were no significant differences between the operated and non-operated side axillary nerve functions. None of the patients complained about hypoesthesia at the lateral side of the shoulder.

Many injuries, especially proximal humerus fractures affect the functional status of the shoulder joint negatively. Severity of the fracture is the main predictor of the functional outcome of the shoulder joint. Robinson et al. [19] pointed that proximal humerus fractures with tuberosity involvement had poor functional outcome. Especially proximal humerus fractures with varus angulation have high complication rates [20,21]. Disruption of the medial vascular supply to the humeral head is stated as the possible cause [22]. Besides, metaphysical impaction and displacement of medial hinge are strong predictors of osteonecrosis of the humeral head [20,23]. Fisher et al. [24] revealed that more complex fracture patterns may be associated with worse outcomes after proximal humerus fracture surgery. In this study, a correlation between CSS and fracture type was determined and lower CSS scores were recorded more frequently in comminuted fractures.

Due to the spherical anatomical structure of the shoulder area, it is difficult to control the entire shoulder with a single surgical approach. Although the deltopectoral approach is a suitable surgical approach for many shoulder pathologies, it may be insufficient, especially in surgeries involving the posterior shoulder area. LDSA provides adequate exposure at the lateral and posterior parts of the shoulder but may cause axillary nerve injury due to its proximity. The results of our study, in which we evaluated the rate of axillary nerve injury and its effect on shoulder functions in patients undergoing LDSA, show that this approach can be used safely.

Limitations

Main limitation of this study is the number of the participants which should be much higher for more accurate results. Another limitation is that only patients who underwent LDSA were evaluated and the effects of deltopectoral approach could not be compared with LDSA, especially for posteriorly extending proximal humerus fractures.

Conclusions

Clinical and electrophysiological findings of this study have revealed that LDSA is an effective and safe approach if it is performed by carefully exploring the axillary nerve. It provides wide and versatile fracture control without compromising the deltoid muscle functions and axillary nerve integrity, especially in fractures extending to the posterior part of the proximal humerus.

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