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Risk of neurological injury in posterior bone block surgery for recurrent glenohumeral instability: a cadaveric study

Maria Valencia Mora[1] · Amaya Martínez Menduiña[2] · Carolina Hernández Galera[2] · Roque Pérez Expósito[2] · Mikel Aramberri Gutiérrez[2,3]

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Abstract

Introduction Recurrent posterior glenohumeral instability poses a challenge for treatment. Bone block procedures have been advocated in cases where a bony defect is present. However, these techniques are not free of complications due to the proximity of neurovascular structures. The aim of this study is to measure the distance to the axillary and suprascapular nerves at the different steps of the procedure.

Materials and methods Ten frozen human cadavers were used. The bone graft was prepared and placed on the posterior aspect of the glenoid, where it was fixed with two K-wires in different positions: parallel to the articular surface and with 20° of medial angulation. The distance from the entry and exit points of the K-wires to the axillary and suprascapular nerves was measured.

Results At the exit point, mean distance from the superior K-wire to the axillary nerve was 4.4 mm in the neutral position and 14.4 mm when medially angulated ($p = 0.01$) and 2.6 mm and 11.5 mm, respectively, for the inferior K-wire ($p < 0.01$). No differences were found at the entry point ($p = 0.7$ and $p = 0.3$). For the suprascapular nerve, mean distance to the entry point of the superior K-wire was significantly greater when it was inserted with 20° of medial angulation than when placed in neutral position ($p = 0.04$). No differences were found for the inferior K-wire ($p = 0.35$).

Conclusion Posterior bone block surgery should be performed taking into consideration the possibility of axillary nerve injury anteriorly at the exit point of the K-wires. Wire and screw insertion parallel to the glenoid articular surface may reduce the risk, while increased wire or screw medial angulation with respect to the glenoid surface may heighten risk.

Level of evidence Not applicable (cadaveric study).

Keywords Neurological injury · Axillary nerve · Suprascapular nerve · Posterior bone block

✉ Maria Valencia Mora
maria.valencia.mora@gmail.com

Amaya Martínez Menduiña
amaia.martinez.menduina@gmail.com

Carolina Hernández Galera
carol.hgalera@gmail.com

Roque Pérez Expósito
roquepe87@gmail.com

Mikel Aramberri Gutiérrez
aramberri@centroalai.es

1 H. Universitario Fundación Jiménez Díaz, Madrid, Spain

2 Hospital Universitario Ramón y Cajal, Madrid, Spain

3 Centro ALAI Sports Medicine Clinic, Arturo Soria, Madrid, Spain

Introduction

Recurrent posterior glenohumeral instability occurs less frequently than anterior instability, accounting for 5–8% of all instability cases [1, 2]. Most often, non-operative treatment with physiotherapy is warranted. In case of rehabilitation failure, surgical intervention is indicated [2].

Several arthroscopic soft-tissue techniques for assessment of post-traumatic recurrent involuntary posterior instability have been described [1, 3, 4]. However, soft-tissue procedures might not be enough to stabilize the joint in the presence of a bony defect, glenoid dysplasia, or in patients with severe hyperlaxity [5, 6]. In these situations, a bony procedure may be necessary to restore glenohumeral congruency and avoid recurrence [7–9]. Glenoid osteotomies [10–12] and techniques aimed at filling the glenoid or humeral bone

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defects have been described [5, 13, 14], though posterior bone block procedure remains the procedure of choice in this clinical scenario. Classically, posterior bone block procedure is performed as open surgery in which the glenoid is augmented posteriorly with an autograft (acromion [15, 16] or iliac crest [17, 18]) or an allograft (distal tibial plateau [8]). It has proven to be successful, with a low rate of recurrence and a high degree of patient satisfaction [7, 19]. Recently, some authors have proposed performing this procedure arthroscopically, allowing for full inspection of the glenohumeral joint and better assessment of other intraarticular findings [2, 20–22].

Though considered safe, the procedure is not free of complications. These might include graft resorption or malposition, need for hardware removal, damage to the posterior deltoid, pain, limitation of external rotation, neurovascular injury, and secondary osteoarthritis [17, 18]. The axillary nerve is at risk when breaching the anterior cortex of the glenoid as it runs across its inferior rim horizontally [15, 23]. Similarly, the suprascapular nerve might be injured during the open posterior approach and graft placement or occasionally during insertion of the K-wires if aiming at the suprascapular notch [17].

The purpose of this study is to measure the distance to the axillary and suprascapular nerves from the working area during the different steps of the surgery to minimize risk of neurological injury.

Materials and methods

Ten frozen male human cadavers with no known history of shoulder trauma or disease were used. The median age was 67.7 years old (range 65–74 years). Data on arm dominance were not available. Of the shoulders included in the experiment, three were right and seven were left.

Each shoulder was set up in beach chair-like position (60° of inclination) and the arm was placed in 20° of forward flexion and 20° of abduction. A clavicle autograft (20 mm × 14 mm × 10 mm) was harvested using a technique resembling that described by Smith et al. for an iliac crest autograft [20]. Two 3.2-mm K-wires were used to make two holes along a line parallel to the long axis of the graft, perpendicular to the midline, as described by Lafosse et al. [24] (Fig. 1). We then undertook a posterior approach in between the infraspinatus muscle and the teres minor muscle interval. The posterior capsule was opened and, when present, the posterior labrum was left intact. The graft was positioned along the posterior inferior glenoid (from the 6 o'clock to 10 o'clock positions) flush with the articular surface in a neutral position and with 20° of medial angulation with reference to the glenoid surface (simulating 20° of anteversion of the graft). Finally, the K-wires were fully introduced, passing over the anterior cortex of the glenoid neck. The distal K-wire was placed prior to the proximal one [2, 24]. Completion of the technique with screw introduction was not performed (Fig. 2).

From the posterior approach, the axillary nerve was carefully identified. The suprascapular nerve was also identified at the spinoglenoid notch. Distances from the entry point of both K-wires to the axillary nerve and to the suprascapular nerve were measured (Fig. 3). Lastly, an anterior deltopectoral approach to the glenohumeral joint was performed and the axillary nerve was identified and tagged at its anterior and inferior location. Distance from the exit point of both K-wires to the axillary nerve was measured (Fig. 4). All measurements were performed in standardized fashion using a calibrated ruler. Postoperatively, specimens were carefully

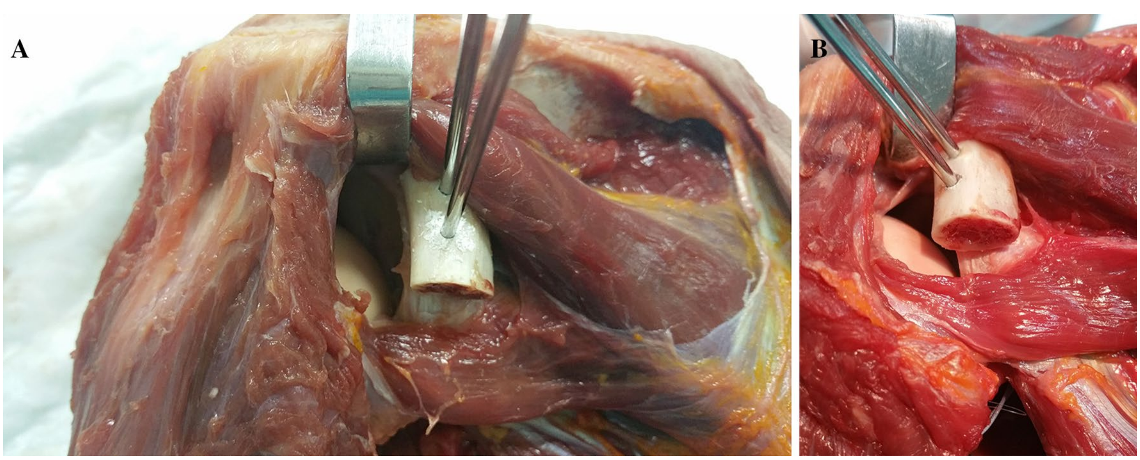

Fig. 1 Positioning of the posterior bone graft and its fixation with two 2.3-mm K-wires from a posterior view. A posterior approach was taken between the infraspinatus and teres minor muscles. **a** Graft positioned with K-wires in a neutral position; **b** graft positioned with K-wires in 20° of medial angulation

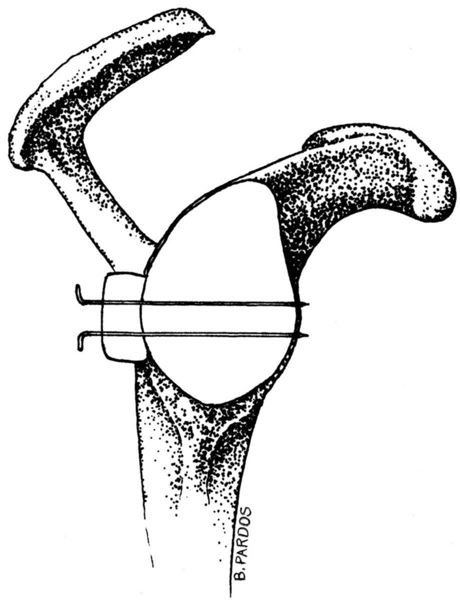

Fig. 2 Surgical technique: sagittal view

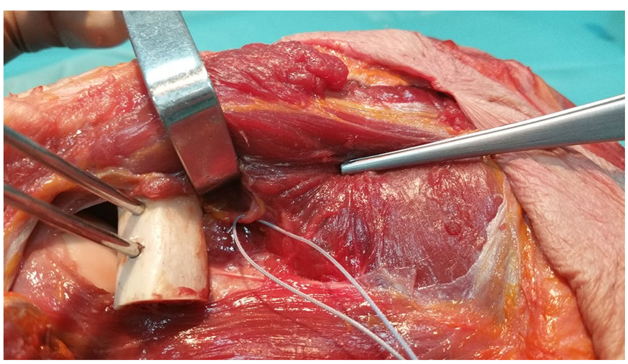

Fig. 3 Posterior view of a cadaveric shoulder. The relation between the graft and suprascapular nerve is shown

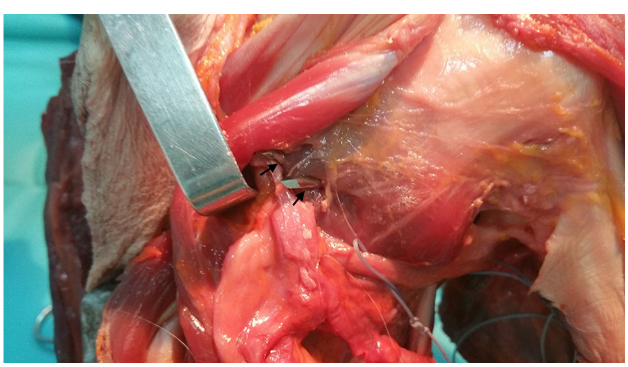

Fig. 4 Anterior view of the shoulder once the K-wires were inserted in the postero-anterior direction. The axillary nerve was tagged with a non-absorbable suture. Black arrows show the tip of the K-wires

inspected to rule out any intra- and extra-articular joint abnormalities, including both soft tissue and bony structures, with special examination to detect glenoid dysplasia.

Statistical analysis

Data were recorded in a computer database and analyzed using IBM SPSS Statistics (version 20.0, SPSS Inc, Chicago, IL, USA). Descriptive statistics were calculated, reporting frequencies and percentages for discrete data and medians with range of values for continuous data. As values for the variables were normally distributed, parametric statistical tests were selected. The *t* test was performed to compare paired measurements. A *p* value of 0.05 was considered significant.

Results

Mean distances from the axillary nerve to the entrance and exit points of the K-wires in both positions are included in Table 1. We established comparisons between measurements in the neutral and medially directed positions. For the superior K-wire, at the exit point, the axillary nerve was significantly closer when it was inserted with 20° of medial angulation ($p=0.01$). No differences were found in measurements performed at the entry point for either position ($p=0.07$). Similarly, for the inferior K-wire, mean distance to the nerve from the exit point was significantly smaller when the K-wire was inserted with 20° of medial angulation ($p<0.01$) but not at the entry point ($p=0.3$) (Fig. 2).

Lastly, regarding measurements for the suprascapular nerve, mean distance to the entry point of the superior K-wire was significantly greater when it was inserted with 20° of medial angulation than in a neutral position ($p=0.04$) (Table 1). No differences were found for the inferior K-wire ($p=0.35$) (Fig. 3). No statistically significant differences were found between any of the measurements when comparing distances from right and left shoulders.

Discussion

Posterior bone block procedures are considered the gold standard for addressing recurrent posterior glenohumeral instability in the presence of substantial bone loss [7, 8, 24]. Although it is a safe procedure, the re-intervention rate is approximately 36%. The majority of re-interventions is related to bothersome hardware and graft malpositioning [24]. In both open and arthroscopic procedures, there is a tendency to place the graft with an anterior tilt, resulting in a prominent rather than a flush graft [24]. In the long term, a prominent graft can increase the rate of iatrogenic

Table 1 Mean distance from entry and exit point of K-wires to axillary and from entry point to suprascapular nerve in both positions (parallel to the glenoid surface and with 20° of medial angulation)

	K-wire position	Mean distance from K-wire entry point to suprascapular nerve	Mean distance from K-wire entry point to axillary nerve	Mean distance from K-wire exit point to axillary nerve
Superior K-wire	Neutral 20°	17 mm (SD 8.6) 19.3 mm (SD 8.7) p value = **0.04**	29.1 mm (SD 7.9) 35 mm (SD 8.4) p value = 0.07	14.4 mm (SD 10.4) 4.4 mm (SD 4.6) p value = **0.01**
Inferior K-wire	Neutral 20°	18.2 mm (SD 7.3) 19.11 mm (SD 8.1) p value = 0.35	24.7 mm (SD 6.4) 27.3 mm (SD 7.9) p value = 0.3	11.5 mm (SD 5.6) 2.6 mm (SD 2.4) p value = **0.01**

Bold indicates significant values ($p < 0.05$)

degenerative arthritis. Also, when misplacing the graft, the K-wire trajectory can vary, and eventually lead to a higher risk of neurovascular damage. To avoid nerve damage, screws shorter than 40 mm have been strongly recommended; however, the influence of K-wire misdirection or graft malpositioning on these anatomical relations is unknown [21, 24, 25]. In our study, we included two positions—one in which the graft was positioned flush with the glenoid and another with 20° of anteversion—to simulate the medial misdirection of the K-wires.

The axillary nerve is one of the most commonly injured nerves during both open and arthroscopic surgical procedures, representing up to 6–10% of all brachial plexus injuries [26, 27]. Anteriorly, it has an oblique course in front of the subscapularis muscle until it reaches its lower border, contained in a triangle bordered by the pectorals minor, coracobrachialis, and axillary artery [27]. The distance between the coracoid process and the axillary nerve has been found to be approximately 3–4 cm [27]. Posteriorly, after surrounding the surgical neck and entering the quadrangular space, it divides into two branches, anterior and posterior. At this location, the mean distance between the posterolateral corner of the acromion and the axillary nerve has been reported to be 6–8 cm [26]. In our study, we measured the mean distance from the entry point of the K-wires to the nerve to evaluate the risk of a traction injury. However, in both positions and for both K-wires, the mean distance was greater than 24 mm, which makes an injury unlikely at this stage of the surgery. On the other hand, the measurements performed in the anterior part of the shoulder demonstrated that the axillary nerve is extremely close to the exit point of the K-wires, especially when they are inserted with a medial direction to the glenoid surface. For the superior K-wire, mean distance was 14.4 mm in neutral position, though this diminished to 4.4 mm when the K-wires were inserted with a medial angulation. For the inferior K-wire, these distances were even smaller: 11.5 mm for the neutral position and only 2.6 mm for the medially angulated position. Slattery et al. published the only previous study on transglenoid pins from posterior to anterior [28]. They found that the mean distance to the neurovascular bundle was 7.4 mm (range 1–19 mm), which is consistent with our findings [28]. Moreover, the authors pointed out the closeness of the thoracic cage and the consequent risk of pneumothorax.

Regarding the suprascapular nerve, we measured the mean distance from the entrance point of the K-wires to the nerve in the closest point, as the principal risk is a neuroapraxia due to excessive traction during dissection and placement of the graft [17, 28]. The mean distance that we found was 17 mm for the superior K-wire and 18 mm for the inferior K-wire. This distance increased to 19 mm when the K-wires were inserted with 20° of medial angulation, and this increase was statistically significant for the superior K-wire. Injury to the suprascapular nerve in bone block procedures has been mainly described as a complication of Latarjet surgery, when the K-wires are placed from front to back [25, 29]. We have not studied mean distances to the musculocutaneous nerve, as this nerve runs far away from the glenoid in an anterior direction and injury to it has been mostly reported when performing a Latarjet procedure due to its relation with the coracoid process and coracobrachialis muscle [30, 31].

Recently, some authors have described surgical techniques aimed at avoiding complications related to screw insertion [30]. For example, Boileau et al. have proposed a new technique using suture implants to avoid the risks associated with screw malposition and misdirection of the K-wires during insertion [21]. Arthroscopic anterior visual control of the glenoid and subscapularis might be recommended when pinning from the back to the front [24].

Our study has several limitations. The sample size was small, which may have influenced the results by limiting the possibility of detecting variations in individual anatomy [33]. However, the sample was homogeneous in terms of range of age and sex, and the results can be considered to have a normal distribution for statistical purposes. Moreover, Longo et al. did not find any differences in gender regarding distances from the supraescapular nerve to the glenoid [25]. We did not have access to data on arm dominance. Glenoid version was not measured, and retroversion might be higher in dominant arms. This fact could introduce differences in between patients [34]. Measurement errors could be possible, as non-digital rulers were used. The positioning of the patient could also influence the results. In our study, the beach chair-like position was reproduced. However, we only performed the measurements in one position, and different inclination angles or arm positions might have resulted in variable distances. For example, Longo et al. demonstrated in a cadaveric study that external rotation of the arm increased the distance from the screws to the supraescapular nerve when performing a Latarjet procedure [25]. On the other hand, Slattery et al. did not find any differences in measurements regarding scapular or thoracic position [28]. Lastly, cadaveric samples corresponded to upper limbs and not complete specimens, which could have altered anatomical relations.

Conclusion

Posterior bone block procedures should be performed taking into consideration the closeness of the neurovascular structures. Medial angulation when drilling from the back to the front or excessive screw length, and overall medial angulation of the distal K-wire should be avoided. At the entry point, care should be taken to avoid traction injuries to the suprascapular and, though less likely, the axillary nerve. Anterior visual control of the exit point of the K-wires or guided insertion should be advocated to avoid neurological injuries.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

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