European **Rev**iew for **Med**ical and **Pharmacol**ogical **Sci**ences 2023; 27: 11550-11559

Risk avoidance of screw-induced suprascapular nerve injury in arthroscopic Latarjet procedure and reliable anatomical landmark analysis of Latarjet surgery

S.-Y. SHI, X.-L. DU, X.-H. OU

Honghui Hospital, Xi'an Jiaotong University, Xian, China

Abstract. – OBJECTIVE: Shoulder dislocation represents a prevalent category within joint dislocation, accounting for about 40% of all joint dislocations, and anterior dislocation stands out as the prevailing type. It has been reported that in 1.6% of patients, the Latarjet procedure performed under arthroscopy involves transferring the coracoid process to the anterior-inferior aspect of the glenoid and fixing it with two bicortical screws. The tip of the screws may impinge the suprascapular nerve located behind the scapula, resulting in shoulder pain and weakness. This study was performed to analyze the risk of suprascapular nerve (SSN) injury caused by bicortical screws during arthroscopic Latarjet surgery and to identify reliable anatomical landmarks for Latarjet surgery.

MATERIALS AND METHODS: Dissection was conducted on 23 fresh adult intact shoulder joint specimens, and the experimental protocol complied with the hospital's ethical requirements for research. Using the glenoid clock face as a reference, the distances between the suprascapular nerve and the anterior edge of the glenoid were measured at the 12:00, 11:00, 10:00, and 9:00 positions, as well as at the level of the suprascapular notch and the level of the spinoglenoid notch. The distances between the suprascapular nerve and the narrowest point of the glenoid rim and the clock scale were recorded. The scapula was divided into three zones, and the number of nerve branches in each zone was recorded. The collected data were subjected to statistical analysis. The suprascapular nerve trunk and branches were marked using radiopaque lines, and measurements were taken at three positions in computed tomography horizontal scans: the suprascapular foramen, the spinoglenoid notch, and the point of entry of the outermost nerve branch into the muscle.

RESULTS: The suprascapular nerve originates from the brachial plexus, passes downward and backward through the suprascapular foramen, closely adheres to the bone surface, and runs outward and downward deep to the supraspinatus muscle. The distances between the suprascapular nerve and the glenoid rim at the 12:00, 11:00, 10:00, and 9:00 positions were 335.18±2.31 mm, 28.23±3.47 mm, 22.32±2.78 mm, and 22.12±2.07 mm, respectively. There was a mean of 1.12 nerve branches in zone 1, 2.86 in zone 2, and 3.64 in zone 3. In the neutral position of the shoulder joint, the horizontal distance between point A and the axillary nerve was 27.37 (19.80, 34.55) mm, and the vertical distance was 16.67 (12.85, 20.35) mm.

CONCLUSIONS: The use of bicortical screws, especially upper screws, for Latarjet fixation at the level of the spinoglenoid notch, is associated with the risk of suprascapular nerve injury. The narrowest distance between the glenoid rim and the suprascapular nerve was found between 9:00 and 9:30 at the glenoid clock surface. Therefore, caution should be exercised when performing any procedure related to this area. Overall, the Latarjet procedure is a reliable and effective surgical technique, providing benefits such as favorable positioning of the coracoid graft and low bone absorption rate, while also avoiding the potential for suprascapular nerve injury.

Key Words:

Shoulder joint, Latarjet procedure, Suprascapular nerve, Three-dimensional reconstruction, Arthroscopy.

Introduction

Shoulder joint dislocation is the prevailing type of joint dislocation, with anterior dislocation accounting for 95% of all cases. The management of anterior instability of the shoulder joint has consistently presented a complex challenge. Shoulder dislocations are frequently complicated by complex bone and soft tissue pathologies, with significant bone defects at the posterior aspect of the humeral head. These dislocations are usually associated with rotator cuff injuries, nerve damage,

Corresponding Author: Xuehai Ou, MD; e-mail: XueHaiOu8729@163.com

and the potential development of glenohumeral osteoarthritis in the future,. The management of chronic shoulder joint dislocations, which require complex surgical interventions, presents a significant challenge due to the presence of severe soft tissue contractures and substantial bone defects. However, no standardized treatment protocol for such chronic joint dislocations has yet been established. Various treatment methods, such as Bankart repair, Remplissage, bone grafting, and shoulder arthroplasty, have been reported in the previous literature. However, most of the existing literature, consists of case reports with limited large-scale case studies, resulting in considerable variability in postoperative outcomes, high failure rates, and a high incidence rate of postoperative complications.

Latarjet surgery is a classic procedure developed to manage recurrent anterior shoulder dislocations. In 1954, Latarjet introduced a coracoid transfer procedure aimed at extending the glenoid arc. This surgery involves securing the coracoid to the anterior-inferior edge of the glenoid using a pair of 3.75 mm fully threaded titanium cortical screws (Arthrex Inc., Naples, Florida, USA), thereby achieving the stabilization of the shoulder joint through the static effect of the coracoid transfer and the dynamic effect of the conjoint tendons,. Latarjet surgery is typically employed in cases with extensive glenoid bone loss, often defined as bone loss exceeding 20% of the glenoid surface. Notwithstanding earlier systematic reviews revealing an occurrence rate of about 3% for postoperative shoulder dislocation and ranging from 3.3% to 7.5% for recurrent subluxation of the humeral head, an increasing body of evidence corroborates the satisfactory clinical and biomechanical outcomes of this procedure. Conventional Latarjet surgery employs metallic screws for the stabilization of the translocated coracoid and glenoid, and the efficacy of screw fixation has been validated by previous studies. However, screw fixation may still induce hardware-related complications, with an incidence rate exceeding 6.5%,.

The success of Latarjet surgery relies on the positioning of the coracoid graft and the proper placement of screws. Multiple biomechanical and clinical studies have demonstrated the impact of proper graft positioning on clinical outcomes. Complications related to nerve injuries associated with screw placement can result in shoulder weakness, pain, and muscle atrophy,. Common postoperative complications of Latarjet surgery include recurrent dislocation, non-union, and nerve damage, encompassing damage to the suprascapular nerve (SSN). The SSN is a branch of the brachial plexus originating from the C5 and C6 nerve roots. The suprascapular nerve passes beneath the transverse scapular ligament, and enters the supraspinous fossa through the suprascapular notch, providing neural innervation to the supraspinatus muscle. Subsequently, it travels through the spinoglenoid notch into the infraspinous fossa, innervating the infraspinatus muscle and providing sensory nerves to the shoulder joint. The SSN runs posteriorly along the scapula, descending at the level of the glenoid neck,. The tips of the bicortical screws utilized in Latarjet surgery present a notable hazard to the suprascapular nerve, giving rise to a matter of concern. To date, little knowledge related to the assessment and avoidance of SSN injury based on arthroscopic anatomical landmarks is available. Therefore, arthroscopic identification of anatomical landmarks during Latarjet surgery is crucial to prevent SSN injury. In our study, we utilized the glenoid clock face clock to indicate the distance from the glenoid rim to the SSN and determine a safe zone. We assessed the risk of injuring the suprascapular nerve during the drilling phase of Latarjet surgery and described the nerve branches in different regions of the scapula.

Materials and Methods

Study Specimens

A total of 23 fresh-frozen adult shoulder joint specimens were utilized for this study, comprising 15 male and 8 female specimens, with 16 specimens corresponding to left shoulders and 7 to right shoulders. The average age was 38.4±7.6 years old. The specimens included intact scapular regions and excluded those with defects or a history of shoulder surgeries.

Inclusion and Exclusion Criteria

Inclusion criteria: 1) Intact brachial plexus system; 2) Complete subscapularis muscle; 3)Intact shoulder joint. Exclusion criteria: 1) History of glenohumeral joint surgery; 2) Noticeable shoulder joint trauma affecting normal anatomical structures.

Anatomical Procedures

Specimens were placed in a prone position. A modified Judet approach was employed to expose the suprascapular nerve. The skin was delicately removed, and soft tissues and fascia were separated. The trapezius muscle was dissected from lateral to medial, followed by flipping it downward to visualize the supraspinatus and infraspinatus muscles. The supraspinatus and infraspinatus muscles were detached from their medial attachments and flipped to expose the transverse scapular ligament, the suprascapular notch, and the spinoglenoid notch. The suprascapular nerve was meticulously dissected to expose its main trunk and branches. A 0.8 mm diameter radiopaque thread (detectable by X-ray due to barium sulfate content) was sutured onto the suprascapular nerve for marking, with each stitch made at 1 cm intervals. Care was taken to maintain the nerve's original course and position during the stitching process. Finally, the muscles were stitched, and the incisions were closed in preparation for subsequent experiments.

Measurement Parameters

A description and recording of the suprascapular nerve branches were conducted. The following data were recorded (using the right shoulder as an example): 1) Distances from the suprascapular nerve to the glenoid rim at 12:00, 11:00, 10:00, and 9:00 positions of the glenoid; 2) Distances from the suprascapular nerve to the glenoid rim at the suprascapular notch and spinoglenoid notch; 3) Narrowest distance between the suprascapular nerve and the glenoid rim, along with its corresponding clock scale. The scapular regions were divided into three distinct zones, as shown in Figure 1: Zone 1, situated above the level of suprascapular transverse ligament at the posterior aspect of the scapula; Zone 2, spanning from the level of suprascapular transverse ligament to the level of the spinoglenoid notch; and Zone 3, encompassing the level and extending beyond the spinoglenoid notch. Shoulder joint specimen measurements were performed using a digital caliper with a precision of 0.01 mm (Absolute super caliper series 500, Mitutoyo, Japan). Every measurement was carried out in triplicate, and the resulting data were subsequently averaged.

Statistical Analysis

Statistical analysis was performed using SPSS 26.0 software (IBM Corp., Armonk, NY, USA). Normally distributed continuous variables were presented as mean ± standard deviation, while non-normally distributed continuous variables were expressed as median (interquartile range). The difference between the two groups was compared by independent sample *t*-test. The difference among groups was compared by analysis of variance (ANOVA). $p < 0.05$ was considered statistically significant.

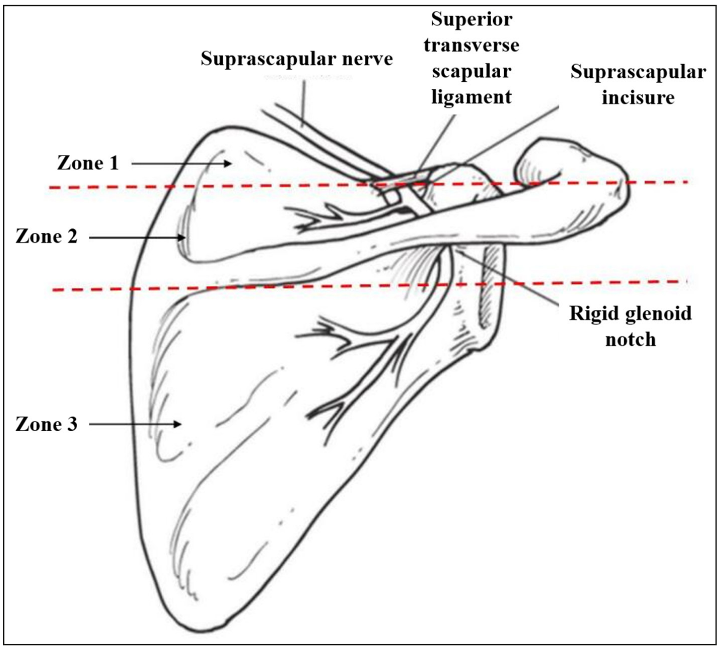

Figure 1. Scapular division.

Table I. Comparison of angles, distances, and height ratios of the suprascapular nerve at three different positions between different genders.

Positions		Internal Rotation at 45°		External Rotation at 45°	
		Male (n=15)	Female (n=8)	Male (n=15)	Female (n=8)
Suprascapular Foramen	Angle (°) between the suprascapular nerve and the line connecting the anterior and posterior edges of the scapular glenoid	52.26±5.24	50.83±2.76	51.75±3.26	54.13±3.52
	Distance (mm) from the suprascapular nerve to the line connecting the anterior and posterior edges of the scapular glenoid	24.33±2.32	24.62±0.75	25.83±0.82	25.24±1.26
Spinoglenoid Notch	Angle (°) between the suprascapular nerve and the line connecting the anterior and posterior edges of the scapular glenoid	32.65±4.94	29.38±4.58	33.24±5.13	31.23±3.76
	Distance (mm) from the suprascapular nerve to the line connecting the anterior and posterior edges of the scapular glenoid	15.16±1.53	14.64±0.95	15.86±1.25	14.23±0.42
	Height ratio (%) relative to the glenoid of the suprascapular notch	16.36±2.42	19.72±6.15	17.04±1.92	19.63±4.73
Muscle Entry Point	Angle (°) between the suprascapular nerve and the line connecting the anterior and posterior edges of the scapular glenoid	11.53±0.64	11.46±0.33	13.33±0.73	13.23±0.84
	Distance (mm) from the suprascapular nerve to the line connecting the anterior and posterior edges of the scapular glenoid	6.52±0.32	6.53±0.23	9.56±1.13	10.58±0.53
	Height ratio (%) relative to the glenoid of the entry point	32.46±3.27	32.52±3.26	36.45±2.52	34.56±3.32

Results

Comparison of Angles, Distances, And Height Ratios of the Suprascapular Nerve at Three Different Positions Between Different Genders

No significant differences were observed within the internal rotation at 45° and external rotation at 45° groups in terms of angles, distances, and height ratios of the suprascapular nerve at three different positions between different genders ($p > 0.05$), as depicted in Table I.

Comparison of Angles, Distances, And Height Ratios of the Suprascapular Nerve at Three Positions on the Left and Right Scapula

No significant differences were observed in the comparison of left and right scapular measurements within the groups of 45° internal rotations and 45° external rotation ($p > 0.05$), as shown in Table II.

Range of Angles, Distances, and Height Ratios for the Suprascapular Nerve in the Three Positions at 45° of Internal and External Rotation

In the external rotation position of 45°, the minimum angle was 12.25°, the minimum distance was 8.33 mm, and the maximum glenoid height ratio was 39.68%. In the internal rotation position of 45°, the minimum angle was 10.79°, the minimum distance was 6.43 mm, and the maximum glenoid height ratio was 37.95%, as shown in Table III.

Anatomy of the Suprascapular Nerve

23 shoulder joint specimens, comprising 15 male and 8 female shoulders, with 16 specimens from the left side and 7 from the right side, were then dissected.

The suprascapular nerve originates from the posterior triangle of the neck, arising from the brachial plexus. It extends downward to the upper part of the scapula, running parallel to the ventral side of the omohyoid muscle. It passes downward and posteriorly through the suprascapular notch (located below the suprascapular notch of the scapular transverse ligament) and then proceeds into the supraspinous fossa. Accompanied by the suprascapular artery and vein, it closely follows the bone surface and deep face of the supraspinatus muscle, extending outward and downward. Separated by fascia, it supplies branches to the supraspinatus muscle, with the main trunk passing through the scapular notch. All 23 shoulder joint specimens exhibited the presence of the transverse scapular ligament.

The suprascapular nerve traverses the spinoglenoid notch, proceeding downward and inward to the infraspinous fossa, where it emits 2-5 branches that innervate the infraspinatus muscles. No instances of compression of the suprascapular nerve were detected in any of the 23 shoulder joint specimens.

Data Measurements

The average distance from the glenoid edge to the suprascapular nerve was measured based on different glenoid positions, as shown in Table IV. The narrowest distance from the suprascapular nerve to the glenoid rim was 18.74±0.84 mm, located at the glenoid position of 9:00-9:30. The branching pattern of the suprascapular nerve was as follows: in Zone 1, there was an average of 1.12 branches of the SSN, 2.86 branches in Zone 2, and 3.64 branches in Zone 3. In the posterior scapular region, different branches were observed in each zone, with up to 1.5 branches of the suprascapular nerve found, as indicated in Table V.

A guidewire was inserted from the posterior to the anterior aspect of the right glenoid, passing through the posterior skin, fascia, muscles, the posterior aspect of the glenoid at the 4:00 position (7:00 position for the left glenoid), and the anterior aspect of the subscapularis muscle. The exit point was precisely the projection of the glenoid plane onto the lower third of the subscapularis muscle, designated as Point A (the point of division of the subscapularis muscle during the Latarjet procedure). In the neutral position of the shoulder joint, the horizontal distance between Point A and the axillary nerve was 27.37 (19.80, 34.55) mm, and the vertical distance was 16.67 (12.85, 20.35) mm.

Table II. Comparison of angles, distances, and height ratios of the suprascapular nerve at three positions on the left and right scapula.

Positions		Internal Rotation at 45°		External Rotation at 45°	
		Left	Right	Left	Right
Suprascapular Foramen	Angle (°) between the suprascapular nerve and the line connecting the anterior and posterior edges of the scapular glenoid	50.23±4.31	53.44±4.57	51.16±3.14	54.35±2.76
	Distance (mm) from the suprascapular nerve to the line connecting the anterior and posterior edges of the scapular glenoid	23.46±1.74	25.43±1.46	25.87±0.96	25.71±1.21
Spinoglenoid notch	Angle (°) between the suprascapular nerve and the line connecting the anterior and posterior edges of the scapular glenoid	31.32±5.21	31.84±5.23	31.75±5.23	33.02±4.33
	Distance (mm) from the suprascapular nerve to the line connecting the anterior and posterior edges of the scapular glenoid	15.43±1.63	14.63±0.75	16.23±1.34	14.63±0.66
	Height ratio (%) relative to the glenoid of the suprascapular notch	16.53±2.64	18.46±5.27	17.53±2.16	18.37±4.25
Muscle Entry Point	Angle (°) between the suprascapular nerve and the line connecting the anterior and posterior edges of the scapular glenoid	11.63±0.65	11.33±0.46	13.12±0.65	13.44±0.86
	Distance (mm) from the suprascapular nerve to the line connecting the anterior and posterior edges of the scapular glenoid	6.92±0.27	6.64±0.23	9.67±1.26	10.43±0.47
	Height ratio (%) relative to the glenoid of the entry point	34.76±2.84	31.82±3.26	36.42±2.86	35.15±3.26

Table III. Range of angles, distances, and height ratios for the suprascapular nerve in the three positions at 45° of internal and external rotation.

Positions		Internal Rotation at 45°	External Rotation at 45°
Suprascapular Foramen	Angle (°) between the suprascapular nerve and the line connecting the anterior and posterior edges of the scapular glenoid	46.35-58.73	47.98-57.64
	Distance (mm) from the suprascapular nerve to the line connecting the anterior and posterior edges of the scapular glenoid	20.55-27.48	23.47-26.74
Spinoglenoid Notch	Angle (°) between the suprascapular nerve and the line connecting the anterior and posterior edges of the scapular glenoid	26.35-37.64	26.80-37.35
	Distance (mm) from the suprascapular nerve to the line connecting the anterior and posterior edges of the scapular glenoid	13.65-17.75	14.66-26.81
	Height ratio (%) relative to the glenoid of the suprascapular notch	13.56-28.80	14.66-26.81
Muscle Entry Point	Angle (°) between the suprascapular nerve and the line connecting the anterior and posterior edges of the scapular glenoid	10.79-12.40	12.25-14.33
	Distance (mm) from the suprascapular nerve to the line connecting the anterior and posterior edges of the scapular glenoid	6.43-7.21	8.33-11.21

Table IV. Distance (mm) from glenoid edge to suprascapular nerve.

	12:00	11:00	10:00	9:00	Suprascapular notch	Spinoglenoid notch	Narrowest distance
Mean	35.18	28.23	22.32	22.12	34.84	21.16	18.74
Standard Error	2.31	3.47	2.78	2.07	6.26	6.48	0.84

Discussion

The shoulder joint, composed of the glenoid, humeral head, joint capsule, and ligaments of the scapula, exhibits the highest range of motion among human joints. Due to the anatomical features of a large humeral head and a small glenoid cavity, the shoulder joint is highly susceptible to dislocation. Literature has reported an incidence rate of up to 2% for anterior shoulder dislocation in the population. Most patients opt for conservative treatment after their first dislocation, often overlooking the issues related to bone and soft tissue, which may lead to recurrent shoulder instability,. The Latarjet procedure holds significant importance in addressing anterior shoulder instability. The proper positioning of the coracoid graft and screw placement are critical steps in the Latarjet procedure. However, the insertion of screws during graft placement or during the surgical exploration of dislocations can result in suprascapular nerve injury, leading to shoulder pain and weakness. Instances of suprascapular nerve injury following Latarjet surgery have been reported: patients who underwent arthroscopic Latarjet surgery for recurrent shoulder dislocation experienced pronounced pain and restricted motion. These symptoms were significantly alleviated after screw removal. Simple cadaver studies and basic shoulder joint CT scans may fail to comprehensively reveal the relationship between the scapula and the suprascapular nerve during screw insertion. Therefore, it is imperative to explore the correlation between the scapula

Table V. Number of branches of the suprascapular nerve.

	Zone 1	Zone 2	Zone 3
Mean	1.12	2.86	3.64
Standard Error	0.27	0.54	0.62

and the suprascapular nerve, replicate coracoid grafting and screw fixation, and take preventive measures against complications arising from nerve damage.

In this study, the distance between the suprascapular nerve and the glenoid rim was measured based on the clock face of the glenoid. The distance between the suprascapular nerve and the glenoid rim at the 9:00 position was found to be 22.12±2.07 mm, and 22.32±2.78 mm at the 10:00 position. The narrowest distance from the suprascapular nerve to the glenoid rim was 18.74±0.84 mm, situated at the 9:00-9:30 position on the glenoid clock face. This implies that the greatest risk of injuring the suprascapular nerve is associated with procedures performed within the 9:00-9:30 position on the glenoid, with a particular emphasis on Zone 2 of the posterior scapular region. Zone 3 encompasses the most substantial cluster of suprascapular nerve branches, underscoring its significance in preoperative planning. Previous research on other types of glenohumeral procedures concluded that drilling forward and backward in the sagittal plane or at angles below 28° in the axial plane is least likely to cause suprascapular nerve injury. However, in Latarjet surgery, bone graft positioning may alter the safe zone in the axial plane, and the screws in coracoid grafts typically point upward. Therefore, previous recommendations about the safe zone for the suprascapular nerve are inapplicable to Latarjet surgery.

During arthroscopic procedures, the position of the glenoid rim remains fixed and unaffected by shoulder movements, rendering it a reliable intraoperative landmark. The anterior clock face of the glenoid rim has been identified as a dependable intra-articular reference point in arthroscopic surgeries. In the present study, measurements were conducted at 9:00, 10:00, 11:00, and 12:00 positions to establish a new safety zone for the distance between the glenoid rim and the suprascapular nerve. According to the results, the narrowest distance between the nerve and the glenoid rim was found to be 18.74 mm, positioned at the 9:00-9:30 region. This highlights the need for cautious dissection during arthroscopic procedures. Furthermore, this study revealed that, on average, there were 1.12 branches of the SSN in Zone 1, 2.86 branches in Zone 2, and 3.64 branches in Zone 3. These findings offer enhanced anatomical support for the physiological functions of the supraspinatus and infraspinatus muscles, potentially leading to more effective rehabilitation strategies for shoulder cuff repairs.

In relation to the axillary nerve, employing probes and the Neviaser portal (PN) provides only approximate measurements of the space between the glenoid rim or labrum and the axillary nerve, due to the non-perpendicular nature of the pathway connecting the nerve to the glenoid. Furthermore, the clarity of the thawed glenoid border is often compromised, posing difficulties in achieving accurate measurements, particularly when performing intraoperative shoulder internal or external rotation maneuvers[29,30]. The position of the axillary nerve may also shift, so this study adopted the neutral position of the shoulder joint. The distance between the glenoid and the axillary nerve was indirectly measured by projecting the glenoid plane onto the subscapularis muscle. During arthroscopic Latarjet procedures, the coracoid necessitates traversing the bifurcated subscapularis muscle and positioning horizontally from anterior to posterior in the inferior-anterior region of the glenoid. The length of the coracoid graft is typically around 15-20 mm, while the width of the split subscapularis muscle is about 20 mm. Although both the findings of this study and literature reports[31,32] indicate the presence of a certain safe distance between the medial border and the axillary nerve, specifically a vertical distance greater than 10 mm from the A point to the axillary nerve, this distance may not suffice to ensure safety within the context of a 20-mm splitting range. Positioning the split in a more medial direction could elevate the potential for axillary nerve impairment. Consequently, it becomes evident that Latarjet procedures entail a multitude of critical considerations to mitigate the risk of nerve injury.

Arthroscopic surgery can lead to transient and permanent nerve injury, manifested as sensory disturbance until paralysis. Strict compliance with intraoperative and all perioperative regulations, especially the operation procedures related to patient positioning, can greatly reduce the risk of nerve injury. The recommended waiting time before surgical nerve repair is 6 months. At the same time, patients should continue to receive physical therapy. The improvement of the disease was evaluated by clinical examination and electromyography at 15-20 days after the lesion, at 3 months and at 6 months after the lesion.

The results of this study demonstrate significant differences in angle, distance, and height ratio comparisons between the spinoglenoid notch and the entry point of the suprascapular nerve. These findings underscore that the external rotation (45°) position offers a larger safety margin compared to the internal rotation (45°) position. This difference could potentially be attributed to the contraction of the infraspinatus muscles during external rotation, resulting in a slight inward displacement and, hence, a safer zone for the nerve. Notably, the lack of significant variation in the height ratio at the spinoglenoid notch could be attributed to the CT measurements being aligned with the bony reference point of the spinoglenoid notch. Intriguingly, intra-group comparisons reveal that the entry point presents a smaller angle and shorter distance relative to the spinoglenoid notch, along with a higher height ratio relative to the glenoid, indicating a heightened vulnerability to nerve damage during surgical procedures. Therefore, when performing internal fixation during Latarjet procedures, it is recommended to operate in the external rotation (45°) position, ensuring that the bone tunnel-to-articular surface angle is less than 12.25° and the distance is lower than 8.33 mm on the inner side of the glenoid, with an upper limit of 39.68% of the glenoid height. In the internal rotation (45°) position, the bone tunnel-to-articular surface angle should be lower than 10.79°, the distance lower than 6.43 mm on the inner side of the glenoid, and the exit point should avoid exceeding 37.95% of the glenoid height.

The innovation of this study lies in several aspects. Firstly, the study introduces the visualization of the suprascapular nerve on CT scans and reconstructs the three-dimensional positional relationship between the suprascapular nerve and the glenoid cavity. Secondly, the study employs a clinical, surgical approach to the Latarjet procedure, where arthroscopic fixation involves drilling bone tunnels from the anterior to the posterior aspect of the glenoid. The difficulty in predicting the exit point of these tunnels on the posterior aspect of the glenoid has been addressed by referencing the depth and angle of the bone tunnels to the glenoid joint surface. Additionally, the study combines anatomical findings with clinical cases to emphasize the need for the surgeon to place screws further away to avoid iatrogenic injuries.

Limitations and Strengths

However, it is important to acknowledge certain limitations within the study. Firstly, the limited number of shoulder specimens and variations in muscle tension within cadaveric specimens might affect inter-observer variability during measurements. Secondly, the effects of formalin preservation on cadaveric specimens could impact the anatomical positioning of the suprascapular nerve. Despite these limitations, the current research establishes a reliable safe zone for the suprascapular nerve during arthroscopic procedures, outlines the risks of suprascapular nerve damage during the drilling process of the Latarjet procedure, and provides valuable anatomical insights into the branches of the suprascapular nerve. These findings serve as crucial clinical details that surgeons should be well-versed in.

Conclusions

This study, integrating CT anatomical analysis of the suprascapular nerve and the clinical surgical process of the Latarjet procedure, enhances the understanding among surgeons regarding the relationship between the suprascapular nerve and the glenoid. By analyzing the surgical safety zone in key posterior glenoid positions, the study aims to reduce the risk of nerve injuries. The safe zone for the suprascapular nerve can be determined using the frontal glenoid clock face, which serves as a reliable intra-articular landmark during arthroscopic procedures. The narrowest distance between the glenoid rim and the suprascapular nerve was observed between 9:00 and 9:30, thus urging caution during any procedures related to this region.

Conflict of Interest

The authors declare that they have no conflict of interests.

Acknowledgments

We thank the members of Honghui Hospital, Xi'an Jiaotong University Medical University for helpful discussions.

Authors' Contributions

Shaoyan Shi conceived the structure of the manuscript. Xiaolong Du did the experiments and made the figure. Xue-hai Ou reviewed and edited the manuscript. All authors read and approved the final manuscript.

Funding

None.

Availability of Data and Materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics Approval

This study was conducted in accordance with the ethical regulations of the Declaration of Helsinki. The experiments were admitted to the Ethics Committee of the Honghui Hospital, Xi'an Jiaotong University. Number of the Ethics Committee approval: 20210907.

Informed Consent

All patients signed the informed consent form.

ORCID ID

Shaoyan Shi: 0000-0002-1918-0975
Xiaolong Du: 0000-0003-1269-1972
Xuehai Ou: 0000-0002-1781-3169

References

1) Koh KH. Editorial Commentary: The Trillat Procedure May Be (Rarely) Indicated Instead of Shoulder Latarjet for Recurrent Instability, Irreparable Cuff Tear, No Pain, Preserved Active Motion, and No Critical Glenoid Bone Loss. Arthroscopy 2023, 39: 946-947.
2) Hurley ET, Ben AE, Lorentz NA, Mojica ES, Colasanti CA, Matache BA, Jazrawi LM, Virk M, Meislin RJ. Both Open and Arthroscopic Latarjet Result in Excellent Outcomes and Low Recurrence Rates for Anterior Shoulder Instability. Arthrosc Sports Med Rehabil 2021, 3: e1955-e1960.
3) Jegatheesan V, Patel D, Lu V, Domos P. Outcomes of Primary Latarjet versus Revision Latarjet after Prior Surgery for Anterior Shoulder Instability - A Systematic Review and Meta-Analysis. J Shoulder Elbow Surg 2023; 32: 2599-2612.
4) Boe B, Stoen RO, Blich I, Moatshe G, Ludvigsen TC: Learning Curve for Arthroscopic Shoulder Latarjet Procedure Shows Shorter Operating Time and Fewer Complications with Experience. Arthroscopy 2022; 38: 2391-2398.
5) Castricini R, Longo UG, Petrillo S, Candela V, De Benedetto M, Maffulli N, Denaro V. Arthroscopic Latarjet for Recurrent Shoulder Instability. Medicina (Kaunas) 2019; 55: 9.
6) Tanaka M, Hanai H, Kotani Y, Kuratani K, Nakai H, Kinoshita S, Hirose T, Hayashida K. Open Bristow Versus Open Latarjet for Anterior Shoulder Instability in Rugby Players: Radiological and Clinical Outcomes. Orthop J Sports Med 2022; 10: 951700150.
7) Ribeiro LM, Lara P, Pochini AC, Andreoli CV, Belangero PS, Ejnisman B. Isokinetic Evaluation of the Shoulder After Bristow/Latarjet Surgical Procedure in Athletes. Rev Bras Ortop (Sao Paulo) 2022; 57: 128-135.
8) Getz CL, Joyce CD. Arthroscopic Latarjet for Shoulder Instability. Orthop Clin North Am 2020; 51: 373-381.
9) Fox A, Bonacci J, Gill SD, Page RS. Evaluating the effects of arthroscopic Bankart repair and open Latarjet shoulder stabilisation procedures on shoulder joint neuromechanics and function: a single-centre, parallel-arm trial protocol. BMJ Open Sport Exerc Med 2021; 7: e956.
10) Fedorka CJ, Mulcahey MK. Recurrent anterior shoulder instability: a review of the Latarjet procedure and its postoperative rehabilitation. Phys Sportsmed 2015; 43: 73-79.
11) Hurley ET, Lim FD, Farrington SK, Mullett H. Open Versus Arthroscopic Latarjet Procedure for Anterior Shoulder Instability: A Systematic Review and Meta-analysis. Am J Sports Med 2019, 47: 1248-1253.
12) Shubert SB. Editorial Commentary: Surgical Treatment of Shoulder Instability With Subcritical Glenoid Bone Loss Requires Innovation: Bankart May Risk Significant Recurrence and Latarjet May Risk Significant Complications. Arthroscopy 2021; 37: 2075-2076.
13) Elganainy AE, El-Nour MA. Latarjet reconstruction in patients with anterior shoulder instability and significant Hill-Sachs lesion. Acta Orthop Belg 2017; 83: 421-427.
14) Jackson GR, Brusalis CM, Schundler SF, Sachdev D, Obioha OA, McCormick JR, Mameri ES, Kaplan DJ, Knapik DM, Chahla J. Isolated Primary Latarjet Procedures for Anterior Shoulder Instability Results in High Rates of Graft Resorption and Glenohumeral Degenerative Changes With Low Rates of Failure at a Minimum 2-Year Follow-Up: A Systematic Review. Arthroscopy 2023; S0749-8063(23)00427-9.
15) Lubowitz JH, Brand JC, Rossi MJ. Comprehensive Review of Shoulder Instability Includes Diagnosis, Nonoperative Management, Bankart, Latarjet, Remplissage, Glenoid Bone-Grafting, Revision Surgery, Rehabilitation and Return to Play, and Clinical Follow-Up. Arthroscopy 2022, 38: 209-210.
16) Deng Z, Zheng Y, Su J, Chen S, Deng Z, Zhu W, Li Y, Lu W. Open Versus Arthroscopic Latarjet for Recurrent Anterior Shoulder Instability: A Systematic Review and Meta-analysis. Orthop J Sports Med 2023; 11: 961779532.
17) Bliven K, Parr GP. Outcomes of the Latarjet Procedure Compared With Bankart Repair for Recurrent Traumatic Anterior Shoulder Instability. J Athl Train 2018; 53: 181-183.
18) Imam MA, Shehata M, Martin A, Attia H, Sinokrot M, Bahbah EI, Gwilym S, Jacob J, Narvani AA, Meyer DC. Bankart Repair Versus Latarjet Pro-

cedure for Recurrent Anterior Shoulder Instability: A Systematic Review and Meta-analysis of 3275 Shoulders. Am J Sports Med 2021; 49: 1945-1953.

19) Guevara BG. Editorial Commentary: The Latarjet: Increased Shoulder Stability, and Increased Risk of Complications in Low Volume Practitioners. Arthroscopy 2021; 37: 814-815.

20) Ari B, Altunkiliç T. A comparison of two surgical methods in the treatment of shoulder adhesive capsulitis. Eur Rev Med Pharmacol Sci 2023; 27: 467-475.

21) Hurley ET, Matache BA, Wong I, Itoi E, Strauss EJ, Delaney RA, Neyton L, Athwal GS, Pauzenberger L, Mullett H. Anterior Shoulder Instability Part II-Latarjet, Remplissage, and Glenoid Bone-Grafting-An International Consensus Statement. Arthroscopy 2022; 38: 224-233.

22) Rossi LA, Tanoira I, Gorodischer T, Pasqualini I, Muscolo DL, Ranalletta M. Are the Classic and the Congruent Arc Latarjet Procedures Equally Effective for the Treatment of Recurrent Shoulder Instability in Athletes? Am J Sports Med 2020; 48: 2081-2089.

23) Griesser MJ, Harris JD, McCoy BW, Hussain WM, Jones MH, Bishop JY, Miniaci A. Complications and re-operations after Bristow-Latarjet shoulder stabilization: a systematic review. J Shoulder Elbow Surg 2013; 22: 286-292.

24) Lafosse L, Piper K, Lanz U. Arthroscopic suprascapular nerve release: indications and technique. J Shoulder Elbow Surg 2011; 20: S9-S13.

25) Castricini R, Castioni D, De Benedetto M, Cimino M, Massarini A, Galasso O, Gasparini G. Arthroscopic Latarjet for Primary Shoulder Instability With Off-Track Lesions or Revision Surgery Yields Satisfactory Clinical Results and Reliable Return to Sport and Work at Minimum 3-Year Follow-Up. Arthroscopy 2022; 38: 2809-2818.

26) Bodine M, Bishai SK, Ball G, King CN, Wait L, Brannan GD. Arthroscopic Latarjet procedure does not lead to loss of clinically significant external rotation at 0 degrees and 90 degrees of shoulder abduction. JSES Int 2022; 6: 1023-1028.

27) Vecchini E, Ricci M, Chiappi J, Ambrosini C, Fasoli G, Crespan B, Maluta T, Magnan B. Anterior shoulder instability: comparison between Latarjet open procedure and arthroscopic capsuloplasty. Acta Biomed 2023; 94: e2023022.

28) An VV, Sivakumar BS, Phan K, Trantalis J. A systematic review and meta-analysis of clinical and patient-reported outcomes following two procedures for recurrent traumatic anterior instability of the shoulder: Latarjet procedure vs. Bankart repair. J Shoulder Elbow Surg 2016, 25: 853-863.

29) Ladermann A. Editorial Commentary: Arthroscopic Latarjet Shoulder Stabilization: Where Are We? Where Are We Going? Arthroscopy 2017; 33: 2136-2138.

30) Yapp LZ, Nicholson JA, McCallum C, Macdonald DJ, Robinson CM. Latarjet as a primary and revision procedure for anterior shoulder instability - A comparative study of survivorship, complications and functional outcomes in the medium to long-term. Shoulder Elbow 2020; 12: 338-348.

31) Arner JW, Tanghe K, Shields T, Abdelaziz A, Lee S, Peebles L, Provencher MT. Shoulder Latarjet Surgery Shows Wide Variation in Reported Indications, Techniques, Perioperative Treatment, and Definition of Outcomes, Complications, and Failure: A Systematic Review. Arthroscopy 2022; 38: 522-538.

32) Amadei F, Basile G, Leigheb M. Nerve lesions during arthroscopic procedure: a literature overview. Orthop Rev (Pavia) 2021; 13: 24441.