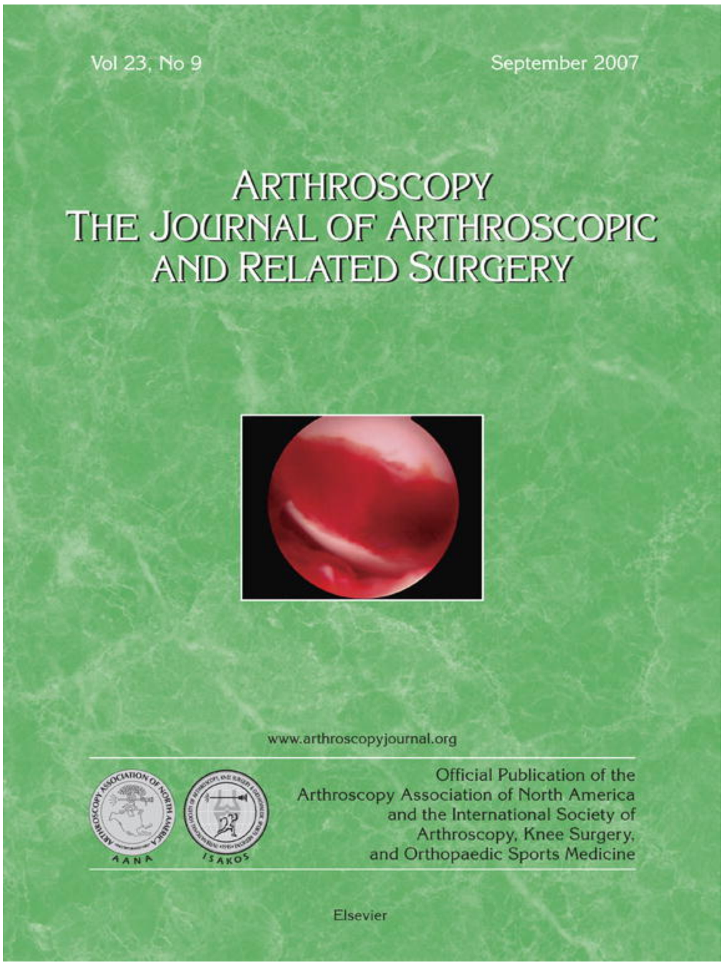
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Posterior Shoulder Pain: A Dynamic Study of the Spinoglenoid Ligament and Treatment With Arthroscopic Release of the Scapular Tunnel

Kevin D. Plancher, M.D., M.S., Timothy A. Luke, M.D.,
Robert K. Peterson, M.D., and Stephen V. Yacoubian, M.D.

Purpose: The purpose of this study was to determine the pressure exerted on the suprascapular nerve by compression of the spinoglenoid ligament during glenohumeral range of motion. In addition, a 2-portal technique was described to arthroscopically visualize and safely release the spinoglenoid ligament while visualizing the suprascapular nerve, artery, and vein. **Methods:** Ten cadaveric shoulders were used for visual observation of variation in the position and tension of the spinoglenoid ligament. In 15 additional shoulders, a transducer was used to sense the pressure changes and was recorded in voltage. Pressure changes created by the spinoglenoid ligament on the distal suprascapular nerve in the scapular tunnel during glenohumeral motion were recorded. **Results:** Internal rotation, rather than external rotation, in any position of the shoulder created a visual increase of tension in the spinoglenoid ligament. Increased pressure readings were noted with internal rotation and with 90° of abduction, full abduction, and full adduction of the shoulder. The suprascapular nerve occupying the space created by the spinoglenoid ligament experiences an increased pressure during glenohumeral range of motion and positions that mimic overhead throwing. The dynamic nature of the ligament with its insertion on the posterior capsule required a new minimally invasive technique for its release that can be safe and straightforward. **Conclusions:** The spinoglenoid ligament was affected by the position of the glenohumeral joint. These changes in pressure in combination with repetitive shoulder movement are likely components that cause repeated trauma or compression on the distal suprascapular nerve created by a scapular tunnel syndrome. The surgical technique provides a treatment option when conservative treatment fails in the patient with posterior shoulder pain. **Clinical Relevance:** The spinoglenoid ligament was affected by the position of the shoulder, with the most pressure noted with the arm in full adduction and internal rotation. This pressure can be treated with arthroscopic release. **Key Words:** Spinoglenoid ligament—Suprascapular nerve compression—Glenohumeral range of motion—Arthroscopic surgical release.

Entrapment of the suprascapular nerve by the spinoglenoid ligament is not known as a common clinical finding, but reports in the literature have continued to increase.[1-4] Recent studies have shown that the spinoglenoid ligament is an identifiable structure in every cadaver investigated.[5] This ligament origi-

From Plancher Orthopaedics & Sports Medicine (K.D.P.), New York, New York; Orthopaedic Foundation for Active Lifestyles (K.D.P., T.A.L.), Cos Cob, Connecticut; Albert Einstein College of Medicine (K.D.P.), New York, New York; Davis Orthopedics & Sports Medicine (R.K.P.), Davis, California; and Providence St. Joseph Medical Center (S.V.Y.), Burbank, California, U.S.A.
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Address correspondence and reprint requests to Kevin D. Plancher, M.D., Plancher Orthopaedics & Sports Medicine, 1160 Park Ave, New York, NY 10128, U.S.A. E-mail: kplancher@plancherortho.com

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nates on the spine of the scapula and inserts on the superior margin of the glenoid neck as a bilaminar structure. The reported incidence of infraspinatus atrophy, with or without posterior shoulder pain, especially among athletes, suggests entrapment[1,2,6-15] or a "sling effect" neuropathy.[16-20] The "sling effect" is reported to be a traction injury to the suprascapular nerve at the transverse scapular ligament during spinatus contractions. The "sling effect" explains atrophy of both the supraspinatus and infraspinatus muscle atrophy but does not explain isolated infraspinatus atrophy.

Isolated infraspinatus atrophy has been associated with many upper-extremity activities. In a recent study of baseball players, starting pitchers had an increased rate of infraspinatus muscle atrophy and posterior shoulder pain after throwing.[21] Glousman et al.[22] and Jobe et al.[11,23] have reported extensively on the glenohumeral joint and the relationship of the rotator cuff musculature during the throwing position. Posterior shoulder pain that does not have any identifiable rotator cuff pathology, posterior SLAP, or internal impingement and does not respond to conservative treatment can be a dilemma for the patient and treating physician because open surgery has not allowed athletes return to their sport.

The purpose of this study was to determine if increased pressure was exerted on the suprascapular nerve by compression of the spinoglenoid ligament during glenohumeral range of motion (ROM). In addition, a 2-portal arthroscopic technique was described to safely visualize and release the spinoglenoid ligament while visualizing the suprascapular nerve, artery, and vein.

METHODS

Dynamic Study

Twenty-five shoulders in 13 fresh frozen cadavers were dissected. All cadavers were kept frozen until the study was performed. This was an institutional review board–exempt study. There were 9 male and 4 female cadavers with an average age of 60 years and a range of 28 to 96 years. No statistically significant difference in age was found between male and female specimens ($P < .05$). For the dynamic study, 10 shoulders were used for visual observation, and 15 shoulders were used to document pressure changes. Cadavers were excluded from the study if they had full-thickness rotator cuff tears or posterior SLAP lesions.

Specimen Preparation

The fresh frozen shoulder specimens were thawed overnight to room temperature before dissections. The scapula of each specimen was mounted on a specially designed stand that allows dissection and unrestricted glenohumeral ROM. The trapezius and deltoid muscles were reflected from the scapular spine and acromion process to expose the supraspinatus and infraspinatus muscles. The supraspinatus and infraspinatus muscles were carefully elevated from their respective fossae, and the structures of the spinoglenoid notch were evaluated and dissected. The identification of the suprascapular nerve was performed, and it remained in its anatomic position as the spinoglenoid ligament was exposed for complete examination.

Dynamic Anatomy: Visual Observation

After dissection, 10 shoulders were immobilized on a specimen stand in an upright anatomic position and then taken through clinically reproducible positions of abduction, adduction, internal rotation, and external rotation. A goniometer as well as horizontal and vertical landmarks were used to ensure reproducibility. A perpendicular line was drawn on the wall and on the floor as landmarks. The glenohumeral joint was then taken through a throwing motion. This was recorded by using a video camera focused on the spinoglenoid ligament to determine variation in the position and tension of the spinoglenoid ligament.

Dynamic Anatomy: Pressure Changes

In 15 shoulders, after dissection performed as described previously, the bulk of the posterior aspect of the supraspinatus and the superior aspect of the infraspinatus muscles were removed while preserving the supraspinatus and infraspinatus tendon insertion into the humerus and shoulder capsule. The removal of a portion of the muscle belly allowed more consistent placement of the custom-designed (MicroStrain, Burlington, VT) contact pressure sensor (Fig 1) and ensured that only pressure from the spinoglenoid ligament was being measured. This contact sensor was based on a commercial absolute pressure sensor (IC Sensors model 1210l; EG&G IC Sensors, Milpitas, CA). The tube was filled with mineral oil that allows direct contact forces to measure the pressure changes. The transducer senses the pressure changes and is recorded in voltage (amps). The voltage change is used to assess increased or decreased pressure changes in the spinoglenoid foramen.

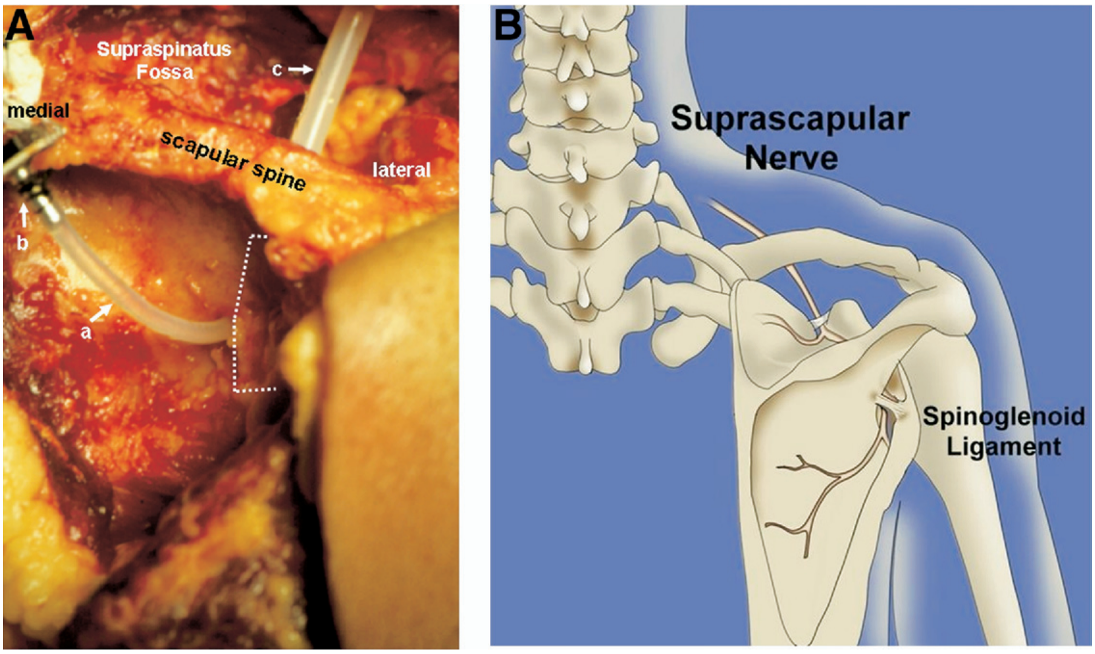

FIGURE 1. (A) Posterior view of a right shoulder with the pressure sensor in position under the intact spinoglenoid ligament. The dotted line outlines the spinoglenoid ligament. Fat is seen overlying the spinoglenoid ligament. Running under the spinoglenoid ligament is the pressure tubing (a) filled with mineral oil and at the opposite end is the metal tranducer (b) sewn in with black suture, alleviating any movement of the transducer during glenohumeral motion. An empty larger tube (c) was placed over the top of the mineral oil tube (a) to stabilitize it to avoid migration during initiation of ROM. (B) The location of the spinoglenoid ligament in relationship to the scapular spine.

The shoulder was then systematically taken through reproducible glenohumeral positions. Each test was performed by documenting the pressure sensor voltage at the start position and then measured at the end position. The start position voltage was subtracted from the end position voltage resulting in the voltage change.

Six glenohumeral positions were tested starting from neutral and moving the glenohumeral joint into the end position. For this study, the neutral position was glenohumeral at 0°, elbow flexion at 90°, and neutral forearm position. When neutral was indicated in charts and graphs, this was the position used for the measurements. Rotation externally (ER) and rotation internally (IR) of 90° was performed each time ER and IR were indicated.

All cadavers were placed in the neutral position, and then ER and IR voltage changes were measured. The second group of measurements involved the start position at neutral and the end position at 90° abduction. The cadaver remained in that position as the start position and was tested for the end positions of ER and then IR. The third group of measurements involved the start position at neutral and the end position at full abduction. The cadaver remained in that position as the start position and was tested for the end positions of ER and then IR. The fourth group of measurements involved the start position at neutral and the end position at 90° flexion. The cadaver remained in that position as the start position and was tested for the end positions of ER and then IR. The fifth group of measurements involved the start position at neutral and the end position at full adduction. The cadaver remained in that position as the start position and was tested for the end positions of ER and then IR. The sixth group of measurements involved the start position at neutral and the end position extension at 90°. The cadaver remained in that position as the start position and was tested for the end positions of ER and then IR.

Each position was measured 3 times by 1 author, and the voltage change under the spinoglenoid ligament was recorded each time. These reproducible positions correlated to maneuvers used in clinical testing as well as the glenohumeral joint during the throwing motion and other sporting events.

In 6 cadavers, the spinoglenoid ligament was then excised and retested in all the same positions described previously. Three measurements were recorded for each specimen with the spinoglenoid ligament released and used as the control.

Statistical Methods

Statistical analysis of the results was performed determining the mean values for all anatomic measurements. Differences between genders were determined by using the independent samples *t* test. For multiple (>2) categorical variables, such as the position of the arm, comparisons were performed by using 1-way analysis of variance with Bonferroni correction to adjust for multiple comparisons. Values of $P < .05$ were considered statistically significant.

Surgical Technique

The surgical technique was performed on 10 shoulders. Positioning the patient in a lateral decubitus position gave good exposure and access to the shoulder. This position allowed the surgeon to easily perform an arthroscopic procedure using the anterior, lateral, and posterior portals. This position also allows access to the posterior shoulder without having to reposition the patient. The beach-chair position can be used, but the hemithorax must be draped up to the spine to give adequate exposure.

Placement of the portals was based on the anatomic dissections of fresh frozen cadaveric shoulders.[5] The spinoglenoid ligament was found consistently when measurements were based off the posterolateral edge of the acromion. Starting at the most posterior lateral aspect of the acromion, 4 cm were measured medially, along the scapular spine. This provided the correct anatomic placement for the lateral portal to allow direct access to the spinoglenoid ligament and the neurovascular structures. The placement of the medial portal was measured another 4 cm medially along the scapular spine (Fig 2). The medial portal was created specifically for a 30° (or 0°), 5.0- or 5.8-mm arthroscope, and the lateral portal was used for a probe or a cutting or motorized instrument. After marking these 2 portals, a sharp incision was made through the skin 1 to 2 cm inferior to the scapular spine. The fascial layer and scapular spine were identified. Placement of a blunt trochar in the medial and a separate blunt trochar in the lateral portal was performed and triangulated to create working space. When placing the blunt trochar, care was taken to stay up against the scapula to create the bone-muscle plane. The arthroscope was placed in the medial portal, and the lateral portal was used for the probe.

This initial dissection was usually performed dry, but, when a washout was required for visibility, the best option was to use gravity in flow or decrease the pressure setting to the lowest that the equipment would allow (40 mm Hg). Once the scope was inserted, the vascular supply from the infraspinatus to the scapula was visualized. The vein was electrocauterized through the newly described posterolateral lateral portal, 4 cm from the edge of the posterior acromion, because it was frequently encountered when dissecting the spinoglenoid ligament.

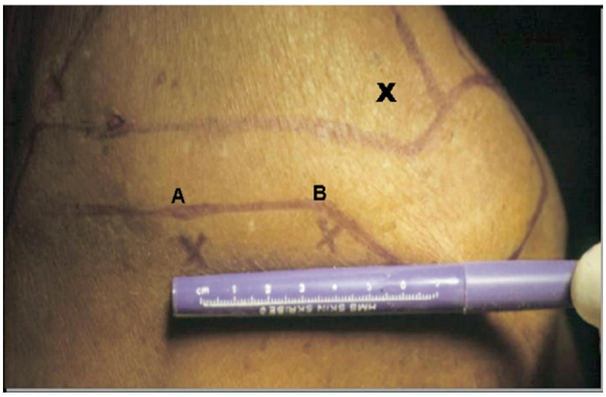

Figure 2. A right shoulder prepared for an arthroscopic spinoglenoid ligament release. The upper portal mark (X) is the location of Neviaser's portal. Portal A, the medial portal is 4 cm from lateral portal. This is the viewing portal in which the scope is placed under the scapula and behind the infraspinatus. Portal B, the posterolateral portal is 4 cm medial to the posterior lateral edge of the acromion. This is the instrument portal that allows for manipulation of the spinoglenoid ligament.

The spinoglenoid notch was anatomically 1 to 2 cm inferior to the lateral portal. The suprascapular nerve, artery, and vein were visualized running together around the scapular spine and then diving into the infraspinatus muscle. The nerve, as well as the vein and artery, traverse beneath the ligament. By using the probe, we identified these structures carefully, and then we placed a hook around the spinoglenoid notch. We used gentle retraction superiorly to verify the identification of the spinoglenoid notch (good bone contact). We then rotated the probe superiorly and laterally to engage the spinoglenoid ligament. Once we defined the suprascapular nerve, artery, vein, and spinoglenoid ligament, we replaced the probe with a cutting device. By using the cutting tool through the lateral portal and under direct visualization, the spinoglenoid ligament was released. Once this was completed, the probe was used to verify that the suprascapular nerve, artery, and vein had adequate space. If we encountered difficulties creating the space with only 2 portals, we used a third portal between the

TABLE 1. *Pressure Changes Between Left and Right Shoulders*

Position	Right Ligament	Left Ligament	NO Ligament
Neutral to ER	0.008	0.004	0.000
Neutral to IR	0.021	0.005	0.001
Neutral to 90° abduction	0.023	0.012	0.001
90° abduction to ER	0.024	0.016	0.000
90° abduction to IR	0.039	0.026	0.001
Neutral to full abduction	0.030	0.031	0.001
Full abduction to ER	0.017	0.019	0.001
Full abduction to IR	0.035	0.031	0.000
Neutral to 90° flexion	0.020	0.015	0.000
90° flexion to ER	0.011	0.006	0.000
90° flexion to IR	0.022	0.008	0.001
Neutral to full adduction	0.046	0.041	0.001
Full adduction to ER	0.008	0.006	0.001
Full adduction to IR	0.056	0.041	0.000
Neutral to extension	0.016	0.026	0.001
Extension to ER	0.016	0.012	0.001
Extension to IR	0.036	0.023	0.001

NOTE. Positive change in voltage is equal to an increase in pressure.

medial and lateral portals to place a retraction tool. An extra probe or the blunt switching stick worked well in this portal. This middle portal provided extended retraction of the infraspinatus, which allowed easier movement of the scope and cutting tool.

RESULTS

Dynamic Anatomy: Visual Observation

Cadaveric observation and a review of videotape recordings of the dynamic anatomy of the spinoglenoid ligament indicated maximal tension in the ligament was seen with maximal adduction and internal rotation (follow through of the pitching motion). The ligament moved considerably, in every tested specimen, from a vertical to a horizontal position from the start to finish of a throwing motion. Internal rotation in any position of the shoulder created a visual increased tension in the ligament rather than external rotation. With tightening of the ligament, the inferior border of the spinoglenoid ligament narrowed the space for the suprascapular nerve to occupy. The measurements of the spinoglenoid ligament had been previously described.[5] These visual findings were reproduced when the specimens were taken through the throwing motion of an overhead baseball pitch. No distinct motion of the suprascapular nerve in our dissections was appreciated during glenohumeral ROM.

Dynamic Anatomy: Pressure Changes

In the specimens in which the ligament was released, no change of pressures during simulated pitching motions was recorded for the right (P = .28) or left (P = .45) shoulders. No significant difference was found when comparing right and left pressure changes with respect to the different glenohumeral positions (Table 1).

Testing the pressure changes under the spinoglenoid ligament during glenohumeral ROM showed distinctive increases in pressure with an intact spinoglenoid ligament. Increased pressure was most prevalent with internal rotation and with 90° of abduction, full abduction, and full adduction of the shoulder (Fig 3). The suprascapular nerve occupying the space created by the spinoglenoid ligament experiences an increased pressure during glenohumeral ROM and positions that mimic overhead throwing. By using the 6 phases of the throwing motion as described by Jobe et al.,[11] we compared the pressure changes from our cadavers to 4 of the throwing positions: wind up, cocking, acceleration, and follow through (Fig 4). The figure shows the increased pressure on the suprascapular nerve by the spinoglenoid ligament during the overhead throwing motion.

When the spinoglenoid ligament was released, shoulder ROM did not cause a pressure change on the distal suprascapular nerve. This is shown in the graph that compares the intact spinoglenoid ligament pres-

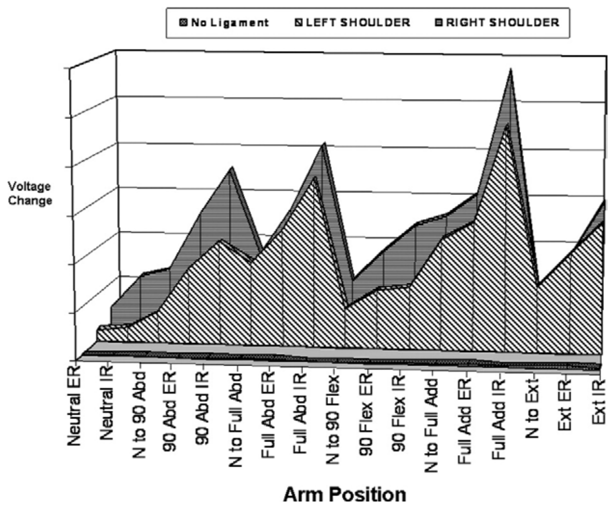

FIGURE 3. The voltage change with respect to the arm position. The right and left shoulders labeled in the legend have intact spinoglenoid ligaments. In all ranges with the spinoglenoid ligament cut, no voltage was measured showing no noise in the system.

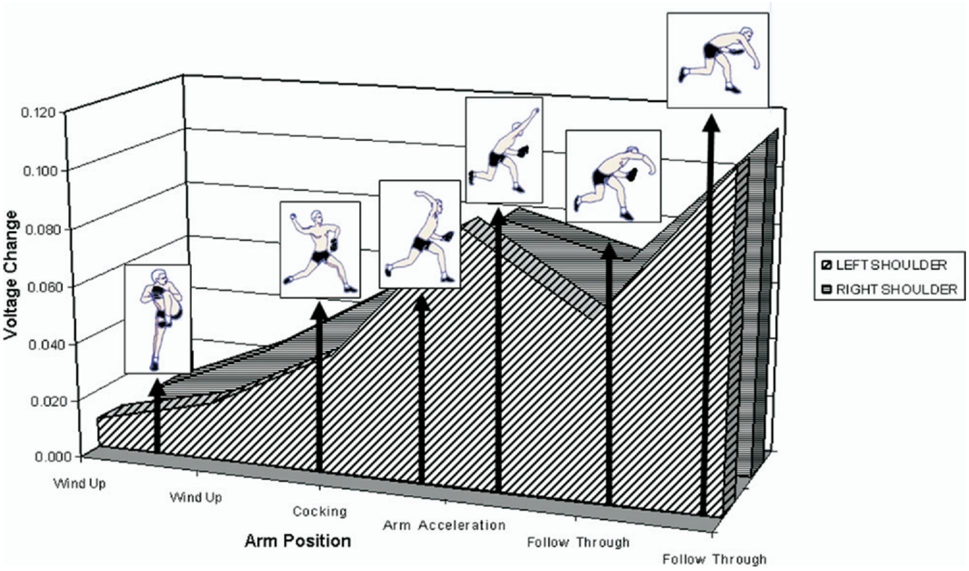

FIGURE 4. The voltage change with throwing motion. The right and left shoulders labeled in the legend have INTACT spinoglenoid ligaments. In all motions with the spinogleniod ligament cut, as seen in Fig 3, no voltage was recorded.

sure changes to the pressure changes with a released spinoglenoid ligament (Fig 3).

DISCUSSION

This study evaluated the pressure changes created by the spinoglenoid ligament on the distal suprascapular nerve during glenohumeral ROM. Tension of the spinoglenoid ligament is affected by the position of the glenohumeral joint. The spinoglenoid ligament is dynamic because of its insertion into the posterior glenohumeral joint capsule; therefore, motions that place the capsule under tension affect the ligament in a similar manner.[1,5,12] These studies support the theory that the spinoglenoid ligament causes a pressure change in the foramen that the ligament forms. These changes in combination with repetitive shoulder movement may cause repeated trauma or compression on the distal suprascapular nerve created by a scapular tunnel syndrome. This cadaveric study showed that internal rotation of the shoulder combined with abduction or adduction causes a more consistent increase in pressure on the suprascapular nerve. Newly reported proximal release of the suprascapular nerve has been shown to be performed safely. In this study, we described a surgical technique to relieve posterior shoulder pain from compression of the distal spinoglenoid ligament.[13]

The clinical features of the dysfunction of the distal branch of the suprascapular nerve have been well described.[1,4,6,20,21,24-32] Overhead athletes and manual labor workers are at an increased risk for entrapment of the distal branch of the suprascapular nerve by the spinoglenoid ligament. By using the 6 phases of throwing, we compared the pressure changes on the suprascapular nerve by the spinoglenoid ligament. Ferretti et al.[9] reported that this neuropathy was seen exclusively in the dominant arm of volleyball players. Correlation has been established between the level of competition, the duration of exertion, and the severity of the neuropathy.[15,31] Cummins et al.[21] raised the possibility that infraspinatus atrophy in baseball players was caused by neuropraxia to the suprascapular nerve, which was supported by their study because no throwers could identify an inciting event before the development of atrophy. Electromyographic studies have shown that the infraspinatus displays peak activity in the late cocking and follow-through stages of throwing.[11,31] The nerve to the infraspinatus could be vulnerable to maximal stretch at either the late-cocking or follow-through position.[8,13]

Suprascapular nerve traction, kinking, or friction with shoulder motion[1,2,5,7-9,18,19,28-30] are the 3 hypotheses recognized in the literature as a cause of isolated infraspinatus atrophy. The most popular theory proposed is that when the infraspinatus contracts, the nerve to the infraspinatus is displaced medially and is forced against the lateral edge of the scapular spine.[12,22]

The treatment of nerve dysfunction to the infraspinatus is often conservative, especially in the acute setting.[6,8,15] Rest, activity modification, and anti-inflammatory medications are the hallmarks of conservative care, yet patients with infraspinatus atrophy often do not recover in many reported cases. Rehabilitation was then focused on strengthening the teres minor to compensate for this deficit.[3] Preventative strengthening of the external rotators has been advocated for patients involved in throwing or overhead sports.[3,9,13,25]

When conservative treatment fails, surgical treatment has focused on increasing the space available for the nerve in the spinoglenoid notch. This has been accomplished through the removal of mass lesions,[4,12,14,21,29,31] shaving of the spinoglenoid notch,[10] resection of the spinoglenoid ligament,[1,2,4,21,27] and the removal of fibrous scar tissue.[4,21] All of these procedures have been performed in an open manner with muscle-splitting dissections. Once the ligament hypertrophies, it would explain why conservative treatment does not relieve the patient's symptoms and would support the good results reported with surgical release of the hypertrophied spinoglenoid ligament.[1,2,4,27]

The technique we described gives the surgeon and the patient a minimally invasive option for treating isolated infraspinatus muscle atrophy from the compression of the distal portion of the suprascapular nerve by spinoglenoid ligament. Although there continues to be increased reports of infraspinatus atrophy in patients participating in activities that require repetitive upper-extremity movements, performance by these athletes may not be optimal. This 2-portal endoscopic/arthroscopic technique gives the surgeon another option for treating this clinical finding.

The limitations of the dynamic study include the testing setup, which did not allow combination of glenohumeral and scapulothoracic motion to be studied. The pressure sensor used was zeroed before each test but was not calibrated to convert the pressure changes to pounds. However, the sensor used was capable of detecting pressure changes in the spinoglenoid foramen, and reproducible positions were used for testing. The order of the testing was not varied. This may have had effects on the spinoglenoid ligament; however, if the ligament were stretched over the ROM, we would have been underestimating the increase in pressure.

Decreasing shoulder pain has been accomplished in the literature by an open technique of release of the spinoglenoid ligament. We believe that with an arthroscopic technique, the same results should occur without violation of the muscle planes, and there would be no need for a lengthy rehabilitation. If pain is alleviated, the patient can return to all activities. We hope this procedure will allow the arthroscopist an easy and predictable technique to help patients.

CONCLUSIONS

The spinoglenoid ligament was affected by the position of the glenohumeral joint. Internal rotation of the shoulder combined with abduction and adduction showed increased pressure on the distal branch suprascapular nerve (follow through). Overhead athletes are repetitively reproducing this motion, which may result in an increased risk for entrapment of the distal branch of the suprascapular nerve by the spinoglenoid ligament. Given the dynamic findings in this study and the literature on infraspinatus muscle atrophy from spinoglenoid ligament hypertrophy, this 2-portal arthroscopic surgical technique has an application in treating posterior shoulder pain in a minimally invasive way.

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