Shoulder Proprioception and Function Following Thermal Capsulorraphy

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Purpose: Because monopolar radiofrequency energy has a denaturing effect on the glenohumeral joint capsule during thermal capsulorraphy, we hypothesized that thermal treatment would have a deleterious effect on the mechanoreceptors present within the capsule, thereby affecting proprioception and function. The purpose of this study was to evaluate proprioception and function following thermal capsulorraphy. **Type of Study:** Case series. **Methods:** Twenty subjects (13 male, 7 female) diagnosed with unilateral anterior, anteroinferior, or multidirectional glenohumeral instability with no significant concomitant pathologies, were treated with monopolar radiofrequency thermal capsulorraphy by one surgeon. Capsular redundancy was the primary diagnosis in all subjects. Subjects were bilaterally tested retrospectively 6 to 24 months (11.90 ± 5.65 months) following surgery. Each subject's ability to actively reproduce joint positions (ARJP) and reproduce paths of motion (PMR) was measured with an electromagnetic motion analysis system. Both passive reproduction of joint positions (PRJP) and threshold to detect passive motion (TTDPM) were measured using a proprioception testing device. Function was quantified with the Shoulder Rating Questionnaire (SRQ). Proprioception data were analyzed with separate repeated measures ANOVA ($P < .05$). **Results:** Statistical analysis revealed a significant ARJP difference between the involved and uninvolved limb ($P = .005$) indicating that reproduction error was less with the involved limb compared to the uninvolved limb. No significant interactions were present for TTDPM, PRJP, or PMR. The SRQ indicates that the subjects returned to near normal function (91.86/100 ± 5.38 points) at the time of testing. **Conclusions:** The results from this study do not support our hypothesis of proprioception and functional deficits following thermal treatment. Normalized proprioception following thermal capsulorraphy may have resulted from the healing effects of thermal treated ligament, as reported in the literature, as well as facilitation of other mechanoreceptors present in adjacent tissue about the shoulder joint during rehabilitation. The results of this study indicate that no appreciative deleterious effects exist with proprioception and function following treatment of shoulder instability with thermal capsulorraphy. **Key Words:** Radiofrequency—Arthroscopy—Shoulder instability—Mechanoreceptor.

Thermal energy denatures the collagenous triple helix infrastructure, leading to a random collagen coil and decreased tissue length.[1-3] It is this decreased tissue length that results in decreased humeral translation.[4,5] Embedded within the denatured collagen of the shoulder capsule are mechanoreceptors responsible for proprioceptive input.[6,7] Proprioception is defined as the afferent neural input originating from mechanoreceptors about the shoulder joint.[8,9] This proprioceptive input can be appreciated consciously as joint position sense, kinesthesia (joint movement sense), and forces application to the joint.[8,9] In addition, the proprioceptive information is appreciated subconsciously and used for joint stability mechanisms and development and alteration motor programs.[8,9]

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Lephart et al.[10] reported that individuals with unstable shoulders exhibit proprioceptive deficits. These deficits are restored following traditional capsulorraphy procedures such as open and arthroscopic procedures.[10] The authors suggested that re-establishment of capsular tension through surgical intervention facilitated stimulation of the capsular mechanoreceptors, accounting for restored proprioception. Given that heat can destroy neural tissue,[11-13] the concern with thermal capsulorraphy is that these mechanoreceptors within the treated tissue are deleteriously affected, thereby altering their proprioceptive capabilities. The authors are unaware of any research to date that examines the viability of these thermal treated mechanoreceptors or the proprioceptive input provided by the treated joint capsule. Therefore, the primary purpose of this study was to assess proprioception following thermal capsulorraphy in patients diagnosed with shoulder instability. It was hypothesized that alterations in proprioception would manifest in patients treated with thermal capsulorraphy. The secondary purpose of this study was to identify functional deficits that might result from thermal capsulorraphy.

METHODS

Twenty subjects (13 male, 7 female; age, 21.4 ± 7.5 years; height, 176.9 ± 7.7 cm; mass, 80.1 ± 18.2 kg) participated in this study. All subjects were diagnosed with unilateral, anterior, anteroinferior, or multidirectional instability with no concomitant pathologies. Capsular redundancy was the primary diagnosis in all cases.

Approximately 40 patients were contacted by mail for this study. Of these patients, 20 volunteered for participation. Each subject was treated with thermal capsulorraphy using a monopolar radiofrequency generator (Oratec Interventions, Menlo Park, CA). A single surgeon performed all thermal capsulorraphy procedures to control differences in technique among physicians. All subjects attended 1 testing session at least 6 months (11.90 ± 5.65 months) following surgery. This minimum 6-month follow up was set to ensure sufficient restoration of histologic and biomechanical properties of the tissue as well as return to activity 3 to 5 months following surgery.[14-17]

During the testing session, each subject signed informed consent forms and completed the Shoulder Rating Questionnaire (SRQ).[18] Given that no proprioceptive differences resulting from limb dominance are reported in the literature,[10,19] all subjects were retrospectively tested bilaterally using the proprioception assessments described later in this report. Limb order was counterbalanced to control for possible learning effects. The proprioception assessments included threshold to detection of passive motion (TTDPM), passive reproduction of joint position (PRJP), active reproduction of joint position (ARJP), and path of motion replication (PMR). This battery of proprioception assessments was chosen to include measures of kinesthesia (TTDPM), joint position sense (PRJP and ARJP), and motor control (PMR).

Threshold to Detection of Passive Motion

Threshold to detection of passive motion was tested using a proprioception testing device (Fig 1). This protocol mimics previously published methods.[10,20,21] Subjects were fitted with a pneumatic sleeve, a blindfold, and headphones with white noise to negate tactile, visual, and audible cues. Ability to detect passive humeral rotation was measured from starting positions of both 0° and 30° of external rotation, moving into both internal and external rotation. A fixed angular velocity of 0.5° per second was used for all trials. Three trials were performed for each direction from each starting position. Direction of rotation and starting position were counterbalanced to control for possible learning effects. Angular displacement in de-

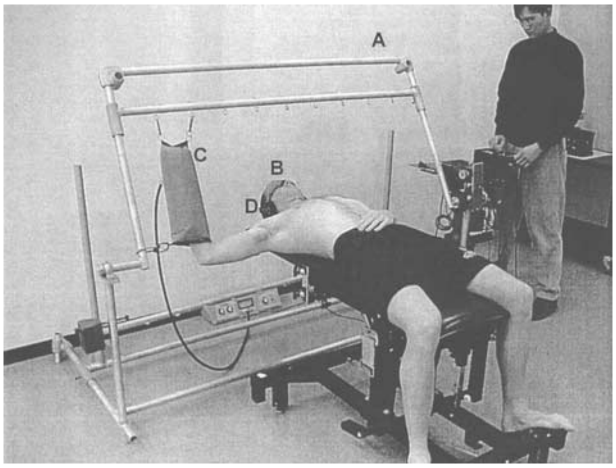

FIGURE 1. A patient performing either passive reproduction of joint position or threshold to detection of passive motion on a proprioceptive testing device. (A) The subject lies supine with the upper extremity supported at 90° of abduction and elbow flexion. The subject is fitted with a blindfold (B), pneumatic air splint (C), and head phones (D) to eliminate visual, tactile, and auditory cues. Using a hand-held switch, the subject signals when either joint positions are passively reproduced or motion is detected.

grees before detection of motion was recorded using a digital processor.

Passive Reproduction of Joint Position

Passive reproduction of joint position was assessed using the proprioception testing device (Fig 1). Like TTDPM, the methods for PRJP mimicked previously reported studies.[10,20] The subject was fitted with a blindfold and the pneumatic sleeve to eliminate visual and tactile cues. Testing began by placing the subject's limb in 1 of 2 starting positions (0° of rotation or 30° of external rotation). The tester then passively rotated the subject's limb using the proprioception testing device to 1 of 4 reference angles depending on the starting position. Those reference angles included 10° of internal rotation or 10° of external rotation from the 0° of rotation starting position, and 20° of external rotation or 40° of external rotation from the 30° of external rotation starting position. The reference angle was held for 10 seconds and then passively returned by the proprioception testing device to the starting position. The subject's limb was passively rotated by the proprioception testing device toward the presented target angle. Using a hand-held switch, the subject disengaged the proprioception testing device when he or she felt that the target angle was reproduced. Both the starting position and reference angles presented were counterbalanced. Three trials were performed at each reference angle, with absolute angular error being recorded for each trial. Absolute angular error was defined as the absolute difference in degrees between the reference and reproduced angle. The reliability of shoulder proprioception testing on the proprioception testing device was reported to range from intraclass correlations 0.87 to 0.92.[10]

Active Reproduction of Joint Position

Active reproduction of joint position was assessed using an electromagnetic tracking device (Motion Monitor; Innovative Sports Training, Chicago, IL) and an isokinetic dynamometer (Biodex System II; Biodex Medical, Shirley, NY) (Fig 2). Electromagnetic receivers were placed on the posterior aspect of the head, on the thorax at the T-1 spinous process, and on the humerus just proximal to the elbow. The electromagnetic transmitter was positioned posterior to the subject on a tripod. Subjects actively moved to 1 of 2 target positions (20° of flexion with 0° of humeral rotation [20 FLEX] and 90° of abduction with 90° of external rotation [90 ABD-ER]) with the isokinetic dynamometer. These positions were chosen to simulate both a position of daily activity (i.e., reaching for a door knob) and a position of apprehension. Subjects were blindfolded to eliminate visual cues.

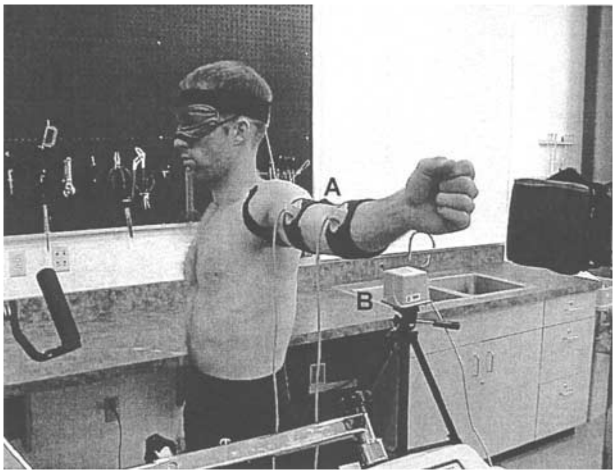

FIGURE 2. A patient actively replicating a joint position or standardized path of motion presented to the subject with an isokinetic dynamometer. Electromagnetic tracking sensors (A) record the 3-dimensional position and orientation of the limb relative to an electromagnetic tracking transmitter (B). The transmitter provides data used to calculate the active joint position replication and path of motion replication.

On reaching the target position, subjects were instructed to appreciate limb position for 10 seconds. After returning to the starting position, subjects were then asked to reproduce the target position without the aid of the dynamometer. The difference in both humeral position and rotation was calculated using the 3-dimensional position data (X,Y,Z) and angular rotation of the sensor on the humerus. The degree of variation in displacement was reported in terms of centimeters of deviation, and differences in humeral rotation were reported in degrees. Each subject performed 3 trials moving from 20 FLEX to the presented position of 90 ABD-ER as well as moving in the opposite direction. The order of the 6 trials was counterbalanced.

Path of Motion Replication

Like ARJP, path of motion replication was assessed with both the electromagnetic tracking device and isokinetic dynamometer (Fig 2). On instruction, the subject actively moved from the starting position of 20 FLEX to the mounted pad at 90 ABD-ER or vice versa, depending on the trial. The dynamometer standardizes the path of motion between the start and end positions, allowing for a single curvilinear path. Once the end point is met, the subject returns to the starting

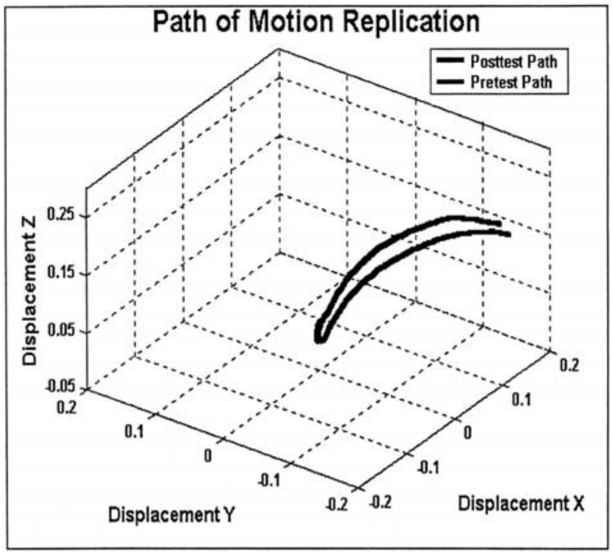

FIGURE 3. The variation between the presented and reproduced path of motion is represented by the area separating the pretest and posttest paths of motion and depicts quality of movement by the patient.

position. The subject then reproduced the presented path of motion without aid from the dynamometer. The quality of movement can be calculated as the variation between the given path and reproduced path of movement using the 3-dimensional humeral position (X,Y,Z) of the sensor on the humerus (Fig 3). The degree error was reported in terms of mean centimeters of deviation between the presented and reproduced path. Each subject performed 3 trials moving from 20 FLEX to 90 ABD-ER as well as moving in the opposite direction from 90 ABD-ER to 20 FLEX. The order of the 6 trials was counterbalanced. The intraclass correlations range from 0.61 to 0.80 for the proprioception assessment on the electromagnetic tracking device.

Functional Assessment

The SRQ as described by L'Insalata et al.[18] is a self-administered instrument designed to assess the severity of symptoms related to the functional status of the shoulder. The 21-question instrument is comprised of 6 separately scored domains that include a global assessment, pain assessment, assessment of daily activities, recreational and athletic assessment, and work assessment. Weighting of the domains were as recommended in the literature.[18] In addition to the individual domain scores, an overall value was calculated with a maximum score of 100 points. Strong reliability, internal consistency, and reproducibility for the SRQ have been established.[18]

Statistical Analysis

Proprioception data were analyzed with repeated measures analysis of variance models in the Statistical Packages for the Social Sciences 9.0 (SPSS, Chicago, IL). A Tukey Honestly Significant Difference post hoc test was used for pairwise comparisons. A level of significance of $P < .05$ was set before all analyses. Descriptive statistics were calculated for the SRQ data.

RESULTS

Proprioception

The descriptive statistics for the proprioception assessments appear in Tables 1, 2, 3, and 4. Statistical analysis revealed a significant limb by direction interaction for active reproduction of joint position displacement data F (1,19) = 9.953 ($P = .005$) indicating that the subjects' ability to reproduce joint positions was significantly greater with the involved limb than the uninvolved limb moving into 90 ABD-ER. No significant differences existed between limbs for TTDPM, PRJP, and PMR assessments ($P > .05$).

Shoulder Rating Questionnaire

The overall functional score obtained by the 20 subjects was 91.86 ± 5.38 points of a possible 100 points. Within the overall functional score, responses

TABLE 1. *Statistics for Threshold to Detection of Passive Motion*

Condition	0° to ER	0° to IR	30° to ER	30° to IR
Involved limb	1.54 ± 1.3	1.72 ± 1.1	1.30 ± 1.0	1.83 ± 1.4
Uninvolved limb	1.33 ± 0.74	1.53 ± 0.97	1.14 ± 0.64	1.62 ± 1.3

NOTE. Values are given as mean ± standard deviation.

Abbreviations: 0° to ER, starting position of 0° moving into external rotation; 0° to IR, starting position of 0° moving into internal rotation; 30° to ER, starting position of 30° external rotation moving into external rotation; 30° to IR, starting position of 30° external rotation moving into internal rotation.

Table 2. *Statistics for Passive Reproduction of Joint Position*

Condition	0° to 10° ER	0° to 10° IR	30° to 40° ER	30° to 20° ER
Involved limb	1.67 ± 0.95	1.87 ± 0.95	2.70 ± 1.6	1.94 ± 1.1
Uninvolved limb	1.92 ± 1.2	2.34 ± 1.2	2.50 ± 2.5	2.53 ± 2.5

NOTE. Values are given as mean ± standard deviation.

Abbreviations: 0° to 10° ER, starting position of 0° and target angle of 10° external rotation; 0° to 10° IR, starting position of 0° and target angle of 10° internal rotation; 30° to 40° ER, starting position of 30° external rotation and target angle of 40° external rotation; 30° to 20° ER, starting position of 30° external rotation and target angle of 20° external rotation.

from the pain domain yielded a value of 37.0 ± 2.29 points of a possible 40, indicating very little pain experienced throughout surgery and rehabilitation. A value of 19.23 ± 1.53 points of a possible 20 points suggested that most of the subjects returned to normal activities of daily living. Occupational ability was also near normal, as evident by the score of 9.85 ± 0.40 points of a possible 10 points. Finally, the athletic-recreational domain yielded a value of 12.80 ± 1.99 points of a possible 15 points.

DISCUSSION

Shoulder Proprioception

The results of this study indicate that no appreciable effects exist between limbs with proprioception following thermal capsulorraphy for shoulder instability. Similar proprioception values are reported in the literature.[10] Using identical proprioception testing device methods as in this study, our laboratory previously compared proprioception in subjects who were diagnosed with shoulder instability and treated with surgical intervention with that in normal healthy subjects.[10] We reported that no significant differences existed bilaterally between normal subjects and those who had undergone surgical repair. Unlike patients with normal and surgically repaired shoulders, patients with unstable shoulders exhibited decreased kinesthesia and joint position sense in the involved limb compared with the uninvolved limb.[10]

Similarly, Smith and Brunolli[22] reported kinesthetic deficits in unstable individuals. Comparing traditional and thermal capsulorraphy procedures, the current study found similar results to those of Lephart et al.[10] TTDPM results in the current study ranged from 1.30° to 1.83° in the limb treated with thermal capsulorraphy while those reported with traditional capsulorraphy[10] ranged from 1.5° to 2.2°. Postsurgical PRJP proprioception values in the present study were similar to those reported by Lephart et al.[10] for traditional capsulorraphy.

Zuckerman et al.[23] prospectively studied 30 individuals diagnosed with unilateral instability treated with surgical intervention. The authors reported hindered joint position sense and kinesthesia before traditional capsulorraphy, partial restoration at 6 months with full restoration occurring by 12 months.[23] A culmination of the literature as well as the results from the current study suggest that proprioceptive deficits exist in individuals with unstable shoulders and that surgical intervention, whether through thermal or traditional means, assists in re-establishing proprioception in patients diagnosed with shoulder instability.

Unlike the original hypothesis that proprioception would be adversely altered, this study indicates that proprioception was normalized and even improved, as evident by the ARJP results, following thermal capsulorraphy. We speculate that 3 mechanisms may account for the normalized proprioception. Those mechanisms include the effects of postoperative reha-

Table 3. *Statistics for Active Reproduction of Joint Position*

Condition	Displacement (cm) 90 ABD-ER	Displacement (cm) 20 FLEX	Humeral Rotation (degrees) 90 ABD-ER	Humeral Rotation (degrees) 20 FLEX
Involved limb	5.9 ± 3.5*	7.5 ± 4.3	7.6 ± 4.9	10.3 ± 7.4
Uninvolved limb	8.6 ± 6.2	5.1 ± 1.8	10.3 ± 10.7	10.0 ± 6.6

NOTE. Values are given as mean ± standard deviation.

*Significantly different from the uninvolved limb (F [1,19] = 9.953 [P = .005]).

Abbreviations: 20 FLEX, 20° of flexion with 0° of humeral rotation; 90 ABD-ER, 90° of abduction with 90° of external rotation.

TABLE 4. *Statistics for Path of Motion Replication*

	Displacement (cm)	
Condition	90 ABD-ER	20 FLEX
Involved limb	5.59 ± 3.5	5.45 ± 3.2
Uninvolved limb	4.68 ± 1.5	4.57 ± 2.0

NOTE. Values are given as mean ± standard deviation.

Abbreviations: 20 FLEX, 20° of flexion with 0° of humeral rotation; 90 ABD-ER, 90° of abduction with 90° of external rotation.

bilitation, the demonstrated healing effects of thermally treated tissue, and re-establishment of capsular tension.

Typically, rehabilitation following shoulder injury and surgery addresses strength of the musculature about the shoulder joint. Interestingly though, exercises geared to improving strength also have had effects on proprioception. Rogol et al.[24] reported that, at the shoulder joint, both open kinetic chain strengthening, such as the supine chest press, and closed kinetic chain exercises, such as standard push-ups, increase joint position sense. Docherty et al.[25] reported similar results at the ankle, showing that a 6-week strength training program using surgical tubing improved ankle strength and joint position sense.

An emphasis on unilateral rehabilitation may account for the significantly enhanced ARJP ability in the involved limb. Lephart and Henry[26] outline functional rehabilitation techniques specifically designed to facilitate return of sensorimotor components of stability such as proprioception. Implementation of exercises such as joint position sense retraining, dynamic stabilization exercises, and plyometrics are common and vital components of shoulder rehabilitation following surgery. Swanik et al.[27] reported enhanced proprioception as measured with TTDPM and PRJP following shoulder plyometric training. Exercises such as muscle strengthening and functional rehabilitation exercises may facilitate restoration of proprioception by both altered as well as other mechanoreceptors such as the muscle spindle and golgi tendon organs present in the musculature. We can only speculate, but it is also possible that any changes within the capsular mechanoreceptors may have been masked by facilitation of other mechanoreceptors about the shoulder joint.

A second mechanism we speculate to be responsible for normalized proprioception following thermal capsulorraphy is the demonstrated healing effects of heated (radiofrequency or laser energy) ligament. Hayashi et al.[14,28] found that robust healing occurs following thermal treatment in vivo. In a laser-treated femoropatellar capsule in a sheep model, no histologic differences, including collagen hyalinization and cell necrosis, were present 60 days following treatment. Biomechanical tissue properties, including failure strength and tissue stiffness, were comparable to normal levels 30 days after treatment. Microscopic analysis showed normal collagen and fibroblastic properties 30 days following surgery.[14]

Samples of inferior glenohumeral ligament complex were harvested before and following laser treatment in vivo in humans diagnosed with glenohumeral instability.[28] Before thermal treatment, no histologic lesions were present in the capsule of subjects with instability. Immediately following treatment, collagen fusion and cell necrosis was present. Three months after treatment, Hayashi et al.[28] found highly active reparative changes histologically. Seven to 38 months after surgery, all capsule samples had a normal appearance.

Unfortunately, no data that specifically address the viability of capsuloligamentous mechanoreceptors following thermal treatment and the ability of capsuloligamentous tissue to reinnervate following treatment currently exist. Instead, inferences concerning reinnervation can be made from other areas of the literature. Denti et al.[29] histologically examined bone–patellar tendon–bone autografts and patellar tendon autografts with ligament augmentation devices in sheep models. The authors reported that reinnervation did occur, with viable mechanoreceptors present in the graft. Tsujimoto et al.[30] reported similar results in a goat model but stated that a 6-month time period was necessary for reinnervation.

A similar 6-month period of reinnervation was also reported for an ACL allograft in a canine model.[31] Barrack et al.[32] also showed that 89% of receptors resulting from reinnervation of a canine patellar tendon graft were mechanoreceptors, with the remaining receptors being free nerve endings. Again, this was after a 6-month period. Because reinnervation can occur in biologic tissue that at one point was completely removed from the body, as in the case with ACL reconstruction grafts, reinnervation of tissue that remains intact within the joint and is subjected to healing is not far fetched. Interestingly, Khullar et al.[33,34] found that sensory information sensitivity from mechanoreceptors improved following low level laser treatment. Low-power laser irradiation has also been shown to increase the rate of regeneration of nervous tissue.[35] These results from lower level lasers may bode well for the use of laser energy in thermal capsulorraphy.

A final mechanism that we speculate may be responsible for restored proprioception following thermal capsulorraphy is the re-establishment of capsular tension. Using cortical evoked potentials, Tibone et al.[36] reported that no significant differences existed between normal subjects and subjects with instability; indicating that, while the mechanical properties of the capsuloligamentous structures were compromised, the afferent pathways were still intact. These results suggest that capsular laxity alone, rather than mechanoreceptor trauma resulting in deafferentation, is responsible for the proprioception deficits as seen with kinesthesia and joint position sense testing. Blasier et al.[37] reported decreased kinesthetic sense in subjects diagnosed with hypermobility but no history of instability or injury.

In the absence of mechanoreceptor trauma, the results again indicate that capsular laxity (resulting from hypermobility) decreases proprioception. Allegrucci et al.[21] focused on kinesthetic awareness in overhead athletes. The authors reported decreased kinesthesia in the dominant limb of overhead athletes when compared with the nondominant limb. This decrease may result from the general capsular laxity present in overhead athletes and again indicates that increased capsular laxity may account for proprioceptive deficits.[21] Synthesis of the literature suggests that capsular laxity results in proprioception deficits and the resulting re-establishment of capsular tension through traditional capsulorraphy facilitates mechanoreceptor stimulation and the resulting restoration of proprioception.[10] Given that thermal energy decreases tissue length, re-establishing capsular tension,[4,5] the normalized proprioception reported in this study may have resulted from stimulation of unaffected, altered, or reinnervated mechanoreceptors present within the newly tensioned capsule.

We recognize that 2 limitations existed with the research design of this study. Because of the retrospective nature of this study, we cannot state that proprioceptive deficits existed before thermal capsulorraphy. We can only speculate, based on previously published data, that individuals with shoulder instability do have proprioceptive deficits.[10,22,23] A true randomized prospective study that assesses all sensorimotor mechanisms, including proprioception, prior to and following surgical intervention is truly needed to determine the effects of thermal capsulorraphy as well as traditional means of surgical intervention on such variables. A randomized prospective study of this type provides a much needed future direction for further research.

A second recognized limitation is the use of the uninvolved limb as a means of comparison. It has been suggested that proprioceptive deficits may exist in the uninvolved limb as well as the injured limb.[38] Fortunately, we do not believe this was a confounding variable. The proprioception values exhibited by the uninvolved limb obtained in the current study mimicked previously reported proprioception data in normal subjects using identical methodology.[10,39]

Shoulder Rating Questionnaire

The results of the SRQ suggest that normal function was achieved by the subjects in this study for all domains. These positive results mimic others reported in the literature. For example, Lyons et al.[40] observed that 26 of 27 shoulders diagnosed with multidirectional instability remained stable and asymptomatic a minimum of 2 years following thermal capsulorraphy. Of the 27 subjects, 14 were athletes; 12 of these subjects returned to preinjury levels of athletic activity. Savioe and Field[41] compared thermal versus suture techniques for surgical intervention with the UCLA, Rowe, and Neer and Foster rating scales. The results showed that of 32 patients treated with thermal capsulorraphy, 31 obtained satisfactory results. Additionally, 28 of 30 patients treated with traditional capsulorraphy also had satisfactory results. In contrast, Levy et al.[42] compared radiofrequency with laser thermal capsulorraphy using the Walsh Duplays score. The results reported by these authors were less favorable. Of 34 laser procedures, 59% of the patients considered themselves better or much better following surgery. Seventy six percent of the radiofrequency patients felt better or much better.

Similar to the current study, many of the outcome studies only follow up a maximum of 2 years after surgery. Additional follow-up is needed to ascertain the long-term success of thermal capsulorraphy. One limitation of the current study as well as of most outcome studies is the lack of uniform assessment instrumentation. It is difficult to compare the results of different outcome measures (such as UCLA, Walsh-Duplay, SRQ, and so forth). In the current study, the SRQ was chosen because of the multiple domain assessments, ease of administration for the patient, and established reliability, consistency, and reproducibility.[18]

CONCLUSIONS

The results of our study do not support our hypothesis of proprioception and functional deficits from thermal treatment. Normalized proprioception after thermal capsulorraphy may have resulted from the healing effects of thermal treatment, as reported in the literature, as well as from facilitation during rehabilitation of other mechanoreceptors in adjacent tissue about the shoulder joint. The results of this study indicate that no appreciable deleterious effects exist with proprioception and function after treatment of shoulder instability with thermal capsulorraphy.

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