Volumetric change in the shoulder capsule after open inferior capsular shift versus arthroscopic thermal capsular shrinkage: A cadaveric model

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The purpose of this study was to compare the percentage of glenohumeral intracapsular volume reduction after open inferior capsular shift and arthroscopic thermal capsulorrhaphy. Twelve matched, fresh-frozen cadaveric shoulders were used for the study. Intraarticular glenohumeral volume measurements were obtained by injecting a viscous fatty acid sulfate solution into the joint. In the 6 right shoulders, a standard anterior-inferior capsular shift was performed, and in the 6 matching left shoulders, an arthroscopic thermal capsular shrinkage was performed. After the procedures, the capsular volumes were re-measured. The open inferior shift procedure resulted in a mean decrease in glenohumeral volume of 50.2% (range, 43%-56%). Arthroscopic thermal capsulorrhaphy decreased shoulder intraarticular volume by a mean of 29.7% (range, 26%-36%). Both the open capsular shift and arthroscopic thermal shrinkage procedures produced well-documented volumetric reductions in the shoulder capsules. The open shift reduced intraarticular shoulder volume significantly more than arthroscopic thermal capsular shrinkage. (J Shoulder Elbow Surg 2004;13: 146-9.)

Multidirectional instability (MDI) of the shoulder was first described by Neer and Foster[21] in 1980. Affected patients have symptomatic laxity of the shoulder joint in multiple planes.[10] An excessively redundant capsule has been shown to be the primary pathology. Standard treatment for MDI begins with a nonoperative regimen of glenohumeral and periscapular muscle strengthening. When this fails, operative treatment may be undertaken.

Since Neer and Foster[21] first described the inferior capsular shift, it has become the gold standard in the operative treatment for MDI. The shift may be done anteriorly or posteriorly, depending on the direction of greatest symptomatic manifestations.[2,4,9,11,28] During the last decade, many authors have reported on the arthroscopic treatment of MDI.[5,17,18,25,27] Thermal capsular shrinkage has gained increasing popularity and shown some early promise in young active patients.[1,6,7,17,23,25] Although glenohumeral volume reduction has been quantified for the open capsular shift,[16] no published studies have compared the percent of shrinkage that open and arthroscopic techniques achieve. The purpose of our study was to measure the percentage of glenohumeral volume reduction obtained after arthroscopic thermal shrinkage and compare it with the reduction obtained with an open capsular shift.

METHODS

Six pairs of matched, fresh-frozen cadaveric shoulders were used for the study. The mean age at the time of death was 66 years (range, 39-80 years). There were 3 women and 3 men. None of the shoulders had any evidence of a rotator cuff tear. A standard anteroinferior capsular shift was performed on all right shoulders, and arthroscopic thermal capsular shrinkage was performed on left shoulders. To reduce bias, all open procedures were performed by one surgeon, and all arthroscopic procedures were performed by a different surgeon.

The specimens were thawed to room temperature, and the skin, subcutaneous tissue, and parascapular muscles were dissected (Figure 1). The rotator cuff muscles and the capsule remained intact. The shoulder was stabilized by fixing the scapula to a specially designed stand allowing the humerus to hang with gravity. A 5-mm midsubstance incision was made in the superior aspect of the supraspinatus tendon. A viscous fatty acid sulfate solution (yellow liquid soap) was the chosen medium to measure intracapsular volume. This solution was injectable and had an easily discernible color, which allowed us to limit the amount of extravasation from the measurement portal. Furthermore, its

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Figure 1 Shoulder with subcutaneous tissue and parascapular muscles dissected.

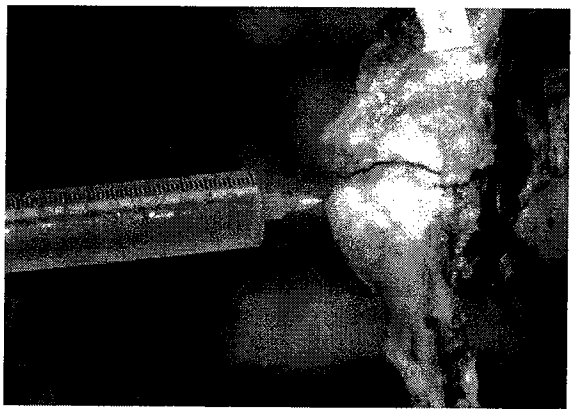

Figure 2 Injection of liquid soap into the glenohumeral joint at the level between the teres minor and infraspinatus tendons.

viscosity was ideal for injecting and filling the joint. A 60-mL syringe with a flexible 18-gauge angiocatheter was used to inject the liquid soap into the glenohumeral joint at the level between the teres minor and infraspinatus tendons (Figure 2). The catheter was inserted deep into the axillary recess, thus facilitating retrograde filling of the joint, with the last space filled being the area immediately adjacent to the superior measurement portal. When the liquid soap began to extrude from the superior rotator cuff incision, the joint was considered filled. The amount left in the syringe was subtracted from 60 mL to provide a volumetric assessment of the joint. For our study, this was operationally defined as glenohumeral volume. The joint was then irrigated with water, and all fluid was suctioned out via the superior measurement portal by use of a small nasogastric tube that reached the inferior-most aspect of the joint. This process was repeated 3 times in each of the 12 shoulders, and the measurements were recorded for statistical analysis.

After preoperative volume measurement, a standard anteroinferior capsular shift was performed on each of the right shoulders by use of the technique originally described by Neer and Foster.[21] The lateral capsule was incised longitudinally from the rotator interval to the 6-o'clock position approximately 10 mm medial to its insertion on the humeral neck. After the flaps were mobilized, the inferior capsular flap was advanced superiorly and repaired with No. 2 braided polyester suture to the superolateral flap on the humeral neck. The superior flap was then advanced over the inferior flap and similarly repaired to the inferolateral flap on the humeral neck. All specimens had rotator intervals, and care was taken to close the interval after the capsular shift was completed. The interval was closed to prevent egress of viscous soap rather than to assist in shifting the capsule. This was done in all specimens so that the 6 o'clock capsular shift was the consistent procedure measured in each specimen.

In the left shoulders, an arthroscopic thermal capsular shrinkage was performed by use of standard anterior and posterior portals. Before the arthroscopic procedure, the superior stab incisions used for preoperative measurements were closed end to end with 2-0 nylon. This was done to facilitate the arthroscopic procedure by decreasing the egress of arthroscopic irrigant. Care was taken not to plicate the tendon, as this would further reduce glenohumeral volume and skew the results. Thermal capsular shrinkage was performed with a monopolar radiofrequency heat probe (Oratec Interventions, Inc, Menlo Park, CA) set at 68°C and 40 W. Radiofrequency energy was applied in a paintbrush fashion to cover the anterior, posterior, and inferior capsule, including the rotator interval capsule, completely. Close attention was paid in order to contract the capsule uniformly throughout the joint. When the procedure was completed, the portal sites were repaired end to end with interrupted 2-0 nylon sutures. Again, care was taken not to plicate the capsule during portal closure. The sutures used to repair the previously placed superior stab incision were removed, and all fluid was suctioned out of the joint with a small nasogastric tube.

When the surgical procedures were completed on each shoulder, intraarticular glenohumeral volume measurements were repeated by use of the technique previously described. The capsule was tightly repaired laterally in a vest-over-pants fashion. At no time was there evidence of measurement media extravasating from the repair site of the open shift.

Data were analyzed by repeated-measures 2-way analysis of variance with measure and side of shoulder as repeating factors.

RESULTS

The mean preoperative volume was 20.7 mL of fluid. There was no significant difference in the preoperative values between the shoulders used for the open capsular shift (mean, 20.3 mL) and arthroscopic thermal capsular shrinkage (mean, 21.0 mL) ($P = .8$) The results of each specimen for both the open and arthroscopic procedures are shown in Table I.

There was a difference in postoperative shoulder

Table I Capsular volume (milliliters of fluid) for open and arthroscopic procedures

Specimen No.	Preoperative				Postoperative			
	Trial 1	Trial 2	Trial 3	Mean	Trial 1	Trial 2	Trial 3	Mean
Right								
1	23	24	24	24	11	11	12	11
2	20	20	19	20	10	10	10	10
3	20	19	19	19	11	11	11	11
4	24	22	23	23	11	11	10	11
5	26	25	25	25	14	13	13	13
6	11	11	12	11	5	5	5	5
Left								
1	22	23	23	23	17	16	17	17
2	19	18	19	19	13	12	13	13
3	20	20	20	20	14	15	13	14
4	25	25	25	25	18	18	19	18
5	24	24	23	24	16	17	16	16
6	15	14	15	15	9	9	9	9

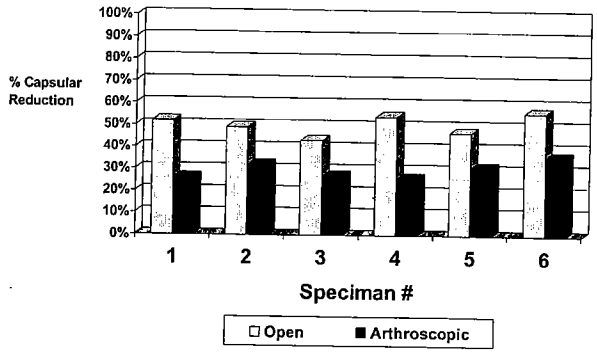

Figure 3 Capsular volume reduction for open and arthroscopic procedures.

volume when the two procedures were compared (open, 10.2 mL; arthroscopic, 14.5 mL) ($P = .03$). The open capsular shift procedure decreased glenohumeral volume by a mean of 50.17%, and the arthroscopic thermal capsular shrinkage procedure decreased glenohumeral volume by a mean of 29.67% ($P = .004$) (Figure 3). In this cadaveric model the open capsular shift procedure decreased glenohumeral volume by 1.7 times (50.17/29.67) more than the thermal capsular shrinkage procedure.

DISCUSSION

Neer and Foster[21] described MDI of the shoulder as symptomatic glenohumeral laxity in more than one of three directions: anterior, posterior, and inferior. The primary pathology in MDI is a redundant inferior capsule.[20,24] Overhead athletes may acquire MDI by repetitive anterior or posterior capsular stretch and a combination of repetitive microtrauma.

In 1980 Neer and Foster[21] described the inferior capsular shift. Several authors have reported excellent results with this procedure, and it has become the gold standard in the operative management of MDI.[3,4,14,21] Arthroscopic techniques have become increasingly popular in treating shoulder pathology. Arthroscopic techniques offer the advantage of less operative time and blood loss, shorter hospitalization, and less postoperative narcotic use.[8] The holmium laser was shown to decrease glenohumeral joint translation and was introduced several years ago as a possible treatment for glenohumeral joint instability.[26] More recently, radiofrequency energy has gained popularity as a surgical modality to treat shoulder instability. The thermal energy produced by this system causes denaturation of the triple helical structure of type I collagen.[15] The collagen molecule contracts into a less organized state, with a significant reduction in length.[12,13,19,22] Clinically, the use of thermal capsular shrinkage has produced variable results but has become an alternative to the open inferior capsular shift procedure.[6]

There have been few studies documenting shoulder joint volume reduction. In the study by Lubowitz et al,[16] the reduction in capsular volume obtained by the inferior capsular shift was measured. They used three different techniques to measure the volume, including the injection of saline solution. Their results showed a 57% reduction in volume, which is similar to the results we obtained (50%) with open capsular shift. Our study compared volumetric changes that occur with two procedures. The open shift procedure produced significantly more glenohumeral volume reduction than the arthroscopic thermal capsulorrhaphy procedure. The implications of this difference are not known at this time.

The limitations of this study include the use of cadaveric specimens with unknown laxity. We could not document reductions in laxity; however, the goal of the study was to determine reductions in the volume of the capsule. Our study does provide a mechanism for comparing a new procedure, arthroscopic thermal capsulorrhaphy, with a procedure considered to be the gold standard. This study technique allows for comparison of volume changes in different procedures and is not meant to measure the procedures' efficacy of reducing glenohumeral laxity.

Future studies will need to address the percent of glenohumeral volume reduction and correlation to long-term stability. They will also need to evaluate the percent of volume decreased and the ability to return to overhead activities versus restricted activity. We do not know how much volume reduction is required for improved functional outcome. Prospective studies, using in vivo models with long-term follow-up, will be required before making definitive conclusions regarding the efficacy of arthroscopic thermal capsulorrhaphy in the treatment of glenohumeral instability. It may be that, with the use of thermal capsulorrhaphy in patients with instability, increased reduction in joint volume may occur over time.

In conclusion, our results indicate that, in a cadaveric model, arthroscopic thermal capsulorrhaphy results in a reduction of capsular volume, though significantly less than that achieved with an open capsular shift procedure.

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