Arthroscopic Capsular Plication in the Treatment of Shoulder Pain in Competitive Swimmers

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Abstract Shoulder pain is a common and difficult problem in competitive swimmers due to cumulative loads from repetitive overhead motion. Capsular laxity has been implicated as a potential etiology for shoulder pain in competitive swimmers. No study has examined the role of capsular plication in addressing recurrent shoulder pain in competitive swimmers. The purpose of this study is to retrospectively describe our series of competitive swimmers treated with arthroscopic capsular plication with a primary outcome of return to competitive swimming. Eighteen shoulders in 15 patients underwent arthroscopic capsular plication from 2003 to 2007. Patients were contacted at an average follow-up of 29 months (range, 8–42) and a swimming history, American Shoulder and Elbow (ASES) scores, and L'Insalata scores were obtained. At time of surgery, all patients demonstrated laxity under examination under anesthesia. All patients had a positive drive-through sign. Eighty percent (12/15) of patients returned to competitive swimming although only 20% (3/15) were able to return to their pre-injury training regimen volume. All patients subjectively reported improved pain after surgery.

The study performed at the Hospital for Special Surgery New York, NY 10021.

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The average ASES score was 78 ± 16 (average, standard deviation). The average L'Insalata score was 82 ± 11 . Although our results demonstrate that arthroscopic capsular plication has utility in the treatment of shoulder pain in swimmers who have failed non-operative treatment, the inability of some athletes to return to pre-injury training volume illustrates the difficult nature of shoulder pain in swimmers.

Level of Evidence: Retrospective case series, Level IV

Keywords shoulder laxity · shoulder instability · shoulder pain · swimming · arthroscopic capsular plication

Introduction

Shoulder pain is common in competitive swimmers and frequently interferes with swimming training and competition. The incidence of shoulder pain in swimmers has been reported from 10 to 42% in surveys based in the United States [1, 2]. In elite swimmers, more than half of the athletes report a history of significant, interfering shoulder pain, with 15% reporting bilateral shoulder pain [2]. Over the course of several years, the repetitive arm movement performed by competitive swimmers during training is believed to be the main etiologic factor causing shoulder pain in competitive swimmers.

To our knowledge, only two dedicated studies describe surgical treatment in the symptomatic shoulder in swimmers [3, 4]. McMaster described arthroscopic findings including labral fraying and a hypothetical “bucket-handle” labral tear analogous to meniscal pathology in a group of swimmers with shoulder problems [4]. A second, more recent study by Brushoj et al. describes poor results with labral debridement and subacromial bursectomy with return to swimming rates of 56% [3].

A number of etiologic factors have been proposed to account for shoulder pain in swimmers. In a study of elite swimmers, Sein et al. concluded that supraspinatus tendinopathy, induced by large volumes of swimming training, was the primary cause of shoulder pain [5]. Abnormal shoulder torques [6] and excessive shoulder laxity [7] have also been proposed as factors contributing to shoulder pain in

swimmers. Electromyographic and cinemagraphic comparisons between symptomatic and asymptomatic shoulders have not demonstrated any statistically significant differences between muscle activity patterns [8]. However, symptomatic shoulders demonstrate a higher relative strength of muscles that internally rotate versus those that externally rotate the shoulder. Increased shoulder laxity and abnormalities in muscle balance and scapulohumeral coordination have been found to correlate with symptomatic shoulders [9].

We believe that abnormal laxity often plays a role in shoulder pain in swimmers. Thus, in cases refractory to comprehensive rehabilitative methods, we have surgically intervened with the intention of reducing the degree of capsular laxity present in the shoulder. The purpose of this study is to retrospectively describe our series of competitive swimmers treated with arthroscopic capsular plication with a primary outcome of return to competitive swimming. Secondary outcomes include shoulder pain symptoms, shoulder function, swim times, and training regimen. We hypothesize that capsular plication is effective in diminishing symptoms of shoulder pain in swimmers and effective in returning patients to competitive swimming.

Materials and methods

Institutional Review Board approval was obtained prior to beginning this study, and all patients gave their informed consent prior to their inclusion in the study. From 2003 to 2007, 15 competitive swimmers, who had chronic shoulder pain defined as constant or recurrent pain persisting greater than 6 months, refractory to extensive rest, training modifications, and rehabilitation, were identified. These patients represent a consecutive series of swimmers treated by the senior author, S. R., with arthroscopic capsular plication for shoulder laxity. No patients were lost to follow-up.

On average, 7 months of formal physical therapy was performed prior to making the decision to have surgery. At this point, most patients could not train or compete effectively due to shoulder pain and were faced with the decision to retire from swimming or to be treated surgically. These athletes underwent arthroscopic capsular plication for abnormal shoulder laxity. Global capsular laxity was found in most of these patients, defined as 2+ anterior translation with load and shift testing, 2+ posterior translation, and a 1+ sulcus sign. This was considered to be equivalent to an exam demonstrating multidirectional instability.

The cohort included 11 female and four male competitive swimmers (Table 1). Eighteen shoulders were included

in the cohort as three patients had both shoulders operated upon. The average age of patients at the time of operation was 17 years (range, 12–29 years). The cohort was limited to patients competing for a United States Swimming club team or at the high school, college, or masters level with chronic shoulder pain and a primary diagnosis of capsular laxity. Patients with a history of previous shoulder surgery or a history of traumatic shoulder instability were excluded.

Patients were identified through operative logs of the senior author, and a retrospective chart review was performed. Pertinent data from the history, physical exam, radiographic studies, and operative notes were reviewed, and details from the surgical procedure were recorded. After chart review, each patient was mailed a survey (Table 2) with detailed questions regarding their shoulder injury as it related to their swimming career as well as the outcome of the capsular plication surgery. The patients were also asked to complete American Shoulder and Elbow (ASES) and L'Insalata shoulder surveys. Phone calls were used to clarify incomplete or missing information from the surveys. The average length of follow-up after the procedure was 29 months (range, 8–45).

Operative technique

An interscalene block was administered, and the patient was placed in beach chair position. An examination under anesthesia was performed and graded. The limb was supported in a McConnell arm holder (McConnell Orthopedic Manufacturing Company, Greenville, TX). A posterior portal was established, and a standard diagnostic arthroscopy was performed of both the glenohumeral joint and subacromial space. An arthroscopic “drive-through” sign was noted if present, and characteristics and laxity of the capsule were assessed. The term “drive-through” refers to the ability to easily pass the arthroscope from the posterior joint compartment into the anterior aspect of the joint.

Table 2 Questions from patient survey

How many months of formal post-op physical therapy did you receive before returning to swimming?
What was the length of time after the operation before you returned to competitive swimming?
If you did not return to competitive swimming, what was the reason?
How did your post-op training regimen compare to your pre-op regimen?
What was your average distance per workout prior to surgery?
What was your maximum average distance per workout after surgery and length of time needed to reach that level?
How did your pre-op and post-op swim times compare?
List your personal best times from before surgery and after surgery in your best three events.
What was your reason for having the surgery?
What symptoms do you have in your other shoulder?
Have the symptoms in the other shoulder affected your ability to return to swimming training?
Would you have surgery again if you had to do it again?
Was your post-op pain better, worse, or unchanged compared to your pre-op pain?

Table 1 Patient demographics

Average age	17 years (12–29 years)	
Sex	11 female, 4 male	
Competition level	NCAA Division I	3
	NCAA Division II	4
	USS Club	8

A high rotator interval portal [10] and an anterior portal were placed, and the anterior capsule was gently roughened with a 4.5-mm arthroscopic shaver without detaching the capsule from the labrum. A Lupine anchor (DePuy-Mitek, Rayham MA) was placed at the glenoid articular margin at approximately the 5 o'clock position (for a right shoulder) in a similar manner to an arthroscopic Bankart repair. An arthroscopic suture passer was used to place sutures through the capsular tissue so as to plicate the anteroinferior capsule, an amount based on the surgeon's judgment as to the degree of capsular laxity and redundancy. A 0 PDS suture was shuttled through the suture passer and used as a relay to draw the nearest limb from the anchor into the plicated tissue. The limbs of the suture anchor were tied using a modified Revo knot. Capsular tissue was plicated to an additional two anchors at the 4 o'clock and 3 o'clock positions on the face of the glenoid. If the shoulder continued to demonstrate excessive inferior laxity, a rotator interval closure was performed by passing a PDS suture in a spinal needle through the inferior edge of the rotator interval capsule. The other limb of the PDS suture was passed through the superior capsular tissue using a spinal needle. An Orthocord (DePuy-Mitek, Rayham, MA) or Fiberwire (Arthrex, Naples, FL) suture was shuttled using the PDS suture and then tied inside the capsule to plicate the rotator interval capsule.

Post-operative rehabilitation

Post-operatively, patients were maintained in a sling for approximately 3 to 4 weeks. Isometric exercises for the rotator cuff and deltoid, scapular strengthening, distal range of motion, and Codman's exercises were emphasized during this time period. At 3 weeks, the patient began active and active assisted range of motion exercises for the next 3 weeks. At 6 weeks, strengthening exercises for the rotator cuff and peri-scapular muscles were emphasized. Kicking drills were begun around 8 weeks and then return to the full swimming stroke at approximately 12 weeks. Training was gradually progressed thereafter, with resumption of near-normal training by approximately 6 months.

Results

Pre-operative symptoms and physical examination

Chronic shoulder pain was the most common presenting symptom, with all patients reporting a history of recurrent shoulder pain of several months duration. The primary description was pain at the "top" (eleven of 18, 61%) or the "front" of the shoulder (six of 18, 33%). Additionally, four of 18 (22%) reported posterior shoulder pain. Seven of 18 (39%) of the cohort reported a subjective sense of instability upon presentation. During swimming, the pain most commonly occurred during the pull-through phase of the stroke. All patients underwent a period of extensive rehabilitation prior to operative intervention. The average duration of pre-op physical therapy was greater than 7 months in this cohort. In addition, three patients had received a previous subacromial injection, and two patients

had received a glenohumeral injection with corticosteroid. One patient underwent prolotherapy prior to seeking care at our institution.

Pre-operative physical examination characteristics demonstrated multidirectional shoulder instability and generalized ligamentous laxity (Table 3). Internal rotation at 90° of abduction ranged from 60° to 90° (average, 82.5); internal rotation measured by vertebral level ranged from T5 to T8 (average, T6–T7); external rotation at 90° of abduction ranged from 90° to 120° (average, 102); and external rotation with the arm at 0° abduction ranged from 45° to 90° (average, 77). Forward flexion of the shoulder was recorded as full in all patients. No patients demonstrated scapular winging or scapulothoracic asymmetry. Additionally, 14 of 18 shoulders (78%) had positive impingement signs (Neer or Hawkins' positive), and seven of 18 shoulders (39%) had a positive active compression test. Belly press testing was negative in all shoulders.

Imaging studies

Radiographic studies were obtained in ten patients, none of which demonstrated any glenohumeral pathology. Magnetic resonance imaging was performed in 14 patients. Six scans demonstrated irregularity of the superior labrum, and one scan demonstrated thickening of the anterior capsule. No scan demonstrated an anterior labral tear or humeral avulsion of the glenohumeral ligaments.

Surgical findings

Examination under anesthesia demonstrated global laxity in all shoulders (Table 4). During arthroscopy, all 18 shoulders had a positive drive-through sign and significant capsular laxity. One shoulder had a hypoplastic anterior labrum, and one had a tear of the anterior labrum. One shoulder had a hypoplastic biceps tendon, but no patients had a SLAP lesion. Six patients had hypertrophic bursae, and one patient had an impingement lesion of the rotator cuff. All 18 shoulders underwent capsular plication and 11 shoulders underwent rotator interval closure.

Table 3 Pre-operative laxity examination

	Percentage of shoulders with finding (%)
Sulcus sign	
Trace	30
1+	30
2+	40
Generalized capsular laxity on load and shift	100
Anterior apprehension	44
Thumb-to-forearm	89
Elbow recurvatum	100

Generalized capsular laxity was recorded in patients with excessive translation posteriorly and anteriorly on load and shift testing, with most patients having 2+ anterior and 2+ posterior translation

Table 4 Laxity examination under anesthesia (graded 1+, 2+, or 3+)

	Number (18 total) of shoulders with given degree of translation		
	1+	2+	3+
Anterior	0	13	5
Posterior	3	15	0
Inferior	6	11	1

Post-operative outcome

A total of 12 of 15 swimmers (80%) returned to competitive swimming (Table 5). Of the 12 patients who returned to competitive swimming, six of 12 (50%) had achieved personal best times in their best swimming event at follow-up. All three National Collegiate Athletic Association (NCAA) Division I swimmers in the cohort successfully competed in the NCAA championships upon returning to swimming. On average, patients returned to competition 9 months after surgery. Of note, only 20% of patients (3/15) were able to return to the same training routine while the others had a reduced training regimen. The cohort reported an average distance per workout of 6,400 yards pre-operatively. The average maximum training volume for the 12 swimmers who returned to competition was 5,300 yards per workout post-operatively. Patients reached their maximum training volume at a mean of 11 months after surgery.

For all patients in the study, the average ASES score was 78 ± 16 (average $\pm$ standard deviation). The average L'Insalata score was 82 ± 11 . All patients in the cohort subjectively reported decreased shoulder pain after the surgery, while 11 out of 15 patients report that, in retrospect, they were content with their decision to have the surgery.

With the exception of one patient's age, the three patients who failed to return to competition did not differ significantly from those who returned to competition with regard to competition level, presenting symptoms, or physical examination findings. However, all three patients listed butterfly as their primary stroke, which places greater demands on the shoulder compared to other strokes. One patient was a 29-year-old Masters level swimmer who had stopped competing because she was starting a family. The other two patients were seniors in high school at the time of the operation and chose not to continue their careers at the collegiate level. Both patients cited educational goals as the reason for not returning to competition; one patient reported that continued shoulder pain during swimming also contributed to her decision to retire. Of note, these three patients reported good general shoulder function compared with those swimmers who had returned to competition: the average ASES was 89, and average L'Insalata score was 88. Moreover, all three patients who did not return to competitive swimming reported that their shoulder pain had improved and that they were satisfied with their decision to have the operation.

Discussion

Shoulder pain in competitive swimmers is a difficult management problem due to the cumulative loads associated with repetitive overhead activity. The purpose of this study was to evaluate the efficacy of arthroscopic capsular plication in competitive swimmers with refractory shoulder pain. We demonstrated an 80% return rate to competitive swimming with post-operative personal best times in 50% of those swimmers. Moreover, all patients reported decreased shoulder pain post-operatively. To our knowledge, this is the only study to report a cohort of swimmers with treatment aimed specifically at capsular laxity.

Our results support the hypothesis that arthroscopic capsular plication is helpful in relieving shoulder pain in competitive swimmers and allowing swimmers to return to competition. Also, by induction, our results suggest that capsular laxity is an important contributor to shoulder pain in swimmers. Two studies have described the relatively high prevalence of abnormal shoulder laxity in swimmers. McMaster and Troup reported "recognizable looseness" in 15% of elite female swimmers, and Bak and Faunl reported that 37 of 49 competitive swimmers had increased humeral head translation with associated apprehension [1, 9]. In this study, all patients were found to have capsular laxity and a positive drive-through sign upon examination under anesthesia. Although six patients were found to have bursal proliferation during arthroscopy and one had a superior labral tear, none had rotator cuff or articular cartilage pathology at the time of operation.

Glenohumeral joint hyperlaxity has been addressed in athletes with capsular shift procedures and thermal capsulorrhaphy. Bigliani et al. described a cohort of 63 athletes treated with an anterior–inferior capsular shift procedure for anterior–inferior shoulder instability. Seventy-five percent of these athletes returned to the same level of competitiveness in their sport [11]. In a cohort of 21 overhead athletes with multidirectional instability treated with an inferior capsular shift procedure, Bak et al. reported that 76% of patients returned to their previous sport [12]. Dugas and Andrews described a series of 170 overhead athletes with excessive shoulder laxity treated with thermal capsular shrinkage and found that 81% returned to competition at average of 8.5 months after surgery [13]. In this study, we have found similarly good outcomes in terms of return to sport in a homogeneous group of competitive swimmers with non-traumatic, multidirectional instability.

Table 5 Cohort average swimming and shoulder function data

Returned to competition	80%
Time to return to competition	9 months (range, 4–19)
Average workout before surgery	6,400 yards
Maximum average workout after surgery	5,300 yards
ASES score	78 ± 12
L'Insalata score	82 ± 12

The maximum average workout after surgery included only the 12 athletes who returned to competition

Other studies have evaluated return to competition after surgical intervention in swimmers with shoulder pain with less promising results. Tibone et al. described a case series of 35 shoulders in athletes with impingement syndrome treated with anterior acromioplasty with 44% of patients returning to sport [14]. All six swimmers included in this series were found to have “fair” or “poor” post-operative outcomes, and none were able to return to competitive swimming at follow-up. In a case series dedicated specifically to return to competitive swimming, Brushoj et al. reported that 56% of swimmers treated with labral debridement and subacromial bursectomy returned to their pre-injury level of competition at a mean of 4 months [3].

Although most patients in this case series successfully returned to competitive swimming, the average distance per workout for those who returned to competition was roughly 1,000 yards less when compared with their pre-operative regimen. Additionally, the mean time to return to sport was roughly 9 months. Patients must be prepared for a gradual re-introduction to swimming before returning to high-level competition. The general shoulder function was decreased in these patients as evidenced by ASES and L'Insalata scores of 78 ± 16 and 82 ± 11 , respectively. Although we do not have pre-operative shoulder scores for these patients, the post-operative results indicate reasonable, but slightly worse post-operative outcomes when compared with historical controls. ASES scores of patients of 87 and 88 with traumatic anterior instability treated with arthroscopic or open procedures have been reported, respectively [15]. In multidirectional instability treated with arthroscopic capsular plication, ASES scores of 94 have been reported [16]. Given the cumulative loads placed on competitive swimmers' shoulders, it is not surprising that, while many of these patients may return to training and competition, few of them will be entirely free of pain. This is consistent with the finding that many “uninjured” swimmers have some level of shoulder discomfort with training.

There are limitations to this study. First, this is a retrospective cohort analysis and is not a prospective, randomized comparison between capsular plication and other treatment methods. The placebo effect of operative intervention is very strong, and it is unclear to what degree capsular plication contributes to improvement over prolonged rest and rehabilitation; however, these athletes all had extensive rehabilitation prior to surgery. Additionally, the length of follow-up in this study was 29 months (range, 8–45). We believe that this is an adequate amount of time to evaluate return to competition, the primary outcome in this study. However, a longer follow-up will be necessary to accurately evaluate the longevity of the results of capsular plication and the extent to which patients have recurrent instability upon returning to training and competition. This is a preliminary report on the technique of arthroscopic capsular plication in swimmers, and further studies with longer follow-up will be needed in the future.

There remains debate about the etiology of shoulder pain in swimming. Shoulder pain in swimmers is most likely multi-factorial. We believe that repetitive overhead

activity results in rotator cuff fatigue, leading to muscle dysfunction and loss of the rotator cuff's role in stabilizing the humeral head. When combined with underlying laxity, the result is altered shoulder kinematics, ultimately resulting in shoulder pain. Similar to other overhead athletes with shoulder laxity, not all swimmers with laxity are symptomatic. Laxity may also have some relationship to swimming technique, training activities, and competition. Understanding these relationships may improve our understanding and treatment of shoulder pain in swimming.

This study documents the results of capsular plication in swimmers. Based on the premise that capsular laxity plays an important role in the pathology of swimmer's shoulder, this approach appears to have measured success in reducing pain and has acceptable rates of return to competitive swimming in this challenging group of patients. However, it is important to emphasize that these gains do not restore full function as evidenced by patient-rated validated outcome measures.

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