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Postarthroscopic Glenohumeral Chondrolysis

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Background: Recent reports have noted the appearance of postarthroscopic glenohumeral chondrolysis. Although this devastating process has been identified, no cause has been directly identified.

Hypothesis: A cause of postarthroscopic glenohumeral chondrolysis will be associated with a specific factor (ie, implanted device, surgical technique, etc), and this factor can be identified by a review and comparison of cases seen in the senior author's office.

Study Design: Case series; Level of evidence, 4.

Methods: Analyze possible etiologic factors with imaging studies, demographics, history, and physical examinations of 10 patients (12 shoulders) with postarthroscopic glenohumeral chondrolysis, and then compare perisurgical information with a focused chart review and comparison with the rest of the 177 arthroscopic shoulder surgeries in the same period of time.

Results: There were 12 cases of postarthroscopic glenohumeral chondrolysis (all were the senior author's patients). Four common factors were identified, and only high-flow intra-articular pain pump catheters filled with bupivacaine and epinephrine were a new addition to years of shoulder surgery by the senior author; 177 shoulders underwent arthroscopy in the identified time frame, and only 19 shoulders, of 30 with capsular procedures, had intra-articular pain pump catheters filled with bupivacaine and epinephrine. Of these, 12 have been identified with chondrolysis.

Conclusion: Use of intra-articular pain pump catheters eluting bupivacaine with epinephrine appear highly associated with postarthroscopic glenohumeral chondrolysis.

Clinical Relevance: Intra-articular pain pump catheters, especially those eluting bupivacaine with epinephrine, should be avoided until further investigation.

Keywords: chondrolysis; arthroscopy; shoulder; pain pump; bupivacaine; epinephrine

Postarthroscopic glenohumeral chondrolysis (PAGCL) has only recently been reported in the literature.²⁶ The cause of this process is unknown, but the consequences are devastating. This condition currently has no effective treatment. Most affected patients ultimately must consider some type of glenohumeral arthroplasty. When chondrolysis occurs in a younger patient, glenohumeral arthroplasty becomes even more problematic.

The authors have encountered 12 cases of chondrolysis after arthroscopic shoulder stabilization procedures. The

purpose of this retrospective case review is 2-fold: first, to report our experience with this condition, and, second, to attempt to discern its origin by looking at factors common to these cases to identify present and future patients at risk for developing this condition.

METHODS

The patients with PAGCL were identified after the index procedure by having all of the following findings. (1) Symptoms of increasing pain. The pain was both at rest and with motion (usually increased with motion). (2) Crepitus and decreasing active motion due to pain. Passive and active forward elevation and abduction were examined, as well as internal and external rotation at neutral and 90° of abduction (strength with these motions was also noted). All motions were noted in degrees except neutral internal rotation, which was noted by the level of hip,

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Figure 1. Preoperative radiograph of a 26-year-old male patient with appropriate glenohumeral joint space.



Figure 2. Postoperative radiograph of the same patient as in Figure 1 three months after arthroscopic labral repair and intra-articular placement of pain pump catheter that eluted bupivacaine 0.25% with epinephrine.

sacrum, or spinous process the patient was able to touch with his or her thumb. Range of motion was compared with that at previous visits. (3) Glenohumeral joint space narrowing on a “true” AP radiograph, Grashey view (a 20% or greater loss of joint space could easily be seen with a 15% magnification ruler). The radiographs were only taken of patients who demonstrated the previously noted clinical symptoms. Figures 1 and 2 show examples of the preoperative and postoperative radiographs in a 26-year-old patient with PAGCL. Axillary views were not obtained on all patients.

After these patients were identified, aspiration, serology, MRI (T1- and T2-weighted with fat saturation without contrast), and basic patient and examination demographics were obtained and noted (Table 1). We also reviewed the operative information on those shoulders with PAGCL (Table 2).

After finding a suspected common etiologic factor from these 10 patients (12 shoulders), we reviewed the records of all 152 patients (177 shoulders) who underwent arthroscopic shoulder surgery (all were patients of the senior author) during the period from August 2003 to March 2005. This time frame was determined by the earliest patient identified with PAGCL to the time this article was written. The chart review was only to identify the operative factors noted in Table 2 to determine any differences. The authors had not experienced this complication before this time; specific attention was directed toward determining any changes in technique from prior patients treated by the senior author.

RESULTS

Our review revealed 177 shoulder arthroscopies performed on 152 patients over a 19-month period between August 15, 2003, and March 15, 2005. Of these cases, 125 shoulders underwent procedures isolated to the bursal space (ie, subacromial decompression, distal clavicle resection, rotator cuff repair, or some combination thereof). Eighteen shoulders underwent procedures involving both bursal and glenohumeral surgery (combined instability repair and rotator cuff surgery). Thirty-four shoulders underwent stabilization procedures alone. Of these, 30 shoulders in 28 patients underwent arthroscopic stabilization, and 4 shoulders in 4 patients underwent open stabilization.

The 12 shoulders with PAGCL were from the group of 30 arthroscopic shoulder stabilization procedures. They were identified based on our criteria of increased pain, stiffness, and crepitus (with or without decreased range of motion) and loss of the glenohumeral joint space as shown on radiographs. All 12 shoulders had been treated with arthroscopic stabilization for symptomatic instability. Table 3 shows the operative histories of the 12 affected patients.

Two patients had bilateral procedures. Surgical indication for 3 shoulders was symptomatic multidirectional instability that did not improve with either a home exercise program or formal physical therapy. Nine shoulders were treated for posttraumatic instability.

TABLE 1
The PAGCL Patient Evaluation^a

Patient	Motion Evaluation Compared With Previous Office Visit	Radiographic Changes (JSN)/MRI	Rheumatology Panel (RF, ANA, CRP, UAC, CBC, ESR)	Shoulder Aspiration (C&S, GS, CC, Crystals)	Intraoperative Specimens on Subsequent Surgeries	Other Notes
1 R	↑ Pain POW 12 with 20° ↓ ER 90°, FE, ABD	100% JSN POM 3/SHEC	Negative	Negative	Humeral head: changes of DJD	2/3 cartilage denuded with conical marrow changes centered on denuded cartilage
2 ^b L	Painful PFROM	95% JSN POM 3/SHEC	Negative	<i>Propionibacterium</i> sp (contaminant)	Humeral head: changes of DJD	Hyperemic synovitis, chalky, flaking cartilage
R	Painful PFROM	50% JSN POM 5	Negative	Negative		Sought second opinion
3 R	Painful PFROM	60% JSN POM 12	Negative	Negative		No follow-up, unable to contact after diagnosis
4 L	Painful PFROM	95% JSN POM 13	Negative	Negative		Sought second opinion
5 ^b L	↑ pain POW 12; 30° ↓ FE, ABD, ER 90°	80% JSN POM 5/SHEC	Negative	Negative		Sought second opinion, hyalagan unsuccessful
R	Painful PFROM	40% JSN POM 3	Negative	Negative		Sought second opinion
6 R	Painful PFROM	90% JSN POM 4/SHEC	Negative	Negative	Humeral head: changes of DJD	Diffuse fimbriated cartilage
7 R	↑ pain POW 5; 60° ↓ FE, ABD, ER 90°	90% JSN POM 3	Negative	Negative	AVN	AVN noted after failed humeral resurfacing
8 L	Painful PFROM	90% JSN POM 15	Negative	Negative		Sought second opinion
9 L	Painful PFROM	90% JSN POM 8/SHEC	Negative	Negative		Sought second opinion
10 L	Painful PFROM	90% JSN POM 9	Negative	Negative		No follow-up, unable to contact after diagnosis

^aPAGCL, postarthroscopic glenohumeral chondrolysis; JSN, glenohumeral joint space narrowing; RF, rheumatoid factor; ANA, antinuclear antibodies; CRP, C-reactive protein; UAC, uric acid crystals; CBC, complete blood count; ESR, erythrocyte sedimentation rate; C&S, culture and sensitivities; GS, gram stain; CC, cell count; R, right; L, left; ↑, increased; ↓, decreased; POW, postoperative week; ER 90°, external rotation at 90° abduction; FE, forward elevation; ABD, abduction; POM, postoperative month; SHEC, subchondral humeral head edema and chondrosis of articular surface; DJD, degenerative joint disease; PFROM, passive full range of motion; AVN, avascular necrosis (osteonecrosis).

^bBilateral.

TABLE 2
Initial Operative Information^a

Patient	Side	Procedure ^b	Lavage Fluid	Radiofrequency Probe	Pain Pump	Suture Anchor	Suture	Position	Surgical Indication	Postoperative Ketorolac	CM Preoperative: Grade 1-4
1	Right	CS (1)	LR	VU	Yes	None	E, PDS	LD	MDI	None	None
2 ^c	Left	PB (1)	GL	VU	Yes	3 BK	P, E, F	LD	TI	K	2 G, 2 HH
	Right	PB (1)	GL	None	Yes	2 BK, Pc	P, E, F	LD	TI	K	1 G, 1 HH
3	Right	AB, SLAP (1)	GL	None	Yes	BT, BK	F, P	LD	TI	K	1 G
4	Left	AB (1)	GL	None	Yes	BK	PDS, P, E	LD	TI	K	2 G, 1 HH
5 ^c	Left	AB, PB (1)	GL	None	Yes	Pc	P, E, F	LD	TI	K	1 G, 1 HH
	Right	CS (1)	GL	None	Yes	None	E, PDS	LD	MDI	K	None
6	Right	AB, CS (1)	GL	VA	Yes	BK	PDS, P, E	LD	TI	None	None
7	Right	AB, CS (1)	LR	None	Yes	Yes	E	BC	TI	None	2 G, 2 HH
8	Left	CS (1)	GL	None	Yes	None	E, PDS	LD	TI	K	None
9	Left	CS (2)	GL	VU	Yes	G2	E, F, PDS	LD	MDI	K	None
10	Left	AB, CS (1)	GL	None	Yes	BK	PDS, P, E	LD	TI	K	None

^aCS, capsular shift; AB, anterior Bankart; PB, posterior Bankart; SLAP, superior labral anterior posterior; LR, lactated ringers; GL, glycine; VU, Vulcan Sapphire (Smith & Nephew, Andover, Mass); VA, VAPR (Arthrex, Naples, Fla); BK, BIOKNOTLESS (Mitek, Norwood, Mass); Pc, PANALOK (Mitek); BT, Bio-Suture Tak (Arthrex); G2, Mitek G2 anchor; E, Ethibond; PDS, polydioxanone suture; P, Panacryl; F, Fiberwire; LD, lateral decubitus; BC, beach chair; MDI, multidirectional instability; TI, traumatic instability; K, Ketorolac; CM, chondromalacia; G, glenoid; HH, humeral head; Yes, unknown anchor.

^bThe (1) indicates primary procedure, and (2) indicates secondary procedure.

^cBilateral.

TABLE 3
Subsequent Surgeries After Index Procedure^a

Patient	Affected Side	Subsequent Surgery			Additional Complications
		1	2	3	
1	Right	HABR			
2 ^b	Left	AMF, AD	HABR	MUA	Arthrofibrosis, PT
	Right	AMF, AD, HWR	AD, LBR		
3	Right				Fractured anchor left in bone
4	Left	HABR ^c			Arthrofibrosis, PT
5 ^b	Left	MUA	HABR ^c		Arthrofibrosis, PT
	Right				
6	Right	AD	HABR		
7	Right	HWR, CS ^c	RsTSA ^c	RevTSA ^c	No relief
8	Left	AD			
9	Left	HABR ^c			
10	Left	AMF, AD			

^aHABR, hemiarthroplasty with biological resurfacing; AMF, arthroscopic microfracture; AD, arthroscopic debridement; HWR, hardware removal; MUA, manipulation under anesthesia; CS, capsular shift; LBR, loose body removal; RsTSA, resurfacing total shoulder arthroplasty; RevTSA, revision total shoulder arthroplasty; PT, physical therapy.

^bBilateral.

^cPerformed by another surgeon.

The procedures included 5 capsular shifts, 6 anterior Bankart repairs, 3 posterior Bankart repairs, and 1 superior labral anterior posterior repair. Five shoulders had some combination of these procedures. Three shoulders had cartilage lesions; all were grade 2 or less at the index arthroscopic procedure (Table 2).

All surgeries but 1 in the chondrolysis group were done with the patient in the lateral decubitus position. Of those shoulders with lateral decubitus positioning, traction time averaged 84 minutes (range, 26-150 minutes) with a range of 5 to 14 lb distal and 5 to 17 lb proximal. Glycine lavage was used in 10 involved shoulders (for improved conduction if there was a need for a thermal probe) and Ringer's lactate in 2.

A thermal radiofrequency probe was used in 4 shoulders in the chondrolysis group to augment the capsular shift effect of a labral repair. In the nonchondrolysis group, thermal probes were used intra-articularly in 51 cases. Various sutures and anchors were used in these procedures without a consistent frequency between types (Table 2). Anchors were made of absorbable polylactic acid (Depuy Mitek, Raynham, Mass) and poly(L-Lactide-co-D, L-Lactide) (Arthrex, Naples, Fla). Two patients had only suture placed (no anchor). One patient in the chondrolysis group had a broken anchor inserter tip noted on postoperative radiographs after the index procedure. This was retrieved at a second procedure after chondrolysis was diagnosed. The metal fragment measured 3 × 1 mm and was encapsulated within the synovium at the time of retrieval.

A preoperative and postoperative intra-articular injection was given in all 12 shoulders consisting of 25 mL of 0.25% bupivacaine HCL (BH) with epinephrine and 5 mg of morphine sulfate without preservative. Ketorolac 30 mg was added to the postoperative injection in 9 of the 12 shoulders that went on to chondrolysis.

All affected shoulders had postsurgical intra-articular pain pump catheters (Stryker Instruments, Kalamazoo, Mich) placed in the shoulder with a drip rate of 4.16 mL/h and filled with 250 mL of 0.25% BH with epinephrine. The patients were told to remove the pain pump catheter from their shoulders 2 days after surgery.

All patients had previously made significant gains in motion after surgery and appeared to be recovering as expected initially, after a period of immobilization lasting 4 weeks. They were noted in the chart review to have progressed with motion and function with physical therapy during postoperative weeks 5 to 12 and subsequently were prescribed a home/gym exercise program. Postoperative clinic notes indicated good clinical and functional return of glenohumeral stability in all patients. All affected patients then were seen with complaints of new onset of pain, stiffness, increased pain with motion, and crepitus within the first year after surgery (range, 3-12 months). Each patient had radiographic evidence of glenohumeral joint space narrowing at the time of diagnosis. Active motion was limited in nearly all patients because of pain and was significantly decreased when compared with the office visits before the onset of their symptoms. Although active motion often decreased because of patient guarding, most patients could obtain full passive range of motion at each follow-up office examination; crepitus was a common feature. Mean onset of symptoms from the time of the index procedure was 4.3 months (range, 3-13 months). Mean age at surgery was 28.9 years (range, 16-47 years).

Rheumatology and serology study results were normal in all chondrolysis patients. Needle aspiration findings of all affected shoulders were negative for an infectious process in all but 1 case. One shoulder culture finding was positive for *Propionibacterium* sp, which grew on 1 of 3 agar plates and was believed to be a contaminant by the hospital's microbiology department. No further evidence of infection developed

subsequently in any patient, and none were treated with antibiotics other than perioperatively. Operative specimens from those patients returning to surgery to treat their chondrolysis included excised humeral heads in 3 patients, which demonstrated cystic changes with giant cells, lymphocytes, and eosinophils, without necrotic bone, and were read by the pathology department as end-stage osteoarthritis. No evidence of osteonecrosis was noted on either microscopy or MRI (Table 1).

At the time of this data collection, 10 patients (10 shoulders, 83%) had been returned to the operating room for at least 1 additional procedure after diagnosis of PAGCL (Table 3).

In addition, further surgery is contemplated in 3 shoulders, 2 having failed to improve by 6 months postoperatively after debridement and microfracture. At last follow-up (range, 5-25 months), all patients continued to have some complaints of disability and pain despite partial improvement after these treatments.

On chart review of the 152 patients treated in this same time frame, another 104 patients were treated with the same preoperative and postoperative injection and pain pump techniques described above but with the catheters placed extra-articularly (superficial to the rotator cuff tendons). None of these patients experienced chondrolysis based on our chart review. Of the 30 arthroscopic stabilization procedures, 19 shoulders in 17 patients were given intra-articular pain pump catheters, of which 12 have developed chondrolysis thus far (63%). An additional 13 patients were treated with arthroscopic stabilization but no pain pump catheters, and none of these patients have since developed symptoms related to PAGCL, as confirmed by continued clinical follow-up through the first postoperative year.

DISCUSSION

Postarthroscopic glenohumeral chondrolysis is a devastating complication that has yet to be etiologically defined. Petty et al²⁶ reviewed several known factors involved in chondrolysis, including gentian violet ("color test"), Chlorhexidine, methyl methacrylate, meniscectomy, thermal radiofrequency energy, HO:YAG laser, prominent hardware, chronic synovitis, and fibronectin (glycoprotein).^{14-16,19,20,22}

Thermal radiofrequency energy was used in 4 of 13 cases presented here. Although suspected as an etiologic factor by some authors,^{9,10,13,19,20} it does not appear to be clearly proven to be the only factor in these cases.

Loose metallic hardware (a broken inserter tip from a suture anchor) was seen in only 1 of our cases. There is limited available literature suggesting a secondary, nonmechanical, immunogenic process that may further erode the hyaline cartilage when a mechanical process, such as pin protrusion, has occurred.^{2,27} The metallic fragment was incorporated within the synovium of this patient and is not suspected to have contributed to chondrolysis in this patient or series.

The use of various suture and anchor types without a consistent pattern seems to preclude their implication as an etiologic factor (Table 2).

No known association of chondrolysis with traction type or time was identified in the literature, nor could we implicate those factors in this series. Glycine lavage was used in all but 2 cases in this series. Ringer's lactate was used in the other 2 cases. There is no known adverse effect of Ringer's lactate⁵ or glycine lavage on articular cartilage. In 1987, Bert⁴ looked at glycine lavage when used with electrocautery and found no evidence of synovial damage or histopathology when chondrocyte function was evaluated with safranin O staining. Glycine has been associated with hyponatremia⁷ and transient blindness³ after arthroscopy. The senior author has used glycine in the vast majority of shoulder and knee procedures he has performed over the past 18 years and has had no prior identifiable cases of chondrolysis. Therefore, we do not believe that traction type, time, or fluids were contributory.

Aside from the same surgeon performing all of the procedures on the patients (C.L.B.), the 1 consistent factor in every patient with chondrolysis is that all of the patients received intra-articular pain pump catheters that eluted 0.25% bupivacaine and epinephrine, and all were arthroscopic capsular procedures. The bupivacaine used in these patients was from several different vendors used by the hospital where the procedures were done.

Bupivacaine is similar to lidocaine but is slightly more lipid soluble and binds protein to a greater extent.¹⁸ It is typically medically administered in the operating room as methyl paraben-free BH to avoid the potential allergic reaction possible from methyl paraben, a potent antiseptic preservative.²⁴ According to the package insert, BH has a half-life of about 2.7 hours in adults and 8.1 hours in neonates; these are increased when epinephrine is added (owing to capillary constriction of epinephrine and delayed local resorption). The pH of methyl paraben-free BH with epinephrine is between 3.3 and 5.5. Stomach acid can be higher than pH 4.0 in conditions such as achlorhydria.¹¹ Although BH is considered a "weak" acid, it can lean toward the acidic side of "weak" acids at pH 3.3. Epinephrine may have played a role in this series. It has been shown to increase neurotoxicity when added to lidocaine.¹²

Nole et al²⁵ looked at $^{35}\text{SO}_4$ incorporation into articular cartilage after intra-articular bupivacaine injection in pigs and dogs. Recovery of $^{35}\text{SO}_4$ incorporation at 1 to 3 days was seen, and therefore no contraindication to intra-articular bupivacaine was found. Dogan et al⁸ looked at the histopathologic affect of intra-articular bupivacaine in rabbits and found articular inflammatory cell infiltration and synovial hypertrophy and hyperplasia when specimens were examined microscopically on days 1, 2, and 10 after the initial injection. These results were compared with those of a saline control group in a blinded fashion. Day 10 showed the most significant inflammatory changes from bupivacaine. These studies looked at a single injection of bupivacaine without epinephrine. No one has yet examined and reported, to the authors' knowledge, on the effects of a constant infusion of BH, either at 2.08 mL/h (as in the pain pump catheters available and used by the surgeon before this series) or at a 4.16 mL/h rate (as used in the

current series), for 24 to 72 hours on hyaline cartilage in vivo. This rate is eluted within the glenohumeral joint, which is a confined space with a limited capacity. This space is reduced further after capsulorrhaphy procedures.

Bupivacaine with epinephrine contains sodium metabisulfite and can cause an allergic reaction in the sulfa-allergic patient (no patients had known sulfa allergies). Possibly there is a secondary link to inflammation and chondrolysis. It is known that inflammatory processes have been implicated in destructive arthritis, as this has been experimentally evaluated.^{21,29} Ketorolac injections have been shown to induce an inflammatory response in both the synovium and hyaline cartilage of animals.¹⁷ We doubt it played a significant role in these chondrolysis patients as it was only used in 9 of the 12 shoulders, and there are no cases of chondrolysis in the 177 comparison patients, of whom 82 had this Ketorolac added to their postoperative injections.

When glucose is added to bupivacaine in regional anesthesia, it appears that less volume is needed to obtain a desired anesthetic affect, and speed of onset is increased.^{3,7,30} A hyperosmolar effect (that may irritate nerves with spinal anesthesia) may have occurred with bupivacaine or in combination with the glycine used in all but 2 patients.^{7,28} This may induce a cartilage dehydration, which can lead to chondrocyte degradation as with the effect of dimethyl sulfoxide on the water content of a chondrocyte matrix.²³

We did not evaluate fibronectin release, although it is implicated in chondrocyte cellular breakdown by proteoglycan suppression.^{1,14-16,22} Cartilage destruction is likely a combination of mechanical and chemical factors.

Most patients' initial symptoms of pain and progressive motion loss occurred by 3 to 5 months after surgery. Radiographic breakdown was typically seen by 5 or 6 months. It is suspected by the authors that the insult to the articular cartilage that led to chondrolysis occurred in the intraoperative and perioperative period. The onset of symptoms and signs is suspected to have been delayed for a few months because of postoperative protected mobilization and lack of significant compressive forces seen by the damaged hyaline cartilage. The hyaline cartilage was thus relatively protected until after 3 months after surgery, at which time increasing forces from more aggressive activities and resistance exercises caused mechanical degradation of the compromised surfaces. Whatever the mechanism may be, the senior author has not seen chondrolysis in arthroscopic shoulder patients before the use of this high-flow pain pump catheter with bupivacaine and epinephrine. It should be noted that 27 of the 177 patients had the high-flow pain pump catheters used in the bursal side, and none have had reported chondrolysis to date.

We believe this information is important to disseminate to the orthopaedic community at large. A recent publication from Chu et al⁶ showed that 0.5% bupivacaine was indeed cytotoxic to bovine cartilage.

The incidence of chondrolysis in this series is startlingly high, with 12 shoulders out of 177 total shoulder surgeries (6.8%). Of those who received arthroscopic capsular stabilization with postoperative intra-articular pain pump catheters with bupivacaine and epinephrine, 63% developed

chondrolysis. The authors have had no other known patients with chondrolysis before or since the dates of this study.

CONCLUSION

We have identified a concerning and strong association between postarthroscopic chondrolysis and intra-articular pain pump catheter use with bupivacaine and epinephrine. It is likely that other unrecognized factors are also involved. Thermal and/or radiofrequency, suture material, and reabsorbable suture anchors may have played a role not yet completely understood at this time. Until further investigation has been done, the authors recommend that the use of intra-articular pain pump catheters in combination with bupivacaine with or without epinephrine be avoided in all joints with an intact cartilage surface. Furthermore, the effective treatment of chondrolysis remains elusive. We believe that further investigation of the possible association of pain pump use with chondrolysis is warranted.

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