Glenohumeral Arthrosis in Anterior Instability Before and After Surgical Treatment

Incidence and Contributing Factors

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Background: Few large series of arthropathy related to anterior glenohumeral instability are available in the orthopaedic literature, preventing analysis of the incidence and the risk factors of preoperative and postoperative glenohumeral arthritis.

Hypothesis: Anterior stabilization surgery influences the risk factors of glenohumeral arthritis.

Study Design: Retrospective review.

Methods: There were 570 patients who underwent an instability procedure. Clinical and radiographic preoperative data were collected for these patients. Arthritis was evaluated preoperatively and postoperatively with the Samilson classification. The mean age at surgery was 31.9 years. Follow-up averaged 6.5 years.

Results: The preoperative incidence of arthritis was 9.2%. Arthritic risk factors were older age at the initial dislocation and at surgery, increased length of time from the initial dislocation until surgery, and the presence of osseous glenoid rim lesions. Postoperative arthritis in patients without any preoperative arthritis occurred in 19.7% and was correlated with older age at the initial dislocation and at surgery, increased number of dislocations, and longer follow-up. Decreased external rotation at latest follow-up correlated with arthritis, although whether this was the cause or the effect was unclear.

Conclusions: Similar factors contribute to preoperative and postoperative arthritis in patients with anterior glenohumeral instability, suggesting that surgery does not influence the risk factors of arthritis. Although decreased external rotation with the arm at side statistically correlated with arthritis in this study, the authors were unable to establish this as an effectual relationship because nearly all patients with glenohumeral osteoarthritis, whether instability related or not, have decreased external rotation.

Keywords: glenohumeral; arthritis; instability; surgery

Neer et al initially reported glenohumeral arthritis after anterior shoulder instability.[20] In 1982, they reported on 26 shoulder arthroplasties performed for arthritis in patients with prior anterior or posterior instability, most of whom had been treated with prior surgery aimed at stabilizing the glenohumeral joint. Samilson and Prieto later reported on 74 patients with arthritis and prior shoulder instability (62 of 74 cases had anterior instability), coined the term *dislocation arthropathy,* and classified this entity radiographically.[25] In addition, they observed that the older age at the time of initial dislocation and the direction of dislocation (posterior more than anterior) influenced the severity of the arthritis that developed. Contrarily, they found that prior stabilizing surgery, the number of dislocations, or the presence of glenoid or humeral osseous lesions played no role in the development of arthritis.

In 1990, Neer reported on 61 shoulder arthroplasties performed for arthritis secondary to prior anterior or posterior glenohumeral instability.[19] Because most of his patients had undergone prior stabilizing surgery, Neer believed that the arthritis he observed was largely related

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to previous instability surgery, as many of the shoulders in this series demonstrated subluxation in a direction opposite of the initial instability, presumably because of excessive tightening of the shoulder at the time of stabilization surgery. Hovelius et al followed 129 shoulders with prior nonoperatively treated anterior shoulder instability for 10 years and found no correlation between the number of dislocations and the severity of arthritis.[11] To our knowledge, these are the only instability arthropathy series including patients with prior nonoperatively treated glenohumeral instability.

In contrast, arthritis developing in patients with prior operatively treated glenohumeral instability has been extensively reported. The incidence of arthritis after operative treatment of anterior shoulder instability has ranged from 12% to 62%.[1,4,22,24] Arthrogenic factors in these patients have included intra-articular hardware,[21,28] a laterally overhanging bone block,[7] and excessive anterior soft tissue tightening, particularly after a Putti-Platt procedure.[3,8,15,16,29] Matsen et al have coined the term *capsulorrhaphy arthropathy* for patients developing arthritis as a consequence of overly tightened soft tissues.[18]

The purpose of this study was to examine factors contributing to the development of arthritis both before and after operative stabilization in patients with operatively treated anterior shoulder instability. In addition, we aimed to evaluate the effectiveness of stabilizing surgery in influencing these arthritic risk factors.

MATERIALS AND METHODS

Files of 1295 patients operatively treated for anterior shoulder instability in 13 centers (each with a shoulder subspecialist) were reviewed. Of these files, 570 patients had at least 3 years of clinical and radiographic follow-up, qualifying them for inclusion in the study population. This same patient population had been previously used to compare the results of 3 different types of operative techniques.[5] The other 725 patients had inadequate follow-up, had inadequate radiographs, or were lost to follow-up.

The population studied consisted of 70.7% male subjects, with the dominant extremity affected in 62.8% of cases. Seventy-two percent of patients reported multiple glenohumeral dislocations (mean, 6.8 dislocations), 48.2% reported multiple subluxations (mean, 17.5 subluxations), 24.1% reported having had both a dislocation and a subluxation of their shoulders, and 3.6% recalled no instability episode but had symptoms (pain) of at least 6 months' duration and indisputable findings (radiographic evidence of a Hill-Sachs lesion or bony lesion of the anterior glenoid rim; magnetic resonance imaging demonstrating a Bankart lesion) consistent with anterior shoulder instability at the time of surgery. Age at the time of the first instability episode was 25.1 years (range, 17-44.5 years), with a mean age at the time of surgery of 29.4 years (range, 21-50 years).

Eighty-seven percent of patients participated in sports (36% competitively and 51% recreationally). Using the system of Duplay,[27] 30% were classified as participating in contact sports, 19% were classified as participating in overhand sports, and 28% were classified as participating in a throwing or high-risk sport.

All patients underwent preoperative radiographs, including anteroposterior views with the humeral head in neutral, internal, and external rotation, as well as bilateral glenoid profile views using the technique described by Bernageau and Patte.[2,6] All radiographs were taken under fluoroscopic control to ensure quality and reproducibility. Radiographs were reviewed by a single evaluator at each center (total of 13 evaluators). Using these radiographs, 53% of patients had a bony lesion of the anterior glenoid, including 24.2% with an obvious fracture fragment, 26.7% with a rounding off of the normal contour of the anterior glenoid margin, presumably from multiple microimpaction fractures, and 2.1% with a large anterior glenoid deficit but no visible fracture fragment (the fracture fragment has presumably been resorbed). In addition, a humeral head impaction fracture was noted in 65.6% of cases.

One of 3 operative procedures was performed on patients in this series, including 279 coracoid transfer procedures, 217 open soft tissue reconstructions, and 74 arthroscopic stabilizations. The coracoid transfer procedures were performed through a deltopectoral approach, splitting the subscapularis in line with its fibers in 64% of cases, performing a superior two-thirds subscapularis tenotomy in 35% of cases, and performing a complete subscapularis tenotomy in 1% of cases.[26] The coracoid was fixated lying on its side in 95% of cases with either 1 (35%) or 2 (65%) screws. In 78% of cases, the joint capsule was sutured to the stump of the coracoacromial ligament.

The open soft tissue procedures were performed through a deltopectoral approach, splitting the subscapularis in line with its fibers in 5% of cases, performing a superior two-thirds subscapularis tenotomy in 26% of cases, and performing a complete subscapularis tenotomy in 69% of cases. A glenoid-based capsulotomy was performed in 54% of cases, and a humeral-based capsulotomy was performed in 46% of cases. Sixty-six percent of patients underwent a capsulolabral repair augmented with a capsular shift, 28% underwent an isolated capsulolabral repair, and 6% underwent an isolated capsular shift. The capsulolabral repair was performed transosseously in 56% of cases and with the use of suture anchors in the remainder of cases. Of the cases in which a subscapularis tenotomy was performed, the subscapularis tendon was repaired anatomically in 68% of cases and plicated in 32% of cases.

For the arthroscopic stabilizations, patients were placed in the beach-chair position in 53% of cases and in the lateral position in the remainder. Two arthroscopic portals were employed in 66% of cases, 3 were employed in 22% of cases, and 4 were employed in 12% of cases. In all cases, a capsulolabral repair was performed using suture anchors. Twelve percent of cases also underwent anteroinferior laser capsular shrinkage as a concomitant procedure.

All patients had postoperative radiographs at their latest follow-up, including an anteroposterior view with the arm in neutral rotation. In all patients, the preoperative and latest follow-up neutral rotation anteroposterior radiographs were reviewed by a single evaluator at each

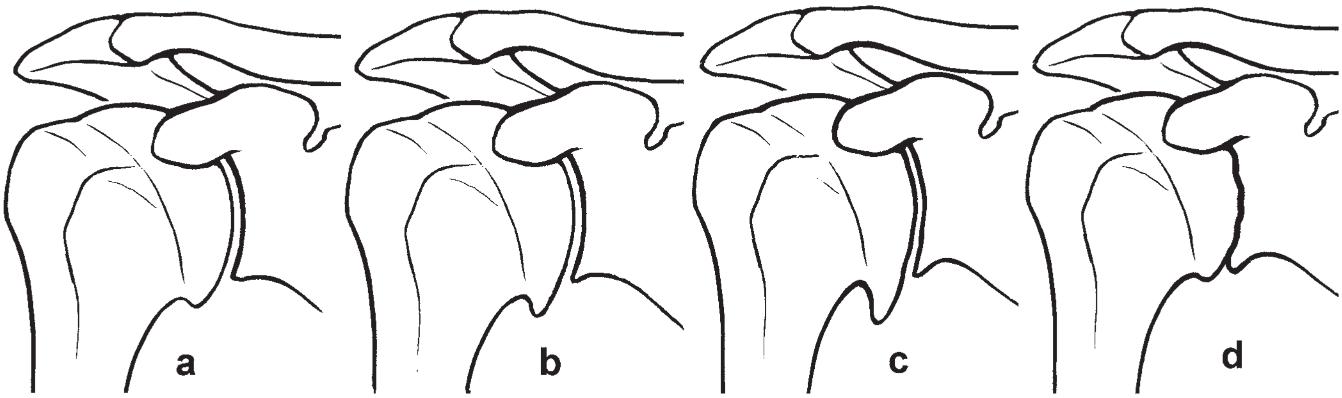

Figure 1. Modified Samilson and Prieto[25] classification. a, stage 1, humeral osteophyte measuring less than 3 mm; b, stage 2, humeral osteophyte measuring at least 3 mm but less than 8 mm; c, stage 3, humeral osteophyte measuring at least 8 mm; d, stage 4, complete obliteration of the glenohumeral joint space.

center (total of 13 evaluators). Glenohumeral arthritis was classified preoperatively and postoperatively using these radiographs, employing a modification of the system of Samilson and Prieto (Figure 1).[25] Using this system, stage 1 consists of osteophytes measuring less than 3 mm in greatest diameter; stage 2 consists of osteophytes measuring between 3 and 7 mm in greatest diameter, with slight glenohumeral joint irregularity; and stage 3 consists of osteophytes measuring more than 7 mm in greatest diameter, with narrowing of the glenohumeral joint and sclerosis. Osteophytes may be located on the humerus, the glenoid, or both. Stage 4 was added to the original system and consists of complete obliteration of the glenohumeral joint space with or without osteophytes (stage 4 was included with stage 3 in the original classification system). Stages 1 through 3 do not involve complete obliteration of the glenohumeral joint space. Specific observations were made for the presence of preoperative arthritis, progression of arthritis on the postoperative radiographs in patients with evidence of preoperative arthritis, and development of arthritis on the postoperative radiographs in patients without preoperative arthritis. Preoperative data are shown in Table 1 (entire population) and Table 2 (patients without preoperative arthritis). In addition, patients were evaluated postoperatively using a Duplay mobility score and measurement of external rotation with the arm at the side.[27]

Statistical analysis was carried out by a professional statistician using StatView software (SAS, Cary, NC). The χ^2 test was used in the evaluation of qualitative variables, and Spearman's test was used in the evaluation of quantitative variables. Association of qualitative variables was analyzed with the χ^2 test and contingency tables. Association of quantitative variables was analyzed with the nonparametric correlation coefficient of Spearman. Association of qualitative variables with quantitative variables was analyzed by factor variance. Multiple comparisons of means were employed if the variable included more than 2 modalities. Finally, a multivariate statistical analysis was employed. Significance was set at $P < .05$.

RESULTS

Follow-up in this series averaged 77 months (range, 37-198 months). Arthritis was apparent on preoperative radiographs (Table 3) in 8.5% of patients, including 6.7% stage 1, 1.4% stage 2, and 0.4% stage 3. There were no cases of

TABLE 1
Data Divided by Type of Operative Procedure of the Entire Study Population

Characteristic	Coracoid Transfer (n = 279)	Open Soft Tissue (n = 217)	Arthroscopy (n = 74)	Total (N = 570)
Follow-up, y	6.3	7.7	3.4	6.5
Males, %	74.2	66.8	68.9	70.7
Hand dominance, %	62.7	63.1	62.2	63.0
Competitive athletes, %	30.6	36.9	52.7	35.9
Recreational athletes, %	56.5	46.5	43.2	51.0
Contact athletes, %	31.9	27.6	32.4	30.4
Overhand-throwing athletes, %	19.4	20.3	16.2	19.3
High-risk athletes, %	25.8	26.7	40.5	28.1
Prior dislocation, %	80.6	68.2	52.7	72.3
No. of dislocations	7.4	5.8	7.3	6.8
Prior subluxation, %	44.8	52.6	48.6	48.2
No. of subluxations	19.7	11.5	26.9	17.5
Age of onset, y	25.5	24.2	26.3	25.1
Time from onset to surgery, y	4.2	4.6	3.7	4.3
Age at surgery, y	29.7	28.8	30.0	29.4
Rotator cuff tear, %	6.3	5.9	6.0	6.0
Rounding off of the glenoid, %	31.5	24.2	16.2	26.7
Glenoid fracture, %	34.1	14.7	14.9	24.2
Glenoid deficiency, %	2.2	1.4	2.7	2.0
Humeral head impaction fracture, %	69.6	59.9	67.6	65.6
Recurrence, %	6.0	5.0	13.3	6.6

TABLE 2
Data Divided by Type of Operative Procedure of Patients Without Preoperative Arthritis

Characteristic	Coracoid Transfer (n = 253)	Open Soft Tissue (n = 200)	Arthroscopy (n = 69)	Total (n = 522)
Follow-up, y	6.3	7.7	3.3	6.5
Males, %	73.5	65.5	66.7	69.5
Hand dominance, %	62.3	64.5	64.7	63.5
Competitive athletes, %	31.0	37.0	53.6	36.3
Recreational athletes, %	56.7	45.0	43.5	50.5
Contact athletes, %	32.0	27.5	34.8	30.7
Overhand-throwing athletes, %	19.8	20.5	15.9	19.5
High-risk athletes, %	26.5	24.5	42.0	27.8
Prior dislocation, %	80.2	69.5	52.2	72.4
No. of dislocations	7.2	5.7	7.6	6.7
Prior subluxation, %	45.0	50.5	47.8	47.5
No. of subluxations	20.5	12.0	28.6	18.4
Age of onset, y	24.8	23.6	25.8	24.5
Time from onset to surgery, y	3.9	4.3	3.7	4.0
Age at surgery, y	28.7	27.9	29.6	28.5
Rotator cuff tear, %	4.9	3.6	4.5	4.4
Rounding off of the glenoid, %	32.8	22.6	14.5	26.5
Glenoid fracture, %	30.8	12.8	14.5	21.8
Glenoid deficiency, %	2.0	1.5	1.4	1.8
Humeral head impaction fracture, %	68.0	57.0	58.1	63.8
Recurrence, %	5.8	4.9	13.5	6.5

TABLE 3
Preoperative Arthritis in the Study Population Divided by Type of Operative Procedure (%)

Samilson Stage	Coracoid Transfer (n = 279)	Open Soft Tissue (n = 217)	Arthroscopy (n = 74)	Total (N = 570)
1	7.9	6.0	4.1	6.7
2	1.1	2.0	1.4	1.4
3	0.4	0.0	1.4	0.4
4	0.0	0.0	0.0	0.0
Total	9.4	8	6.9	8.5

TABLE 4
Postoperative Progression of Arthritis in Patients With Preoperative Arthritis (%)

	Stage of Arthritis at Follow-up			
Stage of Preoperative Arthritis	1	2	3	4
1 (38 cases)	63	16	21	0
2 (8 cases)	0	37	37	26
3 (2 cases)	0	0	50	50

stage 4 arthritis preoperatively. Age at the initial instability episode was a significant contributor to development of preoperative arthritis ($P < .0001$), with older patients at the time of the inciting episode at an increased risk for the development of preoperative arthritis. The mean age at the time of the initial instability episode was 24.5 years for stage 0, 30.3 years for stage 1, 40.0 years for stage 2, and 25.5 years for stage 3. All the patients with stage 3 preoperative arthritis had another contributing factor in the form of a glenoid fracture. Similarly, age at the time of surgery was related to development of preoperative arthritis ($P < .0001$; older patients more prone to develop preoperative arthritis), as was the time interval from the initial instability episode to surgery ($P < .0001$; patients with a longer delay more prone to develop preoperative arthritis). The mean age at the time surgery was 28.5 years for stage 0, 38.7 years for stage 1, 44.5 years for stage 2, and 27.5 years for stage 3. Again, all the patients with stage 3 preoperative arthritis had another contributing factor in the form of a glenoid fracture.

Lesions of the anterior glenoid rim ($P < .0001$) and the humeral head ($P < .0001$) correlated with the development of preoperative arthritis. Of the patients with a bony lesion of the anterior glenoid, 17.6% of those with an obvious fracture fragment, 9.3% of those with a rounding off of the normal contour of the anterior glenoid margin, and 8.2% of those with a large anterior glenoid deficit but no visible fracture fragment had preoperative arthritis, versus 2.7% of patients with no glenoid rim lesion. Eleven percent of patients with a humeral head impaction fracture had preoperative arthritis, versus 3.6% of patients without a humeral head impaction fracture.

Tears of the rotator cuff (identified or confirmed at the time of surgery) were associated with preoperative arthritis ($P < .0001$). The incidence of arthritis in patients with an intact rotator cuff was 7.1%, versus 23% for patients with a partial-thickness rotator cuff tear and 50% for patients with a full-thickness rotator cuff tear.

With the numbers available on the development of preoperative arthritis, factors found to have no statistical influence included the number of preoperative instability episodes, the type of instability symptoms (dislocation, subluxation, pain), the Duplay classification of sport practiced, level of the sport practiced (competitive, recreational), gender, and hand dominance.

Of the 48 cases (8.4%) of patients with preoperative arthritis, 58% had no evidence of arthritic progression at the time of latest follow-up (Table 4). None of the factors analyzed demonstrated any statistical relationship to progression of arthritis, including preoperative osseous lesions, patient age, delay from initial instability episode to surgery, type of operative procedure employed, or the center at which the surgery was performed.

Of the 522 (91.6%) shoulders without preoperative arthritis, 104 (19.9%) developed arthritis postoperatively (Table 5), including 14.4% stage 1, 3.4% stage 2, 1.0% stage 3, and 1.1% stage 4. Multiple factors contributed to the development of postoperative arthritis. The length of

TABLE 5
Postoperative Progression of Arthritis in Patients Without Preoperative Arthritis Divided by Type of Operative Procedure (%)

Stage of Arthritis	Coracoid Transfer (n = 253)	Open Soft Tissue (n = 200)	Arthroscopy (n = 69)	Total (n = 522)
1	14.6	17.0	5.8	14.4
2	3.6	3.5	2.9	3.4
3	2.0	0.0	0.0	1.0
4	0.4	2.5	0.0	1.1
Total	20.6	23.0	8.7	19.9

follow-up was significantly related to the development of arthritis ($P < .0001$), with a mean follow-up of 69 months for stage 0, 109 months for stage 1, 106 months for stage 2, 120 months for stage 3, and 190 months for stage 4. The average number of preoperative instability episodes was significantly higher in patients with stage 4 arthritis (25 episodes, $P = .004$) than in patients with the other stages of arthritis (stage 0, 6.3 episodes; stage 1, 8.2 episodes; stage 3, 5.4 episodes).

The mean Duplay mobility score was inversely related to the development and severity of arthritis (22.5 points for stage 0, 19.9 points for stage 1, 19.2 points for stage 2, 17.0 points for stage 3, and 8.4 points for stage 4; $P < .0001$). External rotation with the arm at the side was related to presence and progression of arthritis, with shoulders with a limitation of external rotation (compared with the unaffected side) more likely to have arthritis ($P < .0001$).

Age at the time of the initial instability episode correlated with the development of postoperative arthritis ($P = .002$), with a mean age at the time of the initial instability episode of 23.8 years for stage 0, 26.3 years for stage 1, 30.7 years for stage 2, 35.4 years for stage 3, and 20.5 years for stage 4 (statistical outlier secondary to small number of cases). Similarly, age at the time of surgery correlated with the development of postoperative arthritis ($P = .01$), with a mean age at the time of surgery of 27.9 years for stage 0, 30.3 years for stage 1, 34.2 years for stage 2, 37.2 years for stage 3, and 25.2 years for stage 4 (statistical outlier secondary to small number of cases).

Based on the numbers available, factors found to have no statistical influence on the development of postoperative arthritis included the delay from the first instability episode to surgery, the type of instability symptoms (dislocation, subluxation, pain), the Duplay classification of sport practiced, level of the sport practiced (competitive, recreational), gender, hand dominance, and the preoperative presence of glenoid or humeral osseous lesions. Postoperative recurrence of instability (dislocation and/or subluxation) did not contribute to the postoperative development of arthritis (recurrence rate for coracoid transfer was 5.8%; recurrence rate for open soft tissue reconstruction was 4.9%; recurrence rate for arthroscopic stabilization was 13.5%). Finally, no statistical differences were discovered in the rate of postoperative arthritis in patients treated with a coracoid transfer procedure (21%; mean follow-up, 6.3 years) and those treated with an open anterior soft tissue procedure (23%; mean follow-up, 7.7 years). Shoulders treated arthroscopically had a substantially lower incidence of arthritis (9%), but the substantially shorter follow-up (3.3 years) in this group limits conclusions that can be drawn. To accommodate for the difference in follow-up between the open and arthroscopic groups, patients undergoing stabilization in 1995 (the year in which the majority of arthroscopic stabilizations were performed) were analyzed separately. In this subgroup, arthritis developed after surgery in 12.7% of coracoid transfers, 11.6% of open soft tissue procedures, and 8.2% of arthroscopic pro-

TABLE 6
Summary of Arthrogenic Factors[a]

Factor	Preoperative Arthritis	Progression of Preoperative Arthritis	Postoperative Arthritis in Patients Without Preoperative Arthritis
Age of onset	<.0001	.85	.002
Age at surgery	<.0001	.78	.01
Time from onset to surgery	<.0001	.45	.83
Rotator cuff tear	<.0001	.51	.79
Bony glenoid lesions	<.0001	.78	.15
Humeral head impaction fracture	<.0001	.29	.08
No. of preoperative dislocations	.40	.40	.004
External rotation of operative side	NA	.37	.0001
Type of surgical procedure	.55	.39	.70
Type of instability symptoms	.31	.50	.53
Duplay classification	.90	.94	.38
Level of sport	.60	.64	.20
Gender	.13	.17	.57
Hand dominance	.89	.39	.29
Length of follow-up	NA	.15	<.0001
Postoperative recurrence rate	NA	.64	.40

[a]Data represent P values. NA, not applicable.

cedures (P = .73). Important arthrogenic factors are summarized in Table 6.

DISCUSSION

Recurrent anterior shoulder instability is a well-established source of glenohumeral arthritis.[17] This large series of 570 operatively treated patients with anterior shoulder instability allows investigation of contributing arthrogenic factors with sufficient power to determine statistical significance. Few studies have investigated factors contributing to development of glenohumeral arthritis before the performance of stabilizing surgery. In addition, to our knowledge no study has investigated progression of preoperative arthritic changes during the postoperative period.

The incidence of preoperative arthritis in our series (8.4%) was intermediate compared with the incidence in other reported series. In addition, the arthritis was discovered to be mild in most of the cases, occurred around 30 years of age, and developed over approximately 4 years (time from first instability episode to surgical stabilization). We acknowledge that the incidence of preoperative arthritis in our series may have been higher because all participating institutions were subspecialty centers and may have attracted more difficult cases, although this is difficult to prove. In comparison, Allain et al[1] reported an incidence of preoperative arthritis of 20% occurring at a mean age of 27.5 years and developing over an unspecified time period, whereas Zwaag and colleagues[29] reported only 5% incidence of preoperative arthritis occurring at a mean age of 26.9 years and developing over a 5-year time period. Finally, Hovelius and associates[11] reported an incidence of preoperative arthritis of 20% occurring at a mean of 10 years after the first instability episode.

This study demonstrated that 5 factors potentially correlate to the development of preoperative arthritis after an anterior instability episode: the age at the time of the initial instability episode, tears of the rotator cuff, bony glenoid lesions, humeral head impaction fractures, and the time interval from the first instability episode to surgical stabilization. The older a patient was at the time of the first instability episode, the more likely the occurrence of preoperative arthritis. This finding may be interrelated with the arthrogenic effects of rotator cuff tearing, which occurs more frequently in older patients sustaining a shoulder dislocation; however, this finding may be related to normal aging because older patients have a higher incidence of arthritis than younger patients. Osseous lesions of the glenoid and/or humeral head may be more frequently observed with repetitive instability episodes; however, the absence of correlation of the number of instability episodes with development of preoperative arthritis suggests that presence of osseous lesions is an independent contributing factor. To our knowledge, few other series have investigated the influence of specific factors on the development of preoperative arthritis in patients with anterior shoulder instability. Hovelius et al reported that the number of instability episodes and the performance of an operative procedure to stabilize the shoulder did not influence the development of arthritis.[11] In addition, Samilson and Prieto previously reported the importance of age at the time of initial instability episode and loss of external rotation in the severity of dislocation-induced arthritis.[25] Analysis of our findings causes us to agree with the speculations of Singer et al[26] and Hovelius[10] in that the risk of developing arthritis after an anterior instability episode and before any surgery is performed is most closely linked to the age at the time of the initial instability episode and the presence of osseous lesions.

With regard to postoperative progression of arthritis that was present before stabilizing surgery, we discovered that mild (stage 1) arthritis is less likely to progress (37% of cases) than more advanced stages (63%). The type of surgical procedure performed did not statistically influence this progression, nor did any other factors analyzed, suggesting the unalterable nature of arthritic progression.

Considerably more has been reported on the development of arthritis after instability surgery. Among series with more than 10 years' follow-up, most reported a similar incidence of arthritis regardless of the procedure performed. Allain and colleagues[1] reported an incidence of 62% at 14 years' mean follow-up after the Latarjet coracoid transfer; Zwaag et al[29] and König et al[14] reported an incidence of 61% at 22 years' mean follow-up and 58% at 26 years' mean follow-up, respectively, with the Putti-Platt procedure; Rosenberg et al[24] and Hovelius et al[12] reported an incidence of 55% at 15 years' mean follow-up and 63% at 18 years' mean follow-up, respectively, with the Bankart procedure. Even if only the more severe cases of arthritis are considered (stage 1 excluded), the incidence of postoperative arthritis is similar among the different types of procedures, ranging from 16% to 26%.[4] Only those series reporting the results of the Eden-Hybbinette bone-grafting procedure have reported substantially higher rates of arthritis (up to 90% overall and 53% to 72% for stage 2 and higher).[9,23]

Our series has comparable rates of postoperative arthritis at comparable follow-up times to other series reported in the literature (if only patients with no preoperative arthritis are considered, we discovered arthritic changes in approximately 45% of patients undergoing a coracoid transfer at a mean 12 years' follow-up and 54% of patients undergoing an open soft tissue procedure at a mean 16.7 years' follow-up). Among our arthroscopically treated patients, our incidence of arthritis (8.7% at a mean 3.3 years' follow-up) in patients without preoperative arthritis is comparable to that reported by O'Neil[22] of 12% at a mean 4.5 years' follow-up (none of O'Neil's patients had preoperative arthritic changes).

To our knowledge, our study is the first to provide data stratified into preoperative and postoperative occurrence. This allowed analysis not only of instability-induced arthrogenic factors but surgically-induced arthrogenic factors as well. Of the 522 shoulders that had no evidence of arthritic change preoperatively, nearly 20% had developed arthritis within the mean 6.5 years' follow-up, most being stage 1. Multiple factors were identified as contributing to postoperative arthritis. Others have previously demonstrated the contribution of age at the time of the initial instability episode and at the time of surgery.[14,27] We discovered that the number of instability episodes statistically influenced the development of postoperative arthritis, although others have found no such phenomenon.[14,23] Interestingly, the number of instability episodes did not influence the incidence of preoperative arthritis, suggesting that the time interval from the initial instability episode to the time of surgery may not have been sufficient to allow for the development of arthritis. This finding may argue for earlier surgery to prevent numerous instability episodes.

Although we found a relationship between limitation of external rotation and arthritis, it is impossible for us to determine if the limitation of external rotation contributes to or is the result of glenohumeral arthritis. Because nearly all patients with primary (not instability related) glenohumeral osteoarthritis have decreased external rotation with the arm at the side, it seems at least (if not more) reasonable that the loss of external rotation is a result of arthritis and not a cause of it. From the data obtained in this study, further clarification of this factor is unfortunately impossible.

In contrast to findings of other investigations, we did not find the time interval from the first instability episode to the time of surgery, the activity level of the patient, or the postoperative recurrence of instability to play a role in the development of arthritis.[23,27] Also, unlike Allain and colleagues, we did not discover the type of instability episode (dislocation, subluxation) to be an arthrogenic factor.[1] Finally, like Hovelius and colleagues, we did not find the type of open procedure performed to influence the development of arthritis. In addition, we were able to demonstrate that the type of open procedure used did not influence arthritic progression.[12] Although our series demonstrated a substantially lower incidence of arthritis in patients undergoing arthroscopic procedures, because of the markedly different durations of follow-up we were unable to meaningfully compare these patients with those undergoing open stabilization. Finally, follow-up in the overall series was intermediate in length, and the prevalence of arthritis might continue to increase with longer follow-up.

Of the preoperative and postoperative arthrogenic factors, age at the time of the initial instability episode seemed to be the most consistently important factor. Attempts at surgical stabilization did not influence this factor. In contrast, osseous lesions of the glenoid and humeral head ceased to be an arthrogenic factor in the postoperative course, suggesting that stabilizing surgery may neutralize this factor.

This investigation was not without limitations. Multicenter reviews have inherent methodological flaws; however, they do provide sufficient patients for meaningful statistical analysis. Multiple procedures using slightly different techniques were used in this investigation. In addition, we were able to review only 570 of a possible 1295 patients (44%); however, this is not markedly dissimilar to other long-term follow-up studies.[1,4,24] Furthermore, the interobserver and intraobserver reliability of the Samilson and Prieto classification has come under question.[13] Despite this, the Samilson and Prieto system remains the standard system for radiographic grading of instability-induced arthritis. We were also unable to analyze some factors that have been suggested to be arthrogenic, such as a laterally overhanging bone block[7] (only reliably diagnosable by postoperative computed tomography) and excessive anterior soft tissue tightening (we did not have access to the patients' early postoperative external rotation measurements).[3,8,15,16,29] Finally, the lack of a control group (patients not undergoing stabilizing surgery) limits the strength and nature of the conclusions that can be drawn from this study and prevents definitive conclusions about the relationship between stabilizing surgery and glenohumeral arthritis.

Despite these acknowledged limitations, this investigation has allowed analysis of arthrogenic factors in anterior shoulder instability in both the preoperative and postoperative periods. Age at the time of initial instability episode seemed to be the most important factor in the development of arthritis, with older patients being particularly at risk for dislocation arthropathy. Surgical stabilization did not seem to have a marked effect in preventing arthritis, although definitive conclusions regarding a cause-and-effect relationship are limited by the lack of a control group. Finally, although a statistical relationship was discovered between loss of external rotation and postoperative arthritis, a cause-and-effect relationship is impossible to establish from the data in this study.

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