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Arthroscopy of the symptomatic shoulder arthroplasty

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Background: Assessment of a painful or stiff shoulder arthroplasty can be challenging. The cause of pain can sometimes be easily identified. However, some patients have normal levels of inflammatory markers, normal plain films, and no clinical signs to indicate a diagnosis. Indolent organisms may not raise blood marker levels or result in obvious radiologic findings such as loosening. We report the utility of performing arthroscopy in these patients for a diagnostic advantage.

Methods: We retrospectively reviewed the health records of all patients who underwent diagnostic shoulder arthroscopy over a 3-year period. Patients were included if they were aged 18 years or older, had undergone previous arthroplasty surgery, and had symptoms of shoulder pain or stiffness. Patients were excluded if they had any traditional symptoms of infection or had a raised serum white cell count or C-reactive protein level prior to diagnostic arthroscopy.

Results: Fourteen patients met the initial inclusion criteria. The mean interval between index surgery and arthroscopic evaluation was 65.4 months (standard deviation, 58 months; range, 17-192 months). Arthroscopic biopsy specimens returned positive culture results in 3 patients (21%). Rotator cuff tears were noted in 8 patients (57%). Capsular contraction requiring release was noted in 2 patients (10%). In all patients, the diagnostic arthroscopy directed the next stage of management.

Conclusions: Diagnostic arthroscopy allows a full assessment of implants, the rotator cuff, the native articular surfaces, and scar tissue, as well as biopsy specimens to be obtained for indolent infection, in patients considering revision arthroplasty surgery. This allows a more informative consent process for patients, directs surgical management, and on occasion, allows for therapeutic intervention in a painful or stiff shoulder arthroplasty.

Level of evidence: Level IV; Case Series; Treatment Study

Keywords: Shoulder; arthroplasty; infection; diagnostic; stiffness; *Cutibacterium acnes*; arthroscopy

Assessment of the painful shoulder arthroplasty can be challenging. The cause of the pain sometimes can be easily identified with plain films or raised inflammatory blood marker levels.[2] The difficulty occurs in the cases in which there are normal levels of inflammatory markers, normal plain films, and no clinical signs to lead to a diagnosis. The

Ethical approval was not required for this study.

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most concerning cause of a painful shoulder arthroplasty is indolent organisms. Such bacteria may not raise blood marker levels or show any obvious sign on imaging. Revision of any implant without prior knowledge of the possible presence of an indolent organism risks future failure of the revision arthroplasty.[17,21,37] Although the painful arthroplasty represents only a small percentage of all implanted shoulder arthroplasties,[26] a rise in the use of shoulder arthroplasty has been documented in national joint registries[25] and strategies for the assessment of these patients will become invaluable.

When considering the possibility of periprosthetic shoulder joint infection, diagnosis has traditionally been based on the clinical history and examination, in combination with serum testing, radiologic findings, and aspiration culture results.[1] The Musculoskeletal Infection Society (MSIS) has produced consensus guidelines for diagnosis of periprosthetic joint infection in other joints, and these have been taken up by some national shoulder societies in their own guidelines.[27,31] However, signs can be subtle and investigations equivocal.[9,11,24,28,32,35] The lack of typical features of infection such as fever and erythema can delay diagnosis, and many authors have concluded that routine investigations for infection have a low efficacy in confirming periprosthetic shoulder joint infection.[13,16,19,22,29,30,33,36,38,39] Synovial biomarkers such as leukocyte esterase or α-defensin can be used to help identify an infection at the time of surgery but do not have the ability to specifically identify which bacterium is present and the antibiotics sensitive to it. Therefore, in cases in which infection is demonstrated, decisions on antibiotics for cement in either a single- or 2-stage revision are still ambiguous.

Indolent infection is only 1 cause of a painful arthroplasty. Although the primary aim of arthroscopy in this situation may be to obtain biopsy specimens to exclude infection, it also permits a full assessment of the implants, rotator cuff, and remaining articular cartilage where relevant.[10] We aimed to report the utility of performing diagnostic arthroscopy in a painful or stiff arthroplasty for a diagnostic advantage and subsequent management.

Methods

We retrospectively reviewed and screened the clinical, radiologic, and operative records of all patients who underwent diagnostic shoulder arthroscopy at our institution in the past 3 years. Patients were included if they were aged 18 years or older at the time of surgery, had undergone previous arthroplasty surgery (hemiarthroplasty, anatomic shoulder arthroplasty, or reverse arthroplasty), and had symptoms of shoulder pain or stiffness to such an extent that patients were requesting further intervention up to and including revision surgery. Patients were excluded if they had reported any symptoms of infection or had a serum white cell count (WCC) or C-reactive protein (CRP) level recorded prior to diagnostic arthroscopy that was outside the normal ranges for our laboratory. Regarding these normal ranges, patients were required to have the following levels of serum inflammatory markers to be included: 11.5×10^9 or less for the WCC and 10 mg/L or less for the CRP level. The erythrocyte sedimentation rate is not available at our institution and thus was not used in the diagnostic pathway.

Patients were also excluded if available preoperative imaging showed evidence of loosening, periprosthetic fracture, or superior or anterior migration of the humerus or showed any other finding suggestive of the cause of pain. Native joint infection prior to implantation of the arthroplasty was an exclusion criterion and hence was not applicable for any considered patients.

Surgical technique

All patients underwent general anesthesia and received an interscalene block. Prophylactic antibiotics were administered at anesthetic induction to diminish the risk of iatrogenic infection. The skin was prepared with a 2% chlorhexidine gluconate solution in 70% alcohol, and exclusion drapes were applied. An aspiration of the glenohumeral joint fluid, if necessary, was performed at this point. Care was taken to introduce a standard posterior shoulder portal so that iatrogenic damage was minimized. This was targeted at the superior aspect of the glenohumeral joint and was easier in cases with a reverse arthroplasty because of the large space superior to the components. A diagnostic arthroscopy was performed, and any abnormal findings were recorded. An anterior portal through the rotator interval was made under direct vision initially using a needle, again to ensure no iatrogenic injury. Five synovial tissue samples were taken from different positions within the joint.[27,31] When appropriate, samples were retrieved between implant interfaces or between implant-bone interfaces.

Each tissue biopsy specimen was taken with a separate, clean arthroscopic punch and was then placed in a separate sterile dry pot and transferred immediately to the microbiology laboratory for incubation in meat broth at 37°C. After a minimum of 7 days, broths were terminally subcultured onto Columbia Agar with ''Chocolated'' Horse Blood (incubated in carbon dioxide) and Fastidious Anaerobic Agar with Horse Blood (incubated anaerobically) (Oxoid, Basingstoke, UK). Extended cultures were interpreted at 15 days after subculture. Biopsy findings were considered positive if the same organism was cultured on 3 or more of the 5 samples.[6]

After biopsy, a simple probe was used to determine whether there was any movement between components and the bone surface. If scar tissue was present, a radiofrequency probe (Serfas Energy; Stryker, Kalamazoo, MI, USA) was introduced through the anterior portal. Under direct vision, the rotator interval was initially cleared of scar tissue, with care taken to preserve the subscapularis. If scar tissue was also present between the 2 articular surfaces, an arthroscopic punch was used to avoid iatrogenic damage with the radiofrequency probe. Once visualization had improved, any remnant of the medial glenohumeral ligament was released posterior to the subscapularis with the radiofrequency probe. This allowed clearance down to the 5-o'clock position. The clearance continued superiorly between the glenoid or implant and superior cuff to the 12-o'clock position. At this stage, a switching stick was used to allow visualization from anterior and the wand to be introduced from posterior. Capsular release could then continue posteriorly to the 7-o'clock position, again staying close to the posterior bone of the glenoid or implant.

Table I Summary of blood marker and microbiology results

Primary procedure	CRP level, mg/L	WCC, $\times 10^9$	Aspirate result	No. of positive biopsy samples	Overall biopsy result
RSR	<1	5.3	*Klebsiella*	0 of 5	Negative
TSR	2	6.5	*Micrococcus*	0 of 5	Negative
TSR	<1	7.2	Negative	0 of 5	Negative
TSR	<1	5.3	*Cutibacterium acnes*	5 of 5	*P acnes*
TSR	2	5.7	*C acnes*	0 of 5	Negative
HA	4	4.7	—	4 of 5	*P acnes*
TSR	<5	7.6	—	0 of 5	Negative
RSR	5	6.9	—	0 of 5	Negative
TSR	2	7.1	—	3 of 5 (3 different organisms)	Negative
HA	<1	4.8	—	0 of 5	Negative
HA	10	11.5	—	0 of 5	Negative
HA	<1	4.7	—	5 of 5	*P acnes*
TSR	10	7.5	—	0 of 5	Negative
TSR	2	6.6	—	0 of 5	Negative

CRP, C-reactive protein; *WCC*, white cell count; *RSR*, reverse shoulder replacement; *TSR*, anatomic total shoulder replacement; *HA*, hemiarthroplasty.

Thereafter, the residual tissue between the 5- and 7-o'clock positions was amenable to a controlled manipulation.

Results

After screening of all patients presenting with a painful or stiff shoulder arthroplasty, 14 patients met the initial inclusion criteria, comprising 12 women and 2 men. The mean age at the time of arthroscopy was 70.8 years (standard deviation, 12 years; range, 54-89 years). The mean interval between index surgery and arthroscopic evaluation and biopsy was 65.4 months (standard deviation, 58 months; range, 17-192 months). Of the 14 primary arthroplasties, 10 had not been performed by the investigating surgeon.

Perioperative glenohumeral joint aspirations undertaken after skin preparation, as outlined in the ''Surgical technique'' section, were performed in 5 patients. Arthroscopic biopsy specimens returned positive culture results for a total of 3 patients (21%).

A new diagnosis of rotator cuff tear was noted in 8 of 12 patients (67%) with an anatomically designed total shoulder replacement or hemiarthroplasty. Capsular contraction requiring release was noted in 2 patients (10%). A summary of the blood marker and microbiology results is presented in Table I. Table II presents the arthroscopic findings in each case and the final management decision.

Discussion

The decision to proceed to a revision arthroplasty should not be undertaken lightly. The history, clinical examination findings, blood tests, and imaging can be suggestive of the underlying problem, but there is a cohort of patients with inconclusive investigations. Radiologic assessment of the rotator cuff in this patient group is particularly difficult because of the interference of the implant on imaging.[24] A missed low-grade infection can have significant long-term consequences. Revision surgery is challenging, and prior knowledge of the likely problem and likely requirements at revision surgery aids planning and allows a more explicit consent process with the patient.

Despite normal blood marker levels preoperatively, the results showed positive biopsy findings in 21% of cases. This corroborates previous work indicating that it is not advisable to rely on a normal CRP level or WCC when considering infection.[5,14,15] This is also supported by criteria from the MSIS, recognizing that serologic markers should not be attributed a great level of importance when considering infection in arthroplasty in general.[5,27,31] It also recommended that a minimum of 8 days' prolonged culture be used to identify indolent bacteria, although up to 21 days has been advocated by some authors.[3,7] This is a balance between ensuring all bacteria are identified and risking a false-positive finding with excessively prolonged culture.

A negative biopsy finding need not necessarily be considered unhelpful when assessing the painful arthroplasty. We considered a normal diagnostic arthroscopy in this setting as a positive or reassuring finding. Of the patients who went on to definitive revision surgery, none had an unexpected positive microbiological result (defined as $\geq$3 positive samples from a further 5 samples) from samples taken at the time of revision surgery. The importance of a negative result should not be underestimated, as it gives confidence to the surgeon and patient that revision surgery will carry a low risk of subsequent infection.

Table II Summary of findings for each patient

Primary procedure	Overall biopsy result	Other arthroscopy findings	Outcome
RSR	Negative	Inferior poly wear with synovitis and notching	Revision to eccentric glenosphere with replacement poly
TSR	Negative	Loose glenoid component and cuff tear	Revision arthroplasty
TSR	Negative	Loose glenoid component and cuff tear	Revision arthroplasty
TSR	*P acnes*	Broken and dislocated poly, erosion of glenoid metal back, metallosis, and cuff tear	Revision arthroplasty (single stage), 6 of 52 antibiotics
TSR	Negative	Loose glenoid component and cuff tear	Revision arthroplasty
HA	*P acnes*	Glenoid wear and cuff tear	Revision arthroplasty (single stage), 6 of 52 antibiotics
TSR	Negative	Posterior instability with poly wear	Revision arthroplasty
RSR	Negative	Excessive scar tissue	Capsular release
TSR	Negative	Normal examination	Not revised
HA	Negative	Cuff tear	Revision arthroplasty
HA	Negative	Excessive scar tissue	Capsular release
HA	*P acnes*	Glenoid wear and cuff tear	Patient decision, 12 of 52 suppressive antibiotics
TSR	Negative	Normal examination	Not revised
TSR	Negative	Loose glenoid component and cuff tear	Revision arthroplasty

RSR, reverse shoulder replacement; *TSR*, anatomic total shoulder replacement; *HA*, hemiarthroplasty.
Samples with the same bacteria cultured from 3 or more separate biopsy sites were deemed positive findings.

Of the 5 patients who underwent perioperative joint aspiration, only 2 had aspiration results that correlated with the biopsy results. Aspiration results in this study did not confirm infection due to the false-positive findings compared with subsequent arthroscopic biopsy and open biopsy at the time of the definitive revision. The 1 negative aspiration did correlate with negative subsequent biopsy results. Although aspiration does not require a general anesthetic, it only gives 1 sample, compared with 5 samples with biopsy. Aspiration results can be included in the MSIS criteria for an infected arthroplasty, but the same criterion does not assume a positive culture result from a single sample (such as in aspiration) to be diagnostic for infection. Retrieving 5 biopsy samples allows for consensus of the samples and allows for a single spurious result to be disregarded. However, exclusion or confirmation of infection is not the only benefit of arthroscopy.

Arthroscopy directed the next stage of management in all 14 patients. The 3 patients with confirmed infection were counseled regarding a 1- or 2-stage procedure and allowed organism-sensitive–directed antibiotic cement and postoperative intravenous antibiotics immediately after the revision. One patient who had previously considered revision surgery did decline further surgery and instead chose suppressive antibiotics.

In particular, we note the value of being able to confirm the presence or absence of a rotator cuff tear in an anatomic or hemiarthroplasty joint replacement. This helped inform the discussion with each patient after his or her procedure. Glenoid wear was confirmed in 2 cases of hemiarthroplasty, and 1 patient was found to have a posteriorly dislocating joint on examination under anesthesia that was demonstrated during arthroscopy. This had not been detected during preoperative clinical examination as it was too painful. The fractured polyethylene liner in a metal-backed glenoid had very inconclusive imaging prior to arthroscopy, but the associated metallosis was immediately obvious on arthroscopy. In 2 patients, the diagnostic arthroscopy was also therapeutic in the form of a simultaneous capsular release. Two patients were found to have no visible abnormality at arthroscopy and to have negative biopsy findings, and although it is our practice to perform biopsy only in patients contemplating revision surgery, the reassurance that nothing untoward could be identified was sufficient for these patients to forgo revision.

We note that our sex ratio is contrary to previous articles reviewing arthroscopy of shoulder arthroplasty.[18] However, on review of all shoulder arthroplasty procedures undertaken at our institution, a strong female predominance was noted in keeping with the ratio in this study.

We found an average time of 65.4 months between the index procedure and diagnostic arthroscopy. As most patients were initially treated by surgeons in other centers, this time was usually attributable to investigations being undertaken at patients' primary centers and includes time taken to be referred. Patients either presented with symptoms persisting immediately after the primary arthroplasty or had a delayed presentation after an initial period of a good outcome after the primary procedure.

Arthroscopy in patients with an arthroplasty in situ does carry the risk of iatrogenic damage and infection. Any needle or instrument that transgresses the skin, hair follicles, and sebaceous glands around the shoulder has the possibility of coming into contact with skin commensals and thereby inoculating the joint.[10-12,28,34] We sought to counteract this risk with the provision of prophylactic antibiotics at induction for all surgical procedures, and as such, arthroscopy was only performed in patients who would consider definitive revision surgery if deemed appropriate from arthroscopy.

The colonization of the glenohumeral joint with indolent bacteria such as *Cutibacterium acnes* is not fully understood and has been shown to be associated with frozen shoulder, arthritis, and instability.[8,20,23] As such, it might not always represent a pathogen that will cause infection.[17,37] However, when involved in revision surgery, ignoring it is risky and could lead to either persistent pain or potential septic arthritis in a prosthetic joint.[4,20]

Conclusion

Diagnostic arthroscopy allows an assessment of implants, the rotator cuff, the native articular surfaces, scar tissue, and indolent infection in patients considering revision arthroplasty surgery. Identifying issues with the painful arthroplasty allows a more informative consent process for the patient prior to potential revision, as well as directing surgical management and, on occasion, allowing for therapeutic intervention. We acknowledge that this is a retrospective study lacking in completely uniform treatment and having relatively low numbers of patients. Furthermore, the decision to undertake arthroscopy only in those patients who would consider revision arthroplasty presents the possibility of investigation bias but does represent a pragmatic clinical approach. We considered the risk of iatrogenic damage or infection to outweigh diagnostic curiosity in patients in whom revision surgery was deemed unsuitable or patients who were unwilling to undergo revision surgery. We believe this technique shows potential benefit to patients, and it will continue to be used as a prospective study in our institution.

Disclaimer

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