The incidence and causative organisms of infection in elective shoulder surgery

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Abstract

Background: Deep infection remains a serious complication of orthopaedic surgery. Knowledge of infection rates and causative organisms is important to guide infection control measures. The aim of the present study was to determine infection rates and causative organisms in elective shoulder surgery.

Methods: Cases complicated by infection were identified and prospectively recorded over a 2-year period. All patients undergoing elective shoulder surgery in the concurrent period at a single Specialist Upper Limb Unit in the UK were identified from the hospital electronic database.

Results: In total, 1574 elective shoulder cases were performed: 1359 arthroscopic (540 with implant insertion) and 215 open (197 with implant insertion). The overall infection rate in open surgery of 2.5% was significantly higher than arthroscopic implant cases at 0.7% ($p < 0.005$). The overall infection rate in implant arthroscopic surgery was significantly higher at 0.7% compared to 0% in non-implant related surgery. ($p < 0.05$)

Conclusions: Patients undergoing open shoulder surgery have a significantly higher risk of infection compared to arthroscopic shoulder surgery. Arthroscopic surgery with implant insertion has a statistically significantly higher risk of developing deep infection compared to procedures with no implant insertion. We recommend prophylactic antibiotics in open shoulder surgery and arthroscopic shoulder surgery with implant insertion.

Keywords

infection, microbiology, shoulder, surgery

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Introduction

Deep infection remains a serious complication of orthopaedic surgery. Infection rates following arthroscopic shoulder surgery have traditionally been low, with a recent study of 165,820 shoulder arthroscopies reporting an infection rate of 0.27%.¹ Infection rates following primary total shoulder arthroplasty range from <0.1% to 3.9%,^{2,3} with rates following primary reverse total shoulder arthroplasty of 5%.⁴

There has been an exponential increase in the volume of shoulder surgery performed in the last decade.⁵ Infection can cause significant patient morbidity, lead to early implant failure and result in increased healthcare costs.⁶ Knowledge of infection rates and causative organisms is important for patient consent, as well as guiding peri-operative infection control measures.

The present study aimed to review the deep infection rates in a single specialist upper limb unit carrying out a large volume of elective shoulder surgery. We aimed to identify causative organisms and compare infection rates between open and arthroscopic surgery.

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Materials and methods

Patients presenting to the orthopaedic clinic or emergency department during a 2-year period with a high index of suspicion for acute deep infection having undergone elective shoulder surgery were recorded prospectively and individual cases were registered for discussion into a weekly multidisciplinary bone and joint infection meeting. Cases of suspected superficial wound infection were excluded.

It was routine protocol in the unit to treat all cases that had developed suspected deep infection based on clinical parameters such as history, physical examination and raised white-cell count and inflammatory markers with surgical debridement to confirm deep infection with positive cultures from deep tissue samples including synovial fluid and biopsies before commencement of antibiotic treatment. Two cases underwent ultrasound-guided fluid aspiration as an adjunct to diagnosis, of which both went onto surgical debridement. All cases where metallic implants were *in situ* underwent radiographic examination. This excluded cuff repairs, where universally non-metallic anchors had been used. Samples routinely underwent prolonged culture; however, they did not routinely undergo culture for tuberculosis. Advanced diagnostic techniques such as α -defensin testing, DNA/RNA detection were not utilized because of the high index of suspicion for infection based on clinical grounds.

For each patient identified, data collected included, patient age, sex, associated co-morbidity, time since index procedure, blood parameters including inflammatory markers, organisms cultured, overall outcome, number of subsequent surgeries performed, length and nature of antibiotic treatment regime.

For purposes of the present study, all patients undergoing elective shoulder surgery during the

concurrent 2-year period were identified from the hospital electronic database. All revision procedures were excluded.

The surgical cases were performed under the care of several consultant orthopaedic surgeons with an interest in shoulder surgery. All arthroplasty cases were admitted to ring-fenced orthopaedic elective beds. Methods of antimicrobial prophylaxis were standardized within the unit. This included standardized surgical draping for arthroscopic and arthroplasty cases, antibiotic prophylaxis using 1.5 g of intravenous cefuroxime for all cases involving implant insertion, surgical field double preparation with chlorhexidine 0.5% with 70% ethanol and the use of incision drapes for open surgical cases. All cases were undertaken in laminar flow operating theatres.

Statistical analysis was performed to calculate overall rates of deep infection in implant-related and non-implant related arthroscopic and open surgical cases. Chi-squared tests were used to determine significance between risk factors for infection such as sex and implant insertion.

To inform the discussion and to characterize the nature of the infection in relation to the cultured organisms, data on the nature of the infections was underwent retrospective analysis, including presence of a sinus tract, nature of any fluid collection (purulent versus nonpurulent), number of samples with positive culture and inflammatory markers. These characteristics have been adapted from the Musculoskeletal Infection Society's (MSIS) criteria⁷ for prosthetic joint infection, as illustrated in Table 1. The MSIS criteria although primarily used for prosthetic joint infection (PJI) primarily or arthroplasty of the lower limb (with varying thresholds between hip and knee), the authors felt it of value to compare the transferable

Table 1. Illustrating the MSIS criteria for the diagnosis of PJI.

Major criteria (one +ve diagnostic)	Sinus present between implant and skin
	Two positive cultures from separate samples taken from around the prosthesis
Minor criteria (four +ve from six)	CRP > 10 or ESR > 30
	Histological analysis with neutrophils per high power in five fields
	Elevated synovial leukocyte count
	One positive culture from joint
	Elevated synovial neutrophil %
	Purulent fluid in joint

CRP, C-reactive protein; ESR, erythrocyte sedimentation rate.

Table 2. Characteristics and nature of the infection for each case.

Case No.	Sinus present	<2 Samples with organism	CRP > 10 and / or ESR > 30	Single sample positive culture	Purulent fluid
1	No	Yes	Yes	NA	Yes
2	Yes	Yes	Yes	NA	Yes
3	No	Yes	Yes	Yes	No
4	No	No	Yes	Yes	No
5	Yes	One	Yes	Yes	Yes
6	No	Yes	Yes	NA	Yes
7	No	No	Yes	Yes	No
8	No	Yes	Yes	NA	No
9	No	Yes	Yes	NA	Yes

CRP, C-reactive protein; ESR, erythrocyte sedimentation rate; NA, not applicable.

aspects of the clinical presentation in this series with the criteria to determine whether there is any correlation and whether the MSIS criteria could be applied to the presentation of PJI in the upper limb. The results of this analysis are shown in Table 2.

Results

A total of 1574 elective shoulder cases were performed: 1359 arthroscopic (540 with implant insertion) and 215 open (197 with implant insertion).

The overall infection rate in open surgery of 2.5% (five cases) was significantly higher than arthroscopic implant cases at 0.7% (four cases) ($p < 0.005$).

The overall infection rate in implant arthroscopic surgery was significantly higher at 0.7% (four cases) compared to 0% in non-implant related surgery ($p < 0.05$).

Seven patients were male and two females. Rheumatoid arthritis was a single co-morbidity in one female. Mean age was 47 years (age range 17 years to 66 years). Eight of the nine patients developing deep infection had implants *in situ*. There was no relationship between co-morbidity, sex, age and infection.

Propionibacterium acnes was cultured in five patients, and was associated with another organism in four cases, either *Staphylococcus aureus* or *Staphylococcus epidermidis*.

Co-Augulase negative *Staphylococcus* (CoNS) alone was cultured in two patients and *S. aureus* in two patients. All cases taken to theatre for surgical debridement and deep tissue sampling returned positive cultures.

All cases were treated with surgical debridement followed by antibiotics, with removal of implants in five cases. After surgery, all cases underwent antibiotic treatment for a minimum period of 3 months, with the nature of the regime being dependent on cultures and the monitoring of inflammatory markers such as C-reactive protein (CRP) and erythrocyte sedimentation rate (ESR). All decisions regarding management were taken as advised by the dedicated multidisciplinary bone and joint infection team, including surgical, microbiology, radiology and infectious diseases teams, until all cases of infection were deemed to have been eradicated.

Table 3 illustrates each case in terms of patient demographics, co-morbidity, original surgical procedure, organism, nature of treatment, time of presentation (days) after index surgery and surgical procedures performed.

All cases demonstrated CRP and/or ESR higher than 10 and 30, respectively. The presence of *S. aureus* organisms appeared to be associated with frank purulent fluid on exploration in contrast to cases with *S. epidermidis* or CoNS.

Discussion

With the increase in need and demand for shoulder surgery, knowledge of infection rates and causative organisms is important in assisting the development of perioperative infection control measures. Knowledge of infection rates is important to ensure patients can be adequately informed during the consent process.

Table 3. Summary of infected cases.

Case No.	Age	Sex	Co-morbidity	Procedure	Organism	Surgery	Time from index procedure (days)
1	63	Male	None	Arthroscopic cuff repair	<i>Propionibacterium acnes</i> <i>Staphylococcus aureus</i>	Arthroscopic implant removal	14 days
2	66	Male	None	Arthroscopic cuff repair	Coagulase negative <i>Staphylococcus</i>	Arthroscopic implant removal	5 days
3	53	Male	None	Arthroscopic cuff repair	<i>Propionibacterium acnes</i> <i>Staphylococcus aureus</i>	Arthroscopic implant removal	12 days
4	59	Female	None	Arthroscopic cuff repair	<i>Propionibacterium acnes</i> <i>Staphylococcus epidermidis</i>	Arthroscopic washout	14 days
5	17	Male	None	Open Latarjet	<i>Propionibacterium acnes</i> <i>Staphylococcus aureus</i>	Open washout	18 days
6	59	Male	None	Arthroscopic cuff Open ACJ excision	<i>Staphylococcus aureus</i>	Arthroscopic washout and open ACJ washout	5 days
7	59	Male	None	Open cuff repair	Coagulase negative <i>Staphylococcus</i>	Multiple debridement and delayed reverse TSR	565 days
8	45	Male	None	Stemmed shoulder hemiarthroplasty	<i>Propionibacterium acnes</i>	First stage revision only (to cement spacer)	300 days
9	63	Female	Rheumatoid Arthritis	Reverse TSR	<i>Staphylococcus aureus</i>	Insert and glenosphere exchange	115 days

ACJ, acromioclavicular joint; TSR, total shoulder replacement.

We have found the infection rate following open shoulder surgery to be significantly higher compared with arthroscopic surgery ($p < 0.005$). In patients undergoing arthroscopic shoulder surgery, the risk of infection was higher in cases with implant insertion ($p < 0.05$). No patient undergoing an arthroscopic shoulder procedure without implant insertion developed a deep infection. There was no relationship between co-morbidity, sex or age on the rate of infection. It is therefore logical to conclude that implant insertion in either open or arthroscopic cases is the single most important factor in infection in shoulder surgery. These findings suggest that prophylactic antibiotics should be used in patients undergoing open shoulder surgery, and arthroscopic procedures involving implant insertion.

The infection rates and organisms cultured in this series are similar to those quoted in the current literature.¹⁻³ The published infection rates with particular reference to arthroscopy tend to be based on healthcare database studies and in comparison this is the largest study from a single unit outside the USA.

Propionibacterium acnes was the most common organism identified as the cause of deep shoulder infection in the present study. *Propionibacterium acnes* is an anaerobic, Gram-positive bacillus that is commonly found in the pilosebaceous follicles of the head, neck and back.⁸ Males have higher levels of *P. acnes* colonization than females⁹ and are at greater risk of a deep infection caused by the organism.¹⁰ This may partly explain why males have been shown to have significantly higher rates of deep peri-prosthetic shoulder infection.¹¹ However, the present study did not demonstrate a significantly higher rate of infection amongst male patients ($p = 0.1842$). The organism often requires prolonged laboratory culture to be isolated, often up to 14 days.⁸ Importantly, several studies have demonstrated a low negative predictive value in diagnosing *P. acnes* infection with shoulder aspiration.^{12,13} Therefore, if the aspirate is negative but infection is suspected, other diagnostic measures such as arthroscopic biopsies may have a role.¹²

The second most common group of organisms cultured in this series were *Staphylococci*, which are the most common causative organism implicated in orthopaedic infection overall.⁷ *Staphylococcus aureus* is highly virulent and often causes acute early-onset infections. Conversely, *coagulase negative Staphylococci* are part of normal human skin flora and have relatively low virulence because they are usually much more indolent and are often responsible for slow-onset chronic infections.

The traditional approach with regards to infection control measures in shoulder surgery has been to extrapolate the evidence from hip and knee infection

literature to the shoulder. More recently, there has been an increase in shoulder-specific infection literature and this is to be welcomed given the important differences between the sites. For example, microbiology results have demonstrated the difference in responsible organisms. The fact that *P. acnes* is the most commonly implicated organism in postoperative shoulder infections is important because this organism requires much longer incubation periods and surgeons need to be aware of the need for prolonged incubation and the high negative predictive value of standard investigations. Although some risk factors are similar between the sites, there are also risk factors which are specific for shoulder infections such as male gender (as a result of the higher levels of *P. acnes* colonization). *Propionibacterium acnes* colonization has been reported pre-operatively even after skin preparation to be as high as in 81.6% in males and 41.6% in females, with a deep penetration of the organism into the shoulder in up to 19.1% of cases, at the time of shoulder arthroscopy.¹⁵ Similarly, in arthroplasty surgery, *P. acnes* infection has been implicated in up to 25% of cases and is the most commonly cultured organism after *S. aureus*.^{16,17} *Propionibacterium acnes* has been implicated as a pathogen in infections including endocarditis, meningitis, conjunctivitis, and various abscesses. Historically in shoulder surgery, when present in cultures, it was assumed to be a contaminant. This historical perspective was mostly propagated by the indolent course of *P. acnes* infections and the organism's slow growth cycle. However, with its increased detection rate its role in shoulder infections has become more recognized.¹⁸

In our series, cases of *P. acnes* infection tended to be synergistic with another organism. This is in keeping with the suggestion by several authors that *P. acnes* maybe an opportunistic organism rather than the causative organism.¹⁹ The exception to this in our series was in case 8: stemmed hemiarthroplasty performed for avascular necrosis of the humeral head. This patient had presented to the outpatient department for routine follow-up having been treated with amoxycillin for recurrent chest infections for a 10-week period, only on examination to have a pointing abscess at the surgical site and a CRP of 26. In this case, six from eight samples taken cultured *P. acnes* alone. In this scenario, failure to culture a synergistic organism could be explained by the prolonged courses of antibiotics that the patient has completed before presentation to the shoulder clinic.

Patients re-presenting with clinical features of infection following shoulder surgery require a detailed history and clinical examination. Blood investigations including CRP, ESR and white cell count should be performed. However, the sensitivity and specificity of

these tests in diagnosing or excluding indolent shoulder infections such as those caused by *P. acnes* and *coagulase negative staphylococcus* infections is low.²⁰ If inflammatory markers are raised, aspiration of the shoulder should be attempted using an aseptic technique. The diagnosis is more difficult in cases with normal inflammatory markers or in those with a negative aspirate and in this situation; judgement is made based on the clinical picture and suspicion of infection. Arthroscopic shoulder biopsies may have a role in this scenario.¹¹ Newer methods of detecting bone and joint infections in the shoulder such as α -defensin may be useful in the detection of PJI in the shoulder; however, their use is not widespread at this time and the role with in non-arthroplasty surgery of the shoulder is unclear.²¹

If infection is confirmed, management should ideally be guided by a dedicated multidisciplinary bone and joint infection team, including an orthopaedic surgeon, microbiologist, radiologist and infectious diseases physician. Management options include arthroscopic or open washout, debridement, antibiotics and implant retention, one-stage or two-stage revision, resection arthroplasty or chronic antibiotic suppression, decisions guided by the multiple factors implicated in postoperative infection.

We acknowledge the limitations of the present study. Patients not presenting back to our institution may have been inappropriately excluded from our series. Additionally, we do not have functional outcomes data on all patients treated for deep infection post-surgery. Nonetheless, we believe the study provides useful information on the epidemiology and causative organisms in shoulder surgery performed in a large volume centre and consider that this information can be used to inform patients and can help to highlight infection control measures to minimize the risk of infection in shoulder surgery; for example, such as choice of antibiotic for cases that undergo implant insertion.

Conclusions

Patients undergoing open shoulder surgery have a significantly higher risk of infection compared to arthroscopic shoulder surgery. Arthroscopic surgery with implant insertion has a statistically significantly higher risk ($p < 0.05$) of developing deep infection compared to procedures with no implant insertion.

Declaration of Conflicting Interests

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Ethical Review and Patient Consent

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