Surgical treatment of shoulder infections: a comparison between arthroscopy and arthrotomy

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Background: Management of bacterial shoulder infections includes antibiotic therapy and surgical joint decompression. Arthroscopy and open arthrotomy are recommended treatment options. Whether 1 of the 2 surgical options is superior remains unclear. The present study aimed (1) to compare the reinfection rates after arthroscopy and open arthrotomy and (2) to identify risk factors of reinfection after surgical intervention.

Materials and methods: The data of 59 consecutive patients were available for final analysis. All patients received arthroscopy or open arthrotomy at our institution between 2001 and 2015. The reinfection rates between the 2 distinct interventions were compared. We also evaluated the influence of potential confounders, such as age, sex, comorbidities, microbiological findings, duration of symptoms, osteoarthritis, Gächter score, and preoperative inflammatory parameters, on the recurrence of infections and compared the functional outcome between the 2 surgery groups.

Results: From 59 included patients, 38 (64.4%) underwent open arthrotomy, and 21 (35.6%) were treated arthroscopically. Reinfection was documented in 18 patients (30.5%). The reinfection rate was significantly higher in arthroscopically treated patients (11 [52.4%]) than in patients who underwent open arthrotomy (7 [18.4%]; \( P = .007 \)). An infection with *Staphylococcus aureus* negatively influenced the treatment success (\( P = .034 \)).

Conclusion: According to our data, open arthrotomy is the more effective treatment method in septic arthritis of the shoulder, with lower reinfection rates and a comparable functional outcome. Furthermore, we could identify *Staphylococcus aureus* as an independent risk factor for the recurrence of infections.

Level of evidence: Level III; Retrospective Cohort Design; Treatment Study

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Septic arthritis is an orthopedic emergency that requires prompt treatment to avoid permanent joint damage and potentially life-threatening complications.\(^{10}\) The incidence of bacterial joint infection is between 4 and 10 per 100,000 patients per year and increases with age.\(^{9,13,17,19,28}\) The diagnosis of septic arthritis is generally based on a clinical examination, laboratory investigations, imaging, and joint aspiration.\(^{17}\)

Apart from the knee, the shoulder is the most frequently affected joint.\(^{28}\) Infections of joints can occur after hematogenous seeding or directly after local trauma or iatrogenic injury. Several studies have identified risk factors for the development of septic arthritis, including osteoarthritis,
immunosuppression, aging, diabetes mellitus, rheumatoid arthritis, intravenous drug use, and previous intra-articular corticosteroid injection.\textsuperscript{10,13,14,16,18}

\textit{Staphylococcus (S) aureus} is responsible for most of the bacterial joint infections, followed by streptococci and other gram-positive bacteria.\textsuperscript{7,11} Residual functional impairment is reported in up to 50\% of the patients.\textsuperscript{2,27} Management of the septic arthritis includes antibiotic therapy and immediate joint decompensation. Serial closed-needle aspiration and surgical interventions, such as an open arthrotomy with débridement or arthroscopic lavage with or without débridement, are accepted treatment options.\textsuperscript{2,6,16,29}

Although needle aspiration appears to be only effective in the early stages of infection,\textsuperscript{3} further clear recommendations of the preferable surgical intervention are lacking. A recent retrospective study and a small-scale prospective study were able to show that arthroscopic irrigation is more effective regarding infection eradication in septic arthritis of the knee.\textsuperscript{5,20} However, information about the treatment of shoulder infections is scarce.\textsuperscript{5,12} Owing to anatomic differences between the knee and the shoulder (i.e., the communication between the glenohumeral joint and the subacromial space), treatment concepts could vary.

Therefore, the current study focuses on the following aims: Firstly, to compare the efficacy of arthroscopy and open arthrotomy in patients with bacterial arthritis of the shoulder. The primary end point was the recurrence of infection that made a second surgical intervention necessary. Secondly, we aimed to identify potential risk factors for a failure of a single surgical débridement. In addition, we analyzed the postoperative range of motion.

\textbf{Materials and methods}

\textbf{Patients}

In this case-control study, we retrospectively reviewed data from consecutive patients who were treated at our department because of a septic monoarthritis of the shoulder between 2001 and 2015. All included patients were treated by arthroscopy or by open arthrotomy. The diagnosis of a septic arthritis had to be confirmed by a positive culture of the joint fluid or by histopathologic examination. The analysis excluded patients with osteomyelitis or any implant in a contiguous bone or soft tissue of the affected joint. The medical and radiologic records of 59 patients were available for final analysis.

A pretreatment joint aspiration for microbiologic diagnosis was conducted in all study participants. Laboratory studies included inflammatory parameters, such as C-reactive protein (CRP, in mg/dL) and white blood cell (WBC, in G/L) count, as well as blood culture at the initial blood examination. Data obtained from each patient comprised demographic data (sex, age at surgery, duration of symptoms before presentation, body mass index [BMI]), medical history, and comorbidities. The Charlson Comorbidity Index (CCI) was also applied to summarize comorbidities.\textsuperscript{5} Range of motion (ROM) in abduction was determined before and after surgery. The postoperative ROM data were chosen from the latest available examination.

Radiographs of the affected shoulder were performed in all patients, and the Kellgren and Lawrence classification was used to determine osteoarthritis severity.\textsuperscript{15} The intra-articular inflammatory process was graded by Gächter’s classification\textsuperscript{26}: stage I indicates turbid effusion, mild synovitis, possible petechial bleeding, and no radiologic alterations; stage II, purulent effusion, fibrinous deposition, pronounced synovitis, and no radiologic alterations; stage III, synovial adhesions, hypertrophic synovitis, necrotic areas of synovia and cartilage, and no radiologic alterations; and stage IV, aggressive pannus, cartilage necrosis, bone erosions, and osteolysis. Days of hospitalization and length of surgery were also registered.

\textbf{Treatment}

Intravenous antibiotic therapy commenced after initial joint aspiration. Cefazolin was generally given except in patients allergic to penicillin or cephalosporins. In such a case, treatment was switched to clindamycin. Dependent on culture results, the antibiotic therapy was adapted in consultation with the department of infectious diseases. Antibiotics were routinely administered for 6 weeks after surgery and replaced with an oral medication after discharge.

The choice of intervention method, arthroscopy or open arthrotomy, was subject to the personal preference of the executing consultant orthopedic surgeon. Operations were conducted with patients under general anesthesia and in the beach-chair position. Arthroscopy was performed in 21 patients, and 38 were treated with open arthrotomy. An anterior deltopectoral approach with subscapularis tenotomy was generally used in case of arthrothotomy. For arthroscopy 3 or 4 standard portals were used: a posterior, an anterosuperior, and a lateral portal, or alternatively, a posterior, an anterosuperior, an anterolateral, and a posterolateral portal.

Both surgical procedures included synovectomy, débridement, and joint irrigation with sterile physiological sodium saline solution as well as sampling for microbiological and histopathologic examination. Débridement, synovectomy, and irrigation were performed in the joint and in the subacromial space. Saline irrigation was performed with 3 to 5 liters in the arthrothotomy group and with 5 to 20 liters in the arthroscopy group. A complete bursectomy was routinely performed. No local antibiotics were applied. At least 1 suction drain was used and usually left for 5 days.

Patients were encouraged to put the arm in a sling for at least 4 to 5 days postoperatively. In case of complete subscapularis te
tenotomy, a sling was necessary for 3 weeks, and outward rotation was not allowed for 6 weeks.

Patients were usually seen at 2 weeks, 6 weeks, and at 3, 6, and 12 months after discharge in the outpatient clinic for treatment response evaluation. These visits included physical examination and blood testing. Recurrence of infection was suspected when inflammatory parameters increased anew or were persistently elevated, pain in the affected joint increased, or purulent joint swelling recurred. In the event of a recurring infection, the patient was readmitted to our institution, and an additional débridement was performed. The median (25\%th, 75\%th percentile) follow-up was 28 (17, 34) months.

\textbf{Statistical analysis}

First, a descriptive statistic assessment was performed. Continuous variables are described by median (25\%th and 75\%th percentile) when
appropriate. The χ² test was used to compare the reinfection rate in the arthroscopy and the open arthrotomy groups. Differences in the presence of potential confounders between the 2 surgery groups and between patients with primary infection eradication and those with reinfection were analyzed. The following parameters were evaluated: age, diabetes mellitus (DM), rheumatoid arthritis (RA), positive culture of *S aureus*, CCI, Kellgren and Lawrence grade, Gäechter score, preoperative CRP and WBC levels, duration of symptom before presentation, BMI, height, weight, and sex. These evaluations were done using the Mann-Whitney *U* test and the χ² test. Odds ratios and 95% confidence intervals were used to describe the influence of potential risk factors for reinfection, applying logistic regression as the calculation method. A comparison of the postoperative ROM was drawn between the 2 surgical techniques and between the reinfection group and the primary eradication group. Again, these comparisons were made using the Mann-Whitney *U* test. Values of *P* ≤ .05 were considered as statistically significant. The statistical analysis was performed with IBM SPSS 20 software (IBM, Armonk, NY, USA).

### Demographics

The presented study included 59 patients with a median (25th, 75th percentile) age of 72 (57, 82) years. Table I summarizes the patient characteristics. Open arthrotomy was performed in 38 patients (64.4%), and 21 (35.6%) underwent arthroscopic treatment. Identification of the causative organism from joint fluid was possible in 31 patients (52.5%). A diagnosis of septic arthritis was confirmed in the remaining patients by histopathologic examination. *S aureus* was the most commonly found (18 [30.5%] patients) isolate. In 4 of these, a methicillin-resistant *S aureus* (MRSA) grew in the culture. The following other bacteria were registered: *Streptococcus* spp in 4 patients (6.8%), other *Staphylococcus* spp than *S aureus*, including *S epidermidis*, in 5 patients (8.5%), *Pseudomonas aeruginosa* in 2 patients (3.4%), and extended-spectrum β-lactamase-producing *Enterobacteriaceae* in 1 patient.

Regarding the etiology of the infection, 23 patients (39%) reported previous intra-articular corticosteroid injections, hematogenous spread with confirmed primary focus was found in 18 patients (30.5%). Table I summarizes the patient characteristics.

### Table I  Patient characteristics and differences between the arthroscopy and arthrotomy groups

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total</th>
<th>Arthrotomy</th>
<th>Arthroscopy</th>
<th><em>P</em> value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients</td>
<td>59</td>
<td>38 (64.4)</td>
<td>21 (35.6)</td>
<td></td>
</tr>
<tr>
<td>Reinfection</td>
<td>18 (30.5)</td>
<td>7 (18.4)</td>
<td>11 (52.4)</td>
<td>.007</td>
</tr>
<tr>
<td>Female</td>
<td>34 (57.6)</td>
<td>25 (65.8)</td>
<td>9 (42.9)</td>
<td>.088</td>
</tr>
<tr>
<td>Age, y</td>
<td>72 (57, 82)</td>
<td>74 (58, 83)</td>
<td>71 (57, 77)</td>
<td>.501</td>
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<tr>
<td>Weight, kg</td>
<td>68 (58, 83)</td>
<td>67 (55, 85)</td>
<td>70 (60, 81)</td>
<td>.926</td>
</tr>
<tr>
<td>Height, cm</td>
<td>167 (158, 175)</td>
<td>165 (156, 176)</td>
<td>168 (163, 174)</td>
<td>.378</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>24.6 (21.8, 27.1)</td>
<td>25.1 (21.8, 28.1)</td>
<td>24.5 (22, 27)</td>
<td>.511</td>
</tr>
<tr>
<td>Hospitalization, d</td>
<td>12 (7, 19)</td>
<td>12 (5, 21)</td>
<td>11 (7, 18)</td>
<td>.804</td>
</tr>
<tr>
<td>Duration of symptoms, d</td>
<td>4 (3, 7)</td>
<td>5 (3, 7)</td>
<td>4 (2, 6)</td>
<td>.494</td>
</tr>
<tr>
<td>CCI</td>
<td>5 (4, 8)</td>
<td>5 (4, 8)</td>
<td>6 (3, 8)</td>
<td>.439</td>
</tr>
<tr>
<td>Rheumatoid arthritis</td>
<td>6 (10.2)</td>
<td>5 (13.2)</td>
<td>1 (4.8)</td>
<td>.307</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>13 (22)</td>
<td>9 (23.7)</td>
<td>4 (19)</td>
<td>.681</td>
</tr>
<tr>
<td><em>Staphylococcus aureus</em></td>
<td>18 (30.5)</td>
<td>11 (28.9)</td>
<td>7 (33.3)</td>
<td>.726</td>
</tr>
<tr>
<td>CRP presurgery, mg/dl</td>
<td>14.3 (6.6, 20.9)</td>
<td>17 (8.1, 23.2)</td>
<td>8 (3, 19.3)</td>
<td>.066</td>
</tr>
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<td>WBC count presurgery, G/L</td>
<td>11.3 (8.5, 14.1)</td>
<td>10.9 (8.6, 14.2)</td>
<td>11.8 (7.5, 13.6)</td>
<td>.546</td>
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<tr>
<td>Length of surgery, min</td>
<td>45 (30, 55)</td>
<td>45 (35, 50)</td>
<td>45 (25, 60)</td>
<td>.950</td>
</tr>
<tr>
<td>Gäechter</td>
<td></td>
<td></td>
<td></td>
<td>.010</td>
</tr>
<tr>
<td>I</td>
<td>16 (28.1)</td>
<td>5 (13.5)</td>
<td>11 (55)</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>21 (36.8)</td>
<td>16 (43.2)</td>
<td>5 (25)</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>17 (29.8)</td>
<td>14 (37.8)</td>
<td>3 (15)</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>3 (5.3)</td>
<td>2 (5.4)</td>
<td>1 (5)</td>
<td></td>
</tr>
<tr>
<td>Kellgren and Lawrence</td>
<td></td>
<td></td>
<td></td>
<td>.346</td>
</tr>
<tr>
<td>0</td>
<td>9 (15.3)</td>
<td>6 (15.8)</td>
<td>3 (14.3)</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>6 (10.2)</td>
<td>2 (5.3)</td>
<td>4 (19)</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>22 (37.3)</td>
<td>17 (44.7)</td>
<td>5 (23.8)</td>
<td></td>
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<tr>
<td>III</td>
<td>14 (23.7)</td>
<td>8 (21.1)</td>
<td>6 (28.6)</td>
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<tr>
<td>IV</td>
<td>8 (13.6)</td>
<td>5 (13.2)</td>
<td>3 (14.3)</td>
<td></td>
</tr>
<tr>
<td>Etiology of infection</td>
<td></td>
<td></td>
<td></td>
<td>.869</td>
</tr>
<tr>
<td>Intra-articular injections</td>
<td>23 (39)</td>
<td>14 (36.8)</td>
<td>9 (42.9)</td>
<td></td>
</tr>
<tr>
<td>Hematogenous spread</td>
<td>18 (30.5)</td>
<td>12 (31.6)</td>
<td>6 (28.6)</td>
<td></td>
</tr>
<tr>
<td>Causative trauma</td>
<td>1 (1.7)</td>
<td>1 (2.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>17 (28.8)</td>
<td>11 (28.9)</td>
<td>6 (28.6)</td>
<td></td>
</tr>
</tbody>
</table>

CCI, Charleston Comorbidity Index; CRP, C-reactive protein; WBC, white blood cell.

* Values for continuous data are presented as the median (25th percentile, 75th percentile) and for continuous data as number (%).

† Bold values are statistically significant (*P* ≤ .05).
A reinfection necessitating a second surgery occurred in 18 patients (30.5%). The reinfection rate was significantly higher in patients who were treated arthroscopically (11 [52.4%]) than in those who underwent open arthrotomy (7 [18.4%]; \( P = .007 \)). Of the 18 patients with recurrent infection, 15 (83%) were treated with open arthrotomy and 3 (17%) arthroscopically.

We compared the 2 surgery groups regarding the presence of potential risk factors. No differences between the 2 surgery groups were found concerning age, sex, BMI, number of patients with RA, number of patients with DM, number of patients with \textit{S aureus} infection, Gächter score, etiology of infection, Kellgren and Lawrence score, preoperative CRP levels, preoperative WBC levels, durations of symptoms before therapy, duration of hospitalization, and duration of surgery. The Gächter score differed significantly between the 2 groups. The open arthrotomy group \( (P = .010) \) showed higher grades. \textbf{Table I} provides a detailed report of the 2 surgery groups and the corresponding \( P \) values.

Of all analyzed potential risk factors, \textit{S aureus} was significantly more often discovered in patients with reinfection \( (P = .034) \). The number of MRSA infections (4 patients) in this study was too low to be considered for separate analysis. All patients with MRSA infection were initially treated with open arthrotomy, of which 2 had a recurrent infection. Other parameters, such as age, sex, BMI, number of patients with RA, number of patients with DM, CCI, osteoarthritis, Gächter score, preoperative CRP levels, preoperative WBC levels, etiology of infection, durations of symptoms before therapy, and duration of surgery, did not differ between the reinfection group and the primary eradication group. \textbf{Table II} summarizes these results.

\begin{table}[h]
\centering
\caption{Differences between primary eradication group and reinfection group}
\begin{tabular}{llll}
\hline
Variable & Primary eradication & Reinfection & \( P \) values\textsuperscript{†} \\
\hline
Patients  & 41 (69.5) & 18 (30.5) & .831 \\
Female    & 24 (58.5) & 10 (55.6) & .954 \\
Age, y    & 73 (54, 83) & 72 (65, 78) & .440 \\
Weight, kg & 68 (59, 84) & 63 (55, 80) & .552 \\
Height, cm & 167 (160, 170) & 170 (158, 175) & .475 \\
Body mass index, kg/m\textsuperscript{2} & 24.6 (22, 27.5) & 24.6 (21.6, 26.3) & .150 \\
Hospitalization, d & 10 (6, 18) & 13 (8, 21) & .086 \\
Duration of symptoms, d & 4 (2, 7) & 6 (3, 26) & .263 \\
CCI       & 5 (3, 8) & 7 (5, 8) & .274 \\
Rheumatoid arthritis & 3 (7.3) & 3 (16.7) & .982 \\
Diabetes mellitus & 9 (22) & 4 (22.2) & .034 \\
\textit{Staphylococcus aureus} & 15 (7.4, 20.3) & 9.1 (3.5, 24.5) & .649 \\
CRP presurgery, mg/dL & 11.3 (8.6, 14.2) & 10.8 (8, 12.6) & .371 \\
WBC count presurgery, G/L & 45 (30, 55) & 45 (40, 50) & 1.000 \\
Length of surgery, min & 45 (30, 55) & 45 (40, 50) & .463 \\
Gächter & & & .938 \\
I & 10 (25.6) & 6 (33.3) & \textsuperscript{†} \\
II & 13 (33.3) & 8 (44.4) & \\
III & 13 (33.3) & 4 (22.2) & \\
IV & 3 (7.7) & 0 & \\
Kellgren and Lawrence & & & .876 \\
0 & 6 (14.6) & 3 (16.7) & \\
I & 5 (12.2) & 1 (5.6) & \\
II & 15 (36.6) & 7 (38.9) & \\
III & 10 (24.4) & 4 (22.2) & \\
IV & 5 (12.2) & 3 (16.7) & \\
Etiology of infection & & & \\
Intra-articular injections & 16 (39) & 7 (38.9) & \\
Hematogenous spread & 13 (31.7) & 5 (27.8) & \\
Causative trauma & 1 (2.4) & 0 & \\
Unknown & 11 (26.8) & 6 (33.3) & \\
\hline
\end{tabular}
\textsuperscript{†} Bold values are statistically significant \((P \leq .05)\).
\end{table}

\textsuperscript{c}CCI, Charleston Comorbidity Index; CRP, C-reactive protein; WBC, white blood cell.

\textsuperscript{a} Values for continuous data are presented as the median (25th percentile, 75th percentile) and for continuous data as number (%).
Consequently, logistic regression was performed to evaluate independent risk factors for failure of a single surgery. In the model, the type of surgery, infection with \textit{S. aureus}, and the CCI could be identified as influencing risk factors for reinfection. Gächter’s score was included in the analysis of this model but did not show significant influences. Table III assembles the results and shows the odds ratios and 95% confidence intervals.

Evaluating the postoperative functional outcome, no differences between patients with reinfection and with successful primary surgery or between the 2 surgery groups could be found. Median (25th, 75th percentile) ROM reached 80° (45°, 90°) in the reinfection group, 100° (45°, 145°) in the successful primary surgery group \((P = .785)\), 100° (30°, 170°) in the arthroscopy group, and 90° (50°, 100°) in the open arthrotomy group \((P = .732)\).

**Discussion**

Septic arthritis is a rare but severe and potentially lethal disease\(^{13}\) that requires immediate antibiotic therapy and surgical joint decompression.\(^{14}\) Up to now, only few studies have compared the surgical treatment options: arthroscopy and open arthrotomy. Most of these studies focused on infections of the knee or did not distinguish between single joints.\(^{2,4,11,29}\) Information about the treatment of infections of the glenohumeral joint is scarce, and surgical treatment concepts may differ from those of the knee. To the best of our knowledge, this is the largest series to compare treatment outcome of bacterial shoulder infections. In the current study, we could demonstrate that the reinfection rate was significantly lower in patients who were treated with open arthrotomy than in patients who underwent arthroscopy. The study further identified \textit{S. aureus} infection and increasing CCI scores as independent risk factors for failure of a single operation.

In the present study, overall 70% of the patients with shoulder infection were successfully treated with a single operation. These results are comparable with other reports, which described primary success rates between 68% and 74%.\(^{1,12}\) Generally, the reinfection rate appears to be slightly higher in the shoulder than in the knee, where primary salvage rates between 82% and 90% were reported.\(^{3,20,26}\) In the open arthrotomy group, a single operation led to infection eradication in 82% of our cohort. Results were significantly poorer in the arthroscopy group, where a single débridement was only successful in 48%. Logistic regression also identified arthroscopy as a risk factor for reinfection.

So far, to our knowledge, no studies are available comparing arthroscopy and open arthrotomy exclusively in infections of the shoulder. By comparison, in infections of the knee, patients treated arthroscopically showed a more favorable outcome with lower reinfection rates.\(^{3,4,20}\) Therefore, the significantly better results of the open arthrotomy group are very intriguing. In our opinion, the communication between the glenohumeral joint and the subacromial space, especially the subacromial bursa, might be responsible. Likewise, tears in the rotator cuff and in the capsule, especially in elderly patients, are common.\(^{22,25}\) Hence, arthroscopic high-pressure irrigation could lead to dissemination of microorganisms in the surrounding soft tissue and might be responsible for an infection recurrence. Moreover, an involvement of the subacromial bursa is prevalent in shoulder infections. Again, arthroscopic bursectomy and high-pressure irrigation could cause a spread of bacteria.

We found no differences between the 2 groups regarding the presence of potential confounders that could have influenced the reinfection rate. Only the Gächter score was higher in the open arthrotomy group. The homogeneity of the 2 groups confirms the independent influence of the surgery type on the reinfection group. Furthermore, although the open arthrotomy is the more invasive procedure, we found no differences regarding the duration of surgery and the duration of hospitalization. Also the ROM in abduction did not differ between the open arthrotomy and the arthroscopy group. Different results are described for the knee, with a significantly better functional outcome after arthroscopy.\(^{4,20,29}\)

In the current study we analyzed several confounders and their influence on the recurrence of infection. As in other studies, \textit{S. aureus} was the most common bacterial isolate.\(^{11,12,21}\) It was detected in 31%, and after patients with no growth on culture were excluded, \textit{S. aureus} accounted for 58% of infections. \textit{S. aureus} was significantly more often found in patients with reinfection and could be identified as an independent risk factor for reinfection in multivariate analysis. These results are in line with a previous report.\(^{11}\) The number of patients with \textit{S. aureus} infection did not differ between the 2 surgery groups.

Also analyzed was the influence of comorbidities on reinfection, including DM, RA, immunosuppressing diseases, the CCI, and age. With the numbers available, no single comorbidity significantly influenced the reinfection rate. The influence of risk factors such as DM and RA might be underestimated because of the limited sample size. However, the multivariate analysis showed that patients with a decreased general condition (ie, higher CCI scores) are at increased risk for failure of primary surgery. Other risk factors that have been discussed in the literature, such as duration of symptoms before treatment and Gächter score, showed no negative influence on the reinfection rate in our cohort.\(^{3,29}\)

<table>
<thead>
<tr>
<th>Table III</th>
<th>Logistic regression of independent risk factors for reinfection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td>Odds ratio</td>
</tr>
<tr>
<td>Surgery type</td>
<td>7.6</td>
</tr>
<tr>
<td>\textit{Staphylococcus aureus}</td>
<td>8.7</td>
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<tr>
<td>CCI</td>
<td>1.5</td>
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<tr>
<td>Gächter score</td>
<td>0.5</td>
</tr>
</tbody>
</table>

CCI, Charleston Comorbidity Index; CI, confidence interval.

* Bold values are statistically significant \((P \leq .05)\).
Further investigate the influence of comorbidities, larger prospective studies are needed.

Our study has several limitations. Firstly, data were acquired retrospectively, and therefore, no randomization to one of the surgical treatments was conducted. A consultant orthopedic surgeon decided, based on personal preferences, which operation should be performed. Furthermore, owing to the retrospective design, the only available functional outcome parameter was the ROM in abduction. In many cases no standardized scores or pain assessments were available and, therefore, could not be included in the study.

Secondly, different surgeons performed the surgical procedures; however, all procedures were performed by experienced orthopedic surgeons.

Thirdly, magnetic resonance imaging was not available for a sufficient number of patients to correlate imaging findings and surgical success rates.

Fourthly, the sample size was limited to 59 patients with a substantial recruiting period of 14 years. Given the sample size of 59 patients, the influence of potential risk factors might have been underestimated. However, this is still one of the largest studies on treatment of septic shoulder infections currently available in the literature. Based on the numbers available, our findings might be helpful for surgical decision making in clinical practice. Future studies with larger sample sizes including prospective randomized-controlled trials are needed to confirm the current findings.

Conclusion

This study demonstrated that open arthroscopy was a more effective treatment method in septic arthritis of the shoulder, with lower reinfestation rates and a comparable functional outcome. Furthermore, we could identify *S. aureus* and the CCI as an independent risk factor for recurrence of infection.

Disclaimer

The authors, their immediate families, and any research foundation with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

References
