RESEARCH ARTICLE

The Surgical Treatment of Deep Infection in the Native Shoulder Joint

Tyler W. Henry, BS[1]; Michael Gutman, BA[2]; Amy Backal, BS[2]; Surena Namdari, MD, MSc[1,2]

Research performed at The Rothman Orthopaedic Institute at Thomas Jefferson University, Philadelphia Pennsylvania, USA

Received: 14 July 2020 *Accepted: 03 October 2020*

Abstract

Background: The overall clinical picture surrounding native shoulder infections, and, in particular, the associated long-term functional outcomes of treatment are presently underreported. The purpose of this study is to examine the demographics, diagnostic and treatment strategies, and functional outcomes of isolated shoulder joint sepsis treated with surgical irrigation and debridement (I&D).

Methods: All patients treated with I&D for native shoulder sepsis between 2007 – 2017 were identified. Those without a minimum of one-year follow-up were excluded. Functional outcomes scores, reoperations, and predictors of poor outcome were evaluated.

Results: Twenty-three patients were included in the final study population. Mean age-adjusted CCI score was 4.1 (SD = 3.4, Range = 0 – 10). Twelve patients (52.2%) were treated with open I&D, while 11 patients (47.8%) were treated arthroscopically. Nine patients (39.1%) required multiple I&Ds (mean total number of I&Ds = 1.7, SD = 1.0, Range: 1 – 4). Five patients (21.7%) had at least one documented reinfection after their initial hospitalization, with the initial recurrence of infection occurring 2 – 15 months after the index procedure. Mean ASES score at final follow-up was 55.3 (SD = 26.7, Range: 5.8 – 98.3) and mean SANE score was 53.3 (SD = 30.6, Range: 0 – 100). Stepwise multiple linear regression modeling identified intravenous drug abuse as the most significant predictor for final ASES score [$F(1,18) = 6.12$, $p = .024$, adjusted $R^2 = .254$].

Conclusion: Following isolated shoulder joint sepsis, infection clearance and acceptable functional outcomes can be achieved using surgical I&D followed by a course of antibiotics, but outcomes are variable.

Level of evidence: IV

Keywords: Infection, Native, Outcomes, Sepsis, Shoulder, Treatment

Introduction

Deep infection of the native shoulder joint is a rare but serious condition that can carry substantial morbidity and mortality. It has been reported that the incidence of septic joint arthritis is between 4 and 12 cases per 100,000 patient-years, with 8 – 21% of these cases involving the shoulder joint (1, 2). While native shoulder infection can occur in otherwise healthy patients, it is often found in older, medically complex patients or those with easily identifiable risk factors, such as intravenous drug abuse (IVDA) or immunocompromised (1, 3, 4). Patients can present with varying severity shoulder pain, often of unknown etiology, with or without signs of local or systemic infection (5, 6). Diagnostic and treatment strategies also vary, but commonly include serum inflammatory markers, joint aspiration, blood cultures, and open

Corresponding Author: Surena Namdari, Sidney Kimmel Medical College, Thomas Jefferson University, Philadelphia, PA, USA
Email: Surena.Namdari@rothmanortho.com

AB&JS THE ONLINE VERSION OF THIS ARTICLE ABJS.MUMS.AC.IR

or arthroscopic irrigation and debridement (I&D). Both open and arthroscopic I&D have demonstrated acceptable infection eradication efficacy, with open I&D historically reserved for more chronic presentations, more virulent organisms, or more severe clinical pictures. Postoperatively, patients are often managed with extended courses of intravenous (IV) antibiotics. Lifelong suppressive antibiotic therapy may be required for immunocompromised patients or those with a history of recurrent infection (7).

Due to the medical complexity of many affected patients, the risk for disseminated infection leading to severe morbidity or mortality, and the often-ambiguous nature of clinical presentation, native shoulder infection is a challenging clinical scenario that requires prompt diagnosis and management. Reported treatment outcomes are highly variable and dependent on the age and comorbidity profiles of affected patients. It is therefore of critical importance to wholly understand the variables associated with native shoulder infection that may impact or prognosticate outcomes (5, 6, 8-12). Although infection eradication and medical stabilization are of the most critical concern upon patient presentation, the potential for morbidity and functional limitations must also be considered within utilized treatment algorithms. The purpose of this retrospective cohort study is to examine the demographics, diagnostic and treatment strategies, and functional outcomes associated with surgically-managed native shoulder infection.

Materials and Methods

Following Institutional Review Board approval, a database search yielded 79 patients surgically treated for septic arthritis of a native shoulder joint between 2007 – 2017 within a single orthopaedic group. This cohort was established through an automated search for all shoulder I&Ds with a diagnosis code or description of septic arthritis, and excluded patients with any prior surgery or trauma to the affected shoulder through manual stratification. Study inclusion criteria required surgically managed patients with documented clinical follow-up and final survey completion at a minimum of one year after initial presentation. Patients with high clinical suspicion for infection despite negative cultures were included if they underwent surgery with a postoperative diagnosis of septic shoulder arthritis.

Thirty-eight patients lacked documented clinical follow-up after their index procedure and were excluded. Sixteen of the initially identified 79 patients (20.3%) were deceased by the time of data analysis. Twelve deceased patients lacked adequate clinical follow-up or survey completion and were also excluded. Of the remaining patients, final follow-up surveys, which included American Shoulder and Elbow Surgeons (ASES) score, Single Assessment Numerical Evaluation (SANE) score, Charlson Comorbidity Index (CCI) score, and the Veterans Rand 12-Item Health Survey scores for physical (VR-12P) and mental (VR-12M) functioning, were collected via telephone, electronic, or in-clinic survey. Six patients refused to participate. Demographic, preoperative, intraoperative, and postoperative variables were collected through electronic medical record review. For reporting purposes, final follow-up was considered to be the time of survey completion, and infection recurrence was considered to be any case in which a patient underwent unplanned reoperation for infection after their initial treatment and hospitalization, and after they had completed their initial course of antibiotic therapy.

Data was recorded and analyzed using the Statistical Package for the Social Sciences (SPSS Inc, Ver 26.0). Demographic variables, treatment characteristics, and overall outcomes were reported using descriptive statistics. Final survey scores were tested for normality using the Shapiro-Wilk test and mean differences between categorical variables were then compared using either the Student's T-test or Mann-Whitney U test. Relative risks for ASES, SANE, VR-12M, and VR-12P scores of 50 or less, referred to as below average scores, were also calculated for the categorical demographic and treatment variables. Finally, multiple linear regression modeling was used to identify any potential predictors of final outcome scores. Statistical significance for all testing was established at $P < .05$.

Results

Twenty-three patients met full criteria. The mean time to final follow-up was 3.2 years (SD = 2.8 years, Range: 1.0 – 11.1 years). Thirteen patients (56.5%) were male and 10 patients (43.5%) were female. The mean age was 62.7 years old (SD = 15.5 years, Range: 31 – 86 years old). Mean CCI score was 2.2 (SD = 2.3, Range: 0 – 7) and mean age-adjusted CCI score was 4.1 (SD = 3.4, Range = 0 – 10). Six patients (26.1%) had a medical history significant for diabetes mellitus and seven patients (30.4%) had moderate to severe chronic kidney disease. Five patients (21.7%) had an active malignancy or prior history of cancer. Two patients (8.7%) had rheumatoid arthritis. Thirteen patients 56.5% were current or former smokers and four patients (17.4%) were active IV drug users. In the study population, five patients (21.7%) had a known history of prior joint infection (two metatarsophalangeal, one carpometacarpal, one knee, and one patient with a history of both metatarsophalangeal and carpometacarpal infections).

Inflammatory markers at initial presentation were documented for 14/23 patients (60.9%). Of these 14 patients, the mean erythrocyte sedimentation rate (ESR) was 75.9 mm/hr (SD = 26.1, Range: 38.0 – 113.0). Ten patients (71.4%) had an elevated C-reactive protein (CRP) (mean CRP = 48.7 mg/L, SD = 69.0, Range: 0.2 – 178.0), and four (28.6%) had an elevated white blood cell (WBC) count (mean WBC count = 9.1, SD = 3.7, Range: 4.9 – 18.8). Eleven patients (47.8%) had documented suspicion for systemic infection at initial presentation and five patients had positive blood cultures on initial presentation (21.7%) [Table 1]. There was a documented suspected factor contributing to infection in 19 patients (82.6%) [Table 2]. The joint was aspirated in 16 patients (69.6%) and the aspiration was culture-positive in seven of these cases (43.8%). The

Table 1. Description of documented rationale for suspicion of systemic infection at initial presentation with frequencies

Sign of Systemic Infection at Presentation	Frequency
Fever	7
Fatigue and tachycardia	1
Fatigue and increased work of breathing	1
Meeting clinical criteria for sepsis	1
Undefined	1
Total	11/23

Table 2. Suspected factors contributing to infection with frequencies. *Culture negative cases

Suspected Contributing Factor	Frequency
Uncontrolled diabetes	4
IV Drug Use	4
Recent corticosteroid injection	3
Infected joint prosthesis or cardiac valve	2
Immunosuppressed state	2
Disseminated infection (2° to meningitis)	1
Recent gadolinium injection for MR arthrogram*	1
Recent tetanus vaccine*	1
Chronic lymphatic obstruction	1
Total	19/23

mean WBC count from joint aspiration was 46,877.9 cells/μL (SD = 31,190.7, Range: 966 – 90,000). Mean time from initial presentation to operation was 3.2 days (SD = 2.5 days, Range: 1 – 8 days).

Twelve patients (52.2%) were treated with open I&D, while 11 patients (47.8%) were treated arthroscopically. Fourteen patients (60.9%) had a peripherally inserted central catheter (PICC) line placed for IV antibiotic administration. Patients receiving IV antibiotics without a PICC line did so through pre-existing hemodialysis access sites. Four patients (17.4%) required lifelong antibiotic suppressive therapy. In all cases, infectious disease specialists oversaw antibiotic therapy, and the specific regimen was selected through culture sensitivities or institutional protocol in culture negative cases. Results of intraoperative cultures were available for 11 patients. Of these, the mean number of cultures was 2.0 (SD = 1.5, Range: 1 – 6) and 57.1% of cultures were positive. Overall, methicillin-sensitive staphylococcus aureus (MSSA) was the most common causative organism [Figure 1].

Nine patients (39.1%) required more than one I&D (mean total number of I&Ds = 1.7, SD = 1.0, Range: 1 – 4). Four of these were planned, repeat I&Ds occurring during the initial hospitalization and within one month from presentation. A total of 11 patients (47.8%) required reoperation of any kind during the study period [Table 3]. Open debridement was associated with a significantly higher mean number of total surgeries required (2.3 versus 1.3, *P=.019*). Three patients (13.0%) underwent reoperation after one year – two for infection recurrence, and one for a rotator cuff tear on the affected side. One patient (4.3%) in the cohort underwent conversion arthroplasty, which occurred five months after initial presentation. Five patients (21.7%) had at least one documented reinfection requiring reoperation after their initial hospitalization, with the

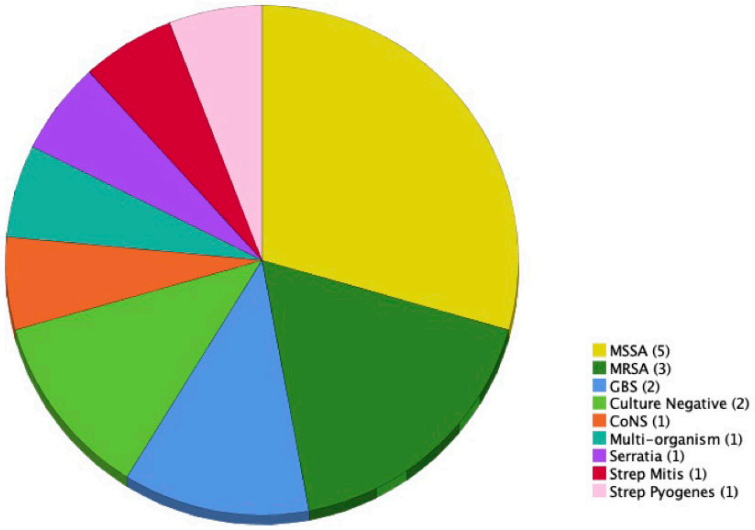

Figure 1. Frequency of causative organism profiles. Causative organism was unknown in six patients. MSSA = methicillin-sensitive staphylococcus aureus, MRSA = methicillin-resistant staphylococcus aureus, CoNS = coagulase negative staphylococcus aureus, GBS = Group B streptococcus. Multi-organism = MRSA and macrobacterium acid-fast bacilli.

Table 3. Patients requiring reoperation during the study period. Note: Staged I&D is a planned I&D during the initial hospitalization, occurring within one month of initial presentation

Patient ID	Index Procedure	Causative Organism	Number of Reoperations	Reason for Reoperation
1	Open	Group B Strep	1	Staged I&D
3	Arthroscopic	Culture Negative	2	Rotator Cuff Repair and Revision
4	Open	MRSA	2	Infection Recurrence (x2)
5	Open	MSSA	1	Staged I&D
6	Open	CoNS	1	Conversion Arthroplasty
10	Arthroscopic	Multi-Organism	1	Infection Recurrence
11	Open	Unknown	1	Staged I&D
13	Open	MSSA	2	Infection Recurrence (x2)
16	Open	Serratia	3	Infection Recurrence, Wound Dehiscence, Distal Clavicle Osteomyelitis and AC Joint Infection
18	Open	MSSA	1	Staged I&D
19	Open	MSSA	3	Infection Recurrence (x3)

initial recurrence of infection occurring 2 – 15 months after the index procedure [Table 3].

Mean ASES score at final follow-up was 55.3 (SD = 26.7, Range: 5.8 – 98.3) and mean SANE score was 53.3 (SD = 30.6, Range: 0 – 100). The mean VR-12M score was 44.4 (SD = 12.8, Range: 17.6 – 65.0) and the mean VR-12P score was 36.3 (SD = 13.3, Range: 21.4 – 59.4) [Table 4]. The mean ASES score was significantly lower with IVDA [31.4 (Range: 5.8 – 48.3) versus 60.9 (Range: 20.0 – 98.3), *P= .037*]. IVDA also carried a significantly increased risk for below average ASES and VR-12P scores at final follow-up (ASES Relative Risk = 2.8, 95% Confidence Interval = 1.5 – 5.4, *P= .002*) (VR-12P Relative Risk = 1.4, 95% Confidence Interval = 1.0 – 1.9, *P= .026*). Stepwise multiple linear regression modeling identified IVDA as the most significant predictor for final ASES score [$F(1,18) = 6.12$, $P = .024$, adjusted $R^2 = .254$] among the variables tested (IVDA, age-adjusted CCI, positive smoking history, open versus arthroscopic procedure). Linear regression modeling did not identify any significant predictors for SANE, VR-12M, or VR-12P scores at final follow-up (all $P > .05$).

Discussion

Native shoulder joint infection often occurs in immunocompromised patients, or those with extensive medical comorbidities. Infection eradication can be reliably achieved through surgical I&D and postoperative antibiotic courses, although this often requires multiple surgeries. Functional outcomes are fair and may be associated with the comorbidity profile of affected patients. IV drug abuse is a particularly significant predictor of poor functional outcomes.

Sixteen of the 79 (20.3%) initially identified patients were deceased at the time of data analysis, underscoring the compromised medical complexity of this population. In our study, medical comorbidities did not reliably

Table 4. Demographic characteristics and functional outcomes of the study cohort. Scores collected at a mean duration of 3.2 years after initial presentation

Variable	n =	ASES	SANE	VR-12M	VR-12P
Total Cohort	23	55.3	53.3	44.4	36.3
Age (mean age = 62.7 years old)					
≥ 65 years old	9 (39.1%)				
≤ 65 years old	14 (60.9%)				
Sex					
Female	10 (43.5%)				
Male	13 (56.5%)				
Dominant Side	10 (43.5%)				
Diabetes	6 (26.1%)				
CKD	7 (30.4%)				
Cancer History	5 (21.7%)				
Prior Joint Sepsis	5 (21.7%)				
Smoking	13 (56.5%)				
IV Drug Use	4 (17.4%)				
Index Procedure					
Open	12 (52.2%)				
Arthroscopic	11 (47.8%)				
Lifelong Antibiotics	4 (17.4%)				
Infection Recurrence	5 (21.7%)				
≥ 1 Reoperation	11 (47.8%)				

predict functional outcomes, though prior reports in the literature have established this connection (3). Our final cohort had an extensive comorbidity profile, including a substantial rate of IV drug abuse, smoking, and other immunocompromised states. Previously reported native infection study populations have demonstrated similar comorbidity profiles. Abdel et al. analyzed 50 native shoulder infections and found that patients were immunocompromised in 57% of cases, with a one year mortality rate of 17% (8). In a similar series of 21 patients, Klinger et al. found that 13 had an underlying medical disease, while Jeon et al. identified underlying disease in 13 of 19 patients (10, 13). Interestingly, joint aspiration WBC count, which is traditionally used to support a diagnosis when > 50,000 cells/μL, was not a reliable marker for infection in the present cohort (8, 14). This could also be suggestive of the underlying comorbidity profile, with immunocompromised patients potentially unable to mount an appropriate WBC response to infection. In terms of IV drug abuse, existing studies have likely underreported rates among affected patients secondary to a lack of follow-up and/or patient reporting. In a review of the literature, Lossos et al. reported five IV drug users in a cohort of 127 patients diagnosed with septic shoulder arthritis and they did not consider this a risk factor for native shoulder infection. The rate of IV drug abuse in our cohort was 17.4%, which is 6.7 times higher than the estimated rate of lifetime use among the United States population (14). In the present study, IV drug abuse carried an increased risk for below average ASES and VR-12P scores, and also predicted final ASES score, with a lower mean ASES score in IV drug users. Overall, the commonality of medical comorbidities and social risk factors associated with poor outcomes in patients with native shoulder infections necessitates aggressive treatment with attention to comorbid conditions and appropriately managed patient expectations (15). Furthermore, surgeons may consider the possibility of little to no patient follow-up when considering potential treatment strategies.

Infections were successfully eradicated in the majority of patients despite over a third of the population requiring multiple I&Ds, which is consistent with the literature. Lifelong antibiotic suppression therapy was also not uncommon (8, 9). Mean ASES and SANE scores were highly variable, but overall fair. Functional outcomes after surgical treatment of native shoulder infection are presently underreported. In a retrospective study including 34 cases of septic arthritis treated with open or arthroscopic I&D and a mean follow-up of 32.4 months, Cho and Oh reported a mean final ASES score of 81.3, considerably higher than the 55.3 observed in our cohort (7). This could perhaps be attributed to differences in the comorbidity profiles of the two study populations. Jeon et al. also measured functional outcomes after arthroscopic I&D in 19 patients using the UCLA scoring system with an average score of 26 at a mean follow-up of 16.4 months, although 11 patients in their cohort had a concomitant rotator cuff tear. Both rotator cuff tear and degenerative arthritis are potential complications of native joint infection and treatment, and may eventually lead to conversion arthroplasty (13). Only one patient in our cohort required conversion arthroplasty, although a recent study examining shoulder arthroplasty as a sequela of native infection may suggest a higher incidence than we were able to identify (16).

There were no significant differences in our study between open and arthroscopic I&Ds in terms of infection eradication or functional outcomes. Open I&D was associated with a higher number of total infections required, but this is likely reflective of the underlying complexities favoring the use of an open approach in these cases, which is consistent with the literature. In their study, Cho and Oh directly compared arthroscopic (22 cases) and open (12 cases) I&D and found no significant differences in clinical outcomes between the two methods. Similar studies have also reported the equal efficacy of open and arthroscopic I&D, with arthroscopic I&D often favored in acute, less virulent infections (7). Future prospective studies could help to elucidate more precisely defined indications for open versus arthroscopic I&D (9, 14, 17).

Limitations

This study has several limitations, including its retrospective design and small population size. Potential inconsistencies in procedural and diagnosis codes allow for the possibility that patients meeting inclusion criteria were unintentionally excluded. The extensive comorbidity profile and mortality rate within this population lend insight into the complexity of these patients, but also substantially hinder the completion of necessary clinical follow-up required for inclusion within the study. Despite the fact that poor follow-up may have impacted our findings, it is an important variable to consider when treating this patient population. Our reported reinfection rate must be appreciated with the understanding that there is room for interpretation in delineating reinfection from persistent infection. As a number of reinfections in our cohort occurred shortly after the completion of antibiotics, some may instead classify these as persistent infections. Additionally, it is possible that potentially confounding variables were unaccounted for during statistical analysis. The retrospective nature of this study most importantly impacted the treatment courses, which lacked standardization. This led to only 14/23 patients with inflammatory marker results at the time of diagnosis, and variable postoperative courses that left us unable to fully assess the utility of specific protocols (i.e. radiographic assessment, repeat diagnostic testing, etc.). And finally, population size should be especially considered when interpreting statistical testing, particularly with multiple linear regression modeling.

In summary, infection clearance and fair functional outcomes following isolated shoulder joint sepsis can be achieved using surgical I&D followed by a course of antibiotics. There may be a high rate of concomitant morbidity and mortality among these patients. Continued investigation into this clinical scenario,

including the appropriate indications for open versus arthroscopic I&D and strategies to prevent long-term morbidity are warranted.

Acknowledgements

The authors gratefully acknowledge the technical assistance of Thema Nicholson, MSc and Camilo Restrepo, MD.

Tyler W. Henry BS[1]
Michael Gutman BA[2]
Amy Backal BS[2]
Surena Namdari MD MSc[1,2]
1 Sidney Kimmel Medical College, Thomas Jefferson University, Philadelphia, PA, USA
2 Rothman Orthopaedic Institute, Thomas Jefferson University Hospitals, Philadelphia, PA, USA

References

1. Kennedy N, Chambers ST, Nolan I, Gallagher K, Werno A, Browne M, et al. Native joint septic arthritis: epidemiology, clinical features, and microbiological causes in a New Zealand population. The Journal of rheumatology. 2015; 42(12):2392-7.
2. Mathews CJ, Weston VC, Jones A, Field M, Coakley G. Bacterial septic arthritis in adults. Lancet. 2010; 375(9717):846-855.
3. Assunção JH, Noffs GG, Malavolta EA, Gracitelli MEC, Lima ALM, Ferreira Neto AA. Septic arthritis of the shoulder and elbow: one decade of epidemiological analysis at a tertiary referral hospital. Rev Bras Ortop. 2018; 53(6):707-713.
4. Maneiro JR, Souto A, Cervantes EC, Mera A, Carmona L, Gomez-Reino JJ. Predictors of treatment failure and mortality in native septic arthritis. Clin Rheumatol. 2015; 34(11):1961-1967.
5. Cleeman E, Auerbach JD, Klingenstein GG, Flatow EL. Septic arthritis of the glenohumeral joint: a review of 23 cases. J Surg Orthop Adv. 2005;14(2):102-107.
6. Sweet MC, Sheena GJ, Liu S, Fisk FE, Lynch JR, Muh SJ. Clinical Characteristics and Long-term Outcomes After Septic Arthritis of the Native Glenohumeral Joint: A 20-Year Retrospective Review. Orthopedics. 2019; 42(1):e118-e123.
7. Cho C-H, Oh G-M. Prognostic Factors Affecting the Clinical Outcome of Septic Arthritis of the Shoulder. J Hand Surg Asian Pac Vol. 2016; 21(3):339-344.
8. Abdel MP, Perry KI, Morrey ME, Steinmann SP, Sperling JW, Cass JR. Arthroscopic management of native shoulder septic arthritis. J Shoulder Elbow Surg. 2013; 22(3):418-421.
9. Duncan SFM, Sperling JW. Treatment of Primary Isolated Shoulder Sepsis in the Adult Patient. Clin Orthop Relat Res. 2008; 466(6):1392-1396.
10. Klinger H-M, Baums MH, Freche S, Nusselt T, Spahn G, Steckel H. Septic arthritis of the shoulder joint: an analysis of management and outcome. Acta Orthop Belg. 2010;76(5):598-603.
11. Smith AM, Sperling JW, Cofield RH. Outcomes are poor after treatment of sepsis in the rheumatoid shoulder. Clin Orthop Relat Res. 2005; 439:68-73.
12. Themistocleous G, Zalavras C, Stine I, Zachos V, Itamura J. Prolonged implantation of an antibiotic cement spacer for management of shoulder sepsis in compromised patients. J Shoulder Elbow Surg. 2007; 16(6):701-705.
13. Jeon I-H, Choi C-H, Seo J-S, Seo K-J, Ko S-H, Park J-Y. Arthroscopic management of septic arthritis of the shoulder joint. J Bone Joint Surg Am. 2006; 88(8):1802-1806.
14. Lossos IS, Yossepowitch O, Kandel L, Yardeni D, Arber N. Septic arthritis of the glenohumeral joint. A report of 11 cases and review of the literature. Medicine (Baltimore). 1998; 77(3):177-187.
15. Lansky A, Finlayson T, Johnson C, Holtzman D, Wejnert C, Mitsch A, et al. Estimating the number of persons who inject drugs in the United States by meta-analysis to calculate national rates of HIV and hepatitis C virus infections. PloS one. 2014; 9(5):e97596.
16. Padegimas EM, Nicholson TA, Silva S, Ramsey ML, Williams GR, Lazarus MD, et al. Outcomes of shoulder arthroplasty performed for postinfectious arthritis. Clinics in orthopedic surgery. 2018; 10(3):344.
17. Stutz G, Kuster MS, Kleinstück F, Gächter A. Arthroscopic management of septic arthritis: stages of infection and results. Knee Surg Sports Traumatol Arthrosc. 2000;8(5):270-274.