Title

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Journal

Arthroscopy, sports medicine, and rehabilitation, 4(3)

ISSN

2666-061X

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Publication Date

2022-06-01

DOI

10.1016/j.asmr.2022.04.014

Original Article

Arthroscopic Treatment Yields Lower Reoperation Rates than Open Treatment for Native Knee but Not Native Shoulder Septic Arthritis

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Purpose: To compare the incidence, patient demographics, complication rates, readmission rates, and reoperation rates of open and arthroscopic surgery performed for septic arthritis in native knee and shoulder joints. **Methods:** Records of patients who were diagnosed with native knee or shoulder septic arthritis and underwent open or arthroscopic irrigation and debridement (I&D) between 2015 and 2018 were queried from the PearlDiver Mariner Database. International Classification of Diseases 10th (ICD-10) diagnosis and procedure codes were used to identify patients and track reoperations. Reoperation procedures, including revision open and arthroscopic I&D, were analyzed at 1 month, 1 year, and 2 years. Complications, emergency department (ED) admissions, and hospital readmissions within 30 days were analyzed and compared between the open and arthroscopic cohorts. **Results:** The query resulted with 1,993 patients who underwent knee I&D (75.3% arthroscopic, 24.7% open, $P < .001$) and 476 patients who underwent shoulder I&D (64.8% arthroscopic, 35.2% open, $P < .001$). One-month complication rates (11.6-22.7%) and hospital readmission rates (15.8-19.6%) were similar for arthroscopic and open treatment for knee and shoulder septic arthritis. Reoperation rates for revision I&D of the knee were higher after open compared to arthroscopic treatment at 1 month, 1 and 2 years (20.9% vs. 16.7%, 32.5% vs 27.6% and 34.1% vs. 29.4%, $P < .05$, respectively). For shoulder septic arthritis 1-month, 1-year, and 2-year reoperation rates were similar for open and arthroscopic treatment (16.0% vs 11.7%, 22.0% vs 19.3%, and 22.7% vs 20.0%, $P = .57$, respectively). Lastly, 6.7% of patients with native septic knee arthritis underwent subsequent arthroplasty by 2 years. **Conclusion:** Arthroscopic treatment carries a lower reoperation rate than open surgery for knee septic arthritis, but in the shoulder, the risk for revision I&D is similar after arthroscopic or open surgery.

Introduction

Septic arthritis of native joints can cause potentially devastating sequelae with rapid destruction of cartilage, as well as providing a nidus for systemic infections.[1,2] Rapid identification and treatment of an infection are imperative to optimally treat this condition and best prevent long-term complications.[3,4] While medical treatment alone has been attempted[5], most treatment algorithms involve urgent irrigation and debridement (I&D) of the joint either with an open arthrotomy or arthroscopic lavage.

Despite requiring urgent operative treatment, little is known regarding the relative efficacy of open versus arthroscopic treatment of these infections. A recent survey study demonstrated that 69% of orthopaedic surgeons preferred arthroscopic treatment of knee infections,[6] yet almost half stated, there was no gold standard. Similarly, a single-institution longitudinal

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The authors report the following potential conflicts of interest or sources of funding: B.T.F. is editor of JSES *and* Current Reviews in Musculoskeletal Medicine. *B.M. reports grants from Anika, Histogenics, Samumed, and Zimmer; personal fees from Histogenics, Medacta, SLACK Incorporated, and Stryker, outside the submitted work. D.A.L. reports grants from Arthrex and Medacta, outside the submitted work. A.L.Z. reports personal fees from Stryker, and Depuy Mitek, outside the submitted work. Full ICMJE author disclosure forms are available for this article online, as supplementary material.*

Received February 4, 2022; accepted April 16, 2022.

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2666-061X/22160

https://doi.org/10.1016/j.asmr.2022.04.014

Table 1. Patient Demographics for Open Versus Arthroscopic Knee Septic Arthritis

	Open ($n = 492$)	Arthroscopic ($n = 1,501$)	*P* Value
Age ± SD	52 ± 21.3	58 ± 18.7	.01
Female	169 (34.3%)	614 (40.9%)	.01
CCI ± SD	3.51 ± 4.05	3.89 ± 3.91	.09
Obesity	220 (44.7%)	696 (46.4%)	.56
Diabetes	244 (49.6%)	792 (52.8%)	.24
Hypertension	368 (74.8%)	1202 (80.0%)	.02
Tobacco usage	182 (37.0%)	544 (36.2%)	.81
Alcohol usage	100 (20%)	273 (18.2%)	.32
Congestive heart disease	87 (17.7%)	302 (20.1%)	.26
Ischemic heart disease	135 (27.4%)	473 (31.5%)	.10
Pulmonary heart disease	117 (23.8%)	369 (24.6%)	.76
Coronary artery disease	171 (34.8%)	601 (40.0%)	.04

CCI, Charlson Comorbidity Index; SD, standard deviation.

study demonstrated that 74.1% of native knee infections were treated arthroscopically[7] with 38% needing repeated operations.[8] American College of Surgeons National Surgical Quality Improvement Project (ACS-NSQIP) database reviews have shown a similar length of stay, total costs, and 30-day complications for arthroscopic and open treatment of knee infections.[9]

Similarly, patients with native shoulder infections have been treated with high efficacy with both arthroscopic and open surgery.[10,11] Attempts of medical management alone has shown longer lengths of stay with less patients discharged to home following inpatient treatment.[12] NSQIP studies of the shoulder have revealed that 61-68% of nationwide shoulder infection debridements in the last 15 years were performed arthroscopically, with no difference in reoperation rates or complications.[13,14]

While open and arthroscopic debridement of native knee and shoulder infections has been instated as the gold standard of surgical treatment, relatively small cohorts have been used in contrasting their efficacy to date. The purpose of this study was to compare the incidence, patient demographics, complication rates, readmission rates, and reoperation rates of open and arthroscopic surgery performed for septic arthritis in native knee and shoulder joints. We hypothesized that arthroscopic treatment of septic arthritis will yield lower complication, readmission, and reoperation rates compared to open treatment with arthrotomy and debridement.

Methods

Data were queried from the Mariner Database (PearlDiver Technologies, Colorado Springs, CO), which has been used previously within orthopaedic and arthroscopic surgery.[15-17] The database contains records from 2010 to 2020, with approximately 122 million patients. Internal Classification of Diseases, 10th Revision, Clinical Modification (ICD-10) diagnosis codes were used to query patients with native shoulder and knee joint septic arthritis (Appendix Table 1 and Table 2). ICD-10 procedure codes for open arthrotomy and I&D of the knee or shoulder, as well as arthroscopic I&D of the knee or shoulder, were used to track surgical treatments following septic arthritis diagnosis. ICD-10 coding specifies the laterality of the procedure, which allows for tracking of subsequent procedures to be on the ipsilateral laterality as the initial procedure. Comorbidities of open and arthroscopic surgery groups were identified using predefined cohorts using ICD-9 and ICD-10 diagnosis codes and included obesity, diabetes, hypertension, tobacco, alcohol, congestive, ischemic heart disease, pulmonary heart disease, and coronary artery disease. Because of the introduction of ICD-10 coding in 2015, analysis only covered the period between 2015 and 2018. Patients with knee and shoulder replacements prior to their septic arthritis diagnosis were excluded.

Hospital readmission and emergency department (ED) admission within 30 days of the procedure were analyzed using ICD-10 codes. Complication rates within 30 days were identified and compared between open and arthroscopic treatment groups for both knees and shoulders using predefined ICD-10 diagnosis codes. Complications included disruption of wound, cardiac arrest, deep vein thrombosis, pneumonia, pulmonary embolism, death, and transfusion. Reoperations for revision irrigation and debridement were analyzed at 1

Table 2. ED Admission and Hospital Readmission Rates Between Arthroscopic Versus Open Drainage for Native Knee Joint Septic Arthritis

	ED Admission Within 30 Days			Hospital Readmission Within 30 Days		
	Open	Arthroscopic	*P* Value	Open	Arthroscopic	*P* Value
Total	80 (16.3%)	210 (14.0%)	.24	92 (18.7%)	237 (15.8%)	.15
Gender						
Female	29 (37.7%)	74 (35.7%)	.87	33 (37.1%)	99 (42.9%)	.42
Male	48 (62.3%)	133 (64.3%)		56 (62.9%)	132 (57.1%)	

ED, emergency department.

Table 3. Complication and Total Reoperation Rate Between Arthroscopic Versus Open Debridement for Native Knee Joint Septic Arthritis

	Open ($n = 492$)	Arthroscopic ($n = 1501$)	Odds Ratio (95% CI)	P Value
30-Day complication	57 (11.6%)	188 (12.5%)	0.92 (0.67-1.25)	.56
1 Month reoperation	103 (20.9%)	250 (16.7%)	1.34 (1.03-1.71)	.04
1-Year reoperation	160 (32.5%)	415 (27.6%)	1.26 (1.01-1.57)	.04
2-Year reoperation	168 (34.1%)	441 (29.4%)	1.25 (1.00-1.55)	.05

CI, confidence interval.

month, 1 year, and 2 years, as well as subsequent total knee arthroplasty (TKA) within 2 years.

Statistical analysis was performed using the R software program integrated into PearlDiver. Chi-square analysis was used to determine statistical significance of procedure percentages, comorbidities, hospital readmissions, emergency department (ED) admissions between open and arthroscopic procedures. T-tests were used to determine significance of Charlson Comorbidity Index (CCI) and mean age differences. Significance was defined as $P < .05$. All patients used in this study were deidentified; therefore, this study was exempt from the Institutional Review Board.

Results

Knee

Between 2015 and 2018, there were 492 (24.7%) native knee septic arthritis patients who underwent open arthrotomy and irrigation and 1,501 patients (75.3%) who underwent arthroscopic irrigation and debridement ($P < .001$). The average age of patients undergoing open surgery was 52 ± 21.3 and 58 ± 18.7 years old for arthroscopic drainage ($P < .001$, Table 1). Males formed the majority of both the open and arthroscopic cohorts (65.7% for open vs. 61.9% for arthroscopic) ($P < .001$) (Table 1).

No differences were found between the open and arthroscopic cohorts with regard to CCI, obesity, diabetes, tobacco usage, alcohol usage, congestive heart disease, ischemic heart disease, or pulmonary heart disease. Patients in the arthroscopic cohort were more likely to have hypertension ($P = .02$) and coronary artery disease ($P = .04$), as shown in Table 1.

Patients who underwent open arthrotomy had similar 30-day ED readmissions (16.3% open vs 14.0% arthroscopic; $P = .24$) and 30-day hospital readmissions (18.7% open vs 15.8% arthroscopic; $P = .15$) (Table 2). In addition, 57 (11.6%) had at least one complication within 30 days after open arthrotomy and 188 (12.5%) after arthroscopic drainage ($P = .64$) (Table 3). Further analysis demonstrated a higher percentage of open arthrotomy patients underwent reoperations for revision I&D at 1 month (20.9% vs. 16.7%; $P = .04$), 1 year (32.5% vs 27.6%; $P = .04$) and 2 years (34.1% vs. 29.4%; $P = .05$) (Fig 1). For reoperations after index, open I&D, 61.2% of revision I&D was performed open, while for index arthroscopic I&D, 81.7% of revision procedures were performed arthroscopically. Additionally, at 2 years, ~7% of patients had undergone

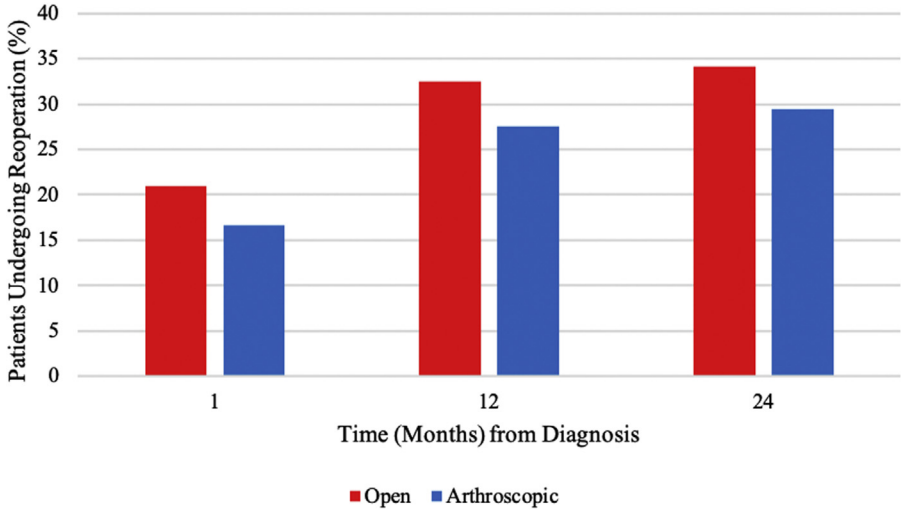

Fig 1. The incidence of knee reoperations following index debridement.

Table 4. Rates for Subsequent Total Knee Arthroplasty Following Arthroscopic Versus Open Debridement for Native Knee Joint Septic Arthritis

	1 Year			2 Year		
	Open	Arthroscopic	*P*	Open	Arthroscopic	*P*
Subsequent Arthroplasty	32 (6.50%)	86 (5.73%)	.60	38 (7.72%)	96 (6.40%)	.36

TKA (7.72% open arthrotomy vs 6.40% arthroscopy; $P = .36$) (Table 4).

Shoulder

Within the shoulder cohort, 163 (35.2%) septic arthritis patients underwent open arthrotomy and irrigation, and 300 (64.8%) underwent arthroscopic irrigation and debridement ($P < .001$) (Table 5). No difference was found between the two cohorts in their age, Charlson Comorbidity Index and incidence of obesity, diabetes, hypertension, alcohol usage, tobacco usage, congestive heart failure, ischemic heart disease, pulmonary artery disease, or coronary artery disease (Table 5).

Additionally, 16.0% of arthroscopic patients were readmitted to the ED within 30 days compared to 13.5% of open arthrotomy patients ($P = .56$), while 19.6% of open arthrotomy patients were readmitted to hospital within 30 days compared to 18.0% of arthroscopic patients ($P = .76$) (Table 6). Patients who underwent open arthrotomy trended toward having a higher risk for complication within 30 days, but this finding was not significant (22.7% open vs 15.7% arthroscopic; $P = .08$) (Table 7). As shown in Fig 2, patients within the open shoulder arthrotomy group demonstrated similar rates of reoperation for revision I&D at 1 month (16.0% open vs 11.7% arthroscopic; $P = .25$), 1 year (22.0% open vs 19.3% arthroscopic; $P = .56$), and 2 years (22.7% open vs 20.0% arthroscopic; $P = .57$) as the arthroscopic irrigation group (Table 7). Finally, as a result of the smaller sample size for revision surgery cases in the shoulder and database constraints, stratification of open or arthroscopic revision I&D, and subsequent shoulder arthroplasty rate could not be assessed.

Table 5. Patient Demographics for Open Versus Arthroscopic Shoulder Septic Arthritis

	Open ($n = 163$)	Arthroscopic ($n = 300$)	*P* Value
Age ± SD	57 ± 19.3	63 ± 16.3	.31
Female	75 (46.0%)	137 (45.7%)	1.00
CCI ± SD	3.98 ± 3.39	4.30 ± 3.50	.42
Obesity	55 (33.7%)	112 (37.3%)	.50
Diabetes	97 (59.5%)	169 (56.3%)	.57
Hypertension	138 (84.7%)	262 (87.3%)	.51
Tobacco usage	65 (39.8%)	116 (36.3%)	.88
Alcohol usage	34 (20.1%)	51 (17.0%)	.37
Congestive heart disease	34 (20.1%)	69 (23.0%)	.68
Ischemic heart disease	55 (33.7%)	113 (37.7%)	.46
Pulmonary heart disease	32 (19.6%)	81 (27.0%)	.10
Coronary artery disease	64 (39.3%)	146 (48.7%)	.07

CCI, Charlson Comorbidity Index; SD, standard deviation.

Discussion

In this large cross-sectional study, we found that from 2015 to 2018, the majority of both septic knee arthritis patients (75.3%) and septic shoulder arthritis patients (64.8%) underwent arthroscopic surgical debridement compared to open arthrotomy and debridement. In addition, arthroscopic treatment for septic knee arthritis yielded a lower risk for reoperation than open treatment.

These findings corroborate prior database studies indicating the shift toward arthroscopic management of native joint infections.[6,14] Jaffe et al. demonstrated that the majority of surgeons (69.8%) prefer treating septic arthritis arthroscopically,[6] and this may stem from surgeon comfort, as arthroscopy has risen over the past 20 years as a critical portion of orthopaedic surgical training. When comparing outcomes in our study, patients who underwent open knee debridements were found to have a greater reoperation rate compared to arthroscopic treatment. Johns et al. also demonstrated a decreased risk for repeat irrigation when using arthroscopy in addition to improved range of motion with arthroscopic treatment in the knee.[7] The authors postulated that smaller incisions and more thorough irrigation from arthroscopy may contribute to its higher advocacy.[7] Minimizing the direct trauma imposed upon the infected tissue may help to prevent the reformation of an infection nidus. Similarly, compared to a medial arthrotomy, arthroscopic treatment of the knee may better access the posterior compartment and lateral gutter. Cumulatively, these factors may contribute to the lower need for repeat irrigation for knee septic arthritis in both this study and those conducted previously.[7]

Our findings also highlighted that nearly one-third of patients underwent a reoperation for I&D in the knee within 1 year of the index surgery, which is consistent with that seen in the studies performed by Jaffe et al. and Bovonratwet et al.[18,19] This indicates that there is a high risk for recurrent infection, which may lead to subsequent articular cartilage destruction.[20] With the ultimate goal of prevention of joint destruction, neither open nor arthroscopic approaches showed superiority in decreasing eventual arthroplasty at 2 years with ~7% of each cohort undergoing TKA conversion.

Table 6. ED Admission and Hospital Readmission Rate Between Arthroscopic Versus Open Debridement for Native Shoulder Joint Septic Arthritis

	ED Admission Within 30 Days			Hospital Readmission Within 30 Days		
	Open	Arthroscopic	*P* Value	Open	Arthroscopic	*P* Value
Total	22 (13.5%)	48 (16.0%)	.56	32 (19.6%)	54 (18.0%)	.76
Gender						
Female	12 (54.5%)	24 (50.0%)	.78	21 (65.6%)	26 (48.1%)	.18
Male	10 (45.5%)	24 (50.0%)		11 (34.4%)	28 (51.9%)	

Table 7. Complication Rate Between Arthroscopic Versus Open Debridement for Native Shoulder Joint Septic Arthritis

	Open (n = 163)	Arthroscopic (n = 300)	Odds Ratio (95% CI)	*P* Value
30-Day complication	37 (22.7%)	47 (15.7%)	1.58 (0.98-2.56)	.08
1 Month reoperation	26 (16.0%)	35 (11.7%)	1.44 (0.83-2.48)	.25
1 Year reoperation	36 (22.0%)	58 (19.3%)	1.18 (0.74-1.89)	.56
2 Year reoperation	37 (22.7%)	60 (20.0%)	1.17 (0.74-1.87)	.57

CI, confidence interval.

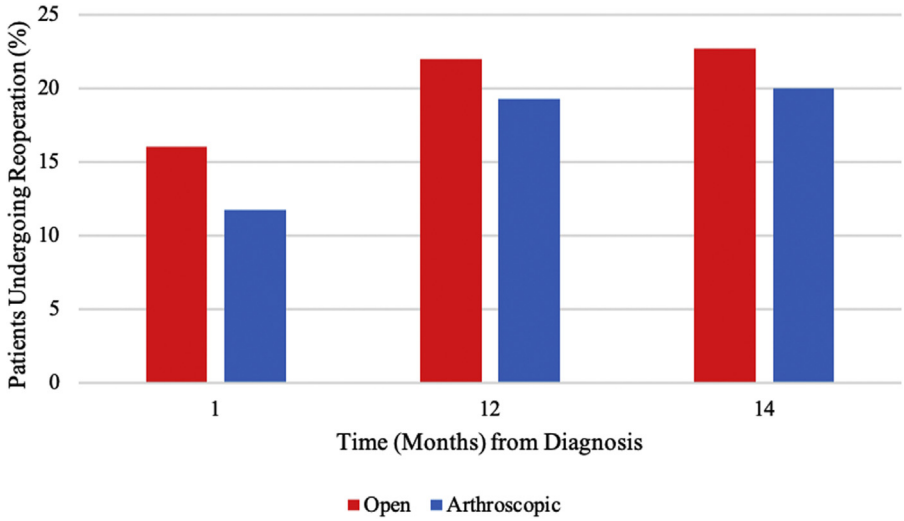

Fig 2. The incidence of shoulder reoperations following index debridement.

These findings are significant, as patients who undergo arthroplasty following septic arthritis have been shown to have strikingly poorer outcomes than those undergoing arthroplasty for osteoarthritis.[21]

Compared to the knee cohort, there was a lower risk for septic shoulder arthritis patients to require reoperation (approximately 20% by 1 year). This may be due to the anatomic nature of the shoulder, which is a ball and socket joint. Septic arthritis of the glenohumeral joint remains localized to the area between the glenoid and humeral head, as there are not additional spaces or compartments for the infection to extravasate to (unless a rotator cuff tear is present). Relative to the anatomy of the knee, this may allow for improved irrigation and debridement as a treatment and decreased risk for recurrent infection. The anatomy of the shoulder joint may also be a reason why there is no significant difference in reoperation rates for open and arthroscopic I&D. As the open deltopectoral approach allows for thorough access to the glenohumeral joint, open I&D may have similar efficacy as arthroscopic I&D in the shoulder. This is consistent with Bovonratwet et al., who reported in 100 patients, open and arthroscopic I&D for shoulder septic arthritis yielded similar reoperation rates.[13] Similar rates of complications have also been reported between the open and arthroscopic cohorts.[12] Finally, too few patients were converted to shoulder arthroplasty by 2 years after shoulder septic arthritis to analyze for this study, although outcomes following arthroplasty for shoulder septic arthritis are similarly poor with high complication rates.[22]

This study also underscores the baseline severity of native joint infections. As approximately one in four patients underwent reoperation by 1 year, the

significance of the initial diagnosis and resultant treatment path must be emphasized to the patient. The high morbidity of these diagnoses should be conveyed precisely to patients to augment their comprehension of their pathology. Given the concomitantly high readmission to the emergency room and the hospital, clear communication with the patient and his or her family must outline what circumstances warrant urgent evaluation and treatment to best streamline hospital resources.

Limitations

There are several limitations within this study. The current study is limited to 2-year follow-up, as ICD-10 coding was only implemented in 2015. Additionally, patient-related outcomes measures are not included within the database to track function following procedural intervention. Whereas the volume of cases captured by PearlDiver makes this study relatively large, the size for treatment of septic arthritis in this cohort is still limited and may be underpowered to assess all demographic variables fully. Lastly, prior surgeries and trauma, the severity of the infection, and overall clinical picture cannot be ascertained from the PearlDiver database. Variables such as availability of arthroscopy equipment at hospitals and staff familiarity with arthroscopy set up may affect surgeon choice for surgical approach, but these factors cannot be differentiated by this study.

Conclusion

Arthroscopic treatment carries a lower reoperation rate than open surgery for knee septic arthritis, but in the shoulder, the risk for revision I&D is similar after arthroscopic or open surgery.

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Appendix Table 1. Procedural Coding Used for Knee Procedures in PearlDiver

Category	Code	Description
Knee Septic Arthritis	ICD-10-D-M00061	Staphylococcal arthritis right knee
Knee Septic Arthritis	ICD-10-D-M00062	Staphylococcal arthritis left knee
Knee Septic Arthritis	ICD-10-D-M00161	Pneumococcal arthritis right knee
Knee Septic Arthritis	ICD-10-D-M00162	Pneumococcal arthritis left knee
Knee Septic Arthritis	ICD-10-D-M00261	Other streptococcal arthritis right knee
Knee Septic Arthritis	ICD-10-D-M00262	Other streptococcal arthritis left knee
Knee Septic Arthritis	ICD-10-D-M00861	Arthritis due to other bacteria right knee
Knee Septic Arthritis	ICD-10-D-M00862	Arthritis due to other bacteria left knee
Knee Replacement	ICD-10-P-0SRC069	Replacement of right knee joint with oxidized zirconium on polyethylene synthetic substitute cemented open approach
Knee Replacement	ICD-10-P-0SRC06A	Replacement of right knee joint with oxidized zirconium on polyethylene synthetic substitute uncemented open approach
Knee Replacement	ICD-10-P-0SRC06Z	Replacement of right knee joint with oxidized zirconium on polyethylene synthetic substitute open approach
Knee Replacement	ICD-10-P-0SRC07Z	Replacement of right knee joint with autologous tissue substitute open approach
Knee Replacement	ICD-10-P-0SRC0EZ	Replacement of right knee joint with articulating spacer open approach
Knee Replacement	ICD-10-P-0SRC0J9	Replacement of right knee joint with synthetic substitute cemented open approach
Knee Replacement	ICD-10-P-0SRC0JA	Replacement of right knee joint with synthetic substitute uncemented open approach
Knee Replacement	ICD-10-P-0SRC0JZ	Replacement of right knee joint with synthetic substitute open approach
Knee Replacement	ICD-10-P-0SRC0KZ	Replacement of right knee joint with nonautologous tissue substitute open approach
Knee Replacement	ICD-10-P-0SRC0L9	Replacement of right knee joint with medial unicondylar synthetic substitute cemented open approach
Knee Replacement	ICD-10-P-0SRC0LA	Replacement of right knee joint with medial unicondylar synthetic substitute uncemented open approach
Knee Replacement	ICD-10-P-0SRC0LZ	Replacement of right knee joint with medial unicondylar synthetic substitute open approach
Knee Replacement	ICD-10-P-0SRC0M9	Replacement of right knee joint with lateral unicondylar synthetic substitute cemented open approach
Knee Replacement	ICD-10-P-0SRC0N9	Replacement of right knee joint with patellofemoral synthetic substitute cemented open approach
Knee Replacement	ICD-10-P-0SRC0NA	Replacement of right knee joint with patellofemoral synthetic substitute uncemented open approach
Knee Replacement	ICD-10-P-0SRC0NZ	Replacement of right knee joint with patellofemoral synthetic substitute open approach
Knee Replacement	ICD-10-P-0SRD069	Replacement of left knee joint with oxidized zirconium on polyethylene synthetic substitute cemented open approach
Knee Replacement	ICD-10-P-0SRD06A	Replacement of left knee joint with oxidized zirconium on polyethylene synthetic substitute uncemented open approach
Knee Replacement	ICD-10-P-0SRD06Z	Replacement of left knee joint with oxidized zirconium on polyethylene synthetic substitute open approach
Knee Replacement	ICD-10-P-0SRD07Z	Replacement of left knee joint with autologous tissue substitute open approach
Knee Replacement	ICD-10-P-0SRD0EZ	Replacement of left knee joint with articulating spacer open approach
Knee Replacement	ICD-10-P-0SRD0J9	Replacement of left knee joint with synthetic substitute cemented open approach
Knee Replacement	ICD-10-P-0SRD0JA	Replacement of left knee joint with synthetic substitute uncemented open approach
Knee Replacement	ICD-10-P-0SRD0JZ	Replacement of left knee joint with synthetic substitute open approach
Knee Replacement	ICD-10-P-0SRD0KZ	Replacement of left knee joint with nonautologous tissue substitute open approach
Knee Replacement	ICD-10-P-0SRD0L9	Replacement of left knee joint with medial unicondylar synthetic substitute cemented open approach
Knee Replacement	ICD-10-P-0SRD0LA	Replacement of left knee joint with medial unicondylar synthetic substitute uncemented open approach
Knee Replacement	ICD-10-P-0SRD0LZ	Replacement of left knee joint with medial unicondylar synthetic substitute open approach
Knee Replacement	ICD-10-P-0SRD0M9	Replacement of left knee joint with lateral unicondylar synthetic substitute cemented open approach

(continued)

Appendix Table 1. Continued

Category	Code	Description
Knee Replacement	ICD-10-P-0SRD0MA	Replacement of left knee joint with lateral unicondylar synthetic substitute uncemented open approach
Knee Replacement	ICD-10-P-0SRD0MZ	Replacement of left knee joint with lateral unicondylar synthetic substitute open approach
Knee Replacement	ICD-10-P-0SRD0N9	Replacement of left knee joint with patellofemoral synthetic substitute cemented open approach
Knee Replacement	ICD-10-P-0SRD0NA	Replacement of left knee joint with patellofemoral synthetic substitute uncemented open approach
Knee Replacement	ICD-10-P-0SRD0NZ	Replacement of left knee joint with patellofemoral synthetic substitute open approach
Knee Replacement	ICD-10-P-0SRT0J9	Replacement of right knee joint femoral surface with synthetic substitute cemented open approach
Knee Replacement	ICD-10-P-0SRT0JA	Replacement of right knee joint femoral surface with synthetic substitute uncemented open approach
Knee Replacement	ICD-10-P-0SRT0JZ	Replacement of right knee joint femoral surface with synthetic substitute open approach
Knee Replacement	ICD-10-P-0SRT0KZ	Replacement of right knee joint femoral surface with nonautologous tissue substitute open approach
Knee Replacement	ICD-10-P-0SRU0J9	Replacement of left knee joint femoral surface with synthetic substitute cemented open approach
Knee Replacement	ICD-10-P-0SRU0JA	Replacement of left knee joint femoral surface with synthetic substitute uncemented open approach
Knee Replacement	ICD-10-P-0SRU0JZ	Replacement of left knee joint femoral surface with synthetic substitute open approach
Knee Replacement	ICD-10-P-0SRV0J9	Replacement of right knee joint tibial surface with synthetic substitute cemented open approach
Knee Replacement	ICD-10-P-0SRV0JA	Replacement of right knee joint tibial surface with synthetic substitute uncemented open approach
Knee Replacement	ICD-10-P-0SRV0JZ	Replacement of Right Knee Joint Tibial Surface with Synthetic Substitute Open Approach
Knee Replacement	ICD-10-P-0SRV0KZ	Replacement of right knee joint tibial surface with nonautologous tissue substitute open approach
Knee Replacement	ICD-10-P-0SRW0J9	Replacement of left knee joint tibial surface with synthetic substitute cemented open approach
Knee Replacement	ICD-10-P-0SRW0JA	Replacement of left knee joint tibial surface with synthetic substitute uncemented open approach
Knee Replacement	ICD-10-P-0SRW0JZ	Replacement of left knee joint tibial surface with synthetic substitute open approach
Knee Replacement	ICD-10-P-0SRW0KZ	Replacement of left knee joint tibial surface with nonautologous tissue substitute open approach
Knee Drainage	ICD-10-P-0S9C30Z	Drainage of right knee joint with drainage device percutaneous approach
Knee Drainage	ICD-10-P-0S9C3ZX	Drainage of right knee joint percutaneous approach diagnostic
Knee Drainage	ICD-10-P-0S9C3ZZ	Drainage of right knee joint percutaneous approach
Knee Drainage	ICD-10-P-0S9C40Z	Drainage of right knee joint with drainage device percutaneous endoscopic approach
Knee Drainage	ICD-10-P-0S9C4ZX	Drainage of right knee joint percutaneous endoscopic approach diagnostic
Knee Drainage	ICD-10-P-0S9C4ZZ	Drainage of right knee joint percutaneous endoscopic approach
Knee Drainage	ICD-10-P-0S9D30Z	Drainage of left knee joint with drainage device percutaneous approach
Knee Drainage	ICD-10-P-0S9D3ZX	Drainage of left knee joint percutaneous approach diagnostic
Knee Drainage	ICD-10-P-0S9D3ZZ	Drainage of left knee joint percutaneous approach
Knee Drainage	ICD-10-P-0S9D40Z	Drainage of left knee joint with drainage device percutaneous endoscopic approach
Knee Drainage	ICD-10-P-0S9D4ZX	Drainage of left knee joint percutaneous endoscopic approach diagnostic
Knee Drainage	ICD-10-P-0S9D4ZZ	Drainage of left knee joint percutaneous endoscopic approach
Knee Drainage	ICD-10-P-0Y9F30Z	Drainage of right knee region with drainage device percutaneous approach
Knee Drainage	ICD-10-P-0Y9F3ZX	Drainage of right knee region percutaneous approach diagnostic
Knee Drainage	ICD-10-P-0Y9F3ZZ	Drainage of right knee region percutaneous approach
Knee Drainage	ICD-10-P-0Y9F40Z	Drainage of right knee region with drainage device percutaneous endoscopic approach
Knee Drainage	ICD-10-P-0Y9F4ZZ	Drainage of right knee region percutaneous endoscopic approach
Knee Drainage	ICD-10-P-0Y9G30Z	Drainage of left knee region with drainage Device percutaneous approach
Knee Drainage	ICD-10-P-0Y9G3ZX	Drainage of left knee region percutaneous approach diagnostic

(continued)

Appendix Table 1. Continued

Category	Code	Description
Knee Drainage	ICD-10-P-0Y9G3ZZ	Drainage of left knee region percutaneous approach
Knee Drainage	ICD-10-P-0S9C00Z	Drainage of right knee joint with drainage device open approach
Knee Drainage	ICD-10-P-0S9C0ZX	Drainage of right knee joint open approach diagnostic
Knee Drainage	ICD-10-P-0S9C0ZZ	Drainage of right knee joint open approach
Knee Drainage	ICD-10-P-0S9D00Z	Drainage of left knee joint with drainage device open approach
Knee Drainage	ICD-10-P-0S9D0ZX	Drainage of left knee joint open approach diagnostic
Knee Drainage	ICD-10-P-0S9D0ZZ	Drainage of left knee joint open approach
Knee Drainage	ICD-10-P-0Y9F00Z	Drainage of right knee region with drainage device open approach
Knee Drainage	ICD-10-P-0Y9F0ZX	Drainage of right knee region open approach diagnostic
Knee Drainage	ICD-10-P-0Y9F0ZZ	Drainage of right knee region open approach
Knee Drainage	ICD-10-P-0Y9G00Z	Drainage of left knee region with drainage device open approach
Knee Drainage	ICD-10-P-0Y9G0ZX	Drainage of left knee region open approach diagnostic
Knee Drainage	ICD-10-P-0Y9G0ZZ	Drainage of left knee region open approach

Appendix Table 2. Procedural Coding Used for Shoulder Procedures in PearlDiver

Category	Code	Description
Shoulder Septic Arthritis	ICD-10-D-M01X61	Direct infection of right knee in infectious and parasitic diseases classified elsewhere
Shoulder Septic Arthritis	ICD-10-D-M01X62	Direct infection of left knee in infectious and parasitic diseases classified elsewhere
Shoulder Septic Arthritis	ICD-10-D-M00011	Staphylococcal arthritis right shoulder
Shoulder Septic Arthritis	ICD-10-D-M00012	Staphylococcal arthritis left shoulder
Shoulder Septic Arthritis	ICD-10-D-M00111	Pneumococcal arthritis right shoulder
Shoulder Septic Arthritis	ICD-10-D-M00112	Pneumococcal arthritis left shoulder
Shoulder Septic Arthritis	ICD-10-D-M00211	Other streptococcal arthritis right shoulder
Shoulder Septic Arthritis	ICD-10-D-M00212	Other streptococcal arthritis left shoulder
Shoulder Septic Arthritis	ICD-10-D-M00811	Arthritis due to other bacteria right shoulder
Shoulder Septic Arthritis	ICD-10-D-M00812	Arthritis due to other bacteria left shoulder
Shoulder Replacement	ICD-10-P-0RRJ00Z	Replacement of right shoulder joint with reverse ball and socket synthetic substitute open approach
Shoulder Replacement	ICD-10-P-0RRJ07Z	Replacement of right shoulder joint with autologous tissue substitute open approach
Shoulder Replacement	ICD-10-P-0RRJ0J6	Replacement of right shoulder joint with synthetic substitute humeral surface open approach
Shoulder Replacement	ICD-10-P-0RRJ0J7	Replacement of right shoulder joint with synthetic substitute glenoid surface open approach
Shoulder Replacement	ICD-10-P-0RRJ0JZ	Replacement of right shoulder joint with synthetic substitute open approach
Shoulder Replacement	ICD-10-P-0RRJ0KZ	Replacement of right shoulder joint with nonautologous tissue substitute open approach
Shoulder Replacement	ICD-10-P-0RRK00Z	Replacement of left shoulder joint with reverse ball and socket Synthetic substitute open approach
Shoulder Replacement	ICD-10-P-0RRK07Z	Replacement of left shoulder joint with autologous tissue substitute open approach
Shoulder Replacement	ICD-10-P-0RRK0J6	Replacement of left shoulder joint with synthetic substitute humeral surface open approach
Shoulder Replacement	ICD-10-P-0RRK0J7	Replacement of left shoulder joint with synthetic substitute glenoid surface open approach
Shoulder Replacement	ICD-10-P-0RRK0JZ	Replacement of left shoulder joint with synthetic substitute open approach
Shoulder Replacement	ICD-10-P-0RRK0KZ	Replacement of left shoulder joint with nonautologous tissue substitute open approach
Shoulder Drainage	ICD-10-P-0R9J30Z	Drainage of right shoulder joint with drainage device percutaneous approach
Shoulder Drainage	ICD-10-P-0R9J3ZX	Drainage of right shoulder joint percutaneous approach diagnostic
Shoulder Drainage	ICD-10-P-0R9J3ZZ	Drainage of right shoulder joint percutaneous approach
Shoulder Drainage	ICD-10-P-0R9J40Z	Drainage of right shoulder joint with drainage device percutaneous endoscopic approach
Shoulder Drainage	ICD-10-P-0R9J4ZX	Drainage of right shoulder joint percutaneous endoscopic approach diagnostic
Shoulder Drainage	ICD-10-P-0R9J4ZZ	Drainage of right shoulder joint percutaneous endoscopic approach
Shoulder Drainage	ICD-10-P-0R9K30Z	Drainage of left shoulder joint with drainage device percutaneous approach
Shoulder Drainage	ICD-10-P-0R9K3ZX	Drainage of left shoulder joint percutaneous approach diagnostic
Shoulder Drainage	ICD-10-P-0R9K3ZZ	Drainage of left shoulder joint percutaneous approach
Shoulder Drainage	ICD-10-P-0R9K40Z	Drainage of left shoulder joint with drainage device percutaneous endoscopic approach
Shoulder Drainage	ICD-10-P-0R9K4ZX	Drainage of left shoulder joint percutaneous endoscopic approach diagnostic
Shoulder Drainage	ICD-10-P-0R9K4ZZ	Drainage of left shoulder joint percutaneous endoscopic approach
Shoulder Drainage	ICD-10-P-0X9230Z	Drainage of right shoulder region with drainage device percutaneous approach
Shoulder Drainage	ICD-10-P-0X923ZX	Drainage of right shoulder region percutaneous approach diagnostic
Shoulder Drainage	ICD-10-P-0X923ZZ	Drainage of right shoulder region percutaneous approach
Shoulder Drainage	ICD-10-P-0X9240Z	Drainage of right shoulder region with drainage device percutaneous endoscopic approach
Shoulder Drainage	ICD-10-P-0X924ZZ	Drainage of right shoulder region percutaneous endoscopic approach
Shoulder Drainage	ICD-10-P-0X9330Z	Drainage of left shoulder region with drainage device percutaneous approach
Shoulder Drainage	ICD-10-P-0X933ZX	Drainage of left shoulder region percutaneous approach diagnostic

(continued)

Appendix Table 2. Continued

Category	Code	Description
Shoulder Drainage	ICD-10-P-0X933ZZ	Drainage of left shoulder region percutaneous approach
Shoulder Drainage	ICD-10-P-0R9J00Z	Drainage of right shoulder joint with drainage device open approach
Shoulder Drainage	ICD-10-P-0R9J0ZX	Drainage of right shoulder joint open approach diagnostic
Shoulder Drainage	ICD-10-P-0R9J0ZZ	Drainage of right shoulder joint open approach
Shoulder Drainage	ICD-10-P-0R9K00Z	Drainage of left shoulder joint with drainage device open approach
Shoulder Drainage	ICD-10-P-0R9K0ZX	Drainage of left shoulder joint open approach diagnostic
Shoulder Drainage	ICD-10-P-0R9K0ZZ	Drainage of left shoulder joint open approach
Shoulder Drainage	ICD-10-P-0X9200Z	Drainage of right shoulder region with drainage device open approach
Shoulder Drainage	ICD-10-P-0X920ZX	Drainage of right shoulder region open approach diagnostic
Shoulder Drainage	ICD-10-P-0X920ZZ	Drainage of right shoulder region open approach
Shoulder Drainage	ICD-10-P-0X9300Z	Drainage of left shoulder region with drainage device open approach
Shoulder Drainage	ICD-10-P-0X930ZX	Drainage of left shoulder region open approach diagnostic
Shoulder Drainage	ICD-10-P-0X930ZZ	Drainage of left shoulder region open approach