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Antibiotic-loaded bone cement reduces deep infection rates for primary reverse total shoulder arthroplasty: a retrospective, cohort study of 501 shoulders

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Background: Deep infection after primary reverse total shoulder arthroplasty is a devastating event and has an increased incidence compared with anatomic total shoulder arthroplasty. Recent reports in the hip and knee arthroplasty literature suggest that antibiotic-loaded bone cement may lower infection rates for primary arthroplasties. We conducted a retrospective cohort study to evaluate the effect of antibiotic-loaded bone cement vs plain bone cement on the prevention of deep infection after primary reverse total shoulder arthroplasty.

Materials and methods: Four surgeons from their respective facilities participated in the retrospective cohort data collection. From 1999 to 2008, 501 consecutive primary reverse total shoulder arthroplasties were performed. Patients with revision of failed previous arthroplasties were excluded, and patients with any other previous shoulder procedure were included. Two groups were examined in this retrospective cohort: In group 1 (265 shoulders), the cement used for humeral fixation did not have antibiotics; in group 2 (236 shoulders), antibiotic-impregnated bone cement containing tobramycin, gentamycin, or vancomycin/tobramycin was used for fixation.

Results: At an average postoperative follow-up of 37 months, no deep infection had developed in the 236 shoulders in group 2, whereas a deep infection had developed in 8 of the 265 shoulders (3.0%) in group 1. This difference between the groups was significant ($P < .001$).

Conclusions: Antibiotic-impregnated bone cement was effective in the prevention of postoperative deep infection after primary reverse total shoulder arthroplasty during short-term follow-up.

Level of evidence: Level III, Retrospective Case Control Design, Treatment Study.

Keywords: Reverse shoulder; arthroplasty; infection; antibiotic; cement; prophylaxis

Deep infection after reverse total shoulder arthroplasty (TSA) is a devastating complication that can require extensive revision surgery and reduce a patient's functional status. Infection has been reported as one of the most common complications of reverse shoulder replacement, ranging from

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1% to 10% in some larger series.[7,8,9,19,20,21] This is likely due to multiple factors, including longer surgical times due to the complexity of the procedure, a steeper learning curve to perform the procedure, and patients with a history of multiple surgical procedures of the shoulder.

Recent reports in the hip and knee arthroplasty literature have suggested that antibiotic-loaded bone cement may lower infection rates for primary arthroplasties.[2,5,6,16] The use of antibiotic-impregnated bone cement has been advocated as a method to further reduce the need for revision surgery after primary hip and knee replacement.[3,16] Large registry databases have shown a decreased rate of revision surgery due to infection in patients who received perioperative intravenous antibiotics and antibiotic-impregnated bone cement at the time of primary arthroplasty.[5,6,16] Proponents of the use of antibiotic-impregnated bone cement point to these data as evidence that it should be used in all primary procedures in which cement is used.[3] Opponents of the use of antibiotic-impregnated bone cement frequently cite its cost as the primary concern, especially given the already low rates of infection and revision.[10] Other concerns include the possible development of antibiotic resistance, allergic reactions, and possible compromise of the mechanical properties of the cement from the admixture of antibiotics.[1,11,12,13,18] Also, because antibiotic-impregnated bone cement has been approved in the United States by the Food and Drug Administration only for second-stage reimplantation after revision due to infection, use of antibiotic-impregnated cement in primary arthroplasty represents an off-label usage in the United States.

To our knowledge, no study currently exists in the literature that evaluates the efficacy of antibiotic-loaded bone cement for the prevention of infection in primary reverse TSA. Therefore, we conducted a retrospective, cohort study to evaluate the effect of antibiotic-loaded bone cement vs plain bone cement on the prevention of deep infection after primary reverse TSA. Our hypothesis was that the addition of antibiotics to bone cement would lower the rates of deep infection after primary reverse TSA and thereby also reduce the rates of revision surgery due to infection-related complications.

Materials and methods

Four surgeons (R.J.N., B.C., G.W., R.G.) from their respective facilities participated in the retrospective, cohort data collection. From 1999 to 2008, 501 consecutive primary reverse TSAs were performed. Patients with revision of failed previous arthroplasties were excluded, and patients with any other previous shoulder procedure were included. These included arthroscopy, acromioplasty, distal clavicle resection, rotator cuff repair, biceps tenotomy/tenodesis, and fracture fixation.

All procedures were performed in a standard operating room without ultraviolet lights or body-exhaust suits. All of the arthroplasties were performed through a deltopectoral or an anterosuperior approach. The Aequalis system (Tornier, Edina, MN, USA) was implanted in 415 shoulders and the DePuy Delta III system (DePuy Orthopaedics Inc, Warsaw, IN, USA) was used in 86 shoulders. Both are based on the Grammont design, with a medialized center of rotation.

Patients were divided into 2 groups to evaluate the effect of antibiotic-loaded bone cement on the prevention of postoperative infection. Group 1 consisted of 265 shoulders, in which plain cement was used for stem fixation and was not mixed with antibiotics. Of these, 223 patients had cuff tear arthropathy (CTA), 37 had post-traumatic arthrosis, 2 were treated for an acute proximal humeral fracture, and 3 had inflammatory arthritis. Group 2 consisted of 236 shoulders, in which antibiotic-loaded bone cement containing tobramycin, gentamycin, or vancomycin/tobramycin was used for stem fixation. Of these, 194 patients had a diagnosis of CTA, 16 were treated for post-traumatic arthrosis, 16 for an acute proximal humeral fracture, 6 for rheumatoid arthritis, 2 for avascular necrosis, and 2 for arthrosis from recurrent instability.

Antibiotic-loaded bone cement used in group 2 was Simplex P bone cement with 1.0 grams of tobramycin per 40 grams of bone cement (Stryker Orthopaedics, Mahwah, NJ, USA), DePuy 1 bone cement with 1.0 grams of gentamycin per 40 grams bone cement (DePuy Orthopaedics), or Simplex Speed-Set (Stryker Orthopaedics) hand mixed with 1.0 grams of vancomycin and 1.2 grams of tobramycin powder. Two surgeons (R.G., B.C.) used antibiotic cement for all procedures, 1 surgeon (G.W.) used cement without antibiotics for all arthroplasty procedures, and the final surgeon (R.J.N.) changed from nonantibiotic cement to antibiotic-impregnated cement during the course of this retrospective study.

Each patient received a preoperative intravenous bolus injection of antibiotic consisting of cefazolin (2.0 grams), clindamycin (900 mg), or vancomycin (1.0 grams). Intravenous antibiotics were continued for 24 hours postoperatively then discontinued. All patients received cefazolin unless they had a documented drug allergy. Clindamycin or vancomycin was then used according to standard institution protocols for antibiotic prophylaxis in patients with drug allergies.

Drain usage was at the discretion of the operating surgeon and was removed on the first postoperative day. The type of anesthesia, operative time, and wound complications were recorded for each patient.

Patients were examined at 2, 6, and 12 weeks, at 6 and 12 months, and yearly thereafter. The average duration of follow-up was 37 months (range, 12-120 months), with most patients having 2- to 5-year follow-up.

Infections classified as deep were diagnosed by a positive postoperative joint aspiration and confirmed during revision surgery by intraoperative cultures. Infections classified as superficial had documented wound complications but no positive postoperative joint cultures. A positive joint aspiration was defined as a positive culture or one that had >90% shift of polymorphonuclear leukocytes or >25,000/mm^3 white blood cells on cell count.

Data were entered and analyzed with SAS software (SAS Institute, Cary, NC, USA). All response variables, including demographic variables and important outcomes, were measured for all patients. Data are shown as the mean and standard deviation for continuous variables and as percentages for discrete variables. The Fisher exact test was used to compare differences between the 2 groups for each discrete variable, and a Student *t* test was used to

Table I Analysis of group 1 and 2 deep and superficial infection

Pt	Age	Sex	Prior surgeries	Infection*		Cement	Treatment
				Type	Organism		
1	74	M	None	Deep	MRSA	Plain	Resection arthroplasty
2	85	F	None	Deep	*Staphylococcus epidermidis*	Plain	I&D, chronic suppressive antibiotics
3	68	F	None	Deep	Dermobacter hominis	Plain	Resection arthroplasty
4	76	F	ORIF, neck nonunion	Deep	*Propionobacterium acnes*	Plain	Resection arthroplasty
5	77	F	None	Deep	MRSA	Plain	Resection arthroplasty
6	84	F	None	Deep	MRSA	Plain	Two-stage exchange arthroplasty
7	66	M	None	Deep	*Propionobacterium acnes*	Plain	Two-stage exchange arthroplasty
8	76	M	RTC repair ×2	Deep	*Propionobacterium acnes*	Plain	Resection arthroplasty
9	78	M	Scope SAD	Superficial	*Staphylococcus epidermidis*	Gentamycin	I&D ×2, IV antibiotics

F, female; *I&D,* irrigation and debridement; *IV,* intravenous; *M,* male; *MRSA,* methicillin-resistant *Staphylococcus aureus*; *ORIF,* open reduction, internal fixation; *RTC,* rotator cuff repair; *SAD,* subacromial decompression.

* All patients with infection received IV antiobiotic treatment with cefazolin.

compare the differences between the groups for each continuous variable. Before the analysis, the P value was set at .05 for each test.

Results

Results of deep and superficial infections are listed in Table I. At an average postoperative follow-up of 37 months, no deep infection had developed in the 236 shoulders in group 2 (antibiotic-impregnated cement). One patient in this group developed a superficial wound infection due to coagulase-negative *Staphylococcus*. This resolved after 2 separate surgical irrigation and debridement procedures combined with intravenous antibiotics. No patient in this group had evidence of radiologic loosening or osteolysis at the most recent follow-up.

In group I (plain cement), deep infection developed in 8 of the 265 shoulders (3.0%). Diagnosis of deep infection was made by positive joint aspiration culture and confirmed by repeat cultures at the time of revision surgery. Time from surgery to the diagnosis of infection was 8 to 40 weeks. Isolated organisms included methicillin-resistant *Staphylococcus aureus*, *S epidermidis*, *Propionobacterium acnes*, and *Dermobacter hominis*.

Surgical treatments included suppressive antibiotics, irrigation and debridement, resection arthroplasty, and 2-stage exchange arthroplasty. Group 1 patients had no evidence of radiologic loosening or osteolysis at the most recent follow-up.

The difference between groups 1 and 2 was statistically significant ($P < .001$) for the use of antibiotic-loaded bone cement on the prevention of deep infection (Table II). There was no significant statistical difference between length of follow-up, time to diagnosis of infection, postoperative radiologic changes, number of previous surgical procedures, or medical comorbidities between the 2 groups.

Discussion

The major focus of this retrospective study was to evaluate the efficacy of antibiotic-impregnated cement in the prevention of infection after primary reverse TSA. The prevalence of superficial and deep infection rates in this series was similar to those in other reports.[8,9,20,21] The antibiotic-impregnated cement did not appear to have an effect on the prevention of superficial infection. The use of antibiotic-impregnated bone cement has been reported to be consistently superior in the prevention of deep infection vs plain bone cement in total hip and knee arthroplasty.[5,6,11,16] Our study presents short-term data that suggest antibiotic-impregnated cement may be effective in the prevention of deep infection in primary reverse TSA.

The main effect of antibiotic-impregnated cement is a stronger local resistance to infection in the postoperative period as a result of elution of antibiotics into the joint fluid.[2] Antibiotic-impregnated cement has been shown to be similar to systemically administered antibiotics and independent and additive when combined with other prophylactic measures.[11,13,15,16,17] Mixing cement with antibiotics is a simple procedure that may enhance the resistance to deep infection after primary reverse TSA, as shown in this study. Many antibiotics can be used to impregnate cement, with only minor adverse effects on the cement's strength: a concentration of up to 2 grams of antibiotic powder does not substantially change the static tensile and compressive strength of cement, although the fatigue strength may be lessened.[1,11,13,14,18] In the present study, the use of antibiotic-impregnated cement had no adverse effect on loosening of the prosthesis, osteolysis, or other effects seen with the altered biomechanical properties of antibiotic-impregnated cement. Longer follow-up might alter this finding, however. The choice of antibiotic in this study was determined by the individual surgeon based on its biologic effectiveness in bone cement, clinical results in earlier hip

Table II Comparison of characteristics between groups 1 and 2

Characteristic*	Group 1 (N = 265)	Group 2 (N = 236)	*P*
Age, years	70 ± 7.4	68 ± 6.9	.157†
Operative time, min	82 ± 32	85 ± 29	.745†
Sex			>.99‡
Male, %	30	31	
Female, %	70	69	
Side			
Left, %	55	51	.638‡
Right, %	45	49	
Length of follow-up, months	41 ± 20	36 ± 17	.331†
Time to deep infection diagnosis, weeks	24 ± 16	0	…
Medical comorbidities, %	29	25	.453†
Superficial infection rate, %	0	0.004	.924‡
Deep infection rate, %	3.00	0	.001‡

* Continuous data are expressed mean ± standard deviation.
† Student *t* test.
‡ Fisher exact test.

and knee arthroplasty studies, and its availability at their respective hospitals.[5,13,14,16,17]

This particular study has several limitations that which could possibly affect ultimate outcomes, including the retrospective nature of the study vs a blinded prospective design, multiple surgeons in the study using varying techniques, and the use of variable types of antibiotic-impregnated cement.

No power analysis was performed because this was a retrospective study that captured all eligible patients at 4 institutions. In this cohort, only the relation of infection and radiologic outcomes to the use of an antibiotic in the cement was examined; thus, no conclusions can be made regarding the clinical outcomes in these 2 groups. In addition, longer follow-up may have allowed for a better assessment of the potential risks associated with loss of mechanical properties of bone cement when antibiotics are added.

Finally, a cost analysis was not performed. Cummins et al[4] examined the quality-adjusted life-years in using antibiotic-impregnated cement in total hip arthroplasty and found that when revision due to infection was considered, the additional cost of the antibiotic-impregnated bone cement would need to exceed $650 or the average patient age would need to be older than 71 years before its cost would exceed $50,000 per quality-adjusted life-years gained. They concluded that because very few patients receive cemented components in the appropriate age range, the average cost of the antibiotic cement would have to decrease significantly for a large benefit in a cost-analysis model to be seen.[4]

During the period of our study, the difference in cost between regular cement and that loaded with antibiotic was $250 to $400. More cost-analysis work needs to be done in the field of reverse shoulder arthroplasty because a cemented humeral component is used in most patients who receive reverse total shoulder prostheses and they are aged older than 70 years, making the application of a cost analysis done for hip arthroplasty limited for our population of shoulder patients.

Conclusions

This retrospective, cohort study supports the efficacy of antibiotic-impregnated cement in the prevention of early and intermediate deep infection after primary reverse TSA. Although no adverse effects were seen with the use of antibiotic-impregnated cement, longer-term follow-up is needed. Future studies may help delineate which factors are most important in preventing infection after reverse TSA.

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