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Cyanoacrylate Microbial Sealant May Reduce the Prevalence of Positive Cultures in Revision Shoulder Arthroplasty

Adam J. Lorenzetti MD, Montri D. Wongworawat MD, Christopher M. Jobe MD, Wesley P. Phipatanakul MD

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Abstract

Background Cyanoacrylate-based, microbial sealant is an adhesive skin barrier designed to prevent bacterial contamination in surgical wounds. This type of adhesive barrier could have use in decreasing the incidence of positive cultures and subsequent infection in shoulder arthroplasty.

Questions/purposes We therefore evaluated whether cyanoacrylate microbial sealant reduced the positive intraoperative culture rates in revision shoulder arthroplasty.

Methods We retrospectively reviewed 55 patients who underwent revision shoulder arthroplasties. Intraoperative aerobic and anaerobic deep tissue culture results taken during the revisions were compared. Cultures were taken of the deep synovial tissue lining the prosthesis. Patients were divided into two groups: those who underwent standard preparations with adhesive, iodine-barrier drapes (Group SP) and those who had placement of cyanoacrylate microbial sealant in addition to the standard prep (Group MS).

Results The prevalence of cases with positive cultures was 18% (seven of 40) in Group SP compared with 7% (one of 15) in Group MS. The prevalence of positive, anaerobic *Propionibacterium acnes* cultures was 13% in Group SP compared with 7% in Group MS. The prevalence of infections confirmed at revision surgery was 8% in Group SP versus 0% in Group MS.

Conclusions Our observations suggest application of a cyanoacrylate microbial sealant may reduce the prevalence of positive cultures and thereby subsequent infections in revision shoulder arthroplasties.

Level of Evidence Level III, retrospective cohort study. See Guidelines for Authors for a complete description of levels of evidence.

Introduction

Infection after shoulder arthroplasty continues to be concerning, especially in revision cases in which the infection rates range from 3.6% to 9.5% [2, 7, 13, 17, 21]. A liquid cyanoacrylate-based, microbial sealant has been designed as an adhesive skin barrier to seal residual bacteria on the skin and prevent bacterial contamination in surgical wounds. In one animal model [1] topical cyanoacrylate reportedly decreased bacterial contamination of the wound from the outside and in another animal model [3] cyanoacrylate microbial sealant decreased bacterial skin contaminations of surgical wounds compared with adhesive iodine-barrier drapes. In two studies, this type of

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A. J. Lorenzetti, M. D. Wongworawat, C. M. Jobe, W. P. Phipatanakul (✉)
Department of Orthopaedic Surgery, Loma Linda University, 11406 Loma Linda Drive, Suite 213, Loma Linda, CA 92354, USA
e-mail: wphipata@llu.edu

sealant decreased wound contamination in inguinal hernia repair [20] and cardiac bypass surgery [22]. The sealant also reduced the rate of surgical site infections in one retrospective [5] and one prospective randomized trial [11] in cardiac surgery. However, in a prospective randomized study of patients undergoing scoliosis surgery, Dromzee et al. [6] found no major reduction in surgical site infections using a microbial sealant.

We began using this microbial sealant in 2009 for shoulder arthroplasty, because this type of adhesive barrier could potentially decrease the incidence of positive cultures and subsequent infections in shoulder arthroplasty, especially with concern for periaxillary contamination.

We asked whether the addition of cyanoacrylate microbial sealant to the surgical preparations of revision shoulder arthroplasty would decrease the prevalence of positive cultures.

Patients and Methods

We retrospectively reviewed 86 patients who had unilateral revision shoulder arthroplasty between January 2005 and December 2011. We excluded 31 patients with a history of previous shoulder infection, clinical signs of preoperative infection, and the lack of intraoperative cultures. These exclusions left 55 patients presumed uninfected at the time of the revision procedures and available for retrospective reviews. Of the 55 patients, 18 underwent revisions to hemiarthroplasties, seven underwent revisions to anatomic total shoulder arthroplasties, and 30 underwent revisions to reverse total shoulder arthroplasties. The indications for surgery included glenoid component loosening (n = 14), fracture sequelae (n = 14), rotator cuff deficiency (n = 10), glenoid arthritis (n = six), prosthetic dislocation (n = six), and stiffness (n = five). All patients received preoperative antimicrobial prophylaxis in accordance with Surgical Care Improvement Project (SCIP) guidelines [18] and no preoperative oral antibiotics were given because all cases were presumed noninfected. One group (n = 40, Group SP) underwent standard, alcohol-based preparation (ChloraPrep, 2% chlorhexidine gluconate and 70% isopropyl alcohol; Enturia, El Paso, TX, USA) with adhesive iodine-barrier drapes (Ioban™ 2 Antimicrobial Incise Drape; 3M™, St Paul, MN, USA) placed over the entire shoulder and axilla, covering all the skin. The second group (n = 15, Group MS) had applications of cyanoacrylate microbial sealant (IntegueSeal®; Kimberly-Clark, Dallas, TX, USA) in addition to the alcohol-based preparation and adhesive iodine-barrier drapes received in Group SP; also in this group, the incise barrier drape was used over the entire shoulder, but because the sealant was in place, its effect was mainly to keep the edges sealed and in place, especially around the axilla. In 2006, IntegueSeal® received FDA approval as a Class II medical device. Our institution pays $26.18 for each IntegueSeal® applicator and takes approximately 15 seconds to apply over the operative area. The study patients were not concurrent. Rather, a change in practice was made in September 2009 after reviewing an article [3] on cyanoacrylate microbial sealant in 2009, after which the microbial sealant was used in all revision cases. At the time of review, the mean followup was 20 months (range, 16 days to 6.7 years). No patients were recalled specifically for this study; all data were obtained from medical records. No patients were lost to followup.

To determine adequate sample size a priori, we reviewed reported positive culture rates in revision shoulder arthroplasty. Reported values range from 11% to 56% [8, 9, 12, 16, 19]. For the control (SP) group, we assumed a 25% rate with a SD of 15%. With sealant, for the (MS) group, we considered the animal study [3] with over a 100-fold reduction. However, on the conservative side, we chose a 50% reduction in positive cultures. Assuming an alpha of 0.05 and beta of 0.20, the required sample size is 18 for each group.

Patient characteristics were similar in both groups (Table 1).

At the time of surgery, two separate cultures were taken from deep synovial tissue lining the prosthesis and sent for aerobic and anaerobic culture as per standard practice at our institution. All culture results were reviewed and the patient was counted as positive if any of the cultures were positive.

Because our purpose was to report intraoperative contamination, patients had a variable length of followup outside the routine postoperative followup period, which consisted of followup at 2 weeks, 6 weeks, 3 months, 6 months, 1 year, and then annually. In the postoperative period, laboratory tests (erythrocyte sedimentation rate,

Table 1. Preoperative patient characteristics

Category	Group SP	Group MS	95% confidence interval
Age (years)	63 ± 12	65 ± 10	−4.6 to 9.5
Male:female patients	10:30	8:7	0.9 to 6.0
ESR (mm/hour)	13 ± 11	10 ± 6	−10.9 to 3.9
CRP (mg/dL)	0.5 ± 0.3	0.3 ± 0.1	−0.3 to 0.1
BMI (kg/m^2)	28 ± 7	30 ± 6	−1.4 to 6.8
ASA score	2.4 ± 0.5	2.6 ± 0.5	−0.1 to 0.5
Charleston Comorbidity Index	0.9 ± 1.5	0.8 ± 0.9	−0.8 to 0.6

SP = standard preparation; MS = microbial sealant; ESR = erythrocyte sedimentation rate; CRP = C-reactive protein; BMI = body mass index; ASA = American Society of Anesthesiologists.

C-reactive protein, and white blood cell count) were ordered on three patients (three in SP and zero in MS) when infections were suspected. We recorded the numbers of patients who failed revision surgery and required additional procedures for infections with either an identical pathogen or intraoperative findings consistent with infection such as purulence or greater than five neutrophils per high-power field seen on histologic analysis.

We determined the proportion of positive cultures and rates of confirmed clinical infections in each group using a chi-square analysis to compare the positive culture rates and a two-tailed t- test to compare the average preoperative laboratory values and age between the two groups using IBM SPSS Statistics (IBM Corporation, Armonk, NY, USA).

Results

Group SP had a similar prevalence ($p = 0.35$) of positive intraoperative cultures (18% [seven of 40] versus Group MS 7% [one in 15]). However, post hoc power analysis revealed a power of 13%. Using the proportions found in our study, each group will require 120 patients to reach a power of 80%. The prevalence of positive aerobic and anaerobic *Propionibacterium acnes* cultures, including when they were subdivided between male and female patients, for both Group SP and Group MS are reported (Table 2).

Although our aim did not include examining postoperative infections, we report three cases of infectious wound complications confirmed at further revision surgeries, three in Group SP and zero in Group MS. Two of these cases had positive aerobic cultures, whereas one was anaerobic (Table 3). The staphylococcus-positive patient underwent a rerevision procedure 20 days later and had a confirmatory culture result at that time. The patient with the positive pseudomonas culture underwent surgical exploration 6 days later as a result of the heavy growth of a highly virulent organism, although it was found on only one or two aerobic cultures, and intraoperative findings were confirmatory of infection as well as a pathology report confirming osteomyelitis; definitive resection arthroplasty was performed at that time. The third patient had a positive anaerobic *P. acnes* culture result that was confirmed to be an infection based on both intraoperative findings of purulence and repeat positive *P. acnes* cultures at a rerevision operation performed 22 months later.

There were no complications, ie, skin reactions, documented in the operative, postoperative inpatient, or postoperative clinic notes related to the application of the cyanoacrylate microbial sealant.

Discussion

A cyanoacrylate-based, microbial sealant is an adhesive skin barrier designed to prevent skin flora contamination in surgical wounds and reportedly decreases wound contamination in inguinal hernia [20] and in cardiac bypass surgery [22]. Cyanoacrylate microbial sealant was also superior to adhesive iodine-barrier drapes in decreasing bacterial skin contaminations of surgical wounds in an animal model [3] and decreases the rate of surgical site infection in cardiac surgery [5, 11] but not during scoliosis surgery [6]. We began using this microbial sealant in all patients undergoing shoulder arthroplasty surgery as of 2009, because this type of adhesive barrier could potentially decrease the incidence of positive cultures by more effectively trapping bacteria and reducing periaxillary contamination and subsequent infections in shoulder arthroplasty. We selected revision cases as the study population because the potential positive culture rate and infection rate are higher, and as a result, there is greater likelihood of achieving a meaningful effect size. We therefore determined the effect of the use of this type of microbial sealant on the prevalence of positive cultures in revision shoulder arthroplasty.

There were several limitations of this study. First, the number of subjects in each group was small, particularly in the group that had cyanoacrylate microbial sealant applications. This was partly the result of our exclusion criteria

Table 2. Rates of positive intraoperative cultures and infections in each group

Category	Group SP	Group MS	Relative risk (95% CI)	p value
Positive intraoperative cultures	18% (7/40)	7% (1/15)	2.63 (0.35–19.58)	0.35
Positive aerobic cultures	8% (3/40)	0% (0/15)	2.73 (0.15–49.9)	0.49
Positive anaerobic *Propionibacterium acnes* cultures	13% (5/40)	7% (1/15)	1.87 (0.24–14.76)	0.55
Positive anaerobic *P. acnes* cultures in male patients	30% (3/10)	13% (1/8)	2.40 (0.30–18.90)	0.40
Positive anaerobic *P. acnes* cultures in female patients	7% (2/30)	0% (0/7)	1.29 (0.07–24.29)	0.86
Infection confirmed at rerevision surgery	8% (3/40)	0% (0/15)	2.73 (0.15–49.9)	0.49

SP = standard preparation; MS = microbial sealant; CI = confidence interval.

Table 3. Revision shoulder arthroplasty cases complicated by infections

Age (years)	Patient sex	Infecting organism	Time to infection	Final outcome
64	Male	*Propionibacterium acnes*	22 months	Resection
47	Male	Pseudomonas	6 days	Resection
55	Male	Coagulase-negative staphylococcus	20 days	Revision TSA

TSA = total shoulder arthroplasty.

of revision cases that had clinical signs or laboratory findings suggestive of infection before surgery. We believed it important to exclude these cases, because our purpose was to specifically analyze the effect that the microbial sealant had on bacterial contamination of presumably sterile wounds. The low number of patients studied resulting from the exclusion criteria and infrequency of revision shoulder arthroplasty made it difficult to achieve statistical significance. To show significance would likely require a multicenter study and a longer study period to gather sufficient numbers of cases. Second was our definition of periprosthetic infection. We are aware of the recent publication by Parvizi et al. [14] that proposed a new definition for "periprosthetic joint infection [PJI]." Because this was a study for which data were collected before the published definition, we did not look at all of the proposed criteria in every case; therefore, we lacked some data points that could have helped in more accurately defining infections in our case, although that study [10] acknowledged that "certain low-grade infections (ie, *Propionibacterium acnes*), several of these criteria may not be routinely met despite the presence of PJI." Third, we found a higher proportion of male patients were in Group MS compared with Group SP. *P. acnes* skin colonization [15] and infection [4, 10] are more prevalent in men. Because we had more men in Group MS and because men have a higher rate of *P. acnes*, we would have expected a greater rate of *P. acnes*-positive cultures in Group MS. However, we found the contrary was true, suggesting the effect of the microbial sealant on *P. acnes* may be greater than what was found. Additionally, we did find a decrease in positive *P. acnes* cultures in Group MS versus Group SP for both men and women. Fourth, although failure of revision surgery may be the result of the pathogen found in cultures at the time of revision surgery, it may also be the result of a different pathogen, which was not prevented by the barrier methods. Even when that same pathogen was found, it cannot be said to be identical without genetic testing such as pulsed field gel electrophoresis, which we did not perform. Fifth, we did not have followup in all patients as a result of the retrospective nature of this study and were unable to properly determine the number of patients with subsequent infections. A prospective study with minimum followup of 2 years would provide more accurate analysis of the microbial sealants effect on infections. However, our study's primary goal was to assess intraoperative cultures and not infections. Lastly, the study did not have adequate power. The p value showed no difference between the positive culture rate of microbial sealant and no sealant (negative result). However, this could be the result of a false-negative because of inadequate power. Post hoc analysis revealed power of only 13% and 120 patients would be required in each group to achieve adequate power. As such, this study can be seen as a pilot for future studies, because there are no other clinical studies showing reduction of cultures from microbial sealant, and we calculated our sample size requirement without clinical data guidance.

Our positive culture rate of 18% in Group SP and overall rate of 15% were comparable to the unexpected positive culture rates ranging from 11% to 56% [8, 9, 12, 16, 19] (Table 4) reported in the literature. We found that the prevalence of positive cultures was more than double in Group SP compared with those receiving the sealant with more than a 2.6 times higher risk of positive cultures in those without the sealant, although without reaching statistical significance as a result of the study being underpowered. There were no positive aerobic culture results; *P. acnes* decreased by almost 50%; and *P. acnes* decreased for both male and female patients who had cyanoacrylate microbial sealant applied in this study. Our finding of higher rates of *P. acnes* in men in this series has been similarly reported in the literature [4, 10, 15].

The uncertain meaning of positive culture results in revision shoulder arthroplasty has been reported multiple times in the literature [9, 12, 19]. Determining which positive cultures that need treatment will require further well-designed and longer-term studies. Most important from a patient perspective as well for overall medical costs and use of resources is minimizing the risk of true infection. We had no infections in those who had cyanoacrylate microbial sealant applied, suggesting another possible benefit of the sealant. Although a positive culture does not necessarily translate to an infection, a decreased proportion of positive cultures can lead to decreased infection rates.

Our observations showed that cyanoacrylate produced an insignificant reduction in culture-positive rates in revision shoulder arthroplasty cases. Further studies with more patients will be required to determine the actual effects of a microbial sealant on surgical site contamination. However,

Table 4. Comparative literature on positive cultures and infections in revision shoulder arthroplasty without obvious infection

Study	Number of positive cultures	Number of *Propionibacterium acnes*-positive cultures	Number of infections from positive cultures	Number of *P. acnes*-positive infections	Followup (average/range)
Topolski et al. [19]	75/439 (17%)	45/75 (60%)	10/75 (13%)	5/10 (50%)	60 months/1 day to 18 years
Kelly and Hobgood [12]	8/28 (29%)	6/8 (75%)	2/8 (25%)	2/2 (100%)	22 months/12–37 months
Grosso et al. [9]	17/156 (11%)	10/17 (56%)	1/17 (6%)	0/1 (0%)	36 months/22–84 months
Pottinger et al. [16]	108/193 (56%)	75/108 (69%)	Not documented	Not documented	None
Foruria et al. [8]	107/678 (15%)	68/107 (64%)	11/107(10%)	10/11 (91%)	67 months/32 days to 25 years
Current study	8/55 (15%)	6/8 (75%)	3/8 (38%)	1/3 (33%)	20 months/16 days to 6.7 years

in the meantime, given the low cost of using a microbial sealant and no reported morbidity, it would seem a reasonable option for the surgeon to use.

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