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Minimizing *Propionibacterium acnes* contamination in shoulder arthroplasty: use of a wound protector

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Abstract

Background: *Propionibacterium acnes* may be transmitted from the subdermal tissues to the deeper tissues during shoulder arthroplasty surgery, resulting in deep infection. The aim of this prospective, clinical study was to determine whether the use of a wound protector drape can lower the incidence of *P. acnes* in the wound during shoulder arthroplasty surgery.
Methods: For a consecutive series of 47 patients undergoing shoulder arthroplasty, a wound protector drape was used during surgery, to isolate the subdermal layer from the surgeons' hands, retractors and other instruments. Microbiological swabs were taken both from the subdermal layer and the exposed drape to determine the incidence of *P. acnes* at both sites.
Results: The overall incidence of *P. acnes* in the subdermal layer was 23%. A fivefold decrease in the incidence of *P. acnes* in the exposed superficial layer was demonstrated by use of the wound protector drape.
Conclusion: Use of a wound protector drape to isolate the superficial tissue layer from the surgeons' gloves, instruments and retractors decreases the incidence of *P. acnes* in the surgical field. This may result in a decreased rate of transmission to the deeper tissues, and a decreased rate of *P. acnes* deep infection.

Introduction

Propionibacterium acnes is well recognized as a pathogen responsible for infections following shoulder surgery.[1] Although it can be difficult to culture, *P. acnes* has been demonstrated to be most prevalent in the subdermal tissues, and it may be transmitted to the deeper tissues via instruments or surgical gloves during shoulder operations.[2,3] A recent publication demonstrated the high prevalence of *P. acnes* in the subdermal layer around the shoulder. It postulated transmission of the bacteria from the subdermal layer to the deeper tissues was a causative factor in the development of *P. acnes* deep infections following shoulder surgery.[4]

In abdominal surgery, wound protector drapes isolating the skin, subdermal and superficial tissues from the abdominal cavity, have been shown to decrease the risk of wound infections, by decreasing the exposure of these tissues to the abdominal contents that may contain bacterial pathogens.[5] Recently, a wound protector drape (Alexis Orthopaedic Protector; Applied Medical, Rancho Santa Margarits, CA, USA) has been introduced for use in orthopaedics. It serves to protect the superficial tissues from trauma related to instruments and retractors while providing retraction of these tissues to improve visualization of the surgical field. We postulate that utilization of this drape in surgery of the shoulder may also serve to minimize transfer of *P. acnes* from the superficial tissues to the deeper tissues by forming an impervious barrier between the subdermal layer and the surgical field, thereby decreasing the risk of deep infections related to this organism. For the purpose of this study, we have used *P. acnes* contamination of the wound protector drape, as a surrogate marker of deep wound contamination.

The aim of this study is to demonstrate a decreased prevalence of *P. acnes* on the exposed surface of the wound protector drape, when compared with the underlying subdermal tissues during shoulder surgery.

Methods

Consecutive patients undergoing shoulder replacement surgery through a delto-pectoral approach at a single institution (four surgeons) were recruited over a 6-month period. Patients with a past history of ipsilateral shoulder infection, or previous surgery through the same approach were excluded.

The Alexis Orthopaedic Protector (Applied Medical) consists of two thermoplastic, polyurethane rings, connected by a polyester laminated, polyurethane film. One ring sits on the skin, while the other is placed deep to the superficial tissues, and the connecting sheet is then tensioned to create the barrier (Fig. 1).

Standardized antibiotic prophylaxis was administered, consisting of 2 g of cephazolin with induction, and 1 g every 8 h for 24 h. For one case vancomycin was used instead of cephazolin due to patient allergy. Skin preparation was either with alcoholic iodine or alcoholic chlorhexidine depending on surgeon preference, and all patients underwent a pre-operative scrub with the same antiseptic preparation.

The surgical approach was standardized for all surgeons. After dissecting through the delto-pectoral interval, a microbiology swab was taken from the subdermal layer on the medial side of the wound. The wound protector drape was then inserted, with the deep ring placed under the deltoid laterally, and deep to the pectoralis major tendon medially, to isolate the superficial tissues (Fig. 2). All gloves were then changed and the shoulder replacement proceeded in a routine fashion. Once the prosthesis was implanted, pulsed lavage was used to washout the deep wound and the subscapularis re-attached. At this point, just prior to removal of the barrier drape, a second microbiological swab was taken, this time from the exposed surface of the barrier drape, overlying the medial edge of the wound. The drape was then removed and a third microbiological swab was taken, from the subdermal layer on the medial side of the wound – the same area as the first swab. The wound was then closed in a routine fashion.

Fig. 1. Proprietary photograph of the Alexis Wound Protector.

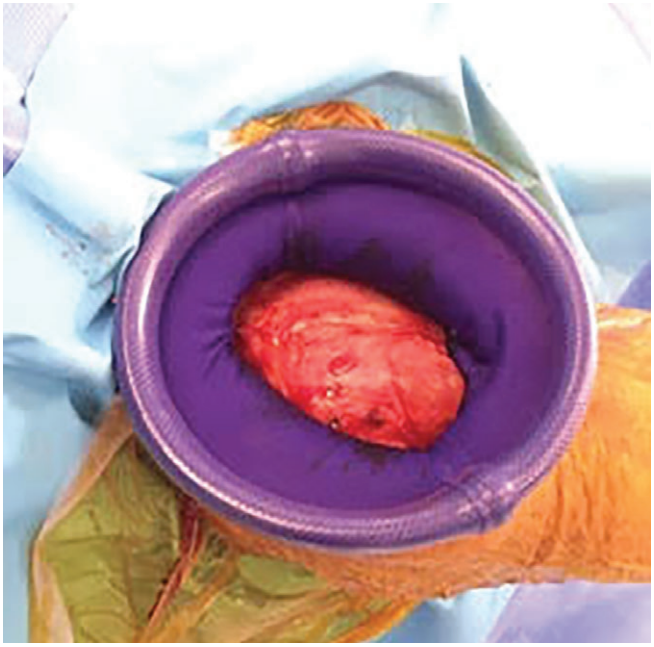

Fig. 2. Wound protector *in situ*, right shoulder.

All swabs were transported to the same pathology laboratory (Dorevitch Pathology) and inoculated onto blood agar and chocolate agar plates, as well as a cooked meat enrichment medium. Aerobic and anaerobic cultures were then undertaken for 14 days, and the plates then examined specifically for the presence of *P. acnes*.

Local Human Research Ethics approval was obtained for this study (approval number 221).

Statistical analysis

Power analysis was determined based on demonstrating a 25% reduction in *P. acnes* positive cultures between the surface of the barrier drape and the subdermal layer at the end of the operation, based on the incidence described by Falconer *et al.*[4] To demonstrate a difference with a power of 0.8 and $P < 0.05$, 42 patients were required. We included an additional 10% to be safe, and set our $n = 47$.

We summarized continuous and discrete variables by mean and standard deviation or medians and interquartile range (IQR) as appropriate, and binary variables as proportions. We performed statistical significance testing of baseline characteristics using Student's *t*-test, Wilcoxon rank sum, Fisher's exact test or chi-squared tests as appropriate.

The primary outcome was reported as a risk ratio with 95% confidence interval. Because our data were paired, statistical significance was calculated using McNemar's exact test to allow for within patient correlation. All analyses were performed using Stata 14 (StataCorp, College Station, TX, USA).

Results

Forty-seven patients were included in the study, 22 males and 25 females. The median age was 70 (IQR 65–77) years, and median

body mass index was 28.5 (IQR 25.9–32.3). The primary diagnosis was osteoarthritis in 23, and cuff tear arthropathy in 24. One hemiarthoplasty was performed, 22 conventional total shoulder replacements and 24 reverse fulcrum shoulder replacements; 27 were right shoulders, while 20 were left shoulders. Median total operative time was 81 min (IQR 71–98).

Overall incidence of *P. acnes* positive swabs in the subdermal layer

Eleven (23%) of the 47 patients had at least one swab, which grew *P. acnes.*

Prior to the insertion of the barrier drape, four swabs grew *P. acnes* from the subdermal layer. After removal of the barrier drape, 10 swabs grew *P. acnes* from the subdermal layer. Three of the four patients who were positive for *P. acnes* on the first swab were also positive on the final swab.

Baseline characteristics of patients are shown in Table 1. Younger age ($P = 0.01$) and male gender ($P = 0.001$) were associated with an increased incidence *P. acnes* in the subdermal layer. There was no evidence of any difference with regards to body mass index, total operative time, skin preparation or operative diagnosis.

Incidence of *P. acnes* on the barrier drape

Two (4.3%) swabs were positive for *P. acnes* on the barrier drape. Both patients who demonstrated *P. acnes* on the barrier drape had positive subdermal swabs after drape removal, but only one had a positive subdermal swab prior to drape insertion.

There was a lower incidence of *P. acnes* on the barrier drape (2/47) compared to the subdermal layer (10/47) at the end of the operation, risk ratio 0.2 (95% confidence interval 0.06–0.70), $P = 0.008$ (McNemar's exact test).

Discussion

Propionibacterium acnes is a gram-positive bacillus that resides in sebum glands. It is a common contaminant in shoulder surgery, and a potential pathogen in post-operative shoulder infections.[6–8] Recent studies indicate a high incidence of *P. acnes* in the subdermal layer, and it is postulated that the organism may be carried into the deeper tissues during surgery by instruments or by hand.[4,9]

This study demonstrates that a wound protector drape designed to protect the superficial soft tissues from damage from retractors and other surgical instruments, also provides a physical barrier against *P. acnes.* The incidence of *P. acnes* on the exposed surface of the wound protector drape is fivefold less than its incidence on the otherwise exposed superficial tissues during shoulder replacement surgery. Although we cannot assume that the wound protector drape will prevent *P. acnes* from passing to the deeper tissues directly, we can assume that this decreased incidence of *P. acnes* in the exposed superficial wound edges will decrease the chance of indirect transfer of *P. acnes* to the deeper tissues via gloves or instruments.

A number of factors have been shown to be associated with positive *P. acnes* culture including: male gender, previous shoulder implants, prosthetic joint infection,[2] presence of hair,[10,11] longer surgical duration,[12] pre-operative corticosteroid injections[13] and age <50 years.[9] As well it has been shown that males have a higher bacterial load than females.[14]

Our study confirms a positive association between younger age, male gender and increased incidence of *P. acnes* in the subdermal layer. We identified no association between diagnosis, body mass index or operative time and incidence of *P. acnes* in the subdermal tissues.

Interestingly we had one patient who cultured *P. acnes* from the subdermal layer at the start of the operation, but not at the end. It is likely that this result relates to the difficulty in culturing this organism in general, and underlies the fact that it is probably more prevalent than our current testing identifies.

Although antibiotic prophylaxis was standardized, skin preparation was variable, with some patients receiving alcoholic chlorhexidine, while others received alcoholic iodine. This variability was a result of surgeon preference, and accepted as part of the study protocol, as recent literature does not demonstrate any one method of skin preparation to be more effective at decreasing the incidence of *P. acnes.*[15] This finding was supported by our results.

A weakness of this study is our inability to determine at what time point the wound protector drape became contaminated with *P. acnes.* If this occurred at the time of insertion, then for those patients the wound protector drape has not provided any additional protection against *P. acnes* being passed into the deeper tissues.

A perceived weakness of this study design is the apparent lack of a control comparator, to determine the incidence of *P. acnes* in the subdermal without the use of the wound protector drape. Our justification for this is that several studies have already reported the incidence of *P. acnes* in the subdermal layer[2–4] and given that our incidence of 23% (positive swabs of the subdermal layer) correlates with those published data, we consider this to be an acceptable comparator.

Table 1 Univariable analysis results

Factor	*P. acnes* negative	*P. acnes* positive	*P* value
N	36	11	
Age, median (IQR)	72 (67–78)	65 (57–68)	0.011
BMI, median (IQR)	28.55 (26.04–31.38)	28.85 (24.50–35.49)	0.63
Operative time, median (IQR)	81.5 (72–96.5)	80 (69–103)	0.96
Male gender, *n* (%)	13 (36)	10 (91)	0.001
Cuff tear arthropathy, *n* (%)	19 (53)	5 (45)	0.67
Osteoarthritis, *n* (%)	17 (47)	6 (55)	
Alcoholic chlorhexidine, *n* (%)	24 (75)	10 (91)	0.26
Alcoholic iodine, *n* (%)	8 (25)	1 (9)	

BMI, body mass index; IQR, interquartile range.

A potential weakness of this study is that the nature of the drape material may play a role in the ability of *P. acnes* to adhere and hence be swabbed. If *P. acnes* does not adhere to the drape, we may be observing a falsely low rate of culture from the drape, despite higher rates of deep wound contamination, making our surrogate outcome measure invalid. Unfortunately there is no evidence regarding this and further studies would be required to determine the differential adhesiability of *P. acnes.*

The use of the wound protector drape carries a technical learning curve. Sufficient mobilization of the deltoid and pectoralis major muscles must be achieved to minimize the risk of inadvertent loss of position of the deep ring of the drape. Similarly, delivery of the proximal humerus into the wound can lead to dislodgement of the deep ring of the drape. Alteration in the deltoid tension needs to be considered particularly with trialling component implantation for stability. There was no instance of skin or muscle necrosis with use of this drape, and this has not been reported with its use elsewhere.

Conclusion

We conclude that the use of a wound protector drape results in a significantly decreased incidence of *P. acnes* contamination of the drape, compared with the underlying subdermal tissues during shoulder arthroplasty surgery. By decreasing the incidence of *P. acnes* in the surgical field, we postulate that the incidence of indirect transfer of the organism to the deeper tissues will be minimized. This will hopefully result in a decreased incidence of *P. acnes* deep infection following shoulder arthroplasty.

Notwithstanding the change to surgical technique when using the wound protector drape, we recommend considering this device as an adjunct to other measures aimed at decreasing infection risk during shoulder arthroplasty surgery.

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Conflicts of interest

None declared.

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