Hydrogen Peroxide Applied Directly to the Dermis following Skin Incision Decreases Deep *Cutibacterium Acnes* Contamination during Total Shoulder Arthroplasty; A Randomized Controlled Trial

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INTRODUCTION:
Despite all efforts to minimize risk, periprosthetic joint infections (PJI) occur in 1-4% of primary total shoulder arthroplasties (TSAs). *Cutibacterium acnes* is the most implicated organism and has been shown to persist in the dermis despite use of preoperative antibiotics and standard skin preparation solutions. Multiple studies have shown decreased *C. acnes* rates with use of preoperative benzoyl peroxide or hydrogen peroxide (H2O2), but positive deep cultures are still common. We sought to determine if an additional application of H2O2 directly to the dermis following skin incision would further decrease deep culture positivity rates.
METHODS:
We performed a blinded, randomized controlled trial comparing rates of positive tissue cultures at the time of primary TSA in male patients with no prior shoulder surgery with either our standard skin preparation of H2O2, ethanol, and ChloraPrep vs. an additional application of H2O2 to the dermis immediately after skin incision. Univariate and multivariate analysis was performed comparing rates of positive cultures based on demographic and surgical factors.
RESULTS:
Positive *C. acnes* dermal cultures occurred at similar rates between experimental and control cohorts during the initial (22% vs. 28%, *P* = .500) and final dermal swabs (61% vs. 50%, *P* = .843). On univariate analysis, the rate of positive deep cultures for both any bacterium and *C. acnes* specifically trended toward being lower in the experimental compared to the control group (any bacterium: 37% vs. 53.7% and *C. acnes*: 28% vs. 44%, respectively), but the differences failed to show statistical significance (*P*=0.061 and *P*=0.054, respectively) (Table 1). Interestingly, however, patients who underwent anatomic TSA compared to reverse TSA had a significantly greater rate of positive deep cultures for both any bacterium and *C. acnes* specifically (any bacterium: 43% vs. 15%, P = .002 and *C. acnes*: 44% vs. 19%, P = .008). When controlling for this on multivariate analysis, dermal H2O2 was found to be associated with a significantly lower odds ratio for positive deep cultures (any bacterium: OR 0.38, *P*=0.022, and *C. acnes*: OR 0.37, *P*=0.023) (Table 2). There were no wound complications in either cohort.
DISCUSSION AND CONCLUSION:
In conclusion, an additional H2O2 application directly to the dermis following skin incision resulted in a statistically significant decrease in the odds of having deep cultures positive for both any bacterium and *C. acnes* specifically without obvious adverse effects on wound healing. It may be considered as an adjuvant to preoperative use of BPO or H2O2 in revisions where accurate culture results will affect further treatment.

Table 1: Patient characteristics and rate of positive cultures compared between experimental and control groups as well as the bacterium isolated.

Characteristic	Experimental	Control	Std. Diff. or *P* value*
Number of samples (n)	18	18	
Age at surgery (years)	67.9 ± 7.7	71.9 ± 8.8	.484
Surgery length (hours)	2.2 ± 0.5	2.3 ± 0.6	.138
Right side operation	77.8% (14)	61.1% (11)	.368
Anatomic TSA	33.3% (6)	22.2% (4)	.250
Diagnosis: OA	50.0% (9)	50.0% (9)	1.000
Intraoperative complication	0.0% (0)	0.0% (0)	*NA*
Prior corticosteroid injection	72.2% (13)	77.8% (14)	.129
Positive cultures: Any bacterium			
Initial dermal swab	33.3% (6)	38.9% (7)	.500
Deep tissue cultures	37.0% (20)	53.7% (29)	.061
Final dermal swab	66.7% (12)	55.6% (10)	.847
Positive cultures: *C. acnes*			
Initial dermal swab	22.2% (4)	27.8% (5)	.500
Deep tissue cultures	27.8% (15)	44.4% (24)	.054
Final dermal swab	61.1% (11)	50.0% (9)	.843

C. acnes, *Cutibacterium acnes*; OA, osteoarthritis; Std. Diff., Standardized Difference.
Bold values denote statistical significance.
Values represent either the mean ± standard deviation or % (n).
*Differences in patient characteristics were evaluated by calculating the standardized difference using Cohen's d; the difference in proportions or means was divided by the pooled standard deviation. The rate of positive cultures was compared between the experimental vs. control group using a one-sided Fisher's exact test hypothesizing lower rates in the experimental group.

Table 2: Multivariable logistic models assessing the influence of the intervention on the rate of positive cultures with any bacterium and *C. acnes* alone (crude) and when controlling for type of shoulder arthroplasty (adjusted).

Model	Anatomic vs. Reverse TSA		Experimental vs. Control Group	
	OR (95% CI)	*P*	OR (95% CI)	*P*
	Any bacterium			
Initial dermal swab				
Crude	4.07 (0.88,18.87)	.073	0.79 (0.2,3.07)	.729
Adjusted	4.41 (0.91,21.3)	.058	0.63 (0.15,2.75)	.539
Deep tissue cultures				
Crude	4.17 (1.68,10.33)	**.002**	0.51 (0.24,1.09)	.083
Adjusted	5.16 (1.97,13.55)	**<.001**	0.38 (0.16,0.89)	**.022**
Final dermal swab				
Crude	9.00 (0.99,81.57)	.051	1.6 (0.41,6.18)	.495
Adjusted	8.69 (0.95,79.23)	**.021**	1.39 (0.33,5.91)	.658
	C. acnes			
Initial dermal swab				
Crude	2.80 (0.57,13.83)	.206	0.74 (0.16,3.38)	.701
Adjusted	3.01 (0.59,15.43)	.187	0.64 (0.13,3.10)	.572
Deep tissue cultures				
Crude	3.33 (1.39,7.98)	**.007**	0.48 (0.22,1.07)	.073
Adjusted	4.1 (1.61,10.42)	**.002**	0.37 (0.16,0.90)	**.023**
Final dermal swab				
Crude	4.67 (0.83,26.34)	.081	1.57 (0.42,5.9)	.503
Adjusted	4.5 (0.79,25.59)	.068	1.39 (0.35,5.59)	.639

C. acnes, *Cutibacterium acnes*.
Bold values denote statistical significance.
Crude (bivariable) and adjusted (multivariable) OR estimates were derived from multivariable logistic regression models. *P* values were calculated using the likelihood-ratio test.