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Incidence of *Cutibacterium acnes* in open shoulder surgery

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ABSTRACT

In recent years, *Cutibacterium acnes (C. acnes)* has been reported to affect postoperative outcomes. The purpose of this study was to examine the detection rate and clinical features of *C. acnes* infection after open shoulder surgery. Fifty-nine patients (33 males and 26 females; mean age, 69.1 years) were included. Samples were collected from a skin swab at the incision site prior to skin preparation. Further samples were collected from synovial swabs at the glenohumeral joint immediately after incision and before incision closure. Samples with *C. acnes*-positive skin swab cultures were defined as Group A, and those with negative cultures were defined as Group N. Age, sex, presence of diabetes mellitus, operation time, presence of deep infection after surgery, and rate of positive synovial swab cultures were compared between groups. There were 27 patients in Group A (mean age 69.1±13.3 [SD], 21 males and 6 females) and 32 patients in Group N (mean age 69.1±11.0 [SD], 12 males and 20 females). No significant difference in the presence of diabetes mellitus and operation time were found between groups. From the glenohumeral joint immediately after incision, *C. acnes* was detected in 22.2% and 0% of patients in Group A and Group N, respectively. For the glenohumeral joint before incision closure, *C. acnes* was detected in 22.2% and 0% of patients in Group A and Group N, respectively, demonstrating a significantly higher rate in Group A. Our findings suggest that the route of infection following open shoulder surgery is via contamination.

Keywords: *cutibacterium acnes*, open shoulder surgery, incidence contamination

Abbreviations:
C. acnes: Cutibacterium acnes
ORIF: open reduction and internal fixation

INTRODUCTION

Cutibacterium acnes (C. acnes) is an indigenous bacterium that resides in human skin. The skin commensal bacterium is found in areas of the body such as the head, back, and axilla that are densely distributed with pilosebaceous glands.[1,2] Recent studies have reported *C. acnes* to be implicated in the pathology of shoulder joints and postsurgical outcomes.[3-7] Moreover, a growing

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body of reports have described the bacterium as an organism that can colonize the shoulder joint and cause complications during the perioperative period.[2,8]

An increasing number of studies on postoperative shoulder infections caused by *C. acnes* have appeared in the literature. Pauzenberger et al[9] demonstrated that after performing arthroscopic rotator cuff repair, *Staphylococcus epidermidis* was the most commonly identified pathogen at 39.3%, followed by *C. acnes* at 28.6%. Several reports have also illustrated the involvement of *C. acnes* in the pathology of shoulder arthropathy in addition to postoperative outcomes.[3-5] Furthermore, a recent study suggested that *C. acnes* may be a perioperative contaminant derived from surgical incisions, surgeon's gloves, and surgical instruments during shoulder arthroplasty.[10]

Kajita et al[11] previously examined the detection rate of *C. acnes* in arthroscopic surgery. One of the problems that that the authors identified in this study was the use of a cannula for synovial swabs during arthroscopic surgery, and the possibility of washout from inadvertent reflux.

The primary aim of this study was to provide a prospective assessment for the detection rate of *C. acnes* after open shoulder surgery using the deltopectoral approach. The secondary aim was to identify possible correlations between patient characteristics and results from culture tests.

MATERIALS AND METHODS

Patient demographics

All participants provided informed consent between April 2016 to April 2017 under a protocol approved by our institutional review board. Patients who underwent open shoulder surgery requiring intraarticular intervention using the deltopectoral approach with a follow-up of at least 2 years were included in this study. A total of 59 patients (33 males and 26 females) underwent shoulder joint surgery, excluding those with a previous history of shoulder surgery, septic shoulder joint, and dermatological disease. The mean age was 69.1 (range, 33–85) years. The surgical procedures included 20 cases of open rotator cuff repair, 20 cases of reverse shoulder replacement for irreparable massive rotator cuff tears, and 19 cases of open reduction and internal fixation (ORIF) for intra-articular fractures. All procedures were performed by a single experienced shoulder surgeon. Within 30 min of beginning the procedure, all patients received a routine antibiotic prophylaxis of 1 g cefazolin. The skin was subsequently prepared using 70% isopropyl alcohol to the exposed shoulder.

Sample Collection

Samples were collected from a skin swab at the incision site prior to skin preparation (Fig. 1A). Further samples were obtained from synovial swabs at the glenohumeral joint immediately after incision (Fig. 1B) and before closing the incision (Fig. 1C). All samples were submitted for culture for a minimum of 3 weeks.

Diagnostic assessment

The focus of this study was to evaluate the detection rate of *C. acnes* from skin swab cultures. Samples with *C. acnes*-positive swab cultures of the skin were defined as Group A, and those with negative cultures were defined as Group N. The following items were assessed and compared between the two groups: age, sex, presence of diabetes mellitus, operation time, results of blood test (preoperative and 2-week postoperative white blood cell count and C-reactive protein values), presence of deep infection after surgery, and rate of positive synovial swab cultures. The minimum follow-up time for a clinical review to exclude infection was 2 years.

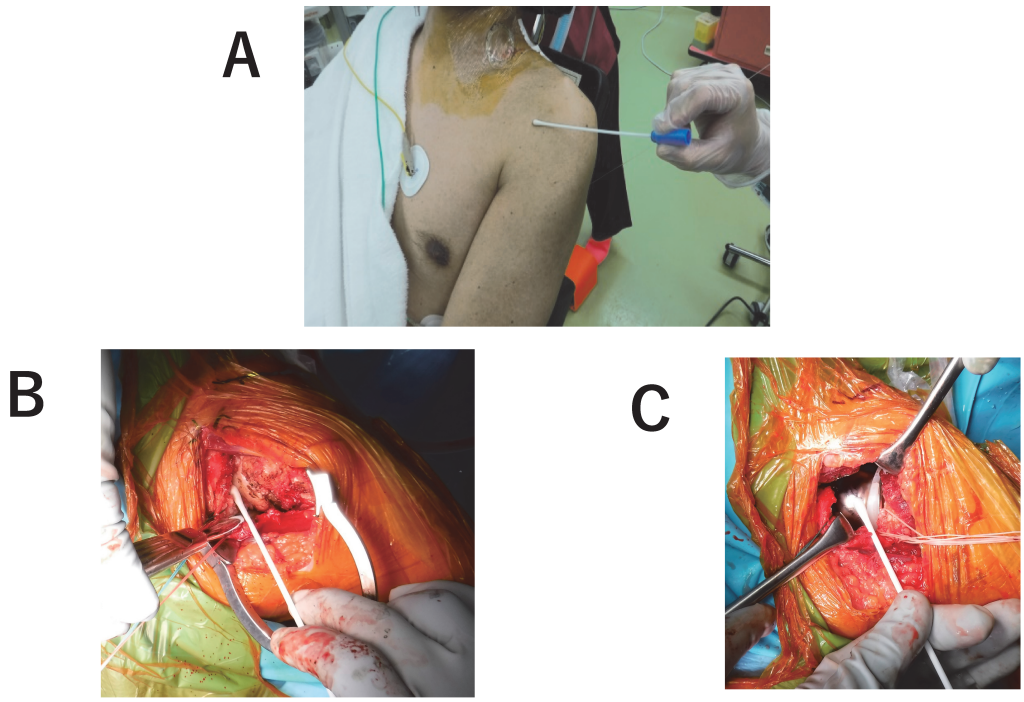

Fig. 1 Sites of sample collection
Fig.1A: Deltopectoral approach; swab culture from the skin above the tip of the coracoid process.
Fig.1B: Synovial swab culture, immediately after surgical exposure of the joint.
Fig.1C: Synovial swab culture, immediately after surgical closure of the joint.

Statistical analyses

All statistical analyses were performed with Statistical Product and Service Solutions (ver. 18.0, SPSS Inc, Chicago, IL). The t-test, paired t-test, McNemar test, and Chi-squared test were applied for statistical analysis with a significance level of $p < 0.05$.

RESULTS

Group A consisted of 27 patients (mean age, 69.1 ± 13.3 [SD], 21 males and 6 females), and Group N consisted of 32 patients (mean age 69.1 ± 11.0 [SD], 12 males and 20 females). There were significantly more males in Group A. There was no significant difference between diabetic complications and operation time between groups (Table 1). Blood tests that were assessed prior to surgery and within 2 weeks postoperatively showed no significant difference in white blood cell count and C-reactive protein between groups (Fig. 2). Deep infection was not observed in either groups. Immediately after surgical exposure, 6 specimens in Group A (22.2%) and 0 specimens in Group N (0%) were tested positive for *C. acnes* in the synovial swab culture. Immediately before surgical closure, 6 specimens in Group A (22.2%) and 0 samples (0%) in group N were tested positive immediately before surgical closure. Group A showed a significantly higher number of *C acnes*-positive specimens (Fig. 3).

Table 1 Patient demographics and clinical characteristics

	Group A	Group N	*P* Value
No. of patients	*n*=27	*n*=32	
Follow up (months)	18.4±7.7	18.5±8.2	0.99*
Age (yr.)	69.1±13.3	69.1±11.0	0.98*
Sex (male/female)	21/6	17/19	0.003**
Diabetes [rate]	2 [7.4%]	3 [9.4%]	1.0**
Duration of surgery (min.)	139.9±46.3	118.4±47.0	0.9*

There was a significant difference in the number of *C. acnes*-positive specimens from skin swabs between sexes. There were no significant differences in other parameters. Values are presented as mean ± standard deviation or number of cases [percentage].

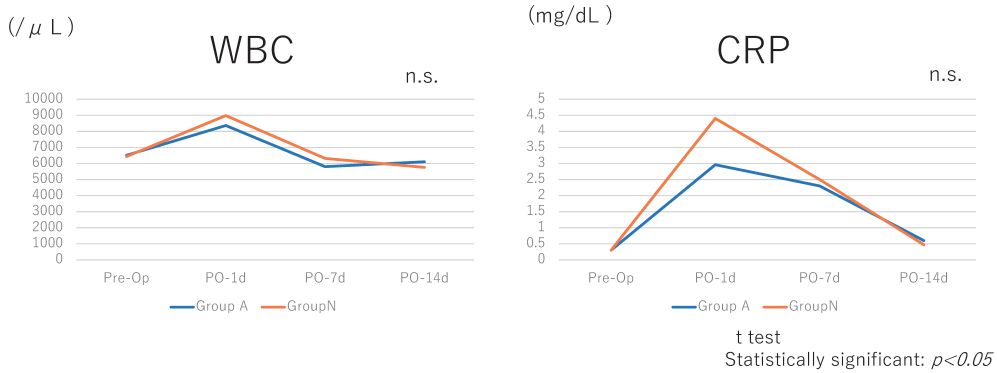

Fig. 2 Blood test results (preoperative and 2-week postoperative white blood cell count values)
There were no significant differences in white blood cell values between the two groups in preoperative and 2-week postoperative blood tests.

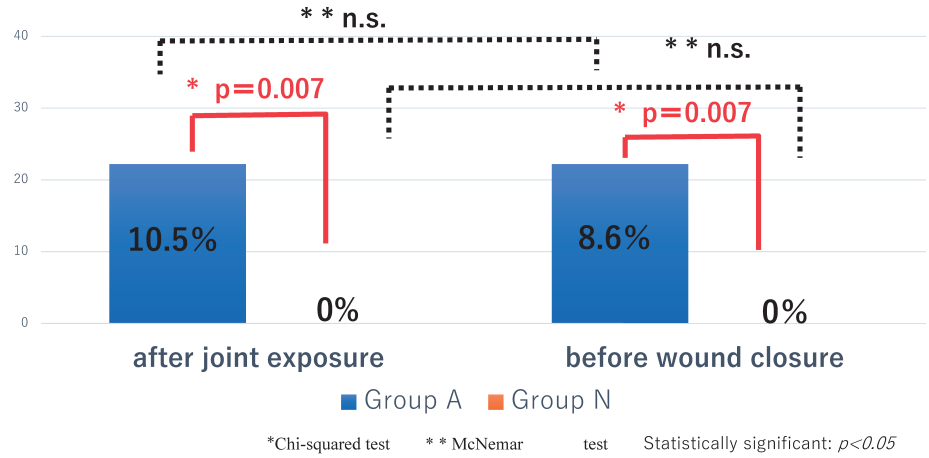

Fig. 3 Blood test results (preoperative and 2-week postoperative C-reactive protein values)
There were no significant differences in C-reactive protein values between the two groups in preoperative and 2-week postoperative blood tests.

DISCUSSION

C. acnes is found in sebaceous glands that lie deeper than the surface of the skin. For this reason, it is known that *C. acnes* reside in sites with a high density of sebaceous glands. An examination of their distribution in the skin around the hips, shoulders, and knees shows that it is most abundant around the shoulders.[5,12] Sebaceous glands are more abundant in males, and it is known that there is a gender-based difference in the detection rate of *C. acnes*. Chuang et al[1] suggested that testosterone, a male hormone, is associated with the colonization of *C. acnes*, and reported a detection rate of 81.6% for males and 46.1% for females. For the detection rate in swab cultures of the skin around the shoulder joint, Chuang et al[1] reported a rate of 81.6% in males and 46.15% in females, while Patel et al[12] reported of 80% in males and 30% in females. Both studies reported that *C. acnes* was detected significantly more in male skin, and our study demonstrated similar results in Group A which included *C. acnes*-positive specimens.

In this study, we examined the detection rate of *C. acnes* for the following open shoulder surgery procedures: open cuff repair, reverse total shoulder replacement, and ORIF for intra-articular fractures. Some studies have suggested that *C. acnes* is associated with postoperative hydrarthrosis and subacromial bursitis in rotator cuff repair.[11,13] *C. acnes* has been reported to cause postoperative pain and implant loosening in reverse total shoulder arthroplasty.[14,15] To the best of our knowledge, there are no reports on the relationship between *C. acnes* and ORIF for fractures.

The route of transmission for *C. acnes* remains largely unclear. In this study, *C. acnes*-positive cases detected from skin swab cultures were also significantly detected from synovial swabs, thus suggesting contamination from the skin. In addition, *C. acnes* was detected in synovial swab cultures immediately after the surgical exposure of the joint, and the detection rate did not increase in synovial swabs before the surgical closure of the joint; thus, we believe that the contamination had occurred prior to or at an early stage of surgery. Levy et al[6] also described the potential preoperative presence of *C. acnes*, as they detected *C. acnes* in synovial fluid and tissues before implantation during total shoulder replacement. Moreover, Kajita et al[16] and Mook et al[15] reported that pre-operative injections can increase the detection rate of *C. acnes* in shoulder surgery. *C. acnes* does not reside in the surface of the skin but in the sebaceous glands of the subcutaneous layer, and it is difficult to completely eliminate the bacteria by skin disinfection. Sethi et al[17] reported a *C. acnes* detection rate of 15.8% in skin swab cultures after skin disinfection. Falconer et al[10] reported that *C. acnes* was found in swab cultures of surgical gloves and implants used during the operation, pointing out the possibility of intraoperative contamination. It is advisable to replace scalpel blades and gloves frequently to prevent *C. acnes* contamination. Although the scalpel blade used for skin incision and gloves used during surgery were replaced frequently, a complete prevention of *C. acnes* contamination would be difficult to achieve. Stull et al[18] stated that the addition of 3% hydrogen peroxide to normal disinfection can significantly reduce the detection of *C. acnes* in the skin. Scheer et al[19] stated that the use of benzoyl peroxide for disinfection can significantly reduce the detection of *C. acnes*. Future studies should explore the implementation of more effective methods for skin disinfection against *C. acnes* and reduction of contact with the subcutaneous tissue where *C. acnes* may be present in order to avoid the risk of intraoperative contamination.

None of the *C. acnes*-positive cases from synovial swab cultures in this study resulted in deep infection within 2 years after surgery. Although several subtypes of *C. acnes* have been described in the literature, only a small number of these have been shown to exhibit virulence and cause deep-seated infections.[5] The particular *C. acnes* detected in this present study may have been subtypes that exhibit low virulence. Deep infections caused by *C. acnes* are called

"stealth"-type infections and do not commonly present with clinical findings such as swelling, hot sensation, and pain as observed in other common forms of deep infections.[20,21] Since this study described a short-term observation after surgery, future studies should aim to investigate the long-term follow-up of deep infection in *C. acnes*-positive cases.

There were several limitations in this study. Firstly, the sample size was small. Secondly, the follow-up period was short. Thirdly, several subtypes of *C. acnes* have been identified that may explain their bacterial diversity and clinical manifestation[5]; however, these variations were not considered in this study. Lastly, surgical indications were varied. Future studies should address these concerns with a larger study population, longer follow-up period, and consistency in terms of surgical indication.

CONCLUSION

A high detection rate of *C. acnes* was observed in male skin for open shoulder surgery. In cases where *C. acnes* was detected from the skin, the bacteria was also significantly detected from synovial swabs, which suggests the route of infection may be via contamination.

DISCLOSURE STATEMENT

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