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Does *Cutibacterium acnes* Associatie with Frozen Shoulder?

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Background: The aim of this study was to assess the positive culture rate for *Cutibacterium acnes* in patients undergoing arthroscopic capsular release for frozen shoulder or arthroscopic Bankart repair for traumatic anterior shoulder instability without limited range of motion.

Methods: Patients who underwent arthroscopic capsular release for frozen shoulder (n＝39, mean age 57.3±8.9 years; group F) or arthroscopic Bankart repair for traumatic anterior shoulder instability (n＝36, mean age 29.5±13.2 years; group B) between April 2016 and May 2017 were retrospectively reviewed. Before antisepsis, swab samples were collected for culture from the anterior and posterior portal incision sites. Intra-articular synovial swabs were also obtained from the glenohumeral joint immediately after the surgical incision and before wound closure. The two groups of patients were compared for diabetes status, operation time, deep-seated infection, and the *C. acnes* detection rate.

Results: Diabetes was significantly more common in group F than in group B (17.9% vs 2.7%). There was no significant difference in the *C. acnes* detection rate between Group F and Group B for synovial swab (11.3% vs 5.6%).

Conclusion: These findings suggest that there is no relationship between *C. acnes* and the pathology of frozen shoulder.

Level of Evidence: Diagnostic level III, Case-control study.

Key words: *Cutibacterium acnes*, arthroscopic capsular release, frozen shoulder, arthroscopic Bankart repair, traumatic anterior shoulder instability, infection

INTRODUCTION

Cutibacterium acnes, formerly known as *Propionibacterium acnes*, is a commensal bacterium found in areas of human skin containing a dense distribution of pilosebaceous glands, particularly the head, back, and axillae[4)18)]. *C. acnes* has recently been implicated in shoulder joint pathology and postoperative outcomes[1)2)8)10)12)20)]. Moreover, there have been several reports on the *C. acnes* detection rate during rotator cuff repair and shoulder joint replacement surgery.

Frozen shoulder syndrome is a common orthopedic condition that affects an estimated 2–5% of the general population and typically occurs in individuals aged between 40 and 60 years. Although a pilot study by Bunker et al. identified *C. acnes* as a potential cause of frozen shoulder[3)], information on the detection rate of *C. acnes* during arthroscopic stabilization of the shoulder is scarce.

Yeranosian et al. reported a postoperative infection rate of 0.29% in patients undergoing

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arthroscopic rotator cuff repair[22]. A further study by Pauzenberger et al.[17] found that 39.3% of pathogens responsible for infection during arthroscopic rotator cuff repair were *Staphylococcus epidermidis* and 28.6% were *C. acnes*. Moreover, Owens et al.[15] found a deep-seated infection rate of 0.22% in 4562 patients who underwent arthroscopic Bankart repair and identified *Staphylococcus aureus* and *S. epidermidis* to be the major causative pathogens. However, there was no mention of *C. acnes* in their report.

The contribution of *C. acnes* to shoulder joint pathology and range of motion remains largely unclear. In this study, we examined the positive culture rate for *C. acnes* in patients undergoing arthroscopic capsular release for frozen shoulder or arthroscopic Bankart repair for traumatic anterior shoulder instability without limited range of motion.

MATERIALS AND METHODS

Ethical considerations

The study was approved by our institutional review board (study number: 2016-H201) and was performed in accordance with the ethical standards outlined in the 1964 Declaration of Helsinki and its later amendments. Informed consent was obtained from all participants.

Patients and indications for surgery

Patients who underwent arthroscopic capsular release for frozen shoulder (group F) or arthroscopic Bankart repair for traumatic anterior shoulder instability without limited range of motion (group B) between April 2016 and May 2017 and were followed up for at least 2 years after surgery were retrospectively reviewed. In group F, the indication for arthroscopic capsular release was a diagnosis of frozen shoulder refractory to conservative treatment (nonsteroidal anti-inflammatory drugs, intra-articular corticosteroid injection, and/or physical therapy) for a minimum of 6 months and a limited range of motion observed in at least two directions (forward flexion $\leq 100^{\circ}$, external rotation $\leq 10^{\circ}$). In group B, an arthroscopic Bankart repair for traumatic anterior shoulder instability was indicated in patients with a history of two or more prior dislocations of the shoulder joint who were experiencing difficulty and discomfort in activities of daily living or sports as a consequence of the dislocations. Patients with a history of shoulder joint surgery or skin disease were excluded.

Surgical procedures

All surgeries were performed by the same experienced shoulder surgeon (Y.K). Patients were instructed to avoid shaving the shoulder area before surgery. All surgical procedures were performed under general anesthesia with addition of an interscalene nerve block and the patient in the beach chair position. Routine antibiotic prophylaxis (cefazolin 1 g) was administered within 30 minutes of starting the procedure with subsequent application of 70% isopropyl alcohol to the skin of the affected shoulder for antisepsis. Transparent adhesive polyurethane film was not applied at the surgical site, and the scalpels used for the skin incisions were discarded after use.

In group F, interior and posterior glenohumeral arthroscopy portals were created, and a 3-mm 30° arthroscope was passed through a cannula for visualization. An arthroscopic shaver (4.5-mm Dyonics Incisor™ Plus Platinum Blade, Smith & Nephew, London, UK) and radiofrequency ablation device (Super Turbovac™ 90, Smith & Nephew) were used for anterior release of the rotator interval. The superior, anterior, and inferior joint capsules were released via the anterior portal at the outer edge of the labrum, and the posterior capsule was released via the posterior portal.

In group B, anterior, anterosuperior, and posterior arthroscopic portals were created, and a 3-mm 30° arthroscope was passed through a cannula for visualization. A rasp was used to debride Bankart lesions with glenoid involvement. Next, a Bankart repair was performed using suture anchors (1.4-mm JuggerKnot®, Biomet, Warsaw, IN). Between 4 and 6 suture anchors were used depending on the size of the lesion and the extent of damage. A suture passer (QuickPass SutureLasso™, Arthrex, Naples, FL) was used as a suture relay for the anterior capsule and anteroinferior glenohumeral ligament. Finally, a sliding knot technique was performed wherein each suture was passed through the anterior capsule and anteroinferior glenohumeral ligament and tied together.

Collection of samples

Samples were collected using intraarticular synovial swabs immediately after the surgical incision at the glenohumeral joint (Fig). The minimum incubation period was 3 weeks for all cultures.

Fig. Sample collection sites. the glenohumeral joint immediately after the surgical incision.

Study variables

Diabetes mellitus, and *C. acnes* detection rates in cultures from intra-articular synovial swabs were compared between the groups. Deep-seated infection was ruled out if no clear signs of infection, such as joint swelling, localized sensation of heat, and redness, were observed after surgery.

Statistical analysis

Statistical analysis was performed using the *t*-test and Fisher's exact test for comparisons between the groups. All statistical analyses were performed using SPSS statistical software (version 18.0, IBM Corp., Armonk, NY). A *P*-value of <0.05 was considered statistically significant.

RESULTS

Group F comprised 39 patients (24 male, 15 female) with a mean age of 57.3±8.9 years and group B comprised 36 patients (26 male, 10 female) with a mean age of 29.5±13.2 years. Diabetes was significantly more common in group F than in group B (17.9% [n=7] vs 2.7% [n=1]; $P=0.03$). The mean operation time was significantly longer in group B than in group F (103.8±26.6 min vs 52.9±17.6 min; $P<0.01$). (Table).

Table. Comparison of patients background between Group F and Group B

	Group F	Group B	*P*-value
Number of patients	39	36	
Age (years)	57.3±8.9	29.5±13.2	<0.01
Sex (male/female)	24/15	26/10	0.46
Diabetes (%)	7 (17.9%)	1 (2.7%)	0.03
Forward elevation (degree)	97.9±18.2	166.2±7.2	<0.01
External rotation (degree)	21.1±12.0	57.7±6.1	<0.01

A *P*-value of <0.05 was considered statistically significant. Group B, arthroscopic Bankart repair for traumatic anterior shoulder instability; Group F, arthroscopic capsular release for frozen shoulder.

In Group F, *C. acnes* was detected in 4 of 39 synovial swab specimens (detection rate, 11.3%). In group B, *C. acnes* was detected in 2 of 36 specimens (detection rate, 5.6%) The difference in detection rate between the two groups was not statistically significant (P= 0.68).

DISCUSSION

C. acnes is considered to be part of the normal skin flora. The bacterium breaks down neutral fats in the sebaceous gland and creates fatty acids that acidify the skin, thereby inhibiting neutrophilic bacterial pathogens such as *S. aureus* and *S. pyogenes*. The acidity facilitated by *C. acnes* counteracts the pH-neutral environment to maintain healthy skin. Previous studies have described *C. acnes* as a bacterium that resides in areas containing a high number of sebaceous glands and therefore colonizes the skin around the shoulder more readily than areas such as the hip and knee[8)13)16)]. *C. acnes* is also known to be more abundant on skin in males. Chuang et al. cultured skin swabs from the shoulder joint and found detection rates of 81.6% in men and 46.1% in women[1)]. A similar study by Patel et al. mentioned a significantly higher *C. acnes* detection rate in men than in women (80% vs 30%)[16)]. The sex-related difference in *C. acnes* detection rates may be due to involvement of testosterone in colonization of this bacterium[4)]. The significantly higher number of men in the present study may explain why nearly half of our skin swabs were *C. acnes*-positive in both groups.

There are reports suggesting that *C. acnes* may be a cause of frozen shoulder and osteoarthritis and that this organism could be associated with restricted range of motion and arthritis of the shoulder joint. Bunker et al. reported that 8 of 10 patients who underwent arthroscopic capsular release for frozen shoulder had *C. acnes*-positive cultures and identified this bacterium as a possible cause of the condition[3)]. Furthermore, Levy et al. reported a detection rate of 41.8% in samples collected from intraoperative joint fluid and tissue specimens in patients undergoing shoulder replacement surgery for osteoarthritis and suggested *C. acnes* as a potential risk factor for osteoarthritis involving the shoulder[12)]. Both of these reports indicate a possible relationship between *C. acnes* and painful and degenerative diseases of the shoulder joint. However, there is limited information in the literature on the association between *C. acnes* and shoulder instability, such as recurrent shoulder dislocation. In this study, no significant difference was observed in the *C. acnes* detection rate between the two groups for either skin or synovial swab cultures, indicating that *C. acnes* was not associated with restricted range of motion or arthritis of the shoulder joint. Furthermore, *C. acnes* was detected in synovial swab cultures immediately after incision in both groups. However, in group F, there was an increase in the *C. acnes* detection rate in synovial swab cultures obtained before wound closure, which suggests that *C. acnes* was present in the synovium preoperatively and that contamination occurred during surgery.

The possibility of *C. acnes* being present preoperatively was raised by Levy et al.[12)], who detected *C. acnes* in joint fluid and synovial tissue specimens obtained before implantation in patients undergoing shoulder arthroplasty. Mook et al.[20)] investigated the *C. acnes* detection rate by collecting specimens from an area of the articular capsule during open shoulder surgery performed for cuff repair, joint arthroplasty, or trauma. They found that the preoperative detection rate within the joint was significantly

higher for patients who had received more than two steroid injections. We also reported that *C. acnes* was detected more frequently in synovial swabs obtained intraoperatively from patients who had received a large number of steroid injections before shoulder arthroscopic surgery[9], which suggested the possibility of contamination from preoperative injections into the shoulder joint. Furthermore, Sethi et al. detected *C. acnes* in 15.8% of skin swab cultures following skin antisepsis, noting that removal of the bacterium was challenging because of its predilection for the subcutaneous sebaceous glands rather than the surface of the skin[22]. In the present study, patients in group F had received several intra-articular injections as conservative treatment while those in group B had received intra-articular injections during reduction of dislocation or saline injections into the glenohumeral joint for preoperative angiography. These injections may increase the risk of *C. acnes* contamination in the shoulder joint. The number of injections in group F were unclear due to all of patients who were required surgery for frozen shoulder introduced after conservative treatment in other hospital. However, a study by Falconer et al. that investigated the *C. acnes* detection rate in swab cultures from gloves and implants used during surgery[2] and another by Yamakado[17] that described detection of the bacterium on sutures used in suture anchors during arthroscopic cuff repair suggested the possibility of intraoperative contamination. Contamination during surgery cannot be ruled out in the present study; therefore, further studies are needed to confirm our findings.

There were no deep-seated infections in this study, even in the *C. acnes*-positive patients. Although there are several subtypes of *C. acnes*, only a few are known to be virulent and to cause deep-seated infection[8]. Considering the diversity of the bacterium, the type of *C. acnes* detected in our cases may have been a subtype with low virulence. Moreover, deep-seated infections caused by *C. acnes* are regarded as stealth infections, which are rarely associated with clinical findings, such as swelling, sensation of heat, and pain[8]. However, there is some evidence to suggest an association of *C. acnes* with clinical findings such as prolonged pain, shoulder joint contracture, and implant loosening following shoulder arthroplasty[1)4)7)19)20)]. This study included a relatively short-term postoperative observation period, and longer follow-up may be warranted in future research on deep-seated infections. If *C. acnes* is present, effective antibiotics with known susceptibility should be administered; these include penicillin, a cephalosporin, and clindamycin, as described in a study by Crane et al. that showed the antimicrobial susceptibility of *C. acnes* isolates from patients undergoing shoulder surgery[19].

This study has several limitations. First, the sample size was small, which may have affected the reliability of our findings. The detection rate of *C. acnes* might have differed according to diabetes status, age, and operation time. However, we found no association between these three variables and the *C. acnes* detection rate in the synovium during shoulder arthroscopic surgery[11]. Therefore, it is unlikely that the *C. acnes* detection rate in the present study was affected by between-group differences in any of these variables. Third, the observation period was short. Long-term follow-up is required because of the possibility of late-onset infection of *C. acnes*. Fourth, *C. acnes* may have been washed out by the irrigation fluid, which would affect the detection of *C. acnes* in synovial swabs. Fifth, the bacterial

diversity of *C. acnes* and its clinical manifestations were not considered in this study.

CONCLUSIONS

We examined the *C. acnes* detection rate in patients with frozen shoulder or recurrent shoulder dislocation treated by arthroscopic surgery. There was no significant difference in the *C. acnes* detection rate in synovial swabs according to type of procedure performed. Therefore, an association between *C. acnes* and the pathology of frozen shoulder is unlikely.

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Conflicts of interest

None.

Ethical approval

This study was approved by Aichi Medical University Hospital (approval number 2016-H201).

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