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Original Article

Unveiling the Potential of Drain Tip Cultures: Impact on Surgical Site Infections in Implant-Based Breast Reconstruction

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ABSTRACT

Purpose: Surgical site infections (SSIs) remain a concern after implant-based breast reconstruction, despite preventive measures. These infections can have serious consequences. This study evaluated the correlation between drain tip culture results and SSIs in this patient population.
Methods: We analyzed data from patients who underwent implant-based breast reconstruction between July 2021 and May 2023. Drain tip cultures were collected, and any SSIs occurring within one month of surgery were documented. We then compared clinical data with the culture results.
Results: A total of 263 drain tip cultures were included. Notably, none of the 61 patients who underwent tissue expander removal and implant insertion had positive cultures. However, among the 202 patients who received tissue expanders or direct-to-implant procedures, 11 (5.45%) had positive cultures, with a total of 12 SSIs identified. Importantly, five of the 11 culture-positive wounds developed SSIs. Multivariate analysis revealed a significant two-way association between infection and positive drain tip cultures. For *Staphylococcus aureus* specifically, drain tip cultures showed excellent predictive value: sensitivity (33.33%), specificity (100%), positive predictive value (100%), and negative predictive value (95.96%).
Conclusion: Drain tip cultures from immediate implant-based breast reconstructions significantly correlated with SSIs. Close monitoring is crucial, especially when *S. aureus* is identified in the culture.

Keywords: Bacteria; Breast Implants; Infections; Suction; Tissue Expansion Devices

INTRODUCTION

Implant-based breast reconstruction, a popular choice for breast cancer patients who have undergone mastectomy [1], is not without its drawbacks. While the number of procedures is increasing, complications like capsular contracture, implant malposition, and infection can occur. Infection is particularly concerning because it can lead to implant loss, additional surgeries, and disruptions in a patient's treatment plan. Various studies have explored

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of micronized human acellular dermal matrix preserving collagen and growth factor for soft tissue filling) funded by the Ministry of Trade, Industry & Energy (MOTIE, Korea).

Conflict of Interest
The authors declare that they have no competing interests.

Data Availability
In accordance with the ICMJE data sharing policy, the authors have agreed to make the data available upon request.

Author Contributions
Conceptualization: Hong KY; Supervision: Hong KY; Writing - original draft: Kim JY; Writing - review & editing: Kim JY, Ma IZ.

preventive measures like skin decolonization, prophylactic antibiotics, and sterile techniques [2,3]. However, despite these efforts, the reported incidence of infection in implant-based reconstruction varies widely, ranging from 1% to 30% [2,4-8].

Closed-suction drainage plays a vital role in various surgeries by effectively reducing dead space and preventing postoperative seroma formation. However, this benefit comes with a potential downside: the drain may create a pathway for bacteria to travel from the external environment to the sterile implant pocket, leading to infection [9-11]. The debate regarding drain management continues. Some advocate for early drain removal to minimize the risk of infection, while others believe closed-suction drains are crucial for preventing seroma and hematoma formation and promoting wound healing [12]. Additionally, studies have shown limited effectiveness of prolonged antibiotic use until drain removal [13,14]. Therefore, establishing a standardized protocol for drain management is essential.

Several studies in other surgical fields suggest drain tip cultures might be useful for early detection of surgical site infections (SSIs), particularly those caused by methicillin-resistant bacteria in spinal surgery [15]. However, their routine use is not universally recommended, as seen in total hip arthroplasty [16]. In implant-based breast reconstruction, leaving the drain in for a longer period has been linked to a higher infection risk [12]. Analysis of bacterial profiles in suction drain fluid showed a 26% positive culture rate, with coagulase-negative *Staphylococci* being the most common bacteria, followed by *Staphylococcus aureus*. The study reported promising clinical value with sensitivity (85.71%), specificity (81.48%), positive predictive value (PPV) of 37.50%, and negative predictive value (NPV) of 97.79% [17]. However, the drainage fluid might not accurately reflect the bacteria within the implant cavity due to the potential contamination of the suction drain bottles. Therefore, no prior studies have explored the usefulness of drain tip cultures for early SSI detection in implant-based breast reconstruction. This study aims to address this gap by investigating whether a positive drain tip culture predicts SSIs in patients who underwent implant-based breast reconstruction. The secondary aim is to gain a deeper understanding of the bacterial profile to provide clinical guidance for interpreting drain tip culture results in this context.

METHODS

We conducted a retrospective chart review of patients who underwent implant-based breast reconstruction at Seoul National University Hospital between July 2021 and May 2023. Patients were divided into two cohorts. The first cohort included patients who underwent breast reconstruction with tissue expander insertion (TEI) or direct-to-implant (DTI) after mastectomy. The second cohort included patients whose previously inserted tissue expanders were removed and replaced with implants. Patients who underwent reconstruction using both implants and autologous tissue, such as a latissimus dorsi flap or fat graft, were excluded.

Perioperative management

All patients received prophylactic antibiotics to prevent infection. They received their first intravenous dose of cefazolin (1 g) at least 30 minutes before surgery. Subsequent doses were administered every eight hours for a total of 24 hours after surgery. Patients whose antimicrobial susceptibility testing showed resistance to cefazolin were switched to moxifloxacin (400 mg/day). The drain insertion site was disinfected with povidone-iodine every other day and dressed with a polyurethane foam (BETAfoam T®; Genewel, Seongnam, Korea) containing 3% povidone-iodine and covered with a transparent film. This dressing remained in place until the drain was removed.

During outpatient follow-up, additional oral antibiotics (cefixime 100 mg twice daily) were prescribed for patients experiencing mastectomy skin flap congestion or necrosis, or if drainage persisted beyond one week. For patients with positive drain tip cultures, the decision to prescribe oral antibiotics or conduct a short-term follow-up was based on the results of the antibiotic resistance test, regardless of whether the patient met the criteria for an SSI. Patients scheduled for adjuvant chemotherapy or radiotherapy had to wait at least one month after surgery to ensure complete healing of the surgical site.

Surgical procedures

TEI or DTI procedures

An acellular dermal matrix (ADM) was used above the pectoralis major muscle to create a pocket for the implant, leaving an opening for implant insertion. For subpectoral reconstruction, a pocket was created for the expander/implant along with the ADM after elevation of the pectoralis major muscle flap. Before inserting the expander/implant, the surgical field was irrigated with a povidone-iodine solution followed by a mixture of cefazolin (2 g) and gentamicin (160 mg) in 1 L of normal saline. Following irrigation, the skin was disinfected again with povidone-iodine, and gloves were changed.

The expander/implant was placed directly into the implant pocket, and the window was closed. An ADM was used in all cases. Two closed-suction drains were placed: one in the subcutaneous (outer pocket) plane and another in the periprosthetic plane (subADM or submuscular). Once the drain output decreased to less than 30 mL over a 24-hour period, the drain was removed. Upon removal, approximately 2 cm from the innermost end of the drain was aseptically cut, placed in a sterile tube, and sent for culture testing.

Tissue expander removal and implant insertion

The skin incision followed the existing scar from the previous TEI procedure. The tissue expander was carefully exposed and removed. A single closed-suction drain was placed in the periprosthetic plane. An implant of the appropriate size was then inserted into the pocket. It is important to note that other sterile techniques employed during this surgery mirrored those used in TEI or DTI reconstruction.

SSIs

SSIs were defined according to criteria established by the Centers for Disease Control and Prevention. These criteria require at least one of the following signs or symptoms to be present within one month of surgery: purulent drainage from the wound, positive culture results from a sterile sample of fluid or tissue collected from the wound, fever greater than 38°C (100.4°F), or localized pain or tenderness in the wound area. Any SSIs that developed post-operatively were identified through clinical examinations and medical record reviews.

For patients diagnosed with an SSI, treatment involves incision and drainage of the wound. The collected material was then sent for culture testing. This procedure was performed when an open wound with purulent drainage was present, or when significant fluid collection occurred within the implant pocket without an open wound. It is important to note that incision and drainage are also indicated for specific types of seromas that develop after surgery, including large seromas, those resistant to repeated aspiration, and those complicated by infection

[18]. For patients with an expander and fluid collection but no open wound, aspiration of the fluid could be performed using a port on the expander. The expander/implant should then be removed from the pocket and subsequently washed repeatedly with a povidone-iodine solution.

Statistical analysis

Continuous variables are presented as means with standard deviations. Categorical variables are presented as counts and percentages. Based on the type and distribution of the variables, statistical analyses were conducted using an independent sample *t*-test for continuous variables and Fisher's exact test for categorical variables. To account for multiple tip culture results per patient and their association with SSIs, generalized estimating equation models were employed. These models helped identify statistically significant variables associated with both tip culture results and SSIs. Further analysis was then performed for clinical factors with a *p*-value of ≤ 0.1. For all statistical tests, a *p*-value < 0.05 was considered statistically significant. All analyses were performed using the SPSS version 26.0 (IBM Corp., Armonk, USA).

Ethical standards

All procedures involving human participants performed in this study were in accordance with the ethical standards of the Institutional Review Board (IRB) of Seoul National University Hospital, which approved the study (IRB No. H-2302-079-1404) and the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Due to the retrospective nature of the study, the requirement for informed consent was waived.

RESULTS

Patient characteristics

A total of 263 drain-tip cultures were collected during the study period. In the first cohort, involving 119 patients who underwent TEI or DTI reconstruction, 202 drain tip cultures were performed. Out of these, 11 (5.45%) yielded positive results (**Figure 1**). Patient demographics and characteristics are presented in **Table 1**.

The average age in the first cohort was 48.19 ± 8.10 years at surgery ($p = 0.590$), and the average body mass index (BMI) was 23.32 ± 4.18 kg/m^2 ($p = 0.832$). There were no significant differences between the culture-positive and culture-negative groups in terms of hypertension ($p = 0.528$) or smoking history ($p = 0.288$). Importantly, the proportion of patients with positive cultures was significantly higher in the culture-positive group compared to the culture-negative group ($p = 0.049$).

Table 1. Patient characteristics in the first cohort

Variables	Negative culture	Positive culture	*p*-value
No. of drain	191 (94.6)	11 (5.4)	
Side			0.536
Right	110 (57.6)	5 (45.5)	
Left	81 (42.4)	6 (54.5)	
Age (yr)	48.27 ± 8.15	46.91 ± 7.41	0.590
BMI (kg/m^2)	23.33 ± 4.08	23.06 ± 5.89	0.832
Comorbidity			
Hypertension	12 (6.3)	1 (9.1)	0.528
Smoking	5 (2.6)	1 (9.1)	0.288
Diabetes	5 (2.6)	2 (18.2)	0.049

Values are presented as number (%) or mean ± standard deviation.
BMI = body mass index.

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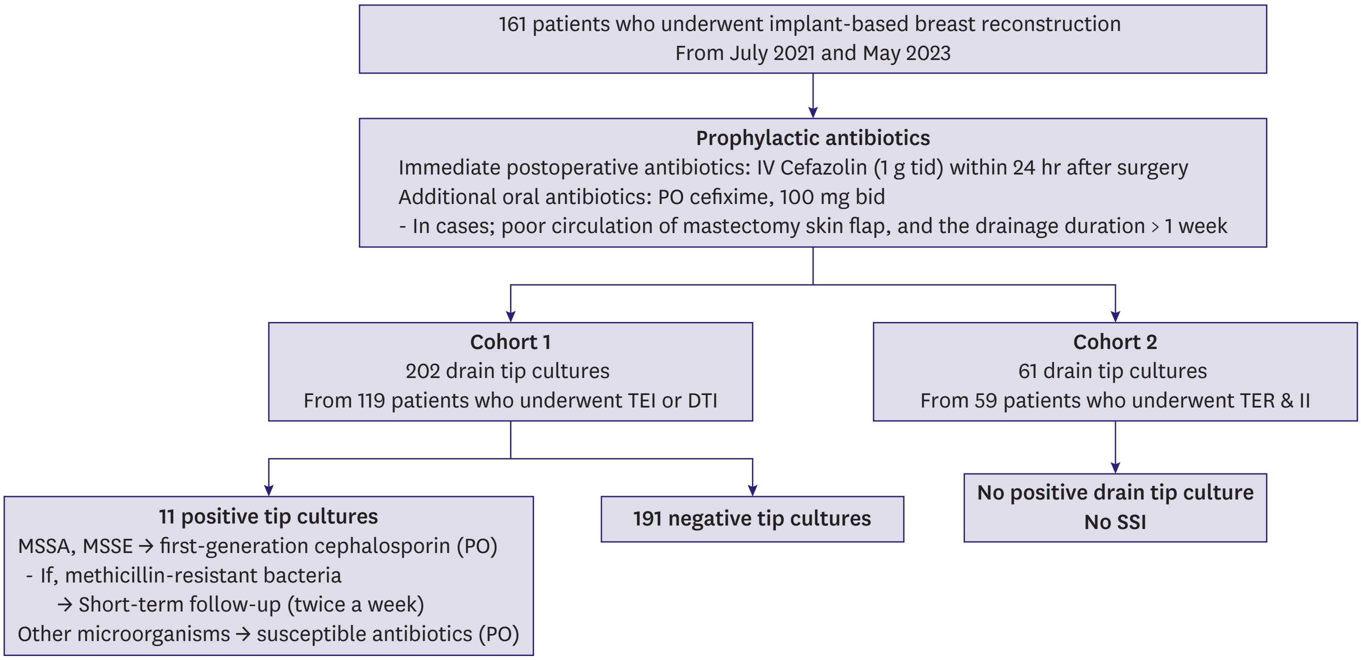

Figure 1. The flow of patients included in the study and tip culture results compared with clinical outcomes in the two cohorts.
IV = intravenous; tid = three times a day; PO = per os; bid = twice a day; TEI = tissue expander insertion; DTI = direct-to-implant; TER & II = tissue expander removal and implant insertion; MSSA = methicillin-sensitive *Staphylococcus aureus*; MSSE = methicillin-sensitive *Staphylococcus epidermidis*; SSI = surgical site infection.

Interestingly, none of the 61 drain tip cultures obtained from the second cohort of patients who underwent expander removal and implant insertion showed positive results (**Supplementary Table 1**).

Operation-related characteristics

There were no significant differences between the culture-negative and culture-positive groups regarding the type of mastectomy performed (**Table 2**). Most patients underwent

Table 2. Operation-related characteristics in the first cohort

Variables	Negative culture	Positive culture	*p*-value
No. of drains	191 (94.6)	11 (5.4)	
Type of mastectomy			0.737
NSM	57 (29.8)	4 (36.4)	
SSM	134 (70.2)	7 (63.6)	
Timing of reconstruction			> 0.999
Immediate	185 (96.9)	11 (100)	
Delayed	6 (3.1)	0 (0)	
Type of reconstruction			0.214
Tissue expander	97 (50.8)	3 (27.3)	
Direct-to-implant	94 (49.2)	8 (72.7)	
Implant insertion plane			0.141
Prepectoral	169 (88.5)	8 (72.7)	
Subpectoral	22 (11.5)	3 (27.3)	
Axillary lymph node dissection	29 (15.2)	3 (27.3)	0.386
Mastectomy flap necrosis	16 (8.4)	2 (18.2)	0.255
Neoadjuvant therapy			
Radiotherapy	12 (6.3)	0 (0)	> 0.999
Chemotherapy	59 (30.9)	5 (45.5)	0.330

Values are presented as number (%).
NSM = nipple-sparing mastectomies; SSM = skin-sparing mastectomies.

skin-sparing mastectomies (69.8%, n = 141), while nipple-sparing mastectomies accounted for 30.2% (n = 61). Nearly all patients (96.9%, n = 196) underwent immediate breast reconstruction, with only a small portion (3.1%, n = 6) undergoing delayed reconstruction. Interestingly, no positive cultures were observed in the delayed-reconstruction group. The distribution of reconstruction methods was similar across both groups, with TEI being used in almost half of the cases (49.5%, n = 100) and the other half (50.5%, n = 102) utilizing DTI. The prepectoral plane was the preferred choice for implant placement in the vast majority of cases (87.6%, n = 177), with only 12.4% (n = 25) utilizing the subpectoral plane. Preoperative radiotherapy was uncommon (5.9%, $p > 0.999$), while neoadjuvant chemotherapy was administered to 31.7% of patients ($p = 0.330$). No statistically significant differences were observed between the groups in terms of these preoperative treatments. While no significant differences were found concerning surgical characteristics, the rate of postoperative infections differed significantly between the groups ($p < 0.001$). Overall, 12 (5.9%) patients experienced infections. However, in the culture-positive group, the infection rate was significantly higher (45.5%, n = 5) compared to the culture-negative group (3.7%, n = 7).

Prognosis of SSIs

All patients received antibiotic treatment. The outcomes included implant removal in four cases, implant change in three cases, and improvement after incision and drainage, or aspiration in three cases (**Table 3**). Among the patients who developed SSIs, four required implant removal. Tissue cultures confirmed *S. aureus* infection in three of these cases. In the remaining case, although final tissue culture results were unavailable, the tip culture revealed *S. aureus*. This finding suggests a poorer prognosis when *S. aureus* is associated with SSIs.

Among the five patients with positive tip cultures, four showed *S. aureus* infection. Interestingly, salvage surgery was successful in 50% of these cases. In contrast, among the five cases with negative tip culture results, three patients eventually had *S. aureus* cultured from tissue or aspiration samples, and salvage surgery was successful in only one case (33%).

Table 3. Epidemiological and microbiological characteristics of surgical site infections

Patient	Age (yr)	Subcutaneous drain		Peri-prosthetic drain		Tissue Cx (within postop 3 mo)	Treatment
		Removal POD	Cx result	Removal POD	Cx result		
1	51	26	MSSA	13	NG	MSSA	Abx Implant removal
2	36	NA		14	MSSA	NA	Abx Expander removal
3	59	NA		17	NG	*Staphylococcus lugdunensis*	Abx I & D
4	59	NA		8	NG	MRSA[A], NG[T]	Abx Expander removal
5	41	NA		12	*Corynebacterium*	NG[A]	Abx Aspiration
6	51	NA		15	NG	MSSA	Abx I & D
7	39	NA		10	NG	*Pseudomonas aeruginosa*	Abx Implant change
8	52	5	NG	14	MSSA	MSSA	Abx Expander change
9	45	NA		8	MRSA	MRSA	Abx Implant change
10	52	NA		13	NG	MSSA	Abx Expander removal

POD = postoperative day; Cx = culture; MSSA = methicillin-sensitive *Staphylococcus aureus*; NG = no growth; Abx = antibiotics; NA = not available; I & D = incision and drainage; MRSA = methicillin-resistant *Staphylococcus aureus*; [A] = aspiration specimen; [T] = tissue specimen.

It is important to note that no SSIs were associated with positive tip cultures from drains removed within the first week of surgery. Additionally, the average time to drain removal differed between culture-positive and culture-negative SSI patients. Patients with positive cultures had drains removed slightly earlier (14.8 ± 6.72 days) compared to those with negative cultures (11.57 ± 4.16 days). Furthermore, the average time to symptom onset differed between these groups. Culture-positive patients showed symptoms earlier (14.6 ± 8.17 days) compared to culture-negative patients (22 ± 7.78 days). This finding, along with drain removal timing, suggests that tip cultures might be more informative for SSI detection when the drain is removed closer to the typical timeframe for symptom onset.

Some patients with negative results from the first drain culture eventually showed bacterial growth in subsequent cultures. This highlights that early tip cultures, particularly those obtained shortly after surgery, are not reliable indicators for completely ruling out infection.

Drain information

Of all drains, 68 (33.7%) were in the subcutaneous plane and 134 (66.3%) were in the periprosthetic plane, with no significant difference between the two groups ($p = 0.513$) (**Table 4**). The average duration of all drains was 10.22 ± 4.23 days, and the duration was significantly longer in the culture-positive group, lasting 12.82 ± 6.06 days, compared to 10.07 ± 4.07 days in the culture-negative group ($p = 0.036$).

Factors influencing infection and positive tip culture

Univariate analysis was conducted to identify factors influencing infection and positive tip culture results. Skin necrosis ($p = 0.020$), drain duration ($p = 0.021$), smoking history ($p = 0.003$), and positive tip culture results ($p < 0.001$) were all found to be significant factors influencing the development of infection. Similarly, diabetes ($p = 0.001$) and the presence of infection itself ($p < 0.001$) significantly influenced positive tip culture results.

Multivariate analysis, focusing on clinical factors with a p-value ≤ 0.1 in the univariate analysis (**Table 5**), revealed that smoking ($p = 0.021$) and positive tip culture results ($p < 0.001$)

Table 4. Drain information in the first cohort

Variables	Negative culture	Positive culture	*p*-value
No. of drains	191 (94.6)	11 (5.4)	
Plane of drains			0.513
Subcutaneous	63 (33.0)	5 (45.5)	
Peri-prosthetic	128 (67.0)	6 (54.5)	
Average drain duration (days)	10.07 ± 4.07	12.82 ± 6.06	0.036

Values are presented as number (%) or mean ± standard deviation.

Table 5. Generalized estimating equations to analyze factors influencing infection

Variables	Regression coefficient B	Standard error	*p*-value
BMI	0.122	0.0741	0.101
Comorbidity			
Diabetes	1.160	2.5000	0.643
Smoking	2.749	1.1850	0.020
Culture result	3.072	0.9448	0.001
Average drain duration (days)	−0.016	0.0724	0.827
Mastectomy flap necrosis	1.070	1.4090	0.448

BMI = body mass index.

Table 6. Generalized estimating equations to analyze factors influencing positive culture result

Variables	Regression coefficient B	Standard error	*p*-value
Comorbidity			
Diabetes	1.627	1.035	0.116
Infection	2.184	0.701	0.002
Implant insertion plane	0.700	0.807	0.385
Average drain duration (days)	−0.139	0.093	0.137

remained independent predictors of infection. Likewise, infection ($p = 0.002$) remained a significant factor influencing positive tip culture results (**Table 6**).

These findings highlight a strong correlation between infection and positive tip culture results. This suggests that tip cultures have the potential to serve as an early diagnostic tool for predicting SSIs in implant-based breast reconstruction.

Microbiological profile of positive tip culture samples

Drain tip cultures were positive for bacteria in 11 patients (5.78%). The most common bacteria identified were *S. aureus* and *Staphylococcus epidermidis*, with four cases each (**Table 7**). Additionally, two *Corynebacterium* spp. and one *Bacillus* spp. were detected. Of the 11 patients with positive cultures, only five developed SSIs.

Analyzing the first cohort's data for all bacterial strains, drain tip cultures demonstrated a sensitivity of 41.67%, specificity of 96.84%, NPV of 96.34%, and PPV of 45.45%.

Notably, all four cases (100.0%) where *S. aureus* was detected in the tip culture resulted in SSIs. Excluding one case without final tissue culture results, all *S. aureus* cases showed consistent findings between the final tissue and tip culture results. For *S. aureus*, drain tip cultures demonstrated a sensitivity of 33.33%, specificity of 100.0%, PPV of 100.0%, and NPV of 95.96%. In contrast, among the seven cases where bacteria other than *S. aureus* were detected, only one patient developed an SSI. This translates to a low PPV (14.29%) for predicting SSIs with these bacteria.

One patient with a *Corynebacterium* spp. SSI presented with fever, erythema, and swelling. However, the infection resolved with antibiotics, and no bacteria were found in the aspirated sample. No SSIs occurred in patients where *S. epidermidis* or *Bacillus* spp. were detected in the tip cultures. These findings highlight the importance of considering the specific bacteria identified in tip cultures when interpreting results. The presence of *S. aureus* showed a significantly higher accuracy in predicting SSIs compared to other bacteria.

Table 7. Microbiological profiles of positive drain tip cultures and postoperative surgical site infection

Gram-positive bacteria	No.	SSI			
		Concordant	Discordant	NA	Total
Staphylococcus aureus	3 (MSSA)	2	0	1	3
	1 (MRSA)	1	0	0	1
Staphylococcus epidermidis	1 (MSSE)	0	0	0	0
	3 (MRSE)	0	0	0	0
Bacillus spp.	1	0	0	0	0
Corynebacterium spp.	2	0	1(A)	0	1
Total	11	3	1	1	5

SSI = surgical-site infection; NA = not available; MSSA = methicillin-sensitive *Staphylococcus aureus*; MRSA = methicillin-resistant *Staphylococcus aureus*; MSSE = methicillin-sensitive *Staphylococcus epidermidis*; MRSE = methicillin-resistant *Staphylococcus epidermidis*; A = aspiration specimen.

DISCUSSION

The drain tip serves as a direct connection between the internal body and the external environment, prompting research into its potential for detecting early signs of infection [15,16]. However, previous studies on implant-based breast reconstruction have not fully explored the usefulness of tip cultures, and lack sufficient statistical data for interpreting results. This study collected drainage tips directly from the implant pocket for bacterial culture analysis. This is a more targeted approach compared to previous research that analyzed drainage fluid from suction drain bottles [17]. This method is expected to provide new insights and improve our understanding of tip culture results in breast implant surgery.

Direct examination of the drain tip yielded a lower culture-positivity rate (5.4%) compared to the 26% reported in a previous study using drainage fluid from the drain bottle [17]. This decrease is likely due to reduced contamination during the culture process, leading to a higher predictive value for specific bacterial species. Notably, *S. aureus* demonstrated a strong correlation with SSIs, with a sensitivity of 33.33%, specificity of 100.0%, PPV of 100.0%, and NPV of 95.96%. This emphasizes the importance of considering bacterial species when interpreting culture results. Studies have shown that individuals colonized with *S. aureus* on their skin have a 7.1-fold increased risk of SSIs regardless of surgery type [19]. In this study, *S. aureus* accounted for 60.0% of the bacteria identified in SSIs. Although *S. epidermidis* was identified in tip cultures as frequently as *S. aureus*, none of these cases developed SSIs. This suggests that *S. epidermidis* is less harmful than *S. aureus*. Unlike *S. aureus*, which produces toxins that facilitate infections, *S. epidermidis* has fewer virulence factors and typically does not cause invasive infections in healthy individuals [20].

When interpreting culture results, it is crucial to consider the surgical approach (performed independently by plastic surgery or in collaboration with another department) and the timing of reconstruction (immediate vs. delayed or secondary). Studies have shown a slightly higher incidence of SSIs and non-infectious wound complications in immediate implant-based reconstruction compared to delayed or secondary procedures [21]. This increased risk might be due to the longer surgery duration in immediate reconstruction, which often involves consecutive mastectomies and reconstructions. Additionally, the placement of the implant in an area with significant dead space and reduced vascularization during immediate reconstruction can contribute to complications like infection, hematoma, or seroma [22]. Culture positivity also reflects these findings. In our study of patients undergoing second-stage surgery (tissue expander removal and implant insertion), all 61 tip cultures were negative. Conversely, all culture-positive drains were observed in patients who underwent immediate reconstruction. These results suggest that drain tip cultures might be more informative for predicting SSIs in immediate reconstruction compared to delayed procedures.

Several factors are known to be associated with SSIs in implant-based breast reconstruction, including BMI, smoking, diabetes, radiation therapy, mastectomy technique, skin flap necrosis, seroma, and hematoma [8,23]. In our study, smoking and positive culture results were identified as the only factors influencing infection development. Concerning the culture results, no other factors affected the outcomes beyond the occurrence of SSI. The risk of infection can vary depending on a center's protocols for preoperative and postoperative antibiotics, as well as patient management practices. In our study, even patients not meeting the standard criteria for SSIs received oral antibiotics on an outpatient basis if deemed at risk based on clinical experience. While antibiotic use after implant-based breast reconstruction has been shown to reduce infection rates [8], recent studies suggest that prolonged use does not significantly decrease SSIs or implant loss [24]. Similarly, oral antibiotics are not effective in preventing infection or implant loss after immediate prosthetic reconstruction [25]. Interestingly, in our study, all patients with SSIs received oral antibiotics regardless of negative culture results, and these antibiotics did not prevent the infections. This aligns with recent findings and highlights the need for further investigation into alternative interventions, potentially including intravenous antibiotics.

This study has some limitations. First, the relatively small number of culture-positive cases and SSIs limited our ability to comprehensively analyze the influence of clinical factors and specific bacterial species. Second, although our center identified *S. aureus* as the primary causative agent in implant-related infections, the varying distribution of bacterial species in SSIs across different institutions could affect how drain tip culture results are interpreted [26-29]. Finally, the study had limitations in proposing a strategy to prevent SSIs when *S. aureus* is detected in tip cultures. Some patients developed SSIs despite receiving antibiotics based on positive cultures. This suggests that multiple factors may contribute to SSIs, and antibiotic resistance is a crucial clinical consideration. Additionally, since tip cultures and subsequent treatment often occur on an outpatient basis, interventions beyond oral antibiotics may be necessary. This aligns with previous research [24]. Large-scale studies are warranted to investigate these factors and potential antibiotic resistance. Despite these limitations, the study has several strengths. To our knowledge, it is the first to explore the importance of drain tip cultures after breast reconstruction surgery. Previously, no research existed on tip cultures in this context. Providing information on tip culture results can be valuable for guiding future research. Furthermore, the 0.0% positivity rate in delayed reconstructions or procedures performed solely by plastic surgeons suggests such surgeries with low positivity rates may not need further investigation.

This study explored the effectiveness of drain tip cultures in implant-based breast reconstruction and provided new insights into culture outcomes. Tip culture results in patients undergoing TEI or DTI procedures showed a significant correlation with SSIs. Among infectious species, *S. aureus* emerged as a major contributor to SSIs, highlighting the importance of considering this bacterium when interpreting culture results. This is especially true when *S. aureus* is cultured, as it warrants close monitoring.

SUPPLEMENTARY MATERIAL

Supplementary Table 1

Patient and operation-related characteristics in the second cohort

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