# Breast Reconstruction Outcome

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# CHAPTER

# VII

# The Effect of Extra Safety Measures on Incidence of Surgical Site Infection After Alloplastic Breast Reconstruction

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## ABSTRACT

**Background:** This study aimed to evaluate whether the implementation of extra perioperative safety measures and precautions through adopted standard operating procedures (SOPs) to ensure optimal anti-microbial conditions has led to less Surgical Site Infections (SSI) after alloplastic breast reconstruction.

**Methods***:* This retrospective study compared two Cohorts of patients treated before and after the implementation of new SOPs (2009 – 2014: Cohort 1 versus 2014 – 2019: Cohort 2). Multivariate logistic regression analyses, adjusting for patient confounders, was implemented to compare SSI incidence between both Cohorts.

**Results:** Overall SSI incidence was equal in both groups (10%, p=0.545). Incidence of deep SSI was 9% for Cohort 1 and 5% for Cohort 2 (p=0.074). Incidence of SSI related explantation was 8% and 5% respectively (p=0.136). After adjusting for patient confounders, no statistically significant difference was seen between both Cohorts in overall SSI , deep SSI incidence and explantation due to SSI ($OR_{adjusted}$: -0.31, p=0.452, $OR_{adjusted:}$ 0.16, p=0.747 and $OR_{adjusted:}$ 0.18, p=0.712). Higher BMI, smoking, one-stage BR and immediate BR were associated with the risk for SSI (p<0.001, p=0.036, p<0.001 and p=0.022 respectively).

**Conclusion:** Extra safety measures to assure optimal anti-microbial conditions did not contribute to lower SSI incidence or SSI related explantation after alloplastic breast reconstruction. Confounders such as BMI, smoking, immediate BR and one-stage BR were correlated to an increased risk for overall SSI, deep SSI and SSI related explantation of TE/implants.

## INTRODUCTION

Surgical site infection (SSI) following alloplastic breast reconstruction (BR) is one of the most disastrous complications, since this often leads to loss of the implant and thus destroys the reconstructed breast.[1-4] Literature shows that 58% of alloplastic BR complicated by implant loss were associated with SSI.[5] Complications overall, but especially implant loss has a major impact on patient's quality of life.[6]

The reported incidence of SSI following alloplastic BR varies between 3% and 30%.[7-10] This percentage is higher than seen after other breast surgeries using implants; cosmetic augmentation has reported infection rates of 0.9% and 1.7%.[11,12] When looking into the pathophysiology of SSIs following alloplastic BR, gram-positive bacteria of which *Staphylococcus* species is mostly seen.[13] Since 2012, there is more awareness of this and multiple measures have been incorporated in standard operating procedures (SOPs) to ensure optimal anti-microbial conditions.[14-18] Research on SSI after alloplastic BR found timing of and use of preoperative antibiotics administration, an alcohol chlorhexidine skin preparation, hypothermia prevention, minimization of OR-door movements and glove exchange before implantation, and implant and pocket washing to be effective in reducing the incidence of SSI following alloplastic BR.[19] Minimal to no evidence was found for duration of antibiotic use, methicillin-resistant *Staphylococcus aureus* (MRSA) screening, laminar air flow, nipple shields, and implant type.[17,19,20] Besides optimal perioperative conditions, various patient and surgical characteristics have been detected as risk factors for SSI.[21-29] Considering the variety in protocols used world-wide, a best practice is yet to be defined.

The aim of this study was to evaluate whether the implementation of extra safety measures and precautions indeed led to a decrease in incidence of SSI following alloplastic BR. This research evaluates the impact of pre-operative antibiotic administration at least half an hour before incision, normal body temperature maintenance, implants rinsing in povidone-iodine solution before implantation, minimal number of people allowed in the operating room (OR) and minimal OR-door movement. We hypothesize that applying these safety measurements reduces the number of SSIs following alloplastic BR and thus reduces the chance of implant loss.

## MATERIALS & METHOD

### STUDY DESIGN & PARTICIPANTS

This retrospective study analyzed and compared two Cohorts of patients treated at our tertiary referral center before (September 2009 until September 2014, Cohort 1) and after implementation of new SOPs (October 2014 until October 2019, Cohort 2). The Medical Ethics Review board (METc) of the UMCG approved this study and judged that this study fell outside the scope of the Medical Research Involving Human Subjects Act (WMO) (METc2020/251).

All female patients of 18 years and older who underwent initial alloplastic BR between September 2009 and October 2019 (either after mastectomy for breast cancer or following preventive mastectomy) were included. Immediate, meaning mastectomy and BR during the same surgery, and delayed, as in BR on a later date after previous mastectomy. BR could be performed as one-stage and two-stage procedure. One-stage surgery meaning that the definitive breast implant was directly placed. In two-stage surgery, first a Tissue Expander (TE) was placed, which was filled until the desired or possible breast size was reached, and at a second surgery the TE was replaced with a definitive implant. Alloplastic BR combined with a Latissimus Dorsi (LD) or a Lateral Thoracodorsal (LTD) flap were also included. Women who did not complete their second surgery of the two-stage BR within the studied period of the Cohort were excluded. The same was true for women who started their trajectory in another medical center, and patients with the request for re-BR. Women who underwent one-stage BR with Strattice™ (GDmedical, Eindhoven, The Netherlands) in the context of another research where also excluded.



### PROCEDURE AND DATA COLLECTION

Using the specific surgical codes for the various types of alloplastic BR, a list of all alloplastic BR surgeries from September 2009 until October 2019 with corresponding patient numbers was requested. Based on inclusion criteria, patient characteristics, surgical procedures and complications were collected from the Electronical Patient Records. The data was pseudonymized and stored, using a code list, in REDCap (Vanderbilt, Nashville, TN, USA). Every type of alloplastic BR surgery was registered as a new record. The first and second surgery of two-stage surgery were examined separately as two separate records belonging to the same patient. If applicable, in the first record, the surgery of the TE placement was described, and the second record described the surgery during which the TE was replaced with the definitive implant.

Before October 2014, the following safety measures applied: implant washing in povidone-iodine solution before placement, minimal handling of the implant, sterile glove exchange before handling the implant and perioperative antibiotic use of 1 gram cefazolin intravenously half an hour before surgery and 1 gram of intravenously administrated cefazolin each six hours for the duration of 24 hours postoperatively.

Since October 2014, multiple measures have been added to the SOPs i.e.: rinsing the wound area and cavity with povidone-iodine solution before placement, more attention to normothermic body temperature maintenance, sterile glove exchange before handling the implant while wearing double sterile gloves, limited number of people (max 8) allowed in the OR and no OR door movements during the actual surgery. All patients received 1 (expected OR-time less than one hour) or 2 grams of cefazolin (Mylan, Amstelveen, The Netherlands) as prophylactic antibiotic intravenously at least half an hour before incision, which was repeated every six hours for the duration of 24 hours in total. When a patient was allergic to cefazolin, an alternative such as clindamycin (Fresenius Kabi, Zeist, The Netherlands), was given.

### OUTCOMES

The primary outcome of this study was the incidence of SSI. SSI was defined using the PREZIES classification. This classification is developed by the National Institute for Public Health and the Environment, the Netherlands.[30] The classification is based on the definition of the European Centre for Disease Prevention and Control (ECDC).[29] PREZIES differentiates superficial SSI, occurring within 30 days after surgery, and deep SSI occurring within 90 days. An infected implant was always defined as a deep SSI, regardless of time.[31] The secondary outcomes were explantation of TE/implant as a result of SSI and cultured micro-organisms.

### DETERMINANTS

The following determinants were analyzed in relation to SSI: being part in either Cohort 1 or 2, age at (first) BR operation, BMI, smoking, bilateral BR, one-stage BR, American Society of Anesthesiologists class (ASA) [32], adjuvant or neo-adjuvant radiotherapy and chemotherapy. Age was calculated in years on the day of the reconstruction. BMI was calculated in kg/m2 and categorized in <25 and ≥25. Smoking status was either yes or no. Smokers included patients who quit smoking less than six months prior to surgery. Bilateral BR was BR of both breasts simultaneously during the same surgery. One-stage BR included those that received a direct implant. Radiotherapy at the reconstructed breast was either pre- or postoperative. Chemotherapy included previous chemotherapy up until one year before reconstruction, neo-adjuvant, or adjuvant chemotherapy.

### STATISTICAL ANALYSIS

Patient characteristics and data regarding to SSI and cultured micro-organisms were summarized using descriptive statistics and compared between both Cohorts. Normally distributed continuous variables were described using means and standard deviation (SD). Non-normally distributed continuous variables and ordinal variables were presented by medians and interquartile ranges (IQR). Dichotomous variables were described by counts and proportions. Overall, deep SSI incidence and incidence of explantation was calculated for all performed surgeries. Separately, overall and deep SSI was calculated on the first (initial) surgery, so excluding the TE exchange for definite implant surgery. Student T-Tests and Pearson's Chi-square tests were used where appropriate.

Multivariate logistic regression was implemented to estimate odds ratios (ORs) and 95% confidence intervals (CIs) in order to evaluate whether the SSI incidence was lower in Cohort 2 compared to Cohort 1. Based on the literature and institutional experience, SSI was adjusted for the following determinants: age, BMI, ASA score of 2 or 3, smoking, one-stage, bilateral, immediate, chemotherapy and radiotherapy.[21-27] For the regression model all initial (first) breast reconstruction surgeries were included. Patients with heterogenic bilateral BR were excluded i.e.: one side immediate with contralateral delayed BR and/or one-stage and contralateral two-stage BR. Analyses was performed on overall SSI incidence, incidence of Deep SSI and explantation of TE/implant as a result of SSI. A p-value ≤ 0.05 was considered statistically significant. The statistical analysis was performed using SPSS 26.0 (IBM, Armonk, NY, USA).

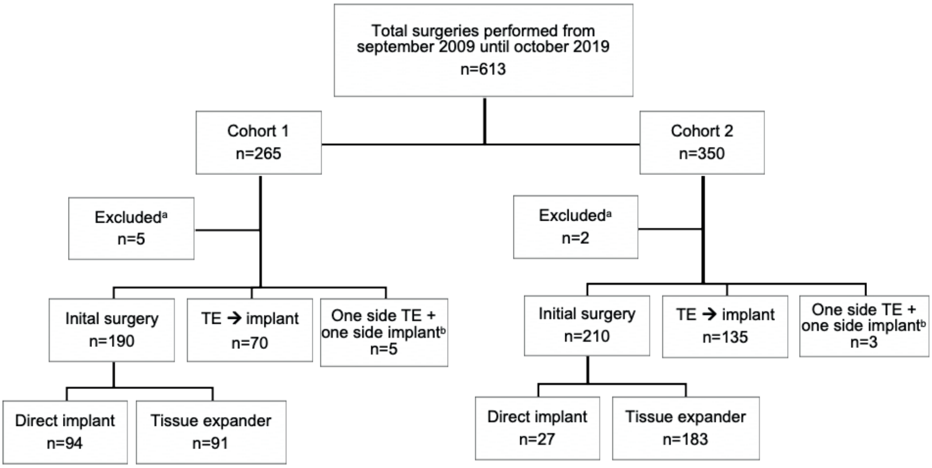
## RESULTS

From September 2009 until September 2014 (Cohort 1), using the hospital's specific surgery encoding we detected in total 265 alloplastic BR surgeries of which 5 surgeries used Strattice™ (GDmedical, Eindhoven, The Netherlands). As such, 260 BR surgeries were included. 190 (190/260=73%) of these were initial surgeries of which in 91 cases (91/190=48%) a TE was placed and in 94 cases (94/190=49%) a definitive silicone filled implant was placed. In five cases (5/190=3%) one side was reconstructed using a TE or a TE exchange and the contralateral side was reconstructed using a direct implant. 70 out of 260 (27%) procedures were secondary surgeries in which the TE was exchanged for the definite implant.



From October 2014 until October 2019 (Cohort 2), in total we detected 350 surgeries of which two were BR surgeries employing Strattice™ (GDmedical, Eindhoven, The Netherlands). In total 348 BR surgeries were included, of which 210 (210/348=60%) were initial reconstruction surgeries. In 183 cases (183/210=87%) a TE was placed, in 27 cases (27/210=13%) a direct implant was placed. In tree cases (3/210=1%), one side was reconstructed using a TE or a TE exchange and the contralateral side was reconstructed using a direct implant. 135 out of 348 (39%) procedures were secondary reconstruction surgeries in which the TE was exchanged for the definitive implant. Figure 7.1 gives an overview of performed procedures among both Cohorts.

**Figure 7.1 Surgeries performed in Cohort 1 (n=260) and Cohort 2 (n=348)**




*TE=tissue expander, N=number, Cohort 1=2009 -2014, Cohort 2=2014-2019. [a]Breast reconstruction with Strattice. [b]Heterogenetic Breast Reconstruction, excluded from regression analysis*

## PATIENT CHARACTERISTICS: COHORT COMPARISON

Mean age was slightly but significantly lower (44 versus 46, p=0.041) and mean BMI was slightly but significantly higher (24.7 versus 25.2, p=0.038) in Cohort 2 compared to Cohort 1. Women in Cohort 1 underwent less often chemotherapy compared to women in Cohort 2 (22% versus 40%, *p=0.023*). In Cohort 2, relatively more preventive mastectomies were performed (44% versus 32%, *p=0.005*). Related to that, more nipple sparing mastectomy's (58% versus 19%, *p<0.001*) and immediate reconstructions were performed in Cohort 2 (93% versus 42%, *p<0.001*). In Cohort 1, more one-stage reconstructions were performed compared to in Cohort 2 (93 versus 25, *p<0.001*) (Table 7.1).

**Table 7.1 Characteristics for Cohort 1 (n=260) and Cohort 2 (n=348)**

| Characteristics | | Cohort 1 n 260 (%) | Cohort 2 n 348 (%) | P-value |
|---|---|---|---|---|
| Age in years | Mean (SD) | 46 (11) | 44 (12) | *0.041* |
| Body Mass Index in kg/m2 | Mean (SD) | 25 (4) | 25 (5) | *0.038* |
| ASA classification | Category 0-1 | 132 (51) | 192 (55) | 0.160 |
| | Category 2-3 | 128 (49) | 156 (45) | |
| Smoking[a] | No | 55 (21) | 72 (21) | 0.484 |
| | Yes | 205 (79) | 276 (80) | |
| Bilateral reconstruction | No | 141 (54) | 191 (55) | 0.469 |
| | Yes | 119 (46) | 157 (45) | |

Table 7.1 Characteristics for Cohort 1 (n=260) and Cohort 2 (n=348) (continued)

| Characteristics | | Cohort 1 n 260 (%) | Cohort 2 n 348 (%) | P-value |
|---|---|---|---|---|
| Chemotherapy[b] | No | 220 (85) | 271 (78) | *0.023* |
| | Yes | 40 (15) | 77 (22) | |
| Radiotherapy[c] | No | 204 (78) | 271 (78) | 0.471 |
| | Yes | 56 (22) | 77 (22) | |
| Reconstruction Indication Left breast | Therapeutic | 173 (67) | 195 (56) | *0.005* |
| | Preventive | 87 (34) | 153 (44) | |
| Reconstruction Indication Left breast | Therapeutic | 176 (67) | 196 (56) | *0.003* |
| | Preventive | 84 (32) | 152 (44) | |
| Reconstruction Timing | Delayed | 140 (54) | 23 (6) | *<0.001* |
| | Immediate | 110 (42) | 322 (93) | |
| | Delayed, contralateral side Immediate | 10 (4) | 3 (1) | |
| Nipple sparing mastectomy | No | 212 (82) | 145 (42) | *<0.001* |
| | Yes | 48 (19) | 203 (58) | |
| Reconstruction Technique Left Breast | No reconstruction | 90 (35) | 96 (28) | |
| | Tissue Expander | 55 (21) | 123 (35) | *<0.001* |
| | Direct Implant | 47 (18) | 22 (6) | |
| | LD + TE | - | 6 (12) | |
| | L(T)D + implant | 29 (11) | 4 (1) | |
| | TE exchange -> implant | 39 (15) | 97 (28) | |
| Reconstruction Technique Right Breast | No reconstruction | 74 (29) | 95 (27) | |
| | Tissue Expander | 69 (27) | 122 (35) | *<0.001* |
| | Direct Implant | 46 (18) | 18 (5) | |
| | LD + TE | - | 4 (1) | |
| | L(T)D + implant | 18 (7) | 7 (2) | |
| | TE exchange -> implant | 53 (20) | 102 (30) | |
| Reconstruction Technique Both Breasts Together | Two-stage | 159 (61) | 318 (91) | *<0.001* |
| | One-stage | 96 (37) | 27 (8) | |
| | One-stage, contra lateral side Two-stage | 5 (2) | 3 (1) | |

SD=standard deviation, ASA= The American Society of Anesthesiologists Classification, LD=latissimus dorsi flap, TE=tissue expander, L(T)D=latissimus dorsi or lateral thoracodorsal flap
[a]No smoking includes quit smoking for more than six months,
[b]Neoadjuvant or adjuvant chemotherapy. No includes received chemotherapy more than one year ago.
[c]Any radiotherapy (previous, neoadjuvant, adjuvant). No includes received radiotherapy for another medical reason.

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## INCIDENCE OF OVERALL AND DEEP SURGICAL SITE INFECTIONS

The incidence of overall SSI among all alloplastic BR surgeries was 10% (27/260) in Cohort 1 and 10% (36/348) in Cohort 2 (p=0.545). The incidence in the initial reconstructive surgery for Cohort 1 was 12% (23/185) versus 13% (28/210) in Cohort 2, (p=0.455). The incidence of deep SSI was 9% (22/260) in Cohort 1 compared to 5% (18/348) in Cohort 2 (p=0.074). The difference in deep SSI incidence between Cohorts was comparable when merely looking at the first surgery (18/185=10% and 15/210=7%, p=0.228).(Table 7.2) As a result of SSI, in Cohort 1 and 2, a comparable percentage of TE/implant removals took place (20/260= 8% and 18/348=5% respectively, p=0.136).

Multivariate logistic regression analysis on the overall SSI incidence among the initial BR surgeries adjusted for, age, BMI, smoking, ASA 2-3, chemotherapy, radiotherapy, one-stage, immediate and bilateral BR showed no statistically significant difference between both cohorts ($OR_{adjusted}$: -0.31 95%CI= 0.33 ; 1.64, p=0.452). Higher BMI, smoking, one-stage BR and immediate BR were associated with the risk for obtaining a SSI (*p<0.001*, *p=0.036*, *p<0.001* and *p=0.022* respectively). The results were similar for deep SSI ($OR_{adjusted}$: 0.16 95%CI= 0.45 ; 3.03, p=0.747) and for explantation due to SSI ($OR_{adjusted}$: 0.18 95%CI= 0.46 ; 3.10, p=0.712).Table 7.3)

**Table 7.2 Incidence of overall and deep SSI for Cohort 1 and Cohort 2 homogenic BR**

| | Cohort 1 n | SSI n (%) | Cohort 2 n | SSI n (%) | p-value |
|---|---|---|---|---|---|
| **Overall SSI incidence** | | | | | |
| All surgeries | 260 | 27 (10) | 348 | 36 (10) | 0.545 |
| Initial surgery | 185 | 23 (12) | 210 | 28 (13) | 0.455 |
| TE -> implant exchange surgery | 70 | 2 (3) | 135 | 5 (4) | 0.552 |
| **Deep SSI incidence** | | | | | |
| All surgeries | 260 | 22 (9) | 348 | 18 (5) | 0.074 |
| Initial surgery | 185 | 18 (10) | 210 | 15 (7) | 0.228 |
| TE -> implant exchange surgery | 70 | 1 (1) | 135 | 1 (1) | 0.567 |

Cohort 0= Cohort 1 from 2009-2014 and 1=Cohort 2 from 2015-2019, n=number of cases, SSI=surgical site infection, TE=tissue expander, first surgery= TE insertion or direct implant reconstruction, TE-> implant=exchange of TE for the definite implant surgery

**Table 7.3 Multivariate logistic regression analysis on SSI incidence compared between Cohort 1 and Cohort 2**

| | Overal Surgical Site Infection | | | Deep Surgical Site Infection | | | Explantation | | |
|---|---|---|---|---|---|---|---|---|---|
| | OR | 95% C.I. | P-value | OR | 95% C.I. | P-value | OR | 95% C.I. | P-value |
| *Cohort 1, yes | -0.31 | 0.33 ; 1.64 | 0.452 | 0.16 | 0.45 ; 3.03 | 0.747 | 0.18 | 0.46 ; 3.14 | 0.712 |
| Age | 0.02 | 0.99 ; 1.06 | 0.248 | 0.01 | 0.97 ; 1.06 | 0.600 | 0.06 | 0.97 ; 1.06 | 0.515 |
| Body Mass Index | ***0.12*** | ***1.06 ; 1.21*** | ***<0.001*** | ***0.13*** | ***1.06 ; 1.23*** | ***0.001*** | ***0.14*** | ***1.07 ; 1.25*** | ***<0.001*** |
| +ASA | -0.13 | 0.44 ; 1.77 | 0.723 | 0.30 | 0.58 ; 3.11 | 0.485 | 0.38 | 0.63 ; 3.44 | 0.377 |
| Smoking, yes | 0.72 | 1.00 ; 4.24 | 0.050 | ***0.89*** | ***1.04 ; 5.72*** | ***0.041*** | 0.83 | 0.95 ; 5.50 | 0.065 |
| Bilateral BR, yes | -0.28 | 0.34 ; 1.69 | 0.500 | -0.41 | 0.25 ; 1.76 | 0.412 | -0.34 | 0.27 ; 1.91 | 0.502 |
| Chemotherapy, yes | -0.58 | 0.22 ; 1.43 | 0.226 | -0.42 | 0.21 ; 2.04 | 0.471 | -0.35 | 0.23 ; 2.22 | 0.554 |
| Radiotherapy, yes | 0.19 | 0.55 ; 2.64 | 0.633 | -0.62 | 0.19 ; 1.56 | 0.253 | -0.87 | 0.13 ; 1.33 | 0.141 |
| Immediate BR, yes | ***1.25*** | ***1.27 ; 9.52*** | ***0.016*** | 0.89 | 0.79 ; 7.52 | 0.122 | 1.08 | 0.91 ; 9.49 | 0.073 |
| One-stage BR, yes | ***-0.31*** | ***1.93 ; 8.63*** | ***<0.001*** | ***1.37*** | ***1.63 ; 9.54*** | ***0.002*** | ***1.31*** | ***1.52 ; 9.11*** | ***0.004*** |

*Cohort 1=1, Cohort 2=0,
+ASA= American Society of Anesthesiologists Classification, 0=no=0-1, 1=yes=2-3, BR=Breast Reconstruction. CI=confidence Interval
Italic/bold= p-value below 0.05

## CULTURED MICRO-ORGANISMS

Among the 27 SSIs in cohort 1, 24 (88%) swabs were taken compared to 23 swabs among 36 SSIs (64%) in cohort 2, p=0.024. In total, 21 different species were cultured. In both cohorts Staphylococcus aureus was cultured most (8/24=33%, Cohort 1 and 10/20=50%, Cohort 2) followed by Coagulase-negative staphylococci (3/24=13% and 3/20=15% respectively).(Table 7.4)

**Table 7.4 cultured micro-organisms compared between cohort 1 and cohort 2**

| Micro-organism | Cohort 1 (SSI, n=26) n (%) | Cohort 2 (SSI, n=36) n (%) |
|---|---|---|
| Number of swabs taken | 24 (92) | 20 (56) |
| Negative: no bacterial growth | 4 (15) | 3 (8) |
| ***Gram-positive species*** | **Times cultured** | |
| *Staphylococcus aureus* | 13 | 12 |
| *Coagulase-negative staphylococci* | 3 | 3 |
| Aerobic gram-positive mixed flora | 6 | 1 |
| *Staphylococcus epidermis* | 2 | |
| *Staphylococcus caprae* | 1 | |
| *Streptococcus anginosus* | 2 | |
| *Propionibacterium acnes* | 2 | |
| *Corynebacterium propinquum* | 1 | |
| *Corynebacterium amycolatum* | | 2 |
| *Granulicatella adiacens* | | 1 |
| *Propionibacterium magnus* | | 1 |
| ***Gram-negative species*** | **Times cultured** | |
| *Pseudomonas aeruginosa* | 1 | 2 |
| *Klebsiella oxytoca* | 1 | 1 |
| *Escherichia coli* | 1 | |
| *Enterobacter cloacae* complex | 2 | 1 |
| *Maroxella catarrhalis* | 1 | |
| *Citrobacter koseri* | 1 | |
| *Stenotrophomonas maltophilia* | | 1 |
| *Acinetobacter* species | | 1 |
| *Aeromonas* species | | 1 |
| *Prevotella bivia* | | 1 |
| **N of different bacteria** | **15** | **14** |

## DISCUSSION

The aim of this study was to see whether the implementation of extra safety measures and precautions have led to a decrease in incidence of SSI following alloplastic BR. The incidence of overall SSI was not lower after the implementation of the renewed SOPs (Cohort 2) compared to before (Cohort 1), ($OR_{adjusted}$: -0.31 95%CI= 0.33 ; 1.64, p=0.452). The same implied for deep SSI ($OR_{adjusted}$: 0.16 95%CI= 0.45 ; 3.03, p=0.747) and SSI leading to explantation of TE/implants ($OR_{adjusted}$: 0.18 95%CI= 0.46 ; 3.10, p=0.712). When comparing both cohorts, we found a noticeable change in the plastic surgeon's preferences to perform less one-stage BR. This change was probably the result of the experiences at the institution and the published research on higher complication rates among one-stage BR. Multivariate analysis confirmed a strong relation between one-stage reconstruction and overall, deep and explantation due to SSI in this study population *(p<0.001)*. Another difference between the cohorts is more use of neoadjuvant and adjuvant chemotherapy in Cohort 2 when comparing to Cohort 1 (p=0.023), while in Cohort 2 more preventive mastectomies and BR were performed. This can be explained by the higher numbers of delayed BR in Cohort 1, compared to Cohort 2 (p<0.001). In these cases, chemotherapy was used earlier during the treatment trajectory, while in Cohort 2 the intervals between receiving chemotherapy and BR was shorter.

### COMPARISON TO THE LITERATURE

BMI and smoking are known risk factors for SSI and other (wound) complications in alloplastic BR and surgeries in general.[21–29] Our results on one-stage versus two-stage BR were very much in line with a meta-analysis comparing 2799 one-stage to 2417 two-stage BR surgeries ($OR_{adjusted}$:1.47, *p<0.001*, compared to $OR_{adjusted}$:=1.87; *p=0.04* respectively).[33] In the literature, chemotherapy, radiotherapy, immediate and alloplastic BR using a flap are described risk factors for SSI.(26,29) Chemotherapy and radiotherapy were not associated in the current study. This is possibly due to the relatively small group that underwent chemo- (15%) and radiotherapy (22%). The literature is inconsistent about the relation between immediate BR and SSI. Some studies find immediate BR to be related to SSI (23), whereas others don't.(21) In this study, overall SSI incidence was higher among immediate BR ($OR_{adjusted}$:1.17, p=0.022) but deep SSI incidence was not higher ($OR_{adjusted}$:0.89, p=0.122). As for the cultured micro-organisms, in both cohorts, Staphylococcus aureus was cultured most (25/65=39%). Staphylococcus aureus is the most frequent identified pathogen in breast implant infections with incidences of 49% an 67% found in the literature.[34,35]

### STRENGTHS AND LIMITATIONS

A major strength of this study is the low chance of selection bias since all women who underwent alloplastic BR between September 2009 and October 2019 were included.

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Another strength is seen in the usage of the PREZIES classification to score overall and deep SSI.

It can be seen as a limitation of this study that it is retrospective. However, the study has a moderately high sample size (608 surgeries in total) and the documentation and registration of patient data in the electronic patient records are assumed to be highly accurate. A flaw of this research is that, drainage time and drain canister replacement were not noted systematically, while these factors have been associated with SSI in other research (OR=2.95; 95% CI=1.17-7.47).[21]

## IMPLEMENTATIONS AND RECOMMENDATIONS

Although this study showed no relation between the implementation of extra safety measures and a drop in SSI incidence, it cannot be ruled out that these measures have contributed to a lower chance of developing SSI. It is still recommended to obtain the best anti-bacterial environment when performing alloplastic BR or implant based surgeries in general. Besides that, multiple, preferably prospective multi-center studies should further assess whether the extra safety measures contribute to a lower incidence of SSI and lower rate of reconstruction failure. Women who smoke should be urged to stop smoking at least four weeks before reconstruction and where possible, women should try to lose weight in order to obtain a healthy BMI (<25).[29] Especially in gene carriers, prophylactic BR could be postponed until women have obtained a healthy life-style.

One-stage reconstruction seems to be highly related to the development of SSI. We hypothesize that the high SSI incidence among one-stage reconstruction is a result of higher tissue tension leading to reduced blood-flow in thin skin flaps as the result of mastectomy. Future research should further investigate blood-flow and oxygen levels in dissected skin flaps, for example using near-infrared cameras, to try to grasp the pathophysiological mechanisms of hypoxia and infection. This could also be used during the expansion phase of two-stage reconstruction to evaluate the quality of the skin perfusion over time. In this way malperfusion and related hypoxia could be detected and treated early-on by removal of the direct implant, which would possibly contribute to lower reconstruction failure rates among two-stage reconstruction. Research has shown the beneficial effects of using this technique in assessing whether a skin flap is more susceptible to necrosis and it possible consequences.[34]

## CONCLUSION

This study compared the incidence of SSI of two BR cohorts, before and after the implementation of extra safety measures to ensure optimal anti-bacterial conditions. The implementation of extra safety did not result in a lower incidence in the observed population. SSI incidence was mostly related to the patients BMI, smoking and the performance of immediate and one-stage BR.

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