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ORIGINAL PAPER

Significance of Infections in Implant Loss After Breast Reconstruction in the Course of Breast Cancer Treatment

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Abstract

The aim of the study was to analyze the reasons for removing implants after breast reconstruction in the course of treatment of breast cancer. The study involved 428 patients, who underwent a total of 648 breast reconstruction procedures using artificial implants. 47 out of 648 cases (7.3%) were identified in which the implant had to be removed. Of the 47 cases, 57.4% had undergone deferred reconstruction, and 42.6% immediate reconstruction; 27.7% had undergone pre-operative chemotherapy and radiotherapy, 27.7% pre-operative chemotherapy, and 2.1% pre-operative radiotherapy; 6.4% were diabetic, 4.3% active smokers, and more than 50.0% had BMI greater than 25 kg/m^2. In 83.0% of the analyzed cases, the reason for removal of the implant was infection, in 8.5% it was local recurrence of breast cancer, in 4.3% it was damage (leakage) of the implant, and in 2.1% it was post-operative pain. About 87.0% of infections appeared within one year of implantation; however, less than a half developed within 90 days of the reconstructive surgery, and up to 30 days only about 13.0% had appeared. Among the etiological agents of infections were: coagulase-negative *Staphylococcus* (31.3%), *Staphylococcus aureus* (18.7%), *Enterococcus faecalis* (9.4%), *Enterobacter cloacae* (18.8%), *Pseudomonas aeruginosa* (12.5%), *Acinetobacter lwoffii* (3.1%), and other Gram-negative fermenting rods accounted for 6.2%. Infections were the most common reason for removing the implant after breast reconstruction. and occurred most often as late infections (> 30 days after surgery). The time of observation for infectious complications should be at least 1 year.

Key words: breast cancer, implants, infections, etiological agents

Introduction

In the last decade, there has been a marked increase in the frequency of breast implantation in patients undergoing surgical treatment for breast cancer. The percentage of patients having breast reconstruction after a mastectomy is as high as 36.4–43.3% (NCIN 2011; Ilonzo et al. 2017). However, this applies to data from specialized treatment centers for patients with breast cancer. In other facilities, the percentage does not usually exceed 20% of the cases of mastectomy (Alderman et al. 2006). The frequency of such treatments in Poland is much lower. However, there is a lack of accurate data on the above problem on a national scale. The previous studies, which are yet not numerous, have shown that a percentage of the patients undergoing mastectomy and breast reconstruction may reach 22.4% (Tarkowski et al. 2017). However, the complications that accompany the introduction of the implant (expander, final prosthesis) remain a major challenge for oncological surgeons. The most frequent complications include infections; it is estimated that up to 29% (mean 5.8%) of breast reconstruction surgery is complicated by infection (Phillips et al. 2013). Infection is cost-intensive and 70–80% of patients ultimately require removal of the implant (Pittet et al. 2005; Seng et al. 2015).

Among the risk factors for infection are associated diseases such as diabetes, renal failure, and skin diseases,

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but also systemic treatment and radiotherapy. Other factors that increase the risk of infection include obesity and nicotinism. Infections are also triggered by factors associated with the surgery itself: an immediate breast reconstruction with the use of a final prosthesis is more often complicated by infection than deferred reconstruction. The prolonged (> 2 h) duration of surgery and post-operative drainage also have an unfavorable effect (Pittet et al. 2005; Araco et al. 2007).

Among the etiological agents of infections, the most common are skin microbiota: coagulase-negative *Staphylococcus*, *Corynebacterium* spp., *Propionibacterium acnes*, and *Staphylococcus aureus*, but more and more frequently there are reports on the increased proportion of Gram-negative bacteria from the order *Enterobacterales* and anaerobic microorganisms among etiological agents of these infections (Halvorson et al. 2007; Weichman et al. 2013; Seng et al. 2015).

This study aimed to retrospectively analyze the causes of removal of implants after mastectomy in the course of breast cancer treatment and to determine the frequency and time of appearance of implant infections as well as the etiological agents causing them.

Experimental

Materials and Methods

The study involved 428 patients treated in one oncological center in the years 1998–2018, who underwent a total of 648 breast reconstruction procedures using artificial implants.

In each case, the implantation procedure was preceded by the test for MRSA (Methicillin-Resistant *Staphylococcus aureus*) and MSSA (Methicillin-Sensitive *Staphylococcus aureus*). The swabs taken for this purpose came from the nasal vestibule, palms, and axilla on the side of the primary tumor of the operated patients. The materials for microbiological tests were seeded on Columbia Agar supplemented with nalidixic acid and amikacin + 5% sheep blood (bioMérieux, France) as well as chromogenic Brilliance MRSA (Oxoid, UK). After 24 h, the morphology of the colonies was assessed, and a catalase and coagulase assays were performed. Also, the sensitivity to methicillin was assessed following the current recommendations of the National Reference Center for Antimicrobial Susceptibility using the disk diffusion method.

Mupirocin eradication was implemented in cases of MRSA colonization in the nasal vestibule. If screening did not show the presence of MRSA, eradication was not performed. On the day before the treatment, in the evening hours, a whole-body cleansing was recommended with the use of an antiseptic intended for skin decontamination or with the body sponges impregnated with an antiseptic (chlorhexidine 4% soap solution). On the day of treatment, the whole-body cleansing was again recommended with the use of an antiseptic intended for skin decontamination. The preparation of the patient for a surgery proceeded under the standards of nursing practice currently in force at the hospital.

In all patients, perioperative prophylaxis was routinely used (cefazolin in a dose of 1.0 g in an intravenous injection – given every 8 hours for 5 days). The first dose of antibiotics was given up to 30 min before the surgery. If the drain remained longer than 5 days, antibiotic therapy was prolonged until the drain was removed. The procedure for perioperative antibiotic prophylaxis was in line with the procedure adopted in our center, i.e., the prolonged antibiotic prophylaxis in the case of wound drainage. Notwithstanding the currently recommended use of 1 dose of antibiotic (Phillips et al. 2013), the procedure referred to the results of the research presented by Brand et al. (1993), which showed greater effectiveness of longer-term use of antibacterial drugs in the prophylaxis of infectious complications after implantation.

From the group of 428 patients with artificial implants used for breast reconstruction, 44 patients were selected for the analysis when it was necessary to remove the implant, which accounted for 10.3% of the patients that underwent surgery. In two out of the 44 patients (4.5%), this occurred twice (after twice reconstructed breast, with a time interval between subsequent surgical procedures – 26 and 27 months, respectively), in one patient (2.3%), the above situation concerned the reconstruction of both breasts (carried out on two different dates – with an interval of 20 months). In none of these three patients were signs of infection of the surgical site before the second surgery. Thus, the total number of removals of implants concerned 47 cases. This accounted for 7.3% of all surgical procedures associated with generative treatment after implantation of an artificial breast implant. The incidence of infection was found in 39 cases, which accounted for 6.0% of all reconstructive procedures. Further epidemiological analyses were based on the number of the performed procedures, which resulted in the loss of the implant.

In 20 cases (42.6%), the need to remove the implant concerned immediate breast reconstruction surgery, while in the remaining 27 cases (57.4%), deferred reconstruction had been performed. The type of reconstructive implant used during the procedure (expander, expander prosthesis, or final prosthesis) as well as the duration of the procedure (immediate or deferred reconstruction) was the result of the current organizational arrangements for treatment and financing of the surgical procedures. They were not the result of the planned choice of the patients.

In 46 cases, the reconstruction of the amputated breast gland consisted of the insertion of an implant in the large pocket created behind the pectoral muscle. In one case, the patient's tissues were used to cover the implant (pedunculated skin-muscle flap taken from the latissimus dorsi muscle).

In 13 cases (27.7%), the reconstruction was preceded by chemotherapy and radiotherapy, in one case (2.1%) – by radiotherapy (this was the case in most patients who underwent restorative treatment in the deferred mode). In 13 cases (27.7%) included in the study, the patients required pre-operative chemotherapy (regardless of the mode of reconstruction). In the remaining patients, the surgery was not preceded by any other type of anticancer treatment (in most cases, these were immediate reconstruction treatments), as it is presented in Table I.

Data were collected on demographics, histopathological diagnosis, stage of cancer, concomitant diseases, surgery performed, implant characteristics, reasons for implant removal, and etiology of infections.

The reasons for the removal of the breast implants were determined, including the frequency of infectious complications. Infection of the implant was defined as surgical site infection (SSI) on the basis of clinical symptoms of infection when at least one of the following criteria was met: the purulent secretion from the drain placed in the operating space; tissue infection confirmed during reoperation; isolation of microorganisms from aseptically collected exudate/operated space, the presence of local symptoms such as redness and inflammatory infiltration, pain and elevated body temperature, as well as diagnosis of infection given by a doctor. Infection occurring up to 30 days after the implantation procedure was categorized as early surgical site infection, while all other cases, i.e. appearing at 31 days and later, were defined as late surgical site infections. The division into early and late infection was in line with Lankiewicz et al. (2012), Phillips et al. (2016), and Sinha et al. (2017). In our study, with infections defined as late, the endpoint of follow-up was the diagnosis of infection/implant loss. At the same time, within the late infections category, two additional groups of patients were created based on the infection development period; in the first group infection developed within 31 and 90 days, in the second group – after 90 days. All infections were classified as deep surgical site infections.

Table I
Characteristics of pre- and post-implantation treatment of cancer patients.

Characteristic	Number of cases n = 47 n (%)
Pre-implantation treatment:	
– RTH	1 (2.1)
– CHTH	13 (27.7)
– RTH+CHTH	13 (27.7)
– No treatment	19 (40.4)
– No data	1 (2.1)
Post-implantation treatment:	
– RTH	1 (2.1)
– CHTH	4 (8.5)
– RTH+CHTH	1 (2.1)
– No treatment	40 (85.1)
– No data	1 (2.1)

RTH – radiotherapy, CHTH – chemotherapy

The material collected for microbiological tests was seeded on solid media: Columbia agar with a supplement of 5% sheep blood (bioMérieux, France), MacConkey agar (bioMérieux, France), Columbia agar supplemented with nalidixic acid and amikacin with a supplement of 5% sheep blood (bioMérieux, France), D-Coccosel agar (bioMérieux, France), Cetrymide agar (bioMérieux, France), chromogenic medium for the identification of MRSA (Oxoid, UK) as well as the liquid medium Trypticase Soy Broth (bioMérieux, France). Incubation was carried out at 35 ± 2°C for 16–24 h. In the absence of microbial growth on solid media, incubation was continued for a further 16–24 h. In addition, the broth was seeded on solid media: Columbia Agar + 5% sheep blood and MacConkey agar (bioMérieux, France). The identification of microorganisms was carried out using the Vitek 2 Compact system (bioMérieux, US) as well as using conventional tests to identify Gram-positive cocci and Gram-negative bacilli: the assessment of catalase and coagulase production, degradation of esculin in the presence of bile salts, production of pyrrolidonyl peptidase in the PYR test, growth in broth containing 6.5% NaCl and production of oxidase, growth in Trypticase Soy Broth at 42°C, and arginine dihydrolase production. The procedures were developed based on the Clinical Microbiology Procedures Handbook (Isenberg 2004). The susceptibility of staphylococci to methicillin was assessed following the current recommendations of the National Reference Center for Antimicrobial Susceptibility using the disk diffusion method.

The etiology of microorganisms was analyzed concerning the type of surgery (immediate and deferred reconstruction) as well as with the oncological therapy before implantation vs. absence of such therapy.

Statistical analysis of the relationship between the profile of microorganisms and the type of reconstruction and oncological therapy administered before implantation (chemotherapy or radiotherapy) was carried out using Fisher's exact test. Differences were considered statistically significant at $p < 0.05$. The results are also shown as a percentage, median and average of the results recorded.

Results

The average age of patients was 48.4 years (range from 27 to 64 years, median 49.0). The mean body mass index (BMI) was 26.1 kg/m^2 (range from 17.7 to 35.2, median 26.1). In 6.4% of patients, diabetes was confirmed, and 4.3% of them were active smokers. Among the patients, eight (17.0%) were MSSA carriers; none of them was a carrier of MRSA. The average time before removal of the implant was 601 days (range 14–9102, median 113 days). The average follow-up time was 601 days. More than half of the patients have an increased BMI, about 1/3 of them received pre-operative radiotherapy; there were active smokers and people with diabetes. The coexistence of recognized risk factors increased the danger of infection. The detailed clinical characteristics of patients are presented in Table II.

Table II
Clinical and histopathological characteristics of patients with implant loss, and the type of reconstruction.

Characteristics	Number of cases n = 47 n (%)
Type of carcinoma	
Ductal carcinoma	36 (76.6)
Lobular carcinoma	2 (4.3)
Other forms of invasive cancer	3 (6.4)
DCIS	4 (8.5)
No data	2 (4.3)
Clinical stage (cTNM)	
IA	14 (29.8)
IIA	17 (36.2)
IIB	5 (10.6)
IIIA	2 (4.3)
IIIB	1 (2.1)
No data	8 (17.0)
Diabetes	
Yes	3 (6.4)
No	44 (93.6)
Nicotinism	
Yes	2 (4.3)
No	36 (76.6)
No data	9 (19.1)
BMI [kg/m^2]	
< 25	21 (44.7)
≥ 25	26 (55.3)
MSSA carrier	
Yes	8 (17.0)
No	26 (55.3)
No data	13 (27.7)
Type of reconstruction	
Immediate	20 (42.6)
Deferred	27 (57.4)
Type of implant	
Expander	23 (48.9)
Expander prosthesis	8 (17.0)
Prosthesis	5 (10.6)
Expander prosthesis/prosthesis (2nd stage of reconstruction – replacement of implant after earlier implantation of expander)	11 (23.4)

BMI – Body Mass Index
MSSA – Methicillin-Sensitive *Staphylococcus aureus*
DCIS – Ductal Carcinoma *In Situ*
cTNM – Clinical TNM (classification system of malignant tumors – tumor, node, metastasis)

In 83.0% (39/47) of cases, the reason for removal of the implant was an infection, in 8.5% (4/47) local recurrence of breast cancer, and in 4.3% (2/47) damage (a leakage) of the implant. In 2.1% (1/47) of cases, the reason for removal of the implant was post-operative pain, in 2.1% (1/47) the reason was unknown. The reasons for implant removal are shown in Table III.

The only reason for removal of the implant up to 30 days after the reconstructive treatment was an infection, which appeared in six of the cases analyzed (12.8%). The implants were removed on average after 18 days (median 16 days, range 14–27 days) after the reconstructive procedure. In 23.4% (11/47) of cases, the infection was recognized between 31 and 90 days after surgery, in 36.2% (17/47) between 91 and 365 days after surgery, and in 10.6% (5/47) after a period longer than one year. Up to 90 days after surgery, 17/39 (43.6%) infections were identified, up to one year – 34/39 (87.2%) cases, and after this period – 5/39 (12.8%) cases. The late infections (> 30 days) appeared on average after 329 days (median 115 days, range 35–4914 days).

The remaining, non-infectious complications that caused the removal of the implant in seven cases (14.9%) appeared on average after 2465 days (median

Table III
Characteristics of postoperative complications.

Characteristics	Number of cases n = 47 n (%)
Infection	
Early (≤ 30 days)	6 (12.8)
Late (> 30 days)	
31–90 days	11 (23.4)
91–365 days	17 (36.2)
> 365 days	5 (10.6)
– Local recurrence of breast cancer	2 (4.3)
– Local recurrence of breast cancer in the chest wall	2 (4.3)
– Postoperative pain	1 (2.1)
– Leakage of prosthesis/expander prosthesis	2 (4.3)
– No data	1 (2.1)

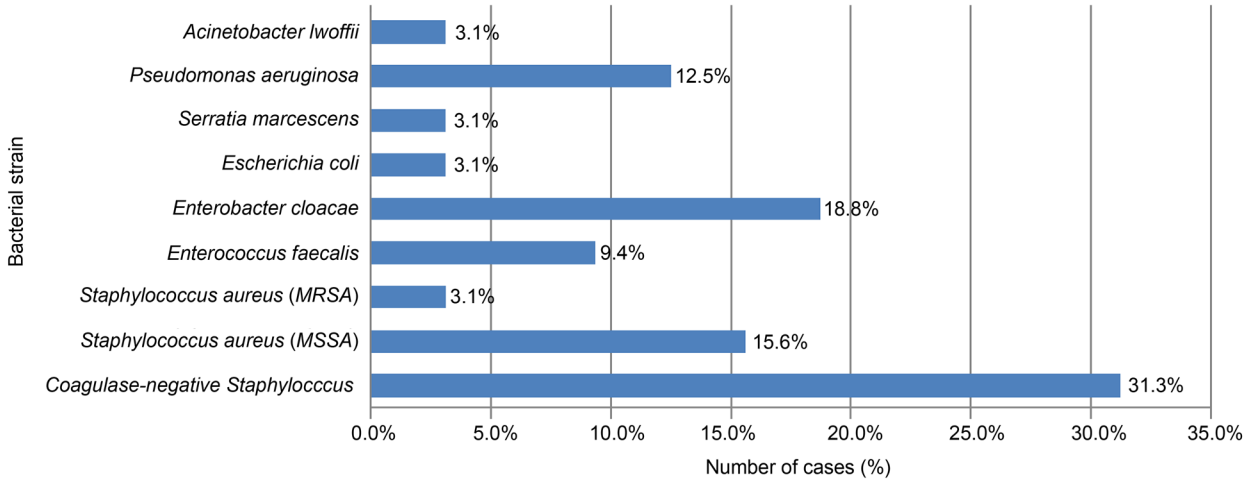

Fig. 1. Bacterial species isolated from the breast artificial implants infections.

1630 days, range 239–9102). The longest time interval between reconstruction and implant removal was 9102 days and it was due to the leakage of the prosthesis. The shortest time interval was 239 days, and the removal of the implant was due to the recurrence of local breast cancer in the chest wall.

In five out of 39 cases (12.8%), the infection was diagnosed only based on clinical symptoms without microbiological diagnosis and no microorganisms were grown in six out of 39 cases of infections (15.4%). In 24 out of 28 (85.7%) microbiologically confirmed cases of infection, bacteria were present in monoculture, in four cases (14.3%) polybacterial infections were found. Among the etiological agents were: coagulase-negative staphylococci (31.3%), *Staphylococcus aureus* (18.7%), *Enterococcus faecalis* (9.4%), *Enterobacter cloacae* (18.8%), *Pseudomonas aeruginosa* (12.5%), and *Acinetobacter lwoffii* (3.1%). Other fermenting Gram-negative rods accounted for 6.2%. The cultured and identified etiological agents of infections are shown in Fig. 1.

There were no statistically significant differences in the etiology of microorganisms (cocci *vs* rods) between the groups of patients after immediate and deferred reconstruction and between cancer patients treated before implantation (radiotherapy and/or chemotherapy) vs. cancer patients that do not receive any treatment ($p > 0.05$).

Discussion

In this study, we show that infections were the most common reason of the removal of the implants after generative treatment in breast cancer and were responsible for the loss of the implant in 83.0% of the cases analyzed. The prevalence of breast implant infection in this study was 6.0% of implantation. Of the infections diagnosed, 87.0% appeared within one year of implantation; however, less than half of the infections developed within 90 days of the reconstructive surgery, while up to 30 days – about 13.0% of infections were diagnosed. Non-infectious complications caused the loss of the implant in about 15.0% of the cases analyzed.

In the available literature, infection after the breast reconstruction surgery appeared with varying frequency and their etiological agents were different. This is related to the adopted definition of infection, the period of time for surveillance, the perioperative prophylaxis applied, and the composition of microbiota inhabiting the operated area (Weichman et al. 2013). The time of observation significantly influences the obtained results. In the studies of Olsen et al. (2017) on a large group of respondents, approximately 17 000 patients undergoing mastectomy, the incidence of SSI up to 90 days after surgery was 3.2–8.9% and was dependent on the type of reconstruction. In the opinion of the authors cited, it is necessary to carry out the infection surveillance up to 90 days after surgery, since the shorter period of observation, limited to 30 days, leads to an underestimation of the rate of infection. Similarly, Lankiewicz et al. (2012) found, however, on a smaller group of patients comprised of 54 women undergoing mastectomy with immediate reconstruction with an implant, that only about 1/2 of the diagnosed SSI developed within 30 days after surgery. Viola et al. (2016), in single-center retrospective studies involving over 3000 patients, found that only 30.0% of all SSIs were diagnosed within the first 30 days after a simultaneous reconstruction using a tissue expander. In our work, we found lower rates than the quoted authors (Lankiewicz et al., 2012; Viola et al. 2016) regarding infection within 30 days after reconstructive surgery. When we limited observation to one month after the procedure we were able to detect only 1/8 of the implant infections confirmed.

The reasons for the variability in the period when the infections appeared were probably related to the eligibility criteria for the reconstructive surgery (the patient's profile), the type of surgery performed, the experience of the center performing the implant treatments, as well as the prophylactic treatment used. In our work, we confirmed that the observation of infections limited to 30 days after surgery was insufficient, as was the 90-days observation. It seems that the optimal time could be a one-year observation. In our study, this allowed the detection of approximately 90% of infections. The necessity to monitor for complications after breast reconstruction during one year after surgery, instead of 30 days, has also been indicated by other researchers (Blough et al. 2018), who used individualized tools to assess the risk of post-surgery complications within one year of breast reconstruction.

The fact that the number of infections within 30 days in the cases we analyzed was lower than the numbers appearing in the studies already published may be related to the strict epidemiological supervision carried out in our hospital and the prophylaxis to prevent perioperative infections.

According to the hospital antibiotic policy, the patients studied in the current work received prophylactically a first generation cephalosporin in therapy extended for five days, or until the drain was removed due to the increased SSI risk associated with drainage (Araco et al. 2007). However, currently, many authors advise against such a procedure, pointing to the side effects that accompany it, namely the increase in resistance among microorganisms responsible for SSI (McCullough et al. 2016). In accordance with the idea of perioperative prophylaxis, a single dose of the first-generation cephalosporin is sufficient to ensure the proper concentration of the antibiotic at the incision site and to prevent infections mainly caused by methicillin-sensitive staphylococci (Pittet et al. 2005). Under the recommendations of scientific societies, it is also not suggested to continue treatment with antibiotics after discharge from the hospital, and the guidelines of the American Society of Plastic Surgeons recommend discontinuation of antibiotics at 24 hours after surgery. Nevertheless, a review of publications (Phillips et al. 2016; Viola et al. 2016) shows that the use of prolonged antibiotic therapy by surgeons, both during hospitalization and after discharge from the hospital, is quite common.

In addition to the prophylactic use of antibiotics, a screening test for *S. aureus* was introduced as a standard in our hospital. When colonization with MRSA strain is confirmed, mupirocin is applied nasally without performing tests confirming the effectiveness of eradication. However, in the cases analyzed in the current work, no MRSA carriers were found. Whereas, concerning the colonization with MSSA strains, we assumed that the perioperative prophylaxis with the first-generation cephalosporin is sufficient protection, with its MSSA spectrum of action. It should be emphasized that screening for *S. aureus* in the group of patients undergoing reconstruction is not recommended. According to the recommendations for microbiological screening tests in hospitalized patients (Fleischer et al. 2017), investigation for the carriage of *S. aureus* is recommended only before cardiac surgery, implantation of joint prostheses and spine procedures, as well as in centers with incidence of SSI caused by *S. aureus* higher than the average reported in literature, mainly in neurosurgery and vascular surgery. Patients qualified for breast reconstruction do not meet the criteria given in these recommendations. Nevertheless, within the framework of the perioperative infections prevention carried out in our center, such examination was undertaken. In the current work, we diagnosed MSSA carriers in 17.0% of the cases. In one case, the host had to remove the implant 14 days after surgery due to infection caused by *S. aureus*. In other cases, the infection caused by MSSA occurred in the late period, on average more than one year after surgery, similarly as in a patient with an MRSA-induced infection.

In the available literature on implant infections, among the etiological agents of infections after breast reconstruction, the microbiota of the skin and at the mouth of the milk ducts were isolated (coagulase-negative *Staphylococcus*, mainly *S. epidermidis* and coagulase-positive *S. aureus*) (Chidester et al. 2016; McCullough et al. 2016; Viola et al. 2016). These species adhere to the smooth surfaces of biomaterials, and may also colonize the skin. They demonstrate the ability to form a biofilm, which protects them against the host's immune system and antibiotics (Vacheethasanee et al. 1998; Costerton et al. 1999; Chessa et al. 2016; Conte et al. 2018).

In our work, staphylococci constituted 50% of the isolated microorganisms. They were in a lower percentage than in the studies by Seng et al. (2015) but similar to the results obtained in Song et al. (2017) (respectively: 71.0%, and 50.0%). In three cases (9.4%), we isolated *E. faecalis* that can adhere, modify the immune response, and form biofilms (Prażmo et al. 2016); however, these species are rarely the etiological agent of implant infections. In the available literature, one can find only a few reports about the participation of these microorganisms in wound infections after immediate breast reconstruction (Abedi et al. 2016).

The incidence of infections caused by Gram-negative rods is varied. In the work of Feldman et al. (Feldman et al. 2010) concerning early infections of breast implants, Gram-negative rods accounted for 6.0% of the microorganisms isolated. Seng et al. (2015) also

confirmed the participation of these bacteria in implant infections: Gram-negative rods were identified in 27.0% of cases, and *P. aeruginosa* was the second most commonly isolated microorganism. In turn, in the work of Chidester et al. (2016) *P. aeruginosa* was the most common causative agent of infections and accounted for 26.8% of them. Research carried out by Song et al. (2017) indicates the involvement of *A. baumanii* in infections alongside with *P. aeruginosa*.

In our work more frequently than in the previous studies (Feldman et al. 2010; Seng et al. 2015; Chidester et al. 2016; Song et al. 2017), Gram-negative bacilli were isolated. They constituted a total of 40.6% of the bacterial isolates. The most commonly isolated rods were *E. cloacae* (18.8%), and *P. aeruginosa* (12.5%). These microorganisms secrete extracellular polymers forming a complex matrix of biofilm. The biofilm matrix plays an important role in survival in tissues and evading the response of the body's immune system, which promotes the development of the infection despite the use of antibiotics (Donlan and Costerton 2002). The occurrence of Gram-negative bacilli, naturally resistant to the first-generation cephalosporin, may be associated with the perioperative prophylaxis. Our work did not show the dependence of the etiology of microorganisms (cocci vs. rods) on the type of reconstruction or oncological treatment.

Polybacterial infections are not associated with implants. However, in this work, in four cases (14.3%) we showed the presence of the polybacterial infections. Similar results were obtained by Seng et al. (2015), as well as Viola et al. (2016), the percentage of polybacterial infections reached 19.0 and 17.0%, respectively, among all diagnosed infections. In the cases analyzed by us, two polybacterial infections related to patients treated with radiotherapy. Radiotherapy is an important risk factor for the occurrence of infection through damage to the skin and other tissues, which may affect the microbiota. In over 1/3 of cases, the adjuvant treatment was radiotherapy (in 14 cases before reconstruction surgery, in 2 cases after surgery). However, in only one case for the reconstruction of the breast beside the implantation, autologous tissues were used (lobe from the latissimus dorsi muscle). According to the current standard of diagnostic and therapeutic procedures, this is the recommended method of treatment (Bocian et al. 2016). This indicates the need to use more complex restorative treatments in the future (especially the use of flap techniques in patients requiring radiation therapy).

The existence of a significant risk of complications (especially infectious) related to radiotherapy was shown by Jagsi et al. (2016) and among the most common adverse effects, they mention an increased risk of wound infection between 7 and 24 months after surgery, and consequently the requirement to remove the implant. Similar observations were also presented by other authors (Momoh et al. 2014; Blough et al. 2018). In our work, the median time to remove the implant after using radiotherapy was 3–4 months after surgery.

In addition to radiotherapy, factors that increase the risk of infection complications according to Warren Peled et al. (2010) also include adjuvant chemotherapy. However, in newer works, this relationship is not shown. The lack of influence of the time of the chemotherapy administration on the risk of SSI (pre-operative vs. post-operative vs. pre- and post- vs. non-chemotherapy) was demonstrated by Chattha et al. (2018).

In approximately 1/6 of the cases discussed by us, there was no confirmation of microbiological infection, despite the presence of clinical symptoms of wound infection. The probable cause of the negative culture results was an occurrence of rare microorganisms, which do not grow on classical microbiological media and also difficulty in culturing microorganisms present in biofilms or the presence of microorganisms with special nutritional requirements (Pajkos et al 2003). This is confirmed by the results of the research made using molecular biology methods. The use of molecular techniques as well as gene sequencing omits the culture and leads to an increase in the recognition of infections (Romero et al. 2017). Management of infections in oncological patients should now include extended microbiological diagnostics to detect hard growing or non-cultivated microorganisms (Pittet et al. 2005; Al-Halabi et al. 2018).

Infections remain the most common reason for removing implants and are a serious complication of reconstruction during the treatment of breast cancer. The existence of risk factors for infection, the diversity of bacterial species that cause the implant infection, their potential for biofilm formation and natural resistance to selected groups of antibiotics, as well as the long time of infection development pose a great challenge for the effective treatment of implant infections, which in turn leads to the removal of the implant. The introduction of standardized data collection protocols in the prospective studies, especially in specialized breast cancer centers, may be helpful in the identification of the factors that increase the risk of surgical site infection after reconstruction, determination the etiology of infections, establishment of the optimal perioperative prophylaxis, in empirical therapy, as well as in post-hospital outpatient care. This should result in lower SSI rates.

Ethical approval

The study proposal was approved by the Bioethics Committee of the Collegium Medicum of Nicolaus Copernicus University in Bydgoszcz, No KB 286/2019.

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Conflict of interest

The authors do not report any financial or personal connections with other persons or organizations, which might negatively affect the contents of this publication and/or claim authorship rights to this publication.

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