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ORIGINAL PAPER

Antibiotic prophylaxis: current recommendations in plastic surgery

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Abstract

Background Guidelines for prophylactic antibiotics in surgery have long been established; however, few have focused on recommendations in plastic surgery. Surgical site infection rates remain low, yet the use of prophylactic antibiotics has surged in the past 30 years. This article summarizes current recommendations of prophylactic antibiotic use to produce consensus guidelines in plastic surgery.

Methods A literature review was conducted in the PubMed, Cochrane, and Ovid databases and studies were included if randomized controlled trials indicated a statistically significant decrease in surgical site infections. Surveys conducted by the American Society of Plastic Surgeons regarding prophylactic antibiotic use from 1975, 1985, 2000, and 2010 were compiled and analyzed.

Results Of 143 articles found, nine randomized controlled trials showed a reduction in surgical site infections after antibiotic prophylaxis for specific plastic surgery procedures. There are evidence-based recommendations for prophylactic antibiotics in breast surgery, abdominoplasty, contaminated hand or face surgery, prosthetic surgery, rhinoplasty, microsurgery, and acute and burn reconstruction cases. The proportion of plastic surgeons using prophylactic antibiotics has steadily increased from 1975 to 2010 with a significant increase from 2000 to 2010.

Conclusions Systemic antibiotic prophylaxis is recommended for use in breast surgery, abdominoplasty, contaminated hand or face surgery, prosthetic surgery, rhinoplasty, microsurgery, and acute and burn reconstruction cases. Recent surveys indicate that the majority of plastic surgeons continue to use prophylactic antibiotics in clean cases of the hand, face, and body despite recommendations. Additional procedure-specific randomized controlled trials are necessary to provide evidence-based recommendations for antibiotic prophylaxis in plastic surgery.

Level of Evidence: Level IV, risk / prognostic study

Keywords Antibiotic prophylaxis · Antibiotic guidelines · Antibiotics plastic surgery

Introduction

Guidelines for prophylactic antibiotics in surgery have long been established; however, few have focused specifically on recommendations for plastic surgery procedures [1]. Plastic surgeons use prophylactic antibiotics in hopes of preventing surgical site infections, but may be doing so based on personal experience, prior training, and medicolegal concerns in an era of defensive medicine [2, 3].

Although the benefits of antibiotics are clear, they are not without risk. Antibiotic overuse has been associated with the creation of multidrug-resistant organisms in addition to harmful side effects especially in the pediatric population [4–6]. The incidence of *Clostridium difficile* infections has been increasing with antibiotic use causing it to become the most common cause of healthcare-associated infections in US hospitals [7, 8]. Likewise, multidrug-resistant organisms such as methicillin-resistant *Staphylococcus aureus* are commonly found in the hospital setting and contribute to increased hospital stay, costs, and additional complications [3, 4]. Furthermore, antibiotics carry risks of allergic reactions, side effects, and anaphylaxis which can be potentially severe or life

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threatening. Some studies suggest that antibiotic prophylaxis are overused in plastic surgery and may not be appropriate to adequately reduce surgical site infection (SSI) occurrence [9, 10]. Thus, when considering antibiotic prophylaxis, one must consider the benefit of reduction in infections as well as these risks.

Surgical wounds are classified as clean, clean-contaminated, contaminated, or dirty (Table 1) and traditionally have cited infection rates of < 2%, 10%, 20%, and 40%, respectively [3]. The majority of cosmetic plastic surgery procedures fall under the clean wound category as they are not infected, are closed primarily, and do not involve entering the respiratory, alimentary, genital, or urinary tracts [11, 12]. SSI rates have been reported to be as low as 1% in clean cases, yet the use of antibiotic prophylaxis has surged in the past 40 years [4, 13–15]. The most common organisms causing SSIs after clean procedures are skin flora including *Staphylococcus aureus* and coagulase-negative staphylococci (e.g., *Staphylococcus epidermidis*) [16–18]. Antibiotics should be aimed at these organisms. Currently, cefazolin remains the most commonly used prophylactic antibiotic worldwide and is administered as a one-time 2 g bolus (3 g bolus if patient weighs > 120 kg) within 60 min before surgical incision with redosing interval at 4 h [4, 19].

This article aims to summarize the recent recommendations for prophylactic antibiotic use in plastic surgery and compare these to the current trends in use. It also identifies deficiencies in current studies and gives direction to future research on the topic of preoperative antibiotics in plastic surgery.

Materials and methods

A primary review of the literature was conducted in the PubMed, Cochrane, and Ovid databases using the search terms "antibiotic prophylaxis," "surgical site infections," and "plastic surgery." Two investigators independently reviewed article titles and abstracts to identify studies of prophylactic antibiotic use in plastic surgery procedures. Articles that met these inclusion criteria then underwent full article review. Additional articles were added by manual review of the references of the articles. Multiple meta-analyses and randomized controlled trials were reviewed and included in the recommendation column if statistically significant reduction in SSI was proven. Articles were excluded if antibiotics were not given within 0 to 60 min preoperatively or if no significant reduction in SSI was found. Both original and review articles were included to maximize the amount of available information for review. Articles demonstrating non-significant reductions in SSIs were excluded due to an inability to draw definitive conclusions for guidelines from this data. These criteria were chosen to draw conclusions about prophylactic antibiotic practices which are shown to reduce SSI (Fig. 1).

To create Table 2, the data from four different surveys of members of the American Society of Plastic Surgeons were reviewed and compiled in an Excel spreadsheet (Microsoft Corp., Redmond, Wash). For all surveys included, the percentages of respondents using prophylactic antibiotics more than 50% of the time for a given procedure were recorded (Table 2). To determine the trend of use of prophylactic antibiotics over time, the 2010 survey responses were compared to the 2000 survey responses using a *z*-test. When there were

Table 1 Surgical wound classification

Class	Type	Definition	Examples in plastic surgery
I	Clean	An uninfected operative wound in which no inflammation is encountered and the respiratory, alimentary, genital, or uninfected urinary tract is not entered. In addition, clean wounds are primarily closed and, if necessary, drained with closed drainage. Operative incisional wounds that follow nonpenetrating (blunt) trauma should be included in this category if they meet the criteria.	Reduction mammaplasty, abdominoplasty, blepharoplasty, rhytidectomy, brow lift
II	Clean-contaminated	An operative wound in which the respiratory, alimentary, genital, or urinary tracts are entered under controlled conditions and without unusual contamination. Specifically, operations involving the biliary tract, appendix, vagina, and oropharynx are included in this category, provided no evidence of infection or major break in technique is encountered.	Septoplasty, rhinoplasty, labiaplasty
III	Contaminated	Open, fresh, accidental wounds. In addition, operations with major breaks in sterile technique (e.g., open cardiac massage) or gross spillage from the gastrointestinal tract, and incisions in which acute, nonpurulent inflammation is encountered are included in this category.	Lacerations, open fractures
IV	Dirty or infected	Old traumatic wounds with retained devitalized tissue and those that involve existing clinical infection or perforated viscera. This definition suggests that the organisms causing postoperative infection were present in the operative field before the operation.	Abscess, grossly infected prosthesis

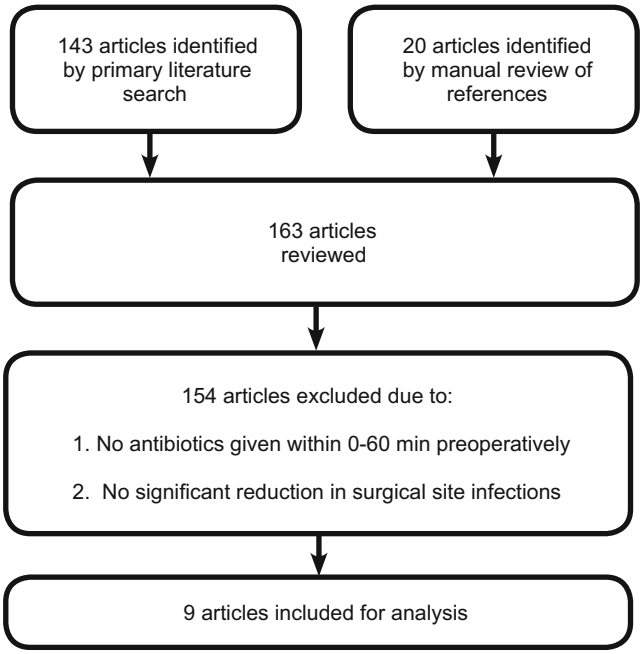

Fig. 1 Study inclusion flow-chart

no results in the 2000 survey, percentages from the 1985 survey were used to compare to 2010 results using a *z*-test. *p*-values less than 0.05% were considered statistically significant.

Results

The primary literature search returned 143 articles. The titles and abstracts were reviewed along with the references, which yielded 20 articles. Articles were excluded if antibiotics were not given within 0 to 60 min preoperatively or if no significant reduction in SSI was found. A final number of nine articles were included (Table 3).

A multitude of articles found antibiotic prophylaxis to be unnecessary in plastic surgery [29]. Despite these recommendations, surveys of American Society of Plastic Surgeons members from 1975, 1985, 2000, and 2010 revealed increased use of prophylactic antibiotics over time [13–15, 30]. In most plastic surgery procedures, antibiotic prophylaxis usage significantly increased from 2000 to 2010 or from 1985 to 2010 ($p < 0.05$). The only procedures for which there was no statistically significant increase were malar/chin implants, rhinoplasty with implants, human bite to face, and inpatient burns. This was thought to be due to the compared values being too similar and thus no significant increase was appreciated between the two values.

Ariyan et al. [20] recently published an evidence-based consensus from the American Association of Plastic Surgeons and included prophylaxis recommendations for a number of plastic surgery procedures. After analysis of randomized controlled trials, the study concluded that antibiotic prophylaxis is recommended for clean breast and contaminated hand or head and neck surgery, but not for clean hand, skin, head and neck, or abdominoplasty procedures, although level of evidence was very weak in the latter procedures [20]. In addition, a prospective, randomized, double-blind study of 1340 patients undergoing hand surgery found no difference in SSI amongst the placebo and antibiotic use groups [31]. A study of 8850 cases by Bykowski et al. [32] also determined that antibiotic prophylaxis had little impact on preventing SSI after clean hand surgery.

Another systematic review by Mundinger et al. [33] from 2015 recommended the use of perioperative antibiotics in all facial fractures, but were unable to prove a statistically significant reduction in SSI. Antibiotic prophylaxis in facial fractures remains a debated topic and no consensus has been reached regarding use for nonoperative management of closed fractures [34].

Breast surgery is widely regarded as clean surgery, although with the use of implants, it has recently been further studied to provide more accurate recommendations for antibiotic prophylaxis. A meta-analysis by Shortt et al. [22] found that preoperative antibiotic use in breast reductions significantly decreased the incidence of SSI when compared to a control group. For augmentation mammoplasty, Hardwicke et al. [21] also found a significant reduction in SSI ($p = 0.02$) and that this was most profound with a single preoperative antibiotic dose ($p = 0.02$) when compared with controls. In an earlier study, Amland et al. [23] proved a significant reduction in surgical site infections when using preoperative antibiotics in breast surgery as well as reconstructive surgery with flaps. Khan [24] determined in a retrospective analysis of antibiotic regimens used to prevent periprosthetic infections in breast augmentation procedures that a single intravenous antibiotic treatment reduced infections from 1.2 to 0.8%.

Prophylactic antibiotic use in abdominoplasty has been debated since 2007. Proponents of use argue that abdominoplasty surgeries are generally more involved, lengthier, and have incisions in abdominal creases and around the umbilicus, which are generally regarded as dirty [35]. A 7-year retrospective audit of 300 abdominoplasties in which no perioperative antibiotic prophylaxis was used found that 8% of patients experienced an infection that needed postoperative treatment [35]. Another study of 258 abdominal dermolipectomies found that 7% of patients developed an infection [36]. Others argue that abdominoplasty is a clean procedure of the skin and does not warrant antibiotic prophylaxis. One randomized control trial by Sevin et al. [25] from 2007 found that there was a statistically significant decrease in surgical site infection in 207 abdominoplasty patients when one preoperative intravenous dose of antibiotic was compared to no antibiotic. Unfortunately, this is the only randomized controlled trial conducted on this topic for this procedure.

Table 2 Procedure-specific recommendations and trends in prophylactic antibiotic use in plastic surgery

Category	Procedure	Recommended	1975	1985	2000	2010	*p* value	
Aesthetic	Abdominoplasty	YES	31	43	88	95	< 0.0001	
	Blepharoplasty	NO	7	11	47	64	< 0.0001	
	Brachioplasty	NO	–	24	81	89	< 0.0001	
	Breast augmentation	YES	43	59	94	98	< 0.0001	
	Breast reduction	YES	30	44	88	94	< 0.0001	
	Brow lift	NO	–	–	67	–	–	
	Buttock lift	NO	–	41	87	83	0.005	
	Chemical peel	NO	–	17	49	39	< 0.0001	
	Dermabrasion	NO	–	17	60	53	0.0005	
	Laser resurfacing	NO	–	–	74	–	–	
	Liposuction (suction-assisted)	NO	–	33	79	86	< 0.0001	
	Liposuction (ultrasound-assisted)	NO	–	–	81	–	–	
	Malar/chin implants	YES	–	64	93	93	0.92	
	Rhinoplasty	YES	25	24	78	88	< 0.0001	≥ 50%
	Rhinoplasty + alloplastic implant	YES	50	74	93	93	0.64	< 50%
	Rhinoplasty + cartilage graft	YES	–	50	88	91	0.02	
	Rhinoplasty + septoplasty	YES	–	31	80	88	< 0.0001	
	Rhytidectomy	NO	16	22	73	84	< 0.0001	
	Thighplasty	NO	–	41	88	93	< 0.0001	
Craniofacial/maxillofacial	Cleft lip	N/A	20	26	–	79	< 0.0001	
	Cleft palate	N/A	44	46	–	83	< 0.0001	
	Facial fracture treatment—closed	N/A	18	43	–	50	0.0006	
	Facial fracture treatment—open	YES	68	76	–	94	< 0.0001	
	Facial lacerations	YES	20	20	–	43	< 0.0001	
	Microtia treatment	N/A	49	58	–	90	< 0.0001	
	Otoplasty	N/A	14	26	–	80	< 0.0001	
	Pharyngeal flap	N/A	–	48	–	84	< 0.0001	
Hand	Arthroplasty with implant	YES	–	78	–	94	< 0.0001	
	Carpal tunnel release	NO	19	18	–	49	< 0.0001	
	Congenital hand	NO	11	19	–	67	< 0.0001	
	Traumatic	YES	69	82	–	91	< 0.0001	
Skin/miscellaneous	Composite graft	N/A	–	–	–	89	–	
	Dog bite to face	YES	78	90	–	94	0.0005	
	Dog bite to hand	YES	–	94	–	97	0.0008	
	Full thickness skin graft	N/A	–	32	–	79	< 0.0001	
	Human bite to face	YES	90	97	–	98	0.13	
	Human bite to hand	YES	–	99	–	98	0.03	
	Split thickness skin graft—clean	N/A	28	25	–	82	< 0.0001	
	Split thickness skin graft—contaminated	YES	–	77	–	94	< 0.0001	
Reconstructive	Breast reconstruction (flap)	YES	–	53	–	95	< 0.0001	
	Breast reconstruction (implant)	YES	–	66	–	98	< 0.0001	
	Free tissue transfer	YES	29	64	–	92	< 0.0001	
	Myocutaneous flap	YES	–	46	–	93	< 0.0001	
Burn	Burn reconstruction	YES	–	36	–	83	< 0.0001	
	Inpatient	YES	85	69	–	66	0.11	

Data values are percentages of plastic surgeons that used prophylactic antibiotics in greater than 50% of the listed cases. Whenever percentages of plastic surgeons from 2000 were not available, then 2010 percentages were compared with 1985 values by *z*-test to arrive at the *p* value. Under the "recommended" heading, YES indicates there is statistically significant evidence that prophylactic antibiotics decrease SSI. N/A indicates that no randomized controlled trials have been done or that conflicting data exists. NO indicates that randomized controlled trials indicate no statistically significant reduction in SSI for the class of procedure

Several study findings demonstrate the need and benefit of using antibiotic prophylaxis in implant and prosthetic surgeries [37–40]. Another study by Toia et al. [26] from 2012 gave a more comprehensive recommendation for prophylactic antibiotic use. It recommended prophylaxis in microsurgery, prosthetic surgery, incisional hernias, clean non-prosthetic osteoarticular surgery, and clean-contaminated procedures of the oral cavity or genitourinary system. Interestingly, it also concluded that in clean surgery and rhinoplasty, antibiotic prophylaxis is only indicated when the operation lasts more than 3 h and/or the American Society of Anesthesiologists score is 3 or more [26]. This is one of the few studies that took into consideration patient comorbidities and length of procedure highlighting the complexity of deciding if prophylactic antibiotics are indicated.

Antibiotic use in burn surgery is recommended perioperatively for both inpatient burns and burn reconstruction procedures. A randomized controlled trial by Alexander et al. [27] from 1982 showed a significant reduction in SSI with preoperative antibiotics in clean skin graft reconstructive

Table 3 Included studies demonstrating statistically significant decrease in surgical site infection

Citation	Study design	Conclusion—yes	Conclusion—no	Year
Ariyan et al. [20]	Evidence-based consensus from AAPS; includes 67 studies	Antibiotic prophylaxis recommended for clean breast and contaminated hand or head and neck surgery	Not recommended for clean hand, skin, head, and neck or abdominoplasty procedures	2015
Hardwicke et al. [21]	Meta-analysis of 2971 patients	Single preoperative antibiotic dose, reduction in SSI in augmentation mammoplasty (50% reduction)		2013
Shortt et al. [22]	Meta-analysis of 3 randomized controlled trials for preoperative antibiotics	Preoperative antibiotic in breast reductions significantly decreased incidence of SSI (75% reduction)		2014
Amland et al. [23]	Randomized double-blind placebo controlled, 171 patients	Preoperative antibiotic in breast and reconstructive surgery with flap-reduced SSI	No reduction in SSI for cleft lip and palate	1995
Khan [24]	Retrospective analysis of 1628 patients	Single IV antibiotic reduced infection in breast augmentation from 12 to 0.8%	Extra duration of antibiotic does not result in reduced superficial or periprosthetic infection	2010
Sevin et al. [25]	Randomized controlled trial, 207 abdominoplasty patients	Significant decrease in SSI with preoperative IV antibiotic compared to no antibiotic		2007
Toia et al. [26]	Prospective trial, 1100 patients	Clean and rhinoplasty—antibiotics indicated if operative > 3 h, and/or ASA score ≥ 3		2012
Alexander et al. [27]	Randomized prospective double-blind trial	Reduction in SSI with preoperative antibiotics in clean skin graft reconstruction for burn injury (0.8% vs. 5.7%)		1982
Avni et al. [28]	Systemic review and meta-analysis of randomized and quasi-randomized controlled trials	Reduction in burn wound infections and pneumonia when prophylactic perioperative antibiotics were used in inpatient burn surgery		2010

procedures after burn injury. Another meta-analysis from Avni et al. [28] showed a significant reduction in burn wound infections and pneumonia when prophylactic perioperative antibiotics were used in inpatient burn surgery.

Discussion

There has been a marked increase in the use of antibiotic prophylaxis in plastic surgery over the last 40 years [13–15, 30]. Despite our increased understanding of the risks of antibiotics, we continue to focus solely on the reduction in surgical site infection as the outcome when measuring prophylactic antibiotic effects. Due to the lack of randomized controlled trials specifically addressing antibiotic prophylaxis in plastic surgery, there are no general guidelines for use in these procedures [1].

Many practicing plastic surgeons do not routinely use Table 1 to categorize the surgical wounds created in their cases, and thus do not truly understand for which procedures antibiotics are recommended. It is our hope that Table 2 will provide a comprehensive review of the trends in antibiotic use along with the current evidence-based recommendations for use by providing procedure-specific guidelines. Based on this analysis, it appears that many surgeons are utilizing antibiotic prophylaxis in cases where they are not recommended and there is little to no evidence for their use and not utilizing antibiotics in cases where they are recommended and there is evidence for their use. While the decision to administer antibiotics must be evaluated on a case by case basis, we hope that the information presented in this study will implore individuals to more thoroughly evaluate the risk-benefit ratio of their antibiotic utilization practices.

There are a number of different factors that alter risk of surgical site infections, such as skin flora, patient comorbidities, preoperative skin wash, preoperative hair shaving, intraoperative airborne particles, and class and length of the procedure as well as antimicrobial prophylaxis. We were unable to find studies that controlled all these factors in addition to antimicrobial prophylaxis. Future studies should include as many of these factors as possible for superior results.

The economic effect of antibiotic prophylaxis is another consideration when deciding use in plastic surgery. In a 2015 study, Skaar et al. [41] developed a Markov decision model to compare the cost-effectiveness of different antibiotic prophylaxis therapies before dental procedures in patients who had undergone total hip arthroplasty. The model determined that the most cost effective strategy was for the patient to receive no antibiotic prophylaxis, suggesting that rates of surgical site infection complications are low and the complications created by antibiotics may have a high cost. More research on the cost-effectiveness of antibiotic prophylaxis for various plastic surgery procedures is needed.

Another consideration when deciding the need for antibiotic use in plastic surgery is the timing and duration of treatment. A

study by Huang et al. [42] found that extended treatment with prophylactic antibiotics postoperatively after breast augmentation could decrease infection compared to treatment limited to within 24 h of the procedure. This study not only verifies the need for antibiotics for breast implantation but also demonstrates that duration of treatment could impact their effectiveness in preventing infection. These findings were further supported by a retrospective study by Clayton et al. [43], which demonstrated that a single treatment resulted in a higher risk of infection in breast reconstruction patients when compared to patients that received a short course of postoperative antibiotics.

On the other hand, several studies have demonstrated that a single preoperative treatment is as effective as continued treatment. For example, a matched cohorts study by Townley et al. [44] found that administration of a preoperative antibiotic in implant-based breast reconstruction surgery was as effective as extended postoperative treatment. Elucidation of the differences in these studies is essential to identifying the most appropriate level of treatment needed under specific conditions to prevent infection without causing additional harm.

In addition to investigating the conditions under which antibiotic prophylaxis is most effective, benefits other than preventing infection should be considered. A retrospective study of 1915 patients that underwent implantation procedures revealed that antibiotic treatment improved tissue healing and increased the success of the procedure [45].

Limitations to our study included poor quality of randomized controlled trials, as well as lack of studies for some specific procedures. We assumed that brow lift, blepharoplasty, brachioplasty, buttock lift, chemical peel, dermabrasion, laser resurfacing, liposuction, rhytidectomy, and thighplasty would fall under the clean classification when providing our recommendations. Additionally, including only studies which demonstrated a significant reduction in surgical site infections leads to a bias in favor of promoting antibiotic use. This study included only studies with significant findings in order to attempt to provide decisive guidelines despite the acknowledgement that this may overestimate the true effect.

Cost of antibiotic is not a significant issue in our recommendations because in the majority of cases cefazolin is the prophylactic antibiotic of choice and is relatively inexpensive. At our institution, a 1-g vial of cefazolin costs $1.04. Likewise, at Shriner's Hospitals for Children, the cost is $0.77. We did not, however, examine the costs of antibiotic prophylaxis-related complications such as longer hospital stays due to side effects, or extended treatment of multidrug-resistant organisms. Again, research should be conducted in this area to examine not only costs, but also the additional morbidity associated with complications of antibiotic use.

In cases where prophylactic antibiotics are not indicated, the risk of surgical site infections can be minimized with standard surgical precautions, including prepping and draping the patient in the normal sterile fashion and strict adherence to sterile technique throughout the case. Patients should be counseled to monitor for common signs and symptoms of surgical site infections, including systemic fever and chills as well as pain, erythema, and drainage from the wound. Additionally, the patient should be instructed to immediately notify the surgical team if these symptoms develop such that treatment is not delayed.

Conclusions

There are evidence-based recommendations for decreasing SSI by providing antibiotic prophylaxis in certain plastic surgery procedures (Table 2). Outside of these cases, randomized controlled trials are lacking, and thus most studies regarding antibiotic prophylaxis in plastic surgery are not helpful. In addition, only focusing on reduction in SSI is not thoroughly examining the effects of antibiotics. The profound risks of antibiotics, especially the creation of multidrug-resistant organisms, must be considered and evaluated in future studies. Likewise, dosing and duration of antibiotics as well as cost analysis need to be studied. Despite the recommendations for or against antibiotic prophylaxis, plastic surgeons are using their own algorithms for deciding use. Until randomized controlled trials are completed for each procedure in plastic surgery, there can be no clear recommendations for antibiotic prophylaxis.

Compliance with ethical standards

Conflict of interest Shana S. Kalaria, Thanapoom Boonipat, J. Michael Smith, and Eric L. Cole declare that they have no conflict of interest.

Ethical approval For this type of study formal consent is not required.

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