



# Noninfectious Wound Complications in Clean Surgery: Epidemiology, Risk Factors, and Association with Antibiotic Use

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Published online: 15 February 2011  
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## Abstract

**Background** Noninfectious wound complications are frequent and often are confused with and treated as infection.

**Methods** We assessed the epidemiology, impact, risk factors, and associations with antibiotic use of noninfectious wound complications in clean orthopedic and trauma surgery. We report a single-center, prospective, observational study in an orthopedic department.

**Results** Among 1,073 adult patients, 630 (59%) revealed clinically relevant postoperative noninfectious wound complications, leading to a significant prolongation of hospital stay (14 vs. 12 days; Wilcoxon rank-sum test;  $p < 0.02$ ) compared with patients without complications. The most frequent and severe complications were discharge with dehiscence ( $n = 437$ ; 41%) and hematoma ( $n = 379$ ; 35%). Forty-seven patients (47/630; 7%) underwent reoperation for dehiscence ( $n = 39$ ) or hematoma ( $n = 8$ ). These patients made up 4.3% of the entire study population (47/1,073). In multivariate analysis, an ASA score  $\geq 2$  points, age  $\geq 60$  years, surgery duration for  $\geq 90$  min, implant-related surgery, and poor compliance toward nurses' recommendations were pronounced risk factors for these complications, whereas antibiotic-related parameters had no influence. Staple use was significantly associated with wound discharge but not with hematoma.

**Conclusions** Wound complications, such as dehiscence with discharge or hematoma after clean orthopedic and trauma surgery, are frequent with an overall incidence of 60%. Although they lead to few surgical reinterventions, they prolong hospital stay by 2 days. Few clinical parameters show association with wound complications. Among them, improvements of patient compliance and avoidance of staples use for skin closure are the most promising actions to decrease complication risk.

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Parts of the manuscript have been presented at the European Wound Management Association's Annual Congress in Geneva, May 27, 2010.

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## Introduction

Noninfectious wound complications in the postoperative patient are far more frequent than surgical site infections (SSI). Even in the absence of infection, wound complications may prolong hospital stay and add to overall costs [1–3]. Nationwide benchmarking has been attempted, but

in contrast to SSI, little is known about the epidemiology, associated risk factors and potential preventive measures regarding noninfectious wound complications [4, 5]. The few available reports in the literature are retrospective or heterogeneous, involving various surgical techniques and disciplines (mostly cardiovascular surgery and orthopedic surgery) [1, 6–12]. Moreover these studies only include a couple hundred patients or solely address severe wound complications that require surgical reintervention [3, 6, 7, 9, 13–17]. Thus, it seems that minor wound complications often go unreported. However, such minor complications may lead to significant morbidity and entail therapeutic consequences on short-term management. For instance, it is not uncommon for discharging and dehiscent wounds to be interpreted as a SSI, especially in the case of concomitant inflammation, fever, and implant surgery. In such cases, many of these patients will presumably undergo empiric antibiotic treatment without clear evidence, with potential undesirable side effects and higher economic costs.

In this prospective cohort study, we assessed the epidemiological profile of clinical relevant noninfectious wound complications with an impact on the length of hospital stay after clean surgery. We chose an orthopedic department as lieu of study. We established risk factors, investigated associations with antibiotic use, and suggest possible means for prevention.

## Methods

### Settings, protocols, and common habits

The Geneva University Hospitals are a 2,200-bed tertiary hospital. Wound healing has been developed and promoted as one of the facility's major multidisciplinary programs. The Wound Care Team, composed of physicians and specialized nurses (<http://plaies-cicatrization.hug-ge.ch>), works on a daily basis at the patient's bedside to enhance wound management (postoperative, traumatic, ulcers, or burns) and helps standardize the approach to wound caring. The Orthopaedic Department has 5 units, 134 acute care beds, and performs more than 500 arthroplasties for a total of 5,000 operations annually [18]. One hospitalization day on a regular ward costs approximately \$1,300 U.S. per capita.

### Antibiotic policy, surgical, and postsurgical period

Surgery is performed according to international recommendations and evidence. "Minimally invasive techniques" were not used during the study period [19]. An intravenous dose of 1.5 g of cefuroxime is considered standard preoperative antibiotic prophylaxis (replaced by

1 g of vancomycin in case of methicillin-resistant *S. aureus* (MRSA) body carriage). The antibiotic prophylaxis is prescribed by surgeons and compliance is generally 100% regarding choice of antibiotic agent and 90% concerning timing [18]. In contrast, duration of antibiotic prophylaxis has not been standardized during the study period and may be excessive in some cases [18].

Preoperative skin preparation consists of two showers using a chlorhexidine or povidone-iodine solution the previous evening and the morning before going into surgery, if feasible. In the operating room, preparation of the surgical site is performed by three successive applications of a povidone-iodine and alcohol-based skin disinfectant immediately before sterile draping. Closed suction drains are removed after 48 h and urinary catheters as soon as possible [14, 20, 21]. The first postoperative dressing change normally occurs at Day 2 and is repeated every 72 h until Day 14 by nurses wearing nonsterile gloves after hand disinfection with an alcohol-based solution [22]. Wound disinfection is performed with a Betadine-based solution before antiseptic (usually povidone-iodine) dressings are applied.

Additional post-prophylactic antibiotic treatment is given in presence of overt and documented infection outside the surgical site (e.g., pneumonia or urinary tract infection). It also is administered in case of malodorous urine or a pathological urine sample in diabetic and/or dementia arthroplasty carriers. The goal of this approach is to avoid hematogenous implant infection in circumstances where the history of present symptoms cannot be relied on, although this is not evidence-based [23].

### Study population, design, and data collection

This prospective single-center, nonrandomized, open observational study included all adult orthopedic patients (age > 18 years) who were admitted from December 1, 1997 to December 1, 1998. The initial purpose of this study was to determine whether pathogens colonizing the surgical wound intraoperatively were responsible for subsequent SSI [24]. However, the database was excessive enough to perform a satellite study. The nurse in the study (AA) followed all wounds on a twice-daily basis (weekends excluded) until hospital discharge and gathered data from 53 variables. The variables included demographic parameters and comorbidities: gender, age, body mass index (BMI), physically demanding professional activity, stay in a home or other long-term care facility, mobility (with or without external help), urine and/or stool incontinence, American Society of Anesthesiology (ASA) score [25], renal function, citizenship, and MRSA carriage. These were completed with surgical parameters: orthopedic diagnosis, body site involved, emergency surgery, trauma, closed fracture,

surgery involving a joint, dislocation, arthroplasty and other implant surgery, delay between admission and surgery, duration of surgery, and wound closure (sutures vs. staples).

Information regarding the postoperative period also was assessed: hospitalization ward (to adjust for nursing bias), length of hospital stay, winter months (defined as November to March), occurrence of infection outside the surgical site, duration of peripheral venous catheter use, duration of urinary catheter use, and poor compliance with nurses' recommendations (compliant vs. noncompliant; according to reports from three nurses in charge of the patient). The investigated recommendations were to stay in bed, do not shower, acceptance of dressing makeover, and wound care. Antibiotic-related parameters were also taken into account: adequacy of antibiotic prophylaxis, number of prophylactic doses administered, antibiotic agents, and duration of treatment in case of postoperative remote infection appearance. Finally, wound occurrences apart from uneventful healing were assessed: dehiscence without discharge, wound dehiscence with various degrees of discharge, hematomas, and need for surgical reintervention. Exceptions were minor seromas, superficial scar necrosis, and persistent rubor of the scar without additional clinical aspects. All data concerning infection and antibiotic treatment were cross-checked by an infectious diseases physician specialized in orthopedic infections (IU) [18, 26]. This study was an observational Institutional Quality Improvement Project. Neither Ethical Committee's approval nor informed consent from participating patients was required.

#### Inclusion and exclusion criteria

An intact skin on admission and a postoperative observation period of at least 5 days were prerequisites to be included in the study. For patients undergoing surgery without implant insertion, clinical follow-up was 1 month; otherwise it was 1 year [24]. Exclusion criteria were: open fractures, presence of coetaneous infection or any preexisting skin lesion upon admission, undergoing antibiotic treatment for any reason at time of admission, use of skin, muscular and/or bone grafts, amputation, oncologic surgery, revascularization procedure in the affected limb during the past 6 months, patients with dermatologic conditions (e.g., psoriasis, eczema), and collagen or autoimmune disorders [16, 17].

#### Statistical analysis

The primary outcome parameter was overall uneventful wound healing. Secondary endpoints were separate substrata of noninfectious wound complications that may prolong hospital stay: wound discharge and hematoma. The number of dry wound dehiscence without discharge was

too small to be investigated in detail. For each outcome parameter, a univariate logistic regression analysis was performed. Age, duration of surgery, BMI, ASA score, and the number of prophylactic antibiotic doses were analyzed both as continuous and categorized variables. Adjustment for case-mix was performed by multivariate logistic regression. Variables with a  $p$  value  $\leq 0.05$  in univariate analysis were included in a stepwise forward selection process, whereas antibiotic-related parameters were fixed covariates. Key variables were checked for collinearity and interaction—the latter by Mantel-Haenszel estimates. The number of variables in the final model was limited to the ratio of 7–10 variables to 1 outcome events [27]. To avoid data clustering and introduction of biases, only the largest surgical wound per patient was considered resulting from the first surgery performed was analyzed. For group comparisons, we used the Pearson  $\chi^2$  test or the Wilcoxon rank-sum test, as appropriate.  $p \leq 0.05$  (all two-tailed) was significant. STATA<sup>TM</sup> software (9.0, STATA Corp, College Station, USA) was used.

## Results

### Patients

A total of 1,073 surgical wounds from 1,073 patients were included in the study; 639 (60%) occurred in women. Median age was 70 (interquartile range (IQR), 53–81) years. The majority (971, 90%) was Swiss citizens and 903 lived at home (84%). A total of 225 patients (21%) were incontinent for urine and/or stool; 241 (22%) had a physically demanding professional activity. Median BMI was 25 (IQR, 22–29) kg/m<sup>2</sup> and 174 patients had an ASA score of one, 542 a score of two, 319 of three, and 38 of four. Four patients died during hospitalization (after Day 5) independently of surgical site occurrences or antibiotic-related issues.

### Surgery, indwelling devices, and antibiotic prophylaxis

All patients underwent surgery with a median delay of 1 day between admission and intervention (IQR, 0–3 days) and a median intraoperative time of 120 (IQR, 90–155) min. Surgery was urgent in 539 cases (50%): for trauma patients ( $n = 550$ ; 51%) with closed fractures ( $n = 540$ ; 50%) or dislocations ( $n = 28$ ; 3%). In 887 urgent and elective interventions, a new implant was inserted (83%); and in 35 (3%), the implant was removed. Among elective surgery, arthroplasty was performed in 418 cases (39%). Regarding body sites, 824 operations involved joint replacement or reconstruction (77%). Left ( $n = 501$ ; 47%) and right limbs were equally distributed. A total of 197

operations were performed on the foot, 42 on the calf, and 54 on the upper extremities. For wound closure, staples were used in 453 cases (42%).

Forty-eight patients (4%) had no preoperative antibiotic prophylaxis, 722 (67%) received a single prophylactic dose, 63 had 1-day prophylaxis (3 doses of cefuroxime, 6%), and 184 for a period of 48 h or more (17%). Six patients were confirmed MRSA skin carriers on admission (0.6%) and received vancomycin as a single-dose prophylaxis. The median duration of peripheral venous catheter and indwelling urinary catheter use was 4 (IQR, 3–6) days and 0 (IQR, 0–4) days, respectively.

#### Surgical site infections and remote infections

Thirteen patients (13/1,073; 1.2%) developed a SSI [28], of whom ten needed drainage in the operating room. Three superficially infected wounds were treated on the ward. The combined surgical and antibiotic treatment was effective without recurrence in all cases. In addition to SSI, 78 patients (78/1,073, 7.3%) were subject to remote bacterial infections during hospital stay [26]: 48 urinary tract infection, 26 pneumonia, 2 combined respiratory and urinary tract infections, 1 septic bursitis, and 1 axillary abscess. All causes taken together, a total of 91 patients (8%) had an overt infectious episode of some sort during the immediate postoperative period. Additionally, 83 arthroplasty carriers were diagnosed with asymptomatic bacteriuria (83/1,073, 7.7%). Of the entire population, 174 (16%) underwent antibiotic therapy for a median duration of 6 (IQR, 4–9) days.

#### Noninfectious wound complications

Wound healing without complication at all occurred in 443 patients (41%). Overall, benign noninfectious wound complications without immediate surgical consequences were seen in 630 patients (630/1,073, 59%): occurrence of discharge with various degree of dehiscence ( $n = 437$ ; 41%), dry dehiscence without discharge ( $n = 9$ ; 1%), and hematoma ( $n = 379$ ; 35%). In 196 cases, hematoma and dehiscence occurred concomitantly. Among all patients with noninfectious wound complications, 47 (47/630; 7%) were considered severe and had to undergo unplanned reoperation for dehiscence ( $n = 39$ ) or hematoma evacuation ( $n = 8$ ). These patients comprised 4.3% of the entire study population (47/1,073).

#### Length of hospital stay

The overall median length of hospital stay was 13 (IQR, 11–16) days. Group comparisons revealed a significantly

longer stay in acute care surgery for patients with any kind of noninfectious wound complication (14 vs. 12 days;  $p < 0.02$ ). Wound discharge taken alone lengthened hospital stay by a median of 2 days (14 vs. 12;  $p < 0.02$ ), whereas hematoma without discharge did not (13 vs. 13 days;  $p = 0.13$ ). In the case of SSI, hospitalization duration was 17 vs. 13 days ( $p < 0.02$ ).

#### Associated factors with wound complications

We assessed risk factors for three different outcomes (Tables 1, 2): uneventful wound healing, wound discharge, and hematoma.

#### No associations

The following variables failed to show any association with all outcomes: BMI, citizenship, physically demanding professional activity, living in a long-term care facility, independent mobility, delay between admission and surgery, occurrence in winter, hospitalization ward, right- or left-sided limb surgery, presence of remote infections, number of prophylactic antibiotic doses administered, and prescription of antibiotic treatment for a remote infection.

In all multivariate analyses, implant surgery and foot and ankle surgery were significantly associated with noninfectious wound complications. Emergency surgery and older than age 40 years were associated with hematoma, but not with discharge. Wound discharge was significantly associated with additional factors that were not shared with hematoma: ASA score  $\geq 3$  points, duration of surgery  $\geq 90$  min, and staple use. The median duration of surgery was equal whether staples or sutures were used for skin closure (120 min vs. 125 min;  $p = 0.72$ ).

Regarding the variables—emergency, trauma, fracture, renal function, implant and/or arthroplasty insertion, duration of peripheral venous catheter use, duration of urinary catheter use, and stay in long-term care facility—hematoma and inflammation showed substantial interaction with each other and are not reported in multivariate analysis (Table 2).

## Discussion

In this study, we evaluated 1,073 patients for postoperative wound complications. We report a 60% incidence of minor or major wound complications, excluding SSI, among adult orthopedic and traumatology patients without preexisting skin or infectious conditions. Our prospectively assessed results are higher than those found in literature, reporting a 13% risk for dehiscence or a complication rate of 6% for elective and 16% for emergency surgery [2, 3]. However,

**Table 1** Patient group comparison of complicated vs. uncomplicated wound healing: key parameters

|  | Complicated<br>(n = 630) | Uncomplicated<br>(n = 443) | p value<br>(two-tailed) |
|--|--------------------------|----------------------------|-------------------------|
| <i>Patient characteristics</i>                         |                          |                            |                         |
| Female gender  | 369 (58%)                | 270 (42%)                  |                         |
| Median age (year)                                      | 74                       | 66                         | 0.01*                   |
| Median body mass index (kg/m <sup>2</sup> )            | 26                       | 25                         |                         |
| ASA score ≥ 3 points                                   | 232 (37%)                | 126 (28%)                  | 0.01*                   |
| Median Charlson index (points)                         | 0                        | 0                          |                         |
| Immune suppression                                     | 39 (6%)                  | 18 (4%)                    |                         |
| Poor compliance to nurses recommendations              | 115 (19%)                | 51 (13%)                   | 0.01*                   |
| Median length of hospital stay in acute care (days)    | 14                       | 12                         | 0.01 <sup>±</sup>       |
| <i>Surgery</i>   |                          |                            |                         |
| Emergency surgery                                      | 347 (56%)                | 192 (47%)                  | 0.01*                   |
| Foot and ankle surgery                                 | 100 (16%)                | 97 (21%)                   | 0.03*                   |
| Wound closure with staples                             | 314 (51%)                | 139 (31%)                  | 0.01*                   |
| Median duration of surgery (min)                       | 120                      | 125                        |                         |
| <i>Antibiotics</i>                                     |                          |                            |                         |
| No antibiotic prophylaxis                              | 24 (4%)                  | 24 (6%)                    |                         |
| Single dose prophylaxis                                | 443 (72%)                | 279 (69%)                  |                         |
| One-day antibiotic prophylaxis (3 doses)               | 46 (7%)                  | 23 (6%)                    |                         |
| Prophylaxis for more than 48 hr                        | 104 (17%)                | 80 (20%)                   |                         |
| Antibiotic treatment for remote infection/colonization | 48 (7%)                  | 30 (7%)                    |                         |
| Median duration of antibiotic treatment (days)         | 6                        | 6                          |                         |

Percentages indicate the proportion of the variables inside the groups, missing data included

Only significant p values ≤0.05 are displayed

\*  $\chi^2$  test; <sup>±</sup> Wilcoxon rank-sum test

**Table 2** Detailed multivariate regression analysis

| Outcome  | Uncomplicated<br>wound healing | Wound<br>discharge  | Hematoma            |
|--|--------------------------------|---------------------|---------------------|
| <i>Patient characteristics</i>                         |                                |                     |                     |
| Age between 40 and 60 year*                            | 0.7, 0.4–1.1                   | 1.5, 0.9–2.5        | <b>1.7, 1.0–2.8</b> |
| Age > 60 year*   | 0.5, 0.3–8.3                   | 1.6, 0.9–2.6        | <b>2.0, 1.3–3.2</b> |
| ASA score ≥ 3 points <sup>+</sup>                      | <b>0.5, 0.3–0.8</b>            | <b>1.5, 1.1–2.1</b> | 0.9, 0.7–1.3        |
| Poor compliance to nurses recommendations              | 0.7, 0.5–1.1                   | <b>1.5, 1.1–2.2</b> | 1.0, 0.7–1.5        |
| <i>Surgery</i>   |                                |                     |                     |
| Emergency surgery                                      | 1.0, 0.7–1.3                   | 0.8, 0.6–1.1        | <b>1.5, 1.1–2.1</b> |
| Insertion of implant                                   | <b>0.4, 0.3–0.6</b>            | <b>1.7, 1.1–2.7</b> | <b>1.7, 1.1–2.7</b> |
| Limb surgery   | 1.1, 0.7–1.6                   | 1.3, 0.5–3.2        | 0.8, 0.4–1.8        |
| Foot and ankle surgery                                 | <b>0.6, 0.4–0.8</b>            | <b>0.2, 0.1–0.4</b> | <b>1.8, 1.2–2.8</b> |
| Duration of surgery for more than 90 min               | <b>0.7, 0.5–0.98</b>           | <b>1.7, 1.2–2.4</b> | 1.3, 0.9–1.9        |
| Use of staples   | <b>0.6, 0.5–0.9</b>            | <b>2.5, 1.8–3.4</b> | 0.9, 0.7–1.2        |
| <i>Antibiotics</i>                                     |                                |                     |                     |
| Single-dose antibiotic prophylaxis                     | 0.7, 0.4–1.5                   | 1.4, 0.7–2.8        | 1.4, 0.7–2.5        |
| Prophylaxis for more than 48 hr                        | 0.7, 0.3–1.7                   | 1.7, 0.8–3.6        | 1.6, 0.7–3.6        |
| Presence of remote infection                           | 0.9, 0.4–2.0                   | 0.9, 0.6–1.5        | 1.0, 0.5–2.0        |
| Antibiotic treatment for remote infection/colonization | 1.6, 0.8–3.2                   | 1.6, 0.9–2.9        | 1.3, 0.8–2.1        |

Bold results are statistically significant (two-tailed  $p \leq 0.05$ )

Results are rounded up to the decimal and are shown as odds ratio with 95% confidence intervals

\* Compared with <40 years

<sup>+</sup> Compared with ASA scores of 1 and 2 points

most available literature is based on retrospective studies or will encompass severe complications only [1, 6–8]. Therefore, the comparison with other studies of our reported rate of wound complications may not be appropriate, because we have acknowledged even the slightest complication arisen at the surgical site independently of its clinical significance [6, 7]. The proportion of patients who need surgical reintervention was small (4.3%), further emphasizing that the vast majority of registered complications had a benign outcome.

However clinically irrelevant such minor complications might be, these wound disorders may have substantial administrative and financial consequences. In our prospective study, patients with wound complications had a median stay in the hospital 2 days longer than patients with uneventful wound healing. Significant prolongation of hospital stays due to noninfectious wound complications also have been reported in other studies [1, 2, 29]. In Switzerland, this additional day in an acute care hospital setting represents an additional cost of \$1,300 U.S. per patient. If we assume certain homogeneity for all patients with wound complications during 1 year, these costs may represent an economic burden of at least 1 million U.S. dollars for a tertiary hospital's orthopedic department. This remains speculative, because the study design was not made for and does not prove any direct financial causal relationship.

Few parameters were significantly associated with the three outcomes uneventful wound healing, hematoma, or wound discharge. Implant-related surgery and foot and ankle surgery were the only parameters that yielded statistically significant relationships with all wound outcomes. Whereas daily clinical experience confirms that implant surgery is a risk factor for wound complications, we are surprised to notice that foot and ankle surgery is an independent risk factor, for which the reasons remain hypothetical. A theory could be that due to thin subcutaneous tissue, postoperative edema might exaggeratedly impede on small vessel functioning through various mechanical and inflammatory factors, thus leading to decreased irrigation of the skin and possibly hindering the healing process. Importantly, antibiotic-related parameters (prophylaxis or antibiotic treatment for a remote infection) did not alter the risk for all noninfectious wound complications. This underscores the fact that if a single dose is clearly evidence-based, prolonged antibiotic administration is not [5].

Other clinical variables showed only significant association with hematoma (emergency surgery, age older than 40 years) or wound discharge (poor compliance, duration of surgery exceeding 90 min, high ASA score, and staple use). Poor compliance meant refusal of the patient to stay in bed, to adequately elevate the operated limb, or to keep

it in the recommended position. In our study, as well as in another concerned with the field of cardiac surgery [10], staples favored wound discharge [11], whereas they are not a known risk factor for SSI [3, 5, 10, 30]. The major indication for staple use is to shorten the wound closure time, perhaps at the expense of higher costs [3]. We showed that stapled wound discharge was associated with a prolonged hospital stay (median, 2 days). In other words, it seems that wanting to spare a few minutes in the operating room by using staples might generate important costs by the use of this same technique. Moreover, this time gain is not guaranteed. In our analysis, comparison between staple use and suture did not influence median procedure time (120 vs. 125 min). Other factors associated with wound dehiscence have been retrospectively investigated for deep fascial dehiscence in abdominal surgery, but not regarding skin dehiscence. Interestingly, the identified factors were almost inherent to the patient, such as age, chronic pulmonary disease, emergency surgery, or jaundice [31, 32] and thus were not modifiable in terms of prevention. Finally, older age, long-lasting surgery, or emergency surgery are sometimes reported as independent risk factors for wound dehiscence [29, 32, 33].

Our study has limitations: (a) It is a single-center study among adult patients, limiting the ability to generalize to other settings or patient populations; (b) Although a lot of exogenous and endogenous variables have been incorporated in the analysis, many others may remain undetected, e.g., patient's race, detailed surgical technique, history of smoking [2, 8, 30], serum zinc level [13], preoperative albumin levels [34, 35], comorbidities [17, 36], such as immune suppression [16, 30, 37] (diabetes [7, 35] or steroid medication [33, 35]), assessment of nutritional status [33, 35], adequacy of subcutaneous suture, suture material [3], wound depth, cosmetic issues [3], surgeon's aptitude [28], intraoperative normoglycemia [38, 39], blood loss [1], time to complete wound healing [39], pain [39], C-reactive protein (CRP) levels, leukocyte count, or postoperative oxygen therapy [40]; (c) For variables associated with hematoma, our database lacked information about anticoagulation [1, 6], bleeding disorders [1, 6], and the degree of peripheral arterial occlusive disease [30]; (d) "Minimally invasive techniques" [19], vacuum-assisted devices [41], and different drainage systems were not used. Hence, we cannot assess their influence on wound complications or hematoma. Literature suggests that there is no difference in wound healing between drained and undrained wounds [12, 14]; (e) We also lack parameters regarding the postoperative wound care, such as the duration of dressing makeover, individual use, and amount of antiseptic agents employed. There exists only sparse literature about surgical wound care and prevention of noninfectious complications and SSI. Level A studies especially are still missing [42].

A Cochrane review assessed the effectiveness of various dressings and topical agents on surgical wound healing (and infection) and stated that the trial's quality was insufficient to determine any superiority of one protocol or one topical agent [43]. Randomized studies comparing occlusive vs. gauze dressings failed equally to detect superiority of one method compared with another in terms of SSI reduction or wound healing [15, 39, 42, 44]. In our study, protocols for wound care were identical for all patients in the department and were applied in a similar fashion during the entire study period. The variable “ward” was not associated with any distinctive outcome in univariate analyses, excluding a substantial bias among healthcare workers.

### Conclusions and perspectives

Our systematic and close follow-up study of all surgical scars after orthopedic procedures in adults shows that numerous benign to more severe local complications occur, that strict compliance to health care provider's recommendations remains a major positive factor for proper wound healing, that foot and ankle surgery as well as staple use are associated with complicated healing, and finally that prolonged antibiotic use has no influence on healing outcome. The incidence of clinically irrelevant wound complications is very high and probably has a significant economic impact. Reducing the incidence of wound complications can most likely be achieved by improving patient compliance and avoidance of staple use. Poor compliance remains a true challenge to deal with on the wards and emphasizes the crucial role of healthcare providers. Much attention should be given to convey clear and simple recommendations about adequate behavior during the post-operative period to achieve optimal wound healing. This is especially true for the elderly and cognitively impaired patient. With the help of this study, we hope to increase surgeons' and nurses' awareness of these too often overlooked, noninfectious wound complications.

**Acknowledgments** We are indebted to Dr. C. Sadowski and to Dr. D. Monin for their invaluable help in performing the study. We thank all surgical teams and the Microbiological Laboratory for their support.

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