# Surgical Site Infections After Foot and Ankle Surgery

## A comparison of patients with and without diabetes

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**OBJECTIVE**—This prospective study was designed to evaluate the rate of surgical site infection (SSI) after foot and ankle surgery in patients with and without diabetes.

**RESEARCH DESIGN AND METHODS**—The study prospectively evaluated 1,465 consecutive foot and ankle surgical cases performed by a single surgeon.

**RESULTS**—The overall SSI rate in this study was 3.5%, with significantly more infections occurring in individuals with diabetes than in those without (9.5 vs. 2.4%, $P < 0.001$). Peripheral neuropathy, Charcot neuroarthropathy, current or past smoking, and increasing length of surgery were significantly associated with SSI on multivariate analysis.

**CONCLUSIONS**—This study demonstrates significant associations between the development of SSI and chronic complications of diabetes. We confirm previous findings that it is peripheral neuropathy and not diabetes itself that most strongly determines the development of postoperative infections in these surgical patients.

Surgical site infection (SSI) in patients with diabetes leads to increased morbidity, mortality, length of stay, and health care costs. Patients with diabetes, particularly when the disease is poorly controlled, may have associated comorbid conditions that place them at increased risk for postoperative infections (1). The hypothesis of this study was that patients with diabetes were at increased risk for SSI after foot and ankle surgery compared with patients without diabetes, and those patients with complications of diabetes would be at even higher risk for SSI.

## RESEARCH DESIGN AND METHODS

—Institutional review board approval was obtained, and a comprehensive registry was created. Patients were evaluated for peripheral neuropathy using the Michigan Neuropathy Screening Index (MNSI) (2). The diagnosis of peripheral artery disease (PAD) was made based on previous recommendations (3). An SSI was defined as an infection that occurred within 30 days of surgery at the site of a surgical incision. Antibiotic coverage consisted of one preoperative intravenous dose for outpatients and 24 h of perioperative coverage for inpatients. If patients were not allergic to penicillin, cefazolin was administered. Alternatively, clindamycin or vancomycin was used in patients with penicillin allergies. Patients with active ulcers who underwent reconstructive surgery were excluded from analysis if intraoperative deep soft tissue or bone cultures were positive. For the purposes of this study, SSI was chosen as the primary dependent variable and various risk factors that have been associated with SSI as potential independent variables. Pearson $\chi^2$ tests and univariate logistic regression were used to analyze dichotomous variables for their associations with SSI. Student $t$ tests with equal variance were used to determine significant differences of the means of normally distributed continuous variables (i.e., age) between groups. For nonparametric data, Wilcoxin rank sum tests were used. Statistical significance was taken at an $\alpha$ level = 0.05 ($P \le 0.05$) with associated 95% CI. Multivariate logistic regression was performed for all independent variables that achieved a univariate $P$ value of $\le 0.05$. Logistic regression was also performed to estimate odds ratios (ORs) with 95% CI for associations with SSI between the various risk factors.

**RESULTS**—Patient demographics are listed in Table 1. Fifteen percent of our patients were diagnosed as having type 1 diabetes, and 85% were diagnosed with type 2 diabetes, although 47% of all patients with diabetes required the use of insulin. The mean duration of diabetes was 13.2 ± 11.9 years, the mean preoperative fasting glucose was 146 ± 59, and the mean glycohemoglobin level was 7.9 ± 1.5%.

Preoperatively, we measured hemoglobin $A_{1c}$ levels in all nondiabetic neuropathic patients, and the mean value was 6.0%, compared with 7.4% in patients with diabetes ($P < 0.0001$).

Three of the 1,465 patients (0.2%) enrolled in this study did not have a minimum follow-up of 30 days. Overall, 51 of 1,462 patients (3.5%) experienced an SSI. Twenty-one of 221 (9.5%) patients with diabetes developed an SSI compared with 30 of 1,241 (2.4%) of patients without diabetes ($P < 0.001$). Univariate analysis demonstrated significant associations between the development of SSI and increasing age, male sex, Charcot neuroarthropathy (CN), diabetes, previous or current ulcer, increasing length of surgery, peripheral neuropathy, and the use of tobacco. American Society of Anesthesiology (ASA) class, serum creatinine, obesity, PAD, rheumatoid arthritis, and history of solid organ transplantation were not significantly associated with SSI.

Stepwise, multivariate logistic regression demonstrated that, when controlling for those variables with significant associations found on univariate analysis, only neuropathy (OR 3.58 [95% CI 1.76–7.30];

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**Table 1—Patient demographics**

|  | No diabetes | Diabetes | $P$ |
|---|---|---|---|
| Number of patients | 1,244 (84.9%) | 221 (15.1%) | |
| Mean age in years (SD) | 46.6 (±16.5) | 57.1 (±11.9) | <0.001* |
| ASA class (SD) | 2.1 (±1.1) | 2.9 (±0.5) | <0.0001* |
| Body mass index (SD) | 28.9 (±6.2) | 34.2 (±7.8) | <0.0001* |
| Charcot neuroarthropathy (%) | 17 (1.4%) | 60 (27.3%) | <0.001* |
| Current ulcer (%) | 45 (3.6%) | 55 (24.9%) | <0.001* |
| External fixation use (%) | 1.5% | 5.9% | <0.001* |
| Inpatient surgery (%) | 382 (30.7%) | 114 (51.6%) | <0.001* |
| MNSI (SD) | 0.7 (±1.7) | 4.8 (±3.5) | <0.001* |
| Neuropathy (%) | 104 (8.4%) | 142 (64.2%) | <0.001* |
| Male/female sex | 38.3/61.7% | 46.6/53.4% | <0.05* |
| Obese (%) | 38.1% | 69.1% | <0.001* |
| PAD (%) | 20 (1.6%) | 40 (18.1%) | <0.001* |
| Previous surgery | 384 (30.1%) | 90 (40.7%) | <0.01* |
| Previous ulcer (%) | 68 (5.5%) | 76 (34.4%) | <0.001* |
| Rheumatoid disease (%) | 53 (4.3%) | 10 (4.5%) | >0.05 |
| Smoking history (%) | 297 (23.9%) | 47 (21.3%) | >0.05 |
| Surgery time in minutes (SD) | 88.3 (±51.3) | 109.9 (±67.4) | <0.001* |
| Transplant patient (%) | 12 (1.0%) | 16 (7.2%) | <0.01* |
| Tobacco pack years (SD) | 9.5 (±16.2) | 13.7 (±19.8) | <0.05* |
| Laboratory studies | | | |
| Creatinine (SD) | 0.97 (±2.87) | 1.26 (±0.99) | >0.05 |
| Glucose (SD) | 93.2 (±13.1) | 146.4 (±58.9) | <0.0001* |
| Hemoglobin $A_{1c}$ (%) (SD) | 6.04 (±0.487) | 7.43 (±1.52) | <0.0001* |

*Statistically significant findings.

the development of a postoperative infection in patients undergoing foot and ankle surgery. The mechanism by which neuropathy increases the rate of infection is unknown. A possible explanation may be related to a deficiency of vasoactive neuropeptides in patients with neuropathy, which may impair normal soft tissue and osseous healing (14). We recognize that our study group of 221 patients with diabetes is relatively small and that future prospective studies should attempt to have a more equal distribution of patients between the study and control groups.

$P < 0.001$), current or past smoking (1.91 [1.04–3.51]; $P < 0.05$), diagnosis of CN (2.38 [1.05–5.39]; $P < 0.001$), and increasing duration of surgery (1.01 [1.01–1.02] $P < 0.005$) remained significantly associated with SSI. Diabetes, male sex, and ulcer history were not found to be associated with SSI in multivariate analysis.

**CONCLUSIONS**—Diabetes, especially when complicated by neuropathy and foot ulcers, is a known contributing factor that increases the risk for postoperative infection after foot and ankle surgery (1). Armstrong et al. (4) also reported that patients with a loss of protective sensation had a postoperative infection rate of 6.7%, providing additional evidence that peripheral neuropathy predisposed diabetic patients to postoperative infection. Two recent large series of operatively treated ankle fractures in patients with diabetes reported significantly higher rates of infection in patients with chronic complications of diabetes, such as neuropathy and PAD (5,6). Other variables that have been associated with SSI after orthopedic surgery include admission for surgery from a health care facility, ASA ≥3, suboptimal

perioperative glycemic control, and prolonged surgery (7–9).

One of the strengths of this study concerns the quantification and diagnosis of neuropathy using the MNSI in surgical patients. A neurologic examination that relies solely on the absence of monofilament perception will not identify diabetic patients with subtle neuropathic changes. We recognize that other screening tests are also validated in identifying diabetic neuropathy, and the specific method of diagnosing neuropathy should be at the discretion of the individual physician (10–13). It is vital to identify the presence of peripheral neuropathy, since up to 50% of patients with diabetic neuropathy may be asymptomatic. Preoperative recognition of peripheral neuropathy allows surgeons to stratify the surgical risks appropriately, since this complication of diabetes increases the risk of SSI by nearly a factor of four. This prospective study of 1,462 surgical cases demonstrates significant associations on multivariate analysis between the development of SSI and neuropathy, CN, current or past smoking, and increasing duration of surgery. Chronic complications of diabetes, such as the presence of peripheral neuropathy and CN, are most strongly associated with

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