Meta-Analysis of Surgical Site Infections in Elective Foot and Ankle Surgery

Mount Auburn Hospital Podiatric Medicine & Surgery Residency

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Statement of Purpose

The pressure to provide high quality health care is higher than ever. Patients expect and deserve the best care possible; but that does not mean perfection. Any surgery entails a degree of risk and post-operative infection is a ubiquitous example. The incidence of surgical site infections (SSI) is well documented in musculoskeletal surgery. The economic burden of surgical site infection management is high. Identifying the epidemiology and potential risk factors of surgical site infections is critical to prevention. Much of that data that is available is all inclusive lumping non-elective and elective information together. As we collectively face increased scrutiny for the care we render, it is incumbent on us to establish the reasonable benchmarks by which we are judged. In that spirit, our goal was to evaluate published SSI rates for elective foot and ankle surgery and establish a reasonable standard to be applied in judging our infection rates.

Level of Evidence: Level 1, Meta-Analysis

Purpose: The primary aim of this meta-analysis was to perform a comprehensive and systematic review of the literature in an attempt to identify the surgical site infection rate and risk factors for elective foot and ankle surgery.

Methods

A meta-analysis was performed on elective foot and ankle SSI articles between 1999 to 2017 (Figure 1). The CDC definition for SSIs was utilized for the metameter. Data extraction included type of procedure, hardware, implants, gender, follow-up, smoking, comorbidities, and immunocompromised status.

Seven articles met selection criteria including 7,310 procedures in 6,257 patients. Demographics included 70% female with a the mean age of 51.22 (Figure 1). Meta-analysis of the data using a random effects model demonstrated a surgical site infection rate of 2.5% (0.025) and using a fixed effects model 2.4% (0.024) with a Q=39.847. (Figure 2)

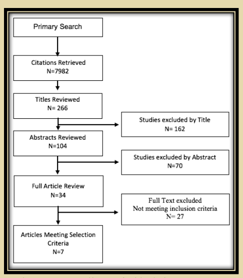


Figure 1. Consort diagram of article selection.

Inclusion Criteria

- adults (>/= 18 years old) who received primary elective foot and ankle surgery
- experimental (randomized or not) or observational studies written in English

Exclusion Criteria

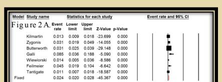
- history of infection, revision, pediatrics, case studies, and trauma
- Studies not written in English

Literature Review

According to the CDC, surgical site infections are the third most frequent nosocomial infection reported and are responsible for over 36% of hospital-acquired infection in the United States (1, 2). This has significant economic burden accounting for the greatest hospital acquired cost estimated at $3.3 billion annually (2). When compared to surgical site infection rates in orthopedic literature, it has been suggested that foot and ankle surgical site infections are higher due to the increased microbiological flora (3). Surgical site infection rates in the foot and ankle have been reported to vary between 1.0% to 5.3% (4). However, the majority of studies have reported surgical site infections as secondary rather than primary outcomes limiting interpretation. Miller first reported rates of clean foot and ankle procedures in 1981 with an overall infection rate of 2.2% in 1,841 procedures (5). Zgonis et al. found an overall 3.1% infection rate in five hundred and fifty-five patients in elective outpatient foot and ankle surgery (6). An Australian study sought to identify the surgical site infection in podiatric surgery by nine surgeons, the overall infection rate was 3.1% with 0.25% of infections requiring re-admission (7). Many factors are associated with increased risk of surgical site infections and few studies have sought to identify these relationships in elective foot and ankle surgery. Weiworski et al. found age, obesity, use of tobacco, diabetes mellitus, multiple procedures on the same foot, operative time, tourniquet time, and duration of hospital stay to be significantly associated with the occurrence of surgical site infections (3). Identifying the surgical site infection rate and risk factors for elective foot and ankle surgery is critical to effectively assess the operative risk for patients, provide patient education, operative treatment course, and for reimbursement systems to establish acceptable reimbursement principles based on accurate data that currently does not exist in the literature.

Results

Seven articles met selection criteria including 7,310 procedures in 6,257 patients. Demographics included 70% female with a the mean age of 51.22 (Figure 1). Meta-analysis of the data using a random effects model demonstrated a surgical site infection rate of 2.5% (0.025) and using a fixed effects model 2.4% (0.024) with a Q=39.847. (Figure 2A)



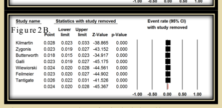


Figure 2A. Forest plot of 7 included studies. 2B. One study removed model.

Groups		Effect size and 95% interval			Test of null (2-Tail)		Heterogeneity			
Group	Number Studies	Point estimate	Lower limit	Upper limit	Z-value	P-value	Q-value	df (Q)	P-value	I-squared
Fixed effect analysis										
Prospective	3	0.040	0.024	0.066	-11.662	0.000	7.740	2	0.021	74.159
Retrospective	4	0.022	0.019	0.027	-43.890	0.000	27.944	3	0.000	89.264
Total within							35.683	5	0.000	
Total between							4.163	1	0.041	
Overall	7	0.024	0.020	0.028	-45.367	0.000	39.847	6	0.000	84.942
Random effects analysis										
Prospective	3	0.039	0.017	0.085	-7.528	0.000				
Retrospective	4	0.019	0.011	0.035	-13.036	0.000				
Total between							1.846	1	0.174	
Overall	7	0.026	0.013	0.050	-10.414	0.000				

Figure 3. Fixed effect and random effects analysis for prospective versus retrospective studies.

Sub-group analysis was performed to determine if there is a difference in the reported infection rate between prospective and retrospective studies. Using the random effects model prospective trials reported a mean infection rate of 0.039 CI95%[0.017, 0.085] while retrospective studies had a mean average of 0.019 CI95%[0.011,0.035]. Using the random effects model this difference was not statistically significant (p=0.174). (Figure 3)

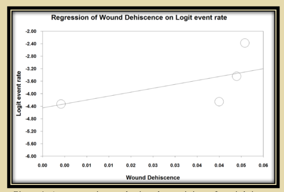


Figure 4. A meta-regression evaluating the association of surgical site infection and wound dehiscence.

A meta-regression evaluating the association of surgical site infection and wound dehiscence showed a relative risk of infection was 21 95%CI[9.96, 32.84] p=0.00024 when wound dehiscence was reported. (Figure 4)

Sub-group analysis of deep versus superficial infections showed a superficial infection rate of 0.009% and deep infection rate of 0.0042% in elective foot and ankle surgery. Only one study reported on SSI causing bone infection at a rate of 0.004%. (Figure 5)

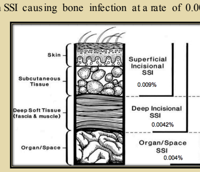


Figure 5. Diagram of SSI rates within tissue planes.

Analysis & Discussion

The primary aim of this investigation was to identify the SSI rate for elective foot and ankle surgery. In the literature surgical site infection rates in the foot and ankle have been reported to vary between 1.0% to 5.3%.(2) Our meta-analysis showed similar results using a the random effects model with a SSI rate of 2.4% and 2.5% with the fixed effects model. It is of note that there was a high level of heterogeneity of the studies (Q=39.847). (Figure 2) In order to address this potential limitation, all analysis were conducted assuming a random effects model. This approach is considered conservative and makes it more difficult to achieve statistical significance. At the same time, the random effects model is effective in estimating heterogeneity and the effect size in this setting. Furthermore, using a 1 study removed model, Galli's 8.47% is the largest deviation and its exclusion results in an overall shift where the new overall mean is now 2.1% [0.015, 0.039] SSI infection rate. This is similar to what is stated in the literature.

A comparison was made to determine if there was a difference in reported infection rate between prospective and retrospective studies. Although a significant difference was observed using a fixed effects model (p=0.041), the observed heterogeneity dictated that a random effects model would be more appropriate. Using this model prospective trials reported a mean infection rate of 0.039 CI95%[0.017, 0.085] while retrospective studies had an observed average of 0.019 CI95%[0.011,0.035]. This difference was not statistically significant (p=0.174) and suggests that study design is a less relevant factor. A contributing factor was likely that the mean number of procedures performed in the prospective studies was 155 while the mean for retrospective studies was much higher, 1712.

Zgonis et al previously reported in their 2004 article that the use of prophylactic antibiotics did not significantly impact surgical site infection rates, finding a 1.4% infection rate with prophylaxis and a 1.6% infection rate without prophylaxis (6). Only three of the selected studies in the current analysis specified the use of pre-operative antibiotics. Two of the studies used pre-operative antibiotics in at least 99% of elective cases, and reported a mean infection rate of 1.2%. What makes this interesting is that Zgonis prophylaxed in 55% of cases and had a far larger overall infection rate 3.1%. It is difficult to confirm this finding because of the relative dearth of data and the lack of infusion time relative to tourniquet application which is a known moderator of antibiotic effectiveness (8).

Analysis & Discussion Continued

Another interesting finding was that in patients where prophylactic antibiotics were provided, the rate of any reported wound complication was higher, 5.5% (3,6,9) versus 1.62% (6) in those not receiving antibiotics beforehand. At least in the case of the Zgonis study, their data indicated that antibiotics were provided more frequently in more complicated cases. This may be driven by the fact that cases with multiple procedures and incisions may be perceived as higher risk by the surgeon and intrinsically carry an elevated risk of wound complication. Clinically, wound dehiscence increases our awareness of the risk of infection following surgery but the magnitude of that risk has yet to be specified. To examine this relationship further, a meta-regression was performed that looked at the association of surgical site infection and wound dehiscence. In this analysis a statistically significant relationship was observed where the relative risk of infection was 21 95%CI[9.96, 32.84] p=0.00024 when wound dehiscence reported. This supports our long held belief that wound dehiscence is a meaningful risk factor for surgical infection. Unfortunately only four of the studies specified the rate of wound dehiscence and reduced the sample size. A significant limitation of the present study was that while a plan to analyze risk factors and subgroups existed, the mechanism for selecting studies did not prioritize their reporting which led to incomplete data. Additional known risk factors for SSI were reported by several of the studies meeting inclusion criteria, but incomplete data limited its inclusion. For example, although four studies reported on populations with diabetes and rheumatoid arthritis, the rate of infection for these subgroups could not be isolated from the overall rate of infection. Only Wiewiorski delineated the infection rate for tobacco users (8.7%) versus >1% in the rest of the cohort (3). Although length of surgery and tourniquet use are reported risk factors, none of the elective studies reported a difference in infection rates based on these factors (8). Wiewiorski did note that longer times do increase the risk of wound complication which our meta-regression indicates is a meaningful risk factor for SSI. Finally, a reliable comparison could not be made based the surgical setting (hospital versus ambulatory surgery center) due to the confounding factor of pre-operative antibiotic prophylaxis.

In conclusion, an established benchmark for infection rates for elective foot and ankle surgery is needed. Our results show that surgical site infection rates with elective foot and ankle surgery are comparable to those documented in orthopedic literature. Due to the large amount of heterogeneity between studies, limited comparable data, and multitude of confounding factors affecting the incidence of infection rate our analysis is limited.

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