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ORIGINAL ARTICLE

A Comparison of Adverse Short-Term Outcomes Following Forefoot Amputation Based on Subject Height

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Background: The objective of this investigation was to evaluate adverse short-term outcomes following partial forefoot amputation with a specific comparison performed based on subject height.

Methods: The American College of Surgeons National Surgical Quality Improvement Program database was analyzed to select those subjects with a 28805 CPT code (amputation, foot; transmetatarsal) that underwent the procedure with “all layers of incision (deep and

superficial) fully closed." This resulted in 11 subjects with a height ≤60 inches, 202 subjects with a height >60 inches and <72 inches, and 55 subjects ≥72 inches.

Results: Results of the primary outcome measures found no significant differences between groups with respect to the development of a superficial surgical site infection (0.0% vs. 6.4% vs. 5.5%; p=0.669), deep incisional infection (9.1% vs. 3.5% vs. 10.9%; p=0.076), or wound disruption (0.0% vs. 5.4% vs. 5.5%; p=0.730). Additionally, no significant differences were observed between groups with respect to unplanned reoperations (9.1% vs. 16.8% vs. 12.7%; p=0.0630) or unplanned hospital readmissions (45.5% vs. 23.3% vs. 20.0%; p=0.190).

Conclusions: The results of this investigation demonstrate no difference in short-term adverse outcomes following the performance of partial forefoot amputation with primary closure based on subject height. Although height has previously been described as a potential risk factor in the development of lower extremity pathogenesis, this finding was not observed in this study from a large US database.

Although partial foot amputation might result from a number of potential etiologies including trauma and peripheral arterial disease, the combination of infection with diabetes mellitus is likely the most common contemporary indication. This is a procedure and underlying pathology with substantial economic implications. The cost of treatment of diabetic foot

ulcerations and amputations is estimated to be billions of dollars annually and rising (1-5). Concomitant acute infection has been further demonstrated to be one of the factors driving increased costs (4), and median hospital stays have been found to be approximately 60% longer for patients with severe, as compared to moderate, foot infections (6). Patients with both diabetes and foot ulcerations have additionally been noted to have more frequent visits to emergency departments, more frequent hospitalizations, and longer length of hospital stays (2, 7-9).

Partial foot amputations, such as the transmetatarsal amputation, are often employed to address localized lower extremity pathologies including bone and soft tissue infection, forefoot gangrene, or chronic and non-healing ulcerations (10). Although widely considered to be a durable limb preservation option, the transmetatarsal amputation might not be as resilient as expected when considering published rates of reoperation (26.9-40%) and progression to major amputation (12.6-33.2%) (10-19). In the setting of a failed partial foot amputation, hospital readmission is often required to address these and other complications (20). This most frequently directly involves the amputation stump, but might also include other medical complications including acute kidney injury, cardiac complications, or gastrointestinal complications (21). Several investigations have demonstrated unplanned hospital readmission rates as high as 34% following this procedure (1,21,22-27).

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One patient demographic variable that might affect outcome following partial forefoot amputation is height. Taller patients, with physically longer arteries and nerves, have previously been found to be an increased risk for the development of peripheral neuropathy, peripheral arterial disease, venous thromboembolism, and fracture (28-35). Therefore, the objective of this investigation was to evaluate adverse short-term outcomes following forefoot amputation with a comparison performed based on subject height.

Materials and Methods

The American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) database was analyzed for the purposes of this investigation. This is a de-identified database not requiring IRB approval for use. It includes two current procedural terminology (CPT) codes for partial foot amputation: 28805 (amputation, foot; transmetatarsal) and 28800 (amputation, foot; midtarsal). We chose to include those subjects with a 28805 CPT code that additionally underwent the procedure with "all layers of incision (deep and superficial) fully closed." This resulted in 11 subjects with a height ≤60 inches, 202 subjects with a height >60 inches and <72 inches, and 55 subjects with a height ≥72 inches.

Extracted information included variable labels "age", "gender", "new race", "ethnicity Hispanic", "height", "weight", "functional health status prior to surgery", "ASA classification",

"estimated probability of mortality", "estimated probability of morbidity", "wound classification", "total operation time", "length of total hospital stay", "diabetes mellitus with oral agents or insulin", "current smoker within one year", "dyspnea", "congestive heart failure (CHF) in 30 days before surgery", "hypertension requiring medication", "currently on dialysis (pre-op)", "open wound/wound infection", "occurrences of superficial incisional SSI", "occurrences of deep incisional SSI", "occurrences of wound disruption", "occurrences sepsis", "unplanned reoperation", and "unplanned readmission" as defined by the ACS NSQIP User Guide (36). The primary outcome measures were considered a frequency count of superficial surgical site infection, deep incisional infection, wound disruption, sepsis, unplanned readmission, and unplanned reoperation within 30 days of the index procedure.

Data was stored in a password protected personal computer for subsequent statistical analysis. All statistical analyses were performed by one study author (AJM) using Statistical Analysis Systems software, version 9.2 (SAS Institute, Cary, NC). Categorical data is reported in terms of a frequency count (percentage) and compared by means of the Kruskal Wallis test. Continuous data is reported in terms of the mean ± standard deviation range and compared by means of the analysis of variance (ANOVA) test.

Results

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A comparison of demographic information between groups (height ≤60 inches vs. height >60 inches and <72 inches vs. height ≤ 72 inches) is provided in Table 1. Statistically significant differences were observed with respect to subject age (69.36 vs. 62.50 vs. 55.62 years; p<0.001), frequency of male gender (90.9% vs. 70.3% vs. 98.2%; p<0.001), frequency of Hispanic ethnicity (36.4% vs. 10.9% vs. 0.0%; p=0.020), subject height (58.55 vs. 67.31 vs. 73.40 inches; p<0.001), subject weight (149.30 vs. 192.04 vs. 233.76 pounds; p<0.001), frequency of hypertension (90.9% vs. 82.2% vs. 67.3%; p=0.034), estimated probability of morbidity (0.161 vs. 0.132 vs. 0.115; p=0.033), and estimated probability of mortality (0.052 vs. 0.027 vs. 0.014; p=0.003).

Results of the primary outcome measures are displayed in Table 2. No differences were observed between groups with respect to the development of a superficial surgical site infection (0.0% vs. 6.4% vs. 5.5%; p=0.669), deep incisional infection (9.1% vs. 3.5% vs. 10.9%; p=0.076), wound disruption (0.0% vs. 5.4% vs. 5.5%; 0.730), sepsis (0.0% vs. 6.9% vs. 5.5%; 0.628), unplanned reoperations (9.1% vs. 16.8% vs. 12.7%; 0.630), nor unplanned hospital readmissions (45.5% vs. 23.3% vs. 20.0%; p=0.190).

Discussion

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As with any scientific investigation, critical readers are encouraged to review the study design and specific results in order to reach their own independent conclusions, while the following represents our conclusions based on the preceding results. We also never consider data to be definitive but do think that these results might be worthy of attention and future investigation.

From information collected and analyzed from a large US database, we observed no differences in adverse short-term outcomes following primarily closed partial forefoot amputations with a comparison performed based on subject height. Although height has previously been described as potential risk factor in the development of lower extremity neuropathy and arterial disease (28-33), no adverse short-term post-surgical outcome differences were observed with respect to superficial infection, deep infection, wound disruption, sepsis and unplanned reoperations/readmissions.

All scientific investigations have limitations, and this one has several important limitations to consider. First, as data was collected from an existing database, we are restricted to only the available information and the original extraction from the medical records. In other words, we cannot personally speak to the accuracy of the data and were unable to collect any data points not found within the database. Second, the database only contains information on short-term (30-day) adverse outcomes, and therefore we cannot speak to anything occurring

with these subjects after 30 days. And finally all retrospective comparison investigations are at risk of an inherent and confounding selection bias, and this investigation is no different.

In conclusion, the results of this investigation demonstrate that, despite some differences in subject demographic characteristics, no significant difference in short-term adverse outcomes following the performance of partial forefoot amputation based on subject height might be expected.

Financial Disclosure: None reported.

Conflict of Interest: None reported.

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Journal of the American Podiatric Medical Association

Table 1. Demographic Comparison Between Height Cohorts

Variable^	Height ≤60 inches (n=11)	Height >60 inches or <72 inches (n=202)	Height ≥72 inches (n=55)	Statistical Comparison^
Age	69.36 ± 13.46 (43-88)	62.50±11.64 (35-89)	55.62 ± 11.29 (33-77)	P<0.001*
Gender (male)	10 (90.9%)	142 (70.3%)	54 (98.2%)	P<0.001*
Race^^	W: 6 (54.5%) B/AA: 2 (18.2%) U/NR: 2 (18.2%) A: 1 (9.1%) AI/AN: 0 (0.0%) NH/PI: 0 (0.0%)	W: 124 (61.4%) B: 46 (22.8%) U/NR: 26 (12.9%) A: 4 (2.0%) AI/AN: 0 (0.0%) NH/PI: 2 (1.0%)	W: 35 (63.6%) B/AA: 12 (21.8%) U/NR: 6 (10.9%) A: 0 (0.0%) AI/AN: 2 (3.6%) NH/PI: 0 (0.0%)	P=0.743
Ethnicity	Hispanic: 4 (36.4%)	Hispanic: 22 (10.9%)	Hispanic: 0 (0.0%) Not: 45 (81.8%)	P=0.020*

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	Not: 6 (54.5%) Unknown: 1 (9.1%)	Not: 149 (73.8%) Unknown: 31 (15.3%)	Unknown: 10 (18.2%)	
Height (inches)	58.55 ± 1.97 (55-60)	67.31±2.94 (61-71)	73.40 ± 1.37 (71-76)	P<0.001*
Weight (pounds)	149.30 ± 31.46 (95-177)	192.04±45.64 (84-400)	233.76 ± 50.67 (141-357)	P<0.001*
Pre-operative functional health status	Independent: 8 (72.7%) Partially/Totally Dependent: 3 (27.3%)	Independent: 173 (85.6%) Partially/Totally Dependent: 25 (12.4%)	Independent: 49 (89.1%) Partially/Totally Dependent: 5 (9.1%)	P=0.260
Diabetes mellitus	11 (100.0%)	202 (100.0%)	55 (100.0%)	P=1.00
Current smoker	1 (9.1%)	47 (23.3%)	17 (30.9%)	P=0.247
Hypertension	10 (90.9%)	166 (82.2%)	37 (67.3%)	P=0.034*

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Congestive heart failure	1 (9.1%)	10 (5.0%)	1 (1.8%)	P=0.459
Dialysis	4 (36.4%)	40 (19.8%)	5 (9.1%)	P=0.055
Open wound/wound infection	8 (72.7%)	139 (68.8%)	38 (69.1%)	P=0.963
Wound classification	1: 1 (9.1%) 2: 1 (9.1%) 3: 2 (18.2%) 4: 7 (63.6%)	1: 0 (0.0%) 2: 17 (8.4%) 3: 45 (22.3%) 4: 93 (46.0%)	1: 8 (14.8%) 2: 6 (10.9%) 3: 12 (21.8%) 4: 29 (52.7%)	P=0.280
ASA classification	1: 0 (0.0%) 2: 0 (0.0%) 3: 7 (63.6%) 4: 4 (36.4%) 5: 0 (0.0%)	1: 0 (0.0%) 2: 6 (3.0%) 3: 140 (69.3%) 4: 54 (26.7%) 5: 0 (0.0%)	1: 1 (1.8%) 2: 2 (3.6%) 3: 43 (78.2%) 4: 9 (16.4%) 5: 0 (0.0%)	P=0.131
Estimated probability of morbidity	0.161 ± 0.087 (0.06-0.35)	0.132±0.060 (0.03-0.36)	0.115 ± 0.047 (0.05-0.25)	P=0.033*

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Estimated probability of mortality	0.052 ± 0.064 (0.0-0.21)	0.027±0.038 (0.00-0.26)	0.014 ± 0.018 (0.0-0.10)	P=0.003*
Total operation time (minutes)	51.18 ± 26.39 (25-111)	58.83±58.57 (15-743)	57.58 ± 35.13 (9-198)	P=0.895
Total length of hospital stay (days)	10.45 ± 8.55 (1-25)	7.84±11.0 (0-43)	6.15 ± 6.18 (0-29)	P=0.347

^Categorical data is reported in terms of a frequency count (percentage) and compared by means of the Kruskal Wallis test. Continuous data is reported in terms of the mean ± standard deviation range and compared by means of the analysis of variance (ANOVA) test.

^^American Indian or Alaska Native (AI/AN), Asian (A), Black or African American (B/AA), Native Hawaiian or Pacific Islander (NH/PI), Unknown or Not Reported (U/NR), White (W).

*Level of significance defined as $p<0.05$.

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Table 2. Comparison Of Short-Term Adverse Outcomes Between Height Cohorts

Outcome	Height ≤ 60 inches (n=11)	Height >60 inches or <72 inches (n=202)	Height ≥ 72 inches (n=55)	Statistical comparison
Superficial surgical site infection	0 (0.0%)	13 (6.4%)	3 (5.5%)	P=0.669
Deep incisional infection	1 (9.1%)	7 (3.5%)	6 (10.9%)	P=0.076
Wound disruption	0 (0.0%)	11 (5.4%)	3 (5.5%)	P=0.730
Sepsis	0 (0.0%)	14 (6.9%)	3 (5.5%)	P=0.628
Unplanned reoperation	1 (9.1%)	34 (16.8%)	7 (12.7%)	P=0.630
Unplanned hospital readmission	5 (45.5%)	47 (23.3%)	11 (20.0%)	P=0.190

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-Categorical data is reported in terms of a frequency count and compared by means of the

Kruskal Wallis test. Level of significance defined as $p<0.05$.