Subjects with radiographically confirmed nonunions were identified using ICD-9 diagnosis codes for ankle and metatarsal fractures. Students (defined by p < 0.2). This was done with BMI as a continuous and data, and peripheral neuropathy impact the occurrence of nonunions.

**Hypothesis**

Obesity, lower albumin and presence of peripheral neuropathy are associated with increased occurrence of nonunion in the foot and ankle fractures.

**Methodology**

This was a retrospective review of patients aged 18 to 90, selected using ICD-9 diagnosis codes for ankle and metatarsal fractures. Subjects with radiographically confirmed nonunions were identified through ICD-9 codes (173.81) and then verified through chart review. Radiographically and/or clinically united knees were matched by age range, sex, and fracture type to those with nonunions, and randomly selected for chart review.

**Inclusion Criteria:**
- Ages 18-90
- Diagnostic code for ankle and metatarsal fractures from January 1, 2006 to January 1, 2012
- Fractures of the digits due to inadequate follow-up
- Pathologic fractures

**Exclusion Criteria:**
- Fractures of the digits due to inadequate follow-up
- Patients deceased prior to 18 months post-fracture diagnosis
- Nonunion

**Nonunion Criteria:**
- Presence of less than 2 cortical continuations, with lytic gapping
- Presence of callus with sclerosis of the fracture margins and lytic gapping of the 5th metatarsal Jone’s fracture.

**Table 1. Demographic Characteristics (N=36)**

<table>
<thead>
<tr>
<th>BMI (mean, SD)</th>
<th>Nonunion (n (%)</th>
<th>Union (n (%)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>24.83, 6.54</td>
<td>9 (23.72)</td>
<td>27 (76.28)</td>
<td>0.005</td>
</tr>
<tr>
<td>Weight (kg, mean, SD)</td>
<td>169.44, 18.9</td>
<td>186.19, 24.25</td>
<td>0.583</td>
</tr>
</tbody>
</table>

**Table 2. Binary Analysis**

<table>
<thead>
<tr>
<th>BMI (mean, SD)</th>
<th>Nonunion (n (%)</th>
<th>Union (n (%)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>32.3, 6.43</td>
<td>33 (91.94)</td>
<td>4 (10.26%)</td>
<td>0.005</td>
</tr>
<tr>
<td>Weight (kg, mean, SD)</td>
<td>99.44, 18.9</td>
<td>89.19, 24.25</td>
<td>0.583</td>
</tr>
</tbody>
</table>

**Discussion**

The incidences of nonunions in foot and ankle fractures has been previously studied, along with the association of nonunion with other contributing factors such as obesity, tobacco use, and peripheral neuropathy [11,13, 23, 24]. Dodson et al. showed that cigarette smoking, obesity, and diabetes were factors linked to high risks of poor prognosis, in a retrospective cohort of 58 subjects [23].

A previous study by Shibuya et al., investigating diabetic subjects and nonunions, showed that peripheral neuropathy was highly associated with the development of nonunions [13]. Lee et al. examined fracture healing in 99 children [11]. Contrary to authors’ expectations, the authors found that non-obese children returned to activity sooner than obese children. However, release to activity was determined by a non-blinded treating orthopedist.

In our study, the mean BMI of all subjects was 31.12. The union group did have a smaller BMI of 29.89 compared to 32.3 in the nonunion group, though this difference was not significant (p-value = 0.17). Of the four diabetic subjects with peripheral neuropathy within the study, all four developed nonunions. In the diabetic subjects without peripheral neuropathy, four of six developed nonunions. However, this was not significant (p=0.055).

No significant differences were found in regard to alcohol, tobacco status or albumin levels. Seventeen of the 48 subjects underwent surgical management of the fracture. Fourteen subjects had ORIF performed while one had a percutaneous procedure and two subjects had other types of surgery performed. Ten of the 14 ORIF treated subjects went on to nonunion while both subjects treated with other means of surgical management also went on to nonunion. The high rate of nonunion within the ORIF group may be due to a selection bias for increased severity of fractures, necessitating surgical management and salvage. In the logistic regression analysis, only fracture management with ORIF was found to be a significant factor.

Several limitations of this study may have contributed to the results.

1. Severity of fractures could not be determined. As a result, there may be a selection bias within the nonunion group for ORIF treated fractures.
2. Specific location of the fractures within the foot and ankle were not specified. However, patients were matched on fracture type by ICD-9 codes.
3. The study does seem from small sample size. A larger sample may find differences in presence of peripheral neuropathy, BMI, etc. between those with and without nonunion.
4. Lab values were not available for many of the patients within the predetermined time period of 3 months before or after the original fracture.

**Conclusion**

Significantly more patients in the nonunion group underwent ORIF procedures. This may have been a result of differences in fracture severity between groups. Our study failed to find a significant relationship between nonunions in subjects with diabetes with peripheral neuropathy, malnutrition, and obesity. However, larger studies are needed to confirm or refute these findings.

**Table 3. Logistic Regression Results**

<table>
<thead>
<tr>
<th>BMI</th>
<th>ORIF</th>
<th>95% CI</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.94</td>
<td>0.68</td>
<td>1.41</td>
<td>0.22</td>
</tr>
<tr>
<td>Diabetes DM with PN</td>
<td>1.09</td>
<td>0.74</td>
<td>0.54</td>
</tr>
<tr>
<td>Nonobese</td>
<td>1.23</td>
<td>0.84</td>
<td>0.28</td>
</tr>
<tr>
<td>Tobacco</td>
<td>0.25</td>
<td>0.86</td>
<td>0.90</td>
</tr>
<tr>
<td>Other</td>
<td>0.91</td>
<td>0.80</td>
<td>0.93</td>
</tr>
</tbody>
</table>

**References**