Fractures Due To Gunshot Wounds: Do Retained Bullet Fragments Affect Union?

Keith P Connolly1, John T Riehl2, George J Haidukewych1,2, Ken J Koval2

1. University of Central Florida College of Medicine, Orlando, FL
2. Level One Orthopedics at Orlando Health, Orlando, FL

Introduction

Modern hollow point projectiles are designed to expand in the body cavity to increase stopping power by making a larger cavity in soft tissue, and prevent over penetration of the intended target. However, when such projectiles hit bone, they often fragment into multiple smaller pieces that are often retained in the fracture site. Information on fractures resulting from gunshot wounds has primarily focused on differences between high and low-energy projectiles. This study was performed to examine the effect of retained bullet material near the fracture site on time to fracture union.

Methods

All operatively treated gunshot injuries treated at a Level 1 Trauma Center between March 2008 and August 2011 were retrospectively reviewed. Inclusion criteria consisted of: 1) patient age 18 years; 2) operative fracture fixation; and 3) minimum follow-up of 4 months or fracture union. Retained bullet load near the fracture site (within 5 mm) was calculated based on percentage of material retained compared to the cortical diameter of the involved bone (lead-cortical ratio). For a fragment to be counted in this calculation it had to be near the fracture site on both the AP and lateral radiographs. The length of these fragments (if laid end to end) was calculated as a percentage of the cortical diameter. To assess energy imparted to bone, fractures were grouped as simple or comminuted. Radiographic evidence of healing was determined by bridging callus on 3 of 4 cortices on AP and lateral views. Delayed union was defined as lack of radiographic union by 4 months from surgery, and nonunion as failure to heal by one year or implant failure requiring reoperation. Analyses were performed to assess the effect of lead-cortical ratio and amount of comminution on time to fracture union.

Results

<table>
<thead>
<tr>
<th>Variable</th>
<th>Union in ≤ 4 months</th>
<th>Delayed or Non-union</th>
<th>Percent (95% CI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Communion</td>
<td>41% (18%, 67%)</td>
<td>5%</td>
<td>29% (10%, 56%)</td>
<td>0.372</td>
</tr>
<tr>
<td>Communion</td>
<td>10</td>
<td>12</td>
<td>71% (44%, 90%)</td>
<td></td>
</tr>
<tr>
<td>&lt; 20 Lead-Cortical Ratio</td>
<td>94% (71%, 100%)</td>
<td>8%</td>
<td>47% (23%, 72%)</td>
<td>0.001</td>
</tr>
<tr>
<td>≥ 20 Lead-Cortical Ratio</td>
<td>6% (0%, 29%)</td>
<td>9%</td>
<td>53% (28%, 77%)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Discussion

The rate of fracture union in this study was related to the quantity of bullet material at the fracture site. There were no significant differences in the lead-cortical ratio, above which a significant effect in fracture union time was observed. Previous studies have demonstrated that bone level affects fracture formation and resorption through impairment of osteoblast and osteoclastic cell pathways. One study in rats showed with increased lead load, fracture calluses showed a significant delay in endochondral ossification with a greater increase in unmineralized cartilage several times that of the unexposed calluses. At lower levels, lead exposure did not completely inhibit fracture healing, but delayed the ossification process. However, at higher exposure, fractures exhibited fibrous non-unions. The results of our study may reflect a local cytotoxic effect of lead from bullet fragments on fracture healing. Whether these results are a product of reduced osteoprogenitor cell formation or an unknown biologic impact of the metal debris requires further research.

Conclusions

The quantity of retained bullet material near the fracture site appears to affect the rate of fracture union:

- Fractures with bullet fragmentation exceeding 20% of the cortical width demonstrated a significantly higher rate of delayed union or nonunion compared to those fractures with less retained bullet material at the fracture site.

The clinical significance of this study is to provide prognostic information on union time with retained lead.

- Although fractures with more retained bullet fragments required more time to heal, almost all eventually went on to union. This may have implications on a surgeon’s decision and timing for secondary surgery, as well as expectations for the patient.

Despite findings of a positive correlation between retained bullet material and delayed union, at this time we do not recommend additional dissection for bullet removal at the fracture site.

Relevant Publications