Unilateral Sacral Fractures Demonstrate Slow Recovery of Patient Reported Outcomes Irrespective of Treatment

Brian H Mullis MD¹, Julie Agel MA, ATC², Cliff Jones MD³, Jason Lowe MD⁴, Heather Vallier MD⁵, David Teague MD⁶, Laurence Kempton MD¹, Andrew Schmidt MD⁷, Darin Friess MD⁸, Saam Morshed MD⁹, Anna Miller MD¹⁰, Ross Leighton MD¹¹, Paul Tornetta III MD¹²

¹Indiana University
²Harborview Medical Center
³Orthopedic Associates of Michigan
⁴University of Alabama
⁵Metro Health Medical Center
⁶University of Oklahoma - HSC
⁷Hennepin Medical Center
⁸Oregon Health and Science University
⁹University of California San Francisco

This is the author's manuscript of the article published in final edited form as:

Corresponding author: Brian Mullis, MD

Brian H. Mullis MD (Corresponding Author)
Professor and Program Director
Department of Orthopaedic Surgery
Indiana University School of Medicine
1801 N Senate Blvd, Ste 535
Indianapolis, IN 46202
317-963-1966
bmullis@iupui.edu

This study was funded by a grant from the Orthopaedic Trauma Association

The authors declare no conflict of interest for this study.
Abstract

Objectives: To report functional outcomes of unilateral sacral fractures treated both operatively and nonoperatively

Design: Prospective, multicenter, observational

Setting: 16 level 1 trauma centers

Patients/participants: Skeletally mature patients with unilateral zone 1 or 2 sacral fractures categorized as: displaced nonoperative (DN), displaced operative (DO), nondisplaced nonoperative (NN), nondisplaced operative (NO)

Main outcome measurements: Pelvic displacement was documented on injury plain radiographs. Short Musculoskeletal Function Assessment (SMFA) scores were obtained at baseline and 3, 6, 12, and 24 months following injury. Displacement was defined as greater than 5 mm in any plane at the time of injury.

Results: 286 patients with unilateral sacral fractures were initially enrolled, mean age 40 and mean Injury Severity Score (ISS) 16 were included. One hundred twenty-three patients completed 2 year follow up as follows; 29 DN, 30 DO, 47 NN, and 17 NO with 56% loss to follow-up at 2 years. Highest dysfunction was seen at 3 months for all groups with mean SMFA dysfunction scores; 25 DN, 28 DO, 27 NN, 31 NO. Mean SMFA scores at 2 years for all groups were 13 DN, 12 DO, 17 NN, 17 NO.
Conclusions: All groups (operative/nonoperative and displaced/non-displaced) reported worst function 3 months following injury and all but (DN) continued to recover for 2 years following injury, with peak recovery for DN seen at 1 year. No functional benefit was seen with operative intervention for either displaced or non-displaced injuries at any time point.

Key words: sacrum fracture, pelvis, pelvic ring, pelvic ring injury, outcomes, SMFA, lateral compression

Level of evidence: Therapeutic Level II. See Instructions for Authors for a complete description of levels of evidence.

Introduction

There is no consensus amongst experts whether unilateral sacral fractures with unilateral or bilateral anterior ring injuries should be treated with surgery or managed conservatively [1]. Furthermore, there is little data to predict functional outcome of these injuries regardless of management[2-4].

The Orthopaedic Trauma Research Consortium is a group of 16 level 1 trauma centers which comprised the setting for this study. Patients with unilateral sacral fractures were enrolled prospectively. As there is considerable disagreement
amongst experts regarding surgical indications, an observational study was undertaken with each individual surgeon treating patients by their routine practice habits[5]. The group has previously reported on this same cohort showing slight improvement in visual analog scores within 1 week for non-displaced fractures treated operatively, but no long term benefit[6]. Patient-reported functional outcomes for patients with displaced and non-displaced fractures and those managed with surgery and conservatively are the basis for this report with up to 2-year follow-up.

Methods

Over a 7-year period, we offered enrollment prospectively to all adult patients with unilateral sacral fractures in 16 level 1 trauma centers that make up the Orthopaedic Trauma Research Consortium (OTRC). Inclusion criteria included patients between ages 18-80 years, unilateral sacral fracture, English speaking, and able to provide informed consent. Exclusion criteria were as follows: anteroposterior (AP) compression injuries, associated displaced acetabulum fractures, sacral fractures across the midline (zone 3), pregnant patients, inability to ambulate prior to injury, symphyseal dislocations, patient unable or unwilling to complete 2-year follow-up, unlikely to follow up in surgeon’s estimation, or current or pending incarceration.
Surgeons were asked to provide their usual treatment, without altering treatment recommendations in any way, including indications for surgery, and rehabilitation plans.

Prospective data collection included demographics, injury, and treatment information [7, 8]. Study data were collected and managed using REDCap electronic data capture tools[9]. REDCap (Research Electronic Data Capture; grant support UL1 TR002319, KL2 TR002317, and TL1 TR002318 from NCATS/NIH) is a secure, web-based application designed to support data capture for research studies.

In addition to plain radiography, consisting of supine AP, inlet, and outlet images, all fractures were evaluated with computerized tomography (CT) of the pelvis at the time of injury. All centers received instructions with examples for making radiographic measurements which were previously described[5]. Measurements were obtained by research coordinators and/or physicians at participating centers. The measurements included displacement in millimeters of the sacrum, proximal ilium, and ischium on the AP and outlet views; the sacrum and the posterior ileum on the inlet views; and the ring width of the injured and uninjured sides on the AP and inlet views. The CT measurements
included location by zone. The physicians at recruiting centers also defined the pelvic ring injury by the Young-Burgess classification system.

Pelvic displacement was documented on injury plain radiographs. Displacement of the sacral fracture greater than 5 mm on any view was considered displaced. If 5 mm or less displacement was present on all 3 plain film views, the fracture was considered non-displaced. Treatment (nonoperative vs operative) was determined by the treating surgeon. This created 4 groups following the treating surgeon’s decision, as follows: displaced nonoperative (DN), displaced operative (DO), nondisplaced nonoperative (NN), nondisplaced operative (NO). All patients who consented were enrolled and followed prospectively.

Three hundred thirty-four patients met screening criteria, and 286 patients agreed to participate in the study. Short Musculoskeletal Function Assessment questionnaires were obtained at baseline (prior to injury), 3 months (range 54-128 days), 6 months (range 151-209 days), 1 year (range 306-424 days), and 2 years (range >640 days) following the injury. The SMFA is a musculoskeletal questionnaire with scores ranging from 0 (least dysfunction)-100 (most dysfunction). The SMFA was administered by research personnel during the initial admission and then either in-person during follow-up visits or by mail.
All data analysis was done with SPSS@IBM v25. Comparisons across the different treatment groups and different time points were done using One-way ANOVA. Statistical significance was set to p<0.05.

Results

Of the 286 patients enrolled initially, 128 completed 1-year follow-up and 123 completed 2-year follow-up. Demographics included a mean age of 40 (range 18-80), 106 male and 168 female (12 declined to identify), 268 lateral compression injuries, 2 vertical shear, and 16 combined mechanism. There were 6 patients initially enrolled over the age of 70 and 6 of these patients completed 2 year follow up. Of the 123 patients that completed 2 year follow up, no difference with respect to mechanism of injury, sex, age, BMI, ISS, Young-Burgess classification[10], or associated injuries was noted (Table 1). There was a significant difference (p <0.01) between sacral zone location across the 4 groups (DO, DN, NO, NN) with 53 of 73 (73%) zone 1 sacral fractures treated nonoperatively and 13 of 36 (36%) zone 2 fractures treated nonoperatively. The fractures were classified by the Young and Burgess system [10]. There were 111 lateral compression (OTA/AO 62B), 10 combined mechanical injury (OTA/AO 62B), and 2 vertical shear injuries (OTA/AO 62C) in the study. The numbers of patients completing 2 year follow up
for each group were 29 DN, 30 DO, 47 NN, and 17 NO with 56% loss to follow-up at 2 years.

The SMFA dysfunction scores were similar across all four groups within each time point (Figure 1, Table 2). Three month scores showed the most dysfunction across all groups ($p < 0.01$); 25 DN, 28 DO, 27 NN, 31 NO. The non-operative non-displaced group demonstrated a statistically significant improvement in function between the 3 and 24 month group ($p < 0.01$); whereas, the nondisplaced operative group demonstrated a statistically significant improvement in function between 3 and 6 months ($p < 0.01$) with a decrease in function at 12 months. For both displaced groups (whether surgery was performed or not) there was statistically significant improvement in function from 3 months to both the 12 and 24 month time points ($p < 0.01$). Final mean scores at 2 years for all groups were 13 DN, 12 DO, 17 NN, 17 NO. All but (DN) continued to recover for 2 years following injury, with peak recovery for DN seen at 1 year. No functional benefit was seen with operative intervention for either displaced or non-displaced injuries at any time point.

Table 2 shows the mean SMFA dysfunction scores for all 4 groups at each time point. Figure 1 is a graph of table 2 (dysfunction) over time. The appendix files include other components of SMFA (daily activities, emotion, arm, mobility,
and bother) and further details on radiographic displacement of patients who completed the study at 2 years (see Appendix files, Supplemental Digital Content 1,http://links.lww.com/JOT/B539 and 2,http://links.lww.com/JOT/B540. If the 6 elderly patients were removed, this would not affect the recovery curve with only a small change in mobility index.

**Discussion**

A considerable debate amongst orthopaedic trauma surgeons regarding surgical indications of unilateral sacral fractures exist. Recent studies by Gaski et al. have shown no apparent clinical benefit with operative intervention for lateral compression (LC) type 1 and 2 pelvic ring injuries displaced less than 1 cm[2, 3]. Gaski’s observation holds even in those injuries with complete sacral fractures, or those fractures that extend to the posterior sacrum[11]. This is consistent with previous work by Tornetta et al. where only 1% of patients displaced with immediate weight bearing in LC pelvic ring injuries with less than 1 cm initial displacement[12]. In contrast, Bruce et al. found that 68% of LC-1 injuries with a complete sacral fracture, bilateral ramus fractures and less than 5mm of initial displacement would displace. However, no functional outcome scores were reported with this study[13]. Functional deficits have been found in pure sacroiliac (SI) dislocations in vertical shear injuries with displacement greater than 5 mm at
final follow up, but this may represent a different injury than the sacral fracture or sacral fracture-dislocation seen in lateral compression injuries[14].

The focus of the current study was on functional outcomes of unilateral sacral injuries. No long-term benefit was seen with operative intervention in either the displaced or non-displaced fractures, defined as less than 5 mm initial displacement on an AP pelvis, inlet, or outlet view. The most interesting finding in this study is the time course of outcome with these injuries, with the worst functional outcomes noted at 3 months following injury and outcomes continuing to improve 2 years following injury for all but the displaced nonoperative group which showed continued improvement up to 1 year following injury. This is consistent with other studies showing prolonged and permanent dysfunction following pelvic ring injury[4, 15].

Initial or final radiographic displacement has poorly correlated with functional outcomes of sacral fractures. Although the treatment of minimally displaced pelvic ring fractures remains controversial, little evidence supports surgery for displaced fractures. Typical arguments for surgery of displaced fractures include pain, immobilization, sitting imbalance, and prevention of further displacement; although, weak evidence supports correlating the degree of displacement with pain or function. Our previous report on pain shows minimal
early pain relief with surgery that may or may not be of significant clinical benefit and is consistent with other studies[3, 6].

The majority of unilateral sacral fractures found in this study were lateral compression type sacral fractures. Previous studies have focused only on lateral compression fractures. The literature has shown repeatedly there is weak to moderate interobserver agreement using the Young-Burgess classification[16-18]. Our consortium felt no universal agreement in how a lateral compression fracture is identified, but complete agreement on a unilateral sacral fracture. A weakness of this approach is one might question the external validity of applying the results from this study to lateral compression fractures; however, 90% of the pelvic ring injuries in this study were lateral compression. This approach is also consistent with our previous reports on indications and pain with unilateral sacral fractures[5, 6].

The strength of this study is the multicenter observational design involving 16 level 1 trauma centers with prospective enrollment of patients with unilateral sacral fractures. This suggests the findings are generalizable and can be extrapolated to most trauma centers. However, a weakness of the study was the inability to prospectively randomize patients to treatment. The practical barrier to a large multicenter randomized study is surgeons are not in relative agreement
about indications, which may have negatively affected enrollment[5]. This likewise may have led to selection bias and inability to enroll a meaningful number of patients. Another weakness was the high loss to follow-up over time, which is consistent with treatment at academic medical centers[19].

Although there may be some individual patients who benefit from surgery, this observational study showed no clinically relevant improvement in functional outcome measurements for patients treated with surgery for unilateral sacral fractures regardless of whether the pelvic ring was initially displaced 5 mm or more. For all groups, the most dysfunction (or worst function) was found at 3 months, and all but the displaced nonoperative group continued to improve for 2 years following injury, with peak improvement noted in the displaced nonoperative group at 1 year.

Acknowledgement

The authors would like to thank Jessica Schisel for assistance with data analysis.

Legend

Table 1: Demographics of all enrolled patients who completed 2 year follow up

Table 2: Mean sMFA dysfunction scores for all 4 groups at all time points
Figure 1: Graphic chart by time of Table 2

References


Table 1. Demographic and injury features of patients treated operatively and nonoperatively.

<table>
<thead>
<tr>
<th></th>
<th>Nonoperative (n=76)</th>
<th>Operative (n=47)</th>
<th>All patients (n=123)</th>
<th>p values</th>
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<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
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<tr>
<td>Male</td>
<td>24</td>
<td>13</td>
<td>37</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>52</td>
<td>33</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td><strong>Mean age (years)</strong></td>
<td>45</td>
<td>44</td>
<td>44.8</td>
<td>0.80</td>
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<tr>
<td><strong>Mean BMI</strong></td>
<td>26</td>
<td>25</td>
<td>25.9</td>
<td>0.14</td>
</tr>
<tr>
<td><strong>Mean ISS</strong></td>
<td>16</td>
<td>19</td>
<td>16.9</td>
<td>0.07</td>
</tr>
<tr>
<td><strong>Mechanism of injury</strong></td>
<td></td>
<td></td>
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<tr>
<td>Motor vehicle collision</td>
<td>39</td>
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<td>58</td>
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<tr>
<td>Pedestrian v vehicle</td>
<td>4</td>
<td>8</td>
<td>12</td>
<td></td>
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<tr>
<td>Motorcycle crash</td>
<td>6</td>
<td>2</td>
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<td></td>
</tr>
<tr>
<td>Fall from height</td>
<td>11</td>
<td>9</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Fall from stand</td>
<td>7</td>
<td>2</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>7</td>
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<tr>
<td><strong>Associated injuries (AIS 1-5)</strong></td>
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<tr>
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<tr>
<td>Extremity</td>
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<td><strong>Young-Burgess classification</strong></td>
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<tr>
<td>Lateral compression</td>
<td>72</td>
<td>39</td>
<td>111</td>
<td></td>
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<tr>
<td>Vertical shear</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Combined mechanism</td>
<td>4</td>
<td>6</td>
<td>10</td>
<td></td>
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<tr>
<td><strong>Sacrum fracture location</strong></td>
<td></td>
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</tr>
<tr>
<td>Zone 1</td>
<td>53</td>
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<td>73</td>
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<tr>
<td>Zone 2</td>
<td>13</td>
<td>23</td>
<td>36</td>
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</tbody>
</table>

BMI: body mass index; ISS: Injury Severity Score; OTA/AO: Orthopaedic Trauma Association/ Arbeitsgemeinschaft fur Osteosynthesefragen
Table 2: SMFA Outcomes

<table>
<thead>
<tr>
<th></th>
<th>Displaced Nonoperative</th>
<th>Displaced Operative</th>
<th>Nondisplaced nonoperative</th>
<th>Nondisplaced operative</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean (Range)</td>
<td>Std. Deviation</td>
<td>N</td>
</tr>
<tr>
<td>Baseline</td>
<td>69</td>
<td>12.5* (0-68)</td>
<td>18.36</td>
<td>48</td>
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<tr>
<td>3 months</td>
<td>37</td>
<td>24.9*# (1-65)</td>
<td>18.3</td>
<td>47</td>
</tr>
<tr>
<td>6 months</td>
<td>29</td>
<td>14.3 (0-51)</td>
<td>12.8</td>
<td>30</td>
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<tr>
<td>1 year</td>
<td>22</td>
<td>10.4# (0-34)</td>
<td>11.09</td>
<td>28</td>
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<tr>
<td>2 years</td>
<td>29</td>
<td>12.8# (0-40)</td>
<td>14.61</td>
<td>30</td>
</tr>
</tbody>
</table>

Mean dysfunction at all time points for all groups (One way ANOVA)
* represents differences between baseline and later time points p < 0.01
# represents differences between 3 months and later time points p < 0.01

There is no difference in scores of the 4 groups by any time point.