Thoracic and Lumbar Compression Fractures in Patients Presenting to a Pediatric Institution

Avrum Joffe¹, Carrie E. Bartley², Tracey P. Bastrom², Peter O. Newton¹, Burt Yaszay²

¹North Jersey Pediatric Orthopaedics, Ridgewood, NJ
²Division of Orthopedics, Rady Children’s Hospital San Diego, San Diego, CA

ABSTRACT

AIM: To assess the demographics, treatments, and radiographic and clinical outcomes of pediatric compression fractures.

MATERIAL and METHODS: A retrospective review of all pediatric patients presenting to a single institution between 2009 and mid 2012 with thoracic or lumbar compression fracture(s) was conducted. The mechanism of injury, degree of initial and final vertebral wedging, treatment employed, and patient reports of pain/ongoing deficits were recorded.

RESULTS: There were 67 patients with a total of 135 compression fractures. The majority of fractures resulted from a fall (40%), MVA (27%), or collision sports injury (25%). Thirty-nine (58%) patients were treated with a brace and 28 (42%) were treated without a brace. None required surgery. A CT scan was ordered for 32 patients. CT identified additional fracture levels in 9 patients (28%). Forty-seven (70%) patients had posterior tenderness initially. Sixteen (24%) continued to report back pain/stiffness at final follow-up for which physical therapy was prescribed.

CONCLUSIONS: Advanced imaging can identify additional levels but does not appear to affect treatment of compression fractures in pediatric patients. The use of bracing in the treatment of these injuries may be beneficial in easing pain, but did not appear to affect the ultimate residual wedging.

KEY WORDS: Compression fracture, lumbar compression fracture, pediatric, spine, thoracic compression fracture

INTRODUCTION

The nature of vertebral compression fractures has been well described and classified in the adult population by Denis (4). The principle of anterior column stress failure remains relevant, and has been confirmed as the mechanism in cadaveric adolescent spine studies by Karlsson et al (9). Additionally, Karlsson et al. identified the growth plate as the weakest portion of the adolescent spine in compression. There have been multiple case series of pediatric spinal injuries wherein compression fractures are discussed, but to our knowledge there are none that specifically focus on compression fractures.

Although compression fractures in the pediatric population have been described by mechanism and analyzed with regards to epidemiology, a review of the literature demonstrates that little has been written regarding the protocols for identification and treatment, particularly regarding diagnostic imaging modalities or the efficacy of immobilization. The evaluation of compression fractures has, in fact, been described in combination with a larger series that includes all types of spine fractures. Pouliquen et al. reviewed their compression fracture radiographic findings at presentation and follow up, as well as their experience with treatment modalities specific to casting and bracing (15).
The purpose of the current study was to collect demographic, clinical, radiographic, treatment, and outcome data on our series of consecutive patients with thoracic and/or lumbar anterior compression fractures presenting to a single pediatric institution over a three-year period.

**METHODS**

Institutional Review Board approval was obtained for this study. A retrospective review of all patients presenting to a single pediatric institution between 2009 and mid 2012 with thoracic or lumbar compression fracture(s) was conducted. Our electronic medical record system using the ICD-9 codes 805.00-805.99 was employed to identify eligible patients. Patients who sustained insufficiency-type injuries secondary to underlying metabolic/malignant conditions were excluded. The mechanism of injury, vertebral levels fractured, imaging obtained, presence of neurologic symptoms, presence of posterior tenderness, and the treatments employed were recorded. Mechanism of injury was consolidated into patients who were injured from 1) a fall, 2) collision sports activity, 3) motor vehicle or all-terrain vehicle or 4) unknown cause. Patient reports of any ongoing deficits or pain were also recorded. The degree of initial and final vertebral wedging on radiographs and advanced imaging (when available) was recorded. The degree of wedging at each affected level was recorded (Figure 1). For analysis purposes, the average wedging on initial radiographs, initial CT, and final radiographs was calculated.

ANOVA was utilized to compare the average age of patients with one, two, or ≥3 levels fractured. Repeated measures ANOVA was utilized to evaluate changes in wedging on initial radiographs compared to final radiographs. The difference in wedging observed on plain radiographs versus CT (in patients with available CT information) was calculated and the standard error of measurement was calculated. ANOVA and chi-square analyses were utilized to compare differences based on the region of the fractures and also to compare differences between patients who were braced versus those who were not. Alpha was set at p<0.05 to declare significance.

**RESULTS**

One hundred and forty three patients with spine fractures were identified in our electronic medical records. Among those 143 patients, compression fracture was the most common injury, with 67 (47%) patients identified. There were 40 male and 27 female patients. Mean age at time of injury was 12.5 ± 3.5 years (range 5.1 to 20.9 years). There were a total of 135 vertebrae fractured (levels per patient ranged from 1-5). Twenty-nine patients had 1 fractured level, 19 had 2 fractured levels, and 19 had ≥3 fractured levels. There was a trend for the patients with ≥3 fractures to be younger (11 ± 3 years) compared to those with single level fractures (13.4 ±3 years) and two levels fractured (12.7 ± 3 years, p=0.07). The most common vertebra fractured was T6. The distribution of vertebra fractured demonstrated a bimodal distribution with a peak in the mid thoracic region and a smaller peak at the thoracolumbar junction (Figure 2). The majority of fractures sustained resulted from a fall (40%), MVA (27%), or collision sports injury (25%). Five patients had a mechanism of injury that was unknown. No patient required surgery.

At presentation, 47 patients (70%) had the physical examination finding of posterior spinal tenderness around the level of injury. There was one patient reported by the ER/trauma service to have had initial loss of rectal tone (ER ordered MRI), but this was not found on examination by the orthopedic service. Six patients complained of subjective neurologic symptoms, such as tingling in the hands or feet, but on physical examination all of these patients were found to have a completely intact neurologic examination.

**Radiographic Findings**

Plain radiograph examination demonstrated at least one fracture in 58 out of 67 patients. Thirty-two patients underwent CT examination (31 of those were ordered by the trauma service or emergency department staff as part of trauma workup). Nine patients (28% of those who had a CT scan, 13% of all patients) had compression fractures that were only evident on CT examination. The compression fractures in these 9 patients were not identified on plain radiographs because of poor image quality or obscuring of osseous structures by mediastinum contents.

Anterior wedging of the fractured vertebrae at the time of injury was 12 ± 4° on plain radiograph. The average wedging of fractured vertebrae at last radiographic follow up was 11 ± 5° (p=0.08). The average degrees of wedging on x-ray were not significantly different from those observed on CT (p=0.9), with a mean standard error of measurement between the modalities of 2.9°.

Fifteen patients had an MRI examination. Six of these were ordered by the orthopedic service and were useful
in identifying levels and/or evaluating acuity of injury. Two patients underwent MRI ordered by the orthopedic service for prolonged symptoms of pain. One patient had an MRI ordered by the ER/trauma service as part of the trauma evaluation over concern for neurologic injury. For the remaining patients, the reason for MRI examination was unclear in the medical record.

Figure 1: Example of a thoracic compression fracture wedged 11° at initial presentation.

Region of Injury

The average age of patients sustaining fractures in only the thoracic region was 12 ± 4 years and those in the thoracolumbar/lumbar region averaged 13 ± 3 years (p=0.13). There was a trend toward a significant difference in the distribution of region of fractures based on mechanism of injury (p=0.06, Figure 3). The majority of fractures occurred in the thoracic region for patients sustaining injury from a fall (67% thoracic region), collision sports injury (88%), or unknown cause (60%); however patients sustaining compression fractures from a motor vehicle injury had a higher incidence of compression fractures in the thoracolumbar/lumbar region (56%).

Bracing

Thirty nine (58%) patients were treated with a brace and 28 (42%) were treated without a brace. Average brace wear was 9 ± 4 weeks. There was a trend for the braced patients to have slightly greater initial wedging (13 ± 5° vs 10 ± 3°, p=0.07) but no statistically significant difference in wedging was seen at final radiographic follow up (12 ± 6° vs 10 ± 3°, p=0.2) (Table 1). There was no difference in number of fractured vertebrae between the braced and non-braced patients (median of 2 levels in braced and non-braced patients, p=0.5). There was no difference in age between the braced (12.6 ± 4 years) and non-braced (12.4 ± 4 years) patients (p=0.09). Neurologic complaints (tingling/numbness described above) did not seem to influence brace treatment with 2/6 (33%) undergoing brace treatment compared to 36/55 (65%) who did not complain of neurologic symptoms (p=0.19). Complaints of posterior tenderness upon initial examination also did not appear...
to influence brace treatment (66% of patients positive for posterior tenderness were braced vs. 57% without posterior tenderness complaints, p=0.55). There was a trend for a greater proportion of patients with fractures in the thoracolumbar/lumbar region to be treated in a brace (74%) compared to those with fractures in the thoracic region (50% braced, p=0.06). There was a significant difference in the proportion of patients braced according to the mechanism of injury categories (p≤0.001) with higher energy mechanisms more likely to be braced. The prevalence of bracing in motor vehicle injuries was 83%, followed by 67% in those sustaining injury from a fall, 35% in sporting injuries, and none (0%) in those with an unknown mechanism of injury.

**DISCUSSION**

Fall/jump injuries, motor vehicle accidents, and collision sport injuries were the most common mechanisms of injury in the current study. These findings are consistent with previous studies that report motor vehicle accidents and falls being the two most common causes of compression fractures (1, 3, 11, 20). Also similar to previous studies, compression

<table>
<thead>
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<th>Table 1: Characteristics of patients braced versus those not braced.</th>
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<tbody>
<tr>
<td><strong>Not Braced</strong></td>
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<tr>
<td>-------------------------</td>
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<tr>
<td>Average radiographic wedging° (initial)</td>
</tr>
<tr>
<td>Average radiographic wedging° (final)</td>
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<tr>
<td>Number of vertebra fractured (median)</td>
</tr>
<tr>
<td>Age</td>
</tr>
<tr>
<td>Neurologic complaints</td>
</tr>
<tr>
<td>No (n=55)</td>
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<tr>
<td>Yes (n=6)</td>
</tr>
<tr>
<td>Positive posterior tenderness</td>
</tr>
<tr>
<td>No (n=14)</td>
</tr>
<tr>
<td>Yes (n=47)</td>
</tr>
<tr>
<td>Region of fractures</td>
</tr>
<tr>
<td>thoracic (n=44)</td>
</tr>
<tr>
<td>TL/L (n=23)</td>
</tr>
<tr>
<td>Mechanism of Injury</td>
</tr>
<tr>
<td>Fall (n=27)</td>
</tr>
<tr>
<td>Sports Collision (n=17)</td>
</tr>
<tr>
<td>Motor Vehicle (n=18)</td>
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<tr>
<td>Unknown (n=5)</td>
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**Figure 3: Location of fracture based on mechanism of injury.**

<table>
<thead>
<tr>
<th>Mechanism of Injury</th>
<th>thoracic</th>
<th>thoracolumbar</th>
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<tbody>
<tr>
<td>Fall</td>
<td>100%</td>
<td>0%</td>
</tr>
<tr>
<td>Collision / sports</td>
<td>70%</td>
<td>30%</td>
</tr>
<tr>
<td>MVA</td>
<td>30%</td>
<td>70%</td>
</tr>
<tr>
<td>Other</td>
<td>0%</td>
<td>100%</td>
</tr>
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fractures were the most common type of fracture noted of all reported thoracic and lumbar vertebral fractures (16). Fifty-seven percent of our patients presented with compression fractures at more than one level. McPhee found that 35% of patients presenting with vertebral injury had more than one level involved (11). Black et al. reviewed 38 patients with thoracic and lumbar spine fractures in 1994 and found that thirteen of those patients had compression fractures only, with 8 of them having 2 or more levels involved (3). Older patients were more likely to have fewer contiguous levels involved, which supports the theory of the flexible juvenile spine's ability to dissipate load. Our data was consistent with these findings, as patients with 3 or more levels fractured trended toward being younger than those with 1 or 2 levels injured. Interestingly, Anderson et al.4 and Dogan et al. (5) found that older pediatric patients were more likely to incur spinal injuries than younger pediatric patients.

Physical examination of the pediatric population is challenging in the setting of acute trauma, with or without spinal injury. Seventy percent of our patients were found to have posterior tenderness upon initial orthopedic evaluation. Santiago et al. retrospectively reviewed the clinical presentation of pediatric patients and found that physical exam was 87% sensitive for the diagnosis of thoracolumbar fractures (18). A subsequent study found that clinicians were able to detect thoracolumbar and sacral fractures with 56% sensitivity and 82% specificity (8).

Plain radiographs of the spine are essential in the workup of acute trauma in addition to physical exam, and some trauma centers have even advocated CT scan as part of initial workup (2). Roche and Carty reviewed and described the radiographic assessment algorithm in pediatric vertebral injuries and highlighted the differences between children and adults, most notably that there may be mild anterior baseline wedging in normal immature vertebrae (16). The authors also noted that CT has been most beneficial in the diagnosis of cervical spine trauma. In our series, CT scan helped us make the diagnosis in 9 patients (although 32 patients underwent CT scan in total), and MRI examination was employed in 15 patients but only twice in the acute setting. The role of MRI examination in the acute evaluation of pediatric spinal trauma has been supported in the pediatric literature (19) and in the adult literature as a modality for identifying more complex and ligamentous injuries (6, 14). Recently, because of associated and non-contiguous injuries, the importance of thorough trauma evaluation and evaluation of the whole spine has been highlighted (17); however, these findings are not specific to compression fractures.

The assessment of CT as a diagnostic modality for evaluation of compression fractures is difficult to analyze using our data. Trauma protocols clearly governed the majority of orders in our case series. In the setting of high energy trauma, such as a fall from a height or motor vehicle accident, the trauma protocol will continue to govern decision-making in the acute evaluation of injuries. Current trauma protocols often employ CT of the chest/abdomen that incidentally encompasses evaluation of the thoracolumbar spine.

In our series, the most commonly fractured vertebra was T6; however a bimodal distribution was noted with a second peak at the thoracolumbar junction. Dogan et al. found that lumbar fractures (L2-L5) were most common in their series (29.8% of all comers in their series of 89 patients), the majority of which were related to motor vehicle accidents (5). In the present series, thoracolumbar/lumbar fractures were observed more frequently in the motor vehicle accident population; whereas collision sports and fall injuries more commonly resulted in thoracic fractures.

The clinical consequences of compression fractures in the young population are largely unknown, but radiologic sequelae have been described. Kerttula et al. (10) performed MRI scans on 14 patients (age range 8.8 to 20.8 years) at a minimum of 1 year after compression fracture and found that seven of 14 patients had disc degeneration at the level of injury. Six of those 7 had endplate damage at the level of trauma. There was no correlation between these MRI findings and clinical symptoms (10).

Moller et al. examined vertebral changes over a much longer time period (12). They performed MRI examinations on 20 patients with vertebral fractures between 33 and 53 years post-injury. Eighteen of 20 had compression fractures, and the remaining 2 had burst fractures. All were treated with activity modification, and without bracing or immobilization. They found no increase in disc degeneration around the injured levels compared to discs at more distant levels. However, they did find more Schmorl's nodes about the injured vertebrae, although the clinical significance of this finding is uncertain (12).

The efficacy of bracing is historically controversial. A previous study of 122 cases of vertebral and spinal cord injuries in pediatric patients found that 41% of those patients...
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presented with fractures only (not specific to compression fractures), and 14 such patients had a thoracic or lumbar fracture treated with a hyperextension brace or bivalve body jacket (7). As in the other reported series, the number of cases increased with patient age. Pouliquen et al. advised immobilization of pediatric patients with compression fractures (hyperextension casts or orthoses), particularly in patients approaching skeletal maturity (15). The cost of bracing may be burdensome, however, and should be taken into consideration when deciding upon a treatment. Other authors have advised immobilization of one-column injuries with orthoses that opposed the vector of injury force (13); however, this was not specific to pediatric trauma. In our series, no patients were immobilized in hyperextension casts. In Black et al.'s study, the younger patients, as opposed to the adolescents, tended to be casted or braced (3). At our institution the use of a brace was variable and at the discretion of the treating physician. Although not entirely clear in the medical records, several driving forces for bracing were identified in retrospective review of our data. Patients who sustained falls or motor vehicle accidents were more likely to be treated with a brace. Additionally, bracing was utilized in a greater number of patients with thoracolumbar or lumbar compression fractures than in those with purely thoracic compression fractures. We are not able to draw conclusions about the efficacy of bracing in our cohort because not all patients were followed to skeletal maturity.

A limitation of our present study is the lack of long-term follow up. For those who failed to return after emergency room consultation or initial clinic presentation, the reason for loss of follow up is unclear. We suspect that many had resolution of pain and symptoms. Few patients were lost to follow up after their initial and only evaluation in the emergency room. Some may have followed-up at their area of residence as we serve a large vacationing population. The retrospective nature of this study also limits our analyses. A prospective analysis of bracing and the utility of imaging modalities would better determine their efficacy.

CONCLUSION

Anterior compression fractures of the thoracic and lumbar spine are stable injuries. Although CT scan was used as an imaging modality in the acute trauma workup of many patients, its use is largely driven by trauma protocols. MRI, though useful to identify additional levels of injury, had no clear impact on treatment and was often performed subacutely. Our data does not support or deny the utility of bracing in the interest of maintaining sagittal alignment, but it may be considered as an option for modification of behavior.

REFERENCES


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Address correspondence to: Burt Yaszay, 3030 Children’s Way, Suite 410
San Diego, CA 92123
Phone: +20 222 913 992
email: byaszay@rchsd.org