RESEARCH ARTICLE

Epidemiology of traumatic spinal fractures in patients aged 50 years or less at a center in Saudi Arabia from 2005 to 2016

[version 1; peer review: awaiting peer review]

Dakheel Aldakheel¹,², Mir Sadat Ali¹,², Abdullah Alothman¹,², Hassan Alsayed¹,², Ahmad Sh Amer¹, Mohammad A Alhassan¹,², Ibrahim M Mutawwam¹, Abdulaziz M Alhawas¹,², Abdulhakem H Alshehri¹, Hussain A Alabdullah¹, Mohammed A Alkhateeb²

¹Department of Orthopaedic Surgery, King Fahd Hospital of the University, Imam Abdulrahman Bin Faisal University, Khobar, Eastern Province, 31952, Saudi Arabia
²College of Medicine, Imam Abdulrahman Bin Faisal University, Dammam, Eastern Province, 31952, Saudi Arabia

v1 First published: 13 Jul 2023, 12:819
https://doi.org/10.12688/f1000research.133527.1

Abstract

Background: We retrospectively reviewed traumatic spinal fractures (TSFs), including their mechanisms of injury and associated injuries in patients aged ≤50 years admitted to our center over a period of 11 years. Our secondary objective was to investigate whether spine injuries have decreased since the introduction of new transportation-related legislation applications.

Methods: Between 2005 and 2016, all patients admitted to the hospital due to TSFs, including cervical, thoracic, and lumbar spinal fractures, who were aged ≤50 years were included in this study. Patient demographics, mechanism of injury, associated injuries, hospital stay duration, treatment, complications, and mortalities were reviewed and analyzed.

Results: Altogether, 373 patients (81% male; 19% female; median age, 28 years) were included in the study, and 579 spinal fractures were identified. The lumbar spine was the most affected part. The most common injury mechanism was motor vehicle accidents (MVA) (69.7%), followed by falls (26.8%). Neurological injuries were detected in 9.4% of patients. Associated injuries were observed in 45.3% of patients, and 33.6% of patients were surgically treated. Thoracic injuries and lower limb fractures were the most common injuries, and the postoperative complication rate was 3.9%.

Conclusions: Although there was a significant decrease in TSFs after the speed control legislation over the study period, MVA and falls remained the most common causes of spinal injuries. Associated injuries, operated patients, and female sex were all associated with a prolonged hospital stay.
Keywords
spine, spine fracture, surgery, spine cord injury, motor vehicle accident, fall from height, Saudi Arabia
Introduction
Traumatic spinal fractures (TSFs) in young patients result from high-energy trauma, such as motor vehicle accidents (MVA) and falls from height (FFH). It has been reported that at one-year post-injury, only 53% of patients with TSFs returned to work, with most working part-time or changing the nature of their work. Poor short- and long-term outcomes in polytraumatized TSF patients have been reported. At a young age, postgraduate education, training, and early career years are typically observed. Long-term disabilities, chronic pain, and lengthy rehabilitation programs are common features, especially with neurological injury, making TSF an economic burden to the patient, family, and nation.

Several epidemiological studies have shown that MVA and FFH were the leading causes of TSF. However, these studies were not directed at patients aged ≤50 years nor reported all mechanisms of injuries, or the associated injuries (AIs) based on injury sites.

The current study investigated TSFs in patients aged ≤50 years admitted to our center over ten years and reviewed the injury mechanisms and AIs. We also reviewed the characteristics of vertebral fractures and determined the association between sex and frequency of AIs and single/multiple vertebral fractures.

Methods
Ethical considerations
The study is conducted in compliance with the principles of the Declaration of Helsinki. The study’s protocol was reviewed and approved by the Institutional Review Committee of the College of Medicine Imam Abdulrahman Bin Faisal University (IRB No. 2020-01-442) dated November 8, 2020. A written informed consent was not required because this was a retrospective review of hospital records, and all data are anonymized. The consent was obtained from all patients for reviews of hospital records upon their admission to the hospital.

Data collection
This study was conducted at a tertiary level 1 trauma center with a 450-bed capacity located in the catchment area of two cities in Saudi Arabia with an estimated population of more than 250,000. The study protocol complied with the principles of the Declaration of Helsinki and was reviewed and approved by the Institutional Review Committee. The data of patients with spinal fractures admitted to the emergency department between January 1, 2005, and December 31, 2016, were collected. The International Classification of Diseases code, tenth revision, was used to search the electronic hospital database system (QuadraMed). Simultaneously, the operative theater logbook was reviewed manually over the same period. Patients admitted with TSF, including cervical, thoracic, or lumbar fractures, aged ≤50 years were included. We excluded patients with low-energy osteoporotic spinal fractures or pathological spinal fractures, those referred to another hospital after admission, and those who refused medical advice. Isolated sacral fractures were omitted because they were considered pelvic fractures (Figure 1).

The medical records were reviewed for demographic data, including age, sex, date and time of presentations, mechanisms of injury, AIs, treatment, complications, and mortalities. AIs like central nervous system injuries, thoracic, abdominal, urological, pelvic, and extremity fractures. The involvement of more than one anatomic site was considered multiple AIs.

Multiple vertebral fractures (MVF) were defined as fractures involving more than one vertebral body. It was considered a single vertebral fracture if the same vertebra had a fracture in different locations, such as the spinous or transverse processes. Double spinal fractures were defined as two non-fractured vertebrae between the fractured vertebrae. Multiple noncontiguous vertebral fractures (MNCVFs) were defined as MVF with at least three normal vertebrae between the fractured vertebrae. Patients underwent a pan-computed tomography (CT) scan as per the trauma protocol. Two senior authors reviewed CT images for patients with double spinal fractures and MNCVF to meet Koress et al.’s criteria. Other miscellaneous data, including hospital stay duration, treatment, time to surgery, and complications, were reviewed. Data and analysis codes are available under Underlying data.

Statistical analyses
Data were tested for a normal distribution using the Shapiro-Wilk test. Continuous data are shown as mean with standard deviation when normally distributed and median and interquartile range (IQR) in non-normally distributed data. Categorical data are shown as absolute values with frequencies or percentages. The chi-squared test was used to test for the association between sex and the number of AIs. A two-tailed Mann-Whitney U-test was used to compare the non-normal continuous variables between two groups. A linear regression analysis was performed to detect differences in TSF cases after applying road safety measures. A P < 0.05 was considered statistically significant. The data were analyzed using GraphPad Prism 6 by GraphPad Software Inc. (San Diego, California, USA) (RRID:SCR_002798). An open-access alternative to GraphPad Prism is R: The R Stats Package.
Between 2005 and 2016, 635 patients were identified, 121 duplicate cases were removed, and 141 were excluded from the study. Altogether, 373 patients (579 spinal fractures) were included in the study, including 302 (81%) men and 71 (19%) women. The median age was 28 years (IQR, 23–36 years) (Table 1). At the time of injury, the women were slightly older than the men, with a median age of 30 (IQR, 24–36 years) and 28 years (IQR, 23–36 years), respectively (Figure 2).

### Mechanism of injury

Overall, MVA was the most common injury (260 patients, 69.7%), followed by FFH (100 patients, 26.8%) (Table 1). Vehicle collisions accounted for 96.5% of MVA cases, while only 3.5% were pedestrian injuries. In men, MVA was the most common mechanism of injury ($n = 238, 78.8$%), followed by FFH in 54 patients (17.8%). Contrarily, FFH was the most common mechanism of injury in 46 female patients (64.7%), followed by MVA in 22 (30.9%) (Figure 3).

**Figure 1.** Methodology of data collection in patients with traumatic spinal fractures aged ≤50 years in Saudi Arabia in 2005–2016.
Associated injuries and mechanisms of injuries
Altogether, 172 patients (46.1%) presented with 235 AIs; 134 (77.9%) were men, of whom 52 (38.8%) had multiple AIs. There were 37 (21.5%) female patients; six (16.2%) sustained multiple AIs. One patient developed an associated injury due to other mechanisms of injury. The overall incidence of AIs in men and women was 44.3% (134/302) and 52.1% (37/71), respectively, with the difference not showing statistical significance (Figure 4).

In the MVA group, 125 patients (48%) had AIs [113 (90.4%), male; 12 (9.6%), female]. In the FFH group, 46 patients (46%) had AIs [21 (45.6%), male; 25 (54.4%), female]. The association between the injury mechanism and the incidence of AIs was not statistically significant.

Description of vertebral fractures
Altogether, 579 spinal fractures were identified, with the lumbar spine (336, 58%) being the most commonly affected parts, followed by the cervical and thoracic spine (122 [21%] and 117 [20.2%], respectively). Sacral fractures that occurred along with spinal fractures at a higher level were identified in four (0.8%) patients (Figure 5). Vertebral fractures affecting L1 (118, 20.5%) and L2 (80, 13.9%) were the most common fractures in all patients (Figure 5).

MVF was reported in 142 patients (38%) [118 (83%), men; 24 (17%), women]. The incidence of MVF between men (118/302, 39%) and women (24/71, 33.8%) of the whole cohort was not statistically significant. Double vertebral fractures were found in four (2.8%) patients, including three with lumbar spine fractures and one with a thoracic spine

Table 1. Demographics, mechanisms of injury, associated injuries, and treatment of patients aged <50 years with traumatic spinal fractures in Saudi Arabia (2005–2016).

<table>
<thead>
<tr>
<th>Patient demographics</th>
<th>Total</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>373</td>
<td>302 (81%)</td>
<td>71 (19%)</td>
</tr>
<tr>
<td>Age, years (median, IQR)</td>
<td>28 (23–36)</td>
<td>28 (23–36)</td>
<td>30 (24–36)</td>
</tr>
<tr>
<td>Affected vertebra, n (%)</td>
<td>Total no. 579</td>
<td>474 (81.9%)</td>
<td>105 (18.1%)</td>
</tr>
<tr>
<td>Cervical</td>
<td>122 (21.2%)</td>
<td>104 (85.2%)</td>
<td>81 (14.8%)</td>
</tr>
<tr>
<td>Thoracic</td>
<td>117 (20.4%)</td>
<td>95 (81.2%)</td>
<td>22 (18.8%)</td>
</tr>
<tr>
<td>Lumbar</td>
<td>336 (58%)</td>
<td>271 (80.7%)</td>
<td>65 (19.3%)</td>
</tr>
<tr>
<td>Sacrum</td>
<td>4 (0.8%)</td>
<td>4 (100%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Mechanism of injury, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motor vehicle accident</td>
<td>260 (69.6%)</td>
<td>238 (91.5%)</td>
<td>22 (8.5%)</td>
</tr>
<tr>
<td>Fall from height</td>
<td>100 (26.7%)</td>
<td>54 (54%)</td>
<td>46 (46%)</td>
</tr>
<tr>
<td>Sport</td>
<td>1 (0.3%)</td>
<td>1 (100%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Assault</td>
<td>2 (0.6%)</td>
<td>0 (0%)</td>
<td>2 (100%)</td>
</tr>
<tr>
<td>Gunshot</td>
<td>1 (0.3%)</td>
<td>1 (100%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Others</td>
<td>9 (2.5%)</td>
<td>8 (88.9%)</td>
<td>1 (11.1%)</td>
</tr>
<tr>
<td>Associated injury, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central nervous system</td>
<td>36 (15.3%)</td>
<td>32 (88.9%)</td>
<td>4 (11.1%)</td>
</tr>
<tr>
<td>Thorax</td>
<td>62 (26.4%)</td>
<td>59 (95.2%)</td>
<td>3 (4.8%)</td>
</tr>
<tr>
<td>Abdomen</td>
<td>23 (9.8%)</td>
<td>21 (91.3%)</td>
<td>2 (8.7%)</td>
</tr>
<tr>
<td>Pelvis</td>
<td>18 (7.6%)</td>
<td>15 (83.3%)</td>
<td>3 (16.7%)</td>
</tr>
<tr>
<td>Urology</td>
<td>2 (0.9%)</td>
<td>2 (100%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Lower limb fractures</td>
<td>62 (26.4%)</td>
<td>38 (61.3%)</td>
<td>24 (38.7%)</td>
</tr>
<tr>
<td>Upper limb fractures</td>
<td>32 (13.6%)</td>
<td>27 (84.4%)</td>
<td>5 (15.6%)</td>
</tr>
<tr>
<td>Treatment, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conservative</td>
<td>244 (66.4%)</td>
<td>212 (86.9%)</td>
<td>32 (13.1%)</td>
</tr>
<tr>
<td>Operative</td>
<td>129 (33.6%)</td>
<td>90 (69.8%)</td>
<td>39 (30.2%)</td>
</tr>
</tbody>
</table>

IQR: interquartile range.

Associated injuries and mechanisms of injuries
Altogether, 172 patients (46.1%) presented with 235 AIs; 134 (77.9%) were men, of whom 52 (38.8%) had multiple AIs. There were 37 (21.5%) female patients; six (16.2%) sustained multiple AIs. One patient developed an associated injury due to other mechanisms of injury. The overall incidence of AIs in men and women was 44.3% (134/302) and 52.1% (37/71), respectively, with the difference not showing statistical significance (Figure 4).

In the MVA group, 125 patients (48%) had AIs [113 (90.4%), male; 12 (9.6%), female]. In the FFH group, 46 patients (46%) had AIs [21 (45.6%), male; 25 (54.4%), female]. The association between the injury mechanism and the incidence of AIs was not statistically significant.

Description of vertebral fractures
Altogether, 579 spinal fractures were identified, with the lumbar spine (336, 58%) being the most commonly affected parts, followed by the cervical and thoracic spine (122 [21%] and 117 [20.2%], respectively). Sacral fractures that occurred along with spinal fractures at a higher level were identified in four (0.8%) patients (Figure 5). Vertebral fractures affecting L1 (118, 20.5%) and L2 (80, 13.9%) were the most common fractures in all patients (Figure 5).

MVF was reported in 142 patients (38%) [118 (83%), men; 24 (17%), women]. The incidence of MVF between men (118/302, 39%) and women (24/71, 33.8%) of the whole cohort was not statistically significant. Double vertebral fractures were found in four (2.8%) patients, including three with lumbar spine fractures and one with a thoracic spine
fracture. MNCVF was identified in 11 patients (7.7%); of these, three patients (27.2%) had neurological deficits on presentation. There was no delay in diagnosis.

In patients involved in MVA, 108 (41.5%) sustained MVF, with frequencies of two in 74 (68.5%), three in 22 (20.4%), four in five (4.6%), five in six (5.5%), and six in one (0.9%) patient. In the FFH group, 31 patients (31%) sustained MVF, in which two vertebral fractures were found in 18 patients (58%) and three vertebral fractures in 13 patients (42%). Moreover, three (2.1%) patients had MVF due to other mechanisms of injury.

**Variation in presentation and trend of traumatic spinal fractures**

There were no significant diurnal or seasonal variations observed. The total number of TSF cases is shown in Figure 6. A significant decrease in TSF cases was observed in the second half of the study. A linear regression analysis of the total number of TSF cases between 2010 and 2016 showed an R-squared of 0.9358 for MVA and 0.8616 for FFH (Figure 7).

**Treatment, time to surgery, hospital stay duration, complications, and mortality**

Altogether, 244 patients (66.4%) were treated conservatively, 129 (33.6%) were treated surgically, 101 (78.3%) underwent posterior procedures, 26 (20.1%) had anterior fixation, two (1.6%) underwent staged posterior and anterior procedures. During the first week of hospitalization, 112 patients (86.8%) underwent surgery.

The median hospital stay was ten days (IQR, 5–18 days). The hospital stay was longer for women (median, 16 days; IQR, 9–22 days) than for men (median, nine days; IQR, 5–17 days) (P-value = 0.0001). Operated patients had more extended hospitalization (median, 13 days; IQR, 9–23 days) than the conservatively treated patients (median, eight days; IQR, 4–16 days) (P-value < 0.0001). Patients with AIs had more extended hospitalization (median, 16 days; IQR, 7–29 days) than those without AIs (median, eight days; IQR, 4–13 days) (two-tailed P-value < 0.0001).

Incomplete neurological and complete spinal cord injuries were observed in 24 (6.5%) and 11 (3%) patients, respectively. Postoperative complications were documented in five patients (3.9%), including three (2.3%) patients who developed postoperative infections and two (1.5%) with neurological worsening due to mal-positioned pedicle screws that required revision.
Figure 3. Number of male and female patients aged ≤50 years and admitted with traumatic spinal fractures per mechanism of injury in Saudi Arabia in 2005-2016.

Figure 4. Distribution of associated injuries in male and female patients in Saudi Arabia in 2005-2016.
Figure 5. Distribution of vertebral fractures per level in male and female patients in Saudi Arabia in 2005–2016.

Figure 6. Number of patients with traumatic spinal fractures per mechanism of injury in patients aged ≤50 years in Saudi Arabia (2005–2016).
Nine patients (2.4%) died in the hospital with a median age of 27 years (IQR, 24–29 years), a median hospital stay of 11 days (IQR, 2–61 days), and a median number of AIs of three. All were victims of MVA sustaining MVF. Patients sustained head injuries, and six (66.6%) patients had additional thoracic and abdominal injuries.

**Discussion**

In 2019, the global median age increased to 30 years, with two-thirds of the world’s population aged <65 years. A population aged between 15 and 64 years is considered the working or independent individuals who contribute to economic and social stability. Several studies have shown that TSF commonly affects those aged 20–40 years.5,7,8,11–13 Others reported more spinal fractures in populations aged >65 years, in which osteoporosis may play a significant role.14 Considering the low reemployment percentage and poor short- and long-term outcomes,2 a study of TSF in young patients will provide better insights into the mechanisms of injury and AIs, which, in turn, will shed light on the treatment challenges in this active age group and the economic burden resulting from TSF.

**Sex and the mechanism of injury**

Men comprised the majority of patients, consistent with local and international studies.5,8,13,15,16 The most common injury mechanism was MVA in the overall cohort; however, FFH was the most common mechanism in women. Falls were the leading cause in older populations.14

**Characteristics of spinal fracture**

The present study showed that the lumbar spine was the most affected part, similar to the findings of other reports.13,14,16–18 However, earlier local studies have reported that the cervical spine was the most commonly affected region.7,8

The incidence of MNCVF in this study was 7.7%, whereas other studies reported an incidence of 5.9–10.3% when using CT.15,18 A higher incidence of 19% of MNCVF using CT was also reported; the difference in the definition of MNCVF in those studies explains the high incidence.19 Earlier studies using plain radiographs show a similar incidence rate of 7.7%.20,21 Contrarily, the incidence of MNCVF detected using magnetic resonance imaging was 34–41.8%.22,23 owing to its high sensitivity for detecting bone bruises and ligamentous injuries. There was no delay in diagnosis because

Figure 7. Linear regression of patients with traumatic spinal fractures admitted between 2010 and 2016 since the application of road safety measures. R-squared of 0.9358 for motor vehicle accidents and 0.8616 for fall from height.
pan-CT is routinely performed in polytraumatized patients at our center; however, the delayed diagnosis rate of 8.4% has been reported in young age groups in a study using regional CT.24

**Associated injuries**

The rate of AI was 46.1% in our study, whereas those of other studies were 30–55%.13,16 Both thoracic injury and lower limb fractures were the most common AIs. However, thoracic injury was the most common in men.

The overall incidence rates of MVF and AIs were 38% and 46.1%, respectively, with men constituting the majority of these cases. However, the incidence rates between men and women were not statistically significant (male 39% vs. female 33.8% in MVF; 44.3% in male and female 52.1% in AIs). Simultaneously, no significant association was found between the incidence of AIs and MVA and between AIs and FFH (48% and 46%, respectively), suggesting that those in the FFH group sustained significant trauma.

A statistically significant difference in hospital stay duration was found between operated and non-operated patients, patients with and without AIs, and women and men. This may be explained by the multiple AIs, extremity fractures that required either medical or surgical management, and in-hospital rehabilitation.

In our study, the in-hospital short-term mortality rate was 2.4%, and different studies have shown a variable incidence rate of 0.1–4.1%.15,25 However, post-TSF long-term mortality rates of 6.8% and 19.1% at one and five years, respectively, have been reported.26

At the beginning of the millennium, Saudi Arabia had a significant expansion in road construction and an increased number of vehicles, explaining the increase in TSF in the first half of the study period. However, in 2009 digitalized speed control traffic cameras were introduced and during the last ten years there has been an increase in the number of these cameras installed in major cities and highways. Over the same period, the government increased gasoline prices and introduced taxes to diversify the economy. Dahim27 reported a significant reduction in transportation-related injuries and mortalities. Similarly, another study has shown that the short-term effect of increasing gasoline prices and the introduction of taxes contributed to the reduction of transportation-related accidents, injuries, and fatalities by 22.4%, 21.9%, and 14.1%, respectively.27 Here, we observed a steady decrease in TSF due to MVA and FFH. Comparing 2016 and 2010, a reduction in TSF due to MVA and FFH, at 44% and 38%, respectively, was observed in our study. In 2018, Saudi women were permitted to drive, and it might be expected that the number of women involved in MVA would increase. However, with these changes in the legislation, further transportation-related injuries are expected to decrease. A future large-scale study comparing MVA between sexes in terms of pattern, severity, and AIs would be beneficial to determine the long-term effects of these legislations.

**Strengths and limitations**

To the best of our knowledge, this is the first study to explore TSFs in patients aged ≤50 years and review the injury mechanism and AIs in such an independent group of society. One limitation is that, although the study was conducted at a level 1 academic trauma center, other local centers, such as the Ministry of Health and Military Hospitals, were not included. Thus, a more comprehensive local and national study is needed to draw more data that might shed more light on the pattern and severity of TSFs. Another limitation is the in-depth analysis of AIs (numbers and severity), which might reflect hospitalizations and surgery time. The lack of further details of the causes and circumstances of FFH at a young age is yet another limitation in which safety or socioeconomic preventive measures can be addressed to decrease the incidence of such mechanisms and AIs.

**Conclusions**

Both MVA and FFH are common mechanisms of injury in patients aged <50 years. A 4:1 male: female ratio, presence of AIs, female sex, and operation were associated with a prolonged hospital stay. Although we detected a decrease in TSF in this age group, the risks of unemployment and poor short- and long-term outcomes are of great concern. Although measures have been applied to decrease transportation-related injuries, the causes and circumstances of FFH need further analysis, and future preventive measures are needed. Another prospective feasibility study involving convalescent facilities where stable patients will be transferred for intense rehabilitation aimed at rapid recovery and shorter hospital stay, which would have future socioeconomic revenue, should be considered.

**Data availability**

**Underlying data**

Figsshare: Underlying data for ‘Epidemiology of traumatic spinal fractures in patients aged 50 years or less at a center in Saudi Arabia from 2005 to 2016’, http://doi.org/10.6084/m9.figshare.22960979.10
This project contains the following underlying data:

Data file: Spine Trauma 10 years KFHU, Saudi Arabia datasheet Coded.xlsx.

Data are available under the terms of the Creative Commons Zero “No rights reserved” data waiver (CC0 1.0 Public domain dedication).

References


10. Aldakheel D: Spine Trauma 10 years KFHU, Saudi Arabia datasheet Coded.xlsx [Dataset]. figshare. 2023. Publisher Full Text


The benefits of publishing with F1000Research:

- Your article is published within days, with no editorial bias
- You can publish traditional articles, null/negative results, case reports, data notes and more
- The peer review process is transparent and collaborative
- Your article is indexed in PubMed after passing peer review
- Dedicated customer support at every stage

For pre-submission enquiries, contact research@f1000.com