



Review Article

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Received: May 1, 2021

Accepted: July 16, 2021



Incidence and Epidemiology of Thoracolumbar Spine Fractures: WFNS Spine Committee Recommendations

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This review aims to search the epidemiology and incidence rates of thoracolumbar spine fractures. A systematic review of the literature of the last 10 years gave 586 results with “incidence,” and 387 results with “epidemiology,” of which 39 papers were analyzed. The review results were discussed and voted in 2 consensus meetings of the WFNS (World Federation of Neurosurgical Societies) Spine Committee. Out of 39 studies, 15 studies have focused on thoracolumbar trauma, remaining 24 studies have looked at all spine trauma. Most were retrospective in nature; few were prospective and multicenter. Some studies have focused on specific injuries. The annual incidence of TL fractures is about 30/100,000 inhabitants including osteoporotic fractures. There is a trend to increase the fractures in elderly population especially in developed countries, while an increase of motor vehicle accidents in developing countries. The mortality rate among male elderly patients is relatively high. The incidence of thoracolumbar spine fractures is increasing because of low-velocity falls in the elderly population. The main reasons are falls and traffic accidents. Learning the regional differences and some special forms of trauma such as extreme sports, war, and gunshot injuries will help the prevention of the thoracolumbar spine fractures.



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Keywords: Thoracolumbar spine fracture, Epidemiology, Osteoporotic fracture, Spinal fusion, Nonfusion surgery

INTRODUCTION

Thoracolumbar spine trauma can have significant affect to the quality of life with neurologic deficits, pain, and deformity. The incidence and epidemiology of thoracolumbar spine trauma would help to develop preventive strategies. This review has focused on this issue by searching the last 10-year literature, reporting evidence on this issue, and giving the recommendations of the World Federation of Neurosurgical Societies (WFNS) Spine Committee after 2 consensus meetings.

MATERIALS AND METHODS

The literature between 2010 and 2020 was reviewed using a search with keywords “thoracolumbar fracture and incidence”; there were 586 results in PubMed and MEDLINE. A similar search, “thoracolumbar trauma and epidemiology,” had 387 results. We removed non-English language papers, case reports, and low-quality case series. Then, we analyzed 39 papers for this review.

Up-to-date information on thoracolumbar trauma incidence or epidemiology was reviewed to reach an agreement in a consensus meeting of the WFNS Spine Committee. The first meet-

ing was conducted in Peshawar in December 2019 with WFNS Spine Committee members' presence and participation. The second meeting was a virtual meeting via the internet on June 12, 2020.

Both meetings aimed to analyze a preformulated questionnaire through preliminary literature review statements based on the current evidence levels to generate recommendations through a comprehensive voting session.

We utilized the Delphi method to administer the questionnaire to preserve a high degree of validity. To generate a consensus, the levels of agreement or disagreement on each item were voted independently in a blind fashion through a Likert-type scale from 1 to 5 (1 = strongly disagree, 2 = disagree, 3 = somewhat agree, 4 = agree, 5 = strongly agree). Results were presented as a percentage of respondents who scored each item as 1 or 2 (disagreement) or as 3, 4, or 5 (agreement). The consensus was achieved when the sum for disagreement or agreement was $\geq 66\%$. Each consensus point was clearly defined with evidence strength, recommendation grade, and consensus level provided.

RESULTS

There were 39 studies. Fifteen studies have focused on thoracolumbar trauma, remaining 24 studies have looked at all spine. Some studies focused on specific injuries such as war-combat injury, penetrating injury, extreme sports, fall from a tree, water sports, child abuse, etc.

Most were retrospective in nature; few were prospective and multicenter; there were also systematic reviews and meta-analyses (Table 1).

DISCUSSION

1. General Epidemiological Features

One prospective multicenter study (Germany and Austria) of the Spine Study Group of the German Association of Trauma Surgery contained 733 patients.¹ The paper was focused on surgical approaches collected for 2 years interval. Conservatively treated patients were excluded. The etiology included falls from a height (225), motor vehicle accidents (173), and simple falls (116).¹

Doud et al.² used United States (US) databases in different time intervals; NTDB (National Trauma Databank), NASS (National Automotive Sampling System), and NIS (National Inpatient Sample) collected. The retrospective review had approximately 40,000 patients. The study aimed to determine if the in-

cidence of thoracolumbar spine injuries increased in the US from 1998 to 2011.²

They reported that while motor vehicle crash-related injuries are declining in general, the incidence of thoracolumbar injury is not reducing.² This may be due to the immediate use of whole-body computed tomography (CT) scans after trauma and sensitive screening and may also be related to the increasing use of seatbelts.

An extensive retrospective series comes from Sweden, including 13,496 patients.³ The authors gathered Swedish Hospital Discharge Registry from 1997 to 2010. They included all fractures, including osteoporotic fractures. Men were in the majority (62%), and the annual incidence of thoracolumbar (TL) fractures was 30 per 100,000 inhabitants. The most frequent etiology was traffic accidents (38.7%) and fell from heights (23.8%).³

That Swedish registry did not document if the patient had osteoporosis. Patients 60 years or older were two-thirds of the study population (66%), and two-thirds were women (68%). More than half of the patients were 80 years or older, and the majority had lumbar vertebral fractures. However, they conclude that the incidence did not change considerably during the study period. The annual incidence was 13 per 100,000 in the age of <60 years. Operated patients were 15% of all patients, most frequent in 20–39 years of age. Among elderly patients (>60 years), operation proportion was 2%.³

A systematic review from the US between 2005–2011 included 12 studies to update practice management guidelines of “The Eastern Association for the Surgery of Trauma”⁴ From 2007 to 2011, the screening of blunt trauma patients changed the multi-detector CT scans as a screening modality of choice. Patients without altered mentation or effective mechanism may be excluded by clinical examination without imaging. Patients with gross neurologic deficits or clinical examination findings with negative imaging are considered for magnetic resonance imaging.⁴

In another study by Shah et al.⁵ from the US using a national database including more than 39,000 lumbar fractures between 2007–2016, showed that lumbar spine fractures have doubled. The majority of the fractures were between ages 80–89 and were more often in females. Falls were the most common cause of lumbar spine injuries.⁵

The conservative treatment of traumatic thoracolumbar vertebral fractures is often not clearly defined. A systematic review of 35 papers has concluded that the choice of a conservative or operative treatment strategy is based on the primary stability of the fracture, the degree of deformity, the presence or absence of

Table 1. Summary of the 39 papers searched in this review

No.	Study	Category	Location of study	Design of study	Period of study	Patients
1	Reinhold et al., ¹ (2010)	Thoracolumbar	Germany, Austria	Prospective, multicenter	2002–2003	733
2	Doud et al., ² (2015)	Thoracolumbar	USA databases: NTDB, NASS, NIS	Retrospective	NTDB 2002–2006, NASS 2000–2011, NIS 1998–2007	Approximately 40,000
3	Jansson et al., ³ (2010)	Thoracolumbar	Sweden	Retrospective	1997–2001	13,496
4	Sixta et al., ⁴ (2012)	Thoracolumbar	USA	Systematic review	2005–2011	12 Studies
5	Spiegl et al., ⁶ (2018)	Thoracolumbar	All world	Systematic review	Till 2018	35 Studies
6	Bouyer et al., ⁷ (2015)	All spine	Multicenter, France	Prospective	2011	580
7	Glennie et al., ⁸ (2015)	Thoracolumbar	Canada, USA	Retrospective	2009–2013	390
8	Marek et al., ⁹ (2018)	Thoracolumbar	Minnesota, USA	Retrospective	2008–2013	138
9	Oliver et al., ¹⁰ (2012)	All spine	California, USA	Retrospective	1996–2008	2,562
10	Katsuura et al., ¹¹ (2016)	Thoracolumbar	All world	Meta-analysis	1980–2014	21 Studies
11	Li et al., ¹² (2019)	Thoracolumbar	Tianjin, China	Retrospective	2006–2015	132
12	Liu et al., ¹³ (2018)	All spine	China National Database	Retrospective	2014	168
13	Wang et al., ¹⁴ (2012)	All spine	China	Retrospective	2001–2010	3,142
14	Aldosari et al., ¹⁵ (2019)	All spine	Saudi Arabia	Prospective	2016–2017	120
15	Brito et al., ¹⁶ (2011)	All spine	Sao Luis, Brazil	Retrospective	2008–2009	87
16	Yousefzadeh et al., ¹⁷ (2010)	All spine	Iran	Retrospective	2005–2006	245
17	Mathur et al., ¹⁸ (2015)	All spine	Jaipur, India	Retrospective	2000–2008	2,716
18	Khurjekar et al., ¹⁹ (2015)	Thoracolumbar	India	Prospective	2009–2012	92
19	Chua et al., ²⁰ (2018)	All spine	Cambodia	Retrospective	2013–2016	277
20	Saul and Dresing ²¹ (2018)	All spine	Germany	Retrospective	1998–2014	546 Pediatric cases
21	Dauleac et al., ²² (2019)	All spine	Lyon, France	Retrospective	2005–2016	73 Children
22	Falavigna et al., ²³ (2018)	All spine	Brazil	Retrospective	Not mentioned	215 Children
23	Babu et al., ²⁴ (2017)	All spine	Bengaluru, India	Retrospective	2002–2014	196 Children
24	Ernat et al., ²⁵ (2016)	All spine	Dallas, USA	Retrospective	2003–2011	97 Children < 10 years
25	Jauregui et al., ²⁶ (2019)	All spine	USA National Database	Retrospective	2000–2012	116 Child abuse
26	Satyarthee et al., ²⁷ (2017)	Thoracolumbar	India	Retrospective	2008–2012	312 Children
27	Mukherjee et al., ²⁸ (2016)	Thoracolumbar	USA	Retrospective	1996–2011	299
28	Pintar et al., ³¹ (2012)	Thoracolumbar	USA	Retrospective	1993–2010	204 Traffic accidents with front crash
29	Beck et al., ³² (2016)	All spine	Victoria, Australia	Retrospective	2000–2010	29 Rear-seat occupants
30	Javadi and Naderi, ³³ (2013)	All spine	Iran	Retrospective	2011	50 Fall from walnut tree
31	Hasler et al., ³⁴ (2012)	All spine	Switzerland	Retrospective	2000–2009	89 Extreme sports
32	Bigdon et al., ³⁵ (2019)	All spine	All world	Systematic review	1994–2012	Winter sports skiing and snowboarding
33	Gosteli et al., ³⁶ (2016)	Thoracolumbar	Switzerland	Retrospective	1998–2008	616 Extreme sports
34	Kane et al., ³⁷ (2015)	All spine	USA	Retrospective	2008–2010	60 Water sports
35	Jakoi et al., ³⁸ (2015)	All spine	Systematic review	Meta-analysis	Not restricted	Gunshot injuries
36	Formby et al., ³⁹ (2015)	All spine	USA	Retrospective	2003–2013	24 War Injuries
37	Eardley et al., ⁴⁰ (2012)	All spine	UK, Iraq, Afghanistan	Retrospective	2005–2009	57 War injuries
38	Freedman et al., ⁴¹ (2014)	Thoraco-lumbar	USA, Germany, Iraq, Afghanistan	Retrospective	2007–2010	65 War injuries
39	de Melo-Neto et al., ⁴² (2017)	All spine	Sao Paulo, Brazil	Retrospective	2008–2012	62 Elderly > 60 years

NTDB, National Trauma Databank; NASS, National Automotive Sampling System; NIS, National Inpatient Sample.

disc injury, and the patient's clinical state.⁶

2. Regional Differences

In a prospective multicenter epidemiological study from France involving 518 patients in 2011,⁷ 67% of the fractures involved the thoracic or lumbar segment. Thirty percent of patients had multiple fractures and 28% had neurological impairment. The authors conclude that spinal trauma is still a source of significant morbidity despite progress in management (minimally invasive surgery techniques and achieving a good sagittal balance). Conserved sagittal balance appeared to be associated with better functional outcomes.

A retrospective review of data in a registry from different centers in Canada and the US collected 390 patients with thoracic and lumbar fractures.⁸ Etiology was falls from height (39.5%), sports (28.0%), and traffic accidents (27.2%). The neurologic deficit was presented in 140 patients (36%). Operative treatment was applied in 276 patients (70.8%). Adverse events in surgical cases were observed in more than half of the patients, and neurologic injury was an important predictor of adverse events.

Marek et al.⁹ have searched the long-term outcomes of traumatic thoracolumbar spine fractures, specifically addressing quality of life, chronic pain, and employment. They collected 138 patients between 2008 and 2013. In general, patients without neurologic deficits were generally able to return to work and had a good quality of life.

A retrospective review from Los Angeles, US, for 13 years (1996 minimally invasive surgery 2008) was done to see if there is any change in epidemiology.¹⁰ They found that the mortality rate due to spinal injury, the incidence rate of spinal cord injury (SCI), and motor vehicle accidents decreased significantly over the study period. However, they reported spinal injuries are increasing with increasing age. There was a reduction in mortality attributable to spinal injury. Decline in SCI due to motor vehicle accidents is related to improvements in motor vehicle safety and traffic regulations.¹⁰

A meta-analysis from 2016 containing 21 studies reported the rate of thoracolumbar fractures in blunt trauma patients as 6.9%.¹¹ It included whole spine injuries. The most common vertebra injured was L1 at a rate of 34.40%. Etiology for TL fractures were motor vehicle collision (36.7%) and high-energy falls (31.7%).

The statements of this review are: mortality rate after a spinal injury is decreasing in developed countries. This is more with motor vehicle accidents due to improvements in motor vehicle

safety and traffic regulations. However, the incidence of low-velocity falls is increasing, especially in the elderly population. The mortality rate among male elderly patients is relatively high. The most common cause of thoracolumbar fractures are falls and traffic accidents. The actual incidences and epidemiology in developing countries are not well known. The annual incidence of TL fractures is about 30 per 100,000 inhabitants, if osteoporotic fractures are also included. Vertebral fractures in children are usually multiple.¹¹

Li et al.¹² have examined the epidemiology profile of thoracolumbar junction (T11–L2) fractures in the Tianjin region of China between 2006–2015. Totally 132 cases were identified and the incidence rate was 2.4 patients per million population. The incidence ratio is increased annually. The average age became older by the time, and the rate of osteoporotic fractures increased by the time.

In a database search from China (China National Fracture Study) involving 512,187 individuals, the incidence rate for traumatic spinal fractures was 32.80 per 100,000 people.¹³ Fractures of the thoracolumbar vertebra (T11–L2) were the most common, followed by fractures of the lumbar vertebra (L3–5). Four independent risk factors were: aging, alcohol drinking, sleeping < 7 hours per day, and having a previous fracture history.

Another epidemiological retrospective study from the Chongqing area of China has collected 3,142 patients in 10 years.¹⁴ Accidental falls and traffic accidents were the most common causes of spinal fractures (58.9% and 20.9%, respectively). The commonest area of fracture was the thoracolumbar spine (54.9%). Lumbar spinal fractures were more common in accidental fall patients. American Spinal Injury Association A injuries were more common in patients who suffered thoracic spinal fractures (15.09%) than in those with fractures in other areas of the spine.

The numbers of fall-induced and sports-related injuries increased steadily with age. These results indicate that there should be an increased concern for the consequences of fall- and sports-related injuries among the elderly.¹⁴

In a retrospective study from Saudi Arabia involving 120 patients, 85 patients had thoracolumbar spinal fractures.¹⁵ Sixty-six point six percent (n = 80) of all patients were managed conservatively, whereas the remaining 33.3% (n = 40) were managed surgically.

A retrospective study from Brazil, including 87 patients with spinal cord injury, has shown the proportion of falls from height was more significant than the number of traffic accidents.¹⁶ The most compromised segment of the spine was the thoracic (33

cases, 37.9%), and the main etiology was traffic accidents.

An epidemiological study from Iran involving 245 cases reported the most common causes as motorcycle vehicle accidents 127 (52%) and fell 106 (43%).¹⁷ The most common fracture in the spine was thoracolumbar (115 patients). Forty-four patients had neurological deficits.

A prospective observational study from India focused on traumatic spinal cord injury for 8 years period collected 2,716 cases, of which 1,400 were cervical and 1,316 thoracolumbar.¹⁸ Around 79% of patients were from rural backgrounds (farmers and laborers). Causes of injury fell from height (53%) and road traffic accidents (28%). Complete paralysis was found in 20.5% cervical and 23.3% in thoracic injuries.¹⁸

Authors have concluded that epidemiological factors of SCI in India are different from Western countries, with the primary cause being fall. The low socioeconomic status and younger age group had a significant financial, social and psychological impact as most of the patients were the immediate earning members of the family.¹⁸

Another prospective study from India¹⁹ contained 92 patients for a 3-year interval. All were surgically treated. The main reason for the trauma was a fall from height (46 patients, 50%).

A retrospective review from Cambodia involving 277 patients, cervical trauma was 71 (25.6%), and thoracolumbar trauma was 206 patients (74.4%).²⁰ Etiology was motor vehicle accidents (31.3%) and fell (51.4%). Motor vehicle accidents were mainly by motorcyclists (66.7%). Falls causing thoracolumbar trauma were predominantly work-related, including falls at construction sites (32.9%) and from palm and mango trees (34.3%).²⁰

The authors have reported that they could have similar surgical costs between \$100 to \$280 per surgery in a significantly resource-limited community.²⁰

3. Pediatric Injuries

In a retrospective pediatric series from Germany, including 546 patients (average age 12.8 ± 6.2 years), the leading cause of trauma was fall from height (58%).²¹ Of all series, 27% were found at T7/T8 and 17% at T12/L1. Multiple fractures are standard 53.2%. The authors have concluded that vertebral fractures in children are usually multiple and should lead to broad diagnostic coverage. Prevention should especially conceal falls and traffic accidents. Lesions for operative fixation are rare due to the excellent elasticity of the pediatric spine.²¹

A retrospective review of pediatric patients in France between 2005 and 2016, including 73 children, with a mean age of 14.1 years, has shown that spinal injuries were more common in the

teenage group (14–18 years).²² The etiology was motor vehicle collision (36%). Teenagers presented more with lumbar traumas, while young children had more cervical traumas. Teenagers had more fractures, while younger ages had more luxations. The authors conclude that disco-ligamentous maturation is an essential concept in spine traumas in children.²²

A retrospective multicenter study from Brazil of 215 spinal trauma cases in individuals < 18 years of age, showed a mean age of 14.7 years.²³ Falls were responsible for 52% of the spinal trauma. Most were located at the thoracic level (58.7%). Neurological impairment was mostly observed due to shallow water diving and fractures between the lower cervical spine and the thoracic spine.²³

A retrospective review of pediatric spinal injuries over 12 years from India contained 90 children with TL spine injuries.²⁴ The mean age was 159 years and the leading cause of injury was fall from height (69 cases, 71.1%), then motor vehicle accidents (18 patients, 20%). The lumbar spine was the most common injury level (53.3%). The authors concluded that TL injuries are most common in children older than 10 years old, and many involve the lumbar region.²⁴

The use of vehicular restraints has reduced the morbidity and mortality of children involved in motor vehicle collisions. The effect of restraint type was examined in a retrospective review below 10 years of age for 8-year period.²⁵ Two- or 3-point seat-belt use is associated with lower rates of cervical spine trauma but higher thoracic and lumbar trauma rates, particularly flexion-distraction injuries, compared with a car or booster seat. Children in car seat/booster seat and those who are unrestrained sustain high rates of cervical spine injury.

A retrospective review of the Kids' Inpatient Database in the US was conducted in pediatric patients below 18 years with child abuse for a 12-year interval.²⁶ Among 22,192 pediatric patients diagnosed with spinal cord or vertebral column injury, 116 (0.5%) had a documented abuse diagnosis. Abused patients were more likely to be below 2 years of age, female. Abused patients had more thoracic and lumbar vertebral column fractures, and the mean length of stay was longer. Physicians should maintain a higher level of suspicion of abuse in patients with spine injuries, especially patients under 2 years of age.²⁶

Satyarthee et al.²⁷ have reported 25 pediatric cases of TL fractures from India. The most common reason was fall (76%). Eleven patients (44%) had a neurologic injury.

4. Motor Vehicle Accidents

In a multicenter database called Crash Injury Research and

Engineering Network,²⁸ the authors searched the incidence of neurological deficits in motor vehicle collisions. Neurological deficits were more common in pediatric ages (0–10 years, 26.7%) and geriatric ages (70–80 years, 18.4%). The highest risk of neurological injury existed in crashes in which airbags deployed and a seatbelt did not restrain the occupant. Collisions with a greater than 50 km/hr had a significantly higher risk of spinal cord injury. Current vehicle safety technologies are geared toward a normative body morphology. They need to be reevaluated for various body morphologies and torso compliances to lower the risk of neurological injury resulting from thoracolumbar fractures.²⁸

Epidemiological studies on motor vehicle accidents in Finland have stressed that seat belts and airbags have created a different environment for automotive trauma.²⁹ The high-energy deaths tended to occur pretty quickly. However, the mortality rate of spine injuries is decreasing.^{29,30}

Pintar et al.³¹ have searched US databases to find a relation between front crushes and injury patterns. There was a significantly increasing trend in thoracic and lumbar vertebral body fractures as a function of vehicle model year. Major burst type fractures occurred predominantly at T12, L1, or L5.

A retrospective review of 29 rear-seat occupants after frontal crashes in motor vehicle accidents (aged 9–80 years) from Australia and 10 years interval has reported that the seat belt was the most common source of injury to rear-seat occupants.³² There is a need to provide an appropriate belt fit and better control seat belt loads for rear-seat passengers.

5. Fall From Height

Falls from trees are often in some countries. A report from Iran has collected 50 cases of falls from walnut trees in one harvest season in 2011.³³ Fractures were detected in 7 patients, including 5 cervical fracture-dislocations and 2 thoracolumbar fractures. Complete spinal cord injury was found in 8 cases. The falls from the walnut trees mainly result in cervical fractures with quadriplegia with a poor prognosis in a young group of workers.

6. Sports Injuries

Airborne sports are associated with a high frequency of severe injuries, especially to the spine. A retrospective analysis from the Swiss Alps for a 9-year period of 181 patients (11 BASE-jumpers, 144 paragliders, 19 parachuters, 1-speed flyer, 4 delta gliders, 2 skysurfers) was included.³⁴ Eighty-nine patients (49.2%) sustained spinal fractures. Type A fractures were predominant

(91.5%), and the most common level was L1 (35.1%). The lumbopelvic junction is especially vulnerable as high impact forces from vertical and horizontal deceleration need to be absorbed.

A systematic review of alpine winter sports and spine trauma yielded 64 studies.³⁵ Skiing, snowboarding, and tobogganing are the reasons for falls. The thoracolumbar spine is the most common region for spinal injury. Spinal cord injury is relatively rare, usually with cervical spine trauma. Disc injuries seem to occur more commonly in alpine winter sports athletes than in the general population.³⁵

A study from Switzerland examined the trauma cases due to extreme sports in Swiss Alpines.³⁶ A total of 616 patients rescued with helicopters for a ten-year interval (1998–2008) were examined. Two hundred nineteen (36%) were high-risk extreme sports accidents. Mortality at 48 hours was 11%, thoracolumbar vertebral fractures were the most common injuries, with at least one of 32% of all cases.

The epidemiology of water sports injuries at a coastal area in the US has collected 105 patients.³⁷ Among water-based activities or recreational sport are counted swimming, surfing, boating, personal watercraft use. Personal watercrafts accounted for the majority of injuries (n = 39). Cervical (33.3%) and thoracolumbar (21.9%) injuries accounted for most injury types. Spinal cord injuries were more common than other types of trauma.

7. War and Combat Injuries

A systematic review of spinal gunshot injuries showed that the gunshot injuries are the third commonest cause of spinal injury.³⁸ Surgical treatment is typically indicated for progressive neurologic changes, spinal instability, persistent cerebrospinal fluid leak, and infection. Surgical exploration and removal of missile fragments in the spinal canal are typically indicated for incomplete or worsening neurologic injury. Surgical treatment for gunshot injuries affecting T12 and caudal often has a better outcome than for those cranial to T12.

A retrospective review of combat-related burst fractures engaged in the wars in Iraq and Afghanistan has collected 24 patients of low lumbar (L3–5) burst fractures.³⁹ Eleven patients had a neurological injury, 4 of which were complete.

One hundred twenty-eight spinal fractures during military deployments of the United Kingdom army between 2005–2009 were collected.⁴⁰ Ballistic (79%) and nonballistic mechanisms contribute to vertebral fracture, a high incidence of lumbar spine fractures, which are more likely to be due to explosion than gunshot wounding. The authors concluded that due to the predominance of explosive injury in current conflicts, and the research

must be directed to this injury mechanism.⁴⁰

War injuries have also been an interest of some studies. The US army collected 65 cases of explosive device assaults on up-armored vehicles during the Afghanistan and Iraq wars.⁴¹ All had thoracolumbar burst fractures, and neurological deficits were present in 43%.

8. TL Injuries in the Elderly

The incidence of low-energy falls increases, and older men have a disproportionate increase in death from spine injuries.²⁹ The authors have commented on this gender difference, with men being less likely to accept age changes, do not use a cane or walker, and continuing activities may result in falls. Fall prevention and bone metabolism optimization must be focused not only on women but also on men in older ages.²⁹

A retrospective study of elderly patients (>60 years of age) with spinal cord injury included 62 elderly patients⁴² showed that elderly individuals with SCI have distinct characteristics and clinical factors. Women had fractures at the thoracolumbar junction, while men had cervical fractures.

CONCLUSIONS

The incidence of thoracolumbar spine fractures is increasing since the low-velocity falls in the elderly population are increasing. The epidemiology in developing countries is not well studied, but the main reasons are falls and traffic accidents. Learning the regional differences and some special forms of trauma such as extreme sports, war, and gunshot injuries will help the prevention of the thoracolumbar spine fractures.

WFNS SPINE COMMITTEE RECOMMENDATIONS

- The most common cause of thoracolumbar fractures are falls and traffic accidents.
- The annual incidence of TL fractures is about 30 per 100,000 inhabitants if osteoporotic fractures are counted together.
- The real incidences and epidemiology in developing countries are not well known.
- The incidence of low-velocity falls is increasing, especially in the elderly population.
- Mortality rate after the spinal injury is decreasing in developed countries. This is more with motor vehicle accidents due to improvements in motor vehicle safety and traffic regulations.

- The thoracolumbar trauma mortality rate among male elderly patients is relatively high.
- Vertebral fractures in children are usually multiple.

REFERENCES

1. Reinhold M, Knop C, Beisse R, et al. Operative treatment of 733 patients with acute thoracolumbar spinal injuries: comprehensive results from the second, prospective, Internet-based multicenter study of the Spine Study Group of the German Association of Trauma Surgery. *Eur Spine J* 2010;19:1657-76.
2. Doud AN, Weaver AA, Talton JW, et al. Has the incidence of thoracolumbar spine injuries increased in the United States from 1998 to 2011? *Clin Orthop Relat Res* 2015;473:297-304.
3. Jansson KA, Blomqvist P, Svedmark P, et al. Thoracolumbar vertebral fractures in Sweden: an analysis of 13,496 patients admitted to hospital. *Eur J Epidemiol* 2010;25:431-7.
4. Sixta S, Moore FO, Ditillo ME, et al. screening for thoracolumbar spinal injuries in blunt trauma: an Eastern Association for the Surgery of Trauma practice management guideline. *J Trauma Acute Care Surg* 2012;73(5 Suppl 4):S326-32.
5. Shah NV, Zhou JJ, Rathod J, et al. Epidemiology and trends of 39,296 fractures of the lumbar spine from 2007 to 2016 in the United States. In: *Proceeding of NASS 33rd Annual Meeting (2018)*. *Spine J* 2018;18:S25.
6. Spiegl UJ, Fischer K, Schmidt J, et al. the conservative treatment of traumatic thoracolumbar vertebral fractures. *Dtsch Arztebl Int* 2018;115:697-704.
7. Bouyer B, Vassal M, Zairi F, et al. surgery in vertebral fracture: epidemiology and functional and radiological results in a prospective series of 518 patients at 1 year's follow-up. *Orthop Traumatol Surg Res* 2015;101:11-5.
8. Glennie RA, Ailon T, Yang K, et al. Incidence, impact, and risk factors of adverse events in thoracic and lumbar spine fractures: an ambispective cohort analysis of 390 patients. *Spine J* 2015;15:629-37.
9. Marek AP, Morancy JD, Chipman JG, et al. long-term functional outcomes after traumatic thoracic and lumbar spine fractures. *Am Surg* 2018;84:20-7.
10. Oliver M, Inaba K, Tang A, et al. The changing epidemiology of spinal trauma: a 13-year review from a Level I trauma centre. *Injury* 2012;43:1296-300.
11. Katsuura Y, Osborn JM, Cason GW. The epidemiology of thoracolumbar trauma: a meta-analysis. *J Orthop* 2016;13:383-8.

12. Li B, Sun C, Zhao C, et al. Epidemiological profile of thoracolumbar fracture (TLF) over a period of 10 years in Tianjin, China. *J Spinal Cord Med* 2019;42:178-83.
13. Liu B, Zhu Y, Liu S, et al. National incidence of traumatic spinal fractures in China: data from China National Fracture Study. *Medicine (Baltimore)* 2018;97:e12190.
14. Wang H, Zhang Y, Xiang Q, et al. Epidemiology of traumatic spinal fractures: experience from medical university-affiliated hospitals in Chongqing, China, 2001-2010. *J Neurosurg Spine* 2012;17:459-68.
15. Aldosari KH, Aldhfyhan YM, Karrar MH, et al. Severity and neurosurgical management of patients with traumatic spinal fractures in Saudi Arabia: a cross-sectional study. *Pan African Med J* 2019;34:26.
16. Brito LM, Chein MB, Marinho SC, et al. Epidemiological evaluation of victims of spinal cord injury. *Rev Col Bras Cir* 2011;38:304-9.
17. Yousefzadeh Chabok S, Safaee M, Alizadeh A, et al. Epidemiology of traumatic spinal injury: a descriptive study. *Acta Med Iran* 2010;48:308-11.
18. Mathur N, Jain S, Kumar N, et al. Spinal cord injury: a scenario in an Indian state. *Spinal Cord* 2015;53:349-52.
19. Khurjekar K, Hadgaonkar S, Kothari A, et al. Demographics of thoracolumbar fracture in Indian population presenting to a tertiary level trauma centre. *Asian Spine J* 2015;9:344-51.
20. Chua MH, Hong R, Rydeth T, et al. Spine trauma as a component of essential neurosurgery: an outcomes analysis from Cambodia. *World Neurosurgery* 2018;114:375-80.
21. Saul D, Dresing K. Epidemiology of vertebral fractures in pediatric and adolescent patients. *Pediatr Rep* 2018;10:7232.
22. Dauleac C, Beuriat PA, Di Rocco F, et al. Surgical Management of pediatric spine trauma: 12 years of experience. *World Neurosurg* 2019;126:e1494-502.
23. Falavigna A, Righesso O, Guarise da Silva P, et al. Epidemiology and management of spinal trauma in children and adolescents <18 years old. *World Neurosurg* 2018;110:e479-83.
24. Babu RA, Arimappamagan A, Pruthi N, et al. Pediatric thoracolumbar spinal injuries: the etiology and clinical spectrum of an uncommon entity in childhood. *Neurol India* 2017;65:546-50.
25. Ernat JJ, Knox JB, Wimberly RL, et al. the effects of restraint type on pattern of spine injury in children. *J Pediatr Orthop* 2016;36:594-601.
26. Jauregui JJ, Perfetti DC, Cautela FS, et al. Spine Injuries in child abuse. *J Pediatr Orthop* 2019;39:85-9.
27. Satyarthee GD, Sangani M, Sinha S, et al. Management and outcome analysis of pediatric unstable thoracolumbar spine injury: large surgical series with literature review. *J Pediatr Neurosci* 2017;12:209-14.
28. Mukherjee S, Beck C, Yoganandan N, et al. Incidence and mechanism of neurological deficit after thoracolumbar fractures sustained in motor vehicle collisions. *J Neurosurg Spine* 2016;24:323-31.
29. Thesleff T, Niskakangas T, Luoto TM, et al. Fatal cervical spine injuries: a Finnish nationwide register-based epidemiological study on data from 1987 to 2010. *Spine J* 2016;16:918-26.
30. Rehtine GR. Dramatic demographic changes in spine trauma mortality over the past quarter-century in Finland: commentary. *Spine J* 2016;16:927.
31. Pintar FA, Yoganandan N, Maiman DJ, et al. Thoracolumbar spine fractures in frontal impact crashes. *Ann Adv Automot Med* 2012;56:277-83.
32. Beck B, Bilston LE, Brown J. Injury patterns of rear seat occupants in frontal impact: an in-depth crash investigation study. *Inj Prev* 2016;22:165-70.
33. Javadi SA, Naderi F. Pattern of spine fractures after falling from walnut trees. *World Neurosurg* 2013;80:e41-3.
34. Hasler RM, Hüttner HE, Keel MJ, et al. Spinal and pelvic injuries in airborne sports: a retrospective analysis from a major Swiss trauma centre. *Injury* 2012;43:440-5.
35. Bigdon SF, Gewiess J, Hoppe S, et al. Spinal injury in alpine winter sports: a review. *Scand J Trauma Resusc Emerg Med* 2019;27:69.
36. Gosteli G, Yersin B, Mabire C, et al. Retrospective analysis of 616 air-rescue trauma cases related to the practice of extreme sports. *Injury* 2016;47:1414-20.
37. Kane I, Ong A, Radcliff KE, et al. epidemiology of aquatic and recreational water sport injuries: a case-control analysis. *Orthopedics* 2015;38:e813-8.
38. Jakoi A, Iorio J, Howell R, et al. Gunshot injuries of the spine. *Spine J* 2015;15:2077-85.
39. Formby PM, Wagner SC, Pisano AJ, et al. outcomes after operative management of combat-related low lumbar burst fractures. *Spine (Phila Pa 1976)* 2015;40:E1019-24.
40. Eardley WG, Bonner TJ, Gibb IE, et al. Spinal fractures in current military deployments. *J R Army Med Corps* 2012;158:101-5.
41. Freedman BA, Serrano JA, Belmont PJ Jr, et al. The combat burst fracture study--results of a cohort analysis of the most

prevalent combat specific mechanism of major thoracolumbar spinal injury. *Arch Orthop Trauma Surg* 2014;134:1353-9.
42. de Melo-Neto JS, de Campos Gomes F, de Morais DF, et al.

Spinal cord injury in elderly patients admitted to a tertiary hospital. *J Back Musculoskelet Rehabil* 2017;30:929-36.