

# “Walnut-Spine” – Nonpenetrating Spinal Trauma: An Orchard Hazard in Kashmir

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## Abstract

**Aims** Among the causes of nonpenetrating spinal cord injuries in this snow bound valley, the fall of young and occupationally productive population from walnut trees, has emerged as a new orchard hazard, locally called *walnut-spine*, which restricts the social and economic development and at the same time increases the social burden of disabilities. We ought to analyze the causes, number, sex, and outcome of nonpenetrating spinal injuries for the epidemiologic purposes, and to project and prevent the occupational hazard such as *walnut-spine*.

**Methods** The study is based on the retrospective work and data from January 2003 to December 2012 in the Department of Neurosurgery. All the patients with nonpenetrating spinal trauma from C2 to L5 vertebral body level were included in the study. The patients with C1 injury and penetrating causes of spinal injuries such as missiles, knives, nails, iron rods, etc. were excluded from the study. The statistical law of variance was used wherever applicable.

**Results** While analyzing 667 cases of nonpenetrating spinal trauma, it was revealed that the males (526/667 = 78.86%) outnumbered the females (141 = 21.14%) by a ratio of 526 (3.7): 141 (1.0). The most prevalent age group was 21–40 years (403/667 = 60.41%). The most common mode of injury was fall from a walnut tree, called *walnut-spine* locally, which led to more than half (337/667 = 50.52%) of the total nonpenetrating-type of spinal injuries. The other causes were fall from building heights (222/667 = 33.28%) such as rooftops, windows, walls, etc. and road-traffic accidents (16.19% = 108/667). The most injured segment of the spine was dorsal spine (282/667 = 42.27%) and cervical spine (35.68% = 238/667). The walnut-tree falls alone have emerged as the cause of most of the cervical, dorsal, and lumbar spinal injuries. About 21.28% (142/667) patients had associated head, thoracic, abdominal, and other skeletal injuries. The outcome of *walnut-spine* was worst in terms of neurodeficits, disability, and mortality.

**Conclusion** A high incidence of walnut-spines – an occupational orchard hazard – among nonpenetrating spinal injuries in younger population has resulted in enormous financial and physical costs for an individual and the society.

## Keywords

- ▶ walnut-spine
- ▶ nonpenetrating spinal injury
- ▶ orchard-hazard
- ▶ outcome

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## Introduction

Spinal cord injury (SCI) is a devastating and debilitating condition that affects all regions of the world.<sup>1</sup> The motor vehicle accidents, falls, sports-related trauma, and the penetrating (missile, knives, iron rods, etc.) injuries are the most common causes of spinal injury but may vary with age and particularly sex since younger age group and males are three to four times more liable to sustain spinal injury than females.<sup>2-6</sup> Significant variation in prevalence and causes of SCI exists among geographic regions, and such data are essential for understanding and planning a cost-effective care and development of preventive strategies. The SCI patients often require extended treatment in the intensive care units, but early pharmacologic and surgical intervention is mandatory as the advent of improved imaging techniques have differentiated between primary and secondary spinal cord injuries.<sup>7-9</sup> The walnut-tree falls and subsequent spinal injury has emerged as the most frequent cause of nonpenetrating spinal trauma in this part of India. The walnut tree is biologically known as *Juglans regia* and originally belongs to (a native tree of) Iran. The tree is foreign to British and North Americans who called the nut as *wealh-hnutu* (meaning foreign nut). India is one among the top 10 walnut-producing countries with 30,000 tonnes annually and 90% of the yield comes from valley of Kashmir. The falls from the walnut trees and subsequent SCI in younger ages, while harvesting the produce, has emerged as the *walnut-spine* locally, indicating severe neurodeficits.

## Subjects and Methods

All the case files of nonpenetrating SCI patients, from January 2003 to December 2012, were retrieved from the Medical Records Department and its referral and polyclinic wing for the data analysis. The spinal cord injuries at the level of atlas (first cervical vertebra) and of penetrating causes were excluded from the study. The collected data included history, general and frequently recorded neurologic examination, all hematologic and biochemical results, roentgenogram, computed tomographic (CT) scan, and magnetic resonance imaging (MRI) of the spine, medical, and surgical treatments and outcome till the patients were discharged from the hospital. The data, regarding the condition of the patient 3 months after the discharge, were retrieved from referral files of polyclinic in outpatient department with an ICD code T09.3. The rush of nonpenetrating spinal injuries has been found most in the walnut-harvesting season of September and October every year. The young adults who climb on the slippery and tall walnut tree with thick-long branches, of the height of 30 to 50 ft on the average (but can reach to above 90 ft) with an average breast-height girth of 4 to 6 ft (but can reach over 8.5 ft) fall forcefully on the grassless-hard ground around the walnut tree. The worker carries a long stick in one hand, to strike and retrieve the walnuts, which results in instability and fall (→ Fig. 1). The bottom or base around a walnut tree is vegetation less and hard because the competitive nature and shade of the tree do not allow any grass or herbs to grow under it. Also, walnuts grow mostly on hard and high lands rather than marshes and the invisible undersurface thick



**Fig. 1** Orchard photograph of a young worker on the walnut-tree and the walnuts (intact and broken) with exposed kernel.

roots of the walnut tree make the ground around it even harder. This, along with force of gravity, increases the impact of a falling-object many fold causing multiorgan injuries. The neurologic level and extent of injury were assessed and defined at different intervals of time by using the international standards set forth by the American Spinal Injury Association (ASIA).<sup>10</sup> The final observations were recorded at 3 months after the discharge. The results were compiled and analyzed using statistical law of variance wherever applicable.

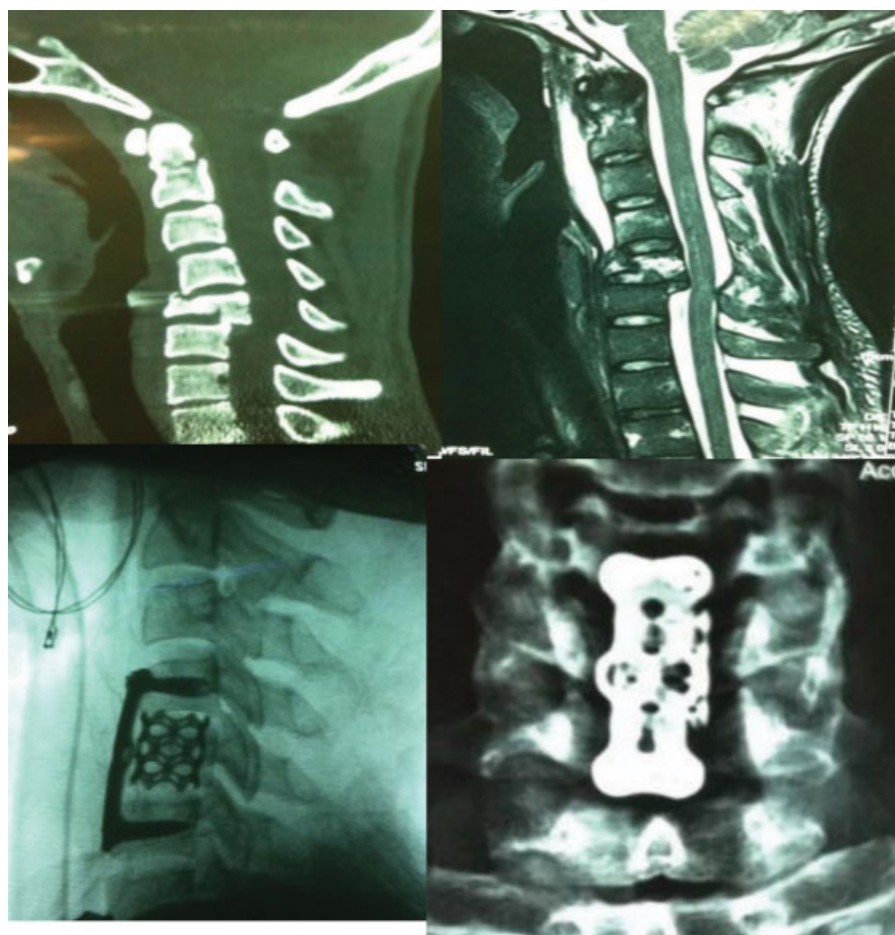
## Results

The males (526/667 = 78.86%) outnumbered the females (141 = 21.14%) by a ratio of 526 (3.7):141 (1.0). The most prevalent age group was 21 to 40 years (403/667 = 60.41%). The most common mode of injury was fall from a walnut tree, called *walnut-spine* locally, which led to more than half (337/667 = 50.52%) of the total nonpenetrating type of spinal injuries (►Table 1). The other causes included fall from building heights (222/667 = 33.28%) such as rooftops, windows, walls, etc. and road-traffic accidents (16.19% = 108/667). The most injured segment of the spine was the dorsal spine (282/667 = 42.27%) and cervical spine (35.68% = 238/667). The walnut-tree falls alone have emerged as the cause of most of the cervical, dorsal, and lumbar spinal injuries (►Figs. 2 and 3). About 21.28% (142/667) patients had associated head, thoracic, abdominal, pelvic, and other skeletal injuries. Most patients were adults (> 18 years of age) forming 95.20% (635/667) and 4.79% (32/667) were children. All types of fractures of vertebral body and lamina were seen in 337 *walnut-spine* injuries such as wedging, compression, subluxation, dislocation, etc. with and without spinal canal compromise (►Figs. 4 and 5). The spinal cord injuries such as compression due to bone fragment, contusion, hemorrhage, edema, and cord transection were observed on the imaging (►Fig. 6). The fracture dislocation was found in 60.83% (205/337) of *walnut-spines* (most of the fracture dislocations were found at D12 body or D12–L1 junction level), whereas vertebral compression was found in 15.43% (52/337), anterior/posterior body wedging in 10.08% (34/337), subluxation in 7.41% (25/337), burst fracture in 4.15% (14/337), and no bony abnormality in 2.07% (7/337) patients. The MRI was the most sensitive tool to outline all the types of spinal cord injuries from edema to contusions and cord transections. The cervical cord injuries due to walnut falls occurred in 44.11% (105/238) patients, of which 94.28% (99/105) developed total quadriplegia and were in the ASIA grades A and B. Similarly, severe injury and neurodeficit in the form of total paraplegia (ASIA grades A and B) were found in 86.92% (133/153) of the dorsal spinal walnut injuries. While in lumbar spinal injuries, due to walnut-tree falls, about 46.83% (37/79) patients had severe deficit in lower limbs (ASIA grade C) and loss of sphincter control. Of all 667 cases, severe neurodeficit to the extent of total quadriplegia, paraplegia, and loss of sphincter control due to all causes was found in 58.47% (390/667) patients, but 40.32%

**Table 1** ASIA worse grade, mortality and level of nonpenetrating spinal injury

Causes	Spinal region										Total		
	Cervical			Dorsal			Lumbar			Total		Deaths	Deaths
	No. of patients	ASIA Gr. A and B (total quadriplegia)	Deaths	No. of patients	ASIA Gr. A and B (total paraplegia)	Deaths	No. of patients	ASIA Gr. A and B (severe neurodeficit)	Deaths	No. (%)	No. (%)		
Walnut-tree falls	105	99 (94.28%)	95 (14.24%)	153	133 (86.92%)	51	79	37 (46.83%)	7	337 (50.52)	153 (22.93%)		
Fall from man-made vertical structures	83	40 (48.19%)	31	86	35 (40.69%)	3	53	17 (32.07%)	0	222 (33.28)	34		
Road-traffic accidents	50	16 (32.00%)	8	43	10 (23.25%)	1	15	3 (20.00%)	0	108 (16.19)	9		
Total	238	155 (65.12%)	134 (20.08%)	282	178 (63.12%)	55	147	57 (38.77%)	7	667	196 (29.38%)		

Abbreviation: ASIA Gr, American Spinal Injury Association Grade. Most dislocations were at D12–L1 body level.



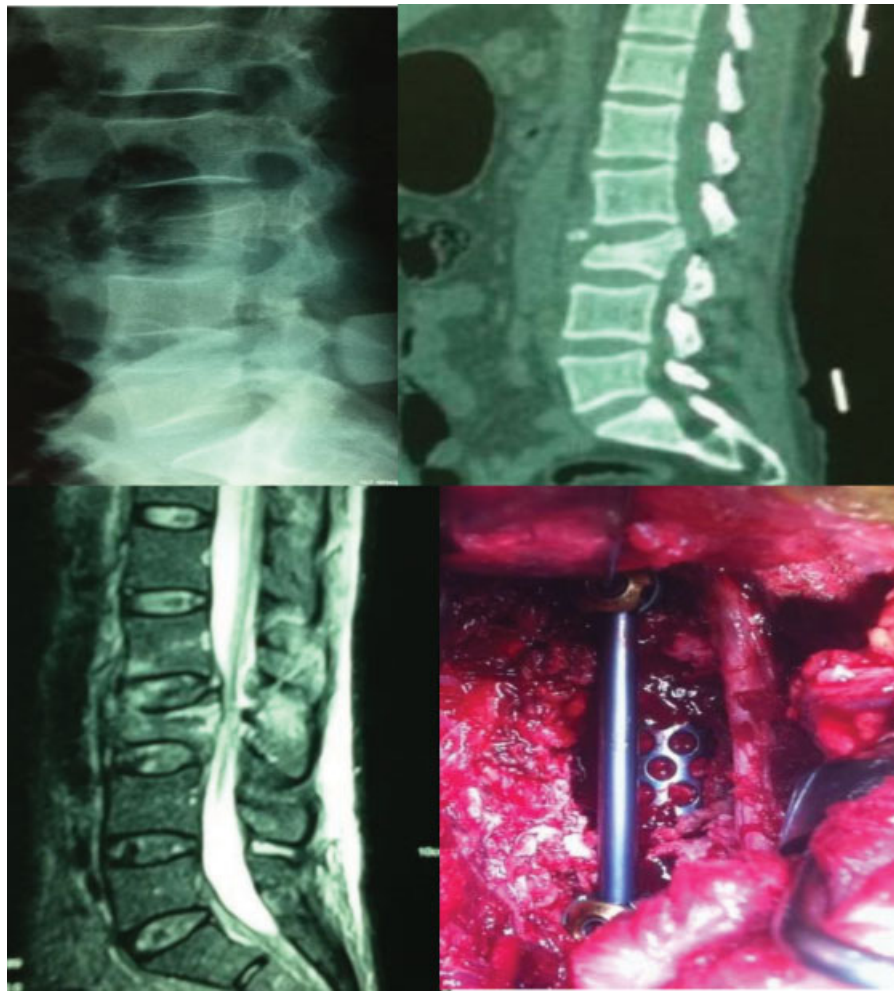
**Fig. 2** Walnut-spine—CT scan (reformative reconstruction), MRI sagittal and X-rays of cervical spine showing fracture odontoid (C2) and C5 vertebral body. C5 corpectomy and cage and plate fixation.

(269/667) cases were contributed by the walnut falls, mostly dorsal spines (19.94% = 133/667). The fractured bony fragments were found and removed from the spinal cord tissue (►Fig. 6). All the walnut-tree injury-related patients had severe neurodeficits (ASIA grades A, B, and C) at admission although 14.09% (94/667) spinal injuries due to other causes were recorded as having no-neurodeficit. More than half of the 667 patients (including 337 *walnut-spines*) were admitted in the months of September and October of every year. An overall mortality of 29.38% (196/667) was revealed up to 3 months after discharge, to which *walnut-spine* contributed most by 22.93% (153/667) patients. Most of the deaths, that is, 20.08% (134/667) occurred in cervical spinal injuries in which walnut-tree cervical injury deaths comprised 14.24% (95/667). However, there was no improvement in 27.58% (184/667) patients having *walnut-spine* or walnut-tree fall spinal injury especially, whereas as 28.93% (193/667) patients in mild, moderate, and even severe neurodeficit due to other falls and road-traffic accidents had neurologic improvements and recovery beyond 3 months on follow-up. A patient of forgotten cervical *walnut-spine* reported 18 months after injury with severe neurodeficits (►Fig. 5) who was operated. The surgery was performed on 79.01% (527/667) patients and

20.98% (140/667) patients were managed conservatively. Surgery aimed first to relieve neural tissue off the bony compression so as to give it a chance to recover and resume back its normal function, and second to construct and stabilize the fractured spinal column in an optimal shape in consideration with all its curvatures and dynamicity (►Fig. 2). Third, surgical intervention reduced hospital stay; encouraged early mobilization; and decreased complications of thromboembolism, fever, pneumonias, decubitus ulcers, and urinary infections. The outcome of *walnut-spine* was the worst in terms of neurodeficits, disability, and mortality (►Table 2).

## Discussion

The *walnut-spine* among local population indicates broken spine, paralysis of limbs, and loss of voluntary control on bowel and bladder as result of fall from walnut tree. To increase the walnut yield so as to cope up with the demands of walnut fruit in the international market, for commercial and economic development, the Department of Horticulture is encouraging the orchard owners to plant and cultivate more and more tall variety of walnut trees that do not need even pesticide sprays. This has led thousands of youth to



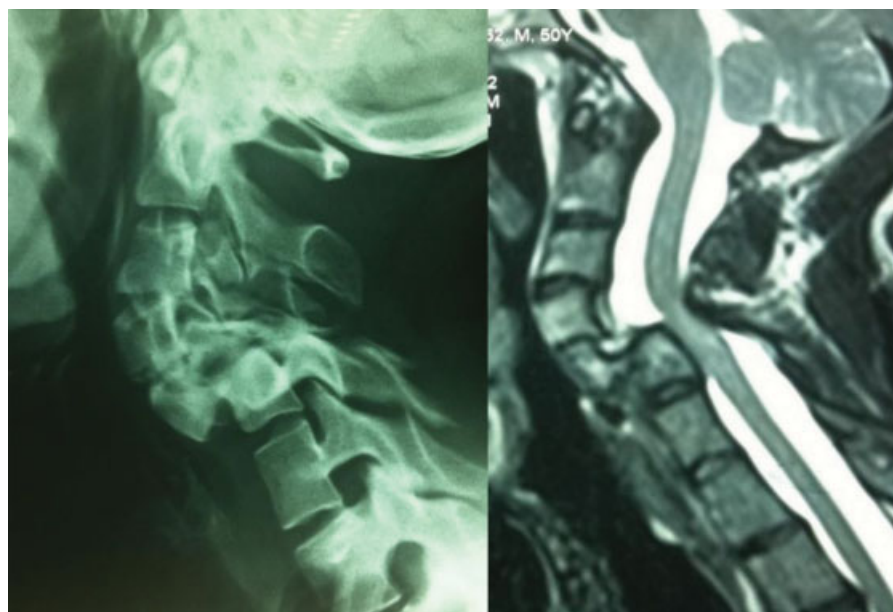
**Fig. 3** Plain X-ray, CT scan (reconstructive reformation), sagittal MRI and operative photograph showing L3 vertebral body fracture, thecal sac compression, and rod and cage fixation in a *walnut-spine*. The dura is seen exposed.

adopt the walnut-related occupation in the orchards. There is no protective gear, such as one used by hikers and rock climbers, or walnut harvesting tools available for the young walnut workers, which can be used while retrieving the fruit from the tall and slippery walnut tree, making it an occupational hazard (→ Fig. 1). The unprotected worker falls helplessly to the hard ground around the tree only to become, *walnut-spine*. The Western countries have cultivated and grown dwarf variety of walnut trees, and additionally, they have all the harvesting technology of tools and equipment such as shakers, sweepers, and harvesters in use, thus avoiding injuries. It has been observed that in the last five decades there is a change in the pattern of some causes of nonpenetrating spinal trauma such as earlier falls from low-lying buildings, walls, roof tops, electric poles to present falls from high-rise buildings, walls, roof tops, etc., and similarly road-traffic accidents from earlier low-speed four-wheeled motors to present high-speed two-wheeled motorcycles and four-wheeled vehicles. However, the falls from trees, especially walnut-trees, have continued to occur in the same pattern and season, and with the same impact to render the orchard workers functionally devastated with

*walnut-spine*. The 10-year data show a male preponderance (M:F = 3.7:1.0) with 21 to 40 years most involved age group in 667 nonpenetrating spinal injury cases similar to other studies.<sup>11-13</sup> The literature from developed countries reports most number of spinal injuries caused by the road-traffic accidents,<sup>14</sup> but the present study revealed the cause of more than half (50.52%) of 667 spinal injuries as the fall from walnut trees and in the same season of autumn. While this study reveals a geographical and seasonal variation of nonpenetrating spinal injuries, it also shows that road-traffic accidents, as a cause, are responsible for only 16.19% of total cases. This disparity between the other studies and present study is due to high number of walnut-tree falls. The preponderance of dorsal spinal injuries (282/667 = 42.27%) followed by the cervical (35.68% = 238/667) and lumbar spinal injuries is unlike what is reported by Jackson et al due to the fact of changing causes in time and geography.<sup>15</sup> The Western literature predominantly reports more number of road-traffic accidents related to the most cervical spinal injuries as compared with the present study that reveals increased number walnut-tree falls contributing to dorsal spinal injuries. Similar findings have been reported



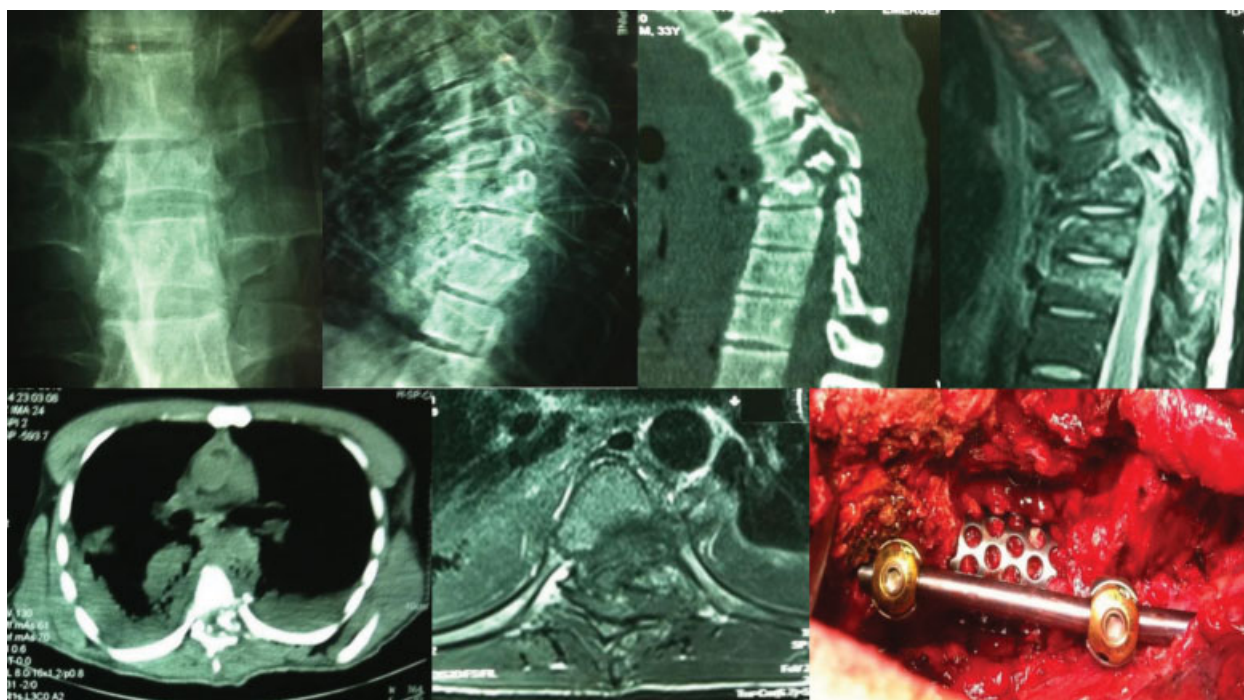
**Fig. 4** Walnut-spine Fracture dislocation of D6 vertebral body seen on sagittal MRI and axial CT scan of the dorsal spine. The operative photograph shows exposed thecal sac.



**Fig. 5** X-rays lateral view of a “forgotten” *walnut-spine* with C5 and C6 vertebral body fracture. He reported after 18 months of the fall and injury.

by Chu et al<sup>16</sup> in their study, where male-to-female ratio of spinal trauma has been 3.6:1.0 and most patients were in the age group of 20 to 39 years. The study shows cervical spine injury as the most common (36.2%) followed by thoracic spine (34.3%) and then lumbar spinal injuries in 29.5% patients. The fall from building heights and trees was the most common cause of spinal trauma in 58.9% followed by road-traffic accident in 21.3% patients. Chu et al reported prevalence of associated injuries, after studying 51,641 cases of spinal injuries from different hospitals of Taiwan, as 17.2% head injury; 2.9% chest injury; 1.5% abdominal trauma; 2.5%

pelvic injury, and injury to extremities as 10.3%.<sup>17</sup> The *walnut-spine* study revealed that about 21.28% (142/667) had associated head, thoracic, abdominal, pelvic, and extremity injuries. Schizas et al advised against surgical treatment in lumbodorsal compression injuries without posterior wall involvement or significant kyphosis, and recommended surgery in fracture dislocations and burst fractures with significant canal narrowing and/or major khyphosis.<sup>18</sup> The present study reveals that all types of approaches and procedures were used in 79.01% (527/667) patients to decompress spinal cord and roots, while



**Fig. 6** A walnut-spine shows a D8 vertebral body fracture dislocation with a bone fragment inside spinal cord tissue as revealed on the CT scan (sagittal reconstruction and axial), MRI (T2WI of sagittal and axial), X-rays, and the operative photograph.

**Table 2** ASIA neurologic outcome and mortality of nonpenetrating spinal injury

Causes	ASIA Grading and Deaths												Total	
	Cervical				Dorsal				Lumbar					
	E	D	CBA	Death	E	D	CBA	Death	E	D	CBA	Death		
Walnut-tree falls	0	0	10	95	0	20	82	51	0	42	30	7	337	
Fall from man-made vertical structures	11	32	9	31	17	34	32	3	26	10	17	0	222	
Road-traffic accidents	7	27	8	8	21	12	9	1	12	0	3	0	108	
Total	18	59	27	134	38	66	123	55	38	52	50	7	667	

Abbreviation: ASIA, American Spinal Injury Association.

E = no neurodeficit; D = preserved motor power of more than grade 3 in half of the key muscles below injury; C = preserved motor power of less than grade 3 in half of key muscles below injury; B = preserved sensory but not motor function below injury level; A = no motor or sensory function below the level of injury.

simultaneously to construct and stabilize the spinal column.<sup>19</sup> Silberstein and Rabinovich reported a mortality of 16.8% and most of the patients who died (84.8%) had injuries to the cervical spinal cord at the level of C4 and above.<sup>20</sup> The present *walnut-spine* study showed that ASIA neurologic grade of A and B on admission in more than 94% cervical injuries and in more than 86% of dorsal spinal injuries caused by walnut-tree falls had worst outcome in terms of severe disabilities and deaths. McLain et al found that surgical instrumentation allowed immediate mobilization of severely injured patients, in turn eliminating thromboembolic and pulmonary complications and reducing overall morbidity and mortality.<sup>21</sup> The *walnut-spine* study showed that the patients who were operated

had less hospital stay and been mobilized earlier, with the result these had faster neurologic recovery than the conservatively managed patients.

## Conclusion

The *walnut-spine*, locally known *occupational orchard-hazard*, has emerged as the most common and worst type of nonpenetrating spinal injury in terms of neurodeficit and outcome in young and productive age group. The workers for the harvesting of walnuts must use protective gears such as hikers and rock climbers to prevent falls. Alternatively, machines may be used or monkeys and lemurs may also be trained to retrieve the walnut fruit from the tree.

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