

*Original Investigation*

Gunshot Acquired Spinal Cord Injury in Civilians

Asad ABBAS, Hafiza Fatima AZIZ, Raza RIZVI, Lal REHAMAN, Farrukh JAVEED, Ali AFZAL

Jinnah Postgraduate Medical Center, Department of Neurosurgery, Karachi, Pakistan

Corresponding author: Asad ABBAS ✉ asad.abbas@live.com

ABSTRACT

AIM: To understand the differences between operative versus conservative treatment in terms of the outcome measured according to the American Spinal Injury Association (ASIA) impairment scale (AIS) in patients with gunshot acquired spinal cord injuries.

MATERIAL and METHODS: A total of 168 patients were included in this retrospective study. The AIS score was recorded for all survivors who provided consent after emergence from spinal shock. Demographic information and level of injury were also recorded. Patients were categorized according to the management approach, and the outcome was measured at the 6-month follow-up, using the AIS score. Univariate statistics were used for data analysis.

RESULTS: Most patients were male (91.6%), with a mean age of 26 ± 4.2 years. A majority of patients (73.2%) had incomplete spinal cord injuries. Among the complete spinal injuries, most involved the thoracic spine (84%). Overall, the thoracic spine was involved in half of the cases (51%). Twenty-six (15.4%) patients underwent surgery. The distribution of AIS score differed between the operative and non-operative groups. In both groups, the AIS score on follow-up differed significantly from admission AIS score ($p < 0.001$). However, no significant differences were found between groups on the AIS score at follow-up ($p > 0.05$).

CONCLUSION: None of the management approaches showed superior neurological recovery. Therefore, we conclude that outcome improvement in young patients depends on appropriate selection of surgical candidates.

KEYWORDS: Firearms, Ballistics, Penetrating spinal injury, Civilian gunshot, Spinal cord injury

INTRODUCTION

Traumatic spinal cord injuries (TSCIs) are relatively more common in the developing part of the world than in developed countries, with a reported incidence of 25.5 million/year (22). Among younger age groups, TSCI commonly results from gunshot injuries and leads to paralysis (13,17,22). Such patients are likely to endure a physically and psychologically hostile life (1,15). Gunshot injuries are classified as either civilian-or military-sustained, according to the ballistic characteristics, the impact mechanism, and the outcome (5,25,29). Because of increasing violence, the incidence of penetrating injuries such as gunshot wounds has increased over time, currently accounting for 17%–31% of all spinal cord injuries among the civilian population (8,13,26).

Compared to other causes, within the younger population (mean age: 27 years), gunshot-related spinal injuries are

associated with considerably lower functional recovery and poor outcomes, in terms of hospital stay and secondary complications (13). A recent review pointed out that these injuries are associated with a major socioeconomic impact and healthcare burden in developing countries (24).

Considering the outcome and impact on healthcare system, TSCI prevention is of major importance and relies on an adequate understanding of the population characteristics. However, this is limited by the scarcity of reported data pertaining to our part of the world. The present study, therefore, aimed to understand the epidemiological and clinical variables associated with TSCIs, as well as their outcomes after operative versus non-operative management. The information gathered is the foremost step toward the development of better preventive strategies.

Asad ABBAS : 0000-0003-3752-058X
Hafiza Fatima AZIZ : 0000-0003-3549-4381
Raza RIZVI : 0000-0001-6586-5206

Lal REHAMAN : 0000-0003-0624-3420
Farrukh JAVEED : 0000-0002-7433-4834
Ali AFZAL : 0000-0002-8388-5427

■ MATERIAL and METHODS

The medical records of 168 civilians presenting with gunshot-acquired spinal cord injuries (GSASCI) admitted to our center were retrospectively reviewed from January 2010 to December 2017. Inclusion criteria were patients with GSASCI older than 16 years and presenting with either acute TSCIs or cauda equina lesions on initial imaging examinations, and persistent impairment after emergence from spinal shock. Patients who died within 48 hours of presentation were excluded.

Demographic and clinical data were obtained, including age, gender, trauma site, and level and extent of neurological impairment. The time from injury, length of stay, concomitant injuries, and surgical interventions performed were also recorded.

The level of injury was classified into cervical, thoracic, and lumbosacral, whereas the extent of injury was recorded 48 hours after admission, according to the American Spinal Injury Association (ASIA) Impairment Scale (AIS) (16,27). Patients were categorized into 2 groups based on whether the injury was conservatively or operatively managed. Surgical indications for incomplete spinal injury were significant canal compromise (>50%), bullet retention within the canal, and presumed instability. Following discharge, patients were referred to either rehabilitation centers or home-based nursing facilities and followed-up at regular intervals for at least 6 months. The AIS score at the final follow-up was recorded. The AIS scores recorded from follow-up visits were compared between groups. The frequency and type of secondary complications were also recorded.

Statistical analysis was performed using the SPSS version 23 for Windows (SPSS Inc., Chicago, IL, USA). Results are

presented as means and standard deviations for continuous variables, and as frequencies and percentages for categorical variables. Within-group comparisons between the pre- and post-management AIS scores were performed using the Chi-square and Fisher exact tests. Between-group comparisons of the AIS score changes according to the type of management (i.e., conservative vs operative) were analyzed using the independent *t*-test. A level of *p*<0.05 was considered statistically significant.

■ RESULTS

A total of 168 GSASCI survivors who met the inclusion criteria were enrolled in this study. The study population mainly consisted of men (91.6%), with a mean age of 26 ± 4.2 years. The mean length of hospital stay was 18.6 ± 7.1 days. Concomitant injuries were found in 40 (23%) patients (Table I). Secondary complications were observed in 61 (36%) patients, with pressure ulcers as the most common complication, especially among patients with complete spinal injury.

Less than three-fourths (73.2%; n=123) of the patients presented with incomplete spinal cord injuries, half of which involved thoracic spine injuries (51%). A total of 45 patients (26.78%) presented with complete spinal injury (AIS-A), 84% of which involved the thoracic spine (Table II).

Twenty-six (15.4%) patients underwent spine surgery, whereas the remaining 142 (84.5%) were managed conservatively (Figures 1, 2). Wound care, including dressing and debridement, was performed for all wounds, as part of general care. Table III presents the distribution of admission AIS scores across groups, as well as the differences between groups. Most injuries within the operative group had an AIS classification of B or C (incomplete injury), whereas within the non-operative group, 31% of patient presented with complete injuries (AIS-A). Results also showed a significant difference on the over all follow-up AIS scores between groups (*p*< 0.001; Table III), whereas no difference was found between groups regarding the change in AIS scores during follow-up (Table IV).

Twenty patients (11.9%) presented with post-management AIS score improvement, including 4 of 26 (15%) patients in the operative group and 16 of 142 (11%) patients in the conservative group. Table V presents the AIS change for each group, indicating that the type of management does not correlate with the outcome.

Table I: Associated Injuries

Injury Type	n	%
Head and Neck	7	4.1
Chest	12	7.1
Abdomen	9	5.3
Extremity	3	1.7
Multiple	9	5.3

Table II: Distribution of Level of Injury according to AIS on Admission

Spinal level	Complete		Incomplete					n (incomplete total)	%
	A	%	B	C	D	E			
Cervical	5	10.6	9	27	5	1	42	89.3	
Thoracic	38	44.1	21	19	8	0	48	55.8	
Lumbosacral	2	5.7	4	11	14	4	33	94.2	
Total	45	26.7	34	57	27	5	123	73.2	

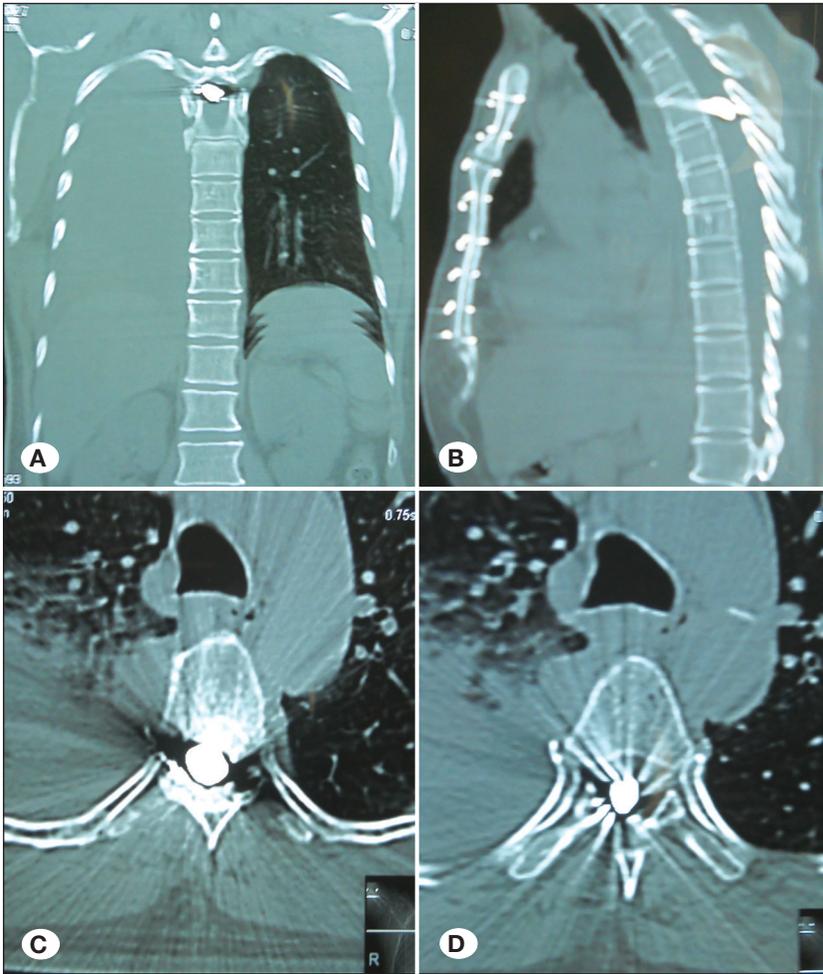


Figure 1: Computed tomography scan of patient showing bullet within the dorsal spinal canal (A: coronal, B: sagittal, C: axial). Posterior elements of the vertebra are fractured (D).

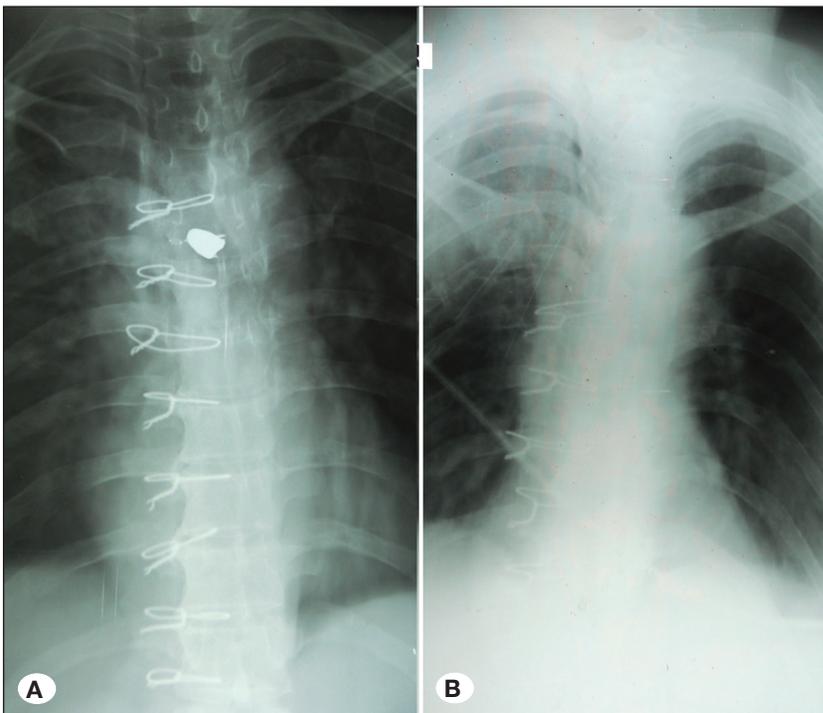


Figure 2: Pre (A) and post-operative (B) X-ray of the same patient showing removal of bullet.

Table III: Comparison of ASIA Score Pre and Post Management within Group

Management	AIS on admission	AIS on follow-up					Total	p
		A	B	C	D	E		
Conservative	A	45	0	0	0	0	45	<0.001
	B	0	24	1	0	0	25	
	C	0	0	38	8	0	46	
	D	0	0	1	13	7	21	
	E	0	0	0	0	5	5	
Operative	A	0	0	0	0	0	0	<0.001
	B	0	7	2	0	0	9	
	C	0	0	10	1	0	11	
	D	0	0	1	4	1	6	
	E	0	0	0	0	0	0	

- **A = Complete.** No sensory or motor function is preserved in the sacral segments S4-S5.
- **B = Sensory incomplete.** Sensory but not motor function is preserved below the neurological level and includes the sacral segments S4-S5, AND no motor function is preserved more than three levels below the motor level on either side of the body.
- **C = Motor incomplete.** Motor function is preserved below the neurological level, and more than half of key muscle functions below the single neurological level of injury have a muscle grade less than 3 (Grades 0–2).
- **D = Motor incomplete.** Motor function is preserved below the neurological level, and at least half (half or more) of key muscle functions below the NLI have a muscle grade >3.
- **E = Normal.** If sensation and motor function as tested with the ISNCSCI are graded as normal in all segments, and the patient had prior deficits, then the AIS grade is E.

Table IV: Comparison of ASIA Class on Follow-up Visit Between Conservative Versus Operative Groups

ASIA Score	Total	Conservative		Operative		p
	Admission	Follow up	Admission	Follow up		
A	45	45	45	0	0	---
B	34	25	24	9	7	0.123
C	57	46	40	11	13	0.440
D	27	21	21	6	5	0.072
E	5	5	12	0	1	1.00

Among the 26 patients who underwent surgery, 21 received laminectomy. The higher proportion of injuries managed operatively was lumbosacral injuries (22.87%; Table VI).

The condition of 2 patients classified as D on AIS-deteriorated after management. Both cases involved the thoracic spine and one was being managed conservatively, whereas the other underwent bullet retrieval because of persistent neurological decline. The condition of both these patients subsequently deteriorated to a lower AIS score (Table V).

DISCUSSION

Previous studies have reported that gunshot injuries constitute 4%-8% of all TSCIs in Pakistan (18, 23), whereas the incidence of these injuries is on the rise in developing countries (22).

The dynamics of the military and civilian gunshot-acquired injuries differs in several parameters: the impact of the low-velocity projectiles used in civilian injuries is more likely to cause direct tissue damage, whereas that of the high-velocity weapons used in war zones is likely to cause cavitatory lesions (7,24). Despite the increasing incidence of high-velocity projectiles within the civilian population, treatment protocols designed for war zone injuries are not empirically used to deal with civilian injuries (7).

A recent review by Sidhu et al. reported that men in third decade of life are the most affected by GSASCIs (24), which is approximately 10 years younger than for other TSCIs (13). The mean age of this study’s cohort was 24 years, which is on average 6 years younger than previously reported for this region (10,18). The fact that, worldwide, traumatic injuries

Table V: Comparison of Change from Admission ASIA Score to Follow up ASIA Score Based on Management

ASIA on admission	Change of ASIA on Follow up	Management			p	
		Conservative	Operative	Total		
A	Change	No Change (0)	45	0	45	----
B	Change	No Change (0)	24	7	31	0.164
		Improved (1)	1	2	3	
C	Change	No Change (0)	38	10	48	0.673
		Improved (1)	8	1	9	
		Deteriorated (-1)	1	1	2	
D	Change	No Change (0)	13	4	17	
		Improved (1)	7	1	8	
E	Change	No Change (0)	5	0	5	----
Overall change between the groups		Mean	0.11	0.12		
Std. Deviation			0.431			0.227
Std. Error Mean			0.028			

Table VI: Regional Distribution of Operative Intervention (n=26)

	Bullet retrieval (n=8)	Stabilization (n=5)	Laminectomy (n=21)	% of operated cases
Cervical	2	2	2	8.5
Thoracic	1	-	14	16.27
Lumbosacral	5	3	5	22.87

occur more among men is not surprising. Previous studies have reported that 8%-94% of GSASCIs occur in men (7,9), which is in line with the findings of the present study (91.6% of the patients were men). GSASCIs are associated with a longer hospital stay than other TSCIs (13), especially when they are managed operatively (20). In the present study, the mean length of hospital stay was 18.6 ± 7.1 days, which is consistent with the findings of other studies (13,17).

Most gunshot injuries involve the thoracic spine (7,9). Sidhu et al. reported a 49% incidence of thoracic spine involvement, followed by cervical (30%) and lumbosacral spine (21%) (24). Results from the present study are consistent with those findings, in that 51% of the cases involved the thoracic spine, 27% involved the cervical spine, and 21% involved the lumbosacral spine. According to previous studies, the incidence of complete GSASCIs ranges between 13% and 78%, whereas the incidence of incomplete GSASCI ranges between 16% and 87% (13,24). Those reports reflect a considerable population variability, which is caused by both intrinsic factors and the type of weapon used. We found a 27% incidence of complete injuries, most of which (84%) involved the thoracic region. Our results contradict those reported by McCoy et al. (19), who found a 65% incidence of complete injuries.

Approximately 80% of the patients with civilian GSASCIs require operative care (10,13). However, a recent review stated that only 18% of the population had surgical indication, with a large proportion (75%) of the procedures performed without indication and being over-used in the field of civilian gunshot injuries (21). According to the existing literature, the time from injury to operative intervention has no clear effects and only 18% of surgeries are performed within 30 days after the injury (21). In our center, surgery is performed as soon as possible, ideally within 72 hours of admission.

In our study, 26 (15%) patients received operative treatment. Considering the poor neurological outcome of patients with complete spinal injury (AIS-A) compared with those with incomplete injury (12,24), a higher rate of unindicated surgeries was performed within this population (21). Although, in general, surgical intervention is better avoided until clearly beneficial, a recent study by Iqbal et al. supported a cautious oversight of operative management in this group, because 30% of complete spinal injuries improve at least one grade in AIS score (10). In our study, none of the patients with AIS-A were treated operatively and all remained within AIS-A with no measurable outcome improvement.

In the present study, most cervical injuries were incomplete (89%), which contradicts the results of previous studies (7,26).

Patients with cervical injury underwent surgery, representing 8.5% of all cervical GSASCIs. The performed procedures included 2 bullet retrievals, 2 laminectomies, and 2 cervical stabilizations. Two patients improved after laminectomy and stabilization. In the current literature, cervical canal bullet retrieval is controversial. However, when there is a possibility of root escape in the nerves supplying the upper limbs, it is deemed indicated (11,21). Stabilization, alone or with decompression, has no proven benefit in terms of neurological outcome (21). It is only justified for unstable injuries or those with evolving neurological deficit (21), which are less likely to occur in low-velocity civilian gunshot injuries, because the ligamentous support remains intact (28).

Most thoracic complete injuries are associated with lower hope of recovery (6,17,24). A little more than half the patients in the present study had thoracic spine involvement (51%), with less evident difference in complete versus incomplete injury (44% and 56%, respectively). Fourteen patients underwent laminectomy (16% of thoracic injury) with no improvement and the condition of 1 patient deteriorated to a lower AIS score, replicating the poor outcome reported by the previous literature (26). Decompressive laminectomy in the thoracic spine exerts a subsidiary role on positive outcome (4), which needs to be considered before deciding for an operative management.

According to a review by Nwosu et al., most lumbosacral injuries are incomplete, with complete injuries accounting only to 17% (21). This is consistent with the findings from the present study, according to which, 94% of the lumbosacral injuries were incomplete. About a quarter (22.8%) lumbosacral injuries were managed operatively, and the performed procedures included 5 bullet retrievals, 5 laminectomies, and 3 stabilization procedures. Surgery seems to improve recovery in lumbosacral and cervical injuries as compared with thoracic injuries (3,24). Within the operative group of the present study, improvements were observed in 25% of the patients with lumbosacral injury and 50% with cervical injury. No improvement was observed among patients with thoracic spinal injury.

Civilian gunshot injuries are low-velocity, mechanically stable injuries that are rarely associated with evolving neurological deficits (2,24). These injuries are less likely to improve with decompressive and stabilizing procedures, except for bullet retrievals from the lumbar spine (21). In the present study, bullet retrieval resulted in improved AIS scores in 2 of 5 (40%) patients with lumbosacral involvement, suggesting the better efficacy of this procedure, as reported by previous studies (17,24).

The rate of concomitant injuries was higher in GSASCIs, with the abdomen and chest being more common than other regions (9,24). Similarly, we found that 18% of study population had concomitant injuries, most commonly located in the chest and abdomen. Half the patients with TSCIs are likely to exhibit one or more complications, among which the most common complications are pressure ulcers, followed by pulmonary infection (13,14). In our study, 61 (36%) patients developed

Table VII: Complications

Complication	Number of Patients	%
Pressure ulcer	20	11.9
Neurogenic bladder	18	10.7
Pneumonia	8	4.7
Wound infection	2	1.1
DVT/PE	8	4.7
Discitis	3	1.7
Neuropathic pain	2	1.1

DVT: Deep venous thrombosis, **PE:** Pulmonary embolism.

secondary complications, such as pressure ulcers (12%) and neurogenic bladder (11%; Table VII). Although pulmonary infection is regarded as a common complication of such injuries (14), in the present study, only 5% of the study population developed this complication.

Our study has several limitations, including its retrospective nature and the unequal distribution of patients between groups. Such limitations might have obscured the true outcome, attenuating the differences between management strategies. Randomized multicenter studies may therefore help formulate a definitive guideline for civilian gunshot injuries.

■ CONCLUSION

The management of gunshot-acquired spinal cord injuries in civilians is controversial. None of the management approaches showed superior neurological recovery, and improving the outcome of such injuries in young patients relies on appropriate selection of surgical candidates.

■ REFERENCES

1. Ali Shah SZ, Ilyas SM: Assessment of the quality of life of spinal cord injury patients in Peshawar. *J Pak Med Assoc* 67:434-437, 2017
2. Aryan HE, Amar AP, Ozgur BM, Levy ML: Gunshot wounds to the spine in adolescents. *Neurosurgery* 57:748-752, 2005
3. Beaty N, Slavin J, Diaz C, Zeleznick K, Ibrahim D, Sansur CA: Cervical spine injury from gunshot wounds. *J Neurosurg Spine* 21:442-449, 2014
4. Bertullo G, Azevedo-Filho HR, de Almeida NS, Brainer-Lima PT, Azevedo R, Azevedo F: Gunshot wounds to the spine: Comparative analysis of two retrospective cohorts. *Am J Biomed* 3:504-522, 2015
5. Bhatoo H, Singh P: Missile injuries of the spine. *Neurology India* 51:507, 2003
6. Bumpass DB, Buchowski JM, Park A, Gray BL, Agarwal R, Baty J, Zebala LP, Riew KD, Santiago P, Ray WZ: An update on civilian spinal gunshot wounds: Treatment, neurological recovery, and complications. *Spine* 40:450-461, 2015
7. de Barros Filho T, Cristante A, Marcon R, Ono A, Bilhar R: Gunshot injuries in the spine. *Spinal Cord* 52:504, 2014

8. Farmer JC, Vaccaro AR, Balderston RA, Albert TJ, Cotler J: The changing nature of admissions to a spinal cord injury center: Violence on the rise. *Journal of Spinal Disorders* 11:400-403, 1998
9. Guzelkucuk U, Demir Y, Kesikburun S, Aras B, Yavuz F, Yasar E, Yilmaz B: Spinal cord injury resulting from gunshot wounds: A comparative study with non-gunshot causes. *Spinal Cord* 54:737, 2016
10. Iqbal N, Sharif S, Hafiz M, Khan AU: Gunshot spinal injury: Factors determining treatment and outcome. *World Neurosurg* 114:e706-e712, 2018
11. Jaiswal M, Mittal RS: Concept of gunshot wound spine. *Asian Spine Journal* 7:359-364, 2013
12. Jakoi A, Iorio J, Howell R, Zampini JM: Gunshot injuries of the spine. *Spine Journal* 15:2077-2085, 2015
13. Joseph C: Characteristics and outcomes of gunshot-acquired spinal cord injury in South Africa. *S Afr Med J* 107:518-522, 2017
14. Joseph C, Wikmar LN: Prevalence of secondary medical complications and risk factors for pressure ulcers after traumatic spinal cord injury during acute care in South Africa. *Spinal Cord* 54:535, 2016
15. Kennedy P, Garmon-Jones L: Self-harm and suicide before and after spinal cord injury: A systematic review. *Spinal Cord* 55:2, 2017
16. Kirshblum S, Waring W 3rd: Updates for the international standards for neurological classification of spinal cord injury. *Phys Med Rehabil Clin N Am* 25:505-517, vii, 2014
17. Le Roux J, Dunn RN: Gunshot injuries of the spine—a review of 49 cases managed at the Groote Schuur Acute Spinal Cord Injury Unit. *S Afr J Surg* 43:165-169, 2005
18. Masood Z, Wardug GM, Ashraf J: Spinal injuries: Experience of a local neurosurgical centre. *Pak J Med Sci* 24:368-371, 2008
19. McCoy E, Eftekhary N, Nwosu K, Fukunaga D, Liu C, Rolfe K: American Spinal Injury Association A (sensory and motor complete) is not different from American Spinal Injury Association B (sensory incomplete, motor complete) in gunshot-related spinal cord injury. *Spine J* 17:1846-1849, 2017
20. McCunniff PT, Ramey JS, Scott ML, Roach MJ, Vallier HA, Moore TA, Kelly ML: Operative versus nonoperative management of civilian gunshot wounds to the spinal cord: Novel use of the functional independence measure for validated outcomes. *World Neurosurgery* 106:240-246, 2017
21. Nwosu K, Eftekhary N, McCoy E, Bhalla A, Fukunaga D, Rolfe K: Surgical management of civilian gunshot-induced spinal cord injury: Is it overutilized? *Spine* 42:E117-E124, 2017
22. Rahimi-Movaghar V, Sayyah MK, Akbari H, Khorramirouz R, Rasouli MR, Moradi-Lakeh M, Shokraneh F, Vaccaro AR: Epidemiology of traumatic spinal cord injury in developing countries: A systematic review. *Neuroepidemiology* 41:65-85, 2013
23. Rathore MFA, Hanif S, Farooq F, Ahmad N, Mansoor SN: Traumatic spinal cord injuries at a tertiary care rehabilitation institute in Pakistan. *J Pak Med Assoc* 58:53-57, 2008
24. Sidhu GS, Ghag A, Prokuski V, Vaccaro AR, Radcliff KE: Civilian gunshot injuries of the spinal cord: A systematic review of the current literature. *Clin Orthop Relat Res* 471:3945-3955, 2013
25. Stefanopoulos P, Soupiou O, Pazarakiotis V, Filippakis K: Wound ballistics of firearm-related injuries—Part 2: Mechanisms of skeletal injury and characteristics of maxillofacial ballistic trauma. *Int J Oral Maxillofac Surg* 44:67-78, 2015
26. Trahan J, Serban D, Tender GC: Gunshot wounds to the spine in post-Katrina New Orleans. *Injury* 44:1601-1606, 2013
27. Waring III WP, Biering-Sorensen F, Burns S, Donovan W, Graves D, Jha A, Jones L, Kirshblum S, Marino R, Mulcahey M: 2009 review and revisions of the international standards for the neurological classification of spinal cord injury. *J Spinal Cord Med* 33:346-352, 2010
28. Waters RL, Sie IH: Spinal cord injuries from gunshot wounds to the spine. *Clin Orthop Relat Res* 408:120-125, 2003
29. Yoshida GM, Garland D, Waters RL: Gunshot wounds to the spine. *Orthopedic Clinics of North America* 26:109-116, 1995