J Turk Spinal Surg 2022;33(4):151-6
DOI: 10.4274/jtss.galenos.2022.36854



# IS SPINAL GUNSHOT WOUND SURGERY REALLY NECESSARY?

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ABSTRACT

**Objective:** The most common causes of spinal injuries are traffic accidents and falls. The third most common cause is spinal gunshot wounds (spinal GSWs). Moreover, the treatment of spinal GSWs remains controversial. The aim of this study was to evaluate the results of treatment options and determine the best treatment for spinal GSWs.

**Materials and Methods:** A total of 33 spinal GSW patients treated at our institution between January 2014 and December 2019 were retrospectively assessed. Epidemiological and medical information, including age, sex, sign, the form of operation, initial examination, follow-up evaluation, and imaging data, was gathered in individuals who had neurological deficits.

**Results:** There were 24 males and 9 females (mean age, 31.5 years at the time of injury). The mean hospital length of stay was 14.3 days (range, 1-85 days). The mean follow-up time was 8.2 months (range, 0-13 months). Of these injuries, 27 caused neurological deficits. A total of 17 (51.5%) patients underwent spinal operations, and 16 (48.5%) had conservative management. Six (18%) patients needed intervention for spinal instability. The neurological conditions of 10 patients worsened during the follow-up period. Five patients did not show improvement in their recent neurological condition ($p>0.05$). Two patients had better outcomes during the follow-up. The surgical intervention did not significantly improve outcomes relative to those of conservative management ($p>0.05$).

**Conclusion:** There is an ongoing need for more extensively studied protocols specific to spinal GSWs to further improve treatment decisions and the standard of care.

**Keywords:** Gunshot, wound, spinal injury, surgery

## INTRODUCTION

Spinal gunshot wounds (spinal GSWs) are the most frequent cause of spinal injuries after traffic accidents and falls[1] and are usually stable injuries that cause neurological deficits. Unfortunately, neurological status rarely recovers[2]. Spinal GSWs mostly occur in military battles, such as those in the Syrian civil war. Of the patients brought to our clinic for spinal GSWs, 91.1% were from the Syrian civil war.

In spinal GSW cases, the spinal cord, spinal column, and nerve roots can be injured directly or indirectly from projectiles. Bone and disc fragmentation caused by the direct impact of bullets, fragments, or pellets can, in turn, cause neurological injuries, and other indirect injuries can be caused by pressure and thermal injury. Even in radiologically normal individuals, the function may be permanently lost because of damage to the delicate cord. Following the initial damage, the neurological status may be worsened by blood flow into the spinal canal, neurological shock, hypotension (due to blood loss), and compression of the spinal cord due to foreign bodies, disc fragments, and bone fragments[3-6].

Some patients with spinal GSWs require surgical evaluation for many reasons, such as rapid neurological deterioration, radiographic evidence of spinal cord or nerve root compression, mechanical instability, cerebrospinal fluid (CSF) leakage, and infection[7-10]. Many studies have published reports on spinal GSWs that describe treatments and outcomes of spinal GSW[11-14]. Despite many studies on this topic, consensus on treatment has not been reached.

The study aimed to evaluate the results of treatment options and determine the best treatment for spinal GSWs.

## MATERIALS AND METHODS

This was a retrospective study with a cohort consisting of patients ≥18 years old admitted to a hospital clinic with spinal GSWs that had been treated between January 2014 and December 2019. Patients with spinal GSW with intracranial injuries were excluded from this study.

The medical information, including age, sex, sign, the form of operation, initial examination, follow-up evaluation, and imaging data, of 33 patients who had neurological deficits was reviewed. The Frankel grading system was used to determine the neurological status.

All patients had undergone X-ray and computed tomographic imaging at admission to specify the exact level of trauma. Each patient had been examined by a neurological surgeon.

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Routinely, the patients were administered a wide spectrum of antibiotics for ⩾7 days unless there was no evidence of another infection. Tetanus prophylaxis was routinely administered. No steroids were given to the patients because of recent research showing that steroid usage after spinal GSW provided no significant benefits[15].

The patients underwent surgical treatment for specific reasons, such as progression in neurological deficit, infection, and CSF leakage, either combined or individually with spinal instability.

Our study was approved by the University of Health Sciences Turkey, Adana City Training and Research Hospital Clinical Research Ethics Committee (approval date: 30/05/2022, approval no: 1950). Written informed consent was obtained from all participants.

### Statistical Analysis

The paired-sample t-test was used to compare the findings both before and after treatment. Pearson's chi-square, likelihood chi-square (for the tables when expected values in cells were less than 5), and Fisher's Exact tests were used to assess qualitative variables. A p-value <0.05 was considered statistically significant. Statistical analyses in SPSS 22.0 (SPSS Inc., Chicago, IL, USA).

## RESULTS

A total of 33 patients were enrolled in the study; 24 males and 9 females; the mean age, was 31.5±8.7 at the time of injury. The mean hospital length of stay was 14.3±12.2 days (range, 1-85 days). The mean patient follow-up was 8.2±2.4 months (range, 0-13 months). A summary of the patient's characteristics and treatment outcomes is presented in Table 1.

The levels of injuries were as follows: cervical (C1-C7), 7 (22%) patients; cervicothoracic (C7-T1), 2 (6%) patients; thoracic (T1-T10), 10 (31%) patients; thoracolumbar (T11-LI), 8 (25%) patients; lumbar (L1-L5), 6 (16%) patients; and multiple vertebral injury levels, 10 (30.3%) patients (Figure 1).

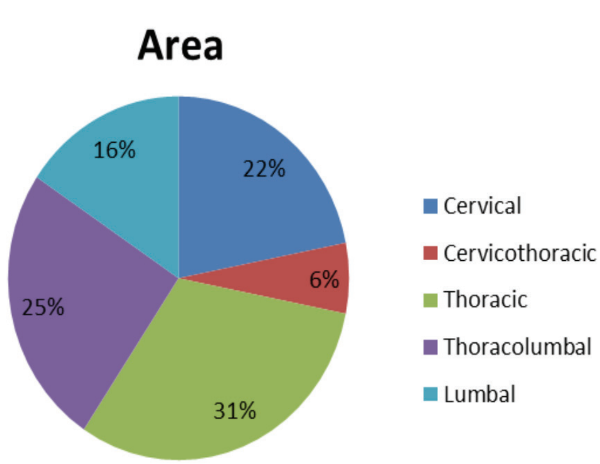



**Figure 1.** The areas of spinal injuries

According to the Frankel grading system, 30% of the patients had complete (Frankel A), and 70% had incomplete neurological damage (Frankel B, C, and D). No Frankel A patients showed neurological recovery. Neurological deficits were present in 82% of the patients, and 18% had no neurological deficit.

A total of 17 (51.5%) patients underwent spinal surgery, and 16 (48.5%) patients had conservative management. Six (18%) patients required intervention for spinal instability. In the case of conservative management, the patients were fitted with cervical collars, thoracolumbosacral orthoses, and halo vests. (Figures 2a-c). Because of CSF leakage, 2 of the 17 surgical fusion patients underwent additional surgery. Eight patients required surgery for CSF fistula repairment or late infection treatment. During conservative management, the neurological condition of four patients worsened during follow-up (p=0.2). Although surgery had been performed, the neurological condition of 10 patients had worsened during the follow-up period. The neurological situation did not improve in five patients (p>0.05). Two patients had better outcomes during the follow-up. The surgical intervention did not significantly improve outcomes relative to those of conservative management (p>0.05) (Figures 3a-d).

The organ injury rate of 28% is shown in the thoracic or abdominal region. During the study, 8 patients died, and 6 of them died from visceral injuries. The risk of complications or deaths was significantly associated with initial neurological injury; patients with more visceral injuries had a higher rate of complications (p=0.001). None of the patients experienced symptoms of copper or lead poisoning from bullet fragments or new neurological complications caused by intraspinal bullet fragment migration.

## DISCUSSION

Management of acute spinal GSW is complicated. The recommended conservative theory supports a nonsurgical approach with careful measures involving pain management and rehabilitation[16]. Additionally, others have recommended surgical intervention with the expectation of rapid improvement in neurological symptoms. Reported cases have involved 20% cervical, 50% thoracic, and 30% lumbar injuries. Although the most lethal damage occurs in the cervical region[5,6], most injuries occur in the thoracic region. In our study, we found results consistent with the literature.

Reported spinal injuries with large vascular or visceral injury rates have been in the range of 21% to 64%. Moreover, surgery or conservative management may not significantly affect the length of hospital stay or complication rate. However, the surgery decision depends on some variables: neurologic status, spinal stability, CSF leak, and injury level along with some others. In our study, 8 patients were operated on for CSF fistula repair or because of infection. Antibiotheraphy and immobilization were provided to accelerate fistula healing after the operation. Therefore, the length of stay of the patients was prolonged. While the mean hospital stay was 14.3±12.2 days, the mean hospital stay was 36±11.6 in 8 patients.

The internal organ injury rate is especially high in the thoracic and lumbar regions. These internal organ injuries increase the mortality rate of patients[3,9]. The indications for surgery imply that this treatment group may have more severe injuries, which could influence the outcome. In our study, the most commonly injured region was the thoracic at 30%, followed by the thoracolumbar (24%) and cervical (21%) regions. The thoracic or abdominal organ injury rate was 28%.

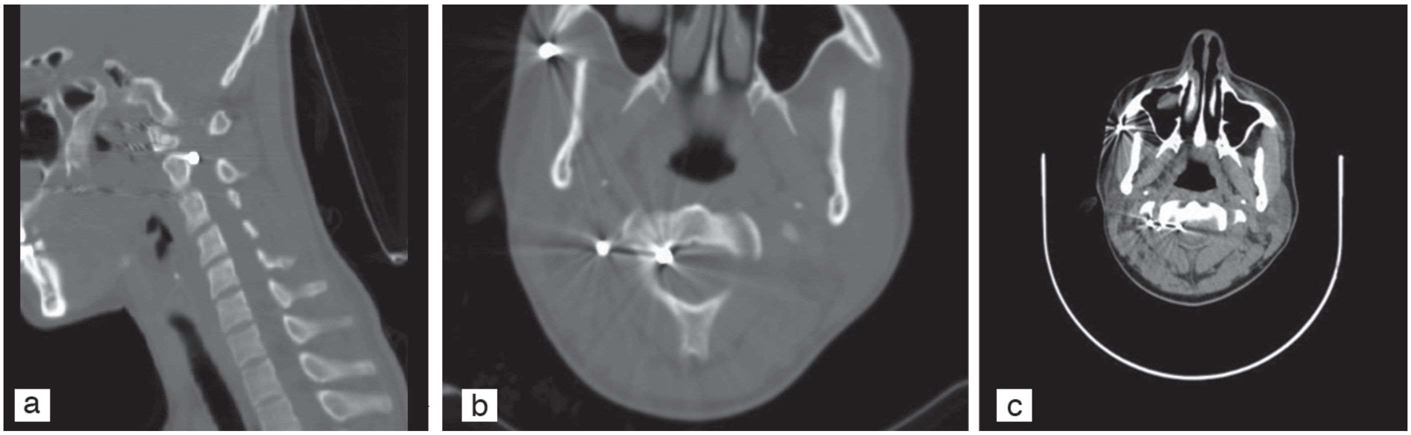
Sidhu et al.[2] reported that they found no difference in the improvement between patients treated with and without surgery. Surgical treatment of spinal GSWs has failed to improve neurological outcomes relative to those of nonsurgical treatment and is associated with higher complication rates. Aarabi et al.[17] gathered 185 spinal GSW patients and decompressed 101 of those patients, but they found no difference in neurological recovery between the patients treated with and without surgery. Kahraman et al.[9] reported an analysis of 106 patients, with 60% having undergone surgery. They reported similar results between the surgical and conservative groups. In contrast, some studies have reported surgical benefits in patients with

**Table 1.** Patient summary

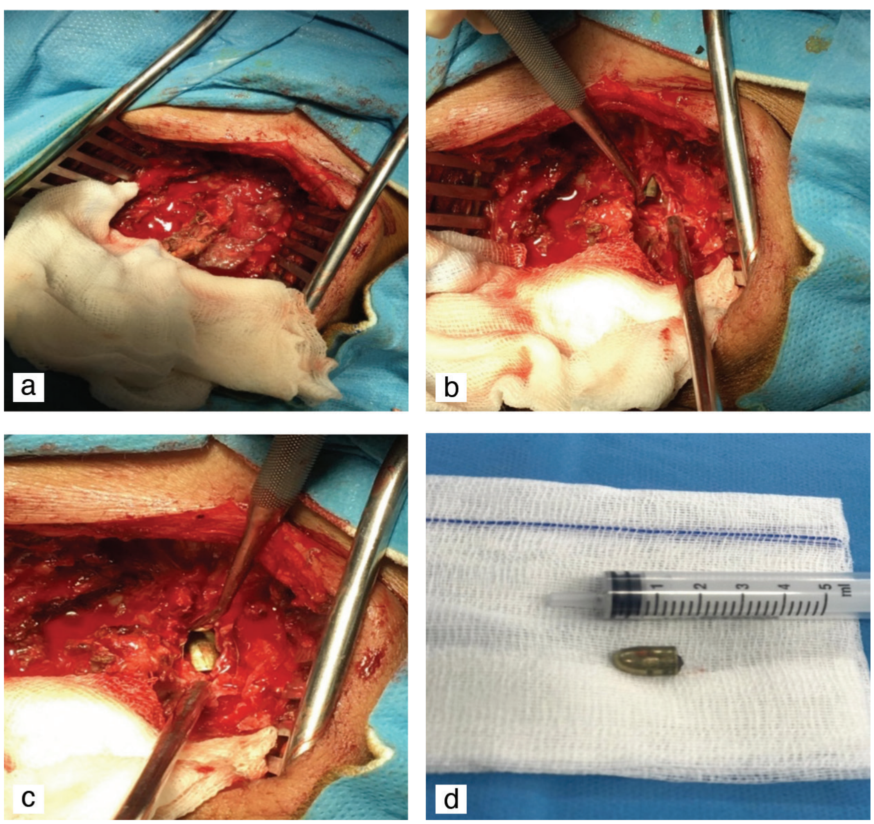
| Patient | Age/sex | Area | Frankel grade | Treatment | Visceral damage | Complication | Mortality | Control |
|---|---|---|---|---|---|---|---|---|
| 1 | 18/M | C | D | Conservative | | | | Same |
| 2 | 26/M | C | B | Surgery | | | | Worse (A) |
| 3 | 22/M | C | A | Conservative | + | Infection | + | EXITUS |
| 4 | 31/M | C | A | Surgery | | Infection | | Same |
| 5 | 32/F | C | B | Surgery | | | | Better (C) |
| 6 | 36/M | C | C | Surgery | | CSF | | Worse (B) |
| 7 | 29/F | C | D | Conservative | | | | Same |
| 8 | 31/M | CT | A | Conservative | + | | + | EXITUS |
| 9 | 22/F | CT | A | Surgery | | Infection + CSF | + | EXITUS |
| 10 | 29/M | T | E | Conservative | + | | | Same |
| 11 | 22/M | T | C | Conservative | | | | Better (D) |
| 12 | 27/M | T | C | Surgery | | Infection + CSF | | Worse (B) |
| 13 | 39/M | T | A | Surgery | + | | | Same |
| 14 | 29/M | T | D | Conservative | | | | Better (E) |
| 15 | 50/F | T | B | Surgery | | | | Same |
| 16 | 43/M | T | A | Surgery | + | CSF | + | EXITUS |
| 17 | 28/M | T | E | Conservative | | | | Same |
| 18 | 25/M | T | C | Conservative | | | | Better (D) |
| 19 | 30/F | T | A | Surgery | + | | | Same |
| 20 | 27/M | TL | D | Surgery | | CSF | | Worse (B) |
| 21 | 43/M | TL | C | Surgery | | | | Same |
| 22 | 33/M | TL | B | Conservative | | Infection | | Worse (A) |
| 23 | 21/M | TL | E | Conservative | | | | Same |
| 24 | 25/M | TL | C | Surgery | + | Infection + CSF | + | EXITUS |
| 25 | 32/F | TL | A | Conservative | | | | Same |
| 26 | 43/F | TL | B | Surgery | | | | Better (C) |
| 27 | 39/M | TL | E | Conservative | | | | Same |
| 28 | 35/M | L | C | Surgery | | CSF | + | EXITUS |
| 29 | 53/M | L | A | Surgery | + | Infection + CSF | + | EXITUS |
| 30 | 38/F | L | E | Conservative | | | | Same |
| 31 | 41/F | L | E | Conservative | | | | Same |
| 32 | 19/M | L | B | Surgery | | | | Worse (A) |
| 33 | 24/M | L | A | Conservative | + | | + | EXITUS |

C: Cervical, CT: Cervicothoracic, T: Thoracic, TL: Thoracolumbal, L: Lumbal, CSF: Cerebrospinal fluid leak progressive neurological deficits and incomplete cord injuries or cord compression[18]. Waters and Adkins [19] 90 patients with intracanal bullet fragments, and 32 of those patients had been treated with decompression surgery. They found that the neurological benefit of surgical decompression was significantly important only for injuries between the T12 and L4 levels, which suggested that decompression of the conus medullaris and cauda equina areas may have some benefit. In our intervention or neurosurgical consultation. This data was consistent with those in other modern large series reports[11] study, 18% of the patients presented without neurological deficits and did not require.

Lead toxicity (plumbism) related to GSWs has been reported[20]. However, the incidence of lead toxicity is very rare. Scuderi et al.[21] reviewed 238 spinal gunshot injuries that occurred over 24 years. They found 12 cases involving patients with bullets in disc spaces during that period. However, clinical signs of lead toxicity only developed in one of these 12 patients. They advised that it was more important to monitor for lead toxicity after injury instead of immediately removing the bullet. In




**Figures 2a-c.** The cervical spine shows a retained bullet in the cervical intradural space. Figures 2a, 2b, and 2c are images of the same patient. Left hemiparesis was observed. Patients had conservative management




**Figures 3a-d.** Perioperative same patient images of the cervical spine showing a bullet. The patient's neurological status worsened. Painful stimuli elicited purposeful movements of the right arm and leg. Further, examination revealed left hemiplegia. Therefore, we decided to remove the migrating bullet after the patient's neurological status improved.

our study, none of the patients experienced symptoms of lead toxicity. The short study period may be the reason why lead toxicity was not detected.

Moreover, in the management of spinal GSW patients, transvisceral injuries should be carefully examined because of possible infection of the spine. Kumar et al.[22] followed up with 31 patients treated with antibiotics for 2 to 43 days. Thirteen of these 31 patients had transcolonic injuries. None of those cases developed vertebral osteitis.

Kihtir et al.[23] studied 21 patients with transperitoneal gunshot injuries, five of whom had transcolonic injuries. There were no vertebral infections. Roffi et al.[24] studied 42 patients with 51 visceral perforations. Including 14 colonic and 15 small-bowel injuries. They used antibiotic treatment and reported three spinal infections. Additionally, that study concluded that early bullet removal did not seem to be helpful. This study illustrated the importance of conservative treatment of the spine and support our study.

Zipnick et al.[25] reported that neurogenic shock is so rare in patients with spinal GSWs secondary to GSWs and that neurogenic shock is less common after GSWs than after spinal GSWs by blunt traumas. This rarity is probably because the mechanism and clinical behavior of spinal GSWs secondary to GSWs are different from those of blunt trauma. In our study, none of the patients experienced symptoms of neurogenic shock. But the mechanisms of these two injury types should be elucidated to determine the most appropriate treatment for each.

One further major finding in our study was that patients treated with surgery had higher rates of complications (29% infection, 47% CSF leak). These results were similar to those found in three previous studies[15,17,26]. However, in the case of radiographic evidence of compression in the spinal cord, surgery should be an option.

### Study Limitations

A limitation of the current study was that it was conducted at a single center and limited to the low number of patients. Therefore, all patients at follow-up do not allow for an exact analysis of those responses. Our conclusions would need to be confirmed by a larger prospective randomized controlled study.

## CONCLUSION

In this study, we found that surgical intervention did not significantly improve neurological deficits after spinal GSW. We believe that surgical intervention may have some neurological benefits in patients with progressive incomplete lesions and radiographic evidence of compression. However, a consideration is that complication rates were greater in the operated patients.

### Ethics

**Ethics Committee Approval:** The study was approved by the University of Health Sciences Turkey, Adana City Training and Research Hospital Clinical Research Ethics Committee (approval date: 30/05/2022, approval no: 1950).

**Informed Consent:** Written informed consent was obtained from all participants who participated in this study.

**Peer-review:** Externally peer-reviewed.

### Authorship Contributions

Surgical and Medical Practices: C.S., M.U., Concept: C.S., M.U., Design: M.U., Data Collection or Processing: C.S., M.U., Analysis or Interpretation: C.S., M.U., Literature Search: C.S., M.U., Writing: C.S.

**Conflict of Interest:** The authors have no conflicts of interest to declare.

**Financial Disclosure:** The authors declared that this study received no financial support.

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