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GRAND ROUNDS

Management of a posterior gunshot injury with a floating pedicle and cerebrospinal fluid leak

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Abstract

Purpose Gunshot injury to the spine can be devastating, and it has increased in the civilian population during the last decade.
Methods We present the case of a 30-year-old male, who received a bullet in his back after exchange of fire with the police. Initial assessment revealed paraparesis with cerebrospinal fluid leak (CSF) from the bullet entry hole, CT scan showed metal debris with two bullet fragments in the L5/S1 right foramen and lateral recess, and another fragment in the central canal posteriorly, and also it revealed two fracture lines creating a right L5 "floating pedicle".
Results The patient was taken to the operating room and underwent L5/S1 posterior approach with right L5 pedicle stabilization with a pedicle screw, removal of the bullet fragments, dural repair with a patch, L5/S1 posterolateral fusion, and insertion of a lumbar CSF drain. The patient could walk with a walking frame on day 7 with a satisfactory radiological result at 1 year but with a remaining partial motor deficit of both ankles, mainly on the right side.
Conclusion Literature contains a lot of controversies regarding the management of spinal gunshot injuries. The current case shows that early surgical management, when partial neurological deficit with a CSF leak is noted, could improve the clinical outcome and prevent related complications.

Keywords Gunshot wound · Floating pedicle · Cerebrospinal fluid leak · Spine injury

Case presentation

A 30-year-old male, in the context of drug dealing, was trying to escape the police in a high-speed car chase, with exchange of fire. He suddenly felt a sharp pain in his low back area and the vehicle stopped. The patient was found with a back bleeding and impossibility to stand up or walk. The initial medical assessment made by the emergency team

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found a man with a normal conscious level associated with a severe low lumbar pain with paraparesis mainly concerning both ankles motion. The patient was transported immediately to the hospital for further evaluation and investigations. Upon arrival to the emergency room, the patient was alert and oriented. Exposure of the back revealed a left paravertebral wound at the level of L5 corresponding to the entry hole of a bullet, with minimal bleeding, but with leak of a transparent fluid corresponding to the cerebrospinal fluid (CSF); sensory and motor exam revealed a saddle anesthesia, weak anal tone, urine retention, with partial deficit of ankle plantar flexors on both sides (2/5), and complete ankle dorsal flexors deficit on the right side (0/5) but sparing the tibialis anterior muscle. Lumbar X-ray and full body CT scan confirmed the gunshot injury with multiple bullet fragments seen at the L5/S1 level posteriorly, along with two fracture lines around the right L5 pedicle. The patient was taken to the operation room for exploration, bullet fragments removal, dural repair, and L5/S1 posterior instrumented fusion.

Diagnostic imaging section

Lumbar X-ray showed multiple bullet fragments seen at the L5/S1 level posteriorly with metal debris (Fig. 1a, b). CT scan revealed the presence of three main fragments, one in the right L5/S1 foramen, one in the right lateral recess, and the third in the central canal posteriorly, no vertebral body fracture was noted, but a fracture of the right L5 isthmus was seen associated with another fracture line at the junction of the right pedicle and vertebral body, which created a right L5 "floating pedicle", and also L5 spinous process was fractured (Fig. 2a–c).

Historical review, epidemiology, diagnosis, pathology, and differential diagnosis

Gunshot wound to the spine is the third most common cause of spine injuries after fall from height and road traffic accident. It accounts for 13–17% of all gunshot injuries and occurs predominantly in the thoracic region in civilian practice, and the rate of incomplete injury in the lumbosacral area is about 70% [1]. The damage caused by a bullet depends on its kinetic energy (KE) that is directly related to its velocity via the kinetic energy formula ($KE = 1/2mv^2$). Low velocity weapons account for most of civilian spinal gunshot injuries and are usually caused by direct trauma from the bullet fragments or vertebral fractured segments, whereas high velocity weapons (mostly encountered in military practice) cause spinal cord injury secondary to shock wave and cavitations generated by very high-speed bullets [2]; therefore, the extent of injury to the spinal cord and neural elements depends on ballistics (especially rotational effect like yaw), degree of contusion and transection, degree of concussive blast injury, compression by displaced bone fragments, and mechanical stability of the spinal segments [3].

Gunshot victim should be examined thoroughly, looking for entrance and exit wounds, and detailed neurological examination must be performed, as for other types of spinal trauma, including motor, sensory, reflexes, and anal

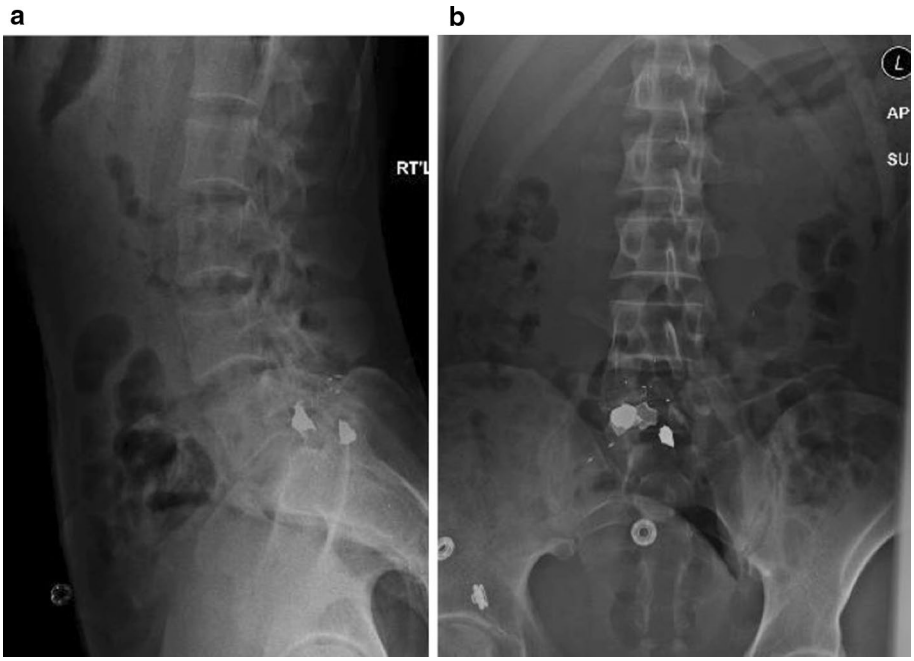

Fig. 1 Lumbar X-ray showing multiple bullet fragments at the L5/S1 level posteriorly with metal debris

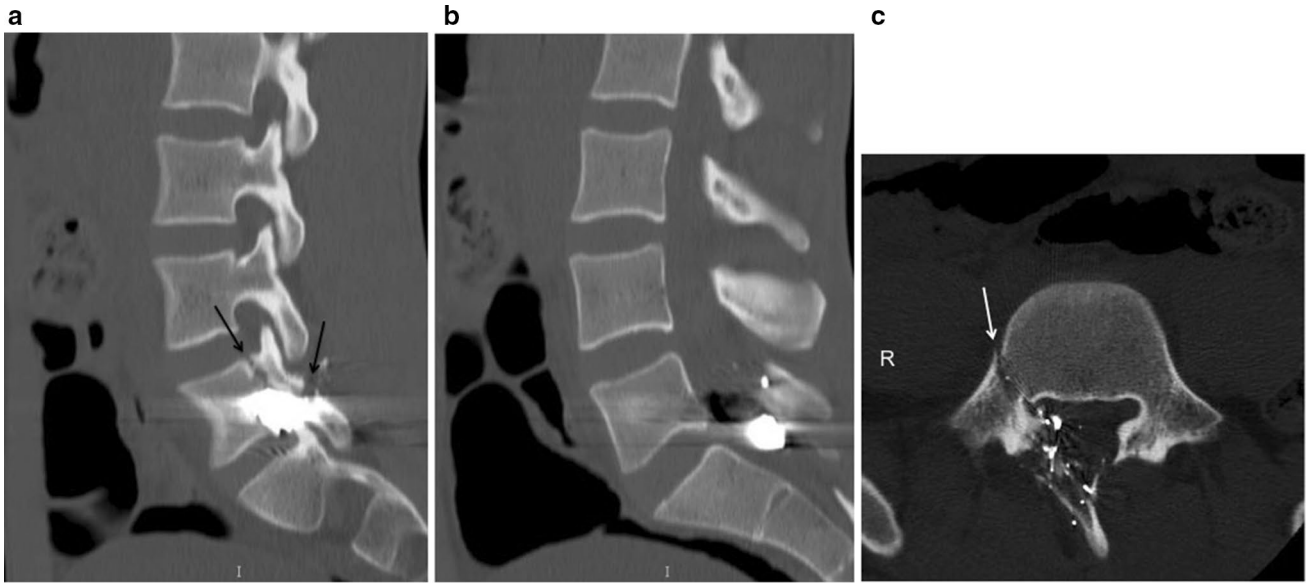

Fig. 2 CT scan sagittal views showing the right L5/S1 foraminal fragment with the 2 fracture lines around the pedicle (**a**, black arrows), the central canal fragment (**b**) and the axial view with the L5 spinous process fracture, metal debris, and right pedicle-body fracture line (**c**; white arrow)

sphincter tone. Two plain radiographic views of the spine (anteroposterior and lateral) can help locate bullet fragments and detect associated fractures; CT scan will allow more accurate localization of any foreign body in the spinal canal or foramen, with some limitation due to artifact in the presence of metallic debris [4]. MRI in patients with retained bullet fragments has been reported to be safe [5]; nevertheless, because of the risk of migration of any ferromagnetic metal, it should be made on a patient-specific case-by-case basis.

Acute infectious complications due to contamination, especially with visceral perforation, are empyema, intra-abdominal sepsis, spinal abscess, psoas muscle abscess, subcutaneous abscess, and bullet tract infection [6]. Lumbar spine is the most common site of infection followed by the thoracic and cervical spines; this is due to the fact that at the lumbar level bullets often pass through the gastrointestinal tract [7].

Retained canal fragments if located below T12 have a risk of secondary migration [8], and also late lead poisoning is a possible complication at a later stage [9]. Rarely, disc material can cause neural defects by compressing the canal when the bullet damages the annulus [2].

Rationale for treatment

Ideal management of gunshot wound to the spine remains a matter of controversy, with studies supporting rather a conservative management to avoid further harm to the spine and associated complications [10, 11], and others recommending surgical interventions as removal of an eventual foreign body would enable higher potential for regeneration of the axons of injured nerve roots, therefore, a better functional outcome [12].

The presence of a bullet is not by itself an indication for surgery and frequently does not require removal (thecal sac often heals spontaneously in a closed injury); the decision to perform surgery actually depends on different main variables: neurologic status, spinal stability, bullet location, injury level, and the existence of a CSF leak.

If a patient is neurologically intact, there are few indications for surgery: evidence of acute lead intoxication, the presence of intracanal copper bullet, or new onset neurologic deficit. In fact, wide laminectomy may destabilize the spine and lead to late postoperative deformity [4]. Partial spinal cord or nerve root injury due to compression by bone, metal fragment, or hematoma may benefit from a surgical decompression in the lumbosacral spine, which may result in motor and sensory improvement [1]. Poor benefit was noted after surgery in complete and partial neurological deficits at the cervical and thoracic levels [4].

Associated fractures are usually stable and rarely require stabilization, but if a bullet in the lumbar or cervical area breaks the pedicle or facet while traversing, it can cause acute or chronic instability that may require stabilization [13], patient may undergo a classical open posterior approach, or minimally invasive surgery may be used in selected cases [14]. Surgery is also indicated for complications such as infection, or persistent external CSF fistulae.

In regards to antibiotic prophylaxis in penetrating spine injuries, there is scant evidence in the literature on its type and duration, and recommendations vary from 2 to 14 days cover with the use of broad-spectrum antibiotic in case of viscus perforation [4]. Steroids are not indicated and may increase the risk of non-spinal complications [4, 15].

In the case of our patient, given the CSF leak, the fact that the right L5 pedicle was unstable, and the partial neurological deficit, decision was made to perform a posterior instrumented L5/S1 fusion with wide laminectomy for good exploration, fragments removal and dural repair, and also right foramen had to be completely opened to remove the foraminal fragments. For the high L5/S1 disc (increased risk of non-union), no interbody cage was put during the procedure because of important intraoperative bleeding, surgery duration, and the risk of infection given the context; the patient was proposed a complementary anterior lumbar interbody fusion (ALIF) surgery after complete posterior wound healing 2 weeks later but he refused.

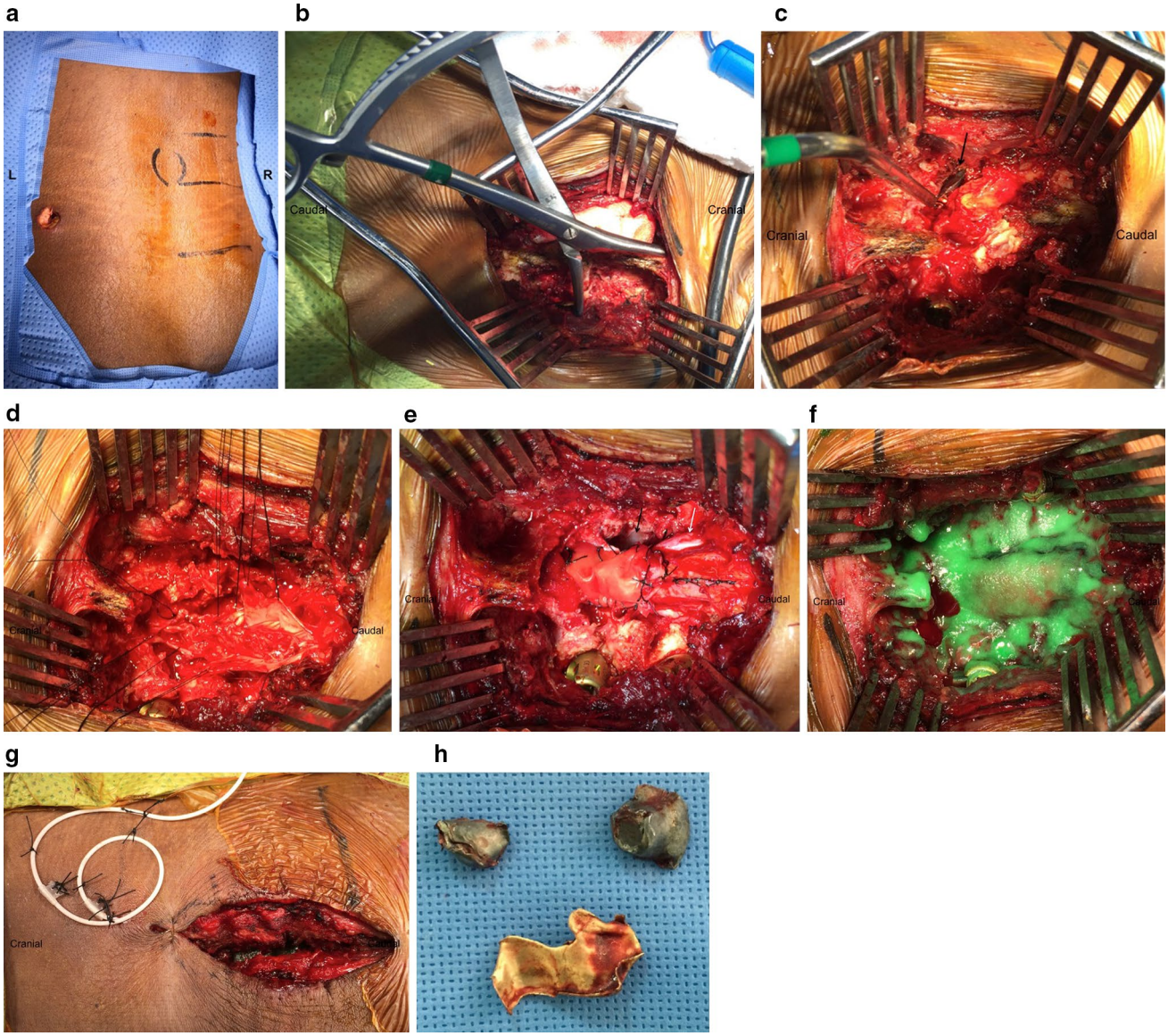

Fig. 3 Intra-operative images showing the bullet entry hole in the left paravertebral area (**a**), stabilization of the right L5 pedicle with the reduction forceps for pedicle screw insertion (**b**), bullet fragment in the right L5/S1 foramen (**c**, black arrow), suspension of the dura and visualization of the important posterior defect (**d**), suture of the dura on a dural patch, the departing right S1 root is seen (**e**, white arrow) with an empty right L5/S1 foramen because of absent right L5 root (e, black arrow), sealant applied after dura suture (**f**), insertion of a sub-arachnoid drain at the L3/L4 level (**g**), the three main fragments removed (**h**)

Operative procedure

Under general anesthesia, with a patient in a prone position, on four cushions, and the field including the bullet entry hole (Fig. 3a), a posterior cutaneous midline incision was made. The spine was exposed subperiosteally from L4 to S1, in a fashion similar to other posterior instrumented surgeries, going laterally to the transverse processes and sacral ala. The right L5 transverse process was completely mobile, along with the right L5 pedicle, "floating" between the vertebral body and right isthmus, confirming the CT scan aspect. After exposure of the spinous process and laminas, clear CSF could be seen coming from the left L5/S1 interlaminar space, which was temporarily packed with gelfoam. Two pedicle screws were put on the left side in L5 and S1 and on the right side in S1 with the free-hand technique. For the right L5 pedicle, a reduction forceps was used between the lower edge of the L5 lamina and the upper edge of the L4 lamina (Fig. 3b), this maneuver put compression on the isthmic area, right pedicle, and the pedicle-body fracture line ultimately, which allowed to stabilize the right L5 pedicle, and enabled insertion of a pedicle screw, under lateral C-arm assistance. Afterwards, the right foramen was opened, with removal of the right superior articular process of S1 and the right inferior articular process of L5, similar to a classical transforaminal lumbar interbody fusion (TLIF) approach, which revealed the presence of two bullet fragments in the foramen and lateral recess (Fig. 3c) that were removed, and the complete absence of the right L5 nerve root in its usual pathway, it was actually cut and burnt at its origin, where it departs from the dura. Then, a wide L5 laminectomy was performed and revealed one bullet fragment in contact with the neurological elements posteriorly, with an important laceration of the dura and a big defect, and also the rootlets below the L5 level were exposed with a lot of small debris within the cauda equina. The fragment was removed and small debris stuck to the rootlets was removed carefully, and then, the dura was suspended bilaterally to clearly visualize its edges and the departing S1 and S2 roots (Fig. 3d). Partial inferior and central laminectomy of L4 was done to enable good control of the dura suture proximally. Thorough washing of the neurological elements was done with a small catheter and serum to evacuate any remaining debris. A dural patch was cut to fit the defect, and was progressively sutured with the use of 4.0 silk sutures (Fig. 3e). Then, the anesthesiologist was asked to perform a Valsalva maneuver to test the suturing, which revealed a minimal and acceptable leakage of CSF. Remaining of the patch was then put on top of the dura and sealed with a dural sealant (Fig. 3f). Two titanium rods were inserted and the setscrews tightened. Posterolateral autologous graft was put after meticulous freshening of the transverse process and ala bilaterally. Intrawound application of 1 g of Vancomycine powder was done at the end of the procedure. Lumbar CSF drain was inserted at L3/L4 to decrease the intrathecal pressure at the level of the injury (Fig. 3g). A regular drain without suction was left in the surgical wound. The three main fragments were given back to the police as evidence (Fig. 3h). Post-operatively, the course was uncomplicated, patient had antibiotic prophylaxis for 3 days with Vancomycin, and he was assisted the first day post-surgery by the physiotherapist with help of a walking frame for verticalization and gait aiding. Surgical drain was removed on day 3. Spinal drain was removed on day 7.

Fig. 4 Postoperative CT scan confirming the good position of the right L5 pedicle screw in the "floating pedicle"

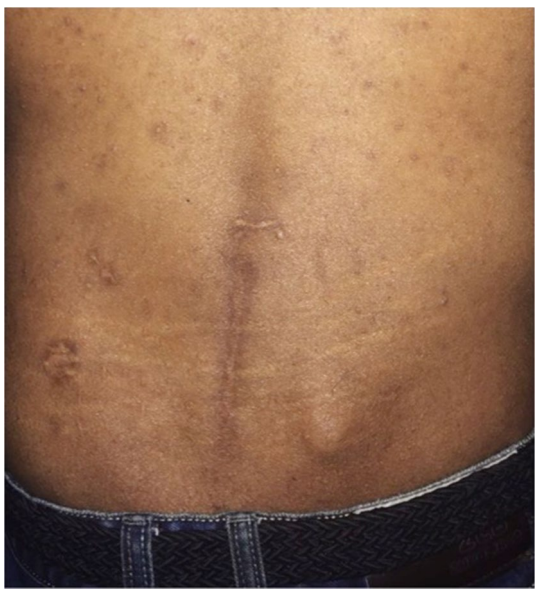

Fig. 5 3-month back picture showing healing of all wounds

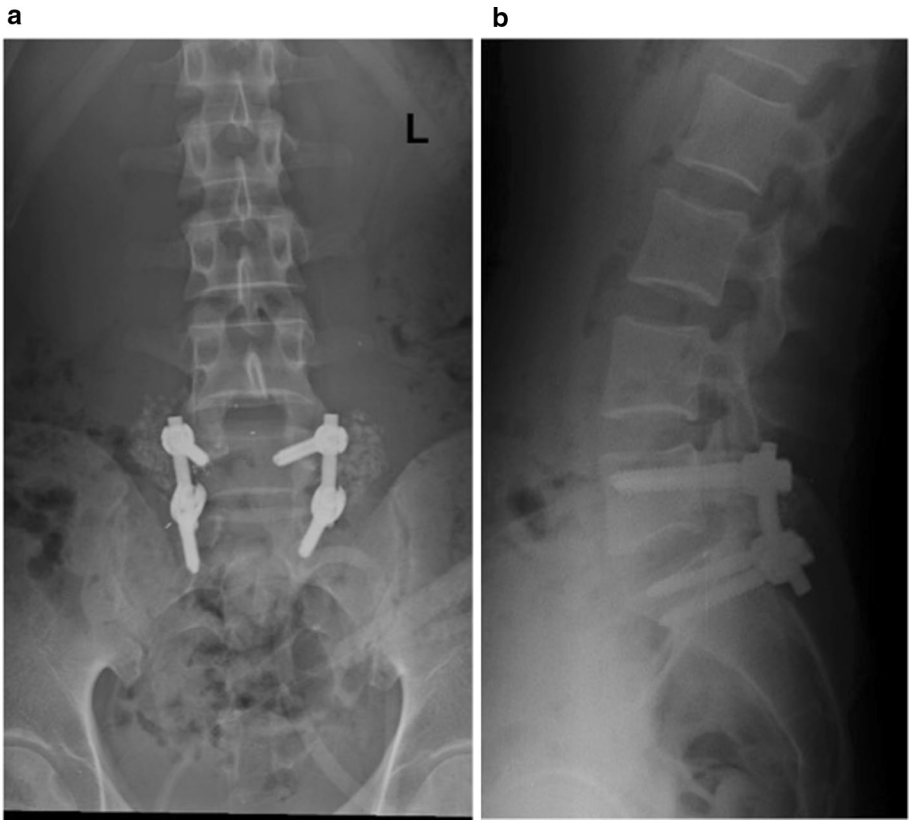

Fig. 6 1-year X-ray showing a stable construct with good alignment

Clinical outcome

The patient showed significant improvement of his neurological symptoms mainly on the ankle plantar flexors bilaterally, walking independently with the walking frame at the end of his 2-week hospital stay. Anal tone improved and Foley catheter was removed at 4 weeks. A postoperative CT scan was performed to confirm the removal of all big bullet fragments and verify the location of the implants especially in the right L5 pedicle (Fig. 4). Surgical wound, bullet entry hole wound, and drains wounds revealed a completely healed aspect at 3 months (Fig. 5). He showed a global satisfactory clinical and radiological result at 1 year (Fig. 6a, b), walking with a cane, but the right ankle dorsal extension weakness in relation with the right L5 root damage remained.

Compliance with ethical standards

Conflict of interest There is no conflict of interest for this case report.

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