

Clinical case

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Spinopelvic dissociation in an adolescent with severe combined injury complicated by cauda equina

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Abstract

Introduction The clinical case demonstrated low prevalence and complexity of spinopelvic dissociation. Up-to-date diagnostic and modern osteosynthesis techniques were used for unstable injuries of the pelvic ring and the sacrum.

The **objective** was to report a rare clinical case of spinopelvic dissociation in an adolescent with severe combined injury complicated by cauda equina that resulted in a positive treatment outcome.

Material and methods An adolescent patient with spinopelvic dissociation as part of a severe multi-trauma injury complicated by cauda equina was reported. Cauda equina root decompression surgery, triangular osteosynthesis and minimally invasive fixation of anterior pelvic ring fractures were performed after four days of injury because of unstable hemodynamics in the patient.

Results A positive treatment outcome was achieved in the form of life-saving, restored musculoskeletal function of the pelvis and lower limbs and complete regression of neurological dysfunction of the pelvic organs demonstrated by the Majeed pelvic score at six months and at one year of injury.

Discussion Spinopelvic dissociation as part of a severe combined injury was caused by a fall from a height in the case. A ISS score of over 25 points is classified as profound and very severe with a high risk of mortality and is often accompanied by traumatic shock. There is a high risk of neurological disorders and damage to other locations in spinopelvic dissociation. The patient suffered damage to the cauda equina roots and disturbed pelvic functions, adjacent pelvic fractures (fractures of the left acetabulum, right pubic and ischial bones), visceral injuries including contusion to the right lung and the brain. Triangular osteosynthesis is considered the method of choice for spinopelvic dissociation providing stable and biomechanically reasonable fixation system for the vertical, rotation and angulation loading on the pelvic ring. Although the risk of postoperative complications is very high and can reach 50 % with open techniques according to international literature the patient developed no postoperative complications. The treatment strategy was adequate for the teenager with spinopelvic dissociation and severe combined trauma and resulted in consolidated pelvic ring fractures and positive long-term functional outcome.

Conclusion Despite the complexity of the injury, high risk of postoperative complications and the lack of experienced specialists the teenager could survive, avoid postoperative complications and restore pelvic and lower limb function due to the coordinated work of a multidisciplinary team, timely diagnosis and modern osteosynthesis techniques used for unstable pelvic injuries.

Keywords: spinopelvic dissociation, combined trauma, unstable pelvic injury, sacral fractures, triangular osteosynthesis

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INTRODUCTION

Spinopelvic dissociation (SPD) is a severe injury characterized by an anatomical separation between the spine and the pelvis. The condition can be caused by a horizontal sacral fracture and bilateral longitudinal fractures, resulting in SPD [1–7]. Due to the rarity, complexity of this injury and the high frequency of postoperative complications, there are not enough experienced specialists to diagnose and treat this pathology [4, 5]. The uniqueness of this clinical observation is associated with the low incidence, severity of the pathology, timely diagnosis and up-to-date methods of osteosynthesis used for unstable injuries of the pelvic ring and sacrum: open bilateral transpedicular spinal-pelvic fixation in combination with iliosacral screws (triangular osteosynthesis) and with retrograde minimally invasive osteosynthesis of the anterior pelvic half-ring. The treatment could save the teenager's life, avoid postoperative complications, and restore functions of the pelvis and lower extremities in the shortest possible time.

The **objective** was to report an uncommon clinical case of SPD in an adolescent with severe combined injury complicated by cauda equina that resulted in a positive treatment outcome.

MATERIAL AND METHODS

A 16-year-old girl was injured in a fall from the fifth floor. She was transported in critical condition by ambulance within 30 minutes to a specialized hospital at the Arkhangelsk Regional Clinical Hospital. Blood pressure was 100×60 mmHg, she was provided with artificial ventilation, inotropic support and neck immobilization with a Shants collar. Anti-shock treatment and diagnostic procedures were performed in the hospital. The patient was examined by a multidisciplinary team including a trauma surgeon, a neurosurgeon, general surgeon, a maxillofacial surgeon, and a resuscitation specialist. A computed tomography (CT) scan of the head, chest, abdomen, and pelvis was performed.

The patient was examined and diagnosed with combined trauma, catatrauma. closed craniocerebral injury, severe brain contusion, closed chest trauma, right lung contusion, unstable pelvic ring injury, comminuted unstable sacral fracture (DENIS type 3, ROY-CAMILL subtype 2), displacement and compression of the cauda equina roots, displaced fractures of the right pubic and ischial bones and the left acetabulum, neurogenic pelvic dysfunction, first-degree traumatic shock, contusions and abrasions of the soft tissues of the right side of the face and external nose, contused, penetrating wound of the lower lip, complete dislocation of teeth 1.1 and 2.1, partial dislocation and fracture of the crown of tooth 1.2, fracture of the nasal bones.

The Injury Severity Score (ISS) was 48, scored as an extremely severe injury. Mortality for injuries with an ISS score ≥ 40 points is the highest, amounting to 65 % [8].

Preoperative CT scan of the pelvis revealed a comminuted unstable fracture of the sacrum with displacement; fractures of the right pubic and ischial bones and the left acetabulum with displacement (Fig. 1).

Blood tests upon admission showed erythrocytes measuring $2.5 \times 10^{12}/l$, hemoglobin 72 g/l, total protein 50 g/l, CPK 2072 U/l, CPK MB 135 U/l.

Urgent surgery performed for the patient at the first stage included stabilization of the pelvic ring fractures using an external fixator (EF) (Fig. 2). Postoperative treatment was provided in the intensive care unit.

With the traumatic shock relieved and the patient's condition stabilized, a surgery performed four days later included removal of the EFD from the pelvis, decompression of the spinal nerve roots (cauda equina) at the level of the S2 vertebra, bilateral lumboiliac triangular fixation of the pelvis (transpedicular lumbar iliac fixation of the posterior pelvis at the level of L4, L5 and transcutaneous iliosacral fixation of sacral fractures with cannulated screws); minimally invasive retrograde metal osteosynthesis of fractures of the right pubic bone and left acetabulum with cannulated screws.

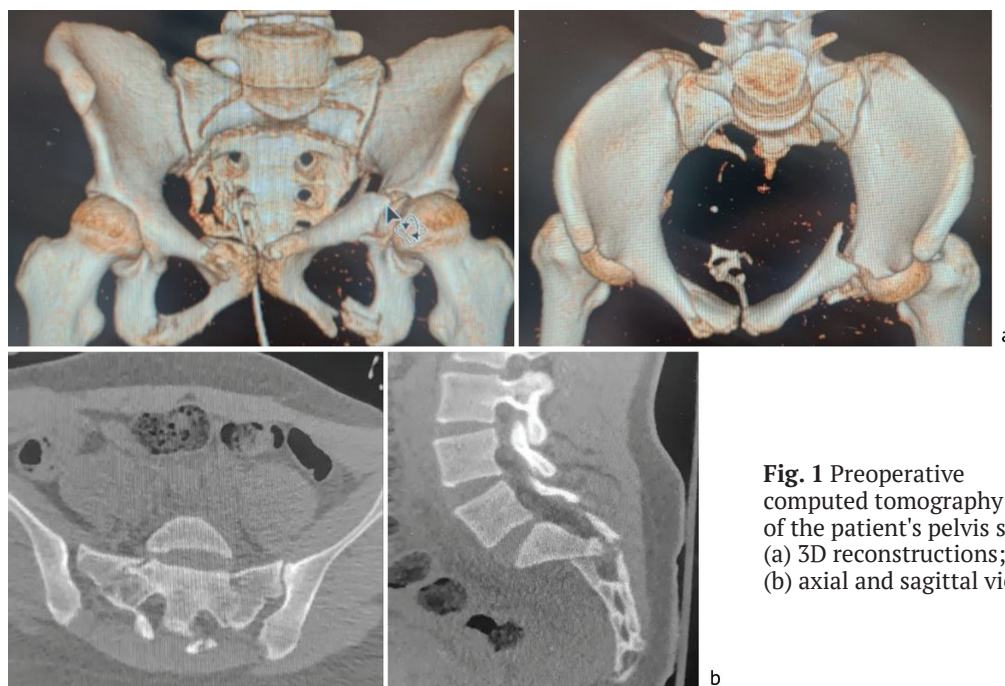


Fig. 1 Preoperative computed tomography scans of the patient's pelvis showing (a) 3D reconstructions; (b) axial and sagittal views



Fig. 2 Postoperative radiograph of the pelvis

The operating team included three trauma surgeons, a neurosurgeon, an anesthesiologist-resuscitator, and an operating nurse.

The EFD was removed from the pelvis under endotracheal anesthesia. With the patient prone, a 22-cm linear midline incision was made at the L5–S3 level in the sacral region. The soft tissues were separated, and the comminuted sacral fracture site was exposed. Hemostasis was achieved. The comminuted fracture plane and angular deformity were visualized at the S2 level. *Spina bifida* was identified at the S2 fracture plane. A laminectomy of S2 and partially S3 was performed. No visible bruising or morphological damage to the dura mater of the spinal cord or roots was detected. Decompression of the roots compressed by bone fragments was performed. Some small bone fragments were removed. The soft tissues were separated, and the arches and facet joints of L4/L5 and L5/S1 were skeletonized. Transpedicular screws were inserted into the roots of the L4 and L5 vertebrae on both sides under image intensifier (II) guidance. The screws were then secured into the iliac wings under II guidance. The sacral fracture dislocation was addressed under visual and radiological control. Transpedicular lumboiliac system was installed after modeling the connecting rods. Radiological examination revealed satisfactory positioning of the fragments. Two 1-cm skin incisions were made in the iliac wings. A cannulated screw was minimally invasively inserted into the body of the S1 vertebra through the longitudinal planes of the sacral fracture using guide wires (90 mm and 80 mm long, 7.3 mm in diameter) under II guidance. Iliosacral fixation of the sacral fractures was performed. A multislice radiograph revealed satisfactory bone position. The treatment performed included hemostasis, vacuum drainage to the fracture site, layered wound sutures and an antiseptic dressing.

In the supine position, retrograde minimally invasive metal osteosynthesis of the fracture of the right pubic bone was performed using two 0.5 cm skin incisions in the area of the pubic symphysis and cannulated screw with a diameter of 5 mm and a length of 40 mm and the fracture of the left acetabulum was fixed with a 110 mm screw with a diameter of 6.5 mm. The skin was sutured and aseptic dressings applied. Multislice radiograph of the pelvis and sacrum revealed satisfactory bone positioning (Fig. 3). The surgery lasted 4 hours 20 minutes, with blood loss of 700 ml.



Fig. 3 Plain radiographs of the pelvis after final osteosynthesis: medial oblique and AP; lateral oblique

RESULTS

The early postoperative period was uneventful. The treatments administered in the intensive care unit (ICU) included respiratory therapy, analgesics, prokinetics, lower extremity thrombosis prophylaxis, stress ulcer prophylaxis, antibacterial therapy, infusion/transfusion therapy, sedation, and enteral nutrition, physical therapy, nursing care, dressings, laboratory monitoring, 1162 ml of packed red blood cells, and 180 ml of cryoprecipitate. The drains were removed after two days. The patient was transferred from the ICU to the trauma and orthopedics department after three days. The patient's condition improved due to the treatment and she was able to walk with crutches without bearing weight on her left leg. The sutures were removed 21 days after surgery. Wound healing occurred by primary intention. Pelvic neurological impairments regressed. Neither vascular nor neurological disorders of the lower extremities were detected. Blood tests at discharge revealed: red blood cells $4.1 \times 10^{12}/L$, hemoglobin 125 g/L, total protein 74 g/L.

The patient was discharged for outpatient treatment after 33 days of injury with recommendations to continue treatment with a trauma surgeon and pediatrician, neurologist at the local clinic, walking with no weight on the left leg for three postoperative months, CT scan of the pelvis at six and 12 months of surgery, anticoagulants (Eliquis 2.5 mg 2 times a day for 11/2 months), elastic compression of the lower extremities, exercise therapy, massage, physiotherapy, analgesics, chondroprotectors, vitamins. A combination of minimally invasive osteosynthesis and open surgical techniques was used for the case for treating pelvic injuries. The patient's life was saved, lower limb function restored, and pelvic neurological disorders regressed. The treatment outcome was excellent.

The patient was examined by an orthopedic and trauma surgeon at the Arkhangelsk Regional Clinical Hospital at 6 and 12 months of surgery. She was satisfied with the treatment results, could walk with full weight-bearing on both lower extremities, and did not limp. Neither swelling nor deformities were detected in the extremities. Squats were painless, knee and hip movements unrestricted and pain free (Fig. 4). No signs of infection in postoperative scars in the pelvic area. Loading the iliac wings was painless. Sensation and movement of the toes were not impaired. Pelvic organ function was normal.



Fig. 4 Photo of the patient at six months of surgery

The patient demonstrated an excellent score of over 85 on the Majeed scale (an international scale for the long-term outcome of surgical treatment of unstable pelvic and sacral injuries) and the metal constructs to be removed. Computed tomography scans of the pelvis (Fig. 5) showed consolidated pelvic and sacral fractures at six and at 12 months of surgery (Fig. 6) with the metal constructs being stable.



Fig. 5 Computed tomography scans of the pelvis at six months of surgery showing (a) 3D reconstruction; (b) scans in frontal and sagittal planes

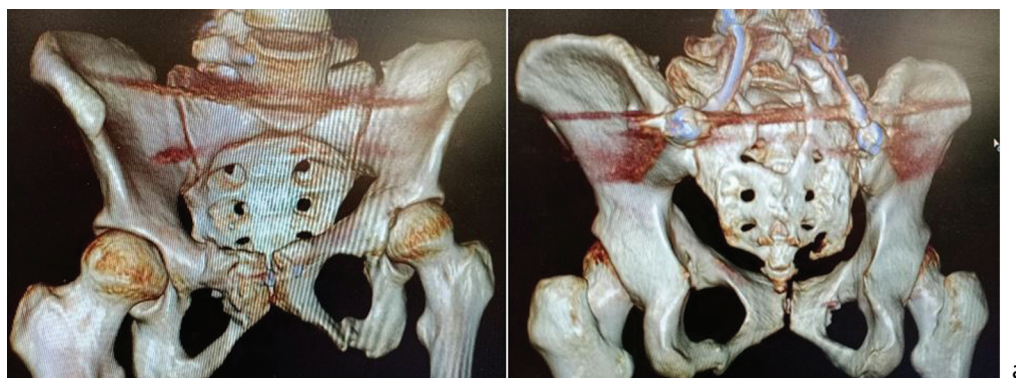


Fig. 6 Computed tomography scans of the pelvis at 12 months of surgery showing (a) 3D reconstruction

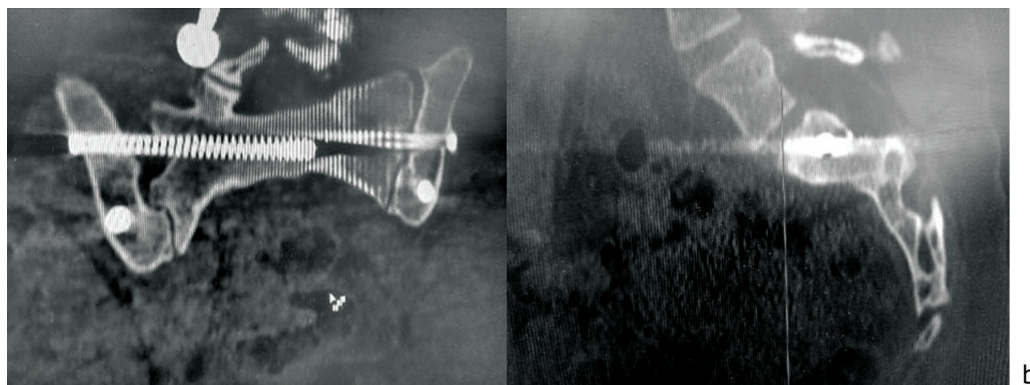


Fig. 6 (continuation) Computed tomography scans of the pelvis at 12 months of surgery (b) scans in frontal and sagittal planes

DISCUSSION

With technological advances in traumatology, treatment of patients with unstable pelvic ring injuries as part of severe combined trauma is challenging and requires an interdisciplinary approach. SPD is a rare injury that may occur in 2–3 % of cases with transverse sacral fractures and in 3 % of cases with sacral fractures associated with pelvic ring injuries. The diagnosis may be difficult or neglected in 25–70 % of cases depending on the diagnostic method used [9, 10].

In our clinical observation, the of high-energy severe combined injury in a teenager was caused by a fall from a height which is the main cause of such injuries along with road traffic accidents [7]. Multislice CT with a sensitivity of 88 % is the “gold standard” for diagnosing lumbopelvic dissociation [1, 7]. Upon admission to a Level 1 trauma center, the patient underwent diagnostic and treatment procedures including a CT scan of the head, chest, abdomen and pelvis to combat shock. This case was classified as extremely severe, with an ISS score of 48 since the mortality rate of 65 % for injuries with an ISS score ≥ 40 [8]. The patient underwent urgent pelvic ring stabilization using an external fixator to be followed by treatment in the ICU.

According to a meta-analysis, neurological deficit is present in 68.1 % of cases, of which 65.1 % show improvement after surgical treatment. There is a high risk of neurological injury when the fracture presents a kyphosis of $\geq 20^\circ$ [5]. In our clinical case, the patient had a neurological deficit (cauda equina syndrome), that regressed after surgical treatment. This type of injury is commonly associated with injuries to other locations with the incidence of 87.5 % associated spinal fractures, 71 % of lower extremity fractures, adjacent pelvic fractures 66.7 % and visceral injuries 28.6 %. The association with soft tissue injuries, such as Morrel-Lavallé syndrome may complicate the treatment of this cohort of patients [5]. The presence of severe traumatic brain injury or other bone and internal organ damage usually complicates neurological examination and early surgical treatment. This means that definitive surgical treatment must often be delayed until hemodynamic stability is achieved, although it is recommended within 72 hours. Some authors set a limit of 14 days after injury. Surgery should be performed as soon as possible for patients with neurological symptoms, preferably within the first 24 hours [5]. According to the literature, in case of SPD is commonly associated with injuries to other localizations, which is confirmed by our clinical case: damage to the roots of the cauda equina with disruption of pelvic functions, adjacent pelvic fractures (fractures of the left acetabulum, right pubic and ischial bones), visceral injuries with contusion of the right lung and contusion of the brain.

Spinal-pelvic fixation combined with iliosacral screws or a plate (triangular osteosynthesis) is considered the method of choice [10–13]. A triangle created is usually formed by two systems: horizontal transverse fixation using iliosacral screws and a vertical lumbopelvic transpedicular system providing optimal conditions for fracture consolidation [14–16]. Open reduction of the sacral

fracture with triangular spinopelvic fixation would be required for neurologically complicated SPD [1, 2, 5]. In our case, decompression of the cauda equina nerve roots, triangular osteosynthesis, and minimally invasive fixation of the anterior pelvic ring fractures were performed after four days of the injury due to unstable hemodynamics. The fractures of the right pubic bone and left acetabulum were fixed using a minimally invasive technique to restore the integrity of the pelvic ring, increasing stability and reducing the risk of failure of the posterior pelvic half-ring. The Association of Osteosynthesis / Orthopedic Trauma Association (AO / OTA) classification, modified by Tile and Young-Burgess, is widely used to describe sacral fractures in the context of the whole pelvic ring [1]. Several classifications have been established for sacral fractures by Denis supplemented by Roy – Camille and later by Strange – Vognsen and Lebech, B. Isler, but they cannot be considered separately from the entire pelvic ring, because the sacrum is a part of the pelvis, and not just one of the sections of the spine [1].

In 2012, A new classification system called lumbosacral injury classification system (LSICS) was devised and fractures with LSICS 4 or greater should be treated operatively [1, 5]. The Letournel – Judet classification system remains the most widely accepted framework for describing these fractures based on which anatomical component of the acetabulum is affected and the subsequent patterns [17, 18]. Several classifications were used for the clinical case to identify adequate treatment strategy for the injury to the pelvic ring and an associated pelvic injury (unstable pelvic ring damage, unstable sacral fracture, SPD, left acetabulum fracture with displacement). There are few experienced specialists for the diagnosis and treatment of this pathology due to the rarity, severity of this injury and high frequency of postoperative complications, which is a limitation of this treatment method [1, 2, 4, 5].

Further study of this pathology and the implementation of strategies with the use of minimally invasive approaches, preoperative planning employing 3D systems, intraoperative navigation or the use of sacroiliac screws are essential to minimize postoperative complications that occur in 30–50 % of cases [19–22]. Most common complications include discomfort due to the metal structure for osteosynthesis (95 %), infections (36–50 %, higher with open surgical approaches), implant instability (11–17 %), nonunion (9.3 %), implant malposition (15 %), root damage (2–15 %), deep vein thrombosis, progression of sacral kyphosis (independent of fixation of the anterior ring), cerebrospinal fluid leakage, ureteral and bladder injury [1, 5]. In our case, we managed to avoid postoperative complications, although, according to world literature, their probability is very high and reaches 50 % with open techniques. Triangular osteosynthesis is considered the method of choice for SPD, as the most stable, biomechanically sound fixation system providing optimal conditions for fracture consolidation and allows the patient to ambulate. Analyzing this clinical case, it can be stated that the treatment strategy for SPD in an adolescent with severe combined injury appeared to be adequate, which was confirmed by the consolidated pelvic ring fractures and positive long-term functional results.

CONCLUSION

The coordinated work of the multidisciplinary team, timely diagnosis, and up-to-date osteosynthesis techniques used for the pelvic ring injuries (triangular osteosynthesis and minimally invasive techniques) saved the life of the patient, helped to avoid postoperative complication, and facilitated quick restoration of the pelvic and lower extremity function in an adolescent with SPD as part of a severe combined injury.

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REFERENCES

1. Aganesov NA, Lazarev AF, Kuleshov AA, et al. Posterior pelvic ring injuries: classification, diagnosis, methods of treatment. *N.N. Priorov Journal of Traumatology and Orthopedics*. 2022;29(2):205-220. (In Russ.) doi: 10.17816/vto109172.
2. Altwaijri NA, Abdulaziz M, Bhat R, et al. Spinopelvic Dissociation Case Report and Literature Review. *Cureus*. 2023;15(5):e39750. doi: 10.7759/cureus.39750.
3. Kim DH, Vaccaro AR, Diekmann KA, et al. Spine. *Surgical anatomy and operative technique*. Russ. ed.: Yu.A. Shcherbuk. Moscow: Panfilov Publishing House; 2016:848. (In Russ.)
4. Sevillano-Perez E, Prado-Novoa M, Postigo-Pozo S, et al. L4 fixation is not necessary in L5-Iliac spinopelvic fixation after trauma, but coadjuvant transilio-transsacral fixation is. *Injury*. 2024;55(3):111378. doi: 10.1016/j.injury.2024.111378.
5. Hirschfeld M, Pascual-Lopez FJ, Guaredo E. Spinopelvic dissociation: Current concepts. *Rev Esp Cir Ortop Traumatol*. 2024;68(4):T398-T408. doi: 10.1016/j.recot.2024.01.025.
6. Liu ZJ, Hu YC, Tian W, et al. Robot-Aided Minimally Invasive Lumbopelvic Fixation in Treatment of Traumatic Spinopelvic Dissociation. *Orthop Surg*. 2021;13(2):563-572. doi: 10.1111/os.12908.
7. Santolini E, Kanakaris NK, Giannoudis PV. Sacral fractures: issues, challenges, solutions. *EFORT Open Rev*. 2020;5(5):299-311. doi: 10.1302/2058-5241.5.190064.
8. Seliverstov PA, Shapkin YG. Assessment of severity and prognosis of polytrauma outcome: the current state of the problem (review). *Modern technologies in medicine*. 2017;9(2):207-218. doi: 10.17691/stm2017.9.2.25.
9. 3Zakirov RI, Akhtyamov IF, Fayzrakhmanova GM. Successful treatment of a patient with multiple trauma including dislocated sacral fracture complicated with caudopathy. *Genij ortopedii*. 2022;28(6):837-841. doi: 10.18019/1028-4427-2022-28-6-837-841.
10. Kuleshov AA, Aganesov NA, Vetrile MS, et al. Biomechanical analysis of variants of spinopelvic fixation of longitudinal sacral fractures by the finite element method. *Russian Journal of Spine Surgery*. 2023;20(1):28-35. doi: 10.14531/ss2023.1.28-35.
11. Petryla G, Bobina R, Uvarovas V, et al. Functional outcomes and quality of life after surgical treatment of spinopelvic dissociation: a case series with one-year follow-up. *BMC Musculoskelet Disord*. 2021;22(1):795. doi: 10.1186/s12891-021-04676-w.
12. Mohd Asihin MA, Bajuri MY, Ahmad AR, et al. Spinopelvic Fixation Supplemented With Gullwing Plate for Multiplanar Sacral Fracture With Spinopelvic Dissociation: A Case Series With Short Term Follow Up. *Front Surg*. 2019;6:42. doi: 10.3389/fsurg.2019.00042.
13. Shi B, Peng Y, Zhang G, et al. Spinopelvic dissociation: extended definition, physical examination, classification, and therapy. *J Orthop Surg Res*. 2023;18(1):56. doi: 10.1186/s13018-023-03523-z.
14. Su PH, Huang YH, Yeh CW, et al. What Are the Key Factors of Functional Outcomes in Patients with Spinopelvic Dissociation Treated with Triangular Osteosynthesis? *J Clin Med*. 2022;11(22):6715. doi: 10.3390/jcm11226715.
15. Shetty AP, Renjith KR, Perumal R, et al. Posterior Stabilization of Unstable Sacral Fractures: A Single-Center Experience of Percutaneous Sacroiliac Screw and Lumbopelvic Fixation in 67 Cases. *Asian Spine J*. 2021;15(5):575-583. doi: 10.31616/asj.2020.0337.
16. Petryla G, Bobina R, Uvarovas V, et al. Functional outcomes and quality of life after surgical treatment of spinopelvic dissociation: a case series with one-year follow-up. *BMC Musculoskelet Disord*. 2021;22(1):795. doi: 10.1186/s12891-021-04676-w.
17. Lazarev AF, Akhtyamov IF, Azizov MZh, et al. *Surgical treatment of acetabulum fractures*. Kazan: OOO "World without borders"; 2019:319. (In Russ.)
18. Kolesnik AI, Borozda IV, Gnetetskiy SF, et al. *Surgical treatment of acetabular fractures: international approaches*. Moscow: GEOTAR-Media; 2021:160. (In Russ.) doi:10.33029/9704-6408-3-STC-2021-1-160.
19. Bagheri H, Govsa F. Anatomical considerations of safe drilling corridor upper sacral segment screw insertion. *J Orthop*. 2019;16(6):543-551. doi: 10.1016/j.jor.2019.04.010.
20. Mohd Asihin MA, Bajuri MY, Ahmad AR, et al. Spinopelvic Fixation Supplemented With Gullwing Plate for Multiplanar Sacral Fracture With Spinopelvic Dissociation: A Case Series With Short Term Follow Up. *Front Surg*. 2019;6:42. doi: 10.3389/fsurg.2019.00042.
21. Wu C, Deng J, Pan J, et al. Anatomical conditions and patient-specific locked navigation templates for transverse sacroiliac screw placement: a retrospective study. *J Orthop Surg Res*. 2020;15(1):260. doi: 10.1186/s13018-020-01752-0.
22. Alshehri A, Alrehaili H, Batayyib S, et al. Spinopelvic in situ fixation and early mobilization: a case report and literature review. *Cureus*. 2023;15(3):e36454. doi: 10.7759/cureus.36454.

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