ORIGINAL STUDY

Complications of Surgical Treatment of Sacral Fractures: Management and Avoidance

Hesham Habba, MD [a,*], Mohammed Alaswad, MD [a], Sherif H. Ali, MD [a], Sam S. Samaan, MD [b], Esam Elkhatib, MD [a], Ali Abou-Madawi, MD [a]

[a] Neurosurgery Department, Faculty of Medicine, Suez Canal University Hospital, Ismailia, Egypt
[b] Orthopedic Surgery Department, Faculty of Medicine, Suez Canal University Hospital, Ismailia, Egypt

Abstract

Background data: **Surgical management for sacral fractures is usually recommended in the presence of instability, dislocation, and neurological deficit. Operative approaches can be classified into two primary entities: posterior pelvic fixation approaches and lumbopelvic fixation approaches. Surgical management of sacral fractures is challenging as it may be associated with a broad variety of complications.**

Purpose: **Evaluation of complications of surgical management of sacral fractures and to present our clinical expertise regarding complication avoidance in future cases.**

Study design: **This is a prospective cohort study.**

Patients and methods: **All patients with unstable sacral fractures according to the AO Spine sacral fractures classification system were recruited for this study. All patients underwent an operation at the Neurosurgery Department, Suez Canal University Hospital, through the period from 2016 to 2023. In total, 15 patients underwent stand-alone lumbopelvic fixation, while 30 patients underwent triangular osteosynthesis in the form of lumbopelvic fixation in addition to iliosacral screw. The following data were included in the study: demographic data (age and gender) and mechanism of trauma. Radiological studies included lumbosacral spine X-ray (AP and lateral views), pelvis X-ray (AP, lateral, inlet, and outlet views), and multislice 3D CT—scan lumbosacral spine and pelvis. Types of fractures were categorized according to the AO Spine sacral fractures classification system.**

Results: **A total of 45 cases were included in this study. Moreover, 24 (53.3%) patients were males and 21 (46.7%) were females. The mean age was 29.8 ± 5.3 (range, 18—67). Reported causes of trauma were falls from height in 27 cases (60%), road traffic accidents in 16 cases (35.6%), and falls of hard objects on the pelvis in two cases (4.4%). Reported complications were as follows: superficial wound infection in three patients (6.7%)—two of them underwent conservative management, while the other patient underwent wound debridement. Deep vein thrombosis (DVT) was reported in one patient and managed well with anticoagulation therapy. One patient had pelvic retroperitoneal hematoma postoperative and underwent conservative treatment. One patient underwent revision surgery for a loosened cross-link. Two patients had misdirected iliosacral screws violating the neural canal, with one patient who underwent screw removal.**

Conclusion: **Complications of surgical treatment of sacral fractures were, in general, minor and avoidable. Surgeon awareness of their importance and diversity is mandatory during planning surgery.**

Keywords: Sacral fracture, Complications, Spinopelvic fixation, Triangular osteosynthesis, Iliosacral screw fixation

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* Corresponding author.
E-mail address: heshamhabba@gmail.com (H. Habba).

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Introduction

The sacrum has a crucial role within the posterior pelvic ring, transferring the weight from the spine to the lower limbs [1]. It maintains stability while transmitting forces from the lumbosacral articulation across the sacroiliac joints to the pelvis. The part of the sacrum lower than the S2 vertebra is not necessary for spinal column strength or walking [2].

Sacral fractures are a diverse entity of fractures happening primarily at a young age after road traffic accidents (RTA) and falls from height (FFH). This diversity, in addition to the rarity of sacral fractures compared to other spine fractures, has led to a shortage of familiarity, with these fractures frequently resulting in missed fractures between medical practitioners, which leads to poor management. Adequate awareness of sacral fractures is necessary to identify and treat them properly [3].

Conservative management is dependent on bed rest, analgesics, and early movement as allowed; it commonly takes more time for recovery and may lead to bedridden complications [4]. Operative management to reconstruct and preserve the pelvic ring architecture is essential in unstable fractures to avoid delayed complications such as malunion, nonunion, pain, and neurologic deficit [5]. It is usually recommended in the presence of instability, dislocation, and neurological deficit [3].

Operative approaches can be classified into two primary entities: posterior pelvic fixation approaches and lumbopelvic fixation approaches [6]. Posterior pelvic fixation approaches fix the ilium to the sacrum and can be done either percutaneously or as an open technique. Iliosacral screw fixation is the most frequently utilized percutaneous approach [7]. Lumbopelvic fixation approaches fix the lumbar spine to the ilium [8]. If the lumbopelvic approach is performed with iliosacral screws, it forms triangular osteosynthesis (TO), which is considered the most stable approach for fixation [9].

The surgical management of sacral fractures is challenging as it may be associated with a broad variety of complications, with reported rates of up to 40% of cases in some fracture types. Intraoperative complications include implant malposition, nerve root injury, extensive blood loss in open techniques, vascular injury, and ureteral and bowel injury in rare situations. Postoperative complications include infection, wound healing problems, instrumentation failure, soft tissue irritation requiring implant removal, cerebrospinal fluid leakage, thrombosis, and embolism, which might lead to mortality. Awareness, avoidance, and proper management of these morbidities are essential for optimizing the surgical outcome [3].

The research aims to evaluate complications of surgical management of sacral fractures and present our clinical experience in the avoidance and management of such clinical situations.

Patients and methods

A total of 45 patients were prospectively recruited for this study. All patients underwent operations at the Neurosurgery Department, Suez Canal University Hospital, between 2016 and 2023. All patients with unstable sacral fractures, according to the AO Spine sacral fractures classification system, who underwent operations at our institution, completed at least 12 months of follow-up, and with complete pre- and postoperative follow-up clinical and radiographic data were reported in this study. In total, 15 patients underwent stand-alone lumbopelvic fixation, while thirty patients underwent TO in the form of unilateral or bilateral lumbopelvic fixation augmented with percutaneous iliosacral screw fixation. Patients with major psychiatric illness, pregnancy, general contraindications for surgery, pathological fractures (e.g., osteoporosis and tumors), and lumbosacral transitional vertebrae were excluded from the study.

The following data were included in the study: demographic data (age and sex), mechanism of trauma, comorbidity, and work status. Clinical assessment of reported patients included full neurological evaluation and general evaluation especially associated limb and visceral injuries. The neurological examination also included Gibbons' classification of cauda equina injury.

Radiological studies were comprised of lumbosacral spine X-ray (AP and lateral views), pelvis X-ray (AP, lateral, inlet, and outlet views), and multislice 3D CT–scan lumbosacral spine and pelvis. The type of fractures was categorized according to the AO Spine sacral fractures classification system.

Surgical technique

After optimization of the patient's general condition, all procedures were performed under general anesthesia with patients in a prone position on the radiolucent operating table and monitored with fluoroscopy. In patients with fracture displacement, fracture reduction was corrected by longitudinal traction done by an assistant. In case of rotation of the pelvis, it was corrected with a pin inserted in the posterior iliac bone to correct mal-rotation of the injured hemipelvis (Figs. 1 and 2).

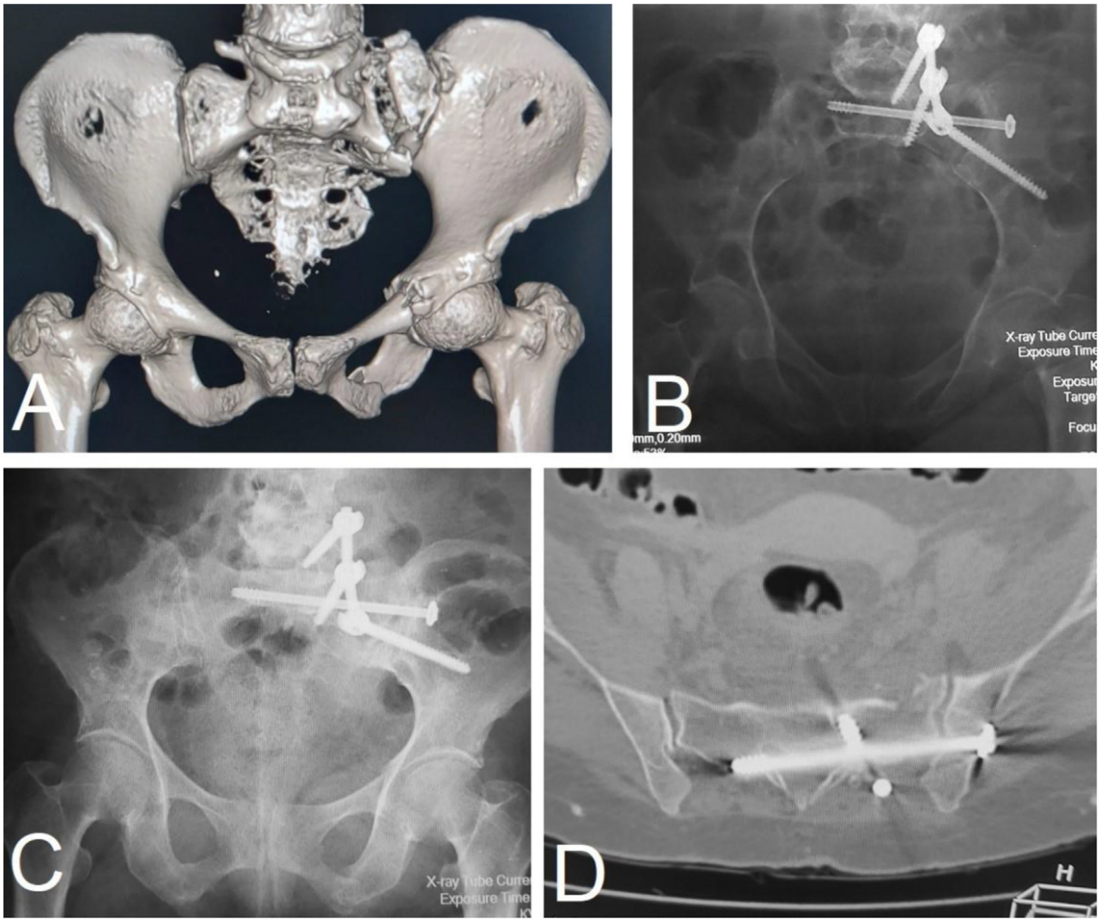

Fig. 1. Images of a 67-year-old female patient (Patient no. 8; Table 2) presented after RTA. She was neurologically intact. (A) Preoperative 3D CT showing left side sacral fracture AO type (B2 N2 M3), (B) immediate postoperative pelvis X-ray inlet view and (C) AP view showing TO, and (D) immediate postoperative MSCT scan axial view showing misdirected iliosacral screw breaching neural canal. The patient underwent screw removal after the failure of conservative therapy.

Iliosacral screw fixation

After the patients' positioning, the entry point for the iliosacral screw was defined by drawing two perpendicular lines: a horizontal line at the level of the greater trochanter and a vertical line at the level of the anterior superior iliac spine (ASIS). The entry point was 2 cm above and caudal to the point of intersection and 1 cm skin incision was made. On the lateral view, the entry point was in the middle of the body of the first sacral vertebra, just below the iliocortical density (ICD) line. On the lateral fluoroscopic view, the tip of the K-wire was positioned on the starting point and impacted into place with a hammer. A pelvic inlet view was done to ensure safe passage of the iliosacral screw within the S1 vertebral body and avoid violation of the spinal canal. Pelvic outlet view helps detect iliosacral screw violation of sacral neural foramina. After checking the adequacy of the trajectory in all views, A power drill was introduced over the K-wire. A measure was introduced over the K-wire to measure the depth for proper screw length. Then, an appropriate length of 7.2 mm cannulated screw was advanced over the guidewire under fluoroscopy. An obturator view was obtained to ensure adequate screw impaction over the iliac bone. The skin was then closed.

Lumbopelvic fixation

The lumbosacral skin incision was made according to the case; in cases with unilateral fracture, an ipsilateral paramedian incision was used, while in cases with bilateral fracture, a midline lumbosacral skin incision was used. The fascia was then opened and subperiosteal dissection of the paraspinal muscle was made to expose the entry point of lumbar screws and the posterior superior iliac spine (PSIS). An appropriate-size polyaxial LV5 pedicle screw was applied under fluoroscopy guidance. The posteromedial aspect of the PSIS was exposed as an entry point for the iliac screw. A screw channel was cannulated in a lateral downwards tilted direction between the inner and outer

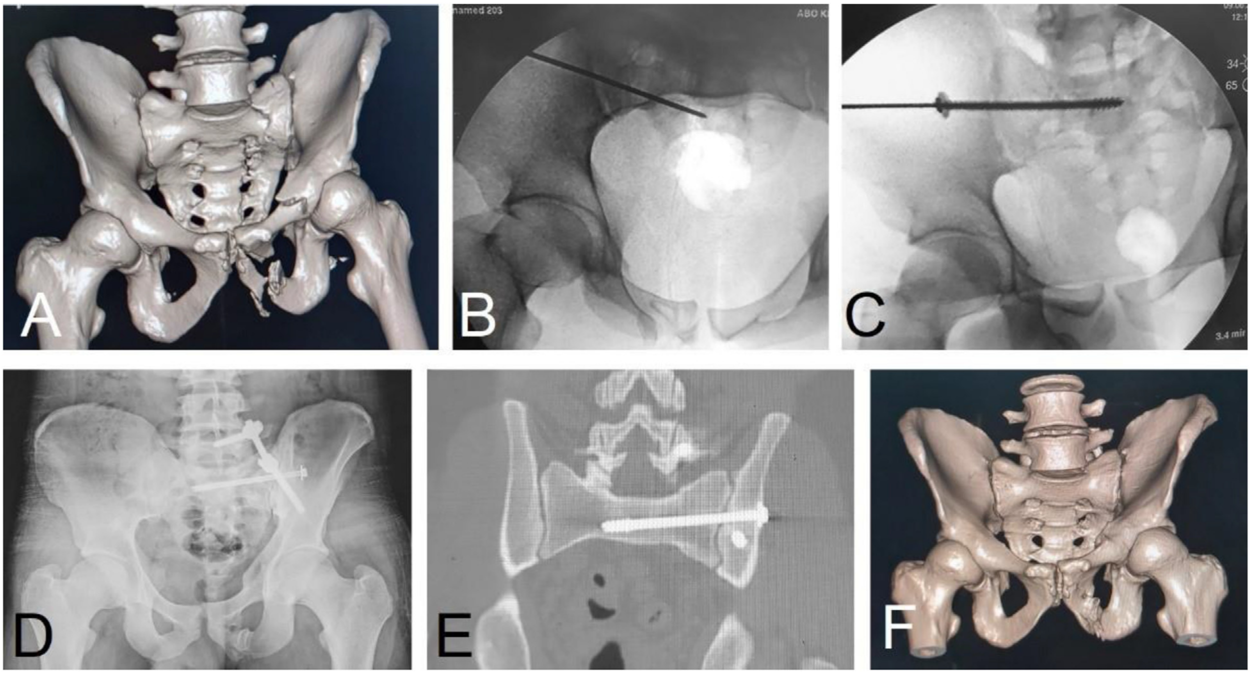

Fig. 2. Images of a 23-year-old male patient (Patient no. 5; Table 2) presented after FFH with weak ankle dorsiflexors and no sphincter affection. (A) Preoperative 3D CT showing left side sacral fractures AO (B3 N3 M3), (B) intraop fluoroscopy image inlet view showing misdirected K-wire into the pelvic cavity, (C) reinsertion of the iliosacral screw after correcting its purchase, (D) one-year postoperative pelvis X-ray AP view showing TO, (E) one-year postoperative MSCT scan coronal view showing adequate iliosacral screw purchase, and (F) one-year postoperative 3D CT scan showing fracture healing. The patient suffered from a postoperative retroperitoneal hematoma that has been treated successfully with monitoring and conservative therapy.

table of the ilium, followed by insertion of the iliac screw above the greater sciatic notch. Screw length is determined based on preoperative imaging measurements and intraoperative probing. Submerging iliac screw heads below the profile of the posterior iliac crest helps decrease screw prominence and hence local pain and pressure sores. A contoured rod of adequate length was applied between the LV5 pedicle screw and iliac screws. After meticulous wound homeostasis, saline irrigation, and insertion of a suction drain, the wound was closed in layers. Intravenous third-generation cephalosporines were used per-operative and 36 h postoperative.

Perioperative data

Operative data were documented, including detailed operative technique, operative time, operative blood loss, operative complications, and hospital stay.

Postoperative follow-up

Immediately postoperative, patients were submitted to full neurologic assessment. Patients were mobilized out of bed 24 h after surgery. Full plain radiographs and MS 3D CT scan of the lumbosacral spine and pelvis were performed to evaluate the adequacy of the construct.

After patients' discharge from the hospital, they were scheduled for routine outpatient clinic follow-up visits at three-month intervals for at least 12 months. At each visit patients were submitted to full clinical and plain radiographic assessments. Clinical parameters included a neurological examination, visual analog scale (VAS) for back pain, Gibbons' classification of cauda equina injury, and Oswestry disability index (ODI), while radiological parameters included lumbosacral spine X-ray (AP and lateral views) and pelvis X-ray (AP, lateral, inlet, and outlet views). Multislice 3D CT—scan lumbosacral spine and pelvis analysis was performed at the six-month follow-up and if there would have been an event that required rescanning.

Fracture healing was documented by the presence of bony trabeculae and callus formation connecting fracture ends and by the maintenance of bony reduction and implant construct.

Results

Of the 52 patients, only 45 patients fulfilled our inclusion criteria and hence were reported in this study. Moreover, 24 (53.3%) patients were males and 21 (46.7%) were females. The mean age was 29.8 ± 5.3 (range, 18–67) years. Reported causes of trauma were FFH in 27 (60%) patients, RTA in 16 (35.6%) patients, and fall of a hard object on the pelvis in two (4.4%) patients. Most reported patients did not have any comorbid diseases; only one patient (2.2%) had hypertension, and two had (4.5%) diabetes (Table 1).

According to AO Spine sacral fractures classification system, 18 (40%) patients were type B2, 10 (22.2%) patients were type B3, four (8.9%) patients were type C0, two (4.5%) patients were type C1, four (8.9%) patients were type C2, and 7 (15.5%) patients were type C3.

Table 1. Summary of perioperative parameters.

Parameters		Results
Age/years		29.8 ± 5.3
Sex	Males	24 (53.3%)
	Females	21 (46.7%)
Type of trauma	FFH	27 (60%)
	RTA	16 (35.6%)
	Fall of hard objects	2 (4.4%)
Gibbon's type		3.14 ± 0.78 (1–4)
AO Spine fracture type	B2	18 (40%)
	B3	10 (22.2%)
	C0	4 (8.9%)
	C1	2 (4.5%)
	C2	4 (8.9%)
	C3	7 (15.5%)
Comorbidities	Hypertension	1 (2.2%)
	Diabetes mellitus	2 (4.5%)
Operative time/min		131 ± 32.4 (90–270)
Operative blood loss/ml		432 ± 150 (100–1000)
Hospital stays/day		10.6 ± 4.7 (5–19)
Follow-up period/month		13.65 ± 4.4 (6–36)

Regarding perioperative data, the mean time between admission and surgery was 7.6 ± 3.2 (range, 3–18) days, the mean operative time was 131 ± 32.4 (range, 90–270) minutes, and the mean operative blood loss was 432 ± 150 (range, 100–1000) ml. The mean hospital stay was 10.6 ± 4.7 (range, 5–19) days and the mean follow-up period was 13.65 ± 4.4 (range, 6–36) months.

The mean VAS of back pain improved from 7.95 ± 1.61 (range, 6–10) preoperatively to 3.3 ± 1.32 (range, 1–5) at the last follow-up (P value < 0.001). Mean preoperative injury type, according to Gibbon's classification, improved from 3.14 ± 0.78 (range, 1–4) preoperative to 1.44 ± 0.65 (range, 1–3) at the last follow-up (P value < 0.001). At the last follow-up, the mean postoperative ODI was 16.04 ± 5.47 (range, 12–24).

Reported perioperative complications in this series of patients were eight complications in eight patients. Reported complications were equally divided among male and female patients, with four patients each suggesting nongender differences. No major complications or perioperative mortality were reported in our study.

Superficial wound infection was reported in three patients (6.7%): two of them underwent conservative management with antibiotics and wound dressings, while the other patient underwent wound debridement followed by insertion of a vacuum drain for 14 days. All three patients with wound infection were from the group who underwent bilateral lumbopelvic fixation with a midline approach.

DVT was reported in one patient and managed well with stocking and anticoagulation therapy. One

Table 2. Summary of reported complications in this study (n = 8/45).

No.	Age/sex	Gibbon's type	Technique	Time to surgery/day	Morbidity	Management	Outcome
1	23/F	1	Bilateral lumbopelvic	10	Wound infection	Antibiotics and wound dressings	Wound healing
2	43/M	2	Bilateral lumbopelvic	5	Wound infection	Antibiotics and wound dressings	Wound healing
3	30/F	2	Bilateral lumbopelvic	9	Wound infection	wound debridement and vacuum drain	Wound healing
4	40/F	1	Bilateral lumbopelvic	7	DVT	Anticoagulant therapy	Resolved
5	23/M	1	Unilateral TO	3	Pelvic retroperitoneal hematoma	IV fluids and blood transfusion	Conservative therapy under monitoring
6	29/M	2	Bilateral lumbopelvic	5	Loosened cross-link	Revision for construct tightening	Stable implant
7	25/M[a]	3	Bilateral triangular osteosynthesis	7	Misdirected iliosacral screw	Medical treatment	Pain resolved
8	67/F	1	Unilateral TO	6	Misdirected iliosacral screw	Revision for screw removal	Pain resolved

[a] Patient no. 7 underwent bilateral triangular osteosynthesis, i.e., bilateral lumbopelvic fixation through midline skin incision and bilateral iliosacral screw.

patient had pelvic retroperitoneal hematoma postoperative that was not evident on preoperative imaging, primarily due to a misdirected K-wire violating the anterior border of the sacrum, leading to injury of the presacral venous plexus. The patient had hypovolemic shock immediately postop, which led to the discovery of the condition. Maximum hematoma diameters were 10 cm, 8 cm, and 6 cm. The patient was managed conservatively and was kept in hospital for six days postoperatively. Multiple follow-up pelviabdominal ultrasounds and CT scans were performed and the patient received IV fluids and packed RBCs.

One patient underwent revision surgery for a loosened cross-link while still in the hospital. No implant breakage or backout was reported during the follow-up period. Two patients had misdirected iliosacral screws violating the neural canal that did not result in added motor deficit but led to added sensory affection. One patient underwent revision surgery to remove the iliosacral screw after three months due to the failure of a conservative treatment to control pain which improved after screw removal. In the other patient, the pain was responsive to medical treatment, and no revision surgery was needed.

Discussion

A total of 45 patients were included in this study: 28 cases were type B and 17 cases were type C according to AO Spine sacral fractures classification system. In total, 15 cases underwent stand-alone lumbopelvic fixation, while 30 cases underwent TO. Reported complications included wound infection, vascular injury, DVT, and implant malpositioning.

In this study, three cases developed surgical site infection, which was primarily in the early cases. One case required wound debridement. All these cases occurred during lumbopelvic fixation with midline skin incision, which led to a large surgical field, excessive muscle mobilization, more tissue devitalization, and muscle injury, resulting in deep hematoma formation and infection.

One of the causes of infection in our cases was excessive usage of electrocautery (monopolar). In the later cases, we relied mainly on sharp dissection techniques using a scalpel, scissors, and bipolar cautery for hemostasis. Overusage of monopolar diathermy leads to more tissue necrosis and more exudate formation, resulting in increased seroma formation and infection. Hak et al. reported the same finding that more soft tissue trauma increases the risk of infection. Although the association between increased usage of electrocautery and infection rates is quite rare in spine surgery, it is well established in many other surgical specialties [10].

We did not encounter any wound infection or wound healing problems in cases of unilateral sacral fractures that were managed by unilateral TO. This was due to the following reasons: the iliosacral screw is percutaneously applied through a small skin incision and the lumbopelvic system is applied through a paramedian skin incision which results in less tissue devitalization and less muscle injury. Another technical detail that helps reduce local pain and pressure sores is submerging the iliac screw head below the profile of the iliac crest.

Morel-Lavallée lesion is a type of soft tissue damage associated with severe pelvic injury in which the subcutaneous tissue is peeled away from the underlying fascia, forming a hematoma and seroma-filled cavity. In addition to leading to more infection rates, the growing hematoma may affect skin vascularity. A study of 24 patients by Hak et al. about Morel-Lavallée in pelvic fractures reported that lumbosacral and flank areas are the most frequently affected sites [10].

Although we did not encounter any cases of Morel-Lavallée lesions in our series, operative site soft tissue edema and muscular hematomas were present in some cases.

In this series, one case had postoperative DVT and was treated with anticoagulants. Generally speaking, the risk of thromboembolism is increased among trauma patients. It was reported that there is a 40% incidence of DVT and a more than 1% incidence of fatal pulmonary embolism in cases with an acute brain or spine injury [11].

Other complications included retroperitoneal hematoma in one patient, primarily due to misdirected K-wire during iliosacral screw insertion that we discovered and redirected intraoperatively, and two patients with misdirected iliosacral screw breaching neural canal with one patient of them undergoing another surgery for iliosacral screw removal after three months.

Schildhauer et al., in their study about TO on 48 cases, had one case of pulmonary embolism that resulted in mortality, three cases with pressure sores due to inadequate submergence of iliac screw head requiring revision surgery, and wound infection in three cases that failed conservative treatment and underwent implant removal [12]. In a study by Jindal et al. that evaluated surgical treatment of sacral fractures in 22 patients, three patients with wound infection were reported, with one patient failing medical treatment and underwent revision surgery for debridement and another two patients with connecting rod backout [13]. Hu et al., in their series of 22 cases, reported two patients with postoperative wound infection who responded successfully to medical treatment [14]. In another study by Mouhsine et al., one case of wound infection was reported out of seven cases. The case underwent revision surgery for implant removal after the failure of medical management [15].

Erkan et al. evaluated the outcome of TO and reported wound infection in 26.3% of cases. This was attributed to utilizing a midline skin incision with a large surgical field, leading to more muscle mobilization and tissue devitalization. They also found that wound healing issues have a higher rate among cases with extensive soft tissue injury [16].

In a systematic review by Protas et al. that reported complications of iliosacral screw fixation and included 1369 cases, the most frequently encountered complication was implant-related complications, including screw malposition which was detected in 55 cases (4%) and fracture nonunion in nine cases (0.66%), screw breakage in eight cases (0.58%), wound infection in eight (0.58%) cases, and thromboembolism including DVT and pulmonary embolism in four cases (0.29%). The study reported a higher incidence of complications among less experienced surgeons and emphasized that understanding not only normal anatomy but also all variants is crucial [17].

High-quality fluoroscopy is essential in inserting an iliosacral screw, which may be compromised by some factors such as obesity, bowel gas, intestinal discharge, a dysplastic pelvis, and inadequate equipment. CT guidance may be helpful in morbidly obese patients. Unfortunately, it is not present in every hospital [18–20].

Bellabarba et al. studied complications associated with surgical stabilization of sacral fractures that included 19 patients. Eight cases (42%) required revision surgery due to wound healing problems and/or implant failure due to fracture of the rod between lumbar screws and iliac screws. They reported that a lack of sacroiliac joint arthrodesis may increase the incidence of eventual fatigue failure of the rods, leading to breakage [21].

The limitations of this study are the short-term follow-up period and the small size of its population which is why a long-term follow-up multicenter study is our next policy. The recommendations of the current research to surgeons are as follows: Try to perform a paramedian skin incision if feasible and rely on sharp dissection and bipolar cauterization more than monopolar cautery and adequate submergence of the iliac screw head. Consider measures for prophylaxis against venous thromboembolism according to each individual risk factor. Intraoperative high-quality image guidance is crucial. Iliosacral screw allows for fracture stabilization in the horizontal plane and decreases the strain on rods, which reduces the incidence of rod breakage.

Conclusion

Complications of surgical treatment of sacral fractures are, in general, minor and avoidable. Surgeon awareness of their importance and diversity is mandatory during planning surgery.

Ethics information

The article does not contain information about medical device(s)/drug(s).

Author declaration of funding statement

No funds were received in support of this work.

Conflict of interest

The authors report no conflicts of interest.

List of abbreviations

RTA	Road traffic accidents
FFH	Falls from height
TO	Triangular osteosynthesis
ASIS	Anterior superior iliac spine
ICD	Iliocortical density
PSIS	Posterior superior iliac spine
LV	Lumbar vertebrae
MSCT	Multislice computed tomography
VAS	Visual analog scale
ODI	Oswestry disability index
DVT	Deep venous thrombosis

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