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Posterior tension band plate osteosynthesis for unstable sacral fractures: A preliminary study

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ABSTRACT

Introduction: Stable reduction and rigid fixation of the sacrum and posterior ring structures are of paramount importance in the management of complex pelvic ring disruptions, Tile B and C. The major concern with the use of conventional methods, like iliosacral screws and iliolumbar fixations is the increased risk for surgical and implant-related morbidity, especially in difficult situations, such as comminuted, bilateral sacral fractures, and fractures in the dysmorphic sacrum. Although various biomechanical studies have reported the posterior trans-iliac plates to provide maximum resistance to distracting forces by the principle of tension band, the literature pertaining to this implication in clinical studies has been limited. The purpose of our study was to assess the efficacy of the trans-iliac plate in the management of unstable sacral fractures and its utility in pelvic disruptions associated with surgical site morbidity.

Methodology: The patients with unstable pelvic fractures (Tile B and C) between 2013 and 2017 were retrospectively analyzed at a trauma center. First, the anterior ring disruptions were stabilized, and then, the sacral fractures (Denis Zone 1–3) treated by posterior tension band plate osteosynthesis (3.5 mm reconstruction plate) were included. Demographic and perioperative data were assessed. The outcome variables studied were surgical morbidity, pain, loss of reduction, and union and implant-related complications. The outcomes were graded using Lindhal's (radiological) and Majeed (functional assessment) scores.

Results: Thirteen patients (nine male/four female) with a median age of 42 years, had sacral fractures in Denis zones 1/2/3 (four/ten/one, respectively), resulting from Tile pelvic injury B and C were included. The pelvis in five patients was stabilized only with the posterior plate due to the anteriorly-associated surgical site morbidity (Morel-Lavallee lesions and urinary tract injuries). The mean follow-up was 21.5 ± 2.8 months. All fractures had a radiological union by 22 weeks; Lindhal's grade A in ten patients and grade B in three patients. Two out of three patients recovered from preoperative neurological involvement. Two had complained of implant prominence (BMI<19 kg/m^2) and there were no implant failures. Four had excellent, six had good, and three had fair or poor functional outcomes.

Conclusion: The posterior trans-iliac plate is a minimally invasive and safe procedure that can be used in a wide range of unstable sacral fractures with notably less implant failure rate. The rigid posterior construct restores the principle tension between the iliac blades and minimizes the secondary displacement of the anterior disrupted structures, thereby useful in managing ring disruptions with surgical site morbidity.

1. Introduction

Sacral fractures causing posterior pelvic ring disruptions result in a rotationally or vertically unstable pelvis.[1] The management of sacral fractures is often challenging due to the high degree of associated injuries and variations in the fracture geometry.[1]It is a potential indicator for severity of injury, mortality, and morbidity. Restoring the stability, alignment of the disrupted pelvic ring and maintaining the achieved reduction during their habilitation phase

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is of paramount importance to prevent long term morbidity.[2]

Various methods like iliosacral screws, trans-iliac bars, iliolumbar fixations, sacral plates are being used.[3,4] However, these methods have limitations in comminuted and irreducible fractures, fractures involving multiple zones, and dysmorphic sacrum.[5–7] The surgical morbidity and implant failure rates are also varied.[8] As assessed from the biomechanical studies, considering a fixation modality that restores the tension band effect of the osseoligamentous structures that make the posterior pelvic ring is essential for maintaining the reduction and preventing implant failures.[8,9]

To overcome the drawbacks and limitations, other methods for managing unstable sacral fractures, like the posterior trans-iliac plates have been in use.[10] Also, there is limited consensus in the management of the anterior ring disruptions, especially with the associated surgical site morbidity (urinary tract involvement and Morel-Lavallee lesions).[11] Although certain authors recommend a stable posterior construct for the anterior ring disruptions, there is little evidence regarding the use of trans-iliac plates for the same.[12] Hence, the purpose of our study was to report the complications and outcomes with the usage of posterior tension band plates for the management of sacral fractures resulting from unstable pelvic ring disruptions and also study its utility in the management of the anterior ring disruptions associated with surgical site morbidity.

2. Materials and methods

This study was conducted in a single center after obtaining the institutional clearance. We retrospectively analyzed a series of patients with unstable sacral fractures treated operatively with posterior tension band plate between 2013 and 2017. Comminuted and displaced sacral fractures (Denis classification) associated with vertical or horizontal instability of pelvis, bilateral sacral fractures, and fractures in a dysmorphic sacrum were considered for the posterior trans-iliac plating.

Operative procedure: The anterior ring disruptions were first stabilized with open reduction and internal fixation with plates and screws, except in selective situations where fixation was hampered due to surgical site morbidity (Morel- Lavellee lesions and bladder, or urethral disruptions). The procedure was done in the prone position with two curvilinear incisions made lateral to the posterior-superior iliac spine (PSIS) (Fig. 1A). The gluteus maximus fascia incised along the line of skin incision and maximus reflected from the posterior iliac wing. An interval was created beneath the PSIS using a long hemostat. A 3.5 mm reconstruction plate was under-contoured or over-contoured according to the fracture pattern (distraction vs compression, respectively) with the average angle of 65–75°. The reduction and plate position were assessed under image intensifier with anterio-posterior, inlet and outlet views (Fig. 1B, C and D). Cortical and cancellous screws were applied alternatively and screw threads advanced simultaneously on both sides in order to maintain tension symmetrically.

The patients were allowed to sit and turn in their bed without support, according to pain tolerance. The decision to allow weight-bearing was based on the associated injuries. The patients were followed up at 6 weeks, 3–4 months, 8–11months, and after 18 months with anterio-posterior (AP), inlet, and outlet view radiographs of the pelvis (Fig. 2A–C). The outcomes were evaluated radiologically (Lindhal's grading) by assessing the reduction parameters till union and functional assessment with Majeed scores.

3. Results

We had thirteen patients (nine male and four female) between the ages of 21–65 years (median- 42 years). Motor vehicle accident (pedestrian vs four wheeler) was the most common mode of injury in our cohort. Eight patients had Tile pelvic injury pattern type C, four had pattern B, and one had ipsilateral transverse fracture of the acetabulum. With regard to Denis pattern of sacral fractures, there were ten fracture lines in zone 2, four in zone 1 and one in zone 3 (Table 1).

Eighty two percent of our patients had associated injuries, such as chest injury (50%), abdominal injury (25%), head injury (32%), long bone fractures (30%), spine factures, and calcaneum and clavicle (four patients). Complications related to fracture, injury, and immobilization were encountered in 65% of the patients. Two patients had Morel-Lavallee lesions in the anterior side, which was treated by debridement and dead space obliteration; three patients had foot drop, urethral rupture was seen in two and bladder injury in one patient for which anterior fixation was withheld and managed accordingly by urologists. Fat embolism was observed in two patients and was adequately managed.

The mean follow up was 21.5±2.8 months. All fractures had radiological union by 22 weeks (Lindhal's grade A in ten patients and grade B in three patients). We had vertical displacement of < 10 mm in one patient, however the fracture united uneventfully. Two patients had recovery of foot drop by twenty four weeks. One did not recover and opted for functional rehabilitation. Three patients had bed sores, which was managed by serial debridement and dressings. Two patients had complaints of implant prominence (body mass index <19 kg/m^2). However, we did not encounter any implant breakage or screw back out in our cohort of patients. The functional outcomes were assessed by the Majeed scoring system. Four patients showed excellent results, six had good, and three patients exhibited fair or poor results (Table 2).

4. Discussion

The management of sacral fractures poses significant challenges for orthopaedicians in various aspects.[1] High degree of associated injuries, high variation in the fracture geometry and sacral anatomy, fracture related complications, and propensity for long term morbidity in inadequately managed fractures are the serious concerns while managing unstable pelvic injuries with comminuted and displaced sacral fractures.[2] Accurate reduction, maintaining stability, and early rehabilitation are of paramount importance to improve the quality of life.[4]

In a severely traumatized patient, stabilizing these sacral fractures by a modality that has minimal surgically site morbid, least neurovascular injuries and ability to maintain reduction through the rehabilitation phase are the main considerations.[2] Routt et al. in their experience with 137 patients with sacral fractures managed by percutaneous iliosacral screws explained that though it is an easily replicable and commonly used method, the usage in irreducible, highly comminuted and bilateral sacral fractures and fractures with dysmorphic sacrum led to higher neurovascular complications.[13] Sacral plates, trans-iliac bars, iliolumbar fixations, and iliosacral screws do have demerits in such fractures, like surgical site morbidity, entrapment neuropathy, loss of reduction, implant prominence, and painful hardware.[3–5] There is lacunae in clinical evidence on the usage of percutaneous posterior trans-iliac plates across various geometrical patterns of pelvic ring fractures.

The management of pelvic fractures associated with urological injuries has been controversial. Very high infection rates, urosepsis, the possibility of multiple urological procedures are major concerns that impede internal fixation.[11] These drawbacks have led to varied clinical practices, and there is no universally agreed approach for the management of anterior ring disruptions associated with urinary tract involvement.[11] According to Matta et al., in a series of 127 pelvic fractures, eighty-eight patients among 105 anterior ring disruptions did not have any mode of anterior fixation, and none of

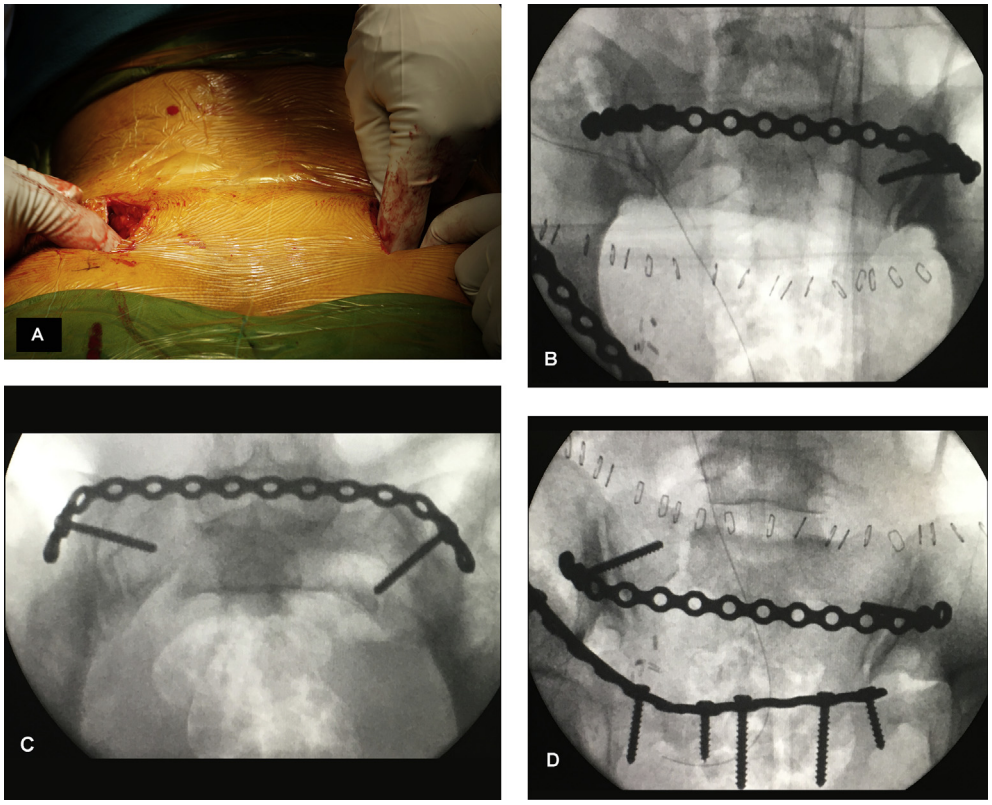

Fig. 1. Deployment of the posterior trans-iliac plate. Under GA and in prone position. Two curvilinear incisions made lateral to PSIS. Fascia incised in line with skin incision and gluteus maximus reflected from the posterior ilium on both sides (A).The contoured 3.5 mm reconstruction plate was passed beneath the PSIS and position confirmed under image intensifier with AP (B), inlet (C) and outlet (D) views. Screws were advanced simultaneously on both sides to maintain tension symmetrically.

Fig. 2. Management of a 23-year male, polytrauma with Tile pelvic injury type C1 and bilateral comminuted sacral fractures. (A) 3D reconstruction film of pelvis demonstrating the geometry of the fracture pattern in pelvis. (B) Post operative radiograph with the pelvis stabilized both anteriorly and posteriorly. (C) At 20 months follow up, sacral and pubic rami fractures are well united (Lindhal's grade A), without loss of reduction or any implant failures.

Table 1
Demographic and Perioperative parameters of the patients included in this study.

Sl. No.	Age/ sex	Mode of injury	Associated injuries	Pelvic # (Tile)	Denis zones	Complications	Surgical Method
1	23/M	Fall from height	# calcaneum (R) #lumbar vertebra 2	C2	2 (R)	-	Anterior pelvis stabilization and one posterior transiliac plate.
2	21/M	MVA	# shaft femur (R) # both bone leg (R)	C3 acetabulum (R)	2 (R) 1 (L)	Foot drop (L), FES Bed sores and Anterior moral lavalle lesion	Acetabulum stabilization and two posterior transiliac plates.
3	49/M	MVA	# clavicle (R) # multiple ribs (R)	B2	1 (L)	Anterior moral lavalle lesion	Only posterior stabilization with one transiliac plate.
4	45/M	MVA	# multiple ribs (B/L) #lumbar vertebrae 1, 2. Head injury.	C2	1 (R) (dysmorphic sacrum)	-	Anterior pelvis stabilization and two posterior transiliac plates.
5	43/F	Roll over injury	Head injury, #humerus (L) #both bone forearm (L)	B3	2 (L)	Bed sores	Anterior pelvis stabilization and one posterior transiliac plate.
6	30/M	Fall from height	# multiple ribs (L) Spleenic injury.	B1	2 (R)	Urethral injury	Only posterior stabilization with one transiliac plate.
7	63/M	MVA	Head injury #clavicle (R)	C2	1 (L) (dysmorphic sacrum)	Foot drop (L)	Anterior pelvis stabilization and one posterior transiliac plate.
8	28/M	Fall from height	# calcaneum (L) #both bone leg (R)	C2	2 (R)	Urethral injury	Only posterior stabilization with one transiliac plate.
9	33/F	MVA	# multiple ribs (L) Splenic injury.	C3	2 (R) 2 (L)	Foot drop (R)	Anterior pelvis stabilization and one posterior transiliac plate.
10	54/M	MVA	# multiple ribs (B/L) Renal injury # shaft femur	B3	2 (R) (dysmorphic sacrum)	Bed sores Pulmonary embolism	Anterior pelvis stabilization and one posterior transiliac plate.
11	38/F	MVA	#proximal humerus (L) Head injury	C1	3	Bladder rupture	Only posterior stabilization with two transiliac plates.
12	68/F	Fall from height	-	#acetabulum (R)	2 (R)	DVT	Acetabulum stabilization and one posterior transiliac plate.
13	26/M	MVA	# multiple ribs (R)	C1	2 (R)	-	Anterior pelvis stabilization and one posterior transiliac plate.

MVA- motor vehicle accident, (L)- left side, (R)- right side, DVT- deep vein thrombosis, #- fracture.

Table 2
Radiological and functional outcomes following tension band plate osteosynthesis for sacral fractures.

Sl. No.	Age/ sex	Pelvic fracture (Tile)	Sacral fracture (Denis zones)	Radiological union (weeks) and [Lindhal's grade]	Follow up (months)	Majeed scores. (final follow up)	Majeed outcomes	Comments
1	23/M	C2	2 (R)	20 [A]	23	92	excellent	-
2	21/M	C3 acetabulum (R)	2 (R) 1 (L)	22 [A]	26	56	fair	Plate prominence. Ankle dorsiflexion power 4/5 at 5 months
3	49/M	B2	1 (L)	20 [A]	25	94	excellent	-
4	45/M	C2	1 (R)	18 [A]	20	72	good	-
5	43/F	B3	2 (L)	22 [B]	18	76	good	-
6	30/M	B1	2 (R)	18 [A]	22	72	good	Plate prominence
7	63/M	C2	1 (L)	16 [A]	20	51[a]	fair	Ankle dorsiflexion power remained 2/5.
8	28/M	C2	2 (R)	18 [A]	26	60	fair	-
9	33/F	C3	2 (R) 2 (L)	20 [B]	22	74	good	Ankle dorsiflexion power 4/5 at 14 weeks.
10	54/M	B3	2 (R)	16 [B]	20	88	excellent	Loss of reduction <8mm. uneventful at union
11	38/F	C1	3	17 [A]	18	86	Excellent	-
12	68/F	#acetabulum (R)	2 (R)	18 [A]	20	80	Good	-
13	26/M	C1	2 (R)	16 [A]	19	84	Good	-

[a] - not working before injury.

them had non-union or significant loss of reduction following a stable posterior fixation (iliosacral screws or sacral plates).[14] Various biomechanical studies suggest that the trans-iliac plates provide a more superior construct than the iliosacral screws and restores the tension effect between the iliac blades, thereby preventing anterior implant failures and secondary loss of reduction.[9,12,15] In our study, we did not perform anterior fixations in five patients (two had anterior Morel-Lavellee, two had posterior urethral ruptures, and one had extra peritoneal bladder rupture), which was managed with posterior-trans iliac plating alone (Figs. 3 and 4). Although displacements of 8 mm were noted in cases of bilateral pubic rami, all had union and none had posterior implant failures.

Nerve injuries are of major concern in sacral fractures.[1] Literature reports have varied between 27.3 and 64.4% and more in comminuted fractures due to the involvement of L5 (most common) to S3 roots, and present as foot drop, bowel, and bladder incontinence, sacral anesthesia, and sexual dysfunction.[1,4] By far

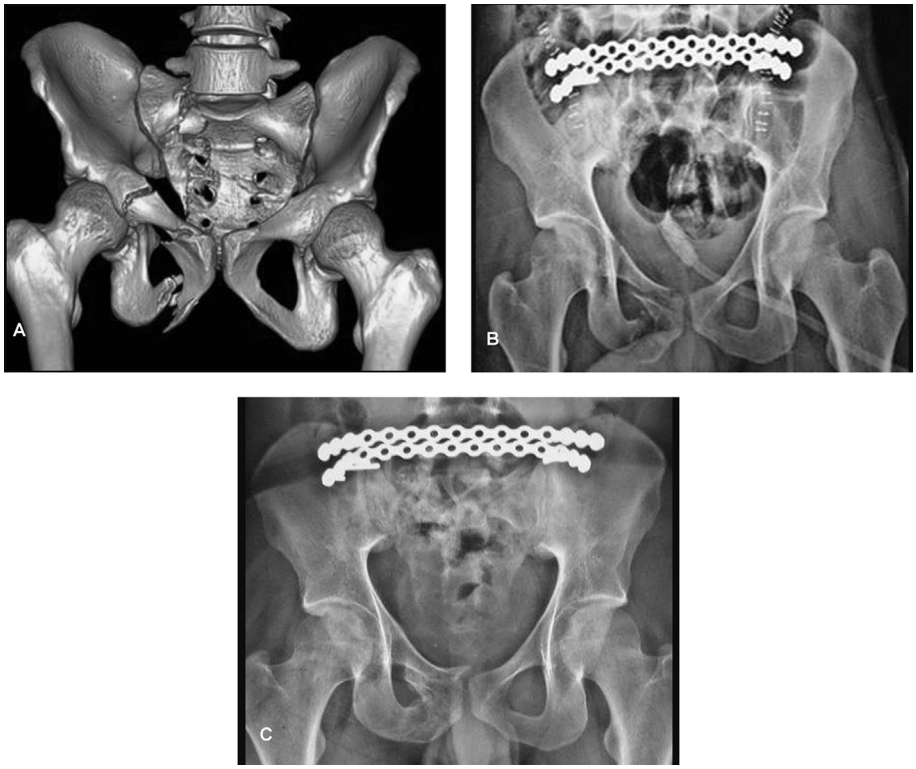

Fig. 3. Management of an unstable pelvis fracture Tile C with associated anterior Morel-lavallee lesion and extra peritoneal bladder rupture in a 42-year male. (A) 3D reconstruction film of pelvis showing comminuted and displaced pubic rami fractures (Right) and ipsilateral zone 2 sacral fracture with comminution. (B) Post operative radiograph shows a stable posterior construct using two percutaneous trans-iliac plates with alignment of anterior ring. (C) At 18 months follow up- sacrum united (Lindhal's grade A). Although, minimal loss of 8 mm was noted, the pubic rami united well without any implant failures.

Fig. 4. Utility of a stable posterior construct with trans-iliac plate in the management of pelvic fracture associated with posterior urethral tear. The patient had multiple urological procedures following stabilization of pelvis. (A) 3D reconstruction film of pelvis – zone 2 sacral fracture with bilateral pubic rami fracture. (B) Post operative radiograph with the pelvis stabilized with posterior fixation alone. (C) At 22 months follow up, sacral and pubic rami fractures well united (Lindhal's grade A).

the most common mechanism of injury to nerve is praxia caused by traction of the displaced fragments (80%) or direct compression by fragments in sacral impaction. Nerve lacerations and root avulsions are infrequent (less than 2%).[3,16] Neurological recovery rate has remained varied (27–93%) irrespective of the method of decompression.[4,17] In this regard, Taguchi et al. in their management of sacral fractures with nerve injuries explained that neurological recovery depended on the degree of posterior ring realignment and reduction, and an open decompressive procedure may be required only in irreducible cases with greater than 1 cm displacement.[18] In our study, we had three patients with neurological impairment. Two were due to displacement of fragments and one had impaction. Disimpaction of the fragments was done using indirect decompression, wherein the bent posterior trans-iliac plate is seated 5 mm off the iliac blade and disintegration of impacted fragments occurred on the application of the cortical screws.[10] Two patients had neurological recovery by 24 weeks; however one patient with foot drop did not recover and opted for functional rehabilitation. Suzuki et al. in a similar study with 18 patients experienced complete or partial recovery in 7 patients by 32 weeks. However, three did not show any sign of recovery in their mean follow up of 26 months despite surgical decompression.[3]

Implant-related complications using other modalities have always varied and higher rates were reported in comminuted and bilateral sacral fractures. Krapinger et al. in a similar study with 23 patients using 4.5 mm recon plates experienced implant prominence in four patients, loss of reduction to maximum of 10 mm in two patients, breakage of plates in two patients, and screw in one patient in their mean follow up of 20 months.[10] However, in our study using 3.5 mm recon plates, except for the subcutaneous hardware prominence in two patients (BMI<19 kg/m^2), we did not encounter any screw back out or implant breakage in our follow up ranging 20–32 months. We recommend additional plates in obese patients, bilateral fractures, and in fractures where the anterior pelvic ring was not stabilized.

The various complications reported in patients with pelvic ring disruptions include heterotopic ossification, infections, deep vein thrombosis, bedsores, and recurrent urinary tract infections.[3,4,10] In our cohort, bedsores were noted in 3 patients that healed in rehabilitation phase; deep vein thrombosis was noted in two patients. Although all the fractures united radiologically and clinically, the functional outcomes as assessed by Majeed scores in our study have varied with other studies considering dissimilar fracture patterns and varied injuries.[4,10] As with the other studies using Majeed scores, the radiological and functional outcomes did not have significant correlation.[4]

5. Conclusion

The use of the posterior trans-iliac tension band plate for unstable sacral fractures is a safe, minimally invasive procedure with less operative complications and radiation exposure. It can provide a more rigid fixation in a wide range of conditions that are limited by other techniques, like highly comminuted, bilateral, dysmorphic sacrum and obese patients. It provides a stable posterior construct and restores the tension in the osseoligamentous structures of the posterior pelvic ring and iliac blades and thereby limits anterior implant failures and loss of reduction, an implication useful in managing ring disruptions with anterior surgical site morbidity.

Contributions

Performed all the surgeries, follow up, manuscript editing and guidance.

Assisted, took to data collection and analysis, manuscript preparation.

Assisted in surgeries, follow up and data collection.

Assisted in surgeries, follow up and data collection.

Assisted in surgeries, follow up and data collection.

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Conflicts of interest

None.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jcot.2019.05.017.

References

1. Denis F. Sacral fractures: an important problem. Retrospective analysis of 236 cases. *Clin Orthop Relat Res*. 1988;227:67–81.
2. Adelved A, Totterman A, Glott T, Madsen JE, Roise O. Functional outcome 10 years after surgical treatment of displaced sacral fractures. *Spine*. 2012;37:E1009–E1016.
3. Suzuki T, Hak DJ, Ziran BH, et al. Outcome and complications of posterior transiliac plating for vertically unstable Sacral fractures. *Injury*. 2009;40:405–409.
4. Ayoub AM. Vertically unstable sacral fractures with neurological insult: outcomes of surgical decompression and reconstruction plate internal fixation. *Int Orthop*. 2009;33:261–267.
5. Sagi HC, Lindvall EM. Inadvertent intraforaminal Iliosacral screw placement despite apparent appropriate positioning on intraoperative fluoroscopy. *J Orthop Trauma*. 2005;19:130–133.
6. van Zwienen CM, van den Bosch EW, Hoek van Dijke GA, Snijders CJ, van Vugt AB. Cyclic loading of sacroiliac screws in Tile C pelvic fractures. *J Trauma*. 2005;58:1029–1034.
7. Vanderschot P, Meuleman C, Lefèvre A, Broosa P. Trans iliac–sacral–iliac bar stabilisation to treat bilateral lesions of the sacro–iliac joint or sacrum: anatomical considerations and clinical experience. *Injury*. 2001;32:587–592.
8. Pohlemann T, Angst M, Schneider E, Ganz R, Tscherne H. Biomechanical analysis of fixation of transforaminal sacral fractures. *J Orthop Trauma*. 1993;7:107–112.
9. Comstock CP, van der Meulen MCH, Goodman SB. Biomechanical comparison of posterior internal fixation techniques for unstable pelvic fractures. *J Orthop Trauma*. 1996;10:517–522.
10. Krappinger D, Larndorfer R, Struve P, Rosenberger R, Arora R, Blauth M. Minimally invasive transiliac plate osteosynthesis for type C injuries of the pelvic ring: a clinical and radiological follow-up. *J Orthop Trauma*. 2007;21:595–602.
11. Marecek GS, Scolaro JA. Anterior pelvic ring: introduction to evaluation and management. *J Orthop Trauma*. 2018 Sep;32(Suppl 6):S1–S3.
12. Avilucea FR, Whiting PS, Mir H. Posterior fixation of APC-2 pelvic ring injuries decreases rates of anterior plate failure and malunion. *J. Bone Joint Surg. Am.* 2016 Jun 1;98(11):944–951.
13. Routt Jr ML, Simonian PT, Mills WJ. Iliosacral screw fixation: early complications of the percutaneous technique. *J Orthop Trauma*. 1997;11:584–589.
14. Matta JM. Indications for anterior fixation of pelvic fractures. *Clin Orthop Relat Res*. 1996 Aug;(329):88–96.
15. Berber O, Amis AA, Day AC. Biomechanical testing of a concept of posterior pelvic reconstruction in rotationally and vertically unstable fractures. *J. Bone Joint Surg. Br.* 2011;93:237–244.
16. Bodkin PA, Choksey MS. Management of a sacral fracture with neurological injury. *J Orthop Sci*. 2006;11:524–528.
17. Zelle BA, Gruen GS, Hunt T, Speth SR. Sacral fractures with neurological injury: is early decompression beneficial? *Int Orthop*. 2004;28:244–251.
18. Taguchi T, Kawai S, Kaneko K, Yugue D. Operative management of displaced fractures of the sacrum. *J Orthop Sci*. 1999;4:347–352.