International Orthopaedics (SICOT) (2005) 29: 333–337
DOI 10.1007/s00264-005-0678-y

ORIGINAL PAPER

**Ahmet Harma · Muharrem Inan**

# Surgical management of transforaminal sacral fractures

Received: 19 March 2005 / Accepted: 9 May 2005 / Published online: 27 July 2005


**Abstract** Fourteen patients with transforaminal sacral fractures were treated with posterior iliosacral instrumentation. Patients were assessed in terms of surgical technique and functional results. A subjective functional scoring with a five-point scale was performed at the last follow-up. Activity pain, pain at rest, limping and patient satisfaction were evaluated. By considering symptom and satisfaction scores, subjective functional assessment revealed that ten patients had excellent results, two good and two moderate. There were no patients with poor functional outcome. The surgical technique is not a new concept. Combining sacral bar and pediculo-iliac fixation methods, provides vertical as well as horizontal stability and allows early weight bearing, the methods has many advantages. However, vertical and horizontal stabilities achieved by this technique may require further assessment with comparative biomechanical studies.

**Résumé** Quatorze malades avec des fractures sacrées transforaminales ont été traités avec une instrumentation iliosacrée postérieure. Les malades ont été étudiés en fonction de la technique chirurgicale, et des résultats fonctionnels. Une échelle fonctionnelle subjective à 5 points a été utilisée au dernier examen. La douleur à l'activité et au repos, la boiterie et la satisfaction des patients ont été évalué. En considérant les symptômes et le score fonctionnel, 10 patients avaient un résultat excellent, 2 un bon résultat et 2 un résultat moyen. Il n'y avait aucun mauvais résultat. La technique chirurgicale n'est pas un nouveau concept. En combinant une barre sacrée et les méthodes de fixation pédiculaires , la stabilité horizontale aussi bien que verticale est obtenue, et une remise en charge précoce est possible. Cependant, les stabilités verticales et horizontales obtenues par cette technique peuvent exiger une appréciation supplémentaire avec des études biomécaniques comparatives.

A. Harma · M. Inan
Department of Orthopaedics and Traumatology,
Turgut Ozal Medical Center,
Inonu University,
Malatya, Turkey

A. Harma (✉)
P.K. 213,
44100 Malatya, Turkey
e-mail: harma@atlas.net.tr
Tel.: +90-422-3410660
Fax: +90-422-3260517

## Introduction

Unstable pelvic fractures, nearly always a result of high-energy injuries, are frequently associated with sacral fractures [1, 8]. Sacral fractures are usually difficult to recognise on routine X-ray films due to the sacrum's anatomical features [4, 11, 12]. Sacral fractures are often associated with neurological symptoms, including urinary, rectal and sexual dysfunction [6], and can also cause mechanical instability [7]. While little is known of the natural course of sacral fractures, different approaches are currently employed in their surgical management. In this study, 14 cases with transforaminal sacral fractures treated with posterior iliosacral instrumentation (PISI) were assessed in terms of surgical technique and functional results.

## Patients and methods

In 2002 and 2003, 16 cases underwent posterior ilio-sacral instrumentation for the treatment of transforaminal sacral fractures. Two cases were excluded because of an associated acetabular fracture. The mean age of the remaining 14 cases (ten men, four women) was 35.4 (19–73) years, and average follow-up was 22.2 (15–33) months. In eight cases the mechanism of injury was a car crash, in four a fall from a height and in two a car to pedestrian motor vehicle accident.

All cases were evaluated pre-operatively with computed tomography (CT) along with antero-posterior, inlet and outlet radiographic films. At the last follow-up, anteropos-

**Table 1** Subjective pelvic symptom scoring[a]

| Symptom | Response | | | | |
|---|---|---|---|---|---|
| | None | Mild | Moderate | Severe | Intermittent |
| Pain at rest<br>Activity pain<br>Limping | 1 | 2 | 3 | 4 | 5 |
| Treatment satisfaction | Very satisfied | Satisfied | Satisfied but sometimes restricting | Not satisfied but not activity restricting | Not satisfied and activity restricting |
| Score | 1 | 2 | 3 | 4 | 5 |

(a) Minor symptoms: when the subjective responses were graded as 1, 2 or 3
Major symptoms: when the subjective responses were graded as 4 or 5
Excellent: none or 1 minor symptom with 1–2 satisfaction scores
Good: two or three minor symptoms with 1–2 or 3 satisfaction scores
Moderate: with or without minor symptom; 1 major symptom with 1–2 or 3 satisfaction scores
Poor: any major symptom with 4 or 5 satisfaction scores

terior, inlet, and outlet radiograms were obtained, and the cases were assessed in terms of union and displacement of the sacral fractures. The clinical assessment was conducted using subjective pelvic symptom scoring (Table 1).

### Management

Cases showing displacement in the vertical or horizontal plane underwent PISI (Figs. 1, 2). Emergency pelvic external stabilisation was performed in pelvic fractures associated with haemodynamic and/or mechanical instability. For permanent pelvic stabilisation, a period of at least 48 h with haemodynamic stability was observed. For anterior pelvic lesions, stability was achieved by pelvic external fixator or plate-screw osteosynthesis. After the operation, CT of all cases was repeated, and subsequently, the patients were allowed partial weight bearing on the second postoperative week and full weight bearing after the third week.

### Surgical technique

We used parallel symmetrical incisions lateral to the posterior iliac tubercle. The double sacral bar was inserted following fracture reduction and was joined using the screw heads previously localised in the S1 and S2 pedicles, on the contralateral side of the fracture. With this technique, the sacral bars are attached to each other using an axial connector and subsequently a flattened plate, which has been adapted to the lateral iliac wing ipsilateral to the fracture and is attached to the rods. We inserted up to eight ilio-sacral screws through the holes in the plate, and a controlled compression was applied through the rods.

## Results

Four cases underwent emergency pelvic external stabilisation as a consequence of haemodynamic and/or mechanical

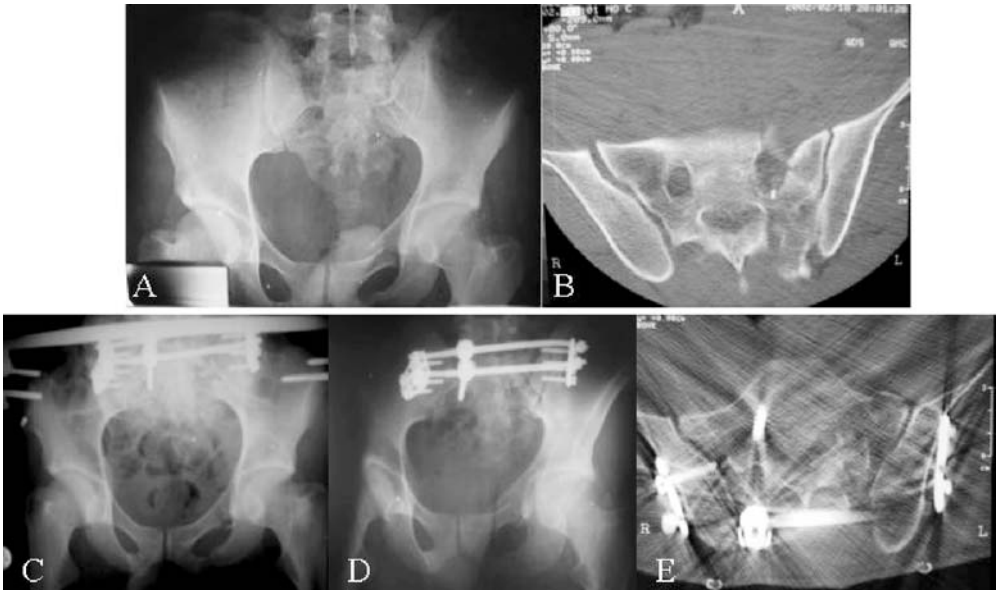


**Fig. 1** Pre-operative roentgenogram (**A**) and computed tomography (CT) scan (**B**) of a male patient with transforaminal sacral fracture with contralateral sacroiliac opening treated with posterior iliosacral instrumentation (PISI) and anterior pelvic external fixator (**C**). Following removal of the external fixator, slight hemi-pelvic deviation developed gradually (**D**). Post-operative CT shows reduction of posterior complex with PISI (**E**)

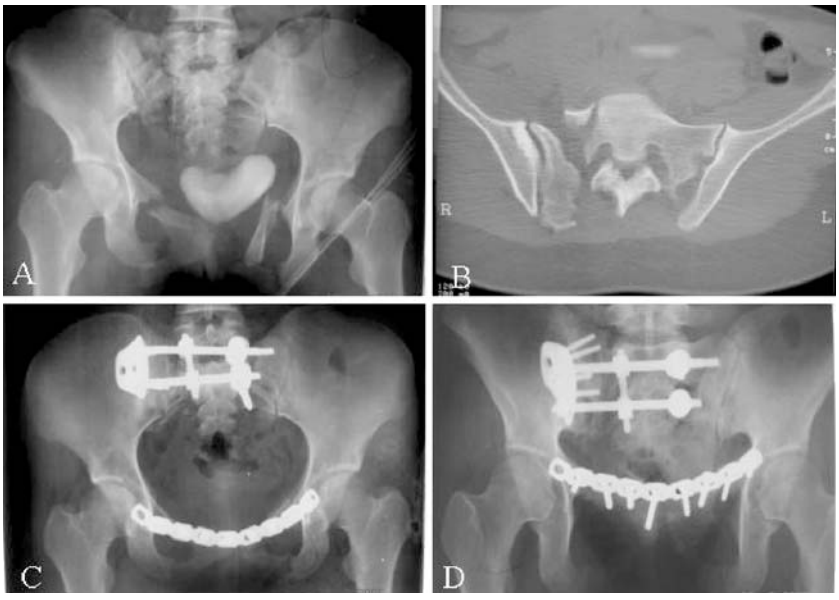


**Fig. 2** Pre-operative roentgenogram (**A**) and computed tomography (CT) scan (**B**) of a female patient with displaced transforaminal sacral fracture. The posterior instability was treated with posterior iliosacral instrumentation (PISI) and the anterior lesions with open reduction and internal fixation (**C**, **D**)

instability. Mean duration of delay for the permanent pelvic stabilisation was 4.2 (3–8) days. For the management of anterior lesions, a pelvic external fixator was used in nine cases and plate-screw osteosynthesis in four. The pelvic external fixator used for permanent stabilisation was removed after a mean of 7 (6–8) weeks.

In one case, a neurological deficit (sensory and motor) was present initially. In another, an iatrogenic neurological deficit (motor) developed. Neurological deficits of both cases showed a full recovery by the end of the first year post-operatively. Seven cases had other accompanying orthopaedic injuries, and three cases were found to have other system injuries (Table 2).

One case developed infection 4 months post-operatively, and the ilio-sacral instruments were removed. Wound healing was achieved after debridement and antibiotics. In another patient complaining of pain during activity and showing radiological hemi-pelvic deviation, the posterior instruments were removed, but intra-operatively, there were no signs of loosening.

At the final follow-up, all patients had complete radiological healing of the fractures. The subjective functional assessment yielded excellent results in ten patients and good and moderate results in two patients each. There were no patients with a poor functional outcome.

**Table 2** Associated orthopaedic and other system injuries of a total of 14 cases

| | |
|---|---|
| Distal radius fracture | 2 |
| Forearm double-bone fracture | 2 |
| Scapular fracture | 1 |
| Clavicular fracture | 2 |
| Vertebral fracture | 2 |
| Femoral fracture | 2 |
| Tibial eminentia fracture | 1 |
| Knee dislocation | 1 |
| Lisfranc fracture dislocation | 1 |
| Bladder-neck rupture | 1 |
| Pneumo-cephaly | 1 |
| Pneumo-haemothorax | 1 |

## Discussion

Posterior pelvic injuries have frequently been detected in unstable pelvic fractures and can be associated with severe haemodynamic instability. These posterior lesions may be overlooked whilst attention is focussed o haemodynamic stability. In addition, posterior injuries may also be missed in patients with polytrauma who were haemodynamically stable. Denis et al. [6] denote that the chance of identifying sacral fractures rises when a concomitant neurological impairment is present. In their own series, sacral fractures were identified in 76% of patients with a neurological deficit while this rate was only 51% in patients without any neurological deficit. While a significant portion of pelvic fractures may be readily diagnosed on the initial films, sacral fractures, on the contrary, are often missed owing to the anatomical features of the sacrum. Unstable pelvic fractures may escape recognition on the initial films because they are reduced. For this reason, the pelvic integrity should be meticulously assessed by means of stress radiograms and a careful examination [2]. As isolated fractures of the anterior pelvis are rarely seen, cases where such fractures are recognised should definitely be scrutinised for a posterior pelvic fracture [3, 5].

Overlooked or neglected sacral fractures can result in neurological symptoms, which appear to benefit from early surgical decompression [17]. Furthermore, as the sacrum supports the vertebral column, and forms a key structure within the pelvis, it serves as a mechanical core for the axial skeleton. Therefore, the management of sacral fractures should be built on the basis of mechanical as well as neurological stability. At presentation, only one of our cases

had a neurological deficit, but an iatrogenic neurological deficit (drop-foot) arose in another. At the last follow-up, both cases were fully recovered 1 year post-operatively.

In the management of unstable pelvic fractures, the best results are obtained by using open reduction and internal fixation. A wide array of fixation methods have been developed, their common objective being to achieve stable fixation that allows for early mobilisation and ambulation and prevents chronic lumbar pain, limb-length discrepancy and complications related to union. Posterior injuries of the pelvic ring frequently occur as a result of transforaminal sacral fractures, and these lesions are probably the most difficult ones to reduce and stabilise [10]. Surgical management of sacral fractures consists of a wide spectrum of options, from minimally invasive techniques to formal open reduction and internal fixation. Minimally invasive procedures can be carried out under CT or advanced three-dimensional imaging methods. Iliosacral screw, sacroiliac plate, sacral bar or lumbopelvic stabilisation methods are reported to bring successful clinical results in various case series. In a comparative biomechanical study, Simonian et al. [16] demonstrated that the various posterior techniques being frequently used in the treatment of transforaminal sacral fractures generated similar stability outcome. In the surgical management of a displaced sacral fracture, techniques allowing early mobilisation as well as mechanical and neurological stability, are clearly an advantage. Although lumbo-pelvic triangular osteosynthesis, described by Schildhauer et al. [15], is introduced as a stable method that allows for early mobilisation, the authors recommend using an ilio-sacral screw or plate to achieve horizontal stability. Disadvantages of lumbo-sacral stabilisation techniques are the restriction of waist movements and the need a second operation to remove the fixation.

The technique we applied is not a new concept for posterior stabilisation. Even so, combining sacral bar and pediculo-iliac fixation methods, providing vertical as well as horizontal stability, requiring no advanced imaging procedures and allowing for early weight bearing, may be an advantage. However, vertical and horizontal stabilities achieved by this technique require further assessment with comparative biomechanical studies. As in all other posterior approach procedures, it is contraindicated in the presence of open or closed (Morel-Lavallée lesion) skin lesions. Kellam et al. [10] and Goldstein et al. [9] reported an increase in the incidence of skin problems when internal fixation materials are used in this region. None of our cases developed pressure sores due to irritation from the materials, but in one case, the instruments were removed due to infection. As an advantage over the pediculo-iliac [13, 14] or lumbopelvic [15] techniques, this technique does not require posterior iliac bone resection, and it allows for controlled compression of the fracture line. We consider that the amount of bleeding may be relatively less since there is no need for bone resection. At the latest follow-up, it was noted that none of the cases had developed significant vertical displacement, but medialisation of the hemi-pelvis on the transforaminal fracture side was seen in two patients whose anterior fractures were treated using a pelvic external fixator. In both cases, the pelvic fixators were removed at the end of the sixth week, and medialisation appeared in subsequent films. In one of these cases, the posterior instruments were removed at the 13th post-operative month, but no sign of loosening was detected. Hemi-pelvic medialisation resulted in limb shortening of less than 2 cm in each of the two cases. We did not see any hemi-pelvic medialisation in cases where the anterior fixation was performed with plate-screw fixation.

While external fixators are recognised as being effective in the treatment of anterior instability, we concede that open reduction and internal fixation could provide greater stability, allowing for early full weight bearing. In an unstable pelvis, an external fixator can be adequate for achieving anterior stability. In displaced anterior lesions, however, we consider that the pelvis may well be subject to a gradual deformation if the external fixator is removed at 6 weeks. For this reason, we suggest that the fixator should not be removed before the end of 10 weeks in such cases.

Associated orthopaedic injuries were present in half of our cases. At the end of the follow-up period averaging 22.2 months, we concluded that the orthopaedic injuries displayed no negative effect on the assessment of the pelvic symptoms and also that the subjective functional assessment is a valuable reflection of the efficacy of the treatment.

Early mobilisation and ambulation may be available with this technique, which involves the reduction and stabilisation of sacral fractures through a posterior approach by gaining support from the contralateral intact S1 and S2 pedicles. We believe that with its various configurations, PISI may well be employed in all vertical sacral fractures. In addition, we recommend biomechanical studies to compare the stability of the various methods.

## References


1. Bonin JG (1945) Sacral fractures and injuries to the cauda equina. J Bone Joint Surg 27:113–127
2. Bucholz RW, Peters P (1988) Assesment of pelvic stability. In: Instructional course lectures, The American Academy of Orthopaedic Surgeons, vol 37. The American Academy of Orthopaedic Surgeons, Park Ridge, Illinois, pp 119–127
3. Bucholz RW (1981) The pathological anatomy of Malgaigne fracture-dislocations of the pelvis. J Bone Joint Surg Am 63: 400–404
4. Bucknill TM, Blackburne JS (1976) Fracture-dislocations of the sacrum. Report of three cases. J Bone Joint Surg Br 58:467–470
5. Burgess AR (1992) Fractures of the pelvis, part I: the pelvic ring. In: Rockwood CA, Green P (eds) Fractures in adults, 3rd edn. J.B. Lippincott, Philadelphia, pp 1399–1442
6. Denis F, Davis S, Comfort T (1988) Sacral fractures: an important problem. Retrospective analysis of 236 cases. Clin Orthop 227:67–81
7. Denis F (1984) Spinal instability as defined by the three-column spine concept in acute spinal trauma. Clin Orthop 189:65–76
8. Fountain SS, Hamilton RD, Jameson RM (1977) Transverse fractures of the sacrum. A report of six cases. J Bone Joint Surg Am 59:486–489

9. Goldstein A, Phillips T, Sclafani SJ et al (1986) Early open reduction and internal fixation of the disrupted pelvic ring. J Trauma 26:325–333
10. Kellam JF, McMurtry RY, Paley D et al (1987) The unstable pelvic fracture. Operative treatment. Orthop Clin North Am 18:25–41
11. Phelan ST, Jones DA, Bishay M (1991) Conservative management of transverse fractures of the sacrum with neurological features. A report of four cases. J Bone Joint Surg Br 73:969–971
12. Purser DW (1969) Displaced fracture of the sacrum. Report of a case. J Bone Joint Surg Br 51:346–347
13. Saiki K, Hirabayashi S, Horie T et al (2002) Anatomically correct reduction and fixation of a Tile C-1 type unilateral sacroiliac disruption using a rod and pedicle screw system between the S1 vertebra and the ilium: experimental and clinical case report. J Orthop Sci 7:581–586
14. Sar C, Kilicoglu O (2003) S1 pediculoiliac screw fixation in instabilities of the sacroiliac complex: biomechanical study and report of two cases. J Orthop Trauma 17:262–270
15. Schildhauer TA, Ledoux WR, Chapman JR et al (2003) Triangular osteosynthesis and iliosacral screw fixation for unstable sacral fractures: a cadaveric and biomechanical evaluation under cyclic loads. J Orthop Trauma 17:22–31
16. Simonian PT, Routt C Jr, Harrington RM et al (1996) Internal fixation for the transforaminal sacral fracture. Clin Orthop 323:202–209
17. Zelle HA, Gruen GS, Hunt T et al (2004) Sacral fractures with neurologic injury: is early decompression beneficial? Int Orthop 28:244–251