

## *Original article*

# Anterior plating and percutaneous iliosacral screwing in an unstable pelvic ring injury

CHANG-WUG OH, POONG-TAEK KIM, JOON-WOO KIM, WOO-KIE MIN, HEE-SOO KYUUNG, SHIN-YOON KIM, SOO-HOON OH, and JOO-CHUL IHN

Department of Orthopedic Surgery, Kyungpook National University Hospital, 50, 2-Ga, Samdok, Chunggu, Daegu 700-721, Korea

### Abstract

**Background.** This study was carried out to evaluate the effectiveness of anterior plating with subsequent percutaneous iliosacral screwing for the management of unstable pelvic ring injuries.

**Methods.** Nineteen patients with unstable pelvic ring injuries were included in this retrospective study. All patients were followed up for at least 1 year, and their mean age was 43 years. According to the Association for Osteosynthesis–Orthopaedic Trauma Association (AO–OTA) classification, there were 5 B2 injuries, 11 C1 injuries, and 3 C2 injuries. After anterior fixation by means of plating, an iliosacral screw fixation was carried out percutaneously using a C-arm fluoroscope.

**Results.** All fractures healed, except for 1 case of nonunion at the pubic ramus. Radiological results showed that there were 9 anatomic, 7 nearly anatomic, 2 moderate, and 1 poor reduction. Sixteen of the 19 patients had good or excellent results for function, and all these had satisfactory (anatomic or nearly anatomic) reductions. The two moderate and 1 poor result were from an unsatisfactory reduction in a type-C injury with residual neurological signs. A screw misplacement with a neurological compromise occurred in 1 patient, but there were no adverse sequelae after its removal. The complications encountered were 2 cases of screw loosening, 2 cases of anterior metal failure, and 1 deep infection.

**Conclusions.** Anterior plating with subsequent percutaneous iliosacral screwing may be a useful method of treatment for unstable pelvic ring injuries, and the reduction quality and residual neurological signs were important in its functional outcome.

the pelvis, and are associated with high rates of mortality and late morbidity.<sup>1</sup> The results of treating these injuries conservatively have been disappointing. Early operative stabilization has been recommended to reduce mortality.<sup>2</sup> Secure fixation of the pelvic ring is required to promote early rehabilitation and diminish the sequelae.<sup>3</sup>

Among the methods of operation, internal fixation has been known to improve mortality and long-term functional results.<sup>4,5</sup> Anterior fractures can be stabilized by plating, which is the method of choice in cases where it is technically feasible. However, the selection of a fixation method for the posterior lesion is controversial, while the stability of a posterior pelvic ring is more important than that of an anterior ring. Although plating or sacral bars have been used until now, they need a wide exposure, which can increase the rate of infection, wound sequelae, and even mortality in this severe injury. In view of these problems, an iliosacral screw fixation is a minimally invasive technique, which can be applied to both sacroiliac joint dislocation and sacral fractures.<sup>6,7</sup>

The purpose of this retrospective study was to evaluate the effectiveness of reduction maintenance and the functional outcome of an iliosacral screw fixation after anterior plating for the management of unstable pelvic ring injuries.

### Materials and methods

From 1999 to 2005, 81 patients with unstable pelvic ring injuries were treated at this institution, and 23 of these were treated with anterior plating and a percutaneous iliosacral screw fixation. Of these 23 patients, 19 were followed up for at least 1 year and studied retrospectively. There were 8 men and 11 women, with a mean age of 43 years (range 22–80 years). The mechanisms of the injuries were traffic accidents for 10 patients, a fall from a height for 7 patients, and a crushing work-related

### Introduction

Unstable pelvis injuries are uncommon, but when they do occur they can result in an extensive disruption of

injury for 2 patients. Among the 10 traffic accidents, 8 were pedestrians, 1 was a car occupant, and 1 was a motor-cyclist. Eighteen of the 19 patients had associated injuries or fractures, and the mean injury severity score<sup>8</sup> was 31.7 (range 16–66).

A preoperative radiological evaluation (anteroposterior, inlet, and outlet views of the pelvis) was carried out with computed tomography (CT) scans to evaluate the exact characteristics of the fractures. According to the AO-OTA classification<sup>9</sup>, there were 5 B2 injuries, 11 C1 injuries, and 3 C2 injuries. In the posterior pelvic ring injuries, there were 16 sacral fractures (4 type I and 12 type II in the Denis<sup>10</sup> classification) and 3 sacroiliac joint dislocations. Four patients had existing neurological deficits at the time of their injury. There were no open fractures.

### Operation

On average, it took 3.8 days (range 0–10 days) from injury to a definitive operative treatment. Seven patients were operated on within 24 h, and the others were operated on after their associated injuries were stabilized and their general medical condition had recovered. There was one patient with hypotensive shock, due to an intrapelvic vessel injury, for whom we performed a provisional pelvic external fixation and arterial embolization as a primary procedure. A secondary definitive fixation was carried out for this patient after 5 days.

All patients were placed in a supine position on a radiolucent table. With the assistance of longitudinal traction and closed manipulation, the anterior pelvic ring disruption was reduced first. We often opened the fracture site to establish exact reduction through a Pfannenstiel incision or ilioinguinal approach. We fixed the anterior ring with a single pelvic reconstruction plate (3.5 mm, Synthes, Switzerland), unless the fractures were located around the symphysis pubis or were not severe enough to have three screws in each segment.

The posterior ring was indirectly reduced and maintained after the procedure for the anterior ring. Percutaneous iliosacral screwing was carried out to fix the posterior pelvic ring without changing the patient's position. After obtaining an adequate lateral view with the fluoroscopic guide, the entry point for the iliosacral screw was determined. With the guidance of the pelvic outlet and inlet views, a guide pin was inserted from the outer table of the iliac wing which did not intrude into the sacral canal or the sacral foramen. Drilling was done over the guide pin, and a single cannulated screw (partially threaded, 7.0 mm in diameter, Synthes, Switzerland) was fixed with a washer in the S1 area. The screw was long enough to pass at least over the center of the sacral body. The screw was tightened until the fractured surfaces were approximately together.

Postoperatively, active hip and knee joint motion was encouraged. Partial weight bearing was allowed with crutches at 4–6 weeks after the operation. Full weight bearing began when a bony union was seen at the fracture site. Sequential follow-up radiographs of the anteroposterior, inlet, and outlet views of the pelvis were observed at regular intervals of 4–8 weeks.

In radiological evaluations, the reduction quality was graded as anatomic (the pelvis was symmetric and displacement was within 4 mm), nearly anatomic (displacement within 4–10 mm), moderate (displacement 1–2 cm), or poor (displacement over 2 cm) according to the criteria of Matta and Saucedo.<sup>11</sup> The location of the iliosacral screw was assessed as being in an adequate or inadequate position by the presence of any intrusion into the sacral canal or sacral foramen.

The clinical results were graded as excellent (no pain, unlimited walking distance with a normal gait), good (limited pain, some limited walking distance with a slightly abnormal gait), moderate (regular pain, limited walking distance with an abnormal gait), or poor (severe pain, very limited walking distance with an abnormal gait) according to the criteria of Rommens and Hessmann.<sup>12</sup> We categorized excellent or good as a satisfactory result, and moderate or poor as an unsatisfactory result.

Fischer's exact test (statistical package for the social sciences (SPSS)) was used to analyze the factors that influenced the clinical results, and a *P*-value less than 0.05 was considered to be statistically significant.

### Results

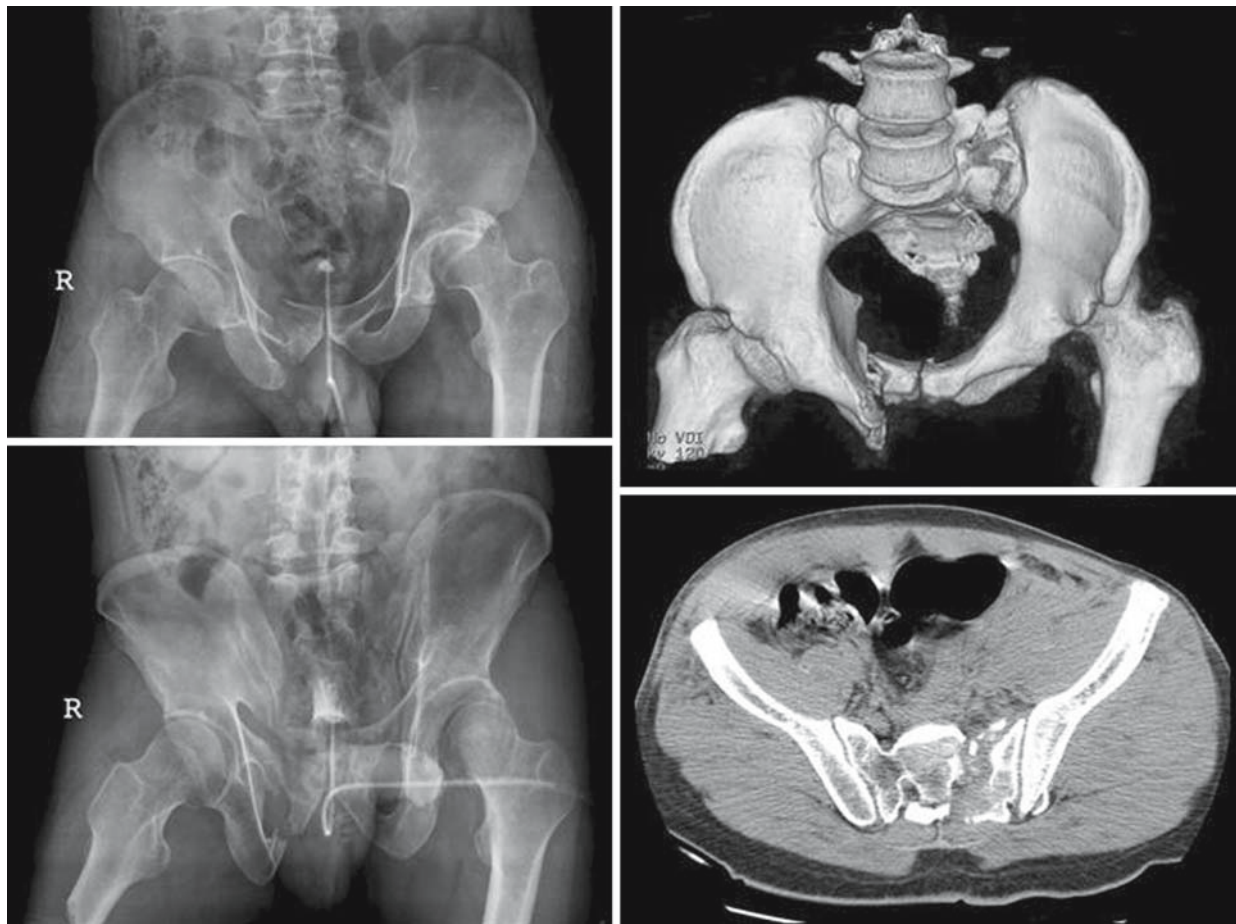
All but one fracture had healed within 15.5 weeks (range 12–20 weeks). One case of nonunion (type C injury) happened at the pubic ramus of the anterior pelvic ring with an implant failure. Since it was asymptomatic, no further procedure was carried out. The radiological results showed that there were 9 anatomic cases, 7 nearly anatomic cases, 2 moderate cases, and 1 poor case, and there was no additional displacement at the time of the last follow-up compared with the immediate postoperative state. In the 3 cases of moderate or poor reductions, two were due to an inaccurate reduction of the posterior fracture (type-C injuries), and one was caused by lack of experience in surgical techniques in the early series of this study. Iliosacral screws were adequately introduced into the sacrum except for 1 case of screw malposition. This patient had a C2 ring injury, which needed bilateral iliosacral screwing. One of the screws intruded into the sacral canal and was removed 1 day postoperatively. There were no additional neurological symptoms.

The clinical results showed 9 excellent cases, 7 good, 2 moderate, and 1 poor. In relation to the radiological

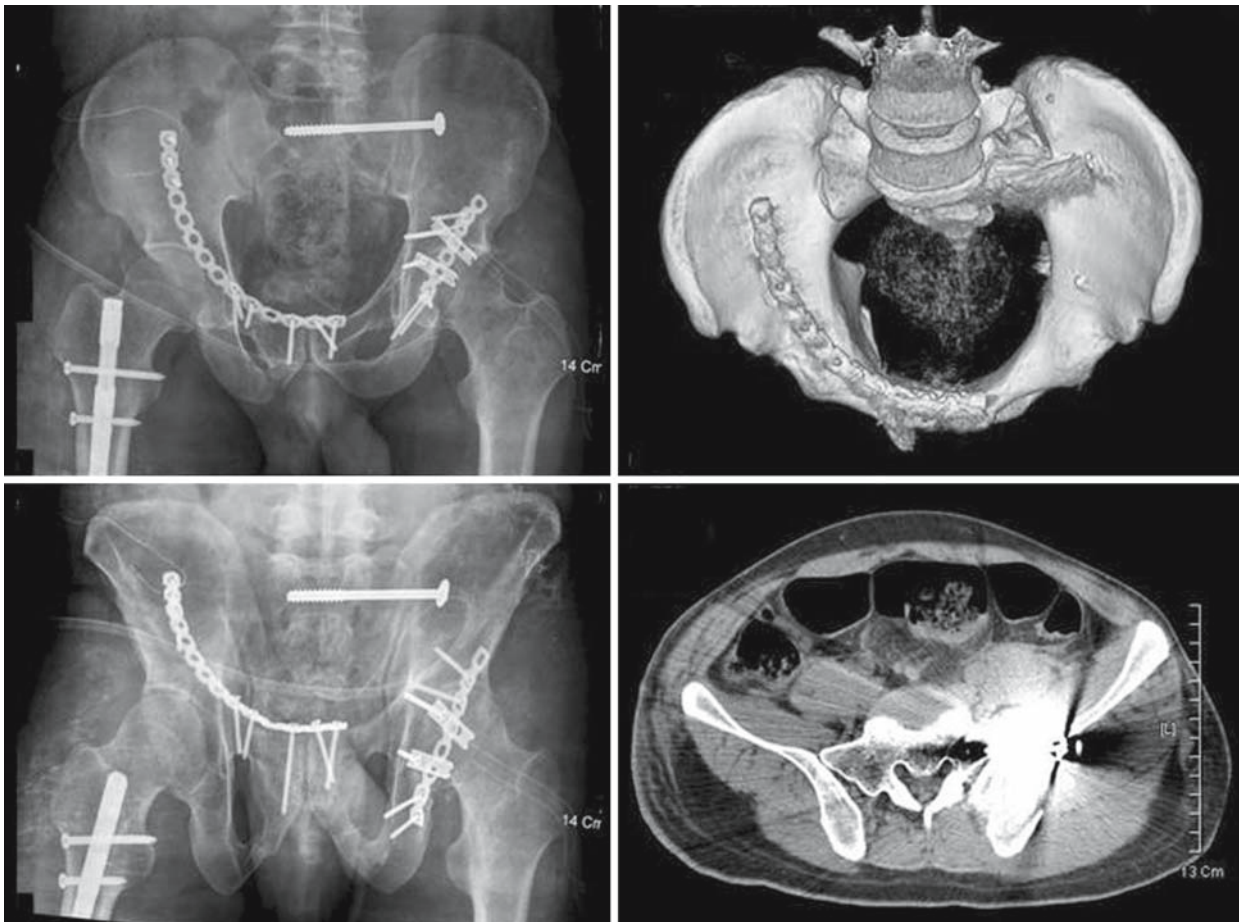
**Table 1.** Data for patients with unstable pelvic ring injuries

No	Age (years)	Sex	Dx	Type	Posterior lesion	Injury	ISS	Reduction	Function	Neurology	Complication
1	36	F	VS	C2	2	Fall	45	Nearly anatomic	Good	Improved	Screw malposition
2	80	F	VS	C1	1	TA	16	Nearly anatomic	Good	—	
3	38	M	VS	C1	SIDL	PI	25	Moderate	Poor	Persisted	
4	40	M	VS	C1	2	Fall	66	Nearly anatomic	Good	—	
5	30	M	VS	C1	2	Fall	43	Nearly anatomic	Good	—	
6	38	F	LC	B2	2	TA	41	Nearly anatomic	Excellent	—	
7	39	M	VS	C1	2	TA	50	Anatomic	Excellent	—	IS screw loosening
8	43	F	VS	C1	2	TA	24	Nearly anatomic	Good	—	
9	56	M	VS	C1	1	TA	29	Anatomic	Excellent	—	
10	22	F	VS	C1	2	Fall	25	Moderate	Moderate	Persisted	
11	46	F	LC	B2	2	TA	24	Anatomic	Excellent	—	Anterior screw breakage
12	45	M	VS	C2	2	PI	29	Anatomic	Excellent	—	
13	45	F	LC	B2	2	Fall	25	Anatomic	Excellent	—	
14	34	F	LC	B2	SIDL	TA	41	Anatomic	Good	—	Deep infection
15	45	F	LC	B2	1	TA	16	Anatomic	Excellent	—	
16	55	F	VS	C1	SIDL	TA	20	Anatomic	Excellent	—	
17	52	M	VS	C1	1	TA	16	Anatomic	Excellent	—	
18	43	M	VS	C1	2	Fall	29	Poor	Moderate	Persisted	Plate failure
19	30	F	VS	C2	2	Fall	38	Nearly anatomic	Good	—	IS screw loosening
Total	43						31.7				

Dx, diagnosis; VS, vertical shear injury; LC, lateral compression injury; Type, AO–OTA classification; Posterior lesion, location of a posterior fracture according to the Denis classification; SIDL, dislocation of the sacroiliac joint; TA, traffic accident; PI, pressure injury; ISS, injury severity score; IS, iliosacral



**Fig. 1.** Case 7. A 39-year old man suffered from a vertical shear injury of the pelvic ring with a right femoral fracture and a left acetabular fracture. On a CT scan, a sacral fracture of Denis type II on the left and pubic rami fractures were evident



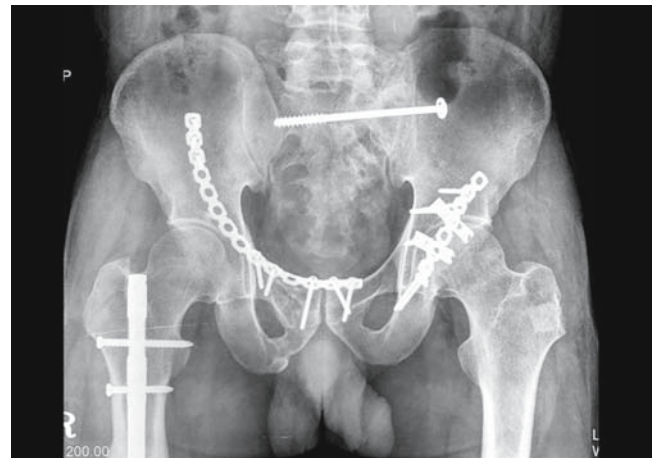
**Fig. 2.** Using a long reconstruction plate, the anterior disruption of the pelvic ring was reduced and fixed. Then the posterior ring was fixed percutaneously with a 7.0-mm cannulated

screw. A CT scan showed a well-reconstructed pelvic ring and a good location of the iliosacral screw

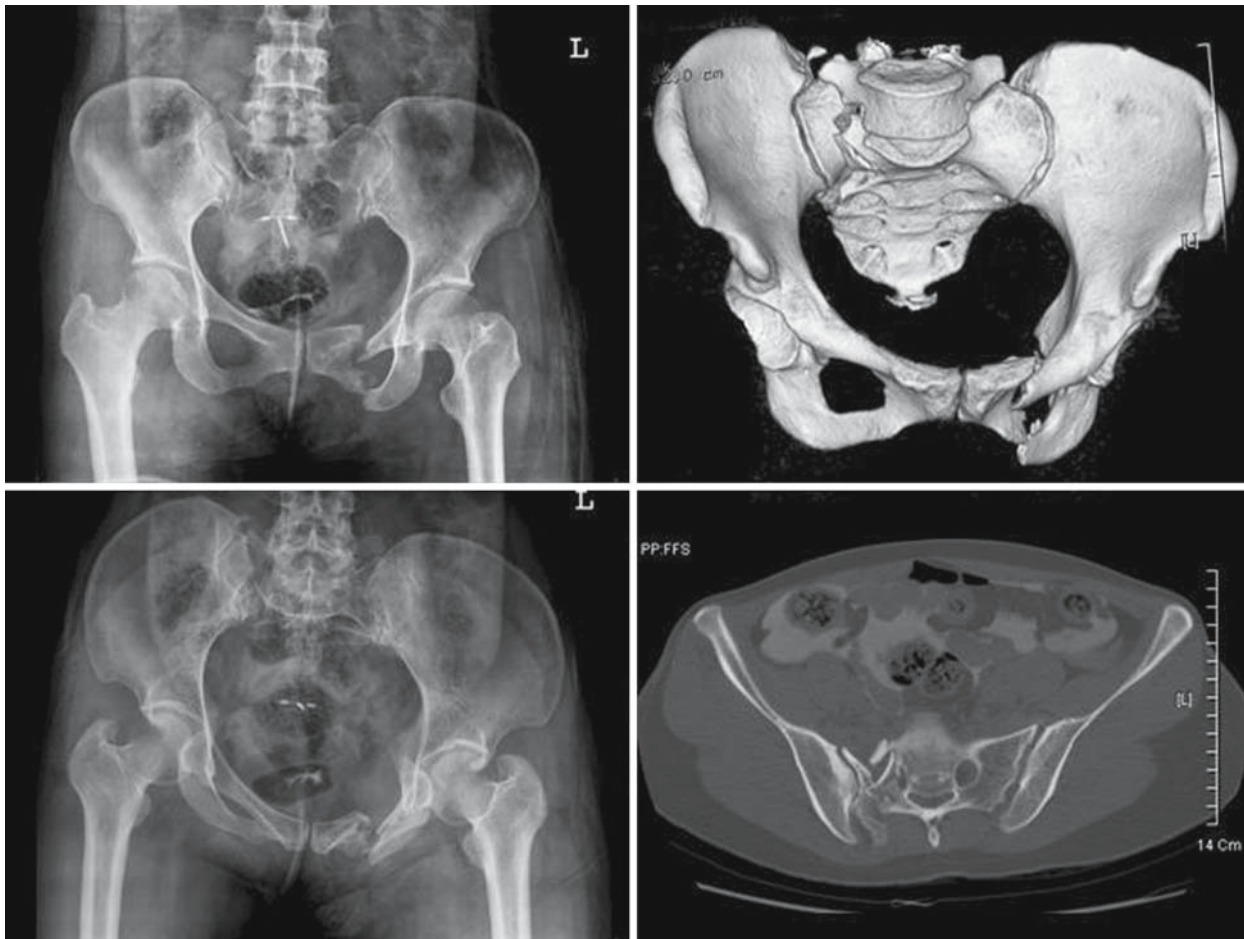
results, 16 cases which were above “nearly anatomical” had satisfactory (above good) results, and 3 cases which were below “moderate” had unsatisfactory (below moderate) results ( $P = 0.001$ ). There were 3 cases of residual neurological signs which coincided with unsatisfactory clinical results (Table 1).

From the viewpoint of fracture types, 11 of 14 type-C fractures (Figs. 1–3) showed satisfactory radiological reductions and clinical results (78%), while all 5 type-B fractures (Figs. 4–6) showed satisfactory radiological reductions and clinical results. Although there was no statistical significance ( $P = 0.530$ ), type-B fractures seemed to have better results than type-C fractures. The types of posterior lesion with a Denis classification did not affect the radiological or clinical results.

Regarding complications, there was one deep infection on the anterior fixation area. After removing the anterior plate and debridement, this healed without further displacement of the fractures. Metal failures occurred in 4 patients, one with type-B and three with type-C fractures. Two failures occurred in the anterior



**Fig. 3.** After 2 years, all fractures had healed with an anatomical reconstruction. The patient had excellent function without limping



**Fig. 4.** Case 6. A 38-year-old woman had a lateral compression injury of the pelvic ring with a left femoral fracture. A CT scan showed an impacted sacral fracture on the right and a tilt fracture of the left pubic rami

plate, one was a plate breakage with nonunion, and one was the loosening of screws. There were two cases of the loosening of iliosacral screws; one required refixation with a longer screw, but one was a mild loosening and this case healed without further management.

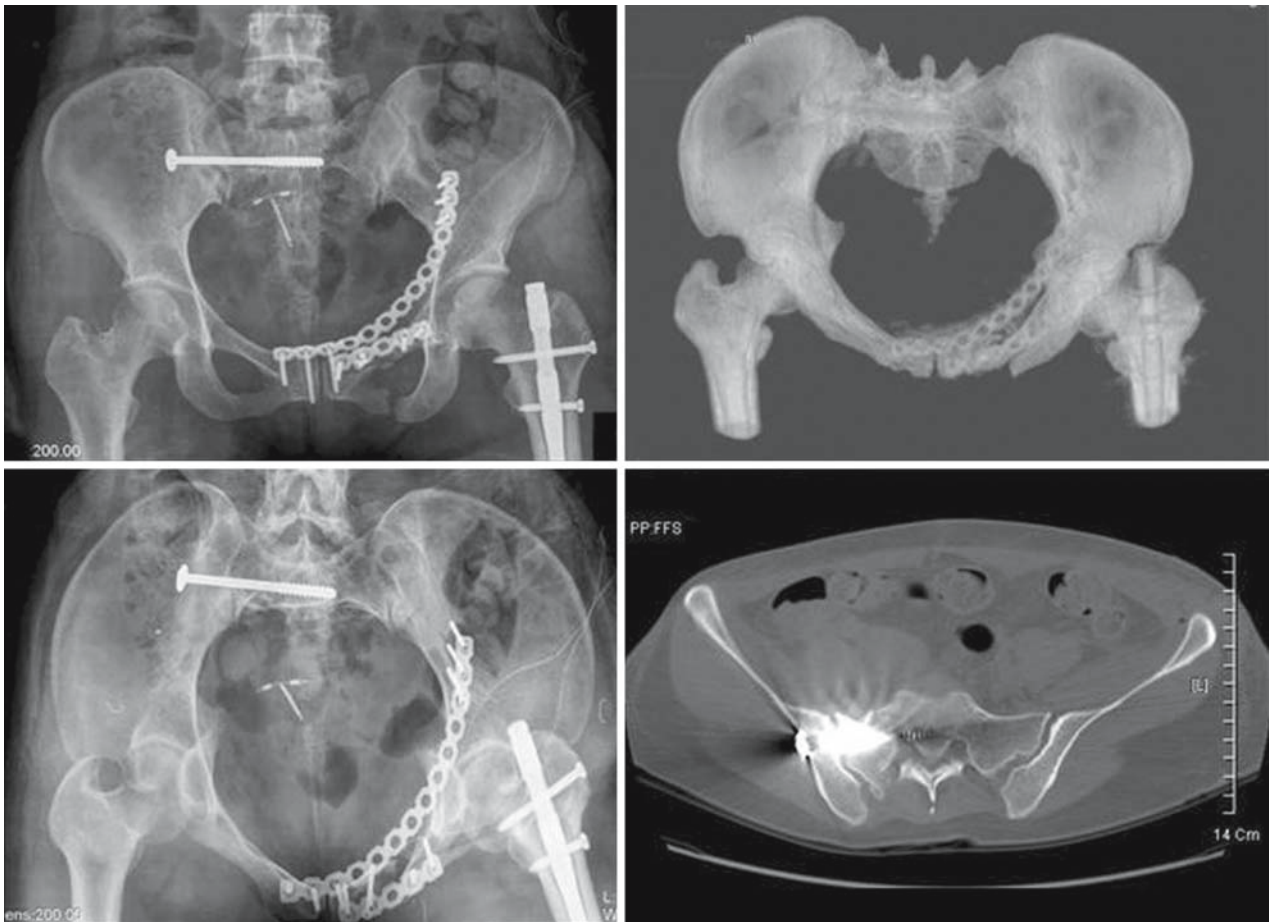
Among the 4 cases with initial neurological symptoms, one recovered but three had residual signs. Two of these had pain due to S1–S3 nerve injuries, dyesthesia, and a limitation of motion, and the other one had mild residual sensory symptoms only.

## Discussion

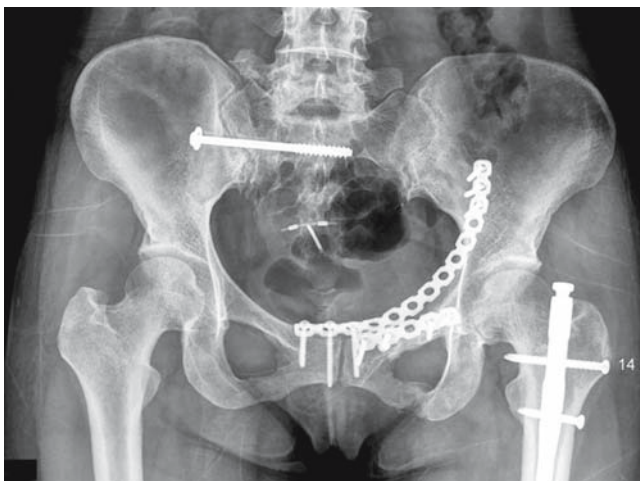
In unstable pelvic ring injuries, conservative treatments involve a long hospital stay and result in an inaccurate reduction with high mortality and morbidity rates.<sup>13</sup> Operative interventions are advocated, since they promote early rehabilitation and diminish complications at the same time.<sup>2,4,5</sup> External fixation remains one of the mainstays in pelvic fracture management, and can

be applied rapidly and early in the management of exsanguinating pelvic ring disruption. However, another method is necessary to stabilize the posterior elements, because its framework is insufficient to control a completely unstable posterior pelvic ring injury.<sup>13</sup> As initiated by Letournel,<sup>14</sup> open reduction and internal fixation, which is a more constructive treatment modality, can diminish such disadvantages and result in a satisfactory functional outcome.<sup>11,12</sup> We could also have a high rate of satisfactory outcomes in radiological reductions and function using the same principle.

In an unstable pelvic ring injury, anterior fixation alone may be not sufficient to maintain reduction of the posterior injury, and the additional fixation of the posterior ring is recommended, especially for a vertically unstable injury.<sup>15</sup> Among the methods of posterior pelvic ring stabilization, sacral bars have the advantage of simplicity and safety and can be used for sacral fractures and sacroiliac joint dislocations. However, there is a risk of over-compression with a nerve injury in sacral fractures, and both ends of the bar are so prominent that it

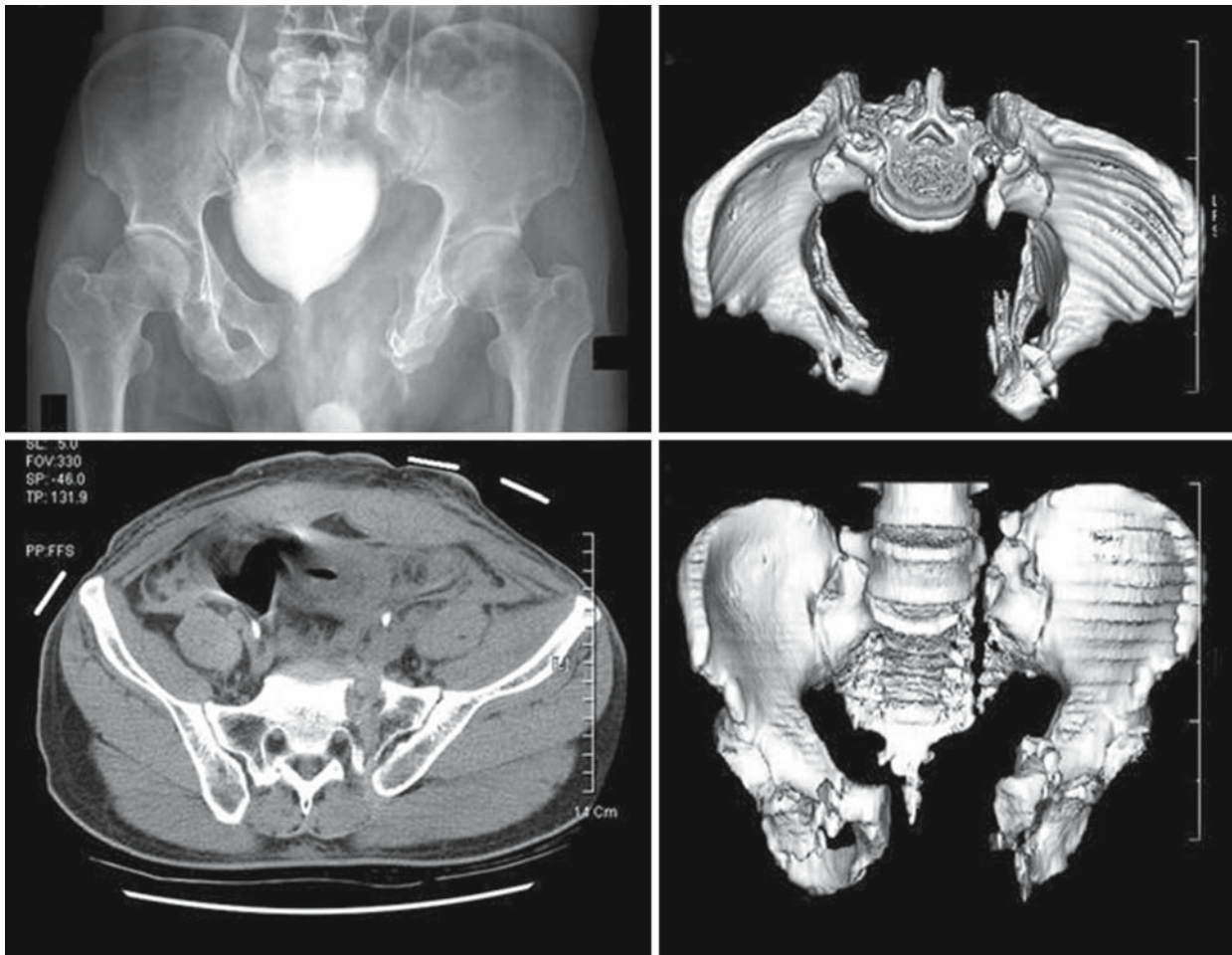


**Fig. 5.** The anterior pelvic ring was reconstructed by double plating and a percutaneous iliosacral screw was fixed. A good reconstruction of the pelvic ring and a safe placement of the iliosacral screw were seen on a CT scan



**Fig. 6.** All fractures had healed anatomically after 2.5 years, and the patient had excellent function

can cause discomfort to patients.<sup>16</sup> Anterior plating of the disrupted sacroiliac joint can stabilize its dislocation easily, but access to the sacral side is limited and is located too close to the 5th lumbar nerve root.<sup>17,18</sup> Plate fixation of the sacroiliac joint through a posterior approach<sup>1</sup> has the same biomechanical stability as sacral bars,<sup>19</sup> but it can cause adverse effects such as hemorrhage, wound sequelae, and a deep infection posterior to the pelvis.<sup>13,15</sup> The iliosacral screw fixation used in this study can be applied to both sacral fractures and sacroiliac joint dislocations, and it is biomechanically stable compared with other posterior fixation methods.<sup>20</sup> It is also a minimally invasive method with a percutaneous fixation. As a result of these advantages, the complication rates of soft tissue problems and neurological injuries could be minimal, while showing the good maintenance of reduction found in our study. Moreover, this screw can be fixed with the patient in a supine position after anterior plating,<sup>21</sup> which is another advantage when treating a multiply injured patient since we would not need to change the patient's position while operating.



**Fig. 7.** Case 18. On a plain radiograph, a 43-year-old man was seen to have a severe displacement injury of the pelvic ring. Initially, he had a hypovolemic shock. A CT scan showed a

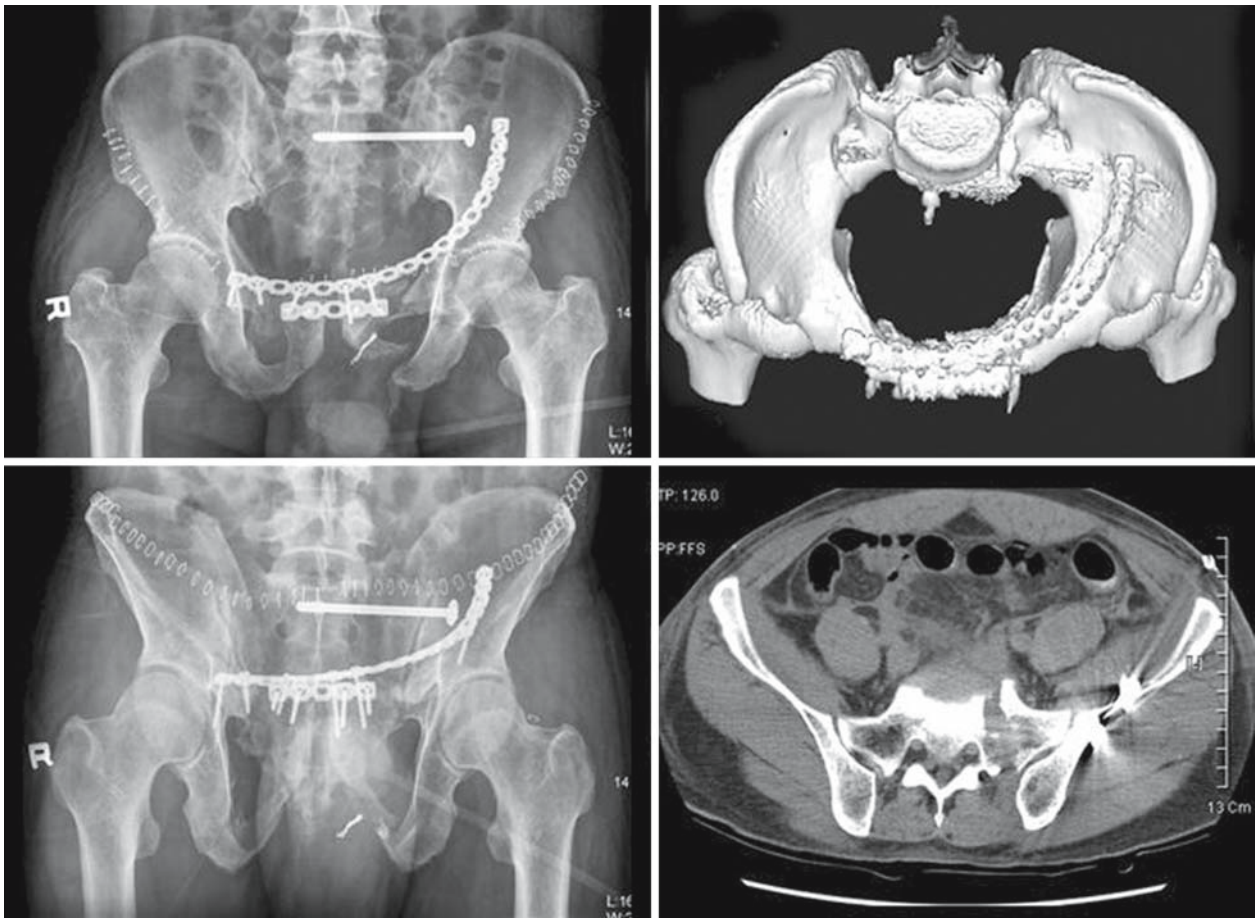
sacral fracture of Denis type II and widely separated symphyseal fractures

However, the percutaneous fixation of an iliosacral screw is not always easy because of the proximity of neurovascular structures with anatomical variations.<sup>7</sup> Although a high-quality image intensifier<sup>22-24</sup> or CT-guidance<sup>25,26</sup> can help this procedure, improper screwing and related complications can arise from inadequate reduction of the posterior ring. To achieve an anatomical reduction of a rotationally unstable pelvic ring injury, plating of the anterior ring can be a good method.<sup>27,28</sup> This is also important in vertically unstable fractures, since a satisfactory reduction of the posterior ring is a first step toward an easy and accurate fixation of the iliosacral screw. We believe that open reduction and plating of the anterior ring injury can facilitate an anatomical reduction and make iliosacral screwing of the posterior ring much easier. A high rate of satisfactory reduction was achieved in our study, and there was only 1 case of misplacement of the iliosacral screw. CT-guided placement is emerging as a new, safe method of iliosa-

cral screw fixation.<sup>25,26</sup> Ebraheim et al.<sup>25</sup> reported good radiological results in 19 of 21 cases, which is similar to that achieved in our series. Therefore, our technique can be seen as a good alternative until CT-guided placement becomes widely used, since Ebraheim et al. also had difficulties in reduction in displaced cases.<sup>25,26</sup>

An unstable pelvic ring injury, especially a vertical shear injury, has a tendency to become displaced again if the posterior ring only is fixed. Anterior plate fixation, rather than an external fixation, is known to have the lowest rate of malunion,<sup>16</sup> which is also important to the functional outcome. Sagi et al.<sup>29</sup> also reported that anterior plating for the vertically unstable hemipelvis significantly increases the stability of the fixation construct. In our study, there were no cases of further displacement after the initial fixation, and a high rate of satisfactory outcomes was obtained.

A residual neurological deficit is another factor affecting the functional outcome. As previously reported,



**Fig. 8.** With anterior plating and posterior iliosacral screwing, the fracture was reduced to one of moderate grade

nerve injuries in type-C fractures are more severe than those in type-B fractures.<sup>10</sup> Our study also showed that unsatisfactory outcomes had occurred with type-C injuries with neurological symptoms (Figs. 7–9). All three cases of moderate or poor results in this study had residual neurological signs, and they all had under-correction of the initial injury. We therefore believe that the severity of the injury and the functional outcome are related,<sup>16,19</sup> since the more severe the initial injury, the higher the incidence of neurological signs.

Although there were only two cases of loosening of the iliosacral screw, it is better to prevent this from happening. Early mobilization is one of the reasons, but a single screw fixation may not be enough in some cases of severely unstable injuries. For those instances, two iliosacral screws may be needed.

There are some limitations in this study, including the small number of patients, the relatively short period of follow-up, and the mixed types of injury.

In summary, it is concluded that anterior plating with a percutaneous iliosacral screw is a safe and feasible method for treating unstable pelvic ring injuries, since



**Fig. 9.** Three years after the operation, metal failure occurred, resulting in nonunion of the pubic ramus, but the posterior ring healed. The patient had poor functional ability because of the persistent neurological deficit in the left limb, which had been present from the beginning



it has shown a high rate of functional success and a low rate of complications.

*Acknowledgments.* This work was supported by BK 21 and a Bio-Medical Research Institute grant, Kyungpook National University, Hospital (2004).

All authors have certified that they have no commercial associations (e.g., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with this article.

## References

- Mears DC, Capito CP, Deleeuw H. Posterior pelvic disruptions managed by the use of the double cobra plate. *Instr Course Lect* 1988;37:143–50.
- Burgess AR, Eastridge BJ, Young JW, Ellison TS, Ellison PS Jr, Poka A, et al. Pelvic ring disruptions: effective classification system and treatment protocols. *J Trauma* 1990;30:848–56.
- Tile M. Pelvic ring fractures: should they be fixed? *J Bone Joint Surg Br* 1988;70:1–12.
- Gruen GS, Leit ME, Gruen RJ, Peitzman AB. The acute management of hemodynamically unstable multiple trauma patients with pelvic ring fractures. *J Trauma* 1994;36:706–11.
- Latenser BA, Gentilello LM, Tarver AA, Thalgott JS, Batdorf JW. Improved outcome with early fixation of skeletally unstable pelvic fractures. *J Trauma* 1991;31:28–31.
- Roult ML Jr, Kregor PJ, Simonian PT, Mayo KA. Early results of percutaneous iliosacral screws placed with the patient in the supine position. *J Orthop Trauma* 1995;9:207–14.
- Roult ML Jr, Simonian PT, Agnew SG, Mann FA. Radiographic recognition of the sacral alar slope for optimal placement of iliosacral screws: a cadaveric and clinical study. *J Orthop Trauma* 1996;10:171–7.
- Baker SP, O'Neill B, Haddon W Jr, Long WB. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. *J Trauma* 1974;14:187–96.
- Orthopaedic Trauma Association Committee for Coding and Classification. Fracture and dislocation compendium. *J Orthop Trauma* 1996;10 Suppl 1:v-ix;1–154.
- Denis F, Davis S, Comfort T. Sacral fractures: an important problem. Retrospective analysis of 236 cases. *Clin Orthop* 1988; 227:67–81.
- Matta JM, Saucedo T. Internal fixation of pelvic ring fractures. *Clin Orthop* 1989;242:83–97.
- Rommens PM, Hessmann MH. Staged reconstruction of pelvic ring disruption: differences in morbidity, mortality, radiologic results, and functional outcomes between B1, B2/B3, and C-type lesions. *J Orthop Trauma* 2002;16:92–8.
- Stocks GW, Gabel GT, Noble PC, Hanson GW, Tullos HS. Anterior and posterior internal fixation of vertical shear fractures of the pelvis. *J Orthop Res* 1991;9:237–45.
- Letournel E. Pelvic fractures. *Injury* 1978;10:145–8.
- Kellam JF, McMurtry RY, Paley D, Tile M. The unstable pelvic fracture. Operative treatment. *Orthop Clin North Am* 1987;18: 25–41.
- Keating JF, Werier J, Blachut P, Broekhuysen H, Meek RN, O'Brien PJ. Early fixation of the vertically unstable pelvis: the role of iliosacral screw fixation of the posterior lesion. *J Orthop Trauma* 1999;13:107–13.
- Leighton RK, Waddell JP. Techniques for reduction and posterior fixation through the anterior approach. *Clin Orthop* 1996;329: 115–20.
- Ragnarsson B, Olerud C, Olerud S. Anterior square-plate fixation of sacroiliac disruption: 2–8 years follow-up of 23 consecutive cases. *Acta Orthop Scand* 1993;64:138–42.
- Pohlemann T, Angst M, Schneider E, Ganz R, Tschernke H. Fixation of transforaminal sacrum fractures: a biomechanical study. *J Orthop Trauma* 1993;7:107–17.
- Comstock CP, van der Meulen MC, Goodman SB. Biomechanical comparison of posterior internal fixation techniques for unstable pelvic fractures. *J Orthop Trauma* 1996;10:517–22.
- Griffin DR, Starr AJ, Reinert CM, Jones AL, Whitlock S. Vertically unstable pelvic fractures fixed with percutaneous iliosacral screws: does posterior injury pattern predict fixation failure? *J Orthop Trauma* 2003;17:399–405.
- Collinge C, Coons D, Tornetta P, Aschenbrenner J. Standard multiplanar fluoroscopy versus a fluoroscopically based navigation system for the percutaneous insertion of iliosacral screws: a cadaver model. *J Orthop Trauma* 2005;19:254–8.
- Gautier E, Bächler R, Heini PF, Nolte LP. Accuracy of computer-guided screw fixation of the sacroiliac joint. *Clin Orthop* 2001; 393:310–7.
- Peng KT, Huang KC, Chen MC, Li YY, Hsu RW. Percutaneous placement of iliosacral screws for unstable pelvic ring injuries: comparison between one and two C-arm fluoroscopic techniques. *J Trauma* 2006;60:602–8.
- Ebraheim NA, Coombs R, Jackson WT, Rusin JJ. Percutaneous computed tomography-guided stabilization of posterior pelvic fractures. *Clin Orthop* 1994;307:222–8.
- Ziran BH, Smith WR, Towers J, Morgan SJ. Iliosacral screw fixation of the posterior pelvic ring using local anaesthesia and computerised tomography. *J Bone Joint Surg Br* 2003;85:411–8.
- Tornetta P III, Dickson K, Matta JM. Outcome of rotationally unstable pelvic ring injuries treated operatively. *Clin Orthop* 1996;329:147–51.
- Van den Bosch EW, Van der Kleyn R, Hogervorst M, Van Vugt AB. Functional outcome of internal fixation for pelvic ring fractures. *J Trauma* 1999;47:365–71.
- Sagi HC, Ordway NR, DiPasquale T. Biomechanical analysis of fixation for vertically unstable sacroiliac dislocations with iliosacral screws and symphyseal plating. *J Orthop Trauma* 2004;18: 138–43.