Management of crescent fracture–dislocation of the sacroiliac joint: iliosacral screws versus plate fixation

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Background
Crescent fracture–dislocations are a well-recognized subset of pelvic ring injuries, which result from a lateral compression (LC) force. They are characterized by the disruption of the sacroiliac joint and extend proximally as a fracture of the posterior iliac wing. They are classically fixed using open reduction and internal fixation using plates and screws. We hypothesized that iliosacral screws (IS) can provide stable fixation in Day type II and Day type III.

Patients and methods
This clinical study was conducted with the aim of assessing the clinical results and functional scores of 43 patients (34 male and nine female patients). Their ages ranged from 16 to 64 years. The study included 43 patients who had sustained LC pelvic fractures (44 fractures) and had been operated upon between April 2000 and June 2010 (one patient had sustained bilateral fractures). Radiography and computed tomography of the pelvis were obtained for all patients. The classification by Day and colleague was used with three distinct types of crescents. Percutaneous IS alone were used in 20 fractures; a plate was used in 22 fractures, and two fractures were fixed with both plates and IS. LC II (LC screws) were added in two cases. The average follow-up period was 53 months (range: 4–126 months). Two patients died and one patient was lost to follow-up. The principal goal of surgical intervention was the accurate and stable reduction of the sacroiliac joint.

Results
Intraoperatively, there was no significant blood loss in cases treated with IS; the average blood loss in cases treated with open reduction and internal fixation using the plate was 600 ml (range: 200–1000 ml). The operative time was shorter for cases treated with IS (40 min; range: 30–60 min) than that for cases treated with plates (100 min; range: 60–150 min). The difference was statistically significant with a *P*-value of less than 0.001.

The clinical results were good in all cases; there were no wound complications, neurological complications, or residual rotational deformity of the limb. The healing rate was 100%.

The Majeed score was used for functional evaluation, and the mean score for the 40 patients was 86.2 points (range: 53–100 points); 26 (65%) patients scored greater than 85 points (excellent), 12 (30%) patients scored 66–84 points (good), and two (5%) patients scored 53 and 64 points (poor).

The average Majeed score for the group fixed with plates was 84.56 points (range: 66–100 points), and it was lower than the Majeed score for IS, which was 87.2 points (range: 53–97 points). However, the difference was not statistically significant, with a *P*-value of 0.404. The average Majeed score for cases fixed with plates and IS was 91.5 points (range: 90–93 points).

Discussion and conclusion
Percutaneous IS fixation is a good option for types II and III crescent fractures, with lesser blood loss and shorter operative time compared with plate fixation. The functional outcome of the cases fixed with IS was better; however, the difference was not statistically significant.

Level of evidence
The level of evidence was IV (case series).

Keywords:
crescent, iliosacral screws, pelvic fracture, sacroiliac fracture–dislocation, sacroiliac plate fixation

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Introduction

Lateral compression (LC) fractures account for more than 50% of all pelvic injuries in most series and are most commonly caused by side impacts [1].

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Crescent fracture–dislocations are a well-recognized subset of pelvic ring injuries, which result from a LC force. They are characterized by the disruption of the sacroiliac joint and extend proximally as a fracture of the posterior iliac wing. Day *et al.* [2] identified three groups of crescent fractures according to the extent of sacroiliac joint involvement. Type I is characterized by a large crescent fragment and the dislocation comprises no more than one-third of the sacroiliac joint, which is typically inferior. Type II fractures are associated with an intermediate-size crescent fragment and the dislocation comprises between one-third and two-thirds of the joint. Type III fractures are associated with a small crescent fragment in which the dislocation comprises most of the joint but not the entire joint (Fig. 1) [2].

The iliosacral joint is considered a weight-bearing joint [3] that can potentially be affected by post-traumatic arthritis, chronic instability, or malunion (with the consequent pain) if not treated appropriately. Holdsworth and Tile have described a high rate of incidence of lumbar pain and incapacity to perform light work in untreated patients, in comparison with those who underwent surgery [4].

To avoid painful sequelae it is indispensable to re-establish joint congruence and stability; therefore, open reduction and internal fixation (ORIF) of iliosacral joint lesions are necessary, except in those cases in which an acceptable joint congruence may be achieved using closed methods [4].

To our knowledge, there was only one publication in the literature that reported the use of iliosacral screws (IS) for the treatment of crescent fractures; six cases with Day type III were treated with closed reduction and percutaneous IS placement.

Two published articles specifically addressed the ORIF of crescent fractures by Borrelli and colleagues; they used a posterior subgluteal approach supplemented by a lag screw and posterior plating technique [2,3,5].

Starr Adam *et al.* [6] described a new technique; they stated that screws placed from the anterior inferior iliac spine to the posterior inferior iliac spine or vice versa can be used to stabilize the iliac wing fracture in LC II.

In this study, we hypothesized that, as a good portion of the outer iliac table is intact in Day types II and III (Figs 2 and 3) at the point of screw insertion, IS can be used and can provide stable fixation. We compared the clinical results and functional scores as well as the complications between the fixation of the SI joint disruption using Iliosacral screws (ISS) and plate fixation.

Patients and methods

This prospective clinical study was conducted in Cairo University Hospitals with the aim of assessing the clinical results and functional scores of 43 patients [34 (79.1%) male patients and nine (20.9%) female patients]. The mean age was 37.3 years (range: 16–64 years). The study included 43 patients who had sustained LC (crescent) pelvic fractures (44 fractures) and had been operated upon between April 2000 and June 2010. All patients sustained high-energy trauma injuries; 28 (65%) patients were victims of road traffic collisions, nine (21%) fell from heights, and six (14%) were crushed by heavy objects.

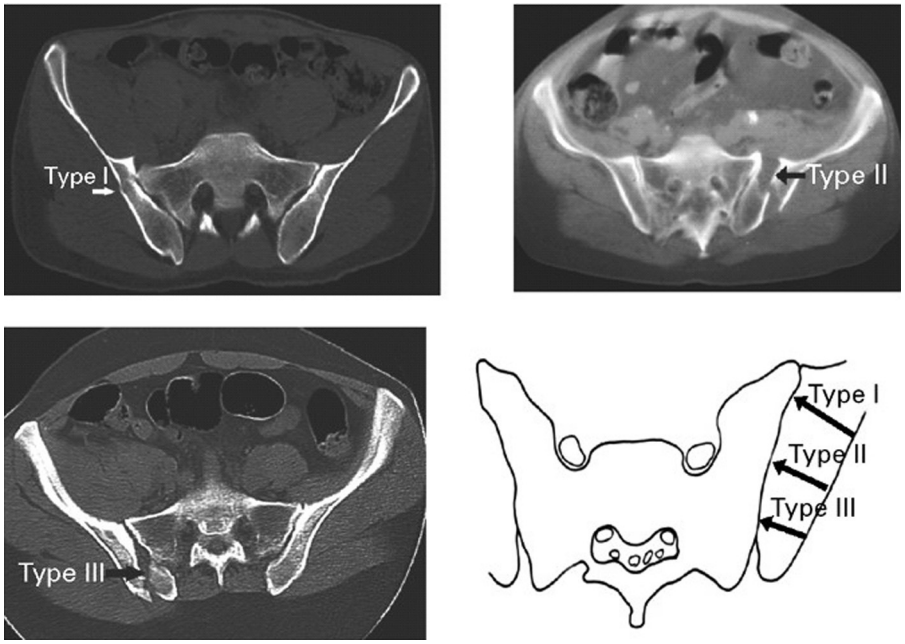
Radiological assessment included plain antero-posterior, inlet and outlet pelvic radiographs. The extent of each principal fracture line was assessed using computed tomography (CT) scan, and in most cases three-dimensional reconstruction was carried out.

According to the Young classification, 21 patients had sustained a combined mechanism of injury and 22 had LC injuries. According to the Tile classification, 27 patients had type C and 16 patients had type B. Percutaneous IS alone were used in 20 (45.46%) fractures (Figs 2 and 3), plates alone were used in 22 (50%) fractures (Fig. 4), and both plates and IS were used in two (4.56%) fractures; we added LC II (LC screws) to the plate in one fracture (Fig. 4) and to IS in another fracture. Anterior fixation was carried out in 26 (60.4%) patients: 14 plates, 11 external fixators, and two anterior column screws (in one case we used both fixator and column screw).

We used a classification by Day *et al.* [2] of three distinct types of crescents: type I is a large crescent fragment and the dislocation comprises no more than one-third of the sacroiliac joint; type II is an intermediate-size crescent fragment and the dislocation comprises between one-third and two-thirds of the joint; and type III is a small crescent fragment in which the dislocation comprises most of the joint but not the entire joint. Fourteen (31.8%) fractures were classified as Day I, 18 (40.9%) fractures as Day II, and 12 (27.3%) fractures as Day III.

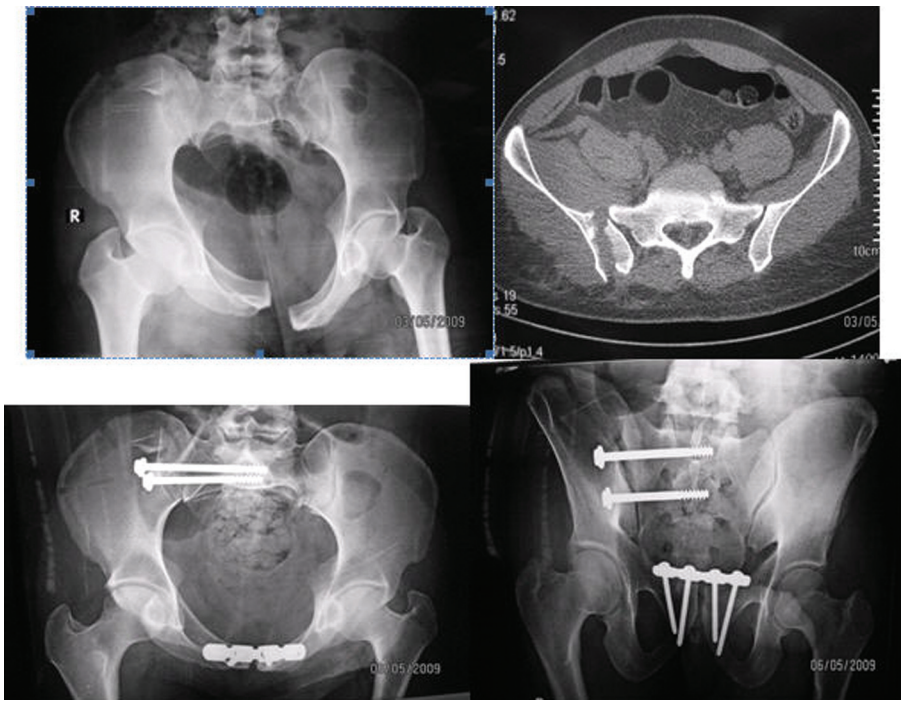
The mean follow-up period was 53 months (range: 4–126 months). One patient was lost to follow-up and two patients died postoperatively from complications related to other associated injuries of the head and abdomen.

Figure 1



The positions of the principal fracture lines are shown for crescent fracture–dislocation types I, II, and III, as defined by axial computed tomography sections, reformatted parallel to the sacroiliac superior end-plate. (a) Type I: the fracture enters the anterior third of the sacroiliac joint. (b) Type II: the fracture enters the middle third of the sacroiliac joint. (c) Type III: the fracture enters the posterior third of the sacroiliac joint. (d) All three fracture types are shown diagrammatically [2].

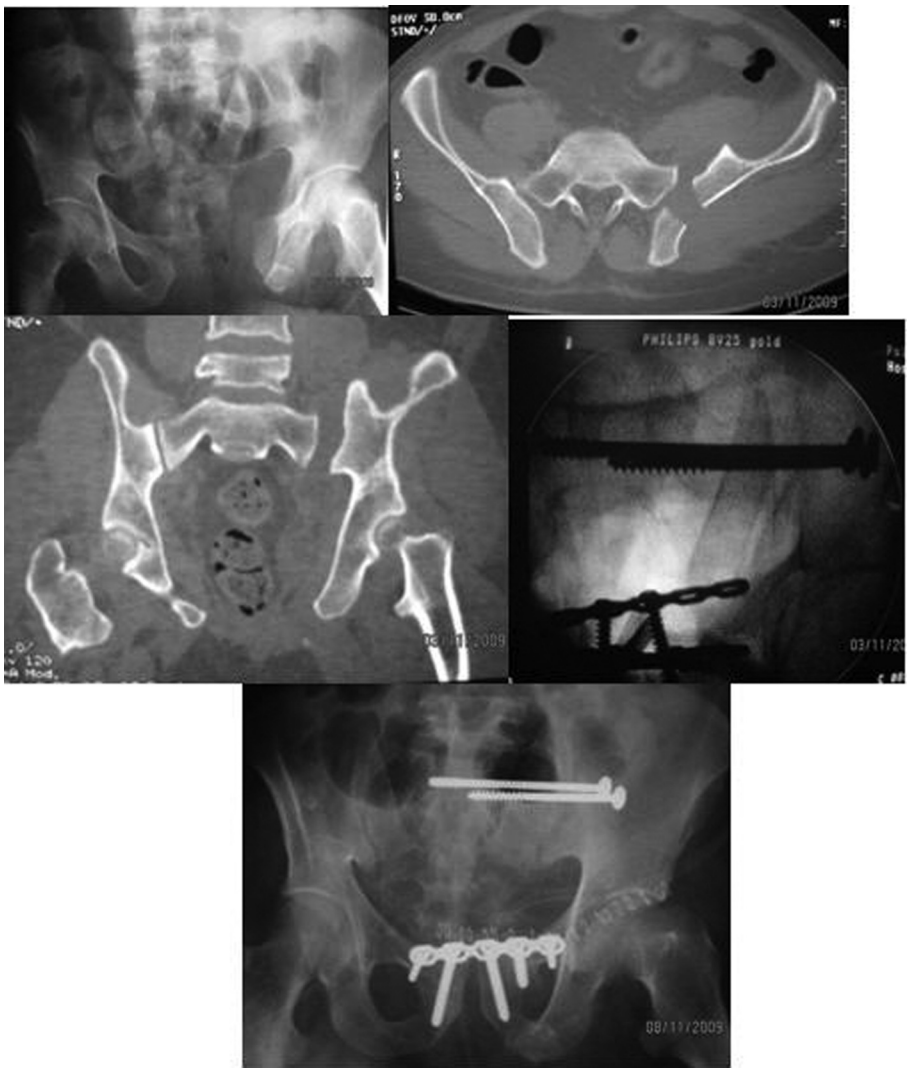
Figure 2



A 31-year-old male patient who suffered a road traffic accident and sustained crescent type III fracture was treated with two iliosacral screws in S1 and S2 and anterior plating.

We chose to perform closed reduction and percutaneous fixation using IS in cases of Day type II and Day type III (Figs 2 and 3) in which the entry point of the screws remained intact and there was a part of the outer table of the ilium at the site of screw insertion large enough to allow guidewire placement and insertion of the screw head and washer without risking breakage of the fragment. Otherwise, the plate was used through the anterior

Figure 3



A 32-year-old male patient who suffered a motor car accident and sustained crescent type II fracture was treated with two iliosacral screws and anterior plating.

approach. The LC II screw was added to two cases to add interfragmentary compression of the fracture site.

Intraoperatively, there was no significant blood loss in cases treated with IS; the average blood loss in cases treated with ORIF was 600 ml (range: 200–1000 ml). The operative time was shorter for cases treated with IS (40 min; range: 30 min to 60 min) compared with cases treated with plate fixation (100 min; 60–150 min).

Closed reduction techniques included reduction of rotation using Schanz screw inserted in the ilium, a ballpoint pusher, and manual rotation by manipulating the freely draped lower limb. We also carried out reduction of the anterior fracture through a Pfannenstiel approach with a pelvic reduction clamp or Matta clamps and then with an anterior reconstruction plate (this helped us to reduce the sacroiliac joint) or an external fixator through the anterior inferior iliac spine.

Postoperatively, patients were evaluated both clinically and radiographically. Radiological criteria as assessed using plain anteroposterior, inlet and outlet projections included the quality of fracture reduction and the evidence of union. CT scans were obtained if there was any doubt about the fracture union. Postoperative assessment also included any limb length discrepancy, wound condition, and any other complications. The Majeed score was used for functional evaluation of our patients as it was more convenient to our population.

The clinical results, functional scores, and the complications were compared between the two methods of fixation – that is, ISS versus plate and screw fixation of the crescent fracture injuries.

Data were statistically described in terms of mean±SD and range, or frequencies (number of cases) and percentages when appropriate. Ninety-five percent

Figure 4

A 26-year-old man who suffered a motorbike accident and sustained crescent type I fracture was treated with plates and lag screws at 2 months' follow-up with healed fracture.

confidence interval was calculated for all quantitative study variables. Comparison between the study groups was made using Student's *t*-test for independent samples. *P*-values less than 0.05 were considered statistically significant. All statistical calculations were carried out using the computer program SPSS (Statistical Package for the Social Science, version 15; SPSS Inc., Chicago, Illinois, USA) for Microsoft Windows.

Results

Intraoperatively, there was no significant blood loss in cases treated with IS; the average blood loss in cases treated with ORIF using the plates was 600 ml (range: 200–1000 ml).

The operative time was shorter for cases treated with IS (40 min; range: 30–60 min) than that for cases treated with plate fixation (100 min; range: 60–150 min). The difference was statistically significant ($P<0.001$).

The clinical results were good in all cases: there were no wound complications, neurological complications, or residual rotational deformity of the limb. The healing rate was 100%.

The Majeed score was used for functional evaluation, and the mean score for the 40 patients was 86.2 points (range: 53–100 points): 26 (65%) cases scored greater than 85 points (excellent), 12 (30%) cases scored 66–84 points (good), and two (5%) cases scored 53 and 64 points (poor) (5%).

The average Majeed score for the group fixed with plates was 84.56 points (range: 66–100 points). This was lower than the Majeed score for IS, which was 87.2 points (range: 53–97 points). However, the difference was not statistically significant, with a *P*-value of 0.404. The average Majeed score for cases fixed with plates and IS was 91.5 points (range: 90–93 points), but the number of cases (two only) was too small to establish any statistically significant difference.

Discussion

Pelvic crescent fractures are a relatively uncommon subtype of LC fracture and are rotationally unstable. There may be some limited vertical displacement; however, in contrast to Tile type C fractures, the sacrotuberous and sacrospinous ligaments, which typically remain intact, limit the vertical displacement [3,5].

Operative intervention in these patients aims to achieve accurate reduction of the sacroiliac joint and stabilization of the associated pelvic ring fractures or dislocations. This facilitates early mobilization and minimizes disability due to post-traumatic malunion and osteoarthritis, or instability of the sacroiliac joint [1,2,5,7,8].

The principal goal of surgical intervention was the accurate and stable reduction of the sacroiliac joint. We chose to perform closed reduction and percutaneous fixation using IS in cases of Day type II and Day type III in which the entry point of the screws remained intact and there was a part of the outer table of the ilium at the site of screw insertion large enough to allow guidewire placement and insertion of the screw head and washer without risking breakage of the fragment. This was based on the study by Day *et al.* [2] and Giannoudis *et al.* [9]. Otherwise, the plate was used through anterior approach. The anterior approach for sacroiliac joint allows visualization of the anterior face of the joint as an aid to accurate reduction. The posterior approach does not allow the surgeon to assess joint congruence accurately and relies on an indirect reduction technique, which may be compromised by

plastic deformation, comminution, and small key-in areas [10]. The LC II screw was added to two cases to add interfragmentary compression of the fracture site.

Although IS were used in our series in 22 fractures (Day type II and type III), there was only one publication in the literature that reported the use of IS for the treatment of crescent fractures; six cases with Day type III were treated with closed reduction and percutaneous IS placement. A skeletal traction pin placed in the proximal tibia applies traction with the hip in flexion on a specialized radiolucent pelvic reduction table (OSI, Union City, California, USA), allowing correction of both the vertical and the posterior displacement. The internal rotation deformity may be corrected with a percutaneous Schanz pin applied to either the anterior iliac crest or the anteroinferior iliac spine [2].

In a recent review article by Flint and Cryer [7], they stated that 'most iliac wing fractures associated with hemipelvis instability require plate osteosynthesis either through a retroperitoneal approach or through a lateral or posterior exposure to the iliac wing. Sacroiliac dislocation or sacroiliac joint fracture requires reduction of the hemipelvis displacement and correction of the rotational malalignment. These dislocations are stabilized in most cases with plate and lag screw techniques' [7].

Rommens [11] advised that a closed anatomical reduction of this fracture is not usually possible; limited open reduction of the iliac wing fracture and percutaneous sacroiliac screw placement can be combined here.

In a biomechanical study by Yinger *et al*. [12], they compared all nine common forms of posterior pelvic fixation and found that the stiffest fixation consists of two IS and two anterior sacroiliac plates and an IS, and the least stiffness was seen with single IS, two anterior sacroiliac plates, a tension band plate in isolation or in combination with an IS, and two sacral bars. These findings were contrary to most of the other studies [8,13–16] that found no differences between the strength of fixation techniques [8,12–16].

Our results were difficult to compare with those of Day *et al*. [2], as they treated only six cases with Day type III with closed reduction and percutaneous IS placement, and their functional scoring was carried out using SF 36. In our series we treated 22 cases of Day type II and Day type III and used the Majeed score for the evaluation of the functional outcome, which was found to be high in our patients compared with other posterior fixation studies.

In comparison with other publications of IS fixation for posterior fractures, our results were similar to the study by Schweitzer *et al*. [17], in 2008, on 73 patients. Although they had no patients with LC injuries, 86% were able to return to their preinjury level; they used the Majeed score but did not report it.

Conclusion

Conventional techniques of ORIF remain the standard of care for definitive treatment of pelvic ring and acetabular fractures. As these are not frequent lesions, recommendations for treatment and surgical techniques must be taught consequently. Anatomic reduction of articular lesions (sacroiliac joint and acetabulum) is the primary goal, followed by adequate stabilization. Only the experienced pelvic and acetabular surgeon is able to decide whether it is possible to achieve these goals through smaller incisions or even with a percutaneous procedure. Some authors consider that minimally invasive procedures can never completely replace conventional techniques for the treatment of these lesions if we do not want to accept compromises in obtaining anatomic reduction. As a consequence, percutaneous fixation is a complementary possibility for distinct fracture patterns and is almost never a first-choice procedure. The only exception may be the sacroiliac joint screw fixation [11].

Percutaneous IS fixation is a good option for types II and III crescent fractures, with lesser blood loss and shorter operative time compared with the plate option. The functional outcome of the cases fixed with IS was better; however, the difference was not statistically significant. ORIF using plate and screws could be used for type I crescent fracture.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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