The Internal Fixator: A Novel Technique for Stabilization of Transforaminal Sacral Fractures as a Part of Pelvic Ring Disruption. A Preliminary Report

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ABSTRACT

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 stabilize. Currently applied procedures for management of these fractures do not provide (In our opinion) the optimum compromise between safety, easiness, minimization of operative time, intraoperative blood loss and postoperative complications and regaining all range of movement around the fractured sacropelvis.

Therefore the authors developed a new technique that is characterized by being rapid, easy, safe, performed by minimally invasive technique and provides a reasonable stability almost without the need of fluoroscopy. It consists of one or two iliac screws connected by a transverse rod/rods and we are here giving this preliminary report about the new method.

KEY WORDS: Minimally invasive spine surgery, Posterior pelvic ring stabilization, Sacral fractures, Transforaminal sacral fractures

INTRODUCTION

Posterior pelvic ring injuries occasionally involve the sacrum. Such sacral fractures are frequently displaced and unstable and sometimes associated with neurologic injuries (9,14). Reduction and stabilization of such fractures are difficult and carries risks of several iatrogenic complications (1,16,17).

Posterior injuries of the pelvic ring frequently occur as transforaminal sacral fractures, and these lesions are probably the most difficult ones to reduce and stabilize (8). The surgical management 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. Transiliac bars, posterior ilio-iliac plates, local plate fixation of sacral bone, iliosacral screws and spino-pelvic triangular fixation have been described (2-4, 11,13, 16-18) and are reported to bring successful clinical results in various case series.

In a comparative biomechanical study, Simonian et al. (15) in 1996 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 mobilization as well as mechanical and neurological stability, are clearly an advantage.
Method

- Surgery was performed 48 hours after injury.
- LMWH given 12 hours before surgery after ultrasonography confirmed that the retroperitoneal haematoma was not expanding, given again 12 hours post operative (60IU) and every 24 hours for 35 days post operative.
- Anterior Pfannenstiel approach with anatomical reduction and superior symphysial plate fixation. Figure 2 shows the postoperative x rays.
- Patient brought to prone position after closure of the anterior wound in layers and in the same operative session.
- Two curvilinear incisions 2 cm long each were made medial to the posterior superior iliac spine (PSIS) (Figure 3). The length of the incision could be shorter (1 cm) but we wanted a larger incision for the first case as we did not know how much space do we need to put the screws and the rod safely, so we reduced size of incision in subsequent cases.
- Exposure of the PSIS.
- Rounger bite to the medial aspect of PSIS and area just below it.
- Application of 2, titanium, polyaxial, Iliac screws, 60 mm long each, 7 mm thick, one on each iliac bone, directed towards each ipsilateral greater trochanter without fluoroscopic aid. Figure 3 shows the surgical steps.
- Deep tunnel was created connecting the two incisions, deep to the paravertebral muscles, for the passage of the interconnecting rod.
- Rod applied between the two polyaxial screw heads (Figure 3).
- No trial was made for further reduction of the sacral fracture depending on the amount of reduction produced by anterior reduction & stabilization, that is because of the fear to compromise the sacral nerve roots by direct manipulation of the sacral foraminal fracture.

We checked the reduction by fluoroscopy once after anterior ring fixation and once after the end of the procedure. This check is not mandatory and can be easily omitted but was done in the first case for documentation.

Reviewing literature and managing large number of such fractures; the authors felt that the currently applied procedures do not provide the optimum compromise between safety, easiness, minimization of operative time, intraoperative blood loss and postoperative complications and regaining all range of movement around the fractured sacropelvis.

Therefore the authors developed a new technique that might be a revival of sacral bar technique but with a much more biomechanically effective way and is characterized by being rapid, easy, safe, performed by minimally invasive technique and provides a reasonable stability almost without the need of fluoroscopy.

Material

The first application of this technique was on a thirty five years old male, who had an unstable fracture pelvis (Diastasis of the symphysis pubis and posterior transforaminal sacral fracture (Figure 1).

Patient was haemodynamically unstable on admission with multiple contusions of the back and loins, fracture of D12 and L1 vertebrae, light haematuria determined to be due to bladder contusion according to the urologic surgery colleague, ultrasonography showed a small retroperitoneal haematoma and angiography showed no specific vessel to be embolizable.

The need for spinal instrumentation to fix the fractured spine inspired the authors with the idea of using polyaxial iliac screw spinal instrumentation connected to a transverse rod to stabilize the sacral fracture. The surgical plan consisted of anterior pelvic fracture reduction and plate fixation followed by posterior pelvic fixation using the novel technique then spinal fixation.

The patient and his next of ken were fully aware that this method is a new one, applied for the first time and that theoretically it should work but that it was still under investigation and that it will at least give primary stability and that when patient's general condition gets better we might choose to add to this posterior fixation in case it proves insufficient and they were consented on that. We followed this case for a full year before we started applying the new method freely to other patients after its efficacy was proven, we have chosen to do this for ethical considerations. We will describe the first procedure in detail and give one other example to the subsequent cases which are still being followed up.
Postoperative x rays showed almost anatomical reduction (Figure 2).

We had no perioperative complications and Patient was discharged from the hospital 5 days postoperative.

Anatomical reduction of pelvic ring anteriorly and secure stabilization, restoring the relation between the two pubic bones are usually the clues of good reduction of the whole pelvic ring per se when this is indicated.

Our total operative time was 70 minutes including both anterior and posterior fixation. Blood loss was 80 cc.
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Post operative protocol and follow up

Sitting was allowed in the first 48 hours postoperative, once postoperative pain permitted. Non weight bearing, crutch aided walking was allowed 4 weeks after the operation and toe touch weight bearing was started at 10 weeks postoperative, which progressed slowly to full weight bearing at 16 weeks postoperative as there was no pain on walking.

The patient was followed regularly every two weeks till 12th week, then every month till 6 months then at 8, 10 & 12 months.

At 6 months postoperative the patient restored a normal gait, had equal limb length and had only minimal back pain on prolonged activity and could return to his previous job (accountant). The patient had very little complaint related to hardware prominence probably because he was a bit overweight.

Radiological follow up revealed a minimal widening of the pubic symphysis gap at 2 months followup, about half a centimeter, and minimal change in the sacral fracture position (Figure 4).

This change stayed throughout the follow up period with no further displacement nor any evidence of hardware loosening or failure.

At three months follow up visit we performed a CT scan for the patient (Figure 5).

Complete fracture union was evident at 12 months follow up x rays (Figure 6). Although the bone filling the

Figure 2: Immediate postoperative x rays of case one. A) Inlet view B) Outlet view.

Figure 3: Operative steps of case one: A) First iliac screw application. B) Screw application to the contra lateral iliac bone. C) Rod applied to both screw heads after passing it in deep sub-muscular tunnel.
Figure 4: Two month follow-up with minimal loss of reduction within acceptable ranges. A) Inlet view. B) AP view.

Figure 5: A,B) Three months follow-up CT: Shows callus formed inside the sacral fracture defect although not as dense as normal sacral bone density. Note the screws between iliac tables (B is a 3D reformat).

Figure 6: 12 months final follow up with full union. New bone at sacral defect is less dense than the rest of the sacrum, but lack of a loss of reduction or implant failure were our clues to full union. A) Outlet view. B) Inlet view.
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DISCUSSION

In the management of sacral fractures, the optimum implant should allow easy and rapid insertion reducing the operative time, surgical dissection and blood loss, preferably applied by minimally invasive technique since most of these patients are poly trauma victims. It should also provide sufficient stability to allow postoperative mobilization or preferably ambulation.

Additional desired implant properties include that the implant can help in manipulating and reducing the sacral fractures if needed. Also the implant should not jeopardize movements around the fractured pelvis allowing patient to regain pre injury level of activity.

Specifically for transforaminal sacral fractures, minimization of manipulation around the fracture is needed to decrease possibility of neurologic compromise. We need a method of fixation that is forgiving for minimal displacements that won’t affect patients’ clinical outcome.

A Low profile implant is preferable to decrease problems of subcutaneous hardware position. Unfortunately the currently used implants do not fully fulfill all these criteria.

Simonain, et al in 1996 demonstrated that transforaminal sacral fractures fixed with transiliac plates, sacral screws, transiliac compression rods or local plates were less stable than intact pelvis (15). Therefore early weight bearing is usually restricted with these implants.

sacral fracture gap remained less dense than the rest of the sacrum, but absence of pain during walking, absence of any hardware failure and maintenance of reduction since the minimal displacement that was noted at 2 months follow up while the patient was fully active and walking; were our clues to full union.

We did not apply this method for any subsequent patients till we were sure that it was a success with our first patient. We applied it to subsequent cases and we shall fully report them when they have a reasonable follow up period.

We did a modification on our technique in some cases. We were able to put two iliac screws on each side connected by two rods (Figure 7 and 8). This modification was done when we needed more posterior stability, like in this case when we did not need anterior ring stabilization. It helped us in this case to reduce anteriorly sheared hemipelvis as we used same idea of reduction of anteriorly slipped vertebra in cases of spondylolisthesis. When we apply our fixation to the iliac bones, connect by rods, this brings the displaced hemipelvis to align to the normal side causing near anatomical reduction (Figure 8).

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Figure 7: Preoperative x rays and CT of the second case that showed the injured hemipelvis to be anteriorly sheared. A) AP view B) CT.
Figure 8: Postoperative x rays and CT of the second case that show full reduction of the fracture using our modified technique and that the two iliac bones became leveled with complete reduction of the anteriorly sheared hemipelvis. The position of the screws between iliac tables is also evident. The anterior ring is fully reduced as well indirectly and needed no fixation. A,B,C) Postoperative CT, D) Postoperative AP view, E) Postoperative inlet view, F) Postoperative outlet view.
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Ilio-iliac plates have been described but they require more dissection with more soft tissue compromise, more blood loss and more operative time. Suziki et al (17) in 2009 had a mean operative time of 243 minutes and a mean operative blood loss of 1053 ml and postoperative wound infection in two of 19 cases. Both cases of infection had a Morel-Lavallée injury of the skin at the back of the sacrum, an injury which is not uncommonly associated with sacral fractures. Ayoub in 2009 had postoperative infection in 4 of 32 cases (2). So although this method is seen to be an effective method for reduction and fixation of vertically unstable sacral fractures especially when associated with neurologic deficit giving the option of directly decompressing sacral nerve roots, it involves major dissection in an area already contused with higher rate of wound dehiscence and skin complications.

Iliosacral screws were described both by percutaneous and open techniques (1,4,16,18). The disadvantages of this technique are that they need an experienced surgeon and good fluoroscopy to achieve anatomical reduction and a perfect screw position. Mal reduction or inadequate screw position may lead to neurologic injury or loss of reduction and fixation (1,4,16). Also the strength of fixation is limited especially in sacral fractures with vertical shear (1,17). There is always a concern of over reduction and there is a continuous debate about best positioning for the patient during surgery whether supine or prone (13).

The lumbo-pelvic triangular fixation provides the highest mechanical stability in Denis zone 2 and 3 sacral fractures. However it is considered an overtreatment in zone 1 sacral fractures (4,17). Disadvantages include being a big operation with operation time of 90 – 120 minutes, also it will cause restriction of waist movement and problems related to prominent hardware (1,12,13).

Transiliac rods have a high incidence of hardware removal due to subcutaneous metal prominence (19). According to McCord et al in 1992 (10), for any implant attached to the sacropelvis, at least part of the fixation tool should pass anterior to the pivot point (which is the axis of rotation at the lumbo-sacral junction and lies in the intersection of middle osteoligamentous column and L5-S1 disc) in order to rigidly fix this area against rotational stresses (10). There is more biomechanical advantage if it extends caudal to this point as well.

Transiliac sacral bars in their traditional form do not fulfill any of these two criteria and thus are only an obstacle for flexion and extension without adding real rigidity for the fracture.

Harma and Inan in 2005 fixed transforaminal sacral fractures by 2 sacral bars assembled on S1&S2 pedicle screws on the intact side and attached to a plate adapted to the iliac wing on the fracture side. Multiple iliosacral screws were inserted through the plate to add to stability (7). Both tools in this method do pass infront of the pivot point and thus are more biomechanically effective than traditional transiliac sacral bar.

But this is a big operation with much hardware & prolonged operation time. Also safe application of S1&S2 pedicle screws and iliosacral screws need much fluoroscopic guidance that adds to operative time and exposure risk for both the patient and the surgery team.

Authors of that work also stated that, as in all other posterior approach procedures, it is contraindicated in the presence of open or closed Morel-Lavallée skin lesions (which are not uncommon with this fracture entity) and that although they did not face this problem, many authors reported increase in the incidence of skin problems when internal fixation materials are used in this region (6,8).

The internal fixator we are introducing has the following advantages:

1- It is a very fast & safe technique that doesn’t need much experience or fluoroscopy thus it is suitable for polytrauma and critically sick patients.

2- Safety of application doesn’t depend on accurate reduction of the sacral fracture. A reasonable reduction obtained through anterior pelvic ring reduction and stabilization is usually enough, and minimal residual sacral mal reduction that would not affect leg length discrepancy could be accepted with no need for further manipulation that might cause neurologic injury (a forgiving technique).

3- Long thick screw up to 90-100 mm long & 7mm thick can be applied. It is possible to apply 2 screws on each side with two connecting rods to add more stability when needed.

The area we aim at when we put our iliac screws is above the acetabulum and along the iliopectineal line, from an anatomic prospective it is an area of strong, thick bone suitable for screw insertion (5).
Also a long part of the iliac screw passes anterior and caudal to the McCord point which gives this method a biomechanical superiority (10).

4- After application of the screws they can be used as joysticks to manipulate the fracture by distraction and compression of the screw heads along the rod/rods.

Mere application of the rod can bring a displaced iliac bone to level the normal side, a kind of reduction that resembles that of anteriorly slipped vertebra gets reduced by means of reduction screws and rods.

So this technique works as a fixator in the ability to readjust the fracture position during the operation after assembling the device if the surgeon feels that reduction is not satisfactory and hence we gave the method the name of INTERNAL FIXATOR.

5- Very small skin incisions and the absence of any major dissection would spare the patient any further jeopardy to the possibly contused or devitalized skin of this area which is a huge advantage especially with suspected or diagnosed Morel-Lavallée skin lesions.

6- The authors feel that the indications of this technique could be extended to other posterior pelvic ring disruption modalities.

The authors are implementing this method in their institute after this initial success with the approval of the school of medicine IRB on all the steps and a biomechanical as well as clinical evaluation of this technique is being conducted and will be subsequently reported. Ideas are also being discussed to get the implant to be of a lower profile although patients did not complain of painful hardware till now. This became possible after we began applying the screws with their heads just medial to the PSIS.

CONCLUSION

The internal fixator is a quick and safe method for fixation of transforaminal sacral fractures. It is also easy and forgiving allowing readjustment and some fracture reduction after implant application.

However further biomechanical and clinical studies are required for further evaluation of the technique on a larger number of patients and for a longer follow up period.

Also further development of specific instrumentation and implants for this technique with a lower profile and optimum stability is one of the authors future goals.

REFERENCES


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