18 Pelvic Fracture Failed Fixation

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History of Previous Primary Failed Treatment

A 59-year-old morbidly obese male, with 23-year pack year history of smoking, was involved in a motorcycle collision 6 weeks prior and underwent operative management of his pelvic ring at a Level 1 hospital in North America. He has been non-weightbearing bilateral lower extremities and original imaging was not able to be transferred. He states that his pain has improved over the past 4 weeks, and he rarely takes narcotics. His pain in the back of his pelvis is worse than the pain in the front. Furthermore, he is interested in starting to weightbearing so he can get back to work.

Radiographic evaluation at 6 weeks utilizing 3 views of the pelvis was performed (Fig. 18.1). Radiographs supported a pubic symphysis disruption that was reduced and plated. One of the six small fragment screws was partially backed out. A partially threaded large caliber cannulated screw used in the posterior aspect of the pelvic ring across a left sided Zone 2/3 junction sacral fracture. The screw was showing evidence of strain with slight bend in the middle and haloing around the screw.

Clinical plan at this point was to keep the patient non-weightbearing bilateral lower extremities and obtain imaging in 2 weeks to determine if signs of hardware failure had progressed. The patient missed appointment and presented at 12 weeks postop with significant increase in pain.

Radiographs at 12 weeks demonstrated multiple failed points of fixation at the anterior aspect of the pelvic ring (Fig. 18.2). The sacroiliac (SI) joint was also slightly wider and in retrospective evaluation of his 6-week films, the joint appeared slightly wide then. Significant haloing was also noted around the posteriorly based screw.

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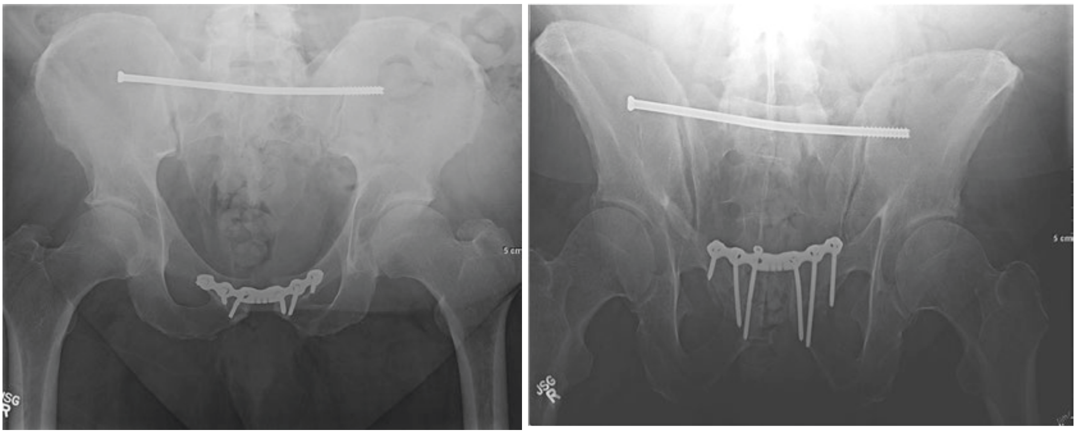

Fig. 18.1 6 week post-op AP and outlet X-rays

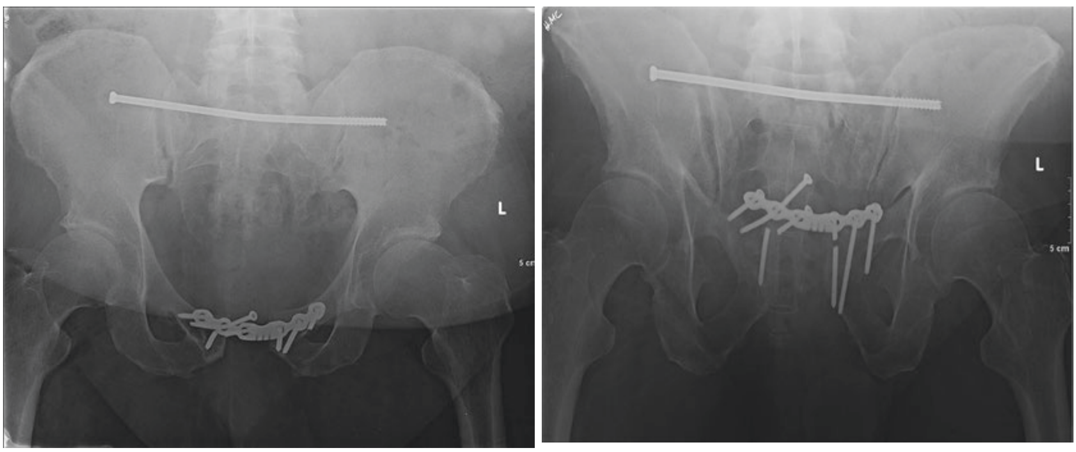

Fig. 18.2 12 week post-op AP and outlet X-rays

Evaluation of the Etiology of Failure of Fixation

This is a challenging case considered the injury pattern and the patient's body mass index (BMI). The etiology leading to hardware failure and non-union was likely the result of insufficient reduction and fixation posteriorly. This resulted in catastrophic failure of the anterior hardware resulting in a pelvic malunion.

Clinical Examination

On examination he is a super obese appearing male of stated age in a wheelchair (BMI 60). He could transfer from wheelchair to clinic bed with significant increase in pain over the anterior aspect of his pelvis. His anterior-based incision is hidden underneath a pannus, it is well healed. The percutaneous screw insertion site wounds have healed. No other pertinent findings on exam.

Diagnostic-Biochemical, and Radiological Investigations

A computed tomography (CT) scan was ordered and demonstrated a partially threaded screw that was crossing a widened SI joint and a gapped left sided sacral fracture (Fig. 18.3). Furthermore, the symphysis was disrupted.

Infection workup was also performed, and erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), and white blood cell (WBC) were within normal limits. Vitamin D was found to be low at 13.1. Calcium levels were normal. The patient was treated with 2000 U daily for 6 weeks to replete his vitamin D levels.

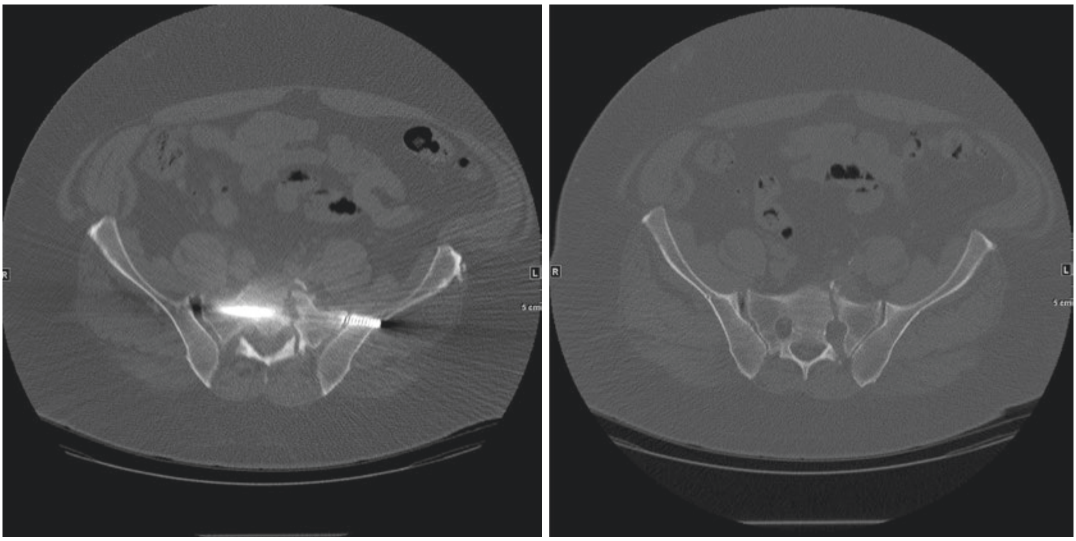

Fig. 18.3 CT posterior pelvic ring with sacral fracture gap and wide right sacroiliac joint

Preoperative Planning

Clinical challenge is failed fracture fixation of the pubic symphysis and posterior pelvic ring in a morbidly obese male at 3 months. This patient has three distinct injuries which have no evidence of healing; a pubic symphysis diastasis, a right sided sacroiliac joint disruption, and a potentially atrophic gapped sacral fracture. The treatment options of the individual components of the injury will be discussed, followed by a summary of the surgical plan.

Anterior Ring Injury

There are several options to be considered regarding the anterior pelvis. Treatment options include non-operative management, external fixation, internal fixation with pedicle screws and bar, and revision internal fixation with plates and screws. Each one offers a different mechanical construct in addition to coming with its own risk benefit profile for this individual patient.

First, given the patient's body habitus and weight, the anterior pelvis could be managed non-operatively to avoid complications associated with surgical intervention. However, non-operative management is likely to result in poor reduction, a greater likelihood of gait disturbance, and overall worse outcomes [1–5]. This patient is at increased risk for developing pelvic pain, symptomatic leg length inequality, and rotational deformity of the lower extremity [1, 2]. Not intervening now could potentially result in an even more difficult surgery as the deformity could worsen and additional scar tissue could form. For these reasons we felt that some form of anterior fixation was needed.

The least invasive surgical intervention anteriorly would be external fixation. Pins can be placed into the iliac crest or into the supracetabular corridor. Risks associated with external fixation include developing a pin site infection, with the potential for development of osteomyelitis, and lateral femoral cutaneous nerve palsy [6–8]. Operative risks are even higher in morbidly obese patients with a BMI of 40 or greater [9]. Additionally, if external fixation was chosen the patient's pannus would likely be rubbing against the external fixation device, limiting the patient's ability to sit up. Hupel et al. showed that anterior external fixation in isolation was unable to provide sufficient stabilization of the pelvic ring in obese patients compared to non-obese patients [10]. Not only is there no literature to support the use of an anterior external fixation device in the setting of revision symphyseal fixation, but it would be unlikely to close the symphysis without opening and removing the scar tissue surgically given the amount of scar tissue that has formed as the patient is 3 months post-op. Given the myriad of complications and the literature demonstrating anterior frames cannot hold the anterior pelvis reduced in obese patients, external fixation was felt to not be a reasonable option for the anterior pelvis.

A minimally invasive form of anterior fixation would be use of pedicle screws with a bar, also known as an in-fix. This would allow for a more stable construct compared to an external fixation device and would also avoid the pin site complications [8, 11]. The patient would also be able to sit upright to a greater extent than a patient in an external fixator. They would not have the external bar rubbing against the pannus or compressing the thighs [12]. However, fixation with pedicle screws and bar would predispose the patient to additional complications such as risk for femoral nerve palsy, deep infection, and heterotopic ossification [6, 11]. Newer techniques have been developed to stiffen the overall construct by adding an additional pedicle screw into the pubic body [8]. Though with this additional pedicle screw it still is not the stiffest construct for the anterior pelvis [7]. Another downside for using an internal fixator is the eventual need for removal of the pedicle screws and bar [6, 8, 11–13].

The most invasive intervention would be an open reduction and internal fixation of the pubic symphysis, which has several advantages. Anterior plating allows for a more anatomic reduction of the symphysis and provides a stiffer construct than the use of pedicle screws and bar [6, 7]. Plating of the anterior symphysis comes with the highest risk of complication, especially in revision cases. Performing an open reduction and internal fixation of the pelvic ring exposes the patient to increased bleeding and risk of deep infection [6]. The dissection of the symphysis is even more difficult in revision cases where scar tissue from previous surgeries can be adherent to the bladder leading to disruption of the bladder wall during dissection, or inadvertently cutting the bladder, or other critical structures such as the corona mortis during the approach. Not only is a revision case more difficult, but the obesity of the patient will add additional challenges to this case. There will be a large amount of soft tissue to dissect, the pannus will make placement of reduction clamps more difficult and will make getting the appropriate trajectory for the symphysis plate screws more difficult. These complications could all be avoided with either an external fixator or internal fixator; however, it is unlikely that the symphysis would be reducible. Opening the symphysis would afford us different reduction techniques such as placing a point-to-point clamp or using a Jungbluth clamp. It was felt that performing an open reduction and internal fixation of the anterior pelvis would provide the best opportunity to obtain an anatomic reduction and provide the most stable construct possible. Also reducing and plating the anterior pelvis would help reduce and stabilize the posterior pelvis. Additionally, opening the anterior pelvis provides the opportunity to add a second plate to increase the stiffness, but this requires additional soft tissue dissection, may prolong the surgery, and increases the bleeding time [14, 15].

Posterior Ring Injury

The posterior pelvic ring provides the issue of having bilateral injuries. On the right side the sacroiliac joint is wide anteriorly and malreduced. On the left side there is a zone two sacral fracture which extends into the S1 sacral body cranially. This fracture is also still gapped, and while there is some callus present at the sacral ala on CT scan, there are no signs of healing throughout the rest of the fracture. The risks and benefits of each possible surgical strategy for each of the posterior injuries must be considered carefully. The left sided sacrum must have bone-to-bone contact and held with a stable construct for it to heal and the right sacroiliac joint must be reduced and held with sufficient fixation for it to heal. In this instance the sacrum was gapped and the whole construct only had one point of fixation with a right to left 6.5 mm partially threaded transiliac transsacral screw with 32 mm of threads placed initially. This screw had threads in the left ilium only and thus was trying to compress the right sacroiliac joint and the left sided sacral fracture. While a single screw may be able to compress the right sacroiliac joint, it will not provide sufficient compression across the left sacral fracture. A single screw is also likely not enough to control the flexion and extension of the right hemipelvis and vertical translation of the left hemipelvis [9, 16].The catastrophic anterior hardware failure and residual displacement in the posterior pelvic ring are likely due to lack of reduction and insufficient fixation construct posteriorly. Now the patient has an anteriorly gapped complete sacral fracture with broken hardware anteriorly, revision surgery was chosen as treatment for this patient.

Given the morbid obesity of our patient the potential complications of each intervention must be considered. Achieving an anatomic reduction of both the right SI joint and the left sacrum is paramount. For the sacrum to heal it must be reduced, compressed, and held with adequate stability. The most aggressive, but likely best means of obtaining an anatomic reduction for the sacral non-union would be to perform a prone open sacral reduction. Performing an open reduction would also allow for the fracture to be debrided of fibrinous tissue and allow for adjuvants such as allograft, autograft, or other factors to be added to the fracture site to help promote healing. However, an open posterior approach in a morbidly obese smoker has a high infection risk and wound complication rate, which could be more detrimental than the non-union [9].

Performing a supine open reduction of the right sacroiliac joint would again predispose the patient to infection and reaching the sacroiliac joint in a patient of this size would be very difficult given his massive body habitus. With this understanding, alternative means of improving the reduction were assessed. One way of adding extra-compression to the posterior pelvic ring would be the use of the c-clamp. This device could be placed either in the posterior aspect of the pelvis or onto the gluteal pillar to help compress the posterior pelvis. Again, because of the body habitus of the patient this would not work as the clamp points would not be long enough to reach the gluteal pillar. An alternative to these methods would be using multiple screws to preferentially squeeze the sacrum and provide additional points of fixation to stabilize the posterior ring. This could be achieved by using partially threated screws to provide compression. Review of the patients pre-operative CT scan showed the patient had large osseous sacral corridors that would be able to accommodate multiple screws. Given the residual displacement of the left sacral fracture and the right sacroiliac joint we felt that using multiple screws from both directions to help further reduction of the right and left posterior ring injuries would compress both and provide adequate stabilization to the posterior pelvic ring to heal.

Additionally, lumbopelvic fixation can be added to stabilize the posterior pelvis. In vitro studies have shown that ilio-sacral screw fixation combined with lumbopelvic fixation, effectively forming an osteosynthesis triangle, provides greater stiffness of the construct compared to ilio-sacral screws alone [17]. While triangular osteosynthesis has shown to increase construct stability it comes with its own set of complications and high need for removal [18]. Adding a lumbopelvic construct to our patient may increase the overall stability, but it increases the risk of infection as there is a high wound complication rate associated with morbidly obese patients undergoing spine fixation [19, 20]. After discussion with our spine colleagues the risk associated with performing lumbopelvic fixation, even percutaneously, would not outweigh the benefits given the high risk of infection and complications that can come with it.

After weighing all options, it was felt that a percutaneous reduction of the posterior ring with a combination of partially threaded ilio-sacral screws and transiliac-transsacral screws was the least invasive and most likely to obtain positive outcomes with relative low risk. The large osseous corridors would allow multiple ilio-sacral screws and transiliac-transsacral screws at both the S1 and S2 corridors. This would allow maximum compression and increase the stability of the fixation construct. Decision was made to forego adding lumbopelvic fixation given the increased morbidity of the procedure and because of the multiple points of fixation that the bony osseous corridors would allow. Furthermore, if the current plan was not successful, then the addition of lumbopelvic fixation could be used as a secondary plan.

As is customary in the treatment of non-unions, allograft, autograft, and other factors are frequently used to help obtain union. Autograft, allograft, and factors such as bone morphogenic protein, could potentially provide a benefit in the setting of sacral non-union [21, 22]. Autograft harvested from the posterior crest would provide ample graft, and it could be used in the fracture after debridement. Alternatively, case reports have shown bone morphogenetic protein (BMP) to potentially be beneficial in cases of refractory sacral non-union [21]. Performing percutaneous reduction and fixation would sacrifice the ability to use bone graft and other substitutes, but in this instance, the minimal gap could most likely be closed down with multiple large caliber lag screws.

Revision Surgery

To summarize there was an anterior symphysis injury with hardware failure, a partial right sacro-iliac joint disruption with gapping anteriorly, and a left zone 2 sacral fracture with minimal signs of biological healing and persistent gapping. Plan for this patient was to start in the front with the removal of hardware and then revision fixation of the anterior symphysis followed by percutaneous posterior public ring fixation. By starting in the anterior portion of the pelvic ring we would be able to remove the broken hardware and then clamp down the symphysis to reduce it. As discussed, considerations to take into account for this surgery are the amount of scar tissue present which may preclude the dissection and freeing up the bladder. Preoperative CT scan showed that the bladder was near the symphysis and may even be partially incarcerated (Fig. 18.4). Given this a urology team member assisted with the dissection of the anterior pelvic ring and inspected the bladder for injury, once the anterior pelvic ring was dissected and the bladder was inspected. There was a small tear noted, which was repaired by the urology team. It was then protected, and the broken hardware was removed. Once the hardware was removed the symphysis was cleared of any scar tissue and the symphyseal cartilage was also removed to increase the construct stability by increasing the frictional forces through bone-to-bone contact [23]. This may also aid in fusion and healing of the symphysis. Attention was then turned to reducing the symphysis. There are multiple ways to approach this. One way to do this would be to apply 5.0 mm supracetabular Shanz pins and apply an external fixator device to help close the symphysis. This technique does not work as well when multiplanar correction is needed. Other considerations for reducing the anterior pelvic ring include the use of a point-to-point reduction clamps placed anteriorly. However, this relies on the quality of the bone and can be challenging to correct when deformity is present in multiple planes. Alternatively, a Jungbluth clamp can also be used, which allows for control in multiple planes. In this instance we used a Jungbluth clamp to aid in the reduction of the anterior surface (Fig. 18.5). This was performed by placing 3.5-mm screws anteriorly on each side of the symphysis and then

Fig. 18.4 CT scan showing bladder near the pubic symphysis

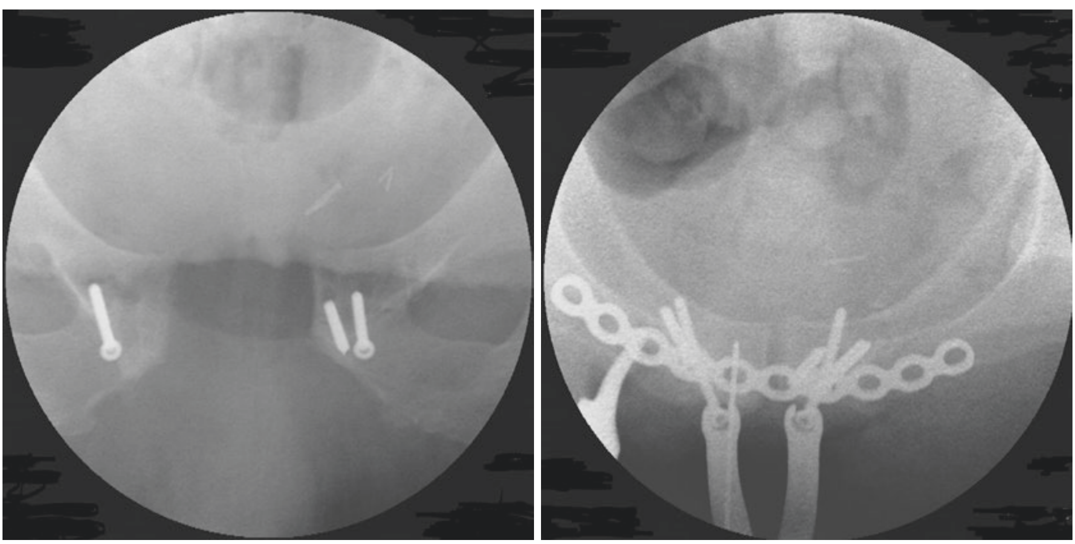

Fig. 18.5 Intra-op fluoroscopic images showing reduction of the anterior pelvis with a Jungbluth clamp

using the clamp to control the reduction. In most cases the following reduction steps can be useful when using a Jungbluth; reduce the pubic symphysis widening, reduce any flexion/extension deformity, and last correct anterior or posterior translation. After reduction was obtained, a 3.5-mm reconstruction plate was placed on the superior aspect of each parasymphysis to hold the reduction and keep the symphysis closed down. This plate was longer than the previous plate and had different hole spacing, which allowed for additional screws to be placed on each side of the symphysis in bone that had not been used at the initial surgery. These screws are placed in a cranial to caudal direction and placed bicortically to make sure that they have a greater purchase. Given the size of the patient and the fact that this was a revision case, a second plate was added anteriorly. This was a 2.7-mm plate placed on the anterior aspect of the symphysis and rami with multiple bicortical screws heading in the anterior to posterior direction. The cranial 1/3 of the rectus attachment site on the pubic body needs to be elevated to allow the placement of this plate. By performing symphysis reduction first, the right sacroiliac joint reduction improved.

Once the anterior pelvic ring was reduced and stabilized, attention was placed on the posterior pelvic ring. Again, given the patient body habitus it was felt that the best option to obtain a stable construct and minimize complications was to perform a percutaneous reduction using a combination of ilio-sacral and transiliac transsacral screws. First started by placing a partially threaded ilio-sacral screw across the right sacroiliac joint to compress this joint and reduce it. The start site started slightly posterior and aimed just cranial to the S1 foramina and directed a screw with a washer into the sacral body stopping just shy of midline, given the fact that he had a fracture line extending into the sacral body on the left side. Before final tightening, the previously placed right sided transiliac-transsacral screw was removed. With final tightening this screw further reduced and compressed the right sacroiliac joint. Then a guide wire was placed for a left to right transiliac-transsacral screw with partial threads inferior and slightly anterior to the right to left transiliac-transsacral screw going across S1. This screw was also a transiliac-transsacral style because the maximum compressive force was desired, by having the threads across multiple cortices. Furthermore, potential screw compromise could occur if the screws were placed into the sacral body, secondary to the left sided sacral fracture extending into the sacral body. This screw also provides support to the right side of the posterior ring and had a force vector that was orthogonal to the fracture line. Prior to final tightening of the left to right transiliac-transsacral screw the right screw was removed to allow for compression across the left sided sacral fracture. Once this was placed another partially threaded transiliac-transsacral screw was placed across the original S1 corridor. Originally a 7.0-mm screw was used, this was upsized to a 7.5-mm screw, which provided excellent purchase and added additional compression across the left sided sacral fracture and again added additional stability to the right side of the posterior pelvic ring. After this screw was placed two partially threaded transiliac-transsacral screw in the S2 corridor to provide further compression to the left sided sacral fracture. Once this screw was final tightened, a fully threaded ilio-sacral screw anterior to the first left to right screw placed in the S1 corridor to reinforce the construct. This construct maximized the posterior pelvic ring stability and took advantage of the large osseous corridors. With revision open reduction and dual plating anteriorly, and six screws posteriorly, this treatment plan maximized construct stability while minimizing the potential risk to the patient.

Post-operative Course

Post-operatively the patient received 24 h of intravenous antibiotics. Immediate post-operative X-rays showed a reduced pelvic ring anteriorly with several screws placed in the posterior pelvis through the ilium and sacrum. All hardware appeared to be safe on imaging (Fig. 18.6). A post-operative CT scan was obtained to make sure all the screws were in a safe position and to evaluate the amount of compression across the posterior pelvic ring (Fig. 18.7). This showed that the technique used compressed the left sacral

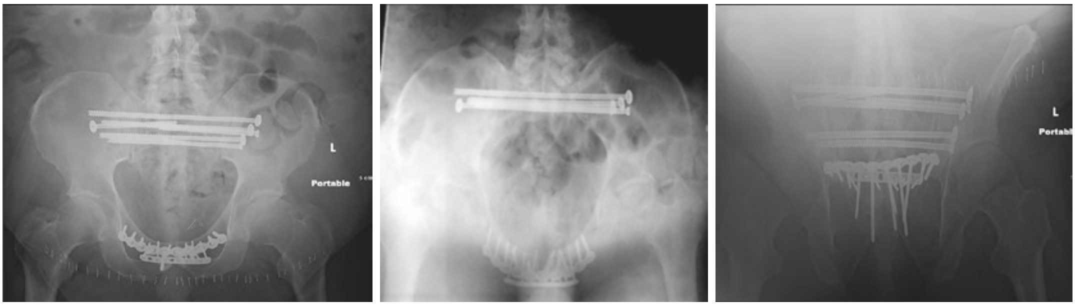

Fig. 18.6 Immediate post-op AP, inlet and outlet X-rays

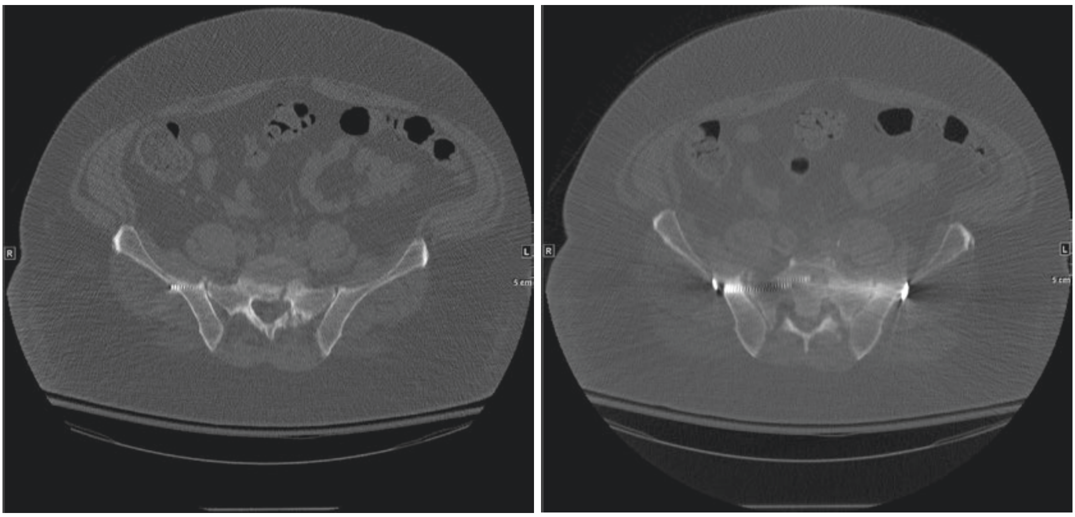

Fig. 18.7 Immediate post-op CT scan showing reduction of the right sacroiliac joint and decreased gap across the left sacral fracture

fracture and had improved the alignment of the right sacroiliac joint. The patient was placed on enoxaparin 40 mg BID for 6 weeks for deep venous thrombosis (DVT) prophylaxis. This was chosen given his BMI. Drains were placed anteriorly to help prevent the formation of a of a post-op hematoma. These were removed once the drainage was less than 10 cc per 12-h shift. He was kept non-weight bearing bilateral lower extremities and was slide board transfer only for 12 weeks. Due to the work of Brinker et al. vitamin D 25-hydroxy and calcium levels were checked. The patient was found to have a low vitamin D 25-hydroxy and was started on 2000 U daily for 6 weeks for repletion to maximize the patient's healing potential.

He was discharged from the hospital post-operative day 8. He was seen back at 2 weeks and staples were removed from his incisions without any issue. At 6 weeks the patient was seen in the clinic and was noted to be pain free. X-rays were obtained that showed maintenance of the alignment of the pelvic ring and without any signs of loosening of the hardware. The patient was seen back at 3 months post-operatively with pelvic X-rays that showed the pelvis had maintained alignment and there were no signs of loosening. He was allowed to be weight bearing as tolerated at this visit. Final follow-up at 2 years post-op showed that the patient had maintained reduction of his pelvic ring (Fig. 18.8) and was pain free and returned to his manual labor job.

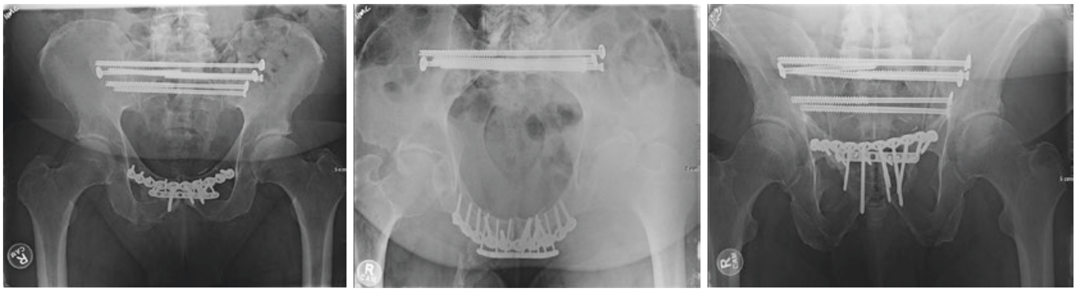

Fig. 18.8 2-year post-op AP, inlet and outlet X-rays

Summary: Lessons Learned

In summary this is a challenging case given the injury pattern and the patient's body habitus. The failure leading to non-union was likely the result of insufficient reduction and fixation posteriorly. This resulted in catastrophic failure of the anterior hardware resulting in a pelvic malunion. Initially, the patient was assessed at regular follow-up intervals. However, the treating team did not have the initial injury imaging. As a result, subtle findings of the right SI joint injury and the left zone 2 sacral fracture were underappreciated. Retrospectively, more effort should have been placed on obtaining the original imaging. Review of these images would have most likely led to an earlier surgical intervention. Even without the initial injury imaging the treatment team could have intervened earlier and added additional fixation to the posterior pelvic ring right when the patient first presented to clinic. However, he did not present until 6 weeks post-op and at this time he was already demonstrating signs of loosening and it is unknown whether additional posterior fixation would have prevented this catastrophic failure. Had the patient been seen immediately post-op with his initial imaging, the team would have likely leaned toward provided additional fixation. As a result, the patient required a significantly more complex revision surgery. However, an excellent outcome was obtained using the discussed treatment strategy.

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