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Original Article

From heel to hip: medial buttressing for quadrilateral plate fractures of the acetabulum with a locking calcaneal plate

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Abstract

Background: Complex acetabular fractures involving the quadrilateral plate (QLP) present significant surgical challenges due to poor bone quality, the inherent thinness of the QLP, and the proximity of significant neurovascular structures. While modern anatomical plates exist, their high cost and limited accessibility remain barriers. This study evaluates a novel, cost-effective surgical technique using a locked titanium calcaneus plate combined with a suprapectineal reconstruction plate for medial buttressing. **Methods:** A total of 60 patients treated for acetabular fractures between 2016 and 2025 were reviewed. Ten patients specifically underwent medial buttressing for QLP fractures. Among these, five patients received a locked titanium calcaneus plate fixed to a suprapectineal reconstruction plate. Clinical and demographic data, fracture classifications (Letournel and Judet), and postoperative reduction quality (measured via CT scans) were analyzed. Reduction was categorized as anatomical (< 2mm) or non-anatomical (≥ 2mm). **Results:** The mean age was 39.5 ± 16.1 years. Posterior wall fractures were the most common elementary pattern (60.6%), while anterior column with posterior hemitransverse fractures predominated the complex group (37%). Postoperative CT scans showed anatomical reduction in 83.3% of the total cohort. The mean follow- up was 11.5 months. The surgical approach was predominantly Kocher-Langenbeck (60%), followed by the modified Stoppa (30%) and ilioinguinal (10%) approaches. **Conclusions:** Combining a locked titanium calcaneus plate with a suprapectineal reconstruction plate is a viable and effective alternative for stabilizing complex QLP fractures. This technique provides stable medial support using widely available implants, making it a good option in clinical settings where patient-specific or modern anatomical plates are unavailable.

Keywords: Quadrilateral plate, calcaneal plate, acetabulum fractures, quadrilateral surface, spring plate, medial buttressing

Introduction

The quadrilateral plate (QLP) refers to the medial wall of the acetabulum and shows age-related thinning [1]. It has a trapezoidal shape with four sides and a thickness of 3-4 mm [1]. In computed tomography (CT)-based analysis of the medial wall of the acetabulum, the thinnest point of the wall has been identified as 0.6 - 1.2 mm [2]. Fractures of the quadrilateral surface (QS) of the acetabulum constitute approximately 10-15% of all acetabular fractures, and the treatment of these fractures remains one of the challenging problems [3]. These fractures can vary from a simple fracture pattern to a highly comminuted pattern [1].

QS is usually associated with medial femoral head subluxation and is seen particularly in elderly patients [1-3]. The deep location of the QS, the thin bone structure, the surrounding anatomical structures, and the fact that it is often seen as a fracture in osteoporotic elderly patients present technical challenges [4-6]. As the population ages, the number of osteoporotic fractures in the QS also increases [5]. Another reason QLP fractures occur is due to high-energy trauma in young patients [1,4-6].

In the current classification of acetabular fractures, QLP fractures are not listed separately. However, all fractures other than simple fractures are included in this region according to the Letournel and Judet classification [5]. The most frequently

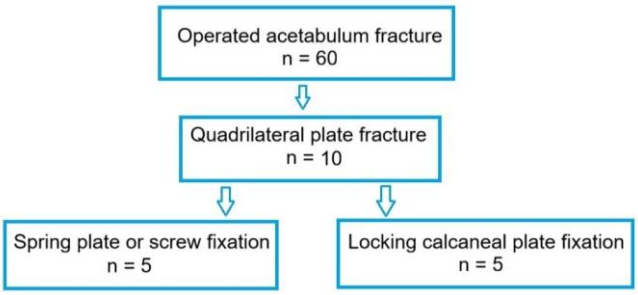

Figure 1. A flow chart of inclusions.

associated fracture types with fractures of the QS are: both-column fractures, anterior column and posterior hemitransverse fractures, posterior column fractures, and transverse fractures, including T-shaped fractures [1,7]. On the other hand, it has been reported that a certain portion of acetabular fractures involving the QS do not conform to the Letournel classification system [6,8].

In general, many surgeons have proposed various methods and implants for the pathology of this region [6]. Currently, specially designed plates are also available for QS fractures [4,6,9-11]. Due to limited use, difficulty in access, and high cost, QS is used by modifying various screw and plate systems [4,6,9-11]. While these fixation techniques can achieve satisfactory results in most patients, they require extensive surgical experience and skills [9-11]. In the surgical fixation of fractures in this region, screws can easily penetrate the joint [9-11]. On the other hand, if an acetabular fracture involving the QLP is inadequately repaired, the resulting discordance can lead to post-traumatic hip arthritis and cause significant pain and dysfunction [4,6,9-11].

We designed a method of applying a locked titanium calcaneus plate combined with a titanium reconstruction plate for the surgical treatment of QLP fractures of the acetabulum. Patient follow-ups showed that it provided reasonable treatment stability and good results for QS fractures. Our aim is to evaluate the clinical and radiological outcomes of our patients with this new surgical technique we have developed, and to demonstrate that locked calcaneus plate modification is a viable treatment option for medial support of QLP fractures of the acetabulum.

Materials and methods

A total of 60 patients who underwent surgical treatment for acetabular fractures between January 2016 and December 2025 were included in this study. Among these, ten patients received medial buttressing for QS fractures. Specifically, four patients underwent QS support using a spring plate (SP) technique secured to a suprapectineal pelvic margin plate. In one patient, the QS was stabilized with screws through a suprapectineal plate. In the remaining five patients, the QS fracture was medially buttressed using a locked titanium calcaneus plate fixed to the suprapectineal pelvic margin plate (Figure 1). Inclusion criteria consisted of patients over 18 years of age diagnosed with an acetabular fracture. Exclusion criteria were pathological fractures, incomplete medical records, conservative treatment, age under 18, or loss to follow-up. Demographic and clinical data were recorded for all participants. Fractures were classified according to the Letournel and Judet system, based on radiographic and intraoperative findings. Postoperative CT scans were analyzed to evaluate the quality of reduction. Step-off and gap measurements were obtained from the most displaced axial or coronal sections. Reduction was categorized as anatomical (< 2mm) or non-anatomical (≥ 2mm) according to established criteria.

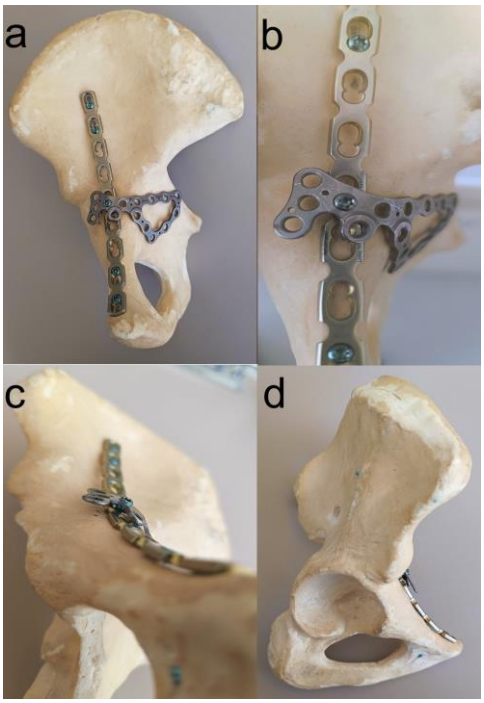

Figure 2. (a, b, c, d) Illustration of a standard reconstruction plate and a contoured titanium locking calcaneus plate positioned along the iliopectineal line to provide medial support to the quadrilateral plate. By aligning the locking screw holes of both plates, screws up to 20 mm in length can be securely inserted without intra-articular penetration. This configuration anchors the plates to each other and to the bone, ensuring stable medial reinforcement.

Surgical technique

Patients were placed in the supine position under general anesthesia, and the acetabulum was accessed using a modified Stoppa approach. All surgeries were performed by the same senior surgeon (F.O.). Pelvic and acetabular fractures were stabilized in a standardized manner according to the fracture type. To support the fracture in the QLP, a locked titanium calcaneus plate was contoured at the appropriate angle and aligned with the screw holes of the titanium reconstruction plate extending along the iliopectineal line at the suprapectineal level. By aligning the locking screw holes of the calcaneus plate with the reconstruction plate superior to the periarticular region, screws up to 20 mm in length could be safely inserted without causing intra-articular penetration (Figure 2). Postoperatively, patients received antibiotic prophylaxis and venous thromboembolism (VTE) prophylaxis. Patients without upper extremity trauma were encouraged to mobilize using a walker without weight-bearing on the affected limb starting the day after surgery. Full weight-bearing was initiated after 2–3 months, depending on the patient's

Table 1. Demographic and clinical characteristics of patients with quadrilateral plate fractures.

Patient	Gender	Age (years)	Localization	Follow-up (years)	Mechanism of injury	Type of acetabular fracture	Surgical technique
1	Male	18	Left	1	Fall	T-shaped	Locking calcaneal plate fixation
2	Male	18	Left	1	Fall	Associated both columns	Locking calcaneal plate fixation
3	Female	29	Right	1	Traffic accident	Associated both columns	Locking calcaneal plate fixation
4	Male	62	Right	2	Fall	Associated both columns	Locking calcaneal plate fixation
5	Male	69	Left	2	Fall	T-shaped	Locking calcaneal plate fixation
6	Male	71	Left	6	Fall	Transverse	Spring plate
7	Male	39	Right	1	Fall	Anterior column + posterior hemitransverse	Spring plate
8	Female	32	Right	3	Fall	Anterior column + posterior hemitransverse	Spring plate
9	Male	35	Left	5	Fall	Anterior column + posterior hemitransverse	Spring plate
10	Female	20	Right	1	Traffic accident	Associated both columns	Screw fixation

tolerance. Polytrauma patients who were unable to use a walker were mobilized in a wheelchair for two months, then transitioned to crutches before progressing to full weight-bearing as tolerated (Figures 3-7).

Results

The mean age of the patients was 39.5 ± 16.1 years (range: 18–72 years), with a male predominance (73.3%, n = 44). The most common mechanism of injury was motor vehicle accidents (61.6%), followed by falls from height (31.6%), simple falls (3.3%), and occupational accidents (3.5%). Concomitant injuries were observed in 56.9% of the patients, including 55% of the elementary fracture group and 45% of the complex fracture group. These included various associated traumas such as thoracic, abdominal, cranial, and additional skeletal injuries. The mean follow-up period was 11.5 ± 7.5 months (range: 6–72), and the mean length of hospital stay was 10.78 ± 5.3 days (range: 3–29). Preoperative neurological deficits were identified in 10% of the cases (n = 6). Among patients with elementary fractures (n = 33), the most common pattern was posterior wall fracture (60.6%, n = 20), followed by anterior column (15.1%, n = 5), posterior column (12.1%, n = 4), and transverse fractures (12.1%, n = 4). In the complex fracture group (n = 27), anterior column with posterior hemitransverse fractures were the most frequent (37.0%, n = 10), followed by transverse with posterior wall involvement (18.5%, n = 5), both-column fractures (29.6%, n = 8), and posterior column with posterior wall fractures (14.8%, n = 4). Postoperative CT scans revealed anatomical reduction in 83.3% of patients (n = 50). Regarding the surgical approach, the Kocher-Langenbeck approach was most commonly used (60%, n = 36), followed by the modified Stoppa approach (30%, n = 18) and the ilioinguinal approach (10%, n = 6).

The demographic and clinical characteristics of patients with QLP fractures are summarized in Table 1. Anatomical reduction was achieved in five patients who had a locked titanium calcaneal plate used to support the fracture in the QLP. On the other hand, anatomical reduction was detected in four of patients with QLP fractures fixed with spring plates and screws. No complications were detected in the patients at the end of the follow-up period.

Discussion

Maintaining joint stability is crucial in the management of acetabular fractures [5,12]. Due to the increasing frequency of high-energy trauma and a growing elderly population, complex acetabular fractures involving the QS are increasingly encountered in orthopedic practice [6,11]. Poor bone quality, the inherent

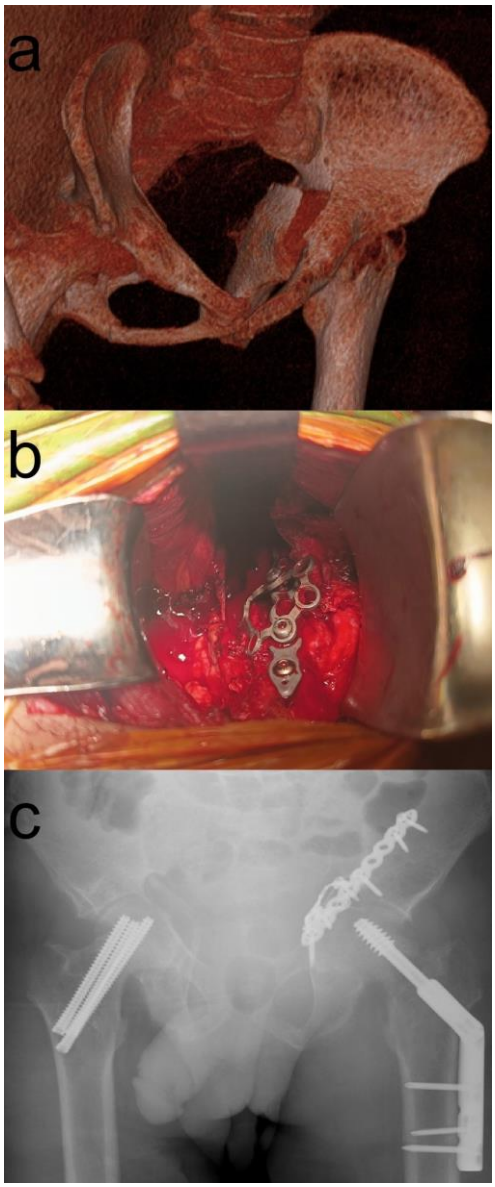

Figure 3. (a) Preoperative 3D computed tomography (CT) imaging of an 18-year-old male patient with a left acetabular fracture, quadrilateral plate fracture, and bilateral femoral neck fractures. **(b)** Intraoperative image of a contoured titanium locking calcaneus plate attached to a suprapectineal reconstruction plate via a modified Stoppa approach. **(c)** Radiograph at the one-year follow-up.

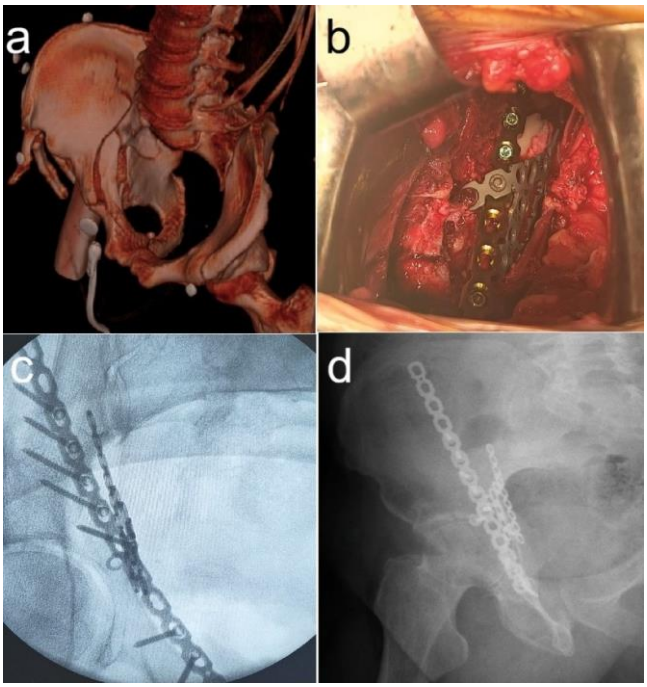

Figure 4. (a) Preoperative 3D computed tomography (CT) imaging of a 62-year-old male patient with a right acetabular and quadrilateral surface fracture. **(b)** Intraoperative view showing a contoured titanium locking calcaneus plate placed over a suprapectineal reconstruction plate for medial support. **(c)** Intraoperative fluoroscopy image. **(d)** Final follow-up radiograph at 1.5 years postoperatively.

thinness of the QLP, and the proximity of significant neurovascular structures make the treatment of these fractures particularly challenging [1,3].

QS fractures are frequently comminuted [1]. Inadequate fixation of these fractures can lead to joint instability and subsequent poor clinical outcomes, even in cases where anatomical reduction is initially achieved [1,4,12]. The QS is located on the medial aspect of the posterior acetabular column [5]. Comminuted fractures in this region typically result from significant axial loading through the femoral neck, causing the femoral head to be displaced medially (protrusio acetabuli) [1,5]. Because the bony architecture of the QLP and the iliopectineal eminence of the anterior column is thin and lies close to the joint, the options for stable internal fixation are often limited [1,5].

Current treatment for QLP fractures often involves non-fixation or indirect fixation to minimize surgical risks [5]. However, it has been noted that inadequate reduction and stabilization of QLP fractures lead to joint incongruity and early-onset osteoarthritis [13]. While combined suprapectineal and infrapectineal plating is commonly used for centrally displaced acetabular fractures [13], achieving stable fixation in complex fractures involving the QLP remains challenging even with innovative techniques using conventional implants [5]. Furthermore, many existing QLP fixation techniques are associated with prolonged operative times [1,3,13].

The buttress plate technique was first described by Mears [14] for acetabular fractures involving the QS. Since then, numerous studies have reported various reduction techniques using buttress plates to ensure stability in QLP fractures [4,6,9-11]. These methods include traditional SP and infrapectineal border buttress plates [4,6,9-11]. Although pre-contoured anatomical plates and patient-specific implants have been developed in recent years, their widespread use is limited by both lack of accessibility and high costs [9-11]. Additionally, in certain QS fracture patterns, pre-contoured plates may provide inadequate fixation, and their clinical effectiveness has not been fully validated [6]. Similarly,

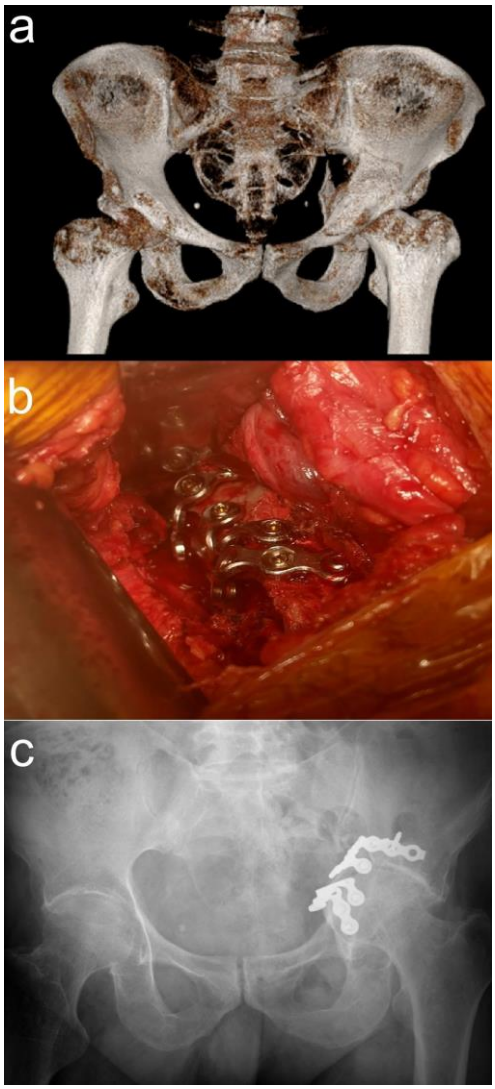

Figure 5. (a) Preoperative 3D computed tomography (CT) imaging of a 71-year-old male patient with an isolated quadrilateral plate fracture of the left hip. **(b)** Intraoperative image demonstrating medial support of the quadrilateral plate using the spring plate technique. **(c)** Final follow-up radiograph at 6 years postoperatively.

three-dimensional (3D) printed plate technology is still in the developmental stage and remains expensive [6].

Therefore, there is a clear need for new, cost-effective strategies to improve the management of these injuries. By combining a reconstruction plate with a locked calcaneus plate, we provided stable fixation that effectively supports the QS fragments. This method allows for extensive coverage of the QS, as the calcaneus plate can be contoured to match the specific anatomy of the patient. This study has some limitations, including a small sample size and the absence of a control group or biomechanical analysis to further evaluate the efficacy and safety of the described technique.

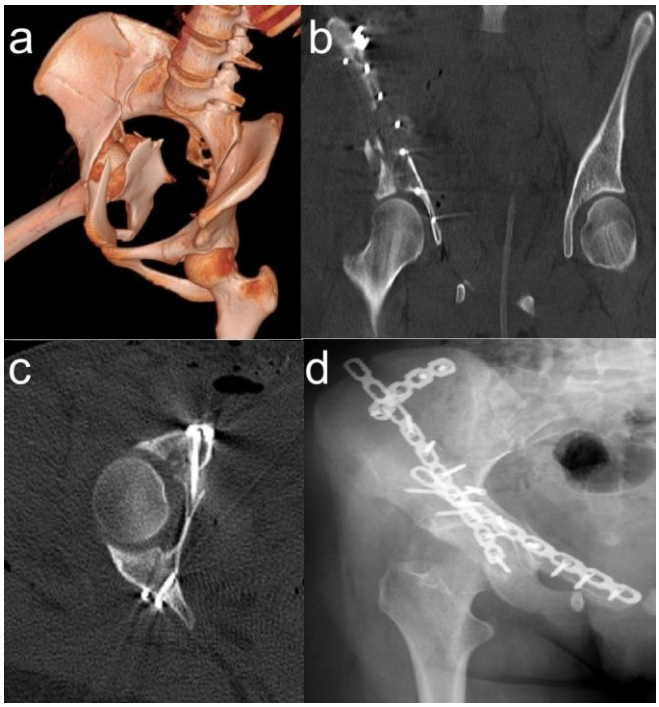

Figure 6. (a) Preoperative 3D computed tomography (CT) imaging of a 20-year-old female patient with a right acetabular fracture, quadrilateral surface involvement, and medial displacement of the femoral head. **(b, c, d)** Images demonstrating the quadrilateral surface stabilized with screws inserted through a suprapectineal reconstruction plate via a modified Stoppa approach.

Conclusions

In the surgical treatment of complex acetabular fractures involving the QS, the combination of a locked titanium calcaneus plate with a suprapectineal reconstruction plate provides a viable and stable fixation alternative. This technique is particularly valuable in settings where specialized, modern suprapectineal or infrapectineal plates are unavailable. By medially supporting the QLP via a reconstruction plate along the iliopectineal line, surgeons can achieve effective stabilization using conventional and accessible implants.

Author contributions

All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by KS, SY, and FO. The first draft of the manuscript was written by KS, SY, and FO, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Statements and declarations

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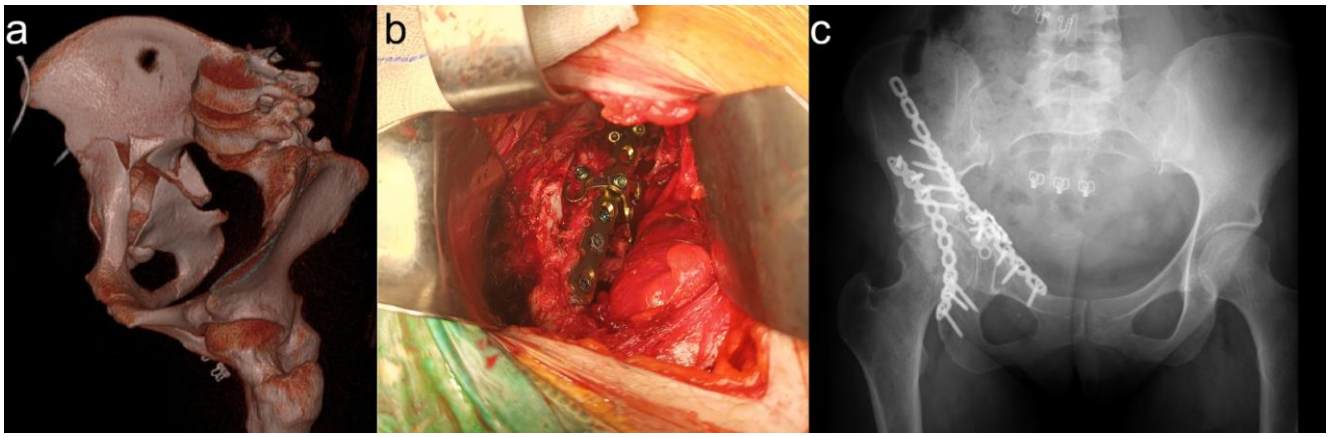

Figure 7. (a) Preoperative 3D computed tomography (CT) imaging of a 29-year-old female patient with a fracture of the right acetabulum and quadrilateral plate. **(b)** Intraoperative view showing a contoured titanium locking calcaneal plate placed over a suprapectineal reconstruction plate for medial support. **(c)** Final follow-up radiograph at 1 years postoperatively.

Conflict of Interest

The authors declare that they have no conflict of interest.

Ethical statement

The authors confirm that this retrospective study was conducted in accordance with the ethical standards outlined in the 1964 Declaration of Helsinki and its later amendments. Informed consent was obtained from each patient to have their medical records reviewed.

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