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Delayed Union of a Sacral Fracture: Percutaneous Navigated Autologous Cancellous Bone Grafting and Screw Fixation

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Abstract

Delayed or non-union of a sacral fracture is a serious clinical condition that may include chronic pain, sitting discomfort, gait disturbances, neurological problems, and inability to work. It is also a difficult reconstruction problem. Late correction of the deformity is technically more demanding than the primary treatment of acute pelvic injuries. Open reduction, internal fixation (ORIF), excision of scar tissue, and bone grafting often in a multi-step approach are considered to be the treatment of choice in delayed unions of the pelvic ring. This procedure implies the risk of neurological and vascular injuries, infection, repeated failure of union, incomplete correction of the deformity, and incomplete pain relief as the most important complications. We report a new approach for minimally invasive treatment of a delayed union of the sacrum without vertical displacement. A patient who suffered a Malgaigne fracture (Tile C1.3) was initially treated with closed reduction and percutaneous screw fixation (CRPF) of the posterior pelvic ring under CT navigation and plating of the anterior pelvic ring. Three months after surgery he presented with increasing hip pain caused by a delayed union of the sacral fracture. The lesion was successfully treated percutaneously in a single step procedure using CT navigation for drilling of the delayed union, autologous bone grafting, and screw fixation.

Key words: Delayed union—Percutaneous bone grafting—CT—Navigation

Delayed or non-unions after posterior pelvic ring fractures are serious medical conditions. Longterm sequelae include chronic pain, sitting discomfort, gait disturbances, neurological problems, all due to the disturbed integrity of the pelvic ring [1, 2]. Late correction of a non-union is technically more challenging than the treatment of acute pelvic injuries [2, 3].

In non-unions of the pelvic ring, the surgical repair usually consists of a multi-stage procedure to accomplish open reduction and internal fixation (ORIF), excision of scar tissue, and bone grafting [1, 2, 4]. Potential procedure-related complications include nerve or vascular injuries, repeated non-union, insufficient pain relief, and bone or soft tissue infection [3]. We offer a minimally invasive approach using CT navigation for all steps from drilling of a delayed union to removing scar tissue and sclerotic bone, to autologous bone grafting, and to percutaneous screw fixation.

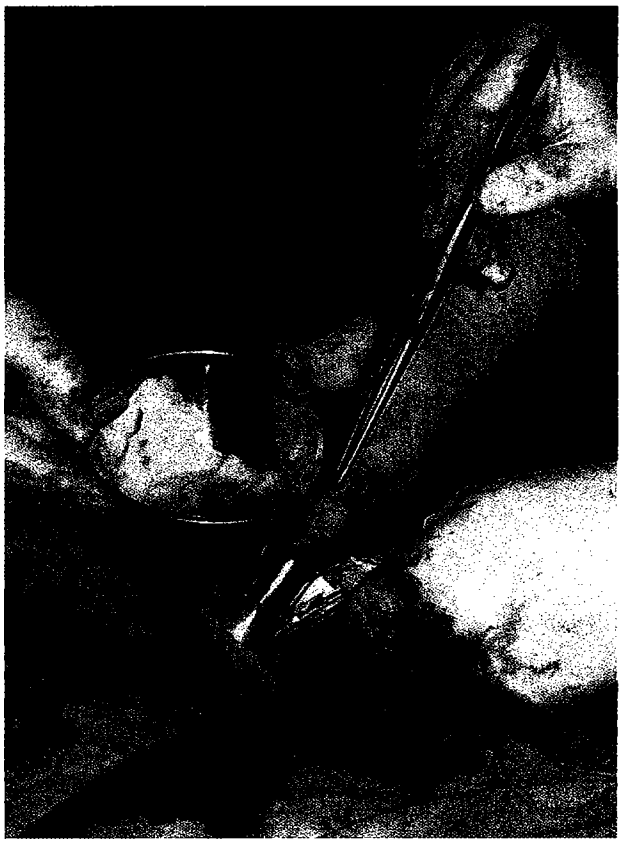

Figure 1. Six weeks after screw fixation of an undislocated fracture of the posterior pelvic ring and reconstruction plating of an anterior pelvic ring fracture. Film demonstrates loosening of the two sacroiliac screws.

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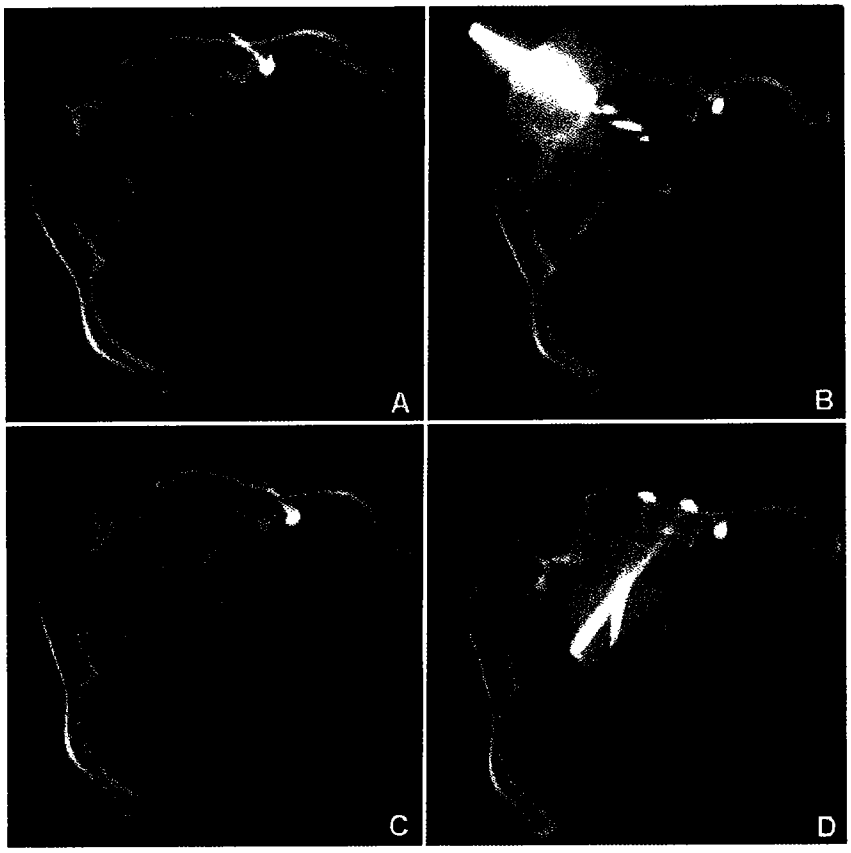

Figure 2. **A** Intraoperative planning CT demonstrating the delayed union of the sacrum. **B** CT-navigated drilling of the delayed union with a 10 mm cannulated trephine over an initially placed 2.8 mm guidepin. Note exact delineation of the drill position in regard to the anterior sacral cortex and the sacral foramina. **C** Intraoperative control after filling of the reamed area with autologous cancellous bone from the iliac crest over a sterile single use proctoscope. CT demonstrates complete filling of the gap from near to far cortex without endangering the presacral soft tissue. **D** CT-navigated placement of two 7.3 mm self-drilling/ self-cutting cannulated AO/ ASIF screws in S1 over previously inserted 2.8 mm guidepins. There was good compression of the fracture and no secondary dislocation.

Case Report

A 55-year-old man fell from a cherry tree and suffered a fracture of the right anterior and posterior pelvic ring with a non-displaced transforaminal fracture of the sacrum (Tile C1.3). The initial treatment consisted of ORIF of the anterior pelvic ring fracture with a 3.5 reconstruction plate followed by CT-navigated closed reduction and percutaneous fixation (CRPF) with two sacroiliac screws of the right-sided transforaminal posterior pelvic ring fracture. Two weeks after surgery the patient was dismissed from the hospital in good medical condition. During the following mobilization period with partial weight-bearing the patient complained of increasing right posterior pelvic pain. A follow-up radiograph 6 weeks after surgery revealed a loosening of the two implanted sacroiliac screws (Fig. 1). CT-guided refixation resulted in only temporary relief for 4 weeks. Conventional radiography and CT at this stage both demonstrated a reloosening of the cranial screw plus a delayed union of the longitudinal right-sided sacral fracture (Fig. 2a).

In an interdisciplinary meeting, trauma surgeons and interventional radiologists decided to choose a minimally invasive approach for revision. The concept consisted of CT-navigated removal of the two cannulated screws initially inserted at the first operation, navigated drill reaming of the delayed union, percutaneous autologous cancellous bone grafting and CT-navigated screw re-fixation. The intervention took place in a multifunctional image-guided therapy suite (MIGTS) where different radiological and surgical modalities (CT, US, fluoroscopy, DSA, new OR-table, modality-based navigation [5]) are integrated into a sterile environment [6].

Surgery was performed under general anesthesia and with antibiotic prophylaxis. The patient was positioned in a lateral decubitus position and immobilized with a vacuum mattress. Cancellous bone was first harvested from the iliac crest. Intraoperative planning was done on a spiral CT scanner (GE Hispeed Advantage, GE Medical Systems, Milwaukee, WI, USA; imaging parameter 140 kV, 380 mA, slice thickness 5 mm, pitch 1.5, slice increment 2.5 mm). The originally inserted cannulated screws were probed with 2.8 mm Kirschner wires using the CT navigation system, and then removed.

The reaming of the delayed union consisted of the following steps. Under CT navigation, two 2.8 mm Kirscher wires were placed into the delayed union in S1. The position of the guidepins was then controlled with intraoperative CT scanning. Definitive drill length to final guidepin position was measured as the distance from near to far cortex. Then the delayed union was bored with a 10 mm cannulated drill (Fig. 2b). A single-use plastic proctoscope was inserted over the drill down to the outer cortex and the drill was removed. The bore-hole was filled with the previously harvested cancellous bone through the proctoscope under intermittent CT fluoroscopy control (Fig. 2c, 3).

Into the already existing drill hole of the more cranial screw in S1, a new but longer 7.3 mm self-drilling/self-cutting cannulated AO/ASIF screw was implanted perpendicular to the delayed union to anchor in the far cortex of S1. A second screw was inserted into S1 more distally and posteriorly (Fig. 2d).

Clinically the patient did extremely well and was mobilized with partial weight-bearing the day after surgery. Total length of hospital stay was 19 days.

At clinical follow-up 3 months after the last intervention the patient felt no pain except for occasional muscular hardening in his buttock. Clinically he revealed a symmetrical pain-free motion of both hips and was able to crouch. Radiography and CT both showed an osseous union and a correct position of the screws (Fig. 4). At this point, full weight bearing was allowed and the patient resumed his work as a cherry farmer 25% of the time.

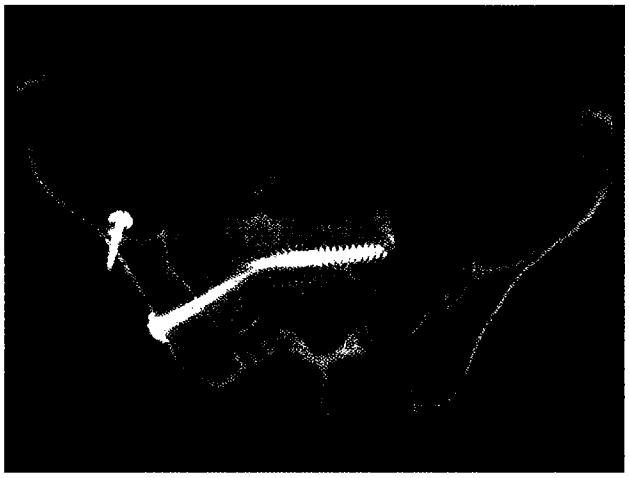

Figure 3. Filling of the reamed delayed sacral nonunion with the previous harvested autologous spongiosa via a sterile disposable proctoscope.

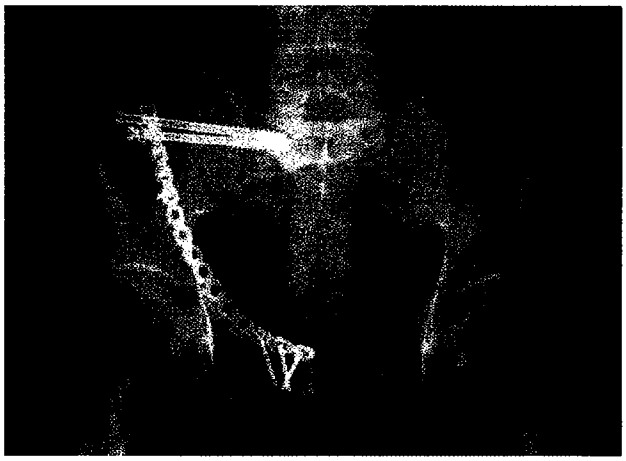

Figure 4. CT control 3 months after revision surgery and partial weight bearing of the patient. There is correct positioning of the two inserted screws without loosening and ingrowth of the autologous bone grafting with subsequent osseous union.

Discussion

A pelvic non-union occurs most often after failed treatment in the unstable types of pelvic ring injuries (types B and C according to the Tile classification [7, 8]) even though primary corrections of traumatic pelvic instabilities tend to be simpler and more successful than late reconstructions [3]. In primary open surgery and revisions the rate of posterior pelvic nonunion ranges from 0–2% [9, 10] and 4–10% [2, 11], respectively. Pseudarthrosis in percutaneous-guided stabilization of iliosacral fracture has an incidence of 0–7% [12–15]. Delayed unions and pseudarthroses in sacral fractures are normally treated with open excision, reaming of the delayed union, and ORIF in a multi-stage approach. There is, however, a significant procedure-related morbidity associated with ORIF such as iatrogenic nerve palsies in up to 8% and vascular injuries in up to 3% [2, 11], intraoperative blood loss [16], tissue loss, and infection in up to 25% [17, 18].

Minimally invasive methods for primary CRPF under fluoroscopy [13, 19, 20] or CT guidance have been described in the literature [12, 16, 17]. Whereas fluorscopic-guided mininally invasive surgery bears the risk of screw malplacement in up to 7% of cases [13, 20], CT-guided intervention overcomes this problem. There is minimal procedural blood loss, no post-procedural wound complications, and no association with neurological injury [16, 21].

We report a possible minimally invasive secondary approach after failed primary surgery or conservative therapy where the whole sequence of necessary steps is carried out percutaneously. Closed reaming of the delayed union using a cannulated drill under CT navigation is a secure procedure of treating the whole distance of the non-union from the near to the far cortex under optimal visual feedback.

Metal artifacts are a minor issue even with low-dose CT imaging. Kirschner wires may easily be located within the surrounding bone. The cannulated titanium screws and the steel drill for the reaming of the delayed union can still be delineated fairly well (Fig. 2). Likewise the autologous bone graft can be introduced percutaneously via a sterile conduit under CT control to ensure an optimal filling of the gap. In an open approach, the debridement of a delayed sacral union may be either incomplete or potentially dangerous for the presacral soft tissue structures because the distance from the near to the far cortex is difficult to appreciate. The intervention was performed in a multifunctional image-guided therapy suite (MIGTS) [6, 22]. It would not have been possible in a conventional operating room without sophisticated intra-operative imaging or a conventional CT-suite that is not sterile. This room integrates the technology and infrastructure for sterile image-guided surgery including implants and grafting.

The cost per intervention is probably higher than in conventional open surgery. In our experience the operating time is comparable between open surgery and CRPF. However, from a socioeconomic point of view the reintegration into the working process is the decisive issue regarding total cost. There is not much literature about working ability after revision surgery for posterior pelvic nonunion. We do know that only between 62–83% of patients suffering a posterior pelvic ring fracture return to work [9, 23–25]. It seems reasonable to assume that this number is even smaller in revision surgery. In our case the patient with a delayed union resumed work 3 months after surgery in his former profession as a cherry farmer.

In conclusion, the case presented here demonstrates that minimally invasive closed percutaneous cancellous bone grafting and CRPF of a delayed union of the sacrum is technically feasible with an excellent clinical result. Further comparative studies with open surgery are necessary to precisely define the place for this new technique.

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