International Orthopaedics (2019) 43:2161–2166
https://doi.org/10.1007/s00264-018-4110-9

ORIGINAL PAPER

Subcutaneous internal anterior fixation of pelvis fractures—which configuration of the InFix is clinically optimal?—a retrospective study

Julian Scherer[1] · Simon Tiziani[1] · Kai Sprengel[1] · Hans-Christoph Pape[1] · Georg Osterhoff[1]

Received: 20 April 2018 / Accepted: 13 August 2018 / Published online: 8 September 2018

Abstract

Introduction Subcutaneous internal fixation (InFix) has become a valid alternative for anterior fixation of pelvic ring injuries. Complications associated with this technique are lateral femoral cutaneous nerve (LFCN) irritation and anterior thigh pain due to prominent implants. The aim of this study was to identify a configuration of the InFix that causes the least adverse side effects.
Methods Nineteen patients (6 females, mean age 61 years) with 38 hemipelves were included. Rod-to-bone distance and symphysis-rod distance were measured on AP- and outlet- radiographs. These distances were analyzed in relation to the primary outcomes: early removal of the InFix, post-operative complications and damage of the LFCN.
Results Regarding rod-to-bone distance, a distance of 20 to 25 mm causes less complications, LFCN damage and no early removals of the InFix. Symphysis-to-rod distance analysis showed the best results regarding LFCN damage and other complications when the rod had a distance of less than 40 mm to the symphysis. A distance more than 40 mm was associated with fewer early removal of the InFix.
Conclusions Planned optimized configuration of the InFix with a rod-to-bone distance between 20 and 25 mm may reduce postoperative complications. Regarding LFCN damage, the rod-to-symphysis distance should not be more than 40 mm.

Keywords Internal fixation · CRIF · Pelvis fracture · Minimal invasive surgery · Lateral femoral cutaneous nerve

Introduction

External fixation of pelvic fractures is a commonly known and established technique for stabilization of pelvic ring fractures [1, 2]. However, external fixation usually requires secondary surgery, limits mobilization of the patient and is associated with pin tract infections in up to 50% [3].

The treatment of pelvic fractures, using subcutaneous supraacetabular pedicle screw internal fixation (InFix), has shown to be a good alternative in stabilizing pelvic ring injuries when conventional external fixation is not suited [4–6]. This technique is associated with less infections, longer implant time and can be applied to obese patients, when external fixation is not practicable [7].

Potential complications of the InFix include damage or irritation of the lateral femoral cutaneous nerve (LFCN) as the rod can compresses the LFCN running lateral to the pedicle screw [7]. Other structures like the femoral neurovascular bundle, the superficial hip flexors and the anterior superficial skin nerves can also be affected by the rod [8, 9]. This phenomenon has been linked to the distance between the bony pelvis and the rod, a distance of 2 cm was considered safe, in terms of less compression of these structures, when sitting and standing [10].

The optimal anatomical rod-to-bone distance has only been investigated in cadaver studies and information from in vivo cases is missing.

Thus, the aim of this study was to investigate the optimal configuration of the InFix in patients with pelvic ring fractures who were treated with subcutaneous internal anterior fixation.

Material and methods

Patients

All patients with an unstable pelvic fracture who received subcutaneous internal anterior fixation at the University

✉ Julian Scherer
julian.scherer@usz.ch

[1] Department of Trauma Surgery, University Hospital of Zurich, Raemistrasse 100, 8091 Zurich, Switzerland

Hospital of Zurich in the years from 2011 to 2017 were investigated. Twenty-seven patients from 15 to 88 years of age met this criteria. Eight patients had not given general consent. An adequate follow-up was defined as a minimum of 12 weeks after surgery, early implant removal of the InFix was defined as less than 90 days after surgery. This left 19 patients with 38 hemipelves for final analysis.

Measurements on radiographs

Conventional AP-radiographs of the pelvis were investigated. Measurements of the radiological markers were performed by the use of ImageJ®. We measured the length of the pedicle screws and the distance between the rod and the bony pelvis in the straight line of the screw in pixels. The screw length known from the operation reports was then divided by the measured screw length and multiplied with the measured rod-to-bone distances (Fig. 1).

To assess the minimal distance between the rod and the symphysis, outlet radiographs were used (Fig. 2). All measurements were performed by one author (JS) and the final values were averaged from three repeated measures.

Statistical analysis

Statistics were performed using SPSS 24® (IBM, Armonk, NY, USA).

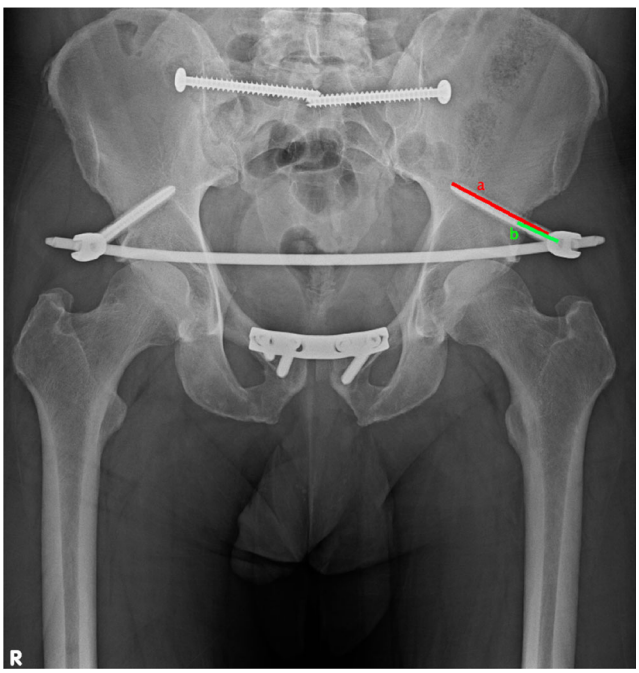

Fig. 1 AP projection. a = screw length; b = rod-to-bone distance; a/screw length × b = rod-to-bone distance

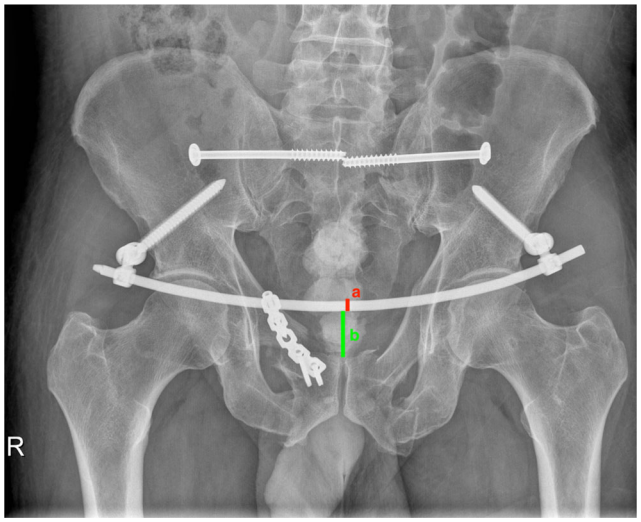

Fig. 2 Outlet projection. a = screw length; b = rod-to-symphysis distance; a/screw length × b = symphysis-rod distance

After the definition of the exclusion criteria, we did not have any missing variables for the primary endpoints. Primary endpoints were defined as LFCN damage (lateral femoral paraesthesia), early implant removal and other complications. As the InFix usually stays implanted for three months, we defined an early removal as removal of the InFix earlier than 90 days after surgery. Complications were defined as paraesthesia of the anterior or medial femur, when patients considered the rod as disturbing, deep infections, loosening of the implant and muscle weakness. Rod-to-bone distance and symphysis-rod-distance were analysed regarding the primary endpoints. In a first step of the analysis, we expressed the mean rod-to-bone distances of the hemipelves. Afterwards, we investigated two rod-to-bone distance groups: 20–25 mm and hemipelves with a distance of less than 20 mm or more than 25 mm.

In analysis second, we determined the mean distance between the symphysis and the rod and the effect on early removal, complications and LFCN damage. Rod-to-symphysis distances were also divided into two groups: < 40 mm and > 40 mm. In this population, outcomes were defined to occur either on the left or right side because rod-to-symphysis distance was not hemipelvis-dependent.

Case presentation

Below two cases are added to illustrate the importance of the bone-to-rod distance.

Case 1 (Fig. 3)

A 90-year-old female patient suffered from a fall from standing height while working in her kitchen. The CT scan of the pelvis

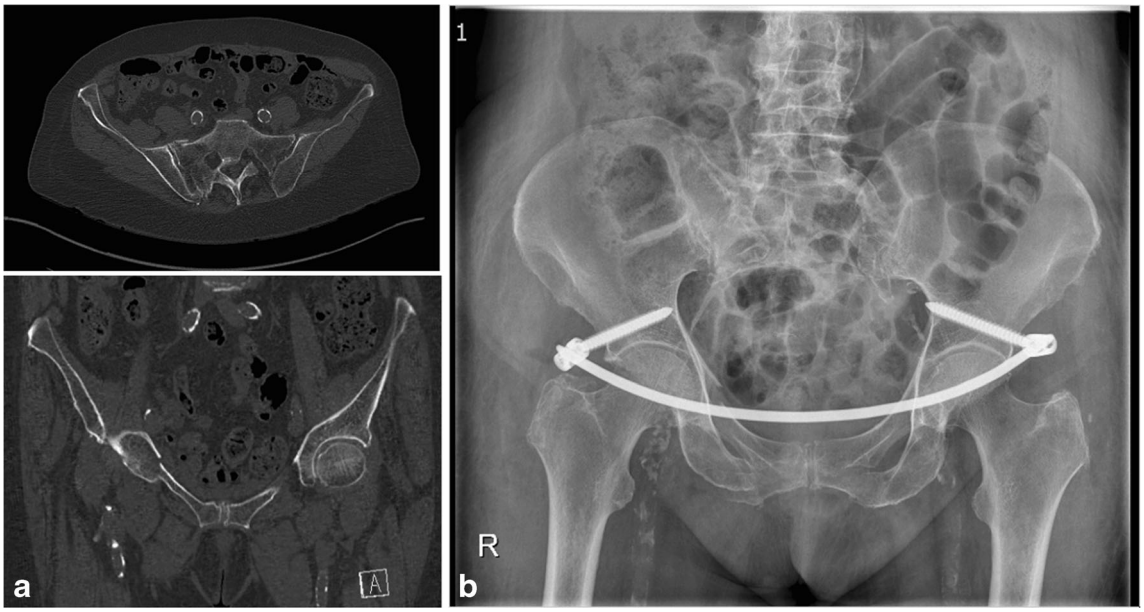

Fig. 3 Ninety-year-old patient after low-energy trauma. **a** Initial CT scan showing a LC I fracture. **b** X-Ray showing full fracture consolidation at last follow-up before implant removal on the 95th post-surgical day

showed a lateral-compression type I according to Young and Burgess. (Fig. 3a) Due to a severe coronary artery disease, which required extensive pre-operative testing and eventually even pre-operative angioplasty, there was a delay of ten days to the definite operative treatment. The patient was eventually taken to the operating room and the fracture was treated with a subcutaneous internal anterior fixator (InFix). This procedure was chosen because of the poor quality of the intra-operative fluoroscopy, which did not allow for percutaneous sacral screw fixation.

Three months post-operatively, the patient complained about pain on the right anterior pelvis. This was especially present in sitting position. Furthermore, the patient described reduced sensation in the ventral and lateral part of the right upper thigh. The rod-to-bone distance was 29.15 mm on the right side and 20.76 mm on the left side. All the above led to removal of the implant 3 months after the initial accident, when full consolidation of the fracture was achieved (Fig. 3b). At the latest clinical follow-up, three years after the initial trauma, the patient suffered from another sacral fracture and was treated with a percutaneous sacral screw fixation. At the point of admission, the patient did not show any signs of remaining deficits or symptoms regarding the lateral femoral cutaneous nerve.

Case 2 (Fig. 4)

A 65-year-old female patient that was run over by a car was admitted to our trauma bay. The whole-body CT scan showed a poly-traumatized patient with thoracic, abdominal and pelvic injuries. In the pelvic region, the patient suffered from a lateral-compression type III injury according to Young and Burgess with an accompanying extraperitoneal bladder rupture (Fig. 4a). Initially, the patient was treated with a supra-acetabular external fixation, chest drains and a crash-laparotomy. Due to the need for further abdominal surgery, the external fixation was converted into a subcutaneous internal anterior fixation accompanying an abdominal second-look. After the patient could be stabilized, an iliolumbal transfixation on the right side was performed to treat the comminuted posterior pelvic ring.

The patient never complained of any pain or constraints in the pelvic region or of reduced sensation in the ventral or lateral thigh. The rod-to-bone distance was 22.12 mm on the right side and 22.26 mm on the left side. The InFix was removed six months after surgery, when full consolidation of the fracture was achieved (Fig. 4b). At the latest clinical follow-up, two years after the initial injury, the patient did not have any residual symptoms stemming from the initial trauma or the operative treatment.

Results

The mean rod-to-bone distance of all hemipelves ($n = 38$) was 32 mm (SD 10 mm). In the group with more than 25 mm or less than 20 mm of distance ($n = 30$), four hemipelves had an early removal compared to the group with a distance between 20 and 25 mm, where no patient had to undergo early removal ($p = 0.275$). Twelve out of 30 hemipelves with a rod-to-bone distance which was not in the range of 20 to 25 mm suffered from complications post-operatively, whereas also no patient with a distance of 20 to 25 mm experienced complications ($p = 0.031$). Thirteen out of 30 hemipelves with a distance of

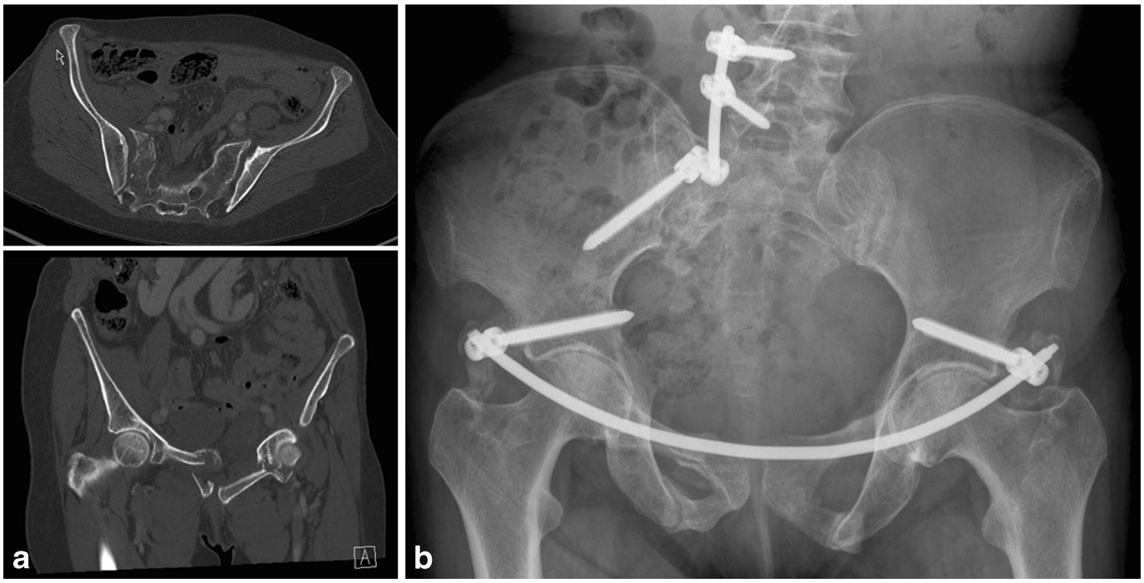

Fig. 4 Sixty-five-year old poly-traumatized patient. **a** Initial CT scan showing a LC III fracture. **b** X-Ray showing full fracture consolidation at last follow-up before implant removal on the 184th post-surgical day

less than 20 mm and more than 25 mm had a significant LFCN damage after implantation of the InFix system compared to 2/8 of the hemipelves with a rod-to-bone distance between 20 and 25 mm ($p = 0.346$) (Fig. 5).

Analysis of the rod-to-symphysis distance ($n = 18$; outlet X-ray of one patient missed) showed a mean distance of 50 mm and a SD of 18 mm. Two out of six patients with a rod-to-symphysis distance of less than 40 mm underwent an early removal of the InFix system compared to no early removal when the InFix was applied at more than 40 mm distance from the symphysis ($p = 0.034$). Three patients with a distance of less than 40 mm from the pubic symphysis and five patients with more than 40 mm suffered from other complications postoperatively ($p = 0.737$). Only one patient with less than 40 mm and eight patients with more than 40 mm had persistent damage of the lateral femoral cutaneous nerve ($p = 0.046$) (Fig. 6).

Discussion

The use of subcutaneous screw-rod-systems in unstable fractures of the pelvis has recently become more popular.

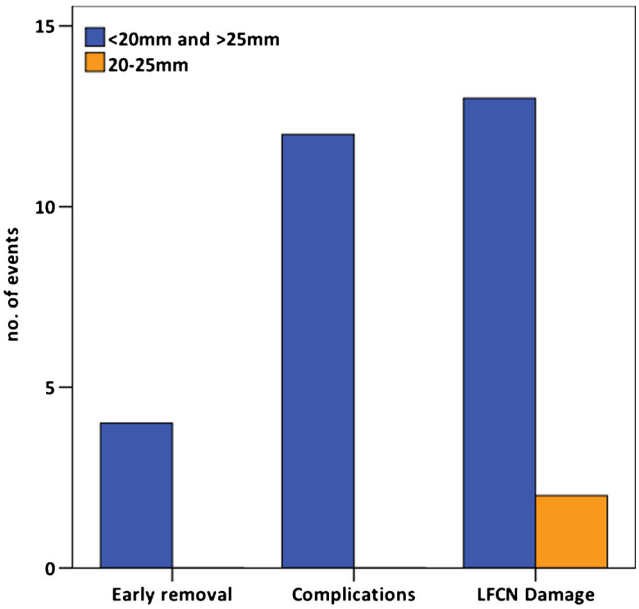

Fig. 5 Rod-to-bone distance: < 25 mm; > 25 mm

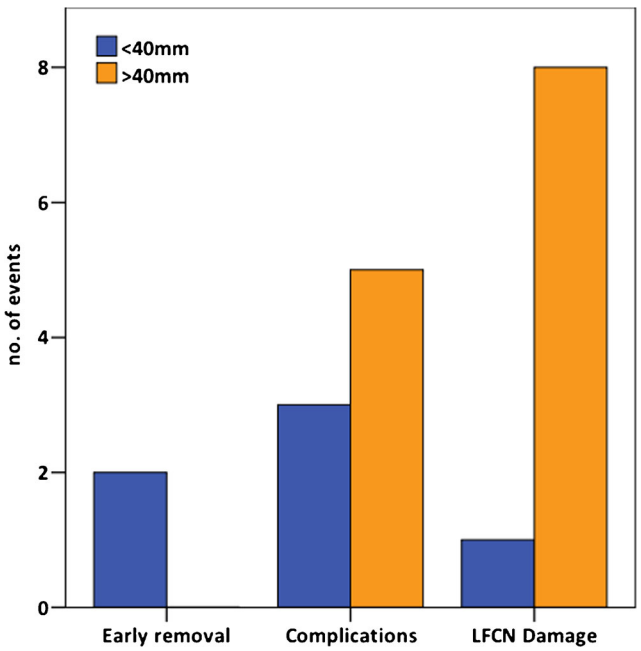

Fig. 6 Symphysis-rod distance

Whereas new subcutaneous screw-rod-systems using Schanz screws have been shown to be a good alternative for the treatment of posterior pelvic ring disruptions, the screw-rod-systems using pedicle screws (InFix) have shown good results in both, anterior and posterior pelvic ring stabilization [11, 12].

As many authors favour an initial stabilization of anterior pelvic injuries using a supraacetabular fixator followed by definite treatment with plates or screws, the InFix can be used as an initial fixation and definite treatment [12–14].

Another advantage of the InFix is its conjunctional use with a laparotomy in unstable pelvic fractures with concomitant acetabular fractures which have to be treated with open reduction and internal fixation using plates or screws [12, 14, 15].

The aim of this study was to investigate the clinically optimal InFix configuration in patients who suffered from an unstable pelvic fracture and were treated with a subcutaneous internal anterior fixation (InFix).

It was shown that a rod-to-bone distance of 20 to 25 mm has the lowest rate of early removal, other complications like compression of the femoral neurovascular bundle or disturbance by the rod and damage of the LFCN. This is consistent with a previous study by Osterhoff et al., who investigated an anatomically optimal rod-to-bone distance of 20 mm, followed by 30 mm [10].

The authors also suggested that the symphysis-rod distance has an influence on the patient's outcome. Patients with a symphysis-rod distance of more than 40 mm had no early removal. The best results regarding paraesthesia of the anterior or medial femur, when patients considered the rod as disturbing, deep infections, loosening of the implant and muscle weakness, were shown when the InFix was set at a distance of less than 40 mm to the symphysis. The best configuration of the InFix with reference to the LFCN damage was also found at a distance of less than 40 mm. All in all, it was not possible to determine the best symphysis-rod distance. Due to the fact that a lesion of the LFCN is the most likely complication of the InFix, a distance of less than 40 mm to the symphysis is suggested by the authors.

This study had some limitations. The measurements were done post-operatively using radiographs which may cause measurement errors. The study population was rather small and therefore the present study may be underpowered.

However, the present study has shown that the patients' outcome could depend on the InFix configuration chosen. An adjusted InFix system could reduce patients' post-operative complications.

Future studies should investigate intra-operative distances in a prospective study with a bigger collective to gain more sufficient data.

Conclusion

The rod-to-bone distance in the subcutaneous internal anterior fixation of the pelvis could have an influence on patient's outcome. Based on our findings, we suggest a distance between 20 and 25 mm. Post-operative complications and harming of the lateral cutaneous femoral nerve can be reduced by setting a symphysis-to-rod distance at less than 40 mm.

Compliance with ethical standards

This study was carried out in accordance with the local institutional ethics committee's terms of reference (Kantonale Ethikkommission Zürich, Switzerland. BASEC-Nr. 2016-01954).

Conflict of interest The authors declare that they have no conflict of interest.

References

1. Bates P, Gary J, Singh G, Reinert C, Starr A (2011) Percutaneous treatment of pelvic and acetabular fractures in obese patients. Orthop Clin N Am 42(1):55–67 **vi**
2. Miller PR, Moore PS, Mansell E, Meredith JW, Chang MC (2003) External fixation or arteriogram in bleeding pelvic fracture: initial therapy guided by markers of arterial hemorrhage. J Trauma 54(3): 437–443
3. Mason WT, Khan SN, James CL, Chesser TJ, Ward AJ (2005) Complications of temporary and definitive external fixation of pelvic ring injuries. Injury 36(5):599–604
4. Vaidya R, Colen R, Vigdorchik J, Tonnos F, Sethi A (2012) Treatment of unstable pelvic ring injuries with an internal anterior fixator and posterior fixation: initial clinical series. J Orthop Trauma 26(1):1–8
5. Scheyerer MJ, Zimmermann SM, Osterhoff G, Tiziani S, Simmen HP, Wanner GA, Werner CM (2014) Anterior subcutaneous internal fixation for treatment of unstable pelvic fractures. BMC Res Notes 7:133
6. Osterhoff G, Tiziani S, Ferguson SJ, Spreiter G, Scheyerer MJ, Spinas GL, Wanner GA, Simmen HP, Werner CM (2014) Mechanical testing of a device for subcutaneous internal anterior pelvic ring fixation versus external pelvic ring fixation. BMC Musculoskelet Disord 15:111
7. Fang C, Alabdulrahman H, Pape HC (2017) Complications after percutaneous internal fixator for anterior pelvic ring injuries. Int Orthop 41(9):1785–1790
8. Hesse D, Kandmir U, Solberg B, Stroh A, Osgood G, Sems SA, Collinge CA (2015) Femoral nerve palsy after pelvic fracture treated with INFIX: a case series. J Orthop Trauma 29(3):138–143
9. Rudin D, Manestar M, Ullrich O, Erhardt J, Grob K (2016) The anatomical course of the lateral femoral cutaneous nerve with special attention to the anterior approach to the hip joint. J Bone Joint Surg Am 98(7):561–567
10. Osterhoff G, Aichner EV, Scherer J, Simmen HP, Werner CML, Feigl GC (2017) Anterior subcutaneous internal fixation of the pelvis - what rod-to-bone distance is anatomically optimal? Injury 48(10):2162–2168
11. Schmitz P, Baumann F, Acklin YP, Gueorguiev B, Nerlich M, Grechenig S, Muller MB (2018) Clinical application of a minimally invasive cement-augmentable Schanz screw rod system to treat

pelvic ring fractures. Int Orthop. https://doi.org/10.1007/s00264-018-3988-6

12. Vaidya R, Nasr K, Feria-Arias E, Fisher R, Kajy M, Diebel LN (2016) INFIX/EXFIX: massive open pelvic injuries and review of the literature. Case Rep Orthop 2016:9468285
13. Blum L, Hake ME, Charles R, Conlan T, Rojas D, Martin MT, Mauffrey C (2018) Vertical shear pelvic injury: evaluation, management, and fixation strategies. Int Orthop. https://doi.org/10.1007/s00264-018-3883-1
14. Cai L, Lou Y, Guo X, Wang J (2017) Surgical treatment of unstable pelvic fractures with concomitant acetabular fractures. Int Orthop 41(9):1803–1811
15. Wu X (2018) A biomechanical comparison of different fixation techniques for fractures of the acetabular posterior wall. Int Orthop 42(3):673–679