

A screw view model of navigation guided minimal invasive percutaneous pelvic screws insertion for lateral compression pelvic ring injuries

A case report

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Abstract

Rationale: The objective of the present study was to evaluate the accuracy, effectiveness, and safety of screw view model of navigation (SVMN) guided minimal invasive percutaneous pelvic screws (PPSs) insertion for lateral compression pelvic ring injuries (PRI).

Patient concerns: A female patient experienced a high falling injury, and presented with pain, swelling, deformity, and movement limitation of the left hip for 3 hours.

Diagnoses: She was diagnosed with pelvic fractures, left iliac fracture, left pubic branch fracture, left ischial branch fracture, and lumbar transverse process fracture.

Interventions: We used a SVMN technique to guide PPSs insertion, including a percutaneous anterior inferior iliac spine screw, a percutaneous iliac screw (PIS), and a percutaneous sacroiliac screw (PSIS).

Outcomes: In total, 3 PPSs were inserted and all were presented with excellent position postoperatively. The designing time of all screws was 11.7 minutes, the time of all guide needles insertion was 18.1 minutes, the time of all screws insertion was 32.8 minutes, blood loss was 21 mL, and the time of radiation exposure lasted 7.2 minutes. Moreover, surgical complications, including neurovascular compromise, wound infection, fracture nonunion, and screw loosening, were not observed during the 12 months follow up visit.

Lessons: SVMN technique guided PPSs insertion is an effective and safety approach for the treatment of PRI in selected patients. Besides, it is necessary for surgeons to master the rationale of computer navigation, to familiar with the anatomy of pelvis and to select suitable patients.

Abbreviations: 3D = three dimensional, CT = computed tomography, PAISS = percutaneous anterior inferior iliac spine screw, PIS = percutaneous iliac screw, PPSs = percutaneous pelvic screws, PRI = pelvic ring injuries, PSIS = percutaneous sacroiliac screw, SVMN = screw view model of navigation.

Keywords: anterior inferior iliac spine screw, pelvic ring injuries, percutaneous, screw view model of navigation

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B-MY and GH have contributed equally to this work.

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The authors have no conflicts of interest to disclose.

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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1. Introduction

Pelvic ring injuries (PRI) commonly result from high energy trauma, such as falling injury and motor vehicle accident injury. According to previous studies, 5% to 20% of the patients experienced severe hematoma, and 10% to 31.1% of the patients suffered death.^[1-4] Among the PRI, lateral compression fractures are the most frequently injuries, which are occasionally reducing closed reduction, and usually vertically stable.^[5,6] In the past, the management of PRI with bed rest and delayed weight bearing has been advocated.^[7-9] The long-term target of treating pelvic ring fractures is to correct deformity, prevent deformity and instability postoperatively, and restore pain-free function,^[10] and early dynamic exercises. In recent years, the management strategies for PRI mainly including reduction and internal fixation through open or closed approach,^[11] anterior subcutaneous internal fixation,^[12] and anterior pelvic external fixation.^[13] Nevertheless, these techniques have many surgical complications, such as nerve compromise, wound infection and deep infection, fracture nonunion, confusional states postoperatively, anemia, urinary tract infection, and pneumonia.^[3,14]

Currently, percutaneous pelvic screws (PPSs) fixation is recommended due to the character of stable fixation, minimal

Table 1					
Basic characteristics of the patient.					
Case	Gender	Age*	Diagnosis	Surgical treatment	Follow up†
1	Female	35	PRI	SVMN aid PPSs	12

PPSs=pelvic percutaneous screws, PRI=pelvic ring injuries, SVMN=screw view model of navigation.
* Years.
† Months.

incision, rapid recovery, less blood loss, and short hospital stay. However, PPSs insertion regarded technique demanding because the complexity of the pelvis anatomy. Moreover, the surgeons and patients with prolonged radiation exposure.^[15,16] Many strategies have developed to facilitate PPSs insertion for PRI, such as a robot-assisted navigation system, a computed tomography (CT)-based navigation and a fluoroscopic-based navigation.^[1,17–20] Nevertheless, there are still occasional surgical complications, such as neurovascular damage and wound infections. Consequently, the purpose of the present study is to evaluate the accuracy, effectiveness, and safety of screw view model of navigation (SVMN) guided PPSs insertion for the treatment of lateral compression PRI.

2. Ethical approval

This report was approved by the ethics committee of the Second Hospital of Jilin University, Changchun, China. The patient a provided written informed consent for this report, and we maintained his anonymity.

3. Case report

3.1. Patient characteristics

A 35-year-old female patient experienced a high falling accident (Table 1), and presented with swelling and pain of left hip. Physical examinations showed that pelvis compression and separation test were positive.

In accordance with the preoperative radiograph (Fig. 1A) and three dimensional (3D) CT scanning images (Fig. 2), there was

bone discontinuity and displacement in the left superior and inferior pubic ramus, and a gap was showed though the ilium. The sacrum was not in regular shape, and the right transverse process of L5 was also found to be irregular. The patient was diagnosed with PRI, including left pubic ramus fracture, iliac fracture, sacroiliac fracture, and transverse process fracture of the L5.

3.2. Surgical technique

The patient was placed in the supine position once the anesthesia took effect.

3.2.1. Image acquisition. A patient tracker (Stryker Leibinger GmbH & Co., Freiburg, Germany) was fixed on the right iliac crest. After the patient tracker, C-arm tracker, and instruments tracker were all opened, a 190° scan was performed at the center of the pelvis fractures and then image date of the fracture site were achieved.

3.2.2. Surgical planning. The work station of navigation system provided multi-planar images of the pelvic fractures, which contribute to design the PPSs, including the length of screw, the diameter of screw, and the optimal direction for screw (Fig. 3). In principle, the inserted 3 PPSs were not perforating bone cortex and through fracture line. A percutaneous anterior inferior iliac spine screw (PAIISS) was designed to fix the iliac fracture along the anterior inferior iliac spine to the posterior superior iliac spine, and a PIS screw was planned and passed through the fracture line from left iliac wing. Besides, a percutaneous sacroiliac screw (PSIS) screw was also designed and inserted, details reference to Yu et al.^[21]

3.2.3. Screw implantation. The screw view model was selected in the workstation of navigation system (Fig. 3). Intraoperatively, the position of guide needle cannular was continuously updated by the infrared camera, and multiplanar images displayed on navigation monitor simultaneously, which allowing real-time feedback of the direction of guide needle cannular and the planned screws preoperative. The trajectory of the guide needle cannular was adjusted until the position of the surgical instrument was completely in accordance with the designing direction of anterior inferior iliac spine screw and iliac screw. It is

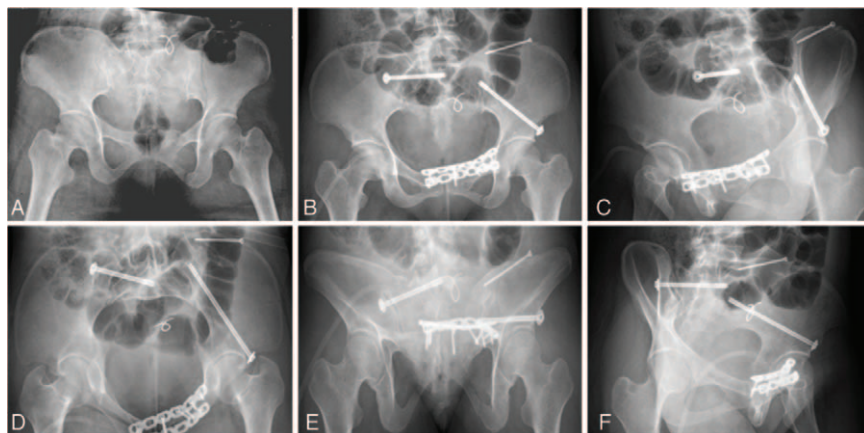


Figure 1. (A) Preoperative radiograph showed that there was bone discontinuity and displacement in the left superior and inferior pubic ramus, and a gap was showed though the ilium. (B–F) Postoperative radiographs demonstrated that the positions of PPSs were excellent. PPSs=percutaneous pelvic screws.

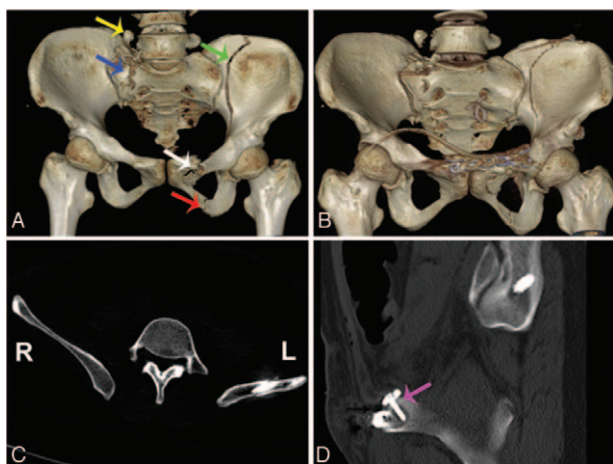


Figure 2. (A) Preoperative 3D CT showed that there was bone discontinuity and displacement in the left superior (the white arrow) and inferior (the red arrow) pubic ramus, and a gap was showed through the ilium (the green arrow). The sacrum (the blue arrow) was not in regular shape and the right transverse process of the L5 vertebral (the yellow arrow) was also found to be irregular. (B) Postoperative 3D CT scanning. (C) Postoperative CT image showed that anterior inferior iliac spine screw was through the fracture line and entirely in cancellous bone. (D) Postoperative CT image revealed that the iliac screw was in good position (the purple arrow). 3D=three dimensional, CT=computed tomography.

the optimal time to insert the guide needle once the image in the lower right corner of the navigation monitor is green (Fig. 4). Then the anterior inferior iliac spine screw and iliac screw were inserted (Figs. 5 and 6).

3.3. Outcomes and follow-up

We evaluated the position of the inserted screw according to Gras et al,^[19] and the location of placed screws were classified as 3 grades: Grade I (the screw was completely within in the cortex bone), Grade II (the screw cut the cortical bone without penetrating), III (the screw penetrating the cortical bone). Moreover, in the present study, we also accessed the time of screws designing, the implantation time of guide wires, the insertion time of screws, the volume of blood loss, and the time of the radiation exposure (Table 2).

Postoperatively radiographs (Fig. 1B–F) and computed tomography (Fig. 2B–D) were preformed to check the position of inserted screws. The results of imaging examination show that all the 3 placed screws were classified as grade I. Besides, totally 3 percutaneous screws were inserted, the designing time of all screws was 11.7 minutes, the time of all guide needles insertion was 18.1 minutes, the time of all screws insertion was 32.8 minutes, blood loss was 21 mL, and the time of radiation exposure lasted 7.2 minutes. No surgical complications, including neurovascular compromise, wound infection, fracture nonunion, and screw loosening, were observed during the 12 months follow up visit.

4. Discussion

Lateral compression fractures are one of the most frequently PRI, and are usually vertically stable.^[22] Many factors make for the stability of these fractures even in patients with fracture to the posterior sacroiliac ligamentous complex, including the impaction of the anterior sacrum, lack of injury to the sacrotuberous ligaments, and integrity of the pelvic floor.^[23] This stable fracture

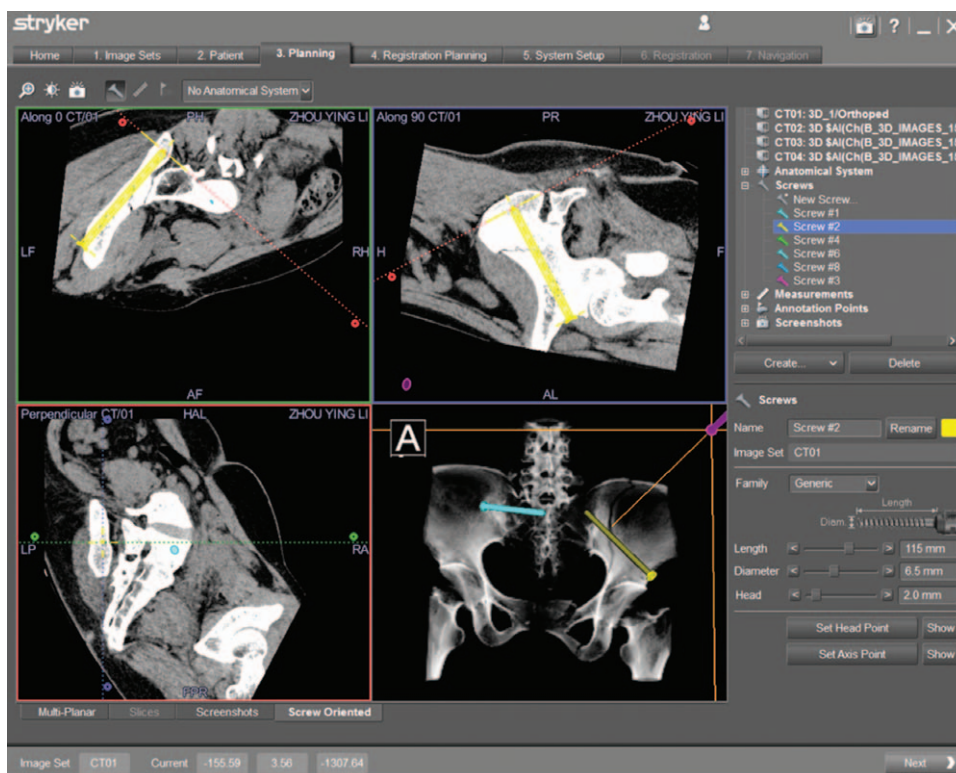


Figure 3. A percutaneous anterior inferior iliac spine screw was designed to fix the iliac fracture along the anterior inferior iliac spine to the posterior superior iliac spine preoperatively. The screw details including the length, the diameter, and the direction were also show in navigation workstation.

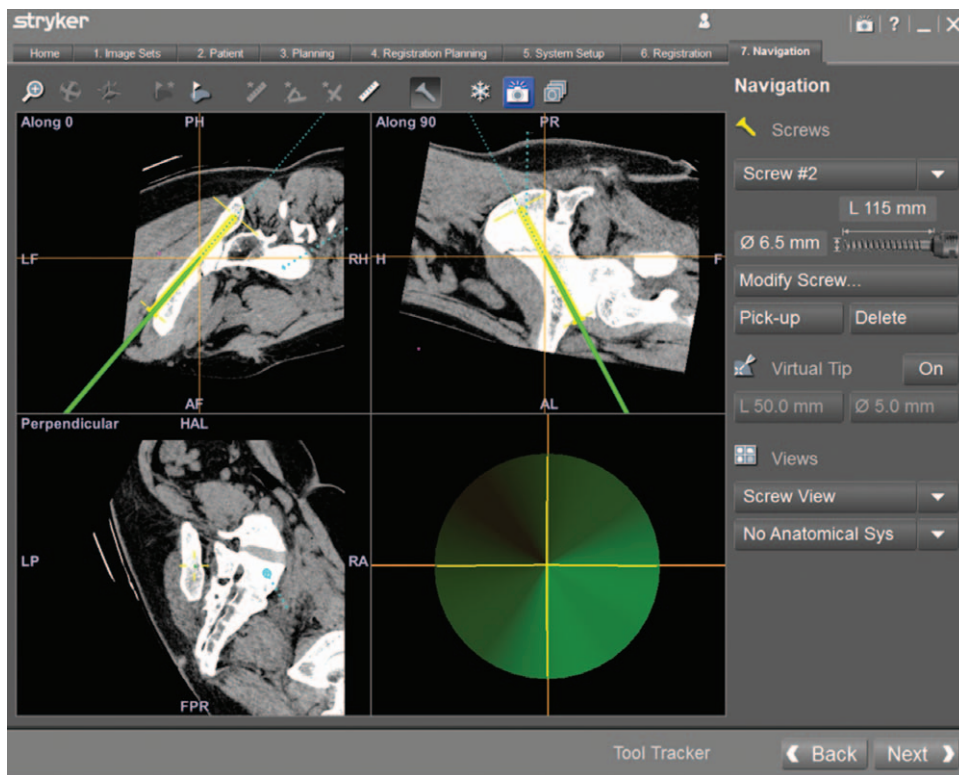


Figure 4. The image of the right lower corner shows green color, which indicates the optimal moment to insert a guide needle from the anterior inferior iliac spine.

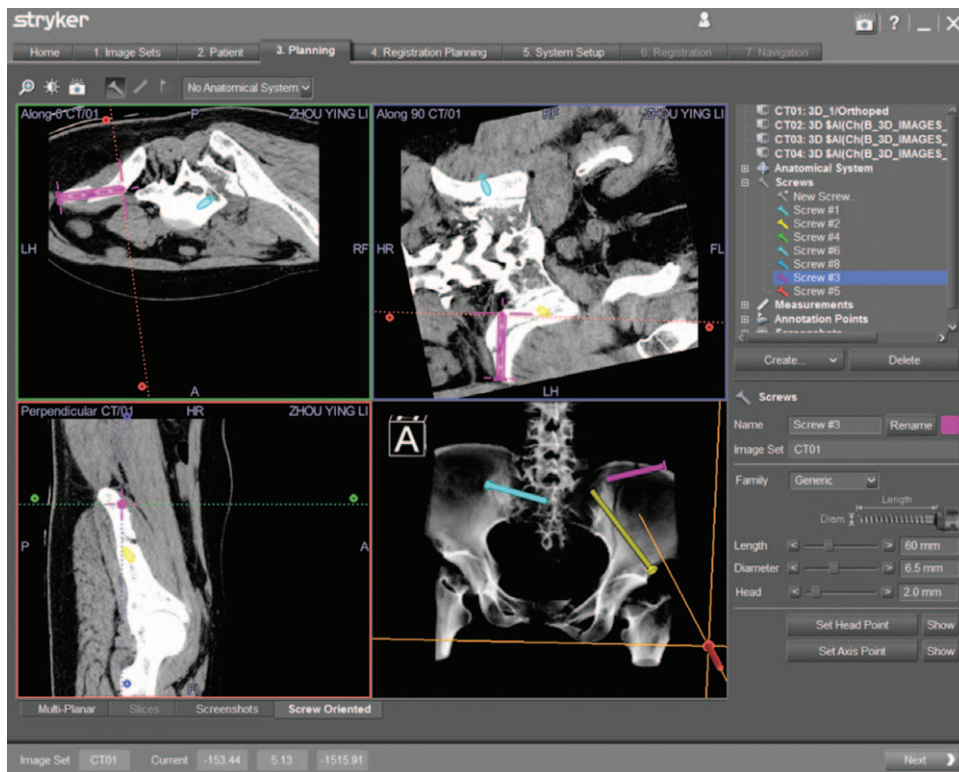


Figure 5. A percutaneous iliac screw was planned preoperatively. The screw details including the length, the diameter, and the direction were also show in navigation workstation.

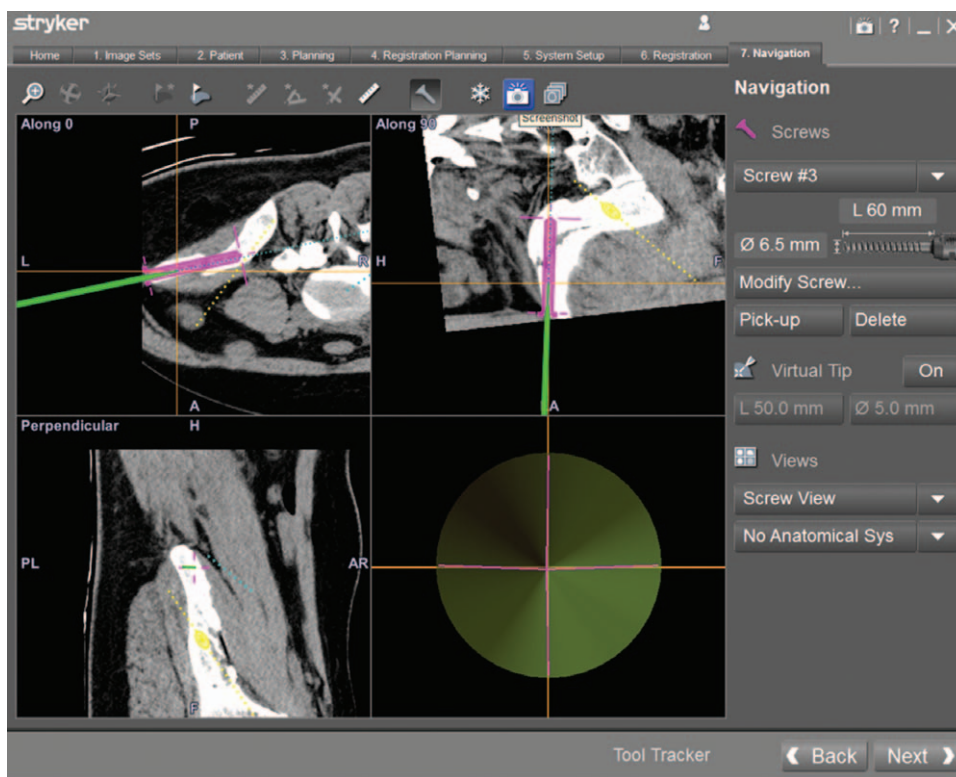


Figure 6. A guide needle of iliac screw was inserted.

provides the good condition for the application of navigation, because unstable fracture will lead to a serious decline in the accuracy of computer navigation. PPSs fixation is a safety and widely applied technique for the management of PRI.^[24–29] However, it is technique demanding due to the complexity of the pelvis anatomy. Thus, to improve the accuracy of PPSs insertion and prevent surgical complications, we used a SVMN technique to guide screw placement.

In the present study, 3 PPSs were inserted during operation, including a PAIISS, PIS, and PSIS. Our guide needle insertion time was shorter when compared with the conclusions of previous studies.^[18,19] Nevertheless, no significant difference was observed concerning the accuracy of screw placement and blood loss. Moreover, no screw loosening was found during the follow up period in this case. According to our experience, it is necessary to

design the position and direction of the screw preoperatively and to use the SVMN technique intraoperatively. With regard to fluoroscopic exposure time, as previous literature reported that navigation guided Kirschner needle has a significantly shorter fluoroscopic time when compared with fluoroscopic guidance.^[30] In this case, PPSs were inserted successfully at the first attempt which avoids postoperative screw loosening caused by multiple insertion attempts.

Gras et al^[19] reported that even under the guidance of 2D navigation, PPSs insertion for PRI still has 6% incidence of screw misplacement. Consequently, precise screw insertion requires a thorough understanding of the pelvis anatomy and a good intraoperative radiograph.^[31,32] In the present study, the positions of inserted screws were excellent without cortical perforation. We attribute this favorable outcome to the use of the SVMN technique for surgical designing and the screw inserting.

According to previous literatures,^[33–38] the biggest advantage of SVMN technique is to improve the accuracy of percutaneous screw placement and reduce the difficulty of surgery, especially for young surgeons. Under the guidance of SVMN, surgeon adjusts the direction of the guide needle according to the screw trajectory designed preoperative. When the direction of the guide needle displayed on the display is completely consistent with the design before operation, the guide needle can be placed.^[33,34,36,38] However, surgeons need to be very careful in the application of SVMN technique intraoperatively, in order to avoid the surgical complications due to inaccurate navigation. In addition, SVMN technique is only suitable for stable pelvic fractures, because unstable fracture may lead to inaccurate navigation during operation. Consequently, to prevent surgical complications, it is necessary for surgeons to master the

Table 2

Basic characteristics of PPSs.

Parameter	PAIISS	PIS	PSIS	Total
Designing time*	3.1	3.9	2.7	11.7
Guide needle insertion time*	6.7	7.3	4.1	18.1
Screw insertion time*	11.2	13.6	8.1	32.8
Radiation exposure time*	2.3	3.1	1.8	7.2
Blood loss [†]	14	17	10	41
Position	Grade I	Grade I	Grade I	–

L=left, PAIISS=percutaneous anterior inferior iliac spine screw, PIS=percutaneous iliac screw, PPSs=percutaneous pelvic screws, PSIS=percutaneous sacroiliac screw, R=right.

* Minute.

[†] mL

application method of computer navigation, to familiar with the anatomy of pelvis and to select suitable patients.

In the present patient, satisfied clinical outcomes were achieved postoperatively. However, there are still limitations. The indications of SVMN technique are limited, only selected patients with stable or minimal dislocation of PRI were suitable. Moreover, SVMN has a steep learning curve, and surgeons need to spend some time studying the application of SVMN.

SVMN technique guidance PPSs insertion is an effective and safety approach for the treatment of PRI in selected patients. Besides, it is necessary for surgeons to master the rationale of computer navigation, to familiar with the anatomy of pelvis, and to select suitable patients.

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