Clinical Case Report

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A screw-view model of navigation aid retrograde transpubic screw fixation for anterior pelvic ring fracture

A case report with 28 months follow-up and technical note

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Abstract

Rationale: The purpose of this study was to evaluate the accuracy of a retrograde transpubic screw fixation assisted by a screw-view model of navigation in treating a pelvic fracture.

Patient concerns: A 30-year-old female patient injured in a motor vehicle accident, displayed symptoms characterized by swelling and pain of the pudendum.

Diagnoses: The patient was diagnosed with a fracture of the pubic ramus.

Interventions: We used a screw-view model of navigation to assist our retrograde transpubic screw fixation in this patient.

Outcomes: In total, 2 screws were inserted into the bilateral pubic ramus and both were excellently positioned. It took 7.4 minutes to design the screws, 8.1 minutes to implant the guidewire, and 39.3 minutes to place the screws. Intraoperative blood loss amounted to 21 mL and the total fluoroscopic time was 3.8 minutes. No clinical complications, such as neurologic, vascular, or urologic injury, infection, screw loosening, or loss of reduction, were found after the operation. Follow-up lasted 28 months.

Lessons: The outcome of our study suggests that the screw-view model of navigation maximizes the retrograde transpubic screw insertion accuracy in the treatment of a pubic ramus fracture, which is made efficient by pain relief and early out-of-bed mobilization. Our suggestion is, therefore, that the relative position between the pubic ramus and the patient tracker must be static to ensure the accuracy of the entire system throughout the operation.

Abbreviations: 3D = 3-dimensional, CT = computed tomography.

Keywords: navigation, percutaneous, pubic ramus, screw-view model

1. Introduction

Injuries of the pelvic ring usually result from high energy trauma and motor vehicle accident injury, with 5% to 20% of the cases prompting severe hemorrhages and 10% to 31.1% leading to death.[1–4] The current treatment method includes an open or closed reduction and internal fixation,[5] anterior subcutaneous internal fixation,[6] and anterior pelvic external fixation.[7] However, this treatment technique has many shortcomings, such as neuronal injury,[3] asymptomatic nonunion,[3] loss of reduction,[8] infection,[3] pneumonia,[9] confusional states,[9] urinary tract infection,[9] and a severe impact on the quality of life of the patient. Percutaneous screw fixation procedures are now being increasingly used[2,9–11] for the sake of improving the effectiveness of treatment.

Percutaneous screw fixation is considered demanding due to the complexity of the 3-dimensional (3D) anatomy of the pelvis and its proximity to neurovascular structures. The method also requires the surgeon to have a detailed anatomic knowledge and extensive surgical experience. Additionally, the patient and the operating team are exposed to high levels of fluoroscopy over an extended period.[12,13]

To minimize the downsides of the percutaneous screw fixation method, a computed tomography (CT)-based navigation, a fluoroscopic-based navigation, and a robot-assisted navigation system have been developed for the screw fixation of pelvic ring injuries.[1,10,14–16] Nevertheless, there are still complications, such as neurologic, vascular, and urologic injuries and infections. This case report aimed to evaluate the accuracy and functional outcome of retrograde transpubic screw fixation of pubic ramus fractures by using an intraoperative 3D imaging-based screw-view model of navigation. The report describes our experience performing the screw-view model of navigation, and expresses our summary of the clinical application of the model to pubic ramus injuries, including its feasibility, merits, and limitations.

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1.1. 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.

2. Case report

2.1. Patient characteristics

A 30-year-old female patient injured in a motor vehicle accident was the subject of our investigation (Table 1). Physical examination revealed pelvic disruption and compression, characterized by swelling and pain.

In accordance with the pre- and postoperative X-ray and CT scan images (Figs. 1 and 2), there was bone discontinuity of the right superior and inferior pubic ramus, bone discontinuity of the left pubic synchondroses pubis, the gap between the left sacroiliac joint and the right side was wider to the left, and the sacrum was not regular. The right transverse process of the lumbar 5 vertebral body was also found to be irregular. The patient was diagnosed primarily with a bilateral pubic ramus fracture, displacement of the left sacroiliac joint, and fracture of the sacrum.

2.2. Surgical procedures

2.2.1. General preparation. The operation was performed under general anesthesia (intubation: propofol, 200 μg/kg; Fresenius Kabi Deutschland GmbH, Bad Homburg vdH, Germany; fentanyl, 250 μg, RenFu LLC, YiChang, China; midazolam, 2 mg; maintenance: propofol, 0.2–0.5 mg/kg/h, Enhua Pharmaceutical Limited by Share Ltd, JiangSu, China). Short-acting muscle relaxants were provided during the intubation only. The patient was placed in the supine position once the anesthesia took effect.

2.2.2. Image acquisition. A patient tracker (Stryker Leibinger GmbH & Co, Freiburg, Germany), piloted with the Navigation System II-CART II using a SpineMap 3D 2.0 software (Stryker Navigation, Kalamazoo, MI), was fixed on the iliac crest at the beginning of the operation. The system's C-arm tracker, patient tracker, and guidewire sleeve tracker were all activated. At the end of a 190° scan performed at the center of the lumbosacral articular surface, 3D images of the lesion were obtained.

Table 1

Basic characteristics of bilateral screws.

Parameter	Screw (L)	Screw (R)	Total
Position	Grade I	Grade I	–
Designing time, min	3.4	4.0	7.4
Guide wire insertion time, min	4.0	4.1	8.1
Screw insertion time, min	17.2	22.1	39.3
Screw loosening	None	None	–
Fluoroscopic time, min	1.9	1.9	3.8
Blood loss, mL	12	9	21
Neurovascular injury	None	None	–
Infection	None	None	–

L = left, R = right.

2.2.3. Surgical planning. The navigation system provided multi-planar images of the pubic ramus fracture, which helped to determine the screw length, diameter, and the best trajectory for screw placement (Fig. 3). In principle, the length of the pubic ramus screw was not to invade the articular surface, and the body of the cannulated lag screws had to be localized in the cortical bone.

2.2.4. Screw implantation. Access to the screw-view model was gained through the navigation system on the workstation (Fig. 3), with the real-time position of the guidewire sleeve displayed on a computer monitor, while the image of the design screw at the fracture site remained static. The infrared camera continuously updated the guidewire sleeve 3D position simultaneously on all displayed images, allowing real-time feedback of the designed screws and the location of the surgical instruments as the surgeon moved the guidewire sleeve. The use of the infrared camera helped the surgeon determine the optimal entry point and direction of each screw accurately. After identifying the precise entry point, the skin was incised at approximately 1 cm from its center. The position of the guidewire sleeve was moved until the direction of the device was completely aligned with the planning retrograde transpubic screw trajectory. At this point, the right

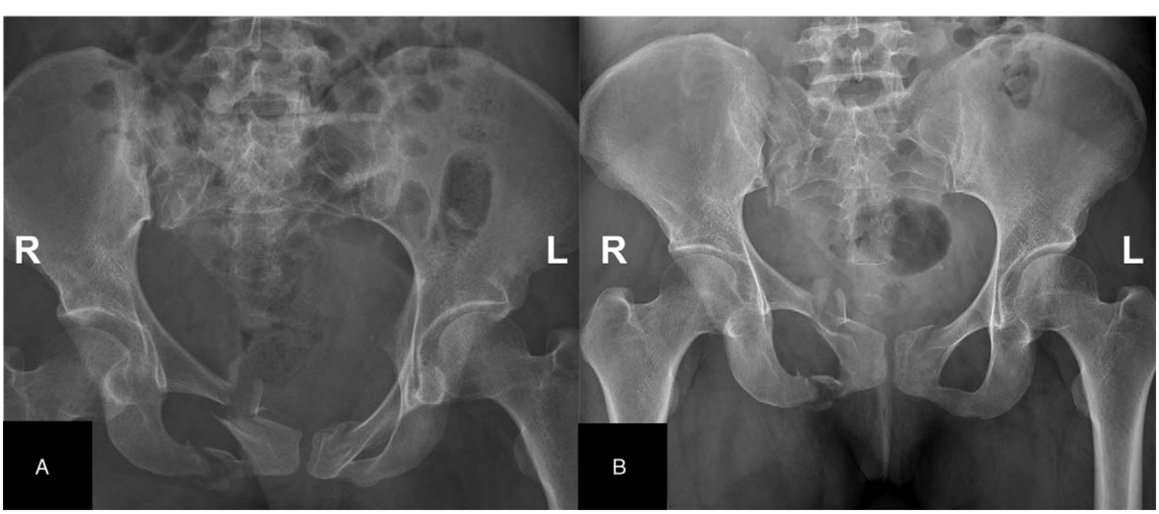

Figure 1. X-ray of the pelvis. A 30-year-old female patient injured in a motorcycle accident. (A) According to the preoperative X-ray image, the bilateral pubic ramus was fractured, and the space between the right sacroiliac joints was widened.

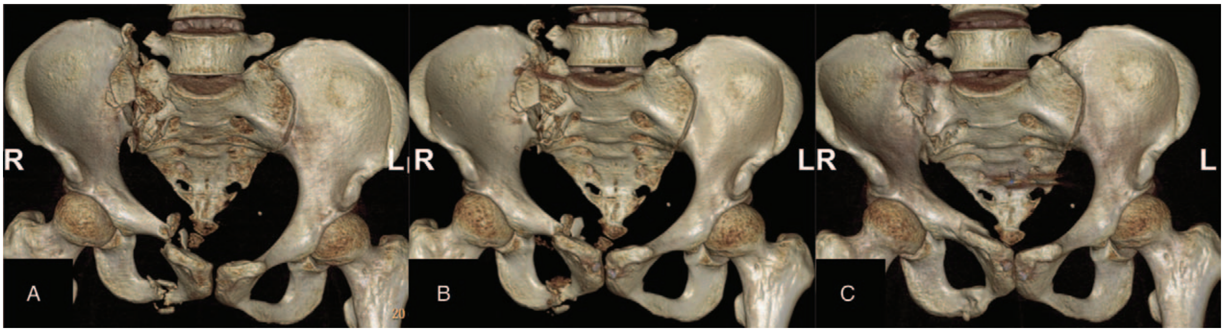

Figure 2. Pre- and postoperative 3-dimensional computed tomography (CT) examination of the pelvis. (A) Three-dimensional CT images examined during admission. (B) Three-dimensional CT images examined 1 month after the operation, (C) Three-dimensional CT images examined half a year postoperative.

lower corner image was highlighted in green, and the guidewire was placed (Fig. 4).

2.3. Outcomes and follow-up

Evaluation of the screws' positioning was graded in three categories: I (secure placement, entirely in the cancellous bone), II (secure placement, but spanning the cortical bone), III (misplacement, penetrating the cortical bone).[10] Also evaluated were: screw design time, guidewire implantation time, screw insertion time, the amount of bleeding, and fluoroscopic time (Table 2).

Postoperative X-ray imaging and 3D CT scanning (Figs. 5 and 6) show the outcome of screw positioning and fracture reduction. The 2 implanted screws were both categorized as grade I placement. Designing 2 screws lasted 7.4 minutes, guidewire implantation took 8.1 minutes, screw insertion took 39.3

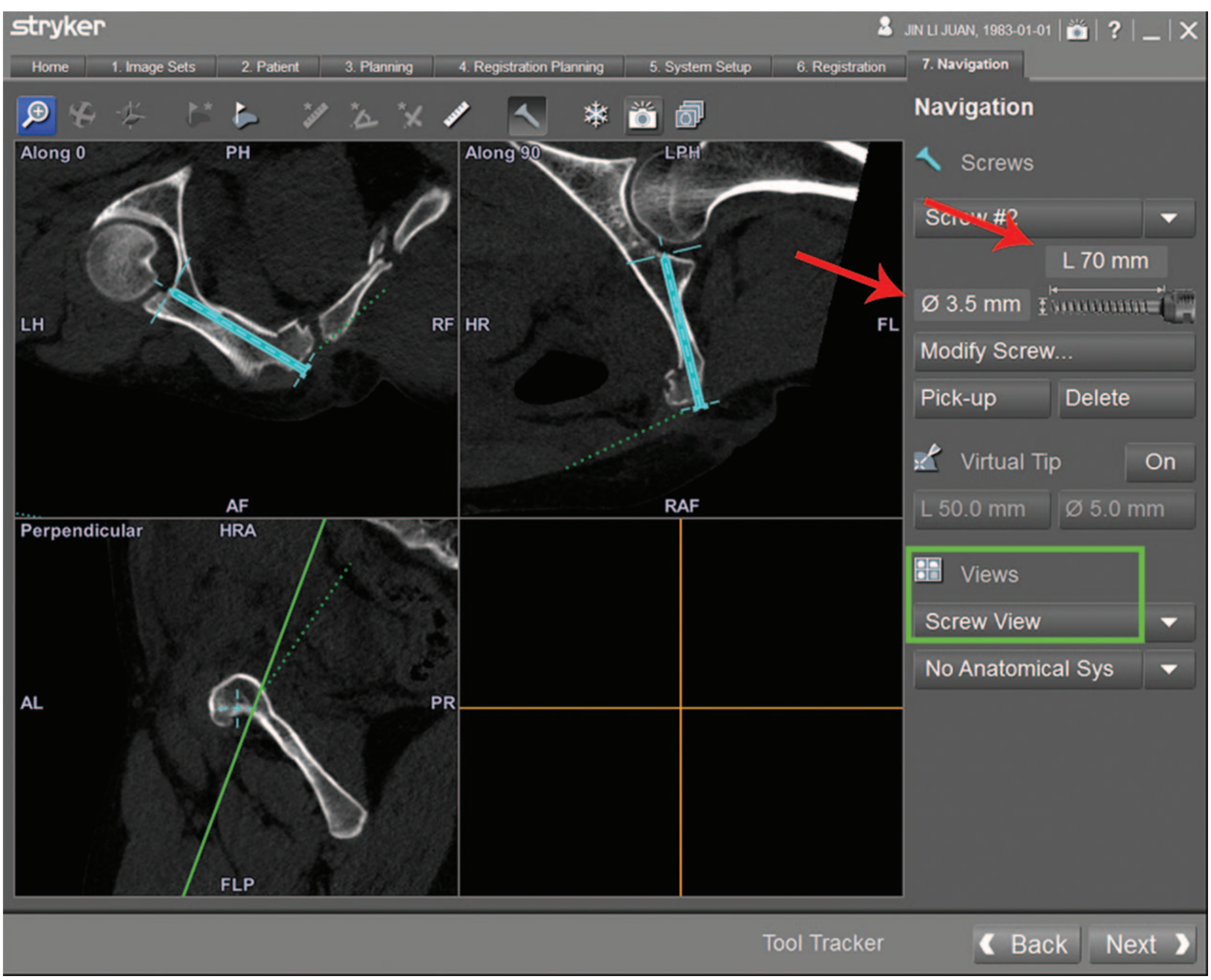

Figure 3. Screw designing. The length, diameter (red arrow) and the best trajectory of screws were determined after image acquisition. The screw-view model (green border) of navigation was selected on the workstation.

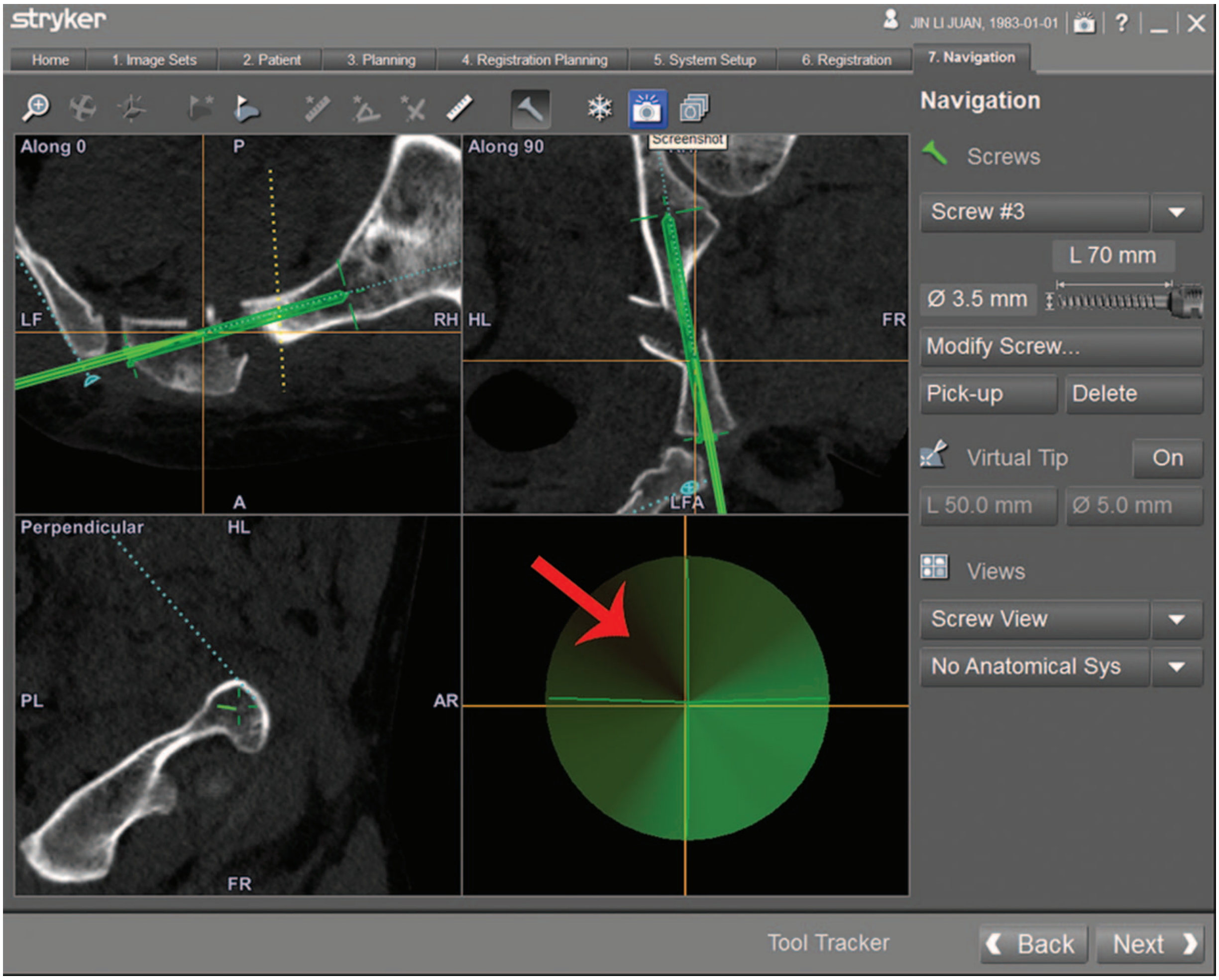

Figure 4. Screw insertion. When the right lower corner of the image shows green (red arrow), it would be the best time to implant a guidewire.

minutes, bleeding amounted to 21 mL, and fluoroscopic time lasted 3.8 minutes. No complications, such as neurological injury, vascular injury, infection on the inside of the articular surface, and screw loosening or breakage, were found during the 28 months of follow-up.

3. Discussion

Fluoroscopy-guided percutaneous minimally invasive screw fixation is an effective and widely used method for the treatment of pelvic ring injuries.[17–22] Retrograde transpubic screw implantation is a technically demanding procedure. Even by experienced hands, there is still as high as 83.3% complication rate[9]; the prevalence of loss of reduction is 15%.[8] We have explored the use of a screw-view model of navigation technique to assist in a retrograde transpubic screw insertion. Compared with the results of previous findings,[10,15] our guidewire implantation time was shorter, without loss of fracture reduction, and there was no significant difference with respect to the accuracy of screw placement, screw implantation time, or intraoperative blood loss. We had no incidence of screw loosening on follow-up. Additionally, a follow-up CT examination showed proper healing at the fracture site. We, therefore, propose that the preoperative surgical planning and intraoperative application of the screw-view model of navigation are very critical procedures.

Retrograde transpubic screw implantation is particularly challenging due to its complex 3D anatomy. A previous clinical study reported a 6% malposition rate of fluoroscopy-guided retrograde transpubic screw implantations.[10] Accurate screw insertion requires excellent intraoperative fluoroscopy and an understanding of the pelvic ring anatomy.[23,24] Possible difficulties associated with screw placement include the inability to insert the screw due to anatomical variations, extramedullary

Table 2

Basic characteristics of the patient.

Case	Gender	Age, yr	Diagnosis	Surgical treatment	Follow–up, mo
1	Female	30	BPRF	SVMN aid RTSF	28

BPRF = bilateral pubic ramus fracture, RTSF = retrograde transpubic screw fixation, SVMN = screw-view model of navigation.

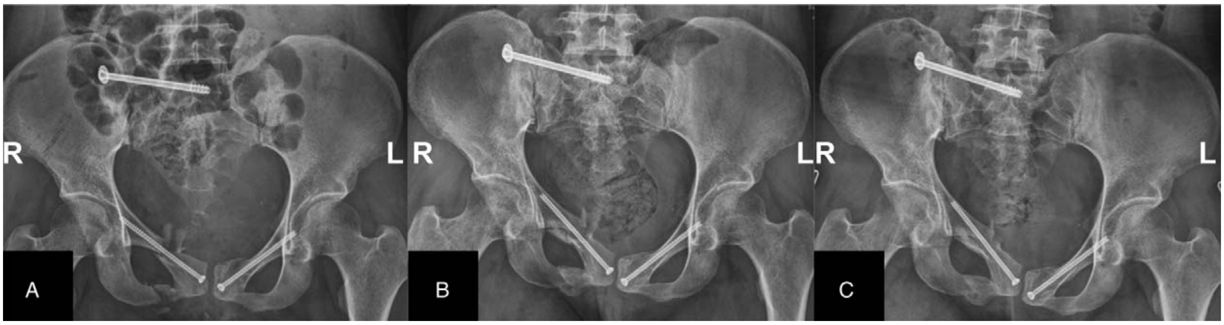

Figure 5. Postoperative X-ray examination of the pelvis. X-ray films of (A) 1 month, (B) 3 months, and (C) half a year after the operation.

misdirection of the screw, and postoperative disengagement.[25] In our study, the accuracy rate of screw positioning as a grade I placement was 100%. We attribute this positive result to the use of the navigation system for preoperative planning and the guidance of pedicle screw insertion with a screw-view model of navigation.

In this report, the implantation of 2 screws, including image acquisition, lasted 39.3 minutes. In all, the durations for surgical design, guidewire insertion, and screw implantation were kept at a minimum. Under the screw-view mode of navigation, the number of guidewire insertion attempts was reduced; each screw was successfully inserted at the first attempt. Moreover, research has demonstrated that using navigation guidance to check the positioning of guidewires results in a significantly shorter fluoroscopic time when compared to the use of fluoroscopic guidance.[26] In accordance with findings from past research, our outcomes suggest that these positive results are associated with the assistance of a screw-view model of navigation.

Many researches have reported excellent results with retrograde transpubic screw fixation in the stabilization of the anterior pelvic ring fracture. However, screw loosening is a typical complication of the pelvic ring fracture, which may be related to osteoporosis.[26,27] Its prevention is crucial, since it has been associated with the occurrence of several complications, including screw breakage, insufficient strength of biomechanics, and even loss of fracture reduction.[8] In our case, no retrograde transpubic screw loosening and loss of fracture reduction were observed, either because of the short time of follow-up or because the screw-view model of navigation was used to assist in the accurate screw implantation. Furthermore, implanting all retrograde transpubic screws at the first attempt avoided multiple drill holes that could have led to screw loosening.

With the screw-view model of navigation, when the right retrograde transpubic screw was inserted, and the surgeon detected an inaccurate indication on the navigation image, he compared it with the anatomical structure of the spinae pubis and confirmed that the image had drifted. The patient tracker was, hence, refixed during the operation, the surgical instruments were recalibrated, and the lesion images were scanned again. Finally, the right retrograde transpubic screw was placed under the guidance of a now accurate navigation system. We opined that the movement of the patient tracker leads to inaccurate intraoperative navigation. Consequently, if the navigation were to be found wanting in accurate in the middle of an operation, the cause of the problem should be seen and the issue resolved to avoid blind cannulated lag screw planting and prevent the occurrence of complications such as neurovascular injury.

As for the drawbacks of this manipulation, this model requires a surgeon who is very familiar with the functional state of the navigation and has to continually relocate the positioning of the image in the navigation system during the operation to avoid navigation inaccuracy stemming from deviation, and, thus,

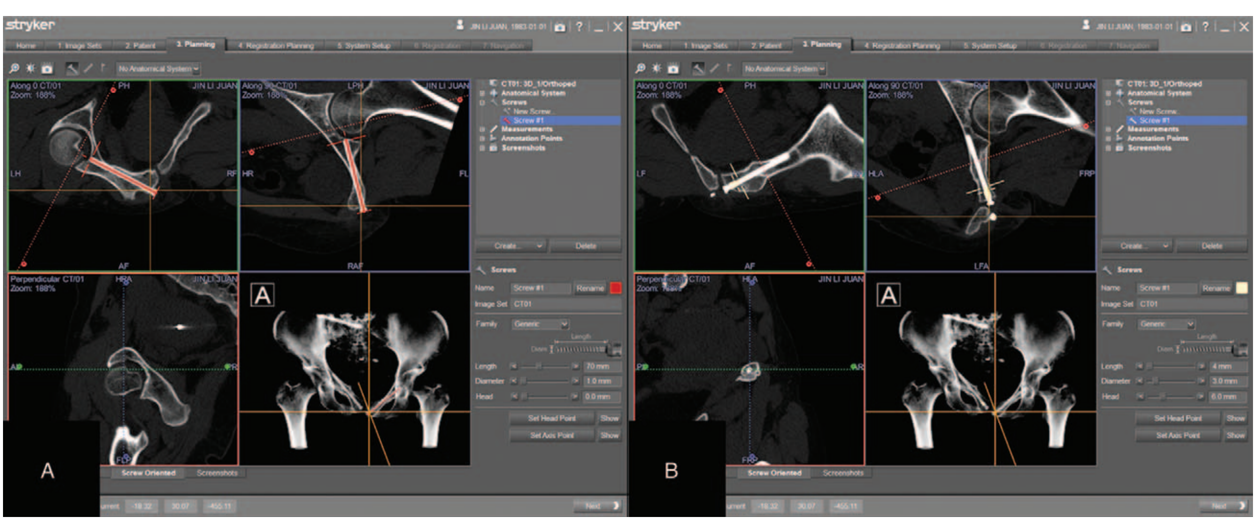

Figure 6. Three-dimensional computed tomography after the operation. The image shows the excellent positioning of the screw (without cortical cutting, or invasion of the hip joint by the tip of the screw).

operation failure. Also, the range of indications in the navigation system is narrower, and it is only suitable for minimal dislocation of pubic ramus fractures.

4. Conclusion

In conclusion, the retrograde transpubic screw insertion assisted by a screw-view model of navigation is a simple and highly feasible procedure for surgeons. Our experience is that the relative position between the pubic ramus and the patient tracker must be static to ensure the accuracy of the entire system throughout an operation.

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Author contributions

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Writing – review & editing: Jian-Wu Zhao.

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