RESEARCH ARTICLE

Safe Corridor for Sacroiliac Screw Insertion Can Be Found Quickly Without the Use of the Lateral Sacral View

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Abstract

Background: Studies have proved that in addition to the inlet and outlet views, the intraoperative lateral sacral view is required to ensure the correct entry point, reduce operating time, and lower radiation exposure. Considering the complex anatomy of the sacrum, we showed a safe corridor for sacroiliac joint (SIJ) screw insertion that was accessible using only inlet and outlet fluoroscopic views.

Methods: From 2013 to 2020, we enrolled 215 patients who underwent percutaneous SIJ screw insertion. Our experience in SIJ screw insertion is presented using only two views (inlet and outlet). We reported on the radiation exposure time, operating time, rate of screw malposition, neurologic injury, and revision surgery.

Results: The screw malposition rate was 5.5%, including 11 foraminal perforations and one perforated anterior sacral cortex. Paresthesia after the surgery was observed in six patients (2.8%). No revision surgery or screw removal was performed. The radiation exposure and operation time for each screw were 21 ± 4.5 s and 13.5 min, respectively.

Conclusion: The most anterior and the lowest part of the S1 vertebra can be easily found using intraoperative inlet and outlet views. It is a safe corridor for SIJ screw insertion with low radiation time, neurologic injury, and revision rates.

Level of evidence: IV

Keywords: Lateral sacral view, Percutaneous fixation, Posterior pelvic ring injury, Sacroiliac joint screw

Introduction

Percutaneous insertion of sacroiliac (SI) screw has become the preferred fixation method in an unstable posterior pelvic ring. [1] Other Indications for this technique include SIJ disruptions, spinopelvic dissociations, and sacral fractures. [1,2] The SIJ screw insertion is associated with less blood loss, less soft tissue injury, and shorter operating time than open surgical techniques. [1]

Despite its popularity, the safe insertion of the SIJ screw requires preoperative computed tomography (CT) and adequate intraoperative fluoroscopic imaging. The surgeons must be familiar with radiographic landmarks and the bony anatomy of the sacrum and must recognize abnormal anatomy in patients with sacral dysmorphism. [2] In sacral dysplasia, the morphology of the upper sacral segment, including orientation and size, limits the safe insertion of an SIJ screw. [3] The aim is to prevent injury to neurovascular structures with a risk of incidence as high as 18%, even among experienced surgeons. [4] Although the introduction of surgical navigation systems has made SIJ screw insertion safer and more accessible, conventional fluoroscopy is the standard technique in most hospitals. [5,6]

Although studies have emphasized the lateral fluoroscopic view to guide the best entry point, we have carried out percutaneous SIJ screw placement without using a lateral sacral view for seven years. [7-9] We hypothesized that the most anterior and the lowest part of the S1 vertebra is the safest corridor for SIJ screws that is easily recognizable by intraoperative inlet and

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outlet views. This study aims to evaluate the accuracy and safety of this corridor. The sacral anatomy and the so-called "safe corridor" discussed on transparent 3D models are included here. We compared our experience with similar studies regarding radiation exposure time, operating time, screw malposition rate, and neurologic injury rate.

Materials and Methods

From January 2013 to December 2020, 248 patients underwent SIJ screw insertion because of the posterior pelvic ring injury in our level I trauma center. It was used for SIJ dislocations, simple or comminuted sacral fractures, and unstable posterior pelvic ring injuries (primary or after anterior osteosynthesis). To facilitate our measurements, patients who underwent S2 screw insertion were excluded. Severe sacral dysmorphism, horizontal sacral fractures, and primary nerve injuries were excluded. Finally, 215 patients were enrolled in this study to assess the radiation time and malposition rates of SIJ screws. The study protocol was reviewed and approved by the local ethics committee. Written informed consent was obtained from all patients before the study began.

The senior author operated on all patients. Before the operation, anteroposterior, inlet, and outlet pelvis radiographs, in addition to CT scans, were obtained to Identify the type of pelvic and sacral injury and any sacral dysmorphism. The procedure was performed in the supine position on a radiolucent bed. A small incision was made in the posterosuperior quadrant formed by the intersection of the two lines; a line perpendicular to the floor from the anterior superior iliac spine (ASIS) and a line with the middle of the femoral shaft. Then a guide pin for a cannulated screw system was directed toward the safe corridor. A drill tip guide pin improved manual control when approaching the corridor only under the inlet and outlet views. The starting point varied between 15 and 30 degrees caudal and superior, depending on the anatomy of each person's sacrum. The corridor was safe and accepted when the guide pin was placed in the anterior-most and the lowest part of the S1 body in the inlet and outlet views, respectively.

To have standard inlet and outlet views, the fluoroscopy machine was perpendicular to the patient from the contralateral side of the injury. The ideal inlet view was obtained when S1 and S2 vertebral bodies overlapped. The perfect outlet view superimposed the pubic symphysis on the S2 body. We used partially threaded 6.5-mm cannulated screws. Besides fluoroscopic views, the feel of the drill was essential to confirm the correct location of the screw within the bone. In osteoporotic patients, a washer was used to prevent accidental screw penetration into the lateral iliac cortex. It also sits against the outer table of the ilium obliquely. Finally, the guide pin was removed, and the surgical wound was closed.

Safe insertion of the SIJ screw was evaluated with a postoperative CT scan. All patients were visited 1, 2, 6, and 12 weeks after the operation. Clinical evaluations were performed to detect postoperative neurologic injuries, including radicular pain and motor deficits. During follow-up visits, AP, inlet, and outlet radiographs were obtained from all patients to search for loss of reduction or device failure after the surgery. Postoperative rehabilitation depended on the type of fractures and associated injuries. Patients with lateral compression (LC) or APC type I/II injuries were allowed to weigh as tolerated with the assistance of crutches or a walker. The goal was full-weight ambulation at 12 weeks after the surgery. The weight-bearings of patients with APC type III or vertical shear (VS) injuries were delayed until after six weeks of toe-touch weight-bearing.

All statistical analyses were performed in SPSS software version 16 and presented in mean ± standard deviation (SD) and median ± range.

Results

Between 2013 and 2020, 215 SIJ screw insertions were enrolled in the study. They included 85 cases of APC, 58 cases of LC, 42 cases of VS, and 30 cases of APC with concomitant LC injury. The anterior pelvic ring was fixed in 198 patients. The mean Injury Severity Score (ISS) was 32 ± 8.4 points. The mean age of the study population was 32 ± 8.4 years, with a the male-to-female ratio of 2.1. The SIJ screw insertion was carried out on average after six days (range: 0-24 days).

Correct screw insertion was found in 199 patients (92.5%). Eleven patients (5.1%) had foraminal perforation (four left, five right, and two bilateral). There were 58 cases of trans-sacral screw insertion, one of which perforated the anterior sacral cortex. Among all patients with screw malposition, six patients (2.8%) suffered from paresthesia after the surgery. All neurologic injuries were detected in the first follow-up visit, one week after the operation. All six cases recovered within a month, and no revision surgery or screw removal was performed. The radiation exposure time for each screw was 21 ± 4.5 s (range, 16-45 seconds). The median time of screwing from the guide pin insertion to the last acceptable intraoperative fluoroscopy was 13.5 min. [9-23,5]

Discussion

In this study, we evaluated an applicable and straightforward hypothesis that helps surgeons quickly find a safe corridor for SIJ screws without using an intraoperative lateral sacral view. With exact knowledge of the sacral anatomy, we believe surgeons can insert SIJ screws in a safe corridor with low operating time and radiation exposure using only inlet and outlet views. The safe corridor is the intraosseous area of the sacrum where SIJ screws can be inserted without perforation of the neural foramen or cannel. The neurologic injury following SIJ screw insertion has been reported as high as 18%. [4]

The safe corridor for the S1 screw is restricted superiorly and inferiorly between the sacral ala and the first sacral neural tunnel, respectively. It is also bordered anteriorly and posteriorly by the anterior sacrum cortex and spinal canal [Figure 1]. The first sacral neural tunnel extends from the posterior (at the spinal canal) to the anterior in a craniocaudal direction exiting through the anterior sacral foramen. This direction means that only part of the

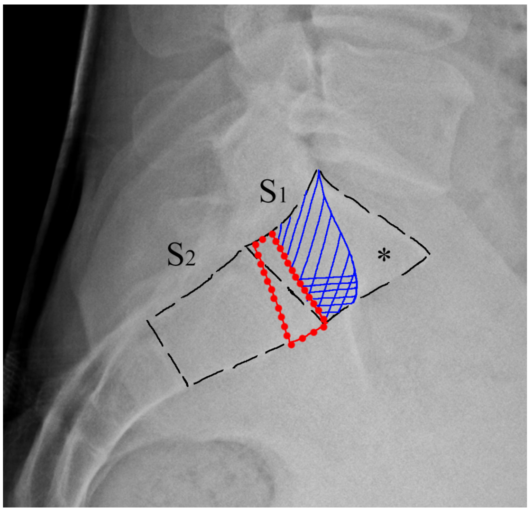

Figure 1. Lateral sacral view. The area marked with dotted lines shows the first neural tunnel that should be avoided during screw insertion. The asterisk denotes the sacral promontory, and any screw entering this area can damage major vessels or the L5 nerve root. The remaining area (line pattern area) can be targeted as the safe corridor. The more anterior and inferior the screw in this area, the lower the risk of nerve injury.

first sacral neural tunnel is in the S1 vertebra. As shown in figure 1, the posteroinferior aspect of the S1 vertebra is occupied by the neural tunnel. It hypothesizes that the anterior-most and the lowest part of the S1 vertebra is the safest place to insert an SIJ screw. By staying anterior and inferior in the S1 vertebra during SIJ screw insertion, the risk of damage to the neural structures of the spinal canal or S1 nerve root remains minimal [Figure 2]. Similarly, the L5 nerve root and great vessel are avoided as this point is always inferior to the sacral ala (iliac cortical density).

The inlet and outlet views are mandatory intraoperative images for SIJ screw insertion. Inlet or outlet views are obtained to determine the corridor's anterior /posterior or superior/inferior position, respectively. [2] Changing between inlet and outlet views during operation ensures the proper placement of the SIJ screw in the anterior and lowest part of the S1 body, respectively. According to this hypothesis, there is no need for a lateral sacral view.

Despite the lack of a comparison group in this study, we found acceptable results compared to similar studies regarding the mean radiation exposure time and screw malposition. Zwingmann et al. measured the radiation time for one screw insertion using computer-assisted navigation systems compared with conventional

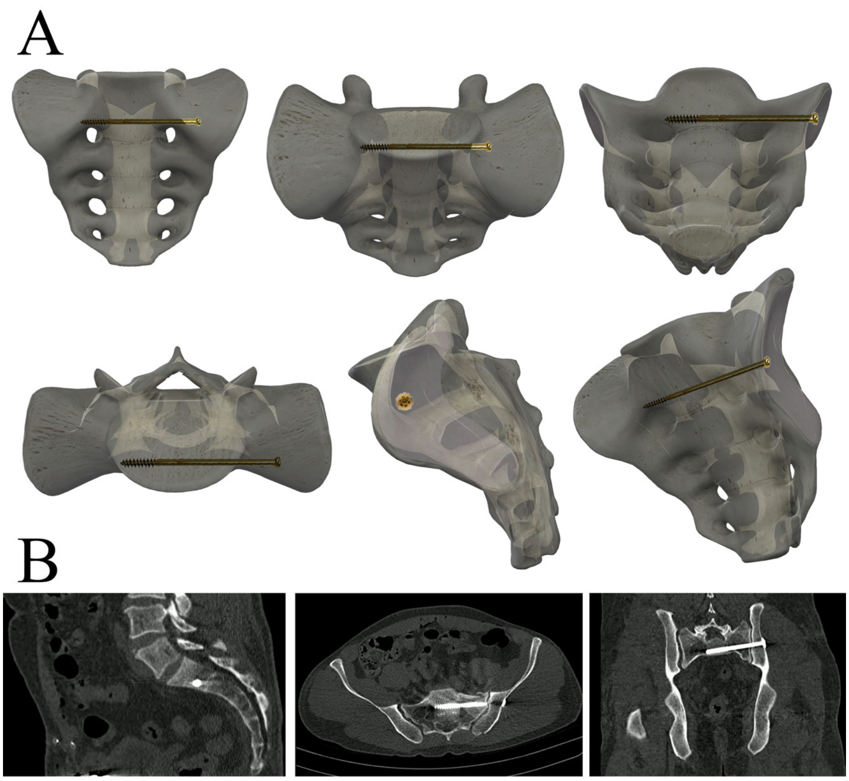

Figure 2. S1 screw in the most anterior and lowest part of the S1 vertebra. 3D transparent model of the sacrum (A) and postoperative sagittal, coronal, and axial CT scan (B) showing the position of the S1 screw in different views.

fluoroscopic techniques (intraoperative inlet, outlet, and lateral views). [10] They observed lower radiation time in navigated groups: 63 ± 15s (36–84) versus 141 ± 69s (42–252). The average exposure time for each screw was reported 36 s in Tonneti et al.'s study. [11] In Giannoudis et al.'s study, the mean radiation exposure time for one S1 screw insertion was significantly lower when using three views (inlet/outlet/lateral) compared with two views (inlet/outlet): 18.6 ± 8.3 s versus 14 ± 5.6 s. [9] The mean exposure time in the current study was 21 ± 4.5s, ranging from 16 to 45 seconds. It is much less than Zwingmann et al.'s study. [10] Although there is no discrepancy between our study data and Giannoudis et al.'s study, it should be noted that their study was performed on plastic pelvic models. [9]

Screw malposition was detected in 5.5% of this study population, with a neurologic injury rate of 2.8%. Studies have reported malposition rates of 2% to 15% when using fluoroscopic views with a neurologic injury incidence of 0.5% to 18%. [12-14] The malposition rate of SIJ screw insertion has been reported only 1.3 % when using modern navigation and reconstruction systems. [14] However, it can vary depending on the surgeon's experience with the navigation techniques. [14,15] Studies have shown a revision rate of 2.7% when using fluoroscopic guidance and 0.8%-1.3% in navigated techniques. [14] However, we did not have any revision surgery during the seven years of study.

Although the SIJ screw malposition rate is the lowest in the computer-assisted navigation techniques, this study showed the advantage of our experience regarding the radiation exposure time, neurologic injuries, and revision surgery. Our method can make conventional intraoperative fluoroscopy the preferable technique for percutaneous SIJ screw insertion, especially since navigation systems are not always available. Furthermore, training of computer navigation technology is expensive, and navigational drift may cause complications such as intestinal damage or neurovascular injuries. [16]

The major limitation of this study is the lack of a control group using three intraoperative views. As most of our cases had concomitant anterior pelvic ring fixation, we considered the operating time from the guide pin insertion to the last acceptable intraoperative fluoroscopy for each screw insertion. Other studies usually considered it from the skin incision until the wound closure. This discrepancy limited us to comparing our operating time with others. The definition of the operating time in this study is similar to that of Chao et al.'s study. [17] In their study, the operating time was 46 minutes in the conventional fluoroscopic group and 25 minutes in the template group. The median time of screwing in this study was 13.5 min. Finally, the data of this study are the results of seven years of experience of the senior author in performing this method. They can vary according to the experience of the surgeon. Therefore, the method presented in this study is a technically demanding procedure.

Staying anterior and inferior in the S1 vertebra during SIJ screw insertion, a surgeon can be sure of a safe corridor without using a lateral view. AS results showed, this was associated with low operating time and radiation exposure and a low incidence of screw malposition and neurologic injuries.

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