Original Article

Posterior Column Triangle Fluoroscopic View for Posterior Column Screw Placement in Acetabular Surgery: A Novel Single Fluoroscopic View Technique

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Abstract

OBJECTIVES: Posterior column screw placement is essential for achieving fracture stability in acetabular fractures involving the posterior column. The conventional technique requires multiple intraoperative fluoroscopic views, increasing both radiation exposure and operative time. This experimental study aimed to assess the efficacy and safety of a single intraoperative fluoroscopic view, guided by the "posterior column triangle" concept, for posterior column screw placement in a pelvic bone model, compared to the conventional two-view technique.

MATERIALS AND METHODS: The study was conducted using pelvic bone models and involved five surgeons with varying levels of experience in pelvic surgery, including pelvic and acetabular specialists and orthopedic trauma fellows. Each surgeon performed posterior column screw insertions using both the conventional two-view fluoroscopic technique (anteroposterior and iliac oblique views) and a novel single-view technique guided by the "posterior column triangle" concept. In this approach, the defined triangle served as the safe corridor for the entry and ending points of the screw trajectory. The optimal fluoroscopic angle for the single-view, termed the "posterior column triangle view," was determined to be 10 degrees obturator tilt and 25 degrees inlet tilt. Data on screw insertion safety and radiation exposure were collected and analyzed.

RESULTS: The novel single-view fluoroscopic technique consistently enabled accurate K-wire placement within the safe corridor of the posterior column, with no cortical breaches observed in any of the tested bone models. Additionally, it was associated with significantly reduced radiation exposure compared to the conventional two-view method. These findings suggest that the single-view approach may serve as a viable alternative in clinical practice, particularly for managing high posterior column fractures.

CONCLUSION: The posterior column triangle-view technique offers a safe alternative for K-wire insertion in posterior column screw fixation while reducing radiation exposure. Implementation of this technique should be considered in high posterior column fracture line. Further larger-scale studies with different pelvic bone samples are warranted.

Keywords: acetabular fracture, posterior column screw, single fluoroscopic view, posterior column triangle, radiation exposure

Acetabular fractures are complex injuries that require thorough knowledge of pelvic anatomy and advanced surgical techniques to restore articular congruity and stability. Different fixation strategies have been investigated and proposed over the past decades. These include the advancements of techniques for column-specific screw placement. Among these advancements, posterior column screw placement was commonly used to stabilize the reduced posterior column fracture which was first proposed by Starr et al. in 2001.[1]

Conventionally, the placement of posterior column screws necessitates multiple intraoperative fluoroscopic views to verify accurate positioning, ensuring optimal biomechanical stability and avoiding intra-articular or neurovascular complications. However, this standard practice is associated with prolonged operative time for processes of changing the position of intraoperative fluoroscopy to obtain appropriate images and increased radiation exposure, both of which pose health concerns for patients and operating room personnel.[2-4]

Pelvic geometry provides a consistent bony landmark known as the **"posterior column triangle"** (Figure 1), which has been described in CT-based studies as a triangular-prism-shaped corridor bordered by the quadrilateral surface medially, the retroacetabular surface of the ilium laterally, and the superoposterior acetabular surface inferiorly.[5] However, the concept's CT-based origin limits its direct applicability during real-time intraoperative procedures.

The authors propose that this anatomical triangle can serve as a reliable landmark for guiding the posterior column screw placement within the safe corridor. This study hypothesizes that a novel single-view fluoroscopic technique for posterior column screw placement will provide safe screw positioning while reducing radiation exposure compared to the conventional two-view technique.

Materials and Method

The study protocol was approved by the Ethics Committee (Approval number COE 2024-02). This is an experimental study using 10 anatomically-matched pelvic bone models (Synbone, Zizers, Switzerland). There were 5 surgeons with different levels of expertise in pelvic and acetabular surgery who are instructed to perform the K-wire for posterior column fixation using both in novel single fluoroscopic view (Figure 3a-b) and conventional two-view techniques.

Pelvic bone model positioning

To simulate the supine posture of an actual patient, a full-body skeletal model was placed in the supine position on a radiolucent operating table (Figure 2a). Pelvic orientation was measured using a goniometer and recorded. Subsequently, an anatomically matched pelvic bone model (Synbone, Zizers, Switzerland)[6] was positioned on the same radiolucent operating table, replicating the recorded pelvic orientation to ensure accurate simulation of pelvic incidence in the supine position (Figure 2b).

C-arm Positioning

The posterior column triangle is a consistent bony landmark, defined by three anatomical borders: medially by the quadrilateral surface, laterally by the retro-acetabular surface of the ilium, and inferiorly by the superoposterior acetabular surface (Figure 1).

All surgeons were instructed on identifying the bony boundaries of the posterior column triangle using a pelvic bone model, which served as a reference for accurate C-arm positioning. The model was then placed on an operating table to simulate a patient in the supine position.

The C-arm was brought into position, and all surgeons participated in adjusting its orientation to achieve the optimal fluoroscopic image of the posterior column triangle.

The final C-arm positioning required a 10-degree obturator oblique tilt combined with a 25-degree inlet tilt (Figure 3a–b). Notably, the C-arm used in this study was the ARTIS pheno system (Siemens, Forchheim, Germany), which features a position memory function, enabling consistent replication of angles during the procedures.

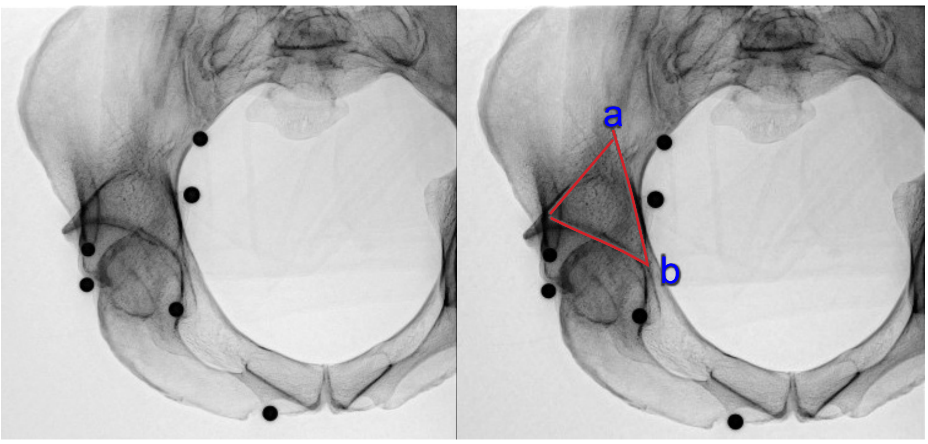

Figure 1

a: Posterior column triangle in cadaveric bone. (please note the six round dots were artifacts which were not relevant to the present study.)

b: Bony boundaries of the posterior column triangle. Medial - quadrilateral surface, Lateral - retro-acetabular surface on the ilium, Lower borders - supero-posterior acetabular surface

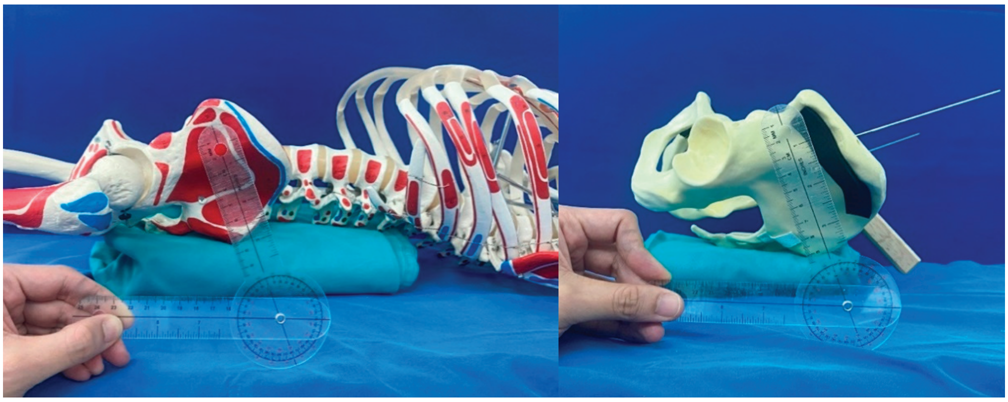

Figure 2: Positioning of the pelvic bone model.
a: Firstly, a full-body skeletal model was positioned supine on radiologic transparent operating table to simulate the actual patient's supine posture. Actual pelvic tilt angle was measured using a goniometer.
b: An anatomically-matched pelvic bone model (Synbone, Zizers, Switzerland) was then positioned to replicate the pelvic orientation shown in Fig 2a. Goniometer was used to verify and ensure similarity of the pelvic incidence.

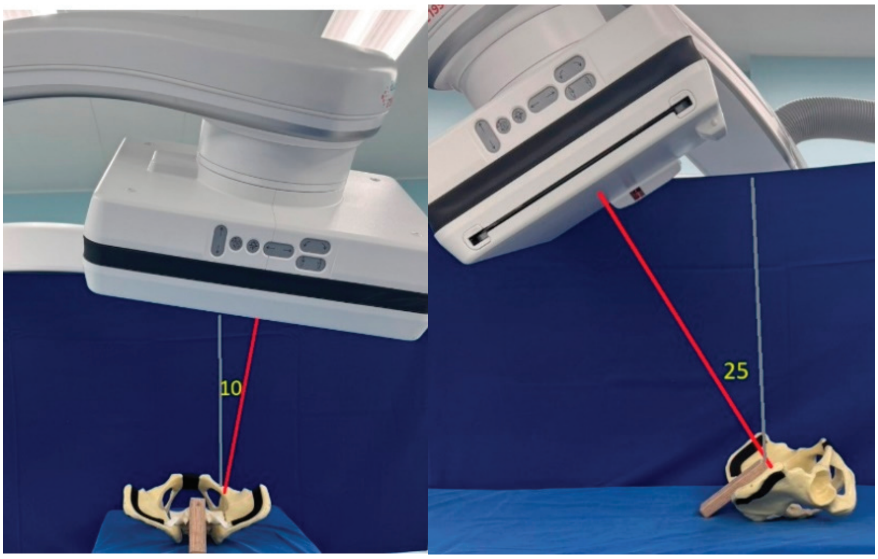

Figure 3: C-arm position of "posterior column triangle view" to obtain the image of "posterior column triangle" of right hemipelvis was a combination of obturator tilt 10 degrees (a) and inlet tilt 25 degrees (b). The fluoroscopic image of posterior column triangle was shown in Figure 1.

Optimal K-wire position

To ensure appropriate bony corridor access for posterior column screw fixation and to achieve sufficient screw length, the entry point for K-wire insertion should begin just lateral to the pelvic brim and distal to point "a," which is in the proximal part of the "posterior column triangle."[7]

The insertion should aim to stop at point "b," which corresponds to the most medial part of the acetabulum. This study was not designed to insert the K-wire beyond this point, as it was intended to use the posterior column triangle as a reference.[7]

With the wide entry point and small area of ischial tuberosity, the corridor can be considered as conical shape (Figure 4).

K-wire insertions

Each surgeon performed two separate trials of single K-wire insertion using two different fluoroscopic methods: one with the novel posterior column triangle view and the other with the conventional two-view technique (anteroposterior and iliac oblique views, as described by Starr et al.[1]).

To minimize bias, a new identical pelvic bone model without any pre-existing K-wire trajectories was used for each insertion. Additionally, all insertions using the novel single-view technique were completed by all surgeons before proceeding to the conventional technique. This sequence was intentionally designed to reduce the influence of tactile memory regarding the wire trajectory.

First Insertion Using the Novel Single Fluoroscopic View Technique

A 2.5-mm K-wire was inserted at a point approximately 1.5 cm lateral to the pelvic brim under direct visualization. Fluoroscopic guidance in the posterior column triangle view was employed to ensure that the wire remained within the safe corridor of the posterior column triangle, distal to point “a” (Figure 4a). The wire was then advanced to the target endpoint, designated as point “b” (Figure 4b).[7]

Radiation exposure, measured in milligray (mGy), was recorded for each procedure.

To establish reference points for the subsequent conventional technique, additional anteroposterior (AP) and iliac oblique views were obtained (Figure 6a–c) to identify the target endpoint in both AP and iliac oblique views.[8]

A new pelvic bone model was then prepared for the next surgeon to perform their first insertion using the single-view technique.

Second Insertion Using the Conventional Two-View Technique

After all surgeons had completed their first insertion, each surgeon performed a second K-wire insertion using the conventional two-view fluoroscopic technique. The same entry point—approximately 1.5 cm lateral to the pelvic brim—was used under direct visualization. Fluoroscopic guidance was provided using AP and iliac oblique views, and the wire was advanced toward the same target endpoint identified in the first insertion. Radiation exposure (mGy) was again recorded for each procedure.

Verification of safe insertion.

Safe insertion was verified through direct visualization of the cortical and joint surfaces of the pelvic bone model. An insertion was considered “safe” if the K-wire tip and shaft remained entirely posterior to the acetabulum, did not enter the greater sciatic notch, and did not breach the medial or lateral cortices of the ischium or the joint surface.[9] Representative examples are shown in Figure 5a–c.

Radiation exposure

Radiation exposure for each surgeon during each procedure was recorded in milligray (mGy), as displayed on the monitor, starting from the initial insertion of the K-wire to its final position at the target endpoint. Radiation doses were analyzed descriptively using both mean and median values.

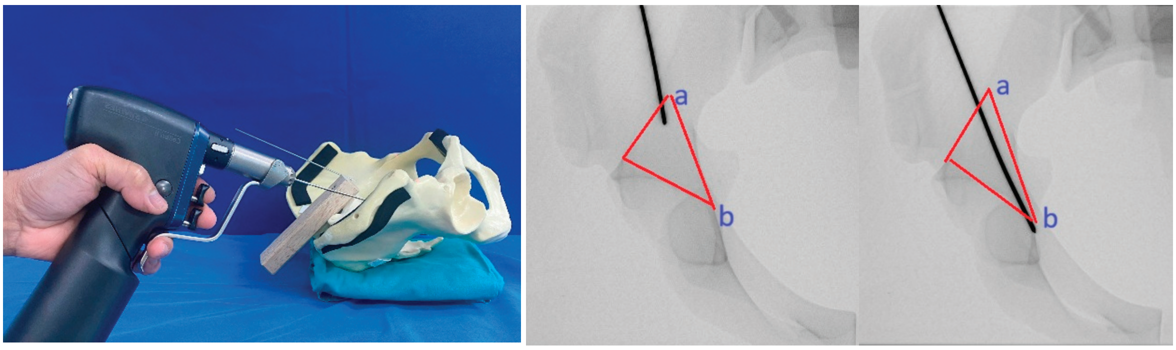

Figure 4: K-wire insertion : entry point is just lateral and distal to point a. K-wire should aim to point b.

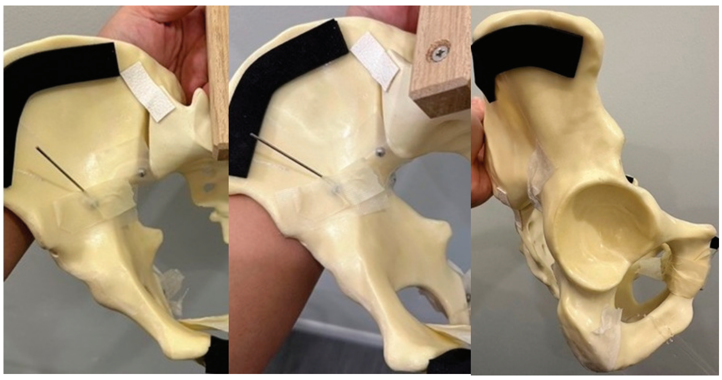

Figure 5: Pelvic bone model after K-wire insertion showing no K-wire breaching out from cortices and no intraarticular penetration.

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Result

The tilting angles required to obtain the single intraoperative fluoroscopic view were 10 degrees in the obturator direction and 25 degrees in the inlet direction (Figure 3a, b). All surgeons consistently positioned the fluoroscope at these angles.

The fluoroscopic images obtained using this single view were reproducible. The K-wire, representing the guide wire for posterior column screw placement, was successfully inserted into the posterior column of the pelvic bone model, beginning from the entry point located within the triangle distal to point "a" (Figure 4b) and extending to the endpoint designated as point "b" (Figure 4c).[7]

Correct placement was confirmed by direct visual inspection. All five surgeons were able to insert the K-wire entirely within the safe corridor, defined as fully intraosseous without cortical or intra-articular breach. This was classified as a "safe insertion" (Figure 5a–c).

Comparable safe insertion within the safe corridor was also observed in all insertions using the conventional two-view technique (Table 1).

Average radiation exposure was significantly lower with the novel single-view technique compared to the conventional two-view method across all surgeons. Staff 1 recorded 0.145 mGy (conventional) vs. 0.063 mGy (single-view); Staff 2, 0.144 mGy vs. 0.061 mGy; Fellow 1, 0.248 mGy vs. 0.108 mGy; Fellow 2, 0.179 mGy vs. 0.093 mGy; and Fellow 3, 0.203 mGy vs. 0.097 mGy (Table 2). These results demonstrate that the novel single-view fluoroscopic technique for posterior column screw placement in acetabular surgery offers comparably safe screw placement while significantly reducing radiation exposure compared to the conventional two-view method.

Table 1: Safe Insertion of K-wires Using Single-view and Two-view Techniques by Surgeons with Varying Experience.

Surgeon (Years of Experience)	Single-view Technique	Two-view Technique
Staff 1 (31 years)	Yes	Yes
Staff 2 (12 years)	Yes	Yes
Fellow 1 (5 years)	Yes	Yes
Fellow 2 (3 years)	Yes	Yes
Fellow 3 (1 year)	Yes	Yes

Note: All surgeons achieved fully intraosseous K-wire placement within the defined safe corridor. No cortical or intra-articular breaches were observed, and all wires remained posterior to the acetabular joint and outside the greater sciatic notch. There was no difference in success between the single-view and two-view techniques.

Figure 6: Position of K-wire in different views.
a: "Posterior column triangle" view, b: AP view, and c: iliac oblique view

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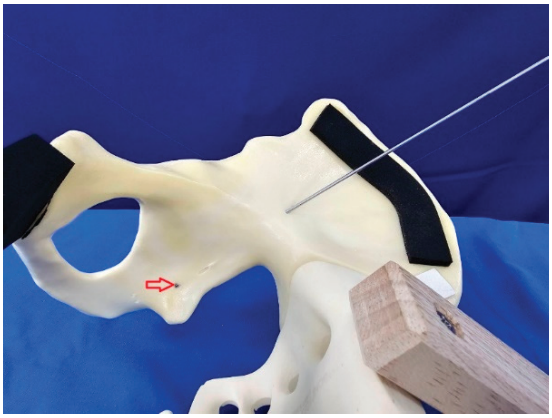

Figure 7: Red arrow shows approximate level of the intramedullary K-wire tip in Figure 6. This implies that the application of this technique should be limited to posterior column fracture line which locates higher than this point.

Table 2: Radiation Exposure per K-wire Placement Using Conventional Two-View and Novel Single-View Fluoroscopic Techniques.

Surgeon	Conventional Two-View (mGy)	Single-View Technique (mGy)
Staff 1	0.145	0.063
Staff 2	0.144	0.061
Fellow 1	0.248	0.108
Fellow 2	0.179	0.093
Fellow 3	0.203	0.097
Mean	0.1838	0.0844
Median	0.179	0.093

Note: Radiation exposure was consistently lower with the novel single fluoroscopic view technique across all surgeons.

Discussion

Posterior column screw insertion is technically demanding due to the proximity of critical neurovascular structures, particularly the sciatic nerve, which runs near the greater and lesser sciatic notches adjacent to the acetabulum. The nerve travels outward and downward from the upper-middle third of the line connecting the posterior superior iliac spine to the ischial tuberosity, passes through the infrapiriform foramen, descends along the posterior acetabular wall, and courses between the greater trochanter and ischial tuberosity. To avoid sciatic nerve injury, the screw trajectory must not breach the posterior cortex. Additionally, care must be taken to prevent intra-articular penetration.

Various authors have proposed techniques for posterior column screw insertion using two or three fluoroscopic views to ensure accurate placement without cortical breach or intra-articular penetration.[1,2,4] The currently accepted standard is the two-view technique—anteroposterior (AP) and iliac oblique views. The AP view confirms that the K-wire does not breach the medial cortex into the pelvis or the lateral cortex of the ischium, where there is a risk of sciatic nerve injury. The iliac oblique view helps ensure that the K-wire remains posterior to the acetabular joint and does not enter the greater sciatic notch.[1]

The concept of posterior column triangle, first introduced in 2022, was based on CT-scan,[10] describing the quadrilateral surface, retro-acetabular surface and supero-posterior acetabular surface as boundaries of the triangle. The authors of the present study propose that this triangle can serve as a reliable fluoroscopic landmark, outlining a safe corridor for posterior column screw placement. For optimal visualization using intraoperative C-arm fluoroscopy, the "posterior column triangle view" requires positioning the C-arm at 25 degrees of inlet tilt and 10 degrees of obturator oblique tilt.

In our experimental study, direct visualization confirmed that K-wires remained entirely posterior to the acetabulum, did not enter the greater sciatic notch, and did not breach the medial or lateral cortices of the ischium or the joint space—demonstrating that all ins ertions remained within the safe corridor.

Regarding radiation exposure, conventional techniques that rely on multiple fluoroscopic views inherently increase both radiation dose and operative time due to the need for repeated repositioning of the C-arm. These factors raise important safety concerns for both patients and surgical staff.[2-4] In contrast, our findings demonstrated a significant reduction in radiation exposure with the novel single-view technique.

Although procedural time was not formally recorded due to the simulated, non-clinical nature of the study, this technique has the potential to reduce operative time in actual surgical practice, as it requires only a single fluoroscopic view.

Clinical Implications and Technical Considerations

It should be noted that this study did not account for gender-based variations in pelvic geometry. Consequently, the optimal C-arm positioning—defined here as 25 degrees of inlet tilt and 10 degrees of obturator oblique tilt—may require adjustment based on individual patient anatomy. Nevertheless, these angles provide a useful starting point for initial C-arm positioning, which can then be fine-tuned intraoperatively as needed.

The ideal screw trajectory depends on fracture morphology, with the goal of orienting the screw perpendicular to the fracture line. In some cases, the trajectory may need to extend toward the ischial tuberosity. A key limitation of the single-view technique is that the posterior column triangle does not encompass the ischial tuberosity, meaning screws placed entirely within this corridor cannot reach that region. This restricts the application of the single-view method in fracture types where distal screw engagement of the ischial tuberosity is required.

Therefore, this technique is most appropriate for fractures involving the high posterior column, such as high posterior column fractures, high transverse fractures, and high T-type acetabular fractures (Figure 7). For low transverse fractures, where long antegrade screws extending to the ischial tuberosity are preferred, the conventional technique with two or three fluoroscopic views may still be necessary.

Study Limitations

This study has several limitations. First, it was conducted using synthetic bone models, which may not perfectly replicate human anatomy or soft tissue density. However, the models were anatomically matched to the human pelvis, and a cadaveric specimen was used initially to identify the posterior column triangle prior to testing in the synthetic models. The reproducibility of the triangle in both models suggests it is a consistent anatomical landmark in clinical practice.

Second, the study did not account for soft tissue attenuation, which may influence actual radiation dose in clinical settings. Nevertheless, the primary objective was to compare radiation exposure between the novel single-view and conventional multi-view techniques under controlled conditions. The significant reduction observed in the single-view group supports its potential to reduce radiation exposure in practice.

Conclusion

The use of a novel single fluoroscopic view for K-wire insertion, simulating posterior column screw placement in a pelvic bone model, appears to be a safe and effective alternative to the conventional two-view technique. This approach provides comparable accuracy in guidewire positioning while significantly reducing radiation exposure. However, since the posterior column triangle view does not encompass the ischial tuberosity, its use should be limited to cases involving high posterior column fractures, where screw fixation can still provide adequate stability. Further studies with larger sample sizes and diverse pelvic models are needed to validate these findings across different anatomical variations in bone shape, size, and gender, and to establish the technique's generalizability and clinical reliability.

Conflict of interest

The authors declare no conflict of interest.

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