# Detection of Protruding Screws in the Radiocarpal Joint Using the "Scaphoid Skyline View"

## *Detección de tornillos prominentes en la articulación radiocarpiana mediante la proyección tangencial del escafoides dorsal*

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## Abstract

**Introduction** One of the complications of the retrograde percutaneous scaphoid fixation is the protrusion of the screw in the radiocarpal joint due to the limited intraoperative visualization of the proximal pole of the scaphoid with the traditional radiographic views.

**Objetive** To evaluate the sensitivity of a novel radiographic view (the skyline scaphoid view, SSV) to detect screws protruding in the radiocarpal joint during the retrograde fixation of the scaphoid.

**Materials and Methods** We studied nine cadaverous fresh frozen wrists. A retrograde cannulated screw was inserted in the scaphoid.

To validate the SSV, 5 wrists were studied, comparing 3 forearm angulations (15°, 30° and 45°) to get the best visualization of the proximal pole and screw.

We compared the ability to identify the protrusion of the screw in the proximal pole of the 30° SSV with that of 5 standard scaphoid radiographic views in 9 wrists. The screw was positioned at the level of the surface of the scaphoid, and was sequentially protruded in 0.5 mm increments, with direct visualization of its tip through a dorsal capsulotomy. After each increment, all views were repeated to determine if they were able to detect screws projecting from the scaphoid.

**Results** The best visualization of the proximal pole of the scaphoid was found with the 30° SSV. In the comparison of the 30° SSV and the standard views, with the SSV we were able to identify the protrusion of the screws at an average of 0.8 mm, followed by the posterior-anterior view with ulnar deviation and extension at 1.3 mm ($p = 0.014$), with high precision and interobserver agreement regarding these views.

**Keywords**
- complications
- scaphoid
- osteosynthesis
- screw fixation
- X-ray view
- fluoroscopy

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**Conclusion** The SSV was the most sensitive view to detect protruding screws in the proximal pole of the scaphoid. Its routine use could avoid complications during osteosynthesis.

## Resumen

**Introducción** Una de las complicaciones de la osteosíntesis retrógrada del escafoides es la protrusión del tornillo en la articulación radiocarpiana, dada la limitada visualización intraoperatoria del polo proximal del escafoides con las proyecciones tradicionales.

**Objetivo** Evaluar la capacidad de una nueva proyección radiológica, la proyección "tangencial del escafoides dorsal", o TED, para identificar tornillos prominentes radiocarpianos durante la osteosíntesis retrógrada del escafoides con tornillos canulados.

**Materiales y Métodos** Estudio cadavérico en muñecas frescas congeladas. Se introdujo en el escafoides un tornillo canulado con técnica retrógrada estándar.

La proyección TED fue evaluada en 5 muñecas, con angulaciones del antebrazo de 15°, 30° y 45° para definir la mejor visualización del polo proximal del escafoides y del tornillo.

Se comparó la capacidad para identificar la prominencia del tornillo en el polo proximal de la proyección TED de 30° con 5 proyecciones tradicionales de escafoides en 9 muñecas. El tornillo se posicionó a nivel de la superficie del escafoides, y luego se avanzó a intervalos de 0,5 mm bajo visualización directa por artrotomía dorsal. Tras cada intervalo, se repitieron todas las proyecciones para determinar su capacidad de detectar tornillos prominentes en el escafoides.

**Resultados** La mejor visualización del polo proximal del escafoides se logró con la proyección TED de 30°. Al comparar la proyección TED de 30° y las tradicionales, con la TED se logró identificar tornillos prominentes a 0,8 mm promedio, seguida por la proyección posteroanterior con cubitalización y extensión a 1.3 mm ($p = 0.014$), con una alta precisión y correlación interobservador de estas proyecciones.

**Conclusión** La proyección TED demostró ser la más sensible para detectar tornillos prominentes en la articulación radiocarpiana. Su uso rutinario podría evitar complicaciones durante la osteosíntesis.

**Palabras claves**
- complicaciones
- escafoides
- osteosíntesis
- fijación de tornillos
- proyección radiográfica
- fluoroscopía

## Introduction and Objective

Osteosynthesis with retrograde headless cannulated screws is one of the most used techniques to treat scaphoid fractures.[1] The therapeutic principles to achieve the greatest fracture stability and consolidation include the placement of the screw perpendicular to the fracture line and its largest possible length.[2]

Correct visualization under fluoroscopy of the dorsal and proximal scaphoid is critical for the retrograde insertion of a screw with the largest possible length, because this is where the tip of the screw will be located. Such visualization can be difficult to achieve during surgery, due to the scaphoid anatomy and the overlap to other carpal bones at the lateral wrist view, potentially resulting in the protrusion of a long screw through the radiocarpal joint.

Several radiological views are traditionally used both for fracture diagnosis and intraoperative radiographic control of scaphoid osteosynthesis. Oblique views enable a better visualization of the proximal pole of the scaphoid, and, therefore, prevent screw protrusion into the joint. However, their sensitivity is far from optimal, and prominent screws up to 1 mm may be missed.[3]

To improve the visualization of the proximal pole and identify protruding radiocarpal scaphoid screws, we propose a new intraoperative radiological view, called the scaphoid skyline view (SSV).

This view is a modification of the tangential view for the dorsal radius proposed by Jacob and Clay,[6] the "skyline view," which is used to evaluate prominent screws at the dorsal radius during volar plate osteosynthesis of the radius.[4–6]

The present study aimed to standardize the technique for the new SSV radiographic view and to evaluate its ability to detect prominent screws in the proximal pole during retrograde osteosynthesis of the scaphoid, comparing it with five other views.

 

## Material and Methods

The present is an experimental study in cadaverous parts. Nine fresh frozen wrists were used. The absence of fractures and/or radial or midcarpal arthrosis was verified under fluoroscopy (posteroanterior and lateral views).

Using a mini volar approach, a cannulated Acutrak2 Mini screw (Acumed, Hillsboro, OR, US) was introduced according to the standard technique for volar retrograde osteosynthesis of the scaphoid bone with fluoroscopic support. The screw tip was placed as close as possible to the proximal dorsal cortex of the scaphoid.[7]

### Scaphoid Skyline View

The SSV image was obtained with the image intensifier in vertical position, oriented axially and tangentially to the dorsum of the scaphoid and carpus. The forearm was placed in supination, with the wrist in maximum flexion and the elbow in semiflexion (►**Figure 1**).

The SSV technique was standardized in five wrists and performed with the forearm in angles of 15°, 30°, and 45° to the vertical beam axis to evaluate the visualization of the screw and the proximal pole of the scaphoid.

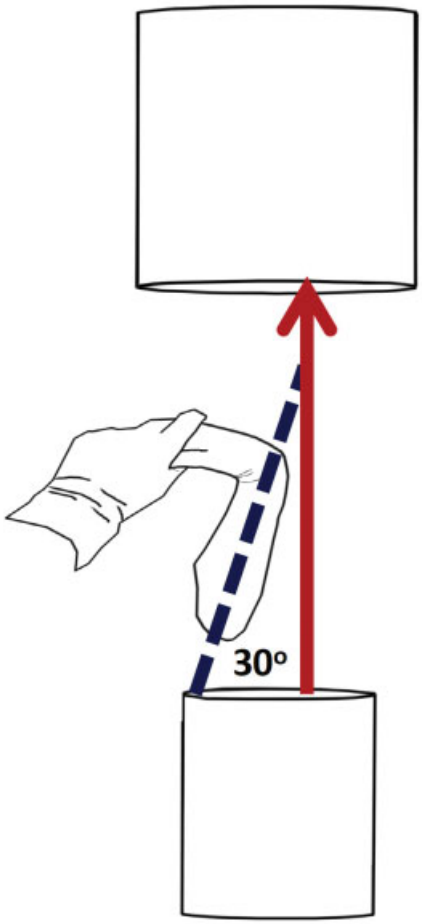


**Fig. 1** Image intensifier and upper extremity positioning with the forearm at a 30° angle for scaphoid skyline view (SSV).

### Radiographic Views Comparison

The location of the screw tip, either inside the scaphoid bone or not, was determined in nine cadaverous wrists using a 30° SSV and 5 traditional views: posteroanterior (PA), ulnar posteroanterior (UPA), extended ulnar posteroanterior (EUPA), pronated oblique (PO), and lateral (L) views[3] (►**Figure 2**).

This series of six views was initially made with the screw tip at the level of the articular surface. Next, the screw was advanced sequentially in 0.5 mm increments to protrude from the proximal pole of the scaphoid. After each advance, the six views were repeated (SSV at 30° and the traditional five views) until the tip of the screw was protruding evidently from the proximal pole in all of the views.

The location and protrusion of the screw tip were confirmed under direct visualization of the proximal pole through a dorsal arthrotomy and screw measurement with a digital caliper (►**Figure 3**).

The radiographs were digitally stored in the Digital Imaging and Communications in Medicine (DICOM) format for later evaluation. Next, they were recoded and randomized for a blind evaluation by three hand surgeons and a general orthopedic surgeon. After a stage of observer standardization, each evaluator independently scored each radiograph, defining whether the screw was inside or outside the scaphoid bone. Cases of iscordance were settled consensually.

The mean minimum distance (in mm) at which long screws could be detected in the different radiographic views was compared using one-way analysis of variance (ANOVA). Before the ANOVA, the Kolmogorov-Smirnoff test was carried out to confirm the normal distribution of the different groups (radiographic views). Post-hoc tests to detect differences between groups were not performed due to the small sample size. The precision of the different views to identify prominent screws was evaluated using the receiver operating characteristic (ROC) curve. Interobserver variability was assessed with the intraclass correlation coefficient. The level of statistical significance was established as $p < 0.05$. The statistical analysis was performed using the Stata (StataCorp, College Station, TX, US) software, version 16.

## Results

For the standardization of the radiographic technique for the SSV, and to compare of the 15°, 30° and 45° angle views of the forearm, no statistically significant differences were observed in terms of sensitivity to detect prominent screws, which were identified at 0.8 mm in the SSV at 30° (standard deviation [SD]: 0.3 mm), 0.94 mm in the SSV at 45° (SD: 0.94 mm) and 1.0 mm in the SSV at 15° (SD: 0.66 mm). During these tests, the researchers subjectively determined that the visualization of the proximal pole was better on the SSV at 30° compared to the remaining techniques. As such, the SSV at 30° was chosen for the comparison with traditional radiographic views.

In comparison to the traditional views, the SSV was able to detect protruding screws at an average length of 0.8 mm (SD: 0.3 mm), followed by the UPA and EUPA views at 1.3 mm (SD: 0.6 mm) (►**Table 1**).

 

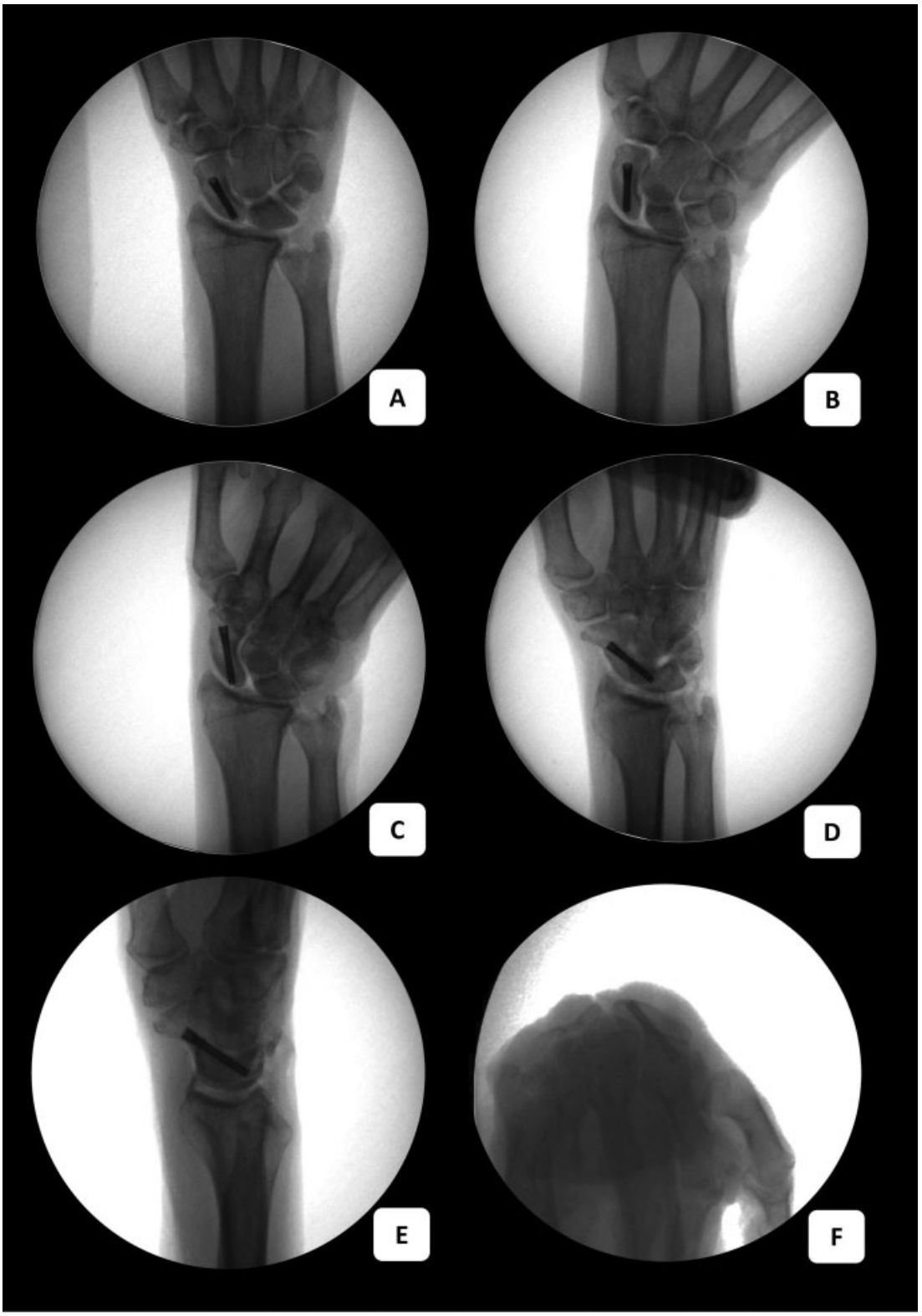


**Fig. 2** Radiographic views. (**A**) Posteroanterior (PA) view; (**B**) ulnar posteroanterior (UPA) view; (**C**) extended ulnar posteroanterior (EUPA) view; (**D**) pronated oblique (PO) view; (**E**) lateral (L) view; and (**F**) scaphoid skyline view (SSV).

Similarly, among the six views studied, the SSV showed the highest precision, with an area under the ROC curve of 0.92 (►**Table 2**).

Regarding the interobserver agreement, all different views showed a very good correlation, with an intraclass correlation coefficient greater than 0.75 (►**Table 3**).

 

**Fig. 3** Measurement of the length of the prominent screw in the radiocarpal joint with a digital caliper.

## Discussion

Several clinical and biomechanical studies[1,2] have confirmed the benefits from retrograde scaphoid osteosynthesis, which requires precise screw positioning and length for fracture stability and consolidation.

A severe complication of retrograde osteosynthesis is screw protrusion at the proximal pole of the scaphoid, resulting in a prominent screw tip in the radiocarpal joint, which leads to damage to the radial articular cartilage, loss of function, and pain.[8]

Intraoperative radiographic views are critical for the correct positioning of the osteosynthesis screw. Scaphoid morphology (with a curved, conical proximal pole) and the overlap to the radius and other carpal bones hinder the definition of the proximal pole of the scaphoid in conventional radiographic views. As such, the screw tip may be outside the scaphoid bone, and the surgeon may not be aware of it.[3,8]

A similar problem occurs in volar plate osteosynthesis for distal radial fractures. During the evaluation of screw length on lateral view, the dorsal tubercle can prevent the correct visualization of a long, prominent screw in the dorsal radius. To avoid this problem, Jacob and Clay[6] described a tangential view to the dorsal cortex of the radius, the so-called "dorsal horizontal view of the radius" or "skyline view," which has been helpful in identifying these prominent screws.[4,6]

The present study describes a modification of the radial "skyline view", increasing elbow extension and thus the angle between the vertical axis of the X-ray beam and the forearm (from 15° of the radial SSV to 30°). As such, it is possible to de-project the dorsal radius and visualize the proximal pole of the scaphoid tangentially, enabling the evaluation of protruding screws towards the radiocarpal joint (►**Figure 4**).

Regarding the best forearm angle for the SSV, although there were no significant differences in the sensitivity to detect prominent screws regarding the 15°, 30°, and 45° angles, we found a slight subjective superiority of the SSV at 30° to visualize the proximal pole of the scaphoid bone. Therefore, we propose it as the optimal angulation for the SSV.

The SSV showed a high sensitivity to detect prominent screws at the dorsal scaphoid. It was the most sensitive of all six views, able to detect screws with an average length of 0.8 mm at the surface of the proximal pole of the scaphoid bone. In addition, the SSV demonstrated high precision, with high sensitivity, low proportion of false-positive results, (area under the ROC curve: 0.923), and a high rate of interobserver correlation.

Regarding the ability of traditional views to identify long screws, our results are consistent to those described by Kim et al.,[3] who observed that the PO view had the highest sensitivity among the traditional views, with values similar to those obtained in our series (1.4 mm).

Based on our evaluation of the SSV, the simplicity of the procedure and the complexity of having a prominent screw, we believe that this view must be used routinely in the clinical practice, thus reducing the complications of protruding long screws. One must consider that clinical factors, such as body mass index, the position of the patient's forearm, and trauma-specific factors (edema, joint effusion etc.) may affect scaphoid visualization with the SSV.

## Conclusion

The SSV is a novel and sensitive method to detect screws protruding from the proximal pole during scaphoid retrograde

**Table 1** Mean length of detection of prominent screws

| Radiographic view | Joint protrusion (mm) | Standard deviation | 95% confidence interval | |
|---|---|---|---|---|
| | | | Minimum | Maximum |
| Scaphoid skyline view | 0.8 | 0.3 | 0.5 | 1 |
| Extended ulnar posteroanterior | 1.3 | 0.6 | 0.7 | 1.9 |
| Lateral | 1.3 | 1 | 0.3 | 2.2 |
| pronated oblique | 1.4 | 0.9 | 0.4 | 2.3 |
| Ulnar posteroanterior | 2.1 | 1 | 1 | 3.2 |
| Posteroanterior | 2.2 | 0.9 | 1 | 3.1 |

Note: Mean minimum length in which each radiographic view detected prominent screws. One-way analysis of variance (ANOVA), Welch correction ($p = 0.014$; $F = 3.756$).

 

**Table 2** Analysis of the receiver operating characteristic curve of the different radiographic views

| Radiographic view | Area under the curve | 95% confidence interval | | *p* |
|---|---|---|---|---|
| | | Minimum | Maximum | |
| Scaphoid skyline view | 0.92 | 0.83 | 1.00 | 0.001 |
| Pronated oblique | 0.77 | 0.62 | 0.93 | 0.06 |
| Lateral | 0.73 | 0.57 | 0.90 | 0.02 |
| Extended ulnar posteroanterior | 0.71 | 0.54 | 0.89 | 0.03 |
| Ulnar posteroanterior | 0.56 | 0.39 | 0.74 | 0.54 |
| Posteroanterior | 0.69 | 0.50 | 0.88 | 0.08 |

**Table 3** Interobserver evaluation of the different radiographic views

| Radiographic view | Intraclass correlation coefficient | 95% confidence interval | | F | *p* |
|---|---|---|---|---|---|
| | | Minimum | Maximum | | |
| Scaphoid skyline view | 0.83 | 0.70 | 0.91 | 6.02 | $< 0.001$ |
| Posteroanterior | 0.89 | 0.82 | 0.93 | 8.88 | $< 0.001$ |
| Ulnar posteroanterior | 0.95 | 0.91 | 0.97 | 18.21 | $< 0.001$ |
| Pronated oblique | 0.91 | 0.85 | 0.95 | 11.48 | $< 0.001$ |
| Lateral | 0.75 | 0.58 | 0.87 | 4.06 | $< 0.001$ |
| Extended ulnar posteroanterior | 0.93 | 0.88 | 0.96 | 14.51 | $< 0.001$ |

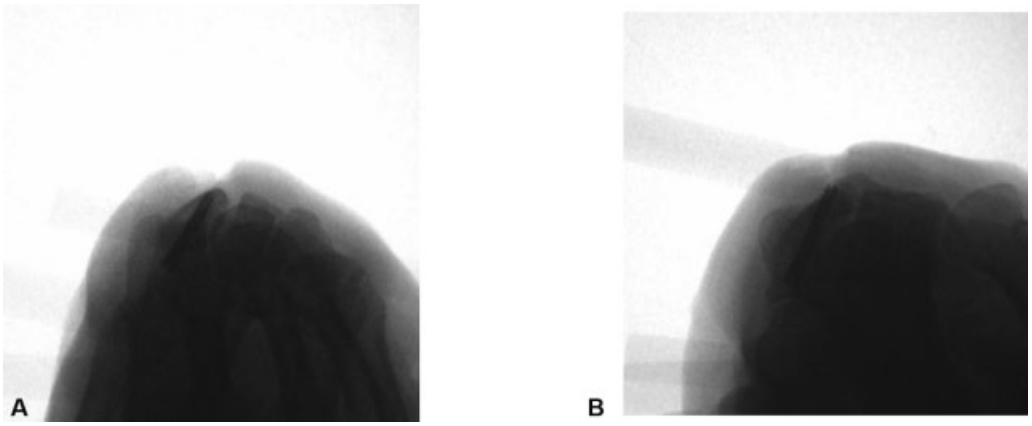


**Fig. 4** Scaphoid skyline views (SSVs). (**A**) Intraosseous screw; (**B**) prominent screw outside the scaphoid bone.

osteosynthesis, and its routine clinical use is highly recommended.

Conflict of Interests

The authors have no conflict of interests to declare.

Dr. Breyer reports non-financial support from the CLP company not related to the submitted work.

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