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Optimal pin position in supraacetabular external fixation

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Abstract

Background: This study focuses on (i) the length of the intraosseous part of the supraacetabular pin using the insertion technique from the spina iliaca anterior inferior to the cortical part of the incisura ischiadica major, (ii) the angle of insertion of the supraacetabular pin in the transversal plane and (iii) gender-specific differences of the measured results.
Methods: Images of uninjured pelves from 49 patients (64-line computed tomography scanner) were evaluated, and virtual external fixator pins were positioned using a three-dimensional reconstructions of computed tomography scans. The length of the pins and the insertion angle were investigated. Descriptive statistics were used, and gender-specific differences were calculated. A *P*-value of <0.05 was considered statistically significant.
Results: The results showed significant differences between male and female pelves concerning both pin length and insertion angel. For male pelves, the mean screw length was 82.7 mm (SD 5.1; range 72.9–94.3). For females, this was statistically significantly shorter ($P \leq 0.001$), with an average of 74.1 mm (SD 5.0; range 63.1–81.9). In the male subgroup, the insertion angle was a mean of 22.6° (SD 3.4; range 12.4–31.8), and the female pelves had an average angle of 19.7° (SD 4.0; range 11.7–24.5). These values differed statistically significantly ($P = 0.0032$).
Conclusion: Based on our measurements, we can confirm that both the length of the Schanz screws and the angle of insertion for the supraacetabular external fixator show a statistically significant difference between males and females.

Introduction

Unstable fractures of the pelvic ring are severe injuries and are mostly caused by high-energy trauma. Only 13% of pelvic ring fractures are isolated injuries.[1,2] The majority of unstable pelvic ring fractures usually affects severely injured patients with multiple injuries who are in a critical condition, where damage-control orthopaedic trauma surgery is the gold standard.[3] For surgical stabilization of the pelvic ring in emergency situations, the external fixator is still the most commonly used treatment.[4–7] By creating an external fixator, it is possible to effectively control haemorrhage in the pelvic region.[8] There are several possible locations to place the Schanz screw in the bone of the pelvic ring.[9] In an emergency setting, very simple configurations of the external fixator are employed for the sake of expediency. Nevertheless, the holding force of the Schanz screw has to be considered. Incorrect drilling direction and poor bone quality can cause perforation of the ilium and necessitate the technically more demanding placement of Schanz screws in the iliac crest.[10,11] To avoid additional placement at the iliac crest, it is necessary to know the expected length and the insertion angel of the Schanz screw before starting the procedure.

The purpose of this study is to determine the length of the intraosseous part of the Schanz screw, the angle of insertion and a possible gender-specific difference concerning supraacetabular placement of the external fixator.

Methods

We analysed computed tomography (CT) scans from 49 trauma patients who were examined with a whole-body CT and had an

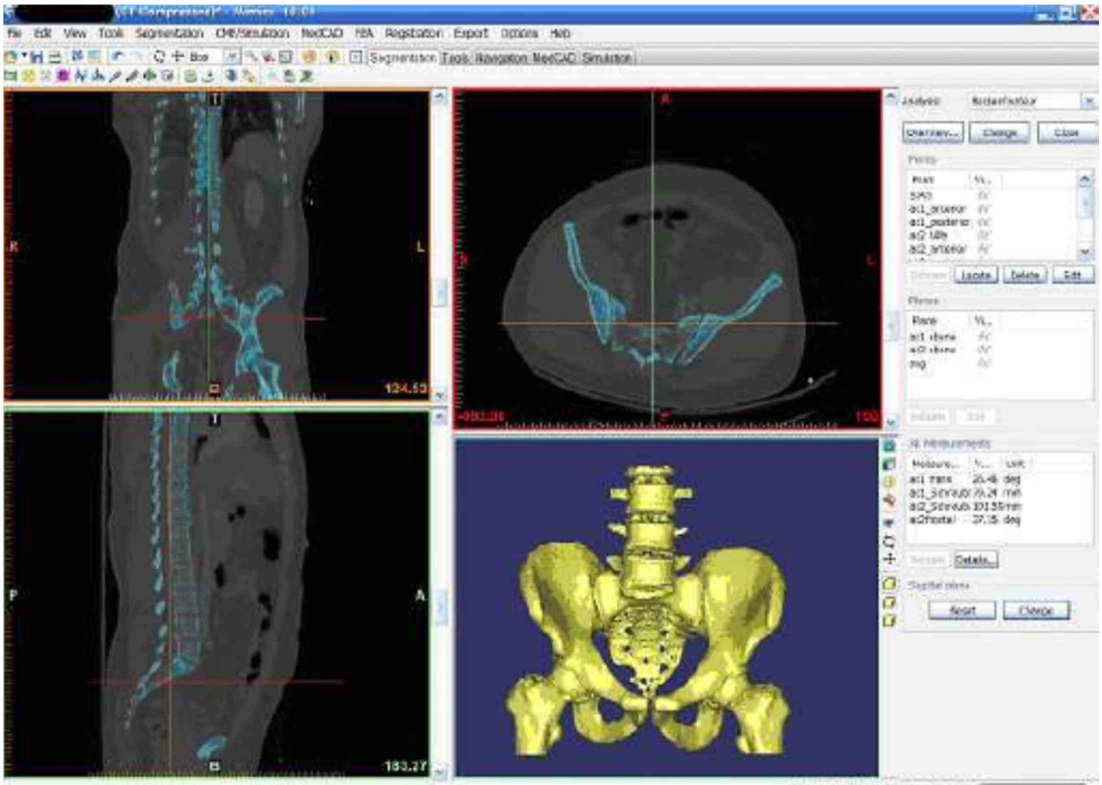

Fig. 1. Mimics interface.

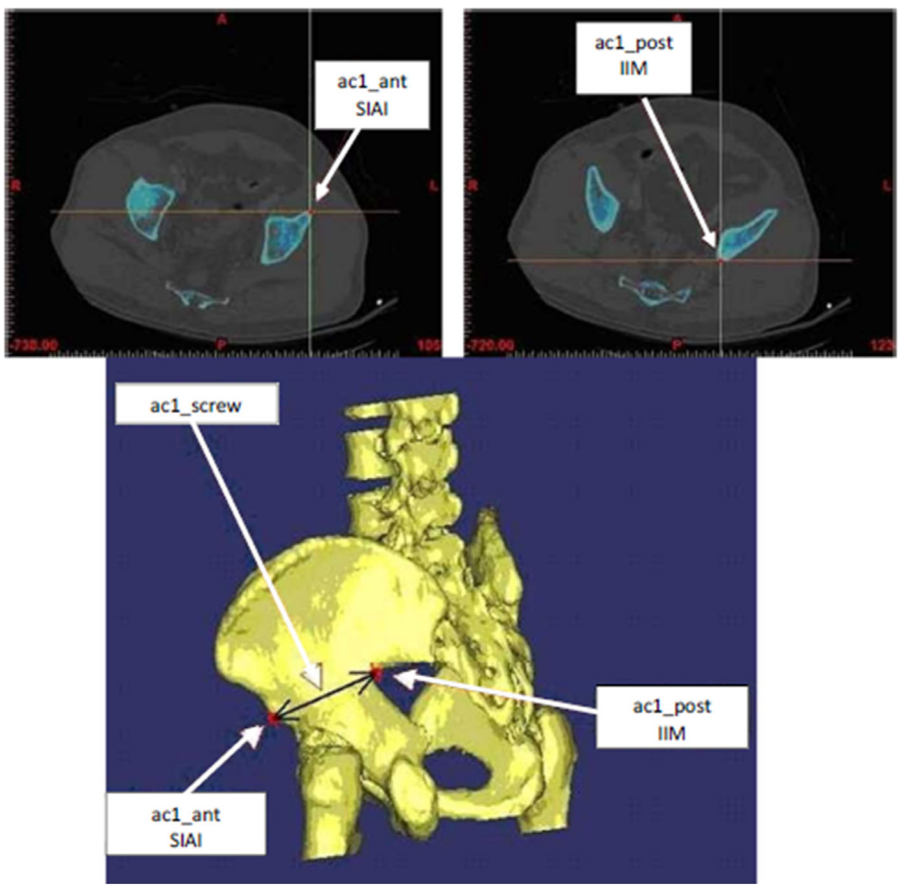

Fig. 2. Determination of screw length (ac1_screw) between the points 'ac1_ant' and 'ac1_post'.

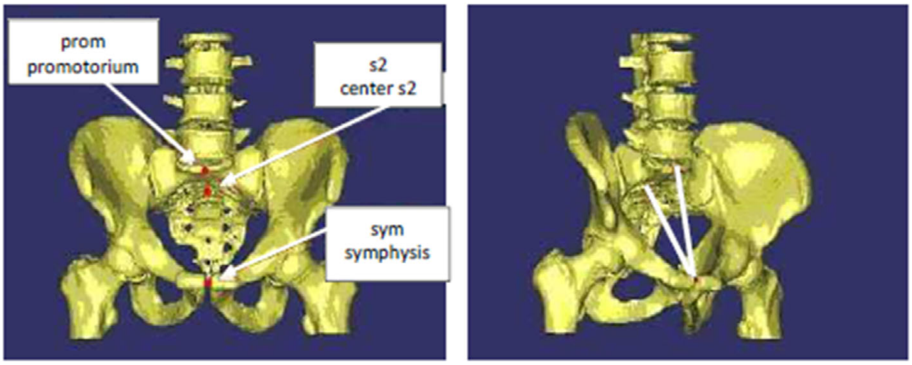

Fig. 3. Determination of insertion angle.

uninjured pelvic region. Images were recorded using a 64-slice Siemens SOMATOM Sensation CT system (Siemens Medical Solution USA Inc., Malvern, PA, USA).

The anatomical measurements were performed using MIMICS image analysis software (Materialise, Leuven, Belgium). This software allows the representation of the conventional CT scan images, as well as the creation of three-dimensional (3D) models, which facilitate an exact measurement. Data were analysed using Microsoft Excel (Microsoft Headquarters, Redmond, VA, USA) and the Plug-In XL Statistics (Dr Rodney Carr, Allanstford, Australia). A *P*-value of 0.05 or less was considered statistically significant.

First, we defined the reference points for our measurements at the MIMICS interface, structured into a horizontal, frontal and sagittal plane and a 3D view (Fig. 1). The different views allowed us to project Schanz screws into the bone in the correct position. To determine the screw length, two points were set in the horizontal plane. The first point was set at the screw entry point at the spina iliaca anterior inferior (‘ac1_ant’) and the second on the cortical bone at the incisura ischiadica major (‘ac1_post’). The distance between the two points corresponds to the screw length (‘ac1_schr’) (Fig. 2).

The insertion angle was defined by the angle that is situated between the Schanz screw and the median sagittal plane. First, the median sagittal plane was specified. Therefore, three points, one in the middle of the promotorium (‘prom’), one in the middle of the second sacral vertebra (‘s2’) and the third in the middle of the symphysis (‘sym’), were marked (Fig. 3). Then, a second plane was created from the position of the Schanz screw inside the bone with respect to the position of the patient as located in the CT scanner. Therefore, a straight line was drawn through the points prom, s2 and sym that determines the position of the pelvis during the scan. Subsequently, the straight line was moved in parallel through the point ac1_post. Along this line, the point ‘ac1_help’ was set, and the screw plane was constructed (Fig. 4).

All measurements were performed by two independent observers (investigators 1 and 2). SPSS Statistics 19 for Windows (SPSS Inc., Chicago, IL, USA) was used to calculate intra-class correlation coefficients (3.1). Based on good intra-class correlation coefficients

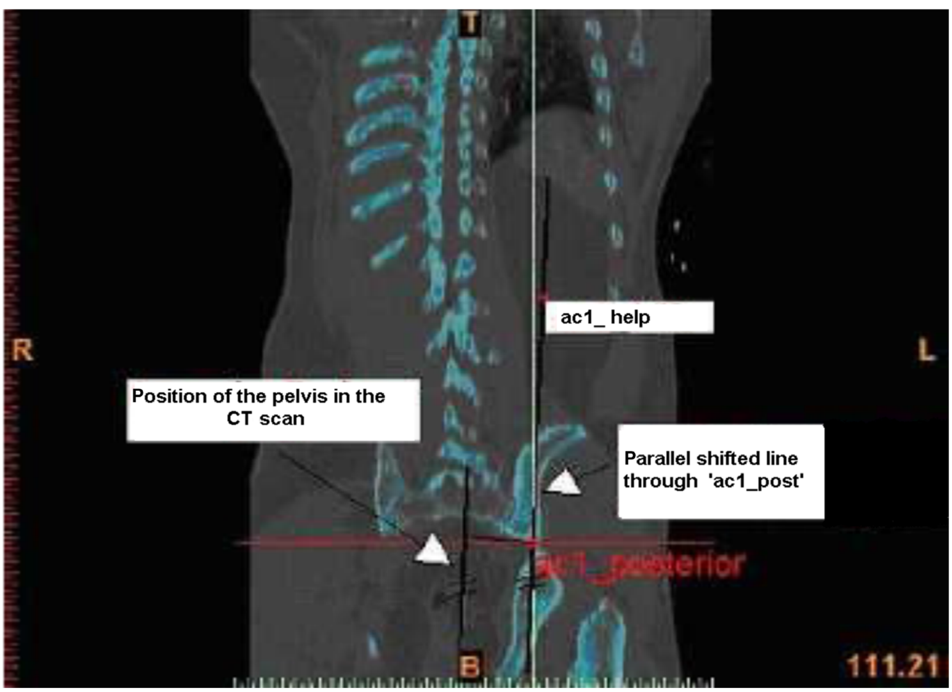

Fig. 4. Construction of the screw plane.

(see Results section), the mean vale of both observers was taken for all measurement results.

Ethical approval

This study was approved by the local ethics committee in accordance with the principles of the Declaration of Helsinki and the ICH harmonised guidelines for good clinical practice (ICH-GCP).

Results

The study sample involved 49 patients with an average age of 40.6 years (range 15–86). Thirteen scans (26.5%) were obtained from female and 36 (73.5%) from male patients.

The mean ac1_scr of the total sample was 80.4 mm (SD 6.3; range 63.1–94.3). With regard to males, the mean ac1_scr was 82.7 mm (SD 5.1; range 72.9–94.3). In females, this was statistically significantly shorter ($P = 0.00000000301$), with an average of 74.1 mm (SD 5.0; range 63.1–81.9). Investigator 1 evaluated a mean screw length of 80.7 mm (SD 6.5; range 66.4–94.3), and investigator 2 evaluated one of 80.1 mm (SD 6.2; range 63.1–91.7). Statistical analysis did not show significant differences between the two observers ($P = 0.665$).

The mean ac1_trans was 21.8° (SD 4.2; range 11.7–31.8) for the total collective. The male subgroup had a mean angle of 22.6° (SD 3.4; range 12.4–31.8), and the female patients had an average angle of 19.7° (SD 4.0; range 11.7–24.5). These values differed statistically significantly ($P = 0.0032$). Investigator 1 measured an average angle of 22.1° (SD 4.2; range 11.7–31.8) for the total collective. The average angle was 21.6° (SD 4.1; range 12.1–29.3) for investigator 2. There was no inter-observer variability ($P = 0.609$).

Discussion

In this study, the anatomical condition of the pelvic bone was studied using 49 CT scan data sets of polytraumatized patients without pelvic injuries. Dimensions of sectional images were assessed, and 3D pelvic models were created using the Mimics software (Materialise). The main interest was the determination of bony structures with a focus on the insertion of a supraacetabular external fixator from the spina iliaca anterior inferior.

The advantage of external fixation systems is their fast and easy assembly, whereby the time factor plays the most important role, especially in polytraumatized, unstable patients. Immediate stabilization, associated with venous tamponade and compression of possible pelvic bleeding by a reduction of the pelvic volume, and early mobilization are significant points that lead to the reduction of mortality. Therefore, the external fixator is not dispensable in the primary care of an unstable pelvic ring fracture.[12–14] The external fixator is the most commonly used method for the stabilization of the pelvic ring, followed by the pelvic wing, which, in contrast to the anterior external fixator, ensures better stabilization of the posterior pelvic ring.

In 2008, Solomon *et al*. published a study in which they reported similar findings concerning the length and angle used to insert Schanz screws. However, they did not take into account that there might be a gender-specific difference between male and female bony pelvic structures.

In our study, the determination of the screw length and the insertion angle of the pin relative to the sagittal plane, as well as the gender-specific evaluation in reference to meaningful differences in pelvic anatomy between men and women, concerning supraacetabular pin insertion were the main interests.

The gender-specific evaluation showed an average screw length of 82.7 mm for men and 74.1 mm for female pelves. The values among the male pelves varied from a minimum of 73 to a maximum of 94.3 mm. In female pelves, the least and farthest distance measured was 63.1 and 81.9 mm, respectively. Thus, a highly significant correlation ($P = 0.00000000301$) between the required screw length and the gender of the patient could be established.

Concerning the insertion angle 'ac1_trans', the mean value at the male pelvis was 22.6°, with a minimum of 12.4° and a maximum of 21.8°. Measurement at the female pelvis showed a mean angle of 21.8°, ranging from 24.5° to 11.7°. The statistical evaluation also showed a highly significant correlation ($P = 0.0032$) between angle and gender in the measurements of the insertion angle of the supraacetabular screw.

In addition to insertion of the external fixator system of the pelvis, the stability of the construction is also very important. As already mentioned, the external fixator, particularly the supraacetabular, has weaknesses in the stabilization of the posterior pelvic ring.

Kim *et al*. reported in their study that the supraacetabular external fixator shows more stability than the one inserted due to the crista iliaca.[9]

Furthermore, biomechanical tests by Egbers et al. showed that the supraacetabular assembly represents a much more stable fixation compared to the other standard configurations.[15]

None of the previously known articles concerning supraacetabular pin placement showed comparable imaging-based measurement methods as have been described in our study with the help of the image processing program MIMICS. The results show that, under the conditions for the installation of a supraacetabular pelvic fixator, the gender of the patient is an essential factor. The parameters determined show significant differences between the male and female pelvis and are relevant for clinical application.

Author Contributions

Gloria Hohenberger: Writing-review and editing. **Paul Simmerl:** Formal analysis; investigation. **Angelika Schwarz:** Validation. **Wolfgang Pichler:** Data curation; methodology; validation. **Paul Puchwein:** Resources; software. **Renate Wildburger:** Supervision. **Renate Krassnig:** Conceptualization; project administration; visualization; writing-original draft.

Conflicts of interest

None declared.

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