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Research Article

CT-Guided Sacro-Iliac Injury Fixation Experience at the University Hospital Fundación Santa Fe de Bogota and Hospital Infantil Universitario de San José from 2012 to 2018

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Abstract

Objective: To describe functional results and complications of internal fixation with Computed Tomography (CT)-guided Sacroiliac Screws (SIS) in patients with sacroiliac injuries.

Patients and methods: A retrospective case series of 18 patients with traumatic sacroiliac injuries who underwent CT- guided percutaneous fixation at the Fundación Santa Fe de Bogotá University Hospital and the Hospital Infantil Universitario de San José from 2012 to 2018.

Results: In the intraoperative period, the average surgical time was 81.4 minutes, intraoperative bleeding of 9.61 ml and no patient presented poor screw positioning with a fracture displacement of <5 mm. The average hospital stay was 8.72 days, and no patients required reintervention during the follow-up time.

Conclusion: Patients who underwent CT-guided percutaneous fixation of sacroiliac injuries presented no complications during surgery nor in the follow-up, presenting adequate fixation and minimal displacement of the fractures without requiring additional intervention.

Keywords: Computed axial tomography; Fluoroscopy; Sacroiliac screws; Pelvic fractures

Introduction

Pelvic fractures are rare in the general population, with an average incidence of 2.37 per 100,000 people. However, this pathology has an important relationship with age, showing an increase in the incidence of 92 people per 100,000 in patients older than 60 years and up to 446/100,000 in patients older than 85 years. Unstable pelvic fractures are commonly caused by high-energy trauma, with traffic accidents being one of the main causes [1].

Although the management of such injuries has improved in the last 15 years, reports indicate that high rates of mortality (10%) and morbidity (52%) still occur [2]. Therefore, they require early management that prioritizes hemodynamic stabilization of the patient and subsequent internal fixation using different techniques [3].

For the fixation of posterior pelvic ring fractures several surgical techniques of internal fixation have been described, ranging from open methods to minimally invasive procedures such as the percutaneous placement of Sacroiliac Screws (SIS) [4]. For the latter, the use of an image intensifier is required, which allows the identification of the safe corridors in different projections to obtain better results in the osteosynthesis process. Its low cost allows it to have high accessibility in different hospital centers [5].

Some major complications of fluoroscopy-guided percutaneous SIS fixation include nerve and vascular injury after misplaced screw displacement. The relative risk of injury to the fifth lumbar nerve (L5) is 8% [6]. The presence of variations in the morphology of the upper sacrum, known as "sacral dysmorphism", is highly related to this specific complication [6,7]. In addition to dysmorphism, the presence of abundant intestinal gases and obesity can affect the appropriate screw placement and reduction of lesions when using conventional biplanar fluoroscopy [8]. Fluoroscopy-guided screw mispositioning rates have been reported to range between 2% and 15%, with an incidence of neurological injury estimated between 0.5% and 7.7%. A screw malposition of as little as 4 degrees can cause damage to neurovascular structures and lead to permanent disability or put patients' lives at risk [9].

On the other hand, the Computed Axial Tomography (CT) guided procedure has been described as a technique allowing better

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precision in screw placement, making it safer and minimizing the risks mentioned above. In a meta-analysis published by Zwingman et al. in 2013, the estimated misplacement rate of the SIS was significantly lower when using CT navigation compared to the conventional fluoroscopic technique (0.1% *vs.* 2.6%) (p<0.0001) [9].

Due to the high occurrence of traffic accidents in our environment and considering they produce most high-energy traumas resulting in pelvic fractures, it is of great importance to carry out studies that describe techniques that allow timely, safe, and efficient treatment. The present report is a retrospective case series of 18 patients with sacroiliac injuries who underwent CT- guided percutaneous fixation. This study is expected to serve as a basis for future prospective studies with larger samples to directly compare both surgical techniques and generate stronger evidence regarding the benefit of performing the tomography-guided procedure as a first-line treatment in these patients.

Materials and Methods

Study design

This is a descriptive study of case series conducted at the University Hospital Fundación Santa Fe de Bogotá and the Hospital Infantil Universitario de San José.

Study population

Patients admitted to two reference centers for musculoskeletal trauma in Bogotá, Colombia (University Hospital Fundación Santa Fe de Bogotá and Hospital Infantil Universitario de San José) between January 2012 and December 2018 who underwent CT- guided percutaneous fixation of a sacroiliac fracture with clinical and imaging follow-up records.

The inclusion criteria for the study were patients over 18 years of age with a diagnosis of traumatic sacroiliac injury classified according to AO fracture classification managed by CT- guided percutaneous internal fixation, fractures or dislocations that could be reduced by compression means, complete medical history, clinical and imaging follow-up. The exclusion criteria were patients with fluoroscopy guided fixation, open pelvic fractures and pathological fractures associated with a primary tumor or metastatic disease.

Study variables

Demographic variables (age and gender), clinical variables (trauma mechanism, hemoglobin (gr/dl) at admission and postoperative control, injury severity score, lactate), intraoperative complications as the duration of the procedure (minutes), intraoperative significative bleeding (>500 ml), poor screw position), post-operative complications (re-intervention in follow-up, displacement of fracture, transfusion of blood products after surgical procedure), length of hospital stay (days).

Data recollection

This study was approved by the corporate research ethics committee of the University Hospital Fundación Santa Fe de Bogotá and the Hospital Infantil Universitario de San José. A search by procedure code was carried out in the digital clinical system of the institutions, identifying the codes for reduction of complex pelvic fracture and the procedure code for sacroiliac arthrodesis, and then the use of tomographic guidance was identified in the surgical descriptions. Subsequently, the previously selected medical records were analyzed, identifying the study variables. The information was collected and systematized in a Microsoft Excel database. Finally, the exploratory and statistical analyses were carried out.

Biases

In a retrospective cohort study, the main bias is that of selection, from the data taken from the medical history already revealing the results of the intervention (CT-guided sacroiliac fracture fixation).

Study sample

A total of 18 patients were selected, all of them patients treated at the University Hospital Fundación Santa Fe de Bogotá and the Hospital Infantil Universitario de San José. between 2012-2018 and meeting inclusion criteria without exclusion criteria.

Statistical methods

To describe the sample, an exploratory data analysis test was performed. For quantitative variables, measures of central tendency (mean and median) and measures of dispersion (range, interquartile range, and standard deviation) were applied. Complications were reported in percentages and absolute frequencies. The Chi-Square and Fisher's Exact Test were used to determine the association between the trauma mechanism and gender and the severity index. The Spearman correlation was used to determine the relationship between severity index and hospital stay. Real statistics V 7.0 May 2020 software was used for the analysis of these data.

Surgical technique

Preoperative x-ray and CT scan were performed in the emergency room in order to classify the injury, evaluate the patient and make a decision. A digital exploration with the CT was performed to assess the morphology of the sacrum and identify the levels to be scanned later (Figure 1).

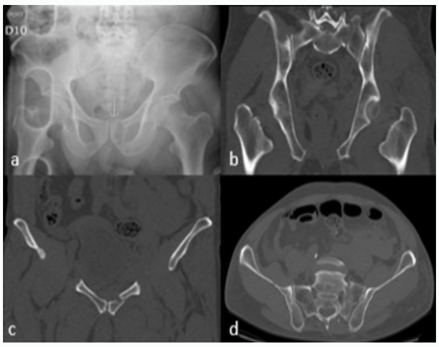


Figure 1: A 72-year-old patient with a left sacral wing and iliopubic branch fracture. A) Anteroposterior x-ray projection of the pelvis. B, C) Anteroposterior and axial pelvis CT projections. D) Axial pelvis CT projection.

In the radiology room under CT- Guide, the patient was placed in a supine position with a 45-degree angle inclination of the pelvis and preoperative marking of surface anatomy was made to identify the probable place of screw insertion (Figure 2).

For the entry point, the entry angle was measured from a horizontal line. The depth of the tissue to penetrate from the skin to the posterior aspect of the iliac bone was identified, and finally, the distance from the external region of the iliac bone was calculated according to the desired depth of penetration of the SIS. The identification of the previous delimitations is carried out in the tomography (Figure 3).

Surgical preparation was performed using an iodine-based cleaning solution and surgical drapes with adhesive shields. The entry

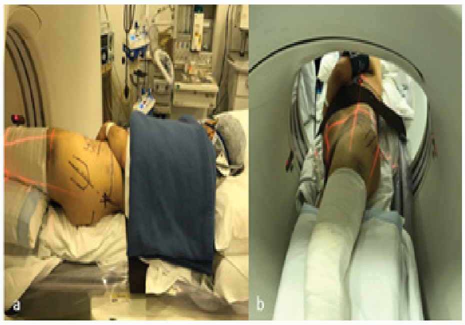


Figure 2: A, B) 40-degree lateral decubitus position of the patient in the tomography room and preoperative marking of surface anatomy.

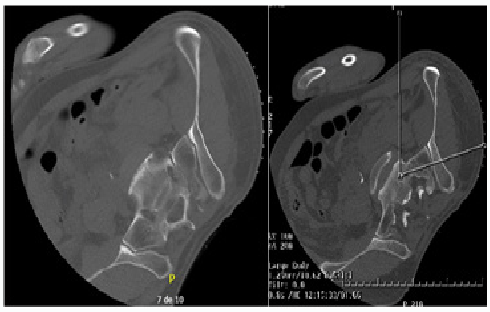


Figure 3: Sacro-iliac screw entry angle determination, axial CT projection.

point was marked on the skin with a sterile pen, and the trocar is inserted through a 1 cm incision until it contacts the bone (Figure 4).

Next, CT images are obtained to verify trocar trajectory and tip location. After obtaining the desired position, the hollow drill bit was attached to the drill, placed over the trocar, and then a small guide hole was drilled through the ilium into the sacrum. Additional CT images were obtained to confirm that the desired trajectory was maintained. Once the desired depth of the guide had been reached, the trocar was advanced to the depth of the hole after the drill and the drill bit were removed (Figure 5).

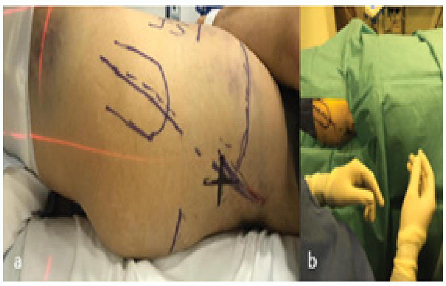


Figure 4: Screw guide entry point. Anatomic references: intersection greater trochanter axis 2 cm below iliac crest line.

The cannulated screw and washer were placed in the trocar and advanced with the manual screwdriver. Screw length selection was determined by direct measurement of the distance from the outer cortex of the ilium to the center of the sacrum. The progress of screw penetration was monitored by CT images.

In most cases, a single screw was sufficient to provide stabilization. In cases of severe instability, a second screw can be placed. When S2, S3 or S4 require fixation, tomographic images provide greater safety for the screw corridor. Once all the screws have been secured, the

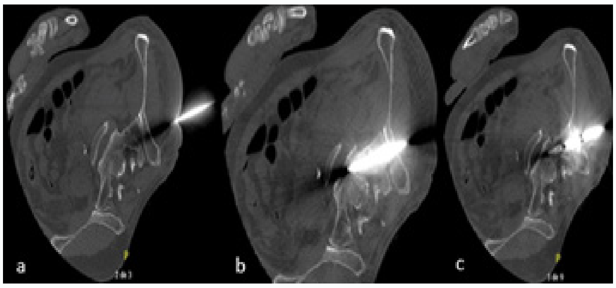


Figure 5: A-C) Tomographic axial view control of the insertion of the iliosacral screw and guide.

wound is flushed with saline fluid and closed with surgical staples or Steri-strips. In case of bilateral instability, the patient is turned over and the procedure is repeated. Before the patient was removed from the CT table, a final scan was obtained. Coronal tomographic reconstruction served as an additional plane to determine screw position (Figure 6). Radiographs can also be used for this purpose. A step-by-step description of our surgical techniques is shown in Table 1.

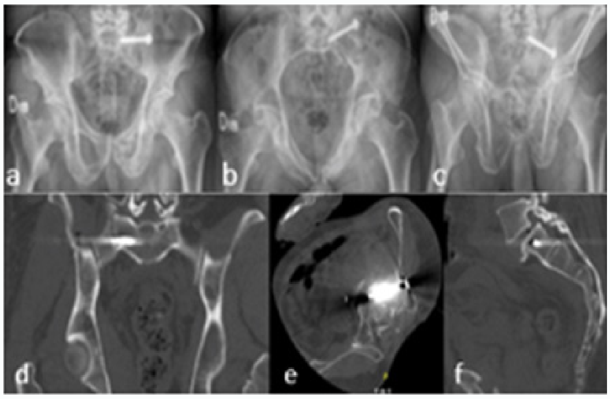


Figure 6: Radiographic immediate postoperative result: A) Anteroposterior, B) Inlet, C) Outlet views. Tomographic postoperative result: D) Anteroposterior, E) Axial, and F) Sagittal views.

Table 1: Characterization of the study population.

Variables	Mean (± SD) n = 18
Age	50.8 (± 21.4)
Time of follow up (months)	6.3 (± 7.8)
Gender	**% (n)**
Female	55.5 (10)
Male	44.4 (8)
AO Fracture Classification	
AO 61C1.1	11.1 (2)
AO 61C1.2	11.1 (2)
AO 61C1.3	50 (9)
AO 61C2.2	11.1 (2)
AO 61C3.1	11.1 (2)

*SD: Standard Deviation

Results

A total sample of 19 patients was collected from which one patient was excluded for being a minor, thus obtaining a total of 18 patients who met the inclusion criteria as part of the final sample (Flowchart 1).

As to demographic characteristics, the mean age of the group was

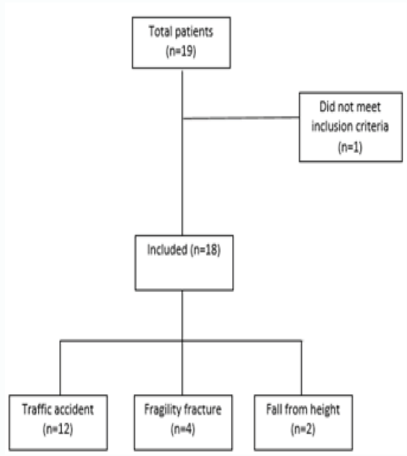
50.8 years and most of the patients were female (55.5%). The most common type of injury was 61C1.3 (according to the AO classification of fractures [10]). The average follow-up period was 6 months (Table 1).

Intraoperative complications

Regarding intraoperative complications, none of the patients presented any complications derived from the procedure, the perioperative results are described in Table 2.

Table 2: Description of operative data. *ISS: Injury Severity Score.

Variables	Mean (± SD) n=18	Min	Max
Intercritical period	5.17 (± 2.85)	1	10
Number of screws	1.06 (± 0.23)	1	2
ISS	12.56 (± 4.15)	4	22
Intraoperative bleeding	9.61 (± 17.15)	0	60
Hospital stays (days)	8.72 (± 4.69)	3	23



Flow chart 1: Flowchart of the study sample.

Additionally, a Chi-Square test and Fisher's tests were performed to determine if there was any association between the trauma mechanism and sex or the severity index, but no association was found (Table 3). However, a 10% positive relationship was identified between severity index and hospital stay, with a correlation index of 44%, that means, the higher the Injury Severity Score (ISS), the longer hospital stay (Figure 7).

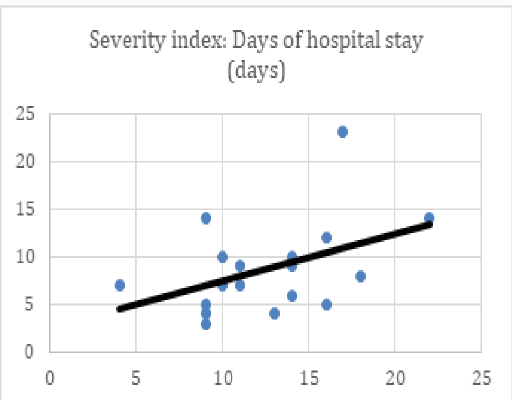


Figure 7: Scatter diagram of the relationship between days of hospital stay and severity index.

Postoperative complications

As for postoperative complications, none of the patients showed screw malposition and all presented a displacement of less than 5 mm.

Major complications and death

None of the patients included in the study presented major complications nor required re-intervention during the follow-up period. There were no deaths in the postoperative period or in the follow-up time.

Postoperative follow-up

During the sixth month postoperative follow-up, functionality was assessed by phone call with the Majeed Score, obtaining an average total score of 73.3 for the collected sample. This result is considered good for those patients who had been working before surgery and excellent for those who had not been (Table 4).

Discussion

Fixation of sacroiliac fractures demands a high level of technical skill from the trauma surgeon. Defining the percutaneous fixation approach between posterolateral and pure lateral has been the subject of discussion. Payne et al. [11] describe that the lateral approach allows the screw to interact with a greater volume of cortical bone and better density bone which could be related to a lower risk of pull-out or implant loosening when compared to the posterolateral approach.

The entry point of the sacroiliac screws has been previously determined [12]. Ebraheim et al. [13] described the entry point for S1, which is 3 cm to 3.5 cm anterior to the posterior border of the iliac bone in the sagittal plane, and 3.5 cm to 4 cm cephalad to the greater sciatic notch, with the screw directed perpendicular to the outer surface of the table from this entry point, as well as the safe length of the sacroiliac pedicular screw is up to 80 mm. Cecil et al. [14], described the entry point for S2 as 1.5 cm ± 0.31 cm superior and 2.5 cm ± 0.3 cm posterior to the apex of the greater sciatic notch and the guide pin is advanced at an angle perpendicular to the long axis of the sacrum. Nevertheless, due to the anatomical pelvic complexity and the individual variability of the posterior pelvic ring, the percutaneous approach still poses a challenge, hence the necessity of determining safe corridors for adequate screw positioning. Mendel et al. [15] described in a CT-based virtual analysis of 3-D bone corridors the safe placement of SI-screws in the first sacral segment, identifying a mean corridor volume of 45.2 cm^3 and a length of 14.9 cm. The oval cross-section measured 2.8 cm^2 and the diameter of the optimal screw pathway with the greatest safety distance was 14.2 mm. Additionally, in 20% of cases the expansion of the S1 corridor was highly influenced by the dimensions of a dysplastic elevated upper sacrum, showing the influence and risk of dysplastic pelvis in the positioning of the SIS., Therefore, surgeons must be knowledgeable about individual patient anatomy and the dysmorphic sacrum characteristics to ensure safe sacroiliac screw placement [6,7,15,16].

Furthermore, considering the narrow safety corridors and the individual variability, the percutaneous positioning of SIS presents a risk of injury to nearby structures. Gardner et al. [17] described sacral dysmorphism in 44% of the patients in his series, where the second sacral segment safe zone was shown to be significantly larger and less oblique than the S1 safe zone. A transverse screw was comfortably possible in 95% of the patients; therefore, in dysmorphic patients, the S2 screw is an easier and more predictable screw to place. O'brien et al. [18] described articular violation in 60% of screws placed in their

Table 3: Association between trauma mechanism and independent variables.

		Automobile (n)	Bicycle (n)	Motorcycle (n)	Pedestrian (n)	Fall from height (n)	Fragility fracture (n)	Total (n)	Fischer Test/Chi-sq
Gender	Male	0	0	3	3	1	1	8	0.522
	Female	2	1	1	2	1	3	10	
AO Fracture Classification	AO 61C1.1	1	0	0	0	0	1	2	0.208
	AO 61C1.2	0	0	1	0	0	1	2	
	AO 61C1.3	1	0	3	3	1	2	10	
	AO 61C2.2	0	1	0	0	1	0	2	
	AO 61C3.1	0	0	0	2	0	0	2	
Indice de serveridad	4	0	0	0	0	0	1	1	0.314
	9	1	0	0	0	1	2	4	
	10	0	0	1	1	0	0	2	
	11	0	0	0	0	1	1	2	
	13	0	0	0	1	0	0	1	
	14	0	0	2	1	0	0	3	
	16	1	0	1	0	0	0	2	
	17	0	1	0	0	0	0	1	
	18	0	0	0	1	0	0	1	
	22	0	0	0	1	0	0	1	

Table 4: Majeed Score.

Function after pelvic injury-Majeed Score	
Assessment	Mean (± SD)
Pain	28.5 (± 3)
Work	3.8 (± 1)
Sitting	7.8 (± 2)
Standing	
A-Walking aids	11.6 (± 1)
B-Gait unaided	11 (± 2)
C-Walking distance	10.6 (± 2)
Total	73.3 (± 8)

*SD: Standard Deviation

study. Various studies have observed SIS misplacement in 3% to 29% the cases, from which 0.5% to 8% have associated L5 nerve injury. Additionally, complications have also been described during follow-up, describing problems related with sexual dysfunction in 56% of women, presenting early and late complications with a frequent distribution [19-23].

The primary objective of this study was to describe the surgical results and complications of the CT guided screw fixation of pelvic fractures with screws in patients admitted into two different hospitals in the city of Bogota, Colombia. The most relevant findings of our study were that none of the patients required transfusion of blood products due to scarce intraoperative bleeding (mean of 9.61 ml), the quality of fracture reduction and fixation were adequate with no malposition of screws and a minimum displacement presented (<5 mm), and no patients required an additional intervention during follow-up.

Our results are in agreement with previous descriptions that suggest that CT-guided fixation is a safe alternative for sacroiliac fixation [24,25]. Ziran et al. [26], described the results of CT guided placement of posterior pelvic screws in a series of 66 patients with unstable pelvic ring injuries and the only significant complication reported occurred in one patient who initiated limb support ahead of time and presented a screw fracture and displacement of 5 mm. Also, Pieske et al. described the outcomes of 71 patients treated with sacroiliac screw placement guided with CT-Scan describing excellent injury reduction and no procedure associated complications [8].

Although the cost of using tomography as a guide to the procedure is higher than that of fluoroscopy, it is suggested that the use of tomography would reduce care costs in these patients, as reported by Daffner et al. This study analyzed the cost of both procedures and found that the total cost of the open reduction and internal fixation procedure in the operating room was higher than the CT-guided procedure ($18,246 and $6,803, respectively). Nevertheless, more cost-effective studies are necessary [2].

The small number of patients included may be regarded as an important limitation to the present study, because it lacks a sufficient range to establish statistically significant differences between the variables evaluated.

Conclusion

CT guided percutaneous fixation of sacroiliac injuries resulted in adequate position of screws and minimal displacement of the present fractures. No patient presented complications during surgery or in outpatient follow-up and there was no requirement for surgical reintervention in any of the cases. This shows that this procedure is a good alternative as a first line surgical management strategy for patients with sacroiliac fractures.

However, due to the epidemiological design of the present study further comparative clinical studies of the two surgical techniques would be necessary to obtain results closer to reality. Nevertheless, the results of this study may serve as a basis for future investigations on the topic.

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