

CASE REPORT

Robotic-assisted percutaneous pelvis fixation: A case report

Austin F. Smith | Jon B. Carlson 

Department of Orthopaedic Surgery,
University of Louisville, Louisville,
Kentucky, USA

Correspondence

Jon B. Carlson, University of Louisville,
Department of Orthopaedic Surgery,
550 S. Jackson St, 1st Floor ACB,
Louisville, KY 40292, USA.
Email: joncarlsonmd@gmail.com

Key Clinical Message

It may be possible to extend the use of the robotic arm to pelvic and acetabular surgery leading to safe, repeatable screw placement, and less radiation exposure for patients, surgeons and OR staff.

Abstract

In this case, a novel, robotic-assisted technique was used to place a sacroiliac screw in a patient with unstable injuries of the pelvic ring. Intraoperative and postoperative fluoroscopic, radiographic, and CT imaging demonstrated a safely positioned 6.5 mm cannulated screw without unplanned cortical violation or impingement on neurovascular structures. To our knowledge, this is the first such reported case using a robot widely available in the Americas or Europe.

KEYWORDS

fracture, pelvis, robot-assisted, robotic, robotic arm, sacroiliac

1 | INTRODUCTION

The use of robotic technology has long been known to be effective in many industries such as manufacturing and automotive industries. The first surgical application of industrial robotic technology was described when an industrial robotic arm was modified to perform a stereotactic brain biopsy with 0.05 mm accuracy.¹ The use of robotic-assisted technology in surgical applications has expanded since then and has been used successfully in neurologic, cardiac, gynecologic, urologic, and more recently orthopedic surgery.^{2–6} Robotic-assisted surgery in the spine has been shown to be effective and safe.⁷ Robotic-assisted surgery in the treatment of traumatic pelvic and acetabular injuries draws parallels to pedicle fixation in that pelvic and acetabular implants are also placed in narrow bony corridors where there is the potential for devastating neurovascular injury. This has traditionally made percutaneous fixation of the pelvis a procedure that requires significant expertise and precise imaging protocols intraoperatively.

In some situations, surgery is postponed due to obstruction of imaging by bladder contrast or bowel gas. With the use of robotic-assisted technology, these issues could be circumvented, and intraoperative robotic arm assistance and real-time data availability on implant position and trajectory could allow for precise and accurate placement of pelvic fixation. Robotic-assisted placement of screws into the pelvis has been reported before using the TiRobot (TINAVI Medical Technologies, Beijing, China).⁸ To our knowledge, we report the first such case to be performed outside of China using a robotic system and instruments widely available in the Americas and Europe.

2 | CASE REPORT

After demonstrating that the ExcelsiusGPS robotic arm (Globus Medical) could be used to place 6.5 mm cannulated screws into the pelvis using cadaveric specimens, a patient was selected for robotic-assisted percutaneous

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FIGURE 1 Preoperative imaging including (A) anteroposterior (B) outlet and (C) inlet radiographs of the pelvis.

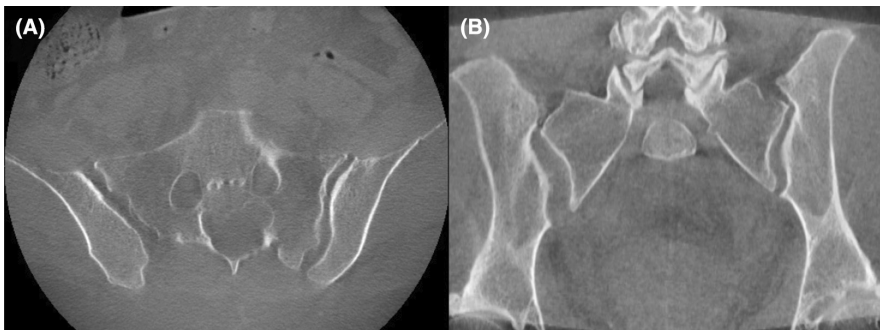


FIGURE 2 Intraoperative CT showing right SI widening the axial (A) and coronal (B) planes.

pelvic fixation. Informed consent was obtained. The patient presented to our Level 1 trauma center in October 2021 with multiple traumatic injuries.

A 57-year-old patient sustained a pelvic ring injury with right SI widening and fractures of the ipsilateral right superior and inferior rami and left inferior ramus extending into the left pubis (Figures 1 and 2). Informed consent for robotic-assisted surgery was obtained.

3 | SURGICAL TECHNIQUE

We utilized a “scan and plan” workflow, where the patient was prepared and draped in usual sterile fashion prior to any screw planning with the robot. The post for the patient reference tracking array (called the “dynamic reference base” or DRB) was first anchored to the operative hemipelvis in the iliac crest starting about 5 cm posterior to the anterior superior iliac spine and perpendicular to the floor to allow for visualization of the array by the robotic camera, which was placed at the head of the bed. The surveillance marker was placed in similar fashion on the contralateral hemipelvis. The purpose of the surveillance marker is to guard against loss of robotic registration if the DRB was disturbed (bumped or otherwise moved) inadvertently by an assistant during the case. The “scan and plan” reference array (called the intraoperative CT marker or “ICT”) was then attached

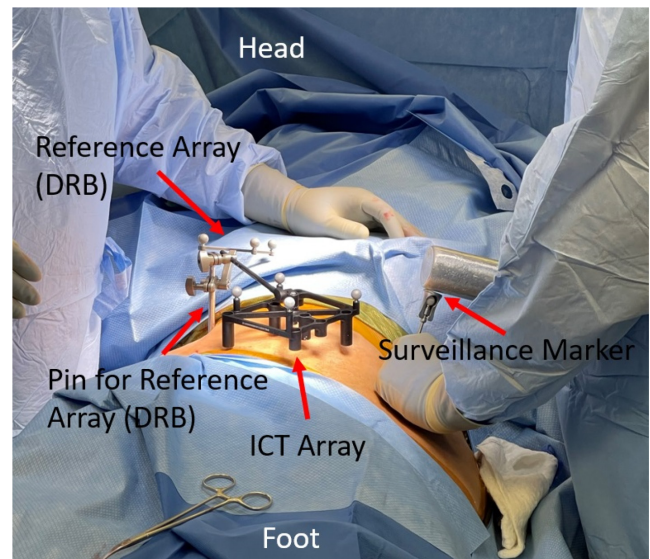


FIGURE 3 Clinical setup for robotic screw placement. Reference array (DRB and pin for DRB) on the operative hemipelvis. ICT attached to that array. Surveillance marker on the contralateral hemipelvis to guard against loss of registration.

to the post for the DRB (Figure 3). The O-Arm was then positioned around the patient, and AP and lateral fluoroscopy views confirmed that all necessary markers from the arrays would be contained within the spin. Note that an O-Arm with the capability to perform a 40 cm spin is required for

FIGURE 4 Robotic plan for the SI screw.

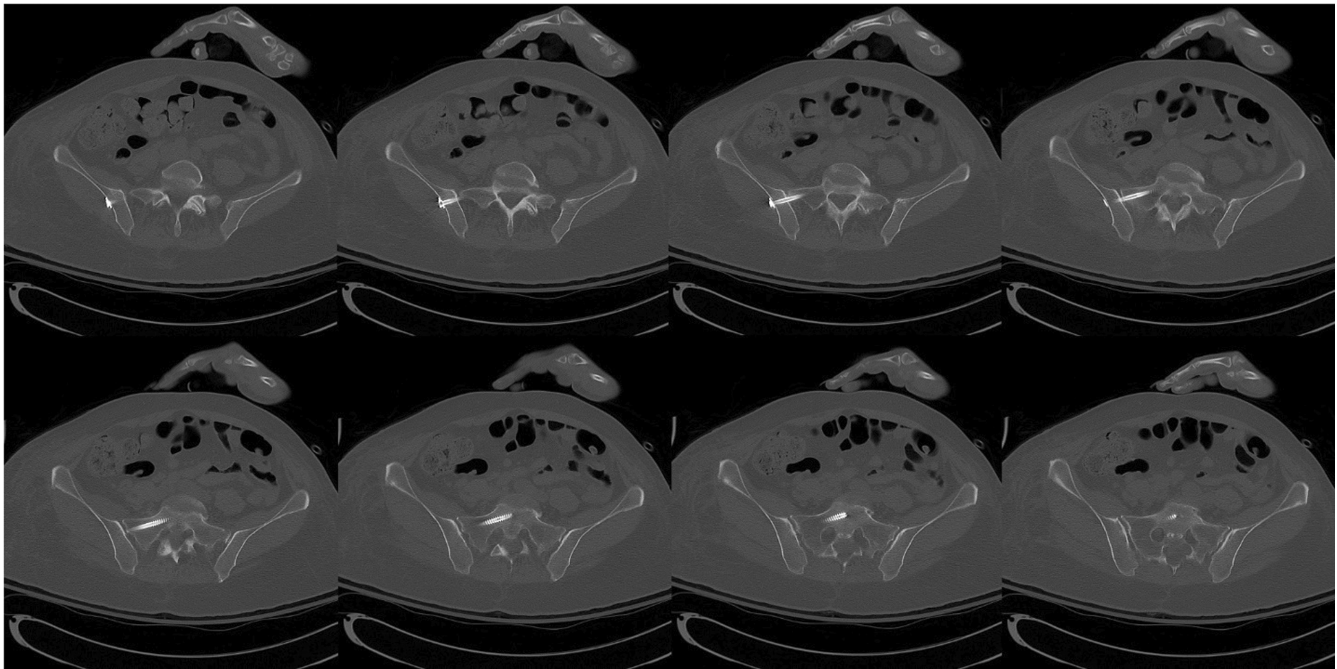
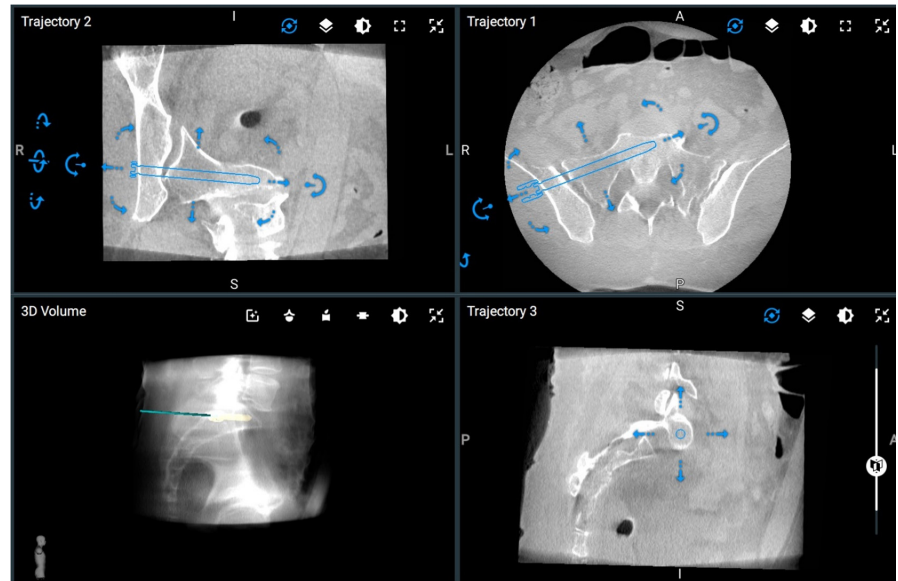


FIGURE 5 Axial CT slices of the screw demonstrating appropriate positioning of the right SI screw.

this technique. An O-Arm spin was then performed, and that data were transferred to the robot. A right-sided SI screw was planned using a 6.5 mm pedicle screw (Figure 4). The robotic instruments were registered, and robotic registration was confirmed by using a navigated probe placed against bony landmarks.

The robot was draped in sterile fashion and brought near the surgical field. The surgical arm was brought into position in line with the planned screw trajectory. Robotic instruments were used to incise the skin. Blunt dissection was carried to bone. The robotic burr was used to open the outer cortex of the ilium. A 5.5mm robotic tap was then placed to the limits of its depth. The tap was removed, and a

robotic awl was placed against the bone. The central trocar from the awl was removed, and a 0.9 mm nitinol wire was placed through the awl into the path created by the tap. The wire position was maintained, and the awl as well as the end-effector from the robot were removed. Using the nitinol wire as a feeler probe bone could be felt circumferentially through the entire course of the tapped bone. The robot was moved away from the surgical field. C-arm was brought in, and the position of the wire in the bone was confirmed to be as planned. A 6.5 mm partially threaded screw was then placed over the wire under fluoroscopic control, and the wire withdrawn. Post-procedure CT scan demonstrated placement of the screw exactly as planned (Figure 5).

4 | DISCUSSION

Robotic-assisted surgery has been demonstrated to be a safe and effective technique in spine surgery where instrumentation is placed in narrow corridors in close proximity to neurovascular structures.⁷ The authors found robotic-assisted percutaneous fixation appealing in traumatic pelvic injuries where fixation is also placed in narrow corridors of bone while avoiding damage to neurovascular structures such as the sacral and L5 nerves and nearby vascular structures such as the superior gluteal artery and its branches. Percutaneous fixation in the pelvis requires detailed knowledge of complex, three-dimensional pelvic anatomy and its variations and the ability to correlate this 3D anatomy to 2D fluoroscopic imaging.⁹ The sacrum is known to have varying anatomy with sacral dysmorphism reported in 44% of patients.¹⁰ These variations in anatomy underscore the importance of accurate and consistent imaging. Quality of c-arm imaging is affected by several factors outside surgeon control such as the presence of bowel gas, bladder contrast, availability of a skilled c-arm technician, and large patient body habitus. The use of robotic-assisted surgery may mitigate some or all of these issues, as intraoperative CT imaging is not constrained by the presence of many of these factors.

Robotic-assisted surgery for percutaneous fixation of traumatic pelvic injuries is a novel technique that allowed for safe and accurate screw placement in this case. To our knowledge, this is the first reported case in the Americas and Europe of robotic-assisted surgery for treatment of traumatic pelvic injuries. The patient was in the supine position, which is standard for most surgeons treating these injuries utilizing standard techniques. Further research is needed to demonstrate accuracy of implant placement relative to the preoperative plan.

AUTHOR CONTRIBUTIONS

Austin F Smith: Writing – original draft; writing – review and editing. **Jon b Carlson:** Conceptualization; methodology; project administration; supervision; writing – review and editing.

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None.

CONFLICTS OF INTEREST STATEMENT

The authors have no conflict of interest to declare.

DATA AVAILABILITY STATEMENT

Data sharing not applicable to this article as no datasets were generated or analyzed during the current study.

CONSENT

Written informed consent was obtained from the patient to publish this report in accordance with the journal's patient consent policy.

ORCID

Jon B. Carlson  <https://orcid.org/0000-0002-1026-7388>

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