


'XX'–Sacropasty: A Novel Technique for Management of “H-Type” Sacral Insufficiency Fractures

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Abstract

Objective: Examine the feasibility, safety, and results of a novel sacral percutaneous injection technique (“XX”) addressing both the vertical and horizontal aspects of sacral insufficiency fractures (SIF). **Methods:** Prospective cohort study. Eight consecutive SIF patients with immobility and pain investigated using CT and nuclear imaging confirmed “H”-type fracture. Demographics, pain level, and ambulation status were recorded. The long-term quality of life was evaluated using the ODI questionnaire and pain VAS scores. Sacropasty procedures in prone positioning using fluoroscopy were used to insert 2 bone trochars through the S1 pedicles and 2 trochars through the sacral ala aiming toward the SIJ, thus forming 2 “X” trochar formations. Balloon kyphoplasty was done through the trocars, and PMM was injected. Postoperative ambulation and VAS were recorded. **Results:** Average age was 81.5 years (± 3.4 years). The time from presenting symptoms to hospital admission was 2 days to 4 months. All patients were significantly limited with ambulation. None had a neurologic compromise. Sacropasty was performed with 2 cases that required additional lumbar kyphoplasty. The mean operative time was 54 min (± 14). The average exposure was 19 mGy (± 12 mGy). Two patients had cement leaks. CT and X-rays revealed good cement filling of the fractures sacral alae and body of S1. The average postoperative hospitalization was 10 days. All patients reported post-operatively pain relief immediately and were able to walk better. Follow-up time was 17 ± 12 months. Follow-up VAS was 2.7 (± 2) and ODI was 57.3% ($\pm 21\%$). **Conclusion:** “XX” technique showed good outcomes for patients with higher complexity SIF, using the same principles as for lumbar VPL/KPL, and was found to be safe and effective.

Keywords

sacral insufficiency fracture, sacropasty, osteoporosis, balloon kyphoplasty

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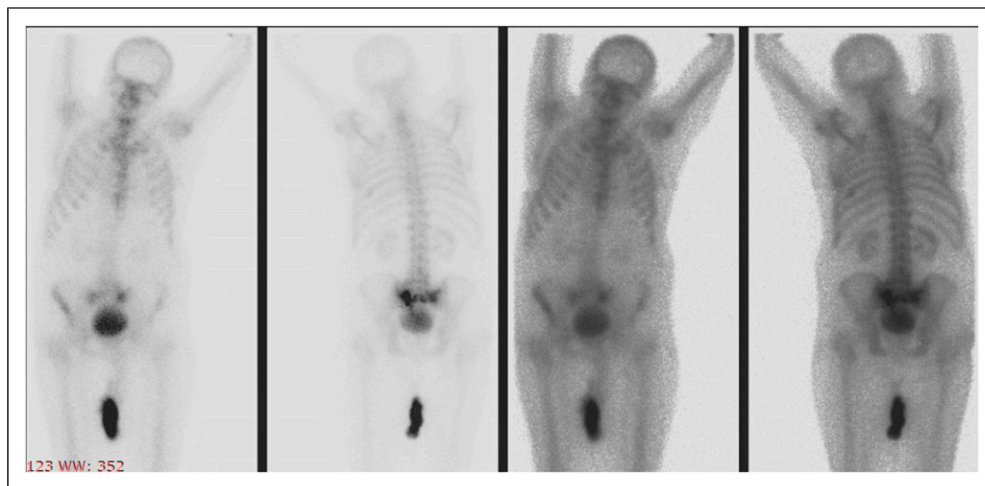


Figure 1. Scintigraphic uptake of SIF, Typical Honda “H” sign.

Highlights

(Sacral insufficiency fracture, sacroplasty, osteoporosis, and balloon kyphoplasty)

1. This study is a prospective case series of a novel technique for managing recalcitrant complex “H-type” sacral insufficiency fractures.
2. Our technique is novel as it employs 2 trochars placed in an X fashion through each sacral pedicle, (XX) addressing both the vertical and transverse fracture lines. The medial trochar allows for cement fill of the sacral body allowing for stabilization of the transverse fracture. The laterally directed trochar is aimed toward the ala and provides for stabilization of the vertical fracture line.
3. The proposed technique is unique in providing a solution to the vertical and horizontal components of the sacral insufficiency fracture.
4. The procedure was found to be safe. There were no neurological, respiratory, vascular, or visceral complications. Minor cement leakage was clinically inconsequential.
5. All patients reported immediate pain improvement following surgery and most importantly regained ambulatory status.

Introduction

Sacral insufficiency fractures (SIFs) are very painful, debilitating, and often missed.¹⁻⁴ SIFs are typical of atraumatic aetiology, and the most common underlying cause is osteoporosis in the elderly leading to bone biomechanical failure under normal physiologic loads or minor trauma.

Other etiologies include overuse injuries in athletes—runners, weightlifters, bicyclists, basketball players, fitness instructors, gymnasts, military recruits, and aerobics and in other cases osteopenia due to chronic corticosteroid therapy, osteomalacia, previous local radiation therapy, and iatrogenic complications following instrumented fusion of the lumbar spine.⁵⁻¹⁴

Typical SIF clinical presentation in the osteoporotic elderly patient includes vague buttock and low back pain, pain worse on sitting and standing, and local sacral tenderness without lower extremity neurologic compromise. The patient is usually bedridden. Although patient complaints are substantial, these fractures remain substantially underdiagnosed.^{1,3,4,15-19}

Most sacral insufficiency fractures are vertical and occur predominantly in the sacral wing (zone 1).²⁰ Less typical are an “H”-type pattern with both vertical and horizontal components of fractures across the sacrum (Figure 1); bilateral or unilateral vertical fractures through the sacral alar regions; or variations of these patterns.^{10,21,22} Computed tomography (CT) (Figure 2), magnetic resonance imaging (MRI), and three-phase bone scans are used to make the diagnosis. MRI is useful to exclude other causes of sacral region pain but is less sensitive than a bone scan in diagnosing SIF.²³⁻³¹

Conservative treatment of SIF consists of bed rest, limited physical therapy, and analgesics. In some cases, SIF can be recalcitrant to treatment. In the elderly with prolonged immobilization, SIF patients are at risk for venous thromboembolic disease, urinary retention, pressure ulcers, depression, pneumonia, and catabolic energy states.^{32,33} One-year mortality in geriatric patients reaches 14.3%.^{34,35} SIF can cause a patient to lose his/her independence and requiring institutionalization.^{32,33}

In the osteopenic bone, significant challenges exist for any form of internal fixation. Spinopelvic fixation is well described in high energy fractures with H-type fracture

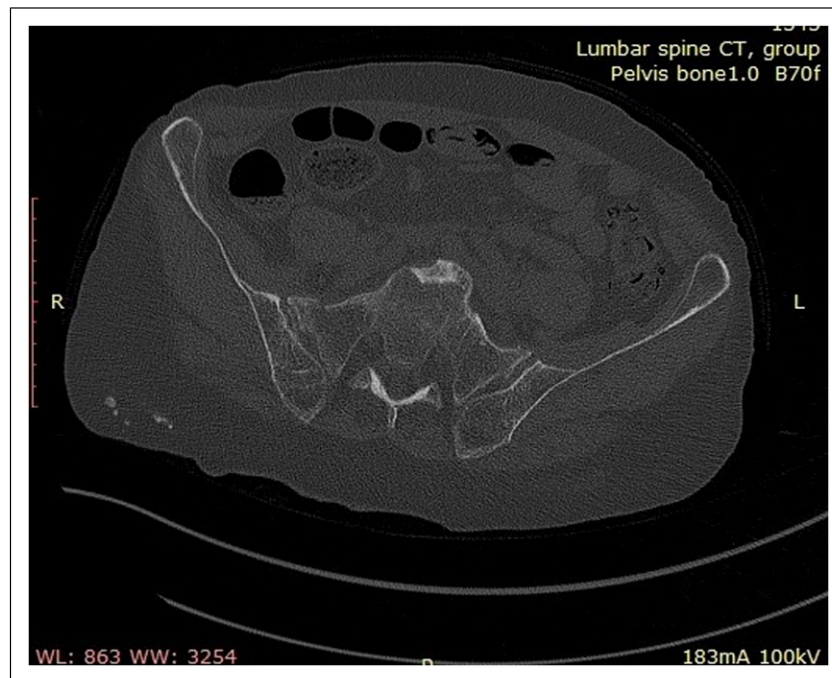


Figure 2. Overt macroscopic fracture of the right sacral ala.

patterns as bone quality is good. In osteoporosis, these same fracture patterns are not amenable to internal fixation.^{36,37} Previous studies have described sacroplasty for lytic lesions due to metastasis and fractures but only for the vertical component of the H pattern.³⁸⁻⁴¹

Sacroplasty consists of percutaneously delivering polymethyl-methacrylate (PMMA) cement into a SIF or sacral metastasis under fluoroscopy or computed tomographic guidance. Proposed mechanisms of the procedure include nociceptive neurolysis, thermal injury, and bone stabilization. Cadaveric biomechanical studies comparing different forms of fixation found no significant difference among fixation types.⁴²⁻⁴⁴ The immediate motion was significantly less after the interventions than baseline, but more motion was seen after cyclic loading in all fixation methods examined.

All series published to date comprise PMMA injection to the sacral alae, which can only address the vertical component of the “H” fractures without addressing the transverse portion of the fracture^{40,45}; this may be due to underestimation of its importance as a pain generator.

The purpose of this study is to examine the feasibility, safety, and results of a novel sacral percutaneous injection technique addressing both the vertical and horizontal aspects of SIFs.

Materials and Methods

A prospective, observational cohort study was conducted on eight consecutive patients suffering SIF, presenting to

our medical centre during 2012–2015. All patients had incapacitating lumbar and/or gluteal pain due to a SIF, documented osteoporosis, evidence of a sacral fracture through increased radiotracer uptake on nuclear imaging, and all patients were investigated with CT scan which documented an H-type fracture pattern. Inclusion criteria were SIFs that were recalcitrant to conservative care. Our institute IRB committee has approved this project, and the patient’s consent was signed as required from each patient.

The more common vertical fracture patterns or simple transverse fractures were not included in this study as often these were managed more successfully with conservative measures. Patients with a history of malignancy or previous radiation to the pelvis were excluded.

Patient gender, age, pre-procedure pain duration, pain level, and patient pre-operative ambulation status were recorded at baseline and immediately post-procedure. A telephone completed Oswestry Disability Index questionnaire, and pain Visual Analogue Scale (VAS) evaluated the long-term quality of life.

Two North American fellowship-trained spine surgeons performed all procedures, whose combined vertebroplasty/balloon kyphoplasty experience surpassed 500 cases. Each sacroplasty procedure was performed under general anaesthesia. One gram of cefazolin, or 600 mg of clindamycin when penicillin or cephalosporin allergy was present, was administered intravenously 30 minutes before the procedure. Patients were positioned prone, and a preliminary fluoroscopy was performed to delineate the

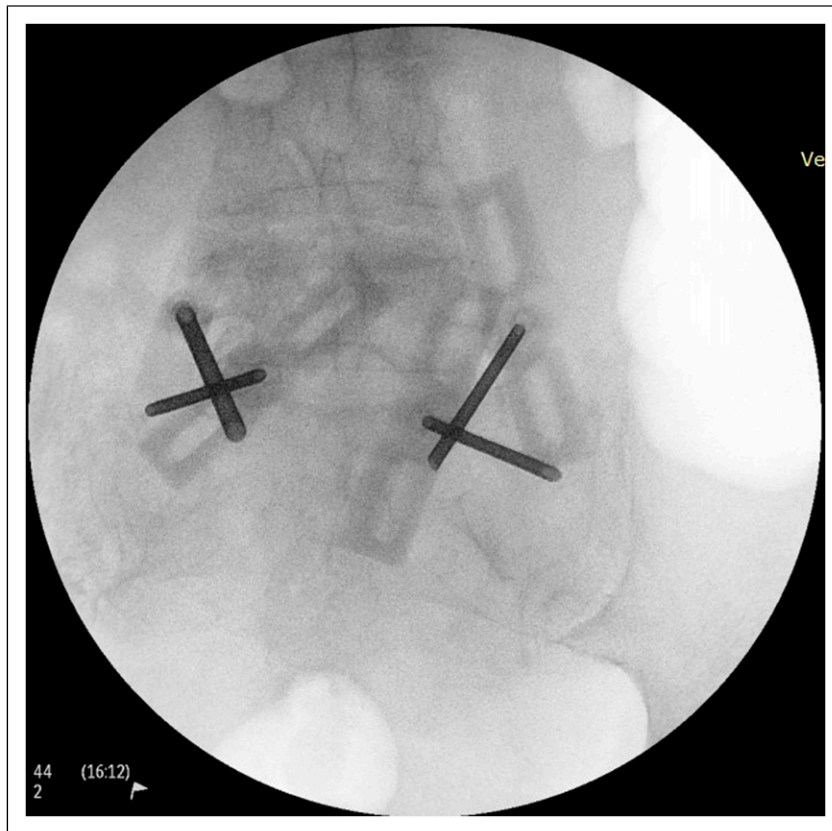


Figure 3 . “XX” Trocar placement.

sacroiliac joints. Following draping, two 0.5 cm skin incisions were made under fluoroscopy over the lateral-caudal portion of the S1 pedicles. Two 13-gauge bone trochars were placed through the S1 pedicles, and 2 trochars were inserted through the same skin incision through the sacral ale aiming to the sacroiliac joint, thus forming 2 “X” trochar formations (Figure 3). Fluoroscopic guidance was used to control trochar placement and advancement. The trochars were advanced into the fracture area, directed a centimetre lateral to the sacroiliac joint. 45-degree oblique views were used to ensure trochars were not placed through sacroiliac joints. Forty degrees cephalad and 40° caudad tilted fluoroscopy was performed to visualize the sacrum axially and view sacral foramina, respectively. A 10 mm inflatable balloon was introduced through the trocars (Kyphon, Medtronic) and inflated under fluoroscopic control. Then balloons were deflated and retracted. After mixing the PMMA cement (HVR or Xpede, Medtronic), achieving toothpaste-like viscosity, under anteroposterior imaging, 2 to 5 mL of PMMA was injected through each trochar, monitoring the spread of the bone cement to avoid medial extension toward the sacral nerve roots or anterior to the sacrum (Figure 4). Each patient was maintained in the supine

position for 60 minutes in the recovery room before returning to the orthopaedic ward.

On postoperative day one, the patient began ambulation with a walker under the physiotherapist’s supervision. Ambulatory status was recorded by the physiotherapists, which was blinded to the new procedure and nature of the study. In cases that PMMA leakage was suspected, patients underwent postoperative CT scans. All patients were discharged to rehabilitation centres according to availability.

Results

The cohort consisted of 8 patients, seven females and one male. The average age was 81.5 years (± 3.4 years). Four patients were admitted following a fall, while the remainder did not sustain any trauma. Time from presenting symptoms to hospital admission was variable and ranged from 2 days to 4 months. Four patients were admitted to Internal Medicine wards due to general deterioration or pelvic pain; 2 of these patients were evaluated by orthopaedic residents and discharged following a “normal” pelvic roentgen exam. The authors diagnosed these patients following pain management issues and sought



Figure 4. PMMA sacral distribution, left SIJ extravasation is noted.

Table 1. Pre- and Postoperative Pain and function.

Patient	Gender	Age	Pre-op VAS	Pre-op Function	Post-op VAS	Post-op function: Distance with walker	Follow-up (months)
1	F	84	6	Bedridden	0	40 m	36
2	F	84	7	Cannot sit in bed	3	50 m	12
3	F	78	6	Cannot walk	3	8 m	8
4	F	86	7	Cannot walk	2	8 m	8
5	F	82	6	Cannot stand	2	12 m	5
6	M	77	7	Cannot stand	0	20 m	33
7	F	78	6	Can walk 3 m with walker	2	18 m	18
8	F	83	5	Can walk 3 m with walker	1	10 m	8

council by the treating physicians. Four patients were admitted directly to the orthopaedic ward (Table 1).

All patients' presenting symptoms were acute sacral pain made worse by standing and sitting. Four patients were bedridden with trouble changing positions in bed due to debilitating pain. Two patients could stand for a few seconds before returning to bed, and the remaining 2 patients could walk for about 5 m with a walker. None of our patients had a neurologic compromise.

Pelvic anterior–posterior X-rays did not reveal SIFs in our study, but CT scan revealed frank fractures in 5 out of the eight patients. Six patients underwent a technetium bone scan that was positive in 5 cases and negative in one case; this case showed an acute frank fracture of sacral ala and thus was operated on. Two

patients did not undergo a bone scan as the fracture was deemed acute on CT scan and was concordant with the clinical setting. None of the patients underwent magnetic resonance imaging as the diagnosis was made by scintigraphy and CT scan.

Sacroplasty was performed within a day to 2 weeks following admission to the orthopaedic department (mean 5.7 days \pm 5). Two cases required an L5 and L3 kyphoplasty as concomitant acute fractures were diagnosed and treated at the same setting based on bone scintigraphy which revealed concomitant acute fractures of the lumbar spine and SIFs. Clinically, the pain was mainly over the sacrum on anamnesis and palpation. The mean operative time of all surgeries was 54 minutes (\pm 14 minutes) with an average blood loss of

8cc (± 4 cc). Average radiographic exposure was 19 mGy (± 12 mGy) or 65 seconds (± 32 seconds) of fluoroscopy time. The two-level kyphoplasty cases did not require greater radiation exposure than average. Two patients had cement leaks and underwent postoperative CT scans that revealed a leak to the SIJ joint in one case and sacral foramina in another, without neurologic compromise.

Postoperative CT scans performed revealed good cement filling of the fractures sacral alae and the body of S1. Similar findings were noted on postoperative pelvic X-rays.

The postoperative medical course was uneventful except for a patient that developed gastrointestinal bleeding treated conservatively. One patient developed postoperative urinary retention, and a CT scan excluded cement leakage or neural compression. By discharge, the patient was weaned from the urinary catheter. Average postoperative hospitalization was 10 days (± 8 days) due to shortage of rehabilitation resources; all patients were listed for rehabilitation by POD 3.

Postoperatively, all patients reported pain relief and could walk for an average of 21 m (± 16 m) using a high or regular walker. Walking ability was gained on the first postoperative day under the physiotherapist's supervision. No differences were found in relation to the onset of symptoms between the patients treated with sacroplasty.

Patients were followed up for an average of 17 months (± 12). Follow-up VAS score was 2.7 (± 2) and Oswestry percentage of disability was 57.3% ($\pm 21\%$), comparable to chronic low back pain patients. During follow-up, 2 patients suffered a perthrochanteric hip fracture requiring operative treatment; a month and 2 months following the SIF, another patient developed lumbar radiculopathy requiring selective nerve root blocks. The radiculopathy was unrelated to the lumbar kyphoplasty patients.

Discussion

This study is a prospective case series of a novel technique for managing recalcitrant complex "H-type" sacral insufficiency fractures. Our technique is novel as it employs two trochars placed in an X fashion through each sacral pedicle (XX), addressing both the vertical and transverse fracture lines. The medial trochar allows for cement fill of the sacral body allowing for stabilization of the transverse fracture. The laterally directed trochar is aimed toward the ala and provides for stabilization of the vertical fracture line.

Sacral insufficiency fractures in the elderly can entail severe morbidity with loss of function and increase mortality; hence, early return to ambulation is crucial. Although this entity has been well described, it is still

underdiagnosed and undertreated due to a lack of effective modalities.

Previous reports of sacroplasty describe single trochar placements directed to the sacral ala fracture site without reinforcing the horizontal component of the "H" fracture. Biomechanical and clinical studies did not reveal a significant difference in immediate sacral stabilization or clinical outcome.

The proposed technique is unique in providing a solution to the vertical and horizontal components of the sacral insufficiency fracture. The procedure was found to be safe. There were no neurological, respiratory, vascular, or visceral complications. Minor cement leakage was clinically inconsequential. All patients reported immediate pain improvement following surgery and, most importantly, regained ambulatory status. We did not find any difference in the procedure's efficiency regarding the onset of symptoms as our selection of patients was based on significant symptoms before surgery with mobility and daily active function, regardless of the time of fall.

The two patients that underwent two-level procedures, including the L3 or L5 vertebra, were treated at the same operative procedure as it was felt that addressing these would provide further benefit. Osteoporotic fractures are often multiple. This study has demonstrated that as the lumbar fractures, the sacral level can be treated with these in the same way a two-level lumbar fracture could be managed.

The complications of osteoporosis can create other insufficient fractures and cause new-onset disability and non-spinal disability. This was a factor in two patients who developed hip fractures in the months following the sacroplasty. One patient further developed L5 radiculopathy due to degenerative aetiology with lateral recess stenosis. This was managed with selective nerve root blocks as an outpatient.

Long-term success of sacroplasty in SIF patients is challenging to establish due to the development of comorbid conditions in the elderly and other osteoporotic complications. This is seen in the current state of the literature as long-term follow-ups are lacking. Nevertheless, there is value in short-term pain relief and, as early as possible, return to ambulation. This new technique has shown promising outcomes for these patients with more complex sacral insufficiency fractures. It is safe and effective in the hands of experienced spinal surgeons, using the same principles as for lumbar vertebroplasty/kyphoplasty.

Take Home Messages

Sacral insufficiency fractures in the elderly can entail severe morbidity with loss of function and increase mortality; hence early return to ambulation is crucial. Although this entity has been well described it is still

underdiagnosed and undertreated due to lack of effective modalities.

This new technique termed “XX”, (double X), has shown good outcomes for patients with higher complexity sacral insufficiency fractures, using the same principles as for lumbar vertebroplasty/kyphoplasty, and was found to be safe and effective.

Author’s Note

With the submission of this manuscript, we would like to undertake that the manuscript mentioned above has not been published, accepted for publication under editorial review for publication elsewhere; and that my Institute’s representative is fully aware of this submission. All authors who participated in this study meet each of the authorship requirements as stated in the Uniform Requirements for Manuscripts Submitted to Biomedical Journals, and it has been IRB approved.

Declaration of Conflicting Interests

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