Percutaneous sacroplasty: Technical description for the treatment of sacral insufficiency fractures

Sacroplastía percutánea: descripción técnica para el tratamiento de las fracturas por insuficiencia del sacro

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Resumen

Introducción: Las fracturas por insuficiencia sacra son una causa creciente y frecuentemente infradiagnosticada de dolor lumbopélvico intenso en adultos mayores. El tratamiento conservador prolongado conlleva altos riesgos de inmovilización, dependencia, complicaciones médicas y dolor incapacitante. Ante esta situación, la sacroplastia percutánea guiada por fluoroscopia presenta una alternativa mínimamente invasiva con beneficios clínicos en casos seleccionados con síntomas refractarios y graves. **Objetivo:** Presentar una descripción técnica detallada y reproducible de una sacroplastia percutánea, integrando su justificación anatómica, estrategia quirúrgica y aplicación clínica en pacientes frágiles. **Método:** Se describe el procedimiento quirúrgico paso a paso, incluyendo la colocación, la planificación radiológica, la selección del acceso, la preparación e inyección de cemento de PMMA de alta viscosidad y el seguimiento postoperatorio. Se ilustran dos casos clínicos representativos: uno osteoporótico y el otro secundario a una metástasis sacra, ambos con dolor refractario al tratamiento conservador y progresión clínica documentada. **Resultados:** Ambos pacientes experimentaron alivio del dolor en 24 horas (reducción de la EVA $\geq$ 5 puntos), lo que les permitió sentarse y caminar precozmente. No se reportaron complicaciones ni fugas sintomáticas. El seguimiento mostró la consolidación de la fractura y la recuperación funcional completa. En un caso, la biopsia identificó enfermedad metastásica, lo que subraya su valor diagnóstico adicional. **Conclusión:** La sacroplastia percutánea guiada por fluoroscopia ofrece una solución concreta, eficaz y reproducible para el tratamiento del dolor incapacitante en pacientes con fracturas por insuficiencia sacra. Acorta el tiempo de rehabilitación, previene las complicaciones de la inmovilización y restaura la autonomía del paciente de forma rápida y segura. Esta técnica representa una herramienta quirúrgica clínica de alto impacto que debería incorporarse al manejo estandarizado de los pacientes modernos con enfermedad osteoporótica frágil.

Palabras clave: Sacroplastía, fracturas por insuficiencia del sacro, cementación ósea, fracturas osteoporóticas de la pelvis, cirugía de columna mínimamente invasiva.

Abstract

Introduction: Sacral insufficiency fractures are a growing and frequently underdiagnosed cause of severe lumbopelvic pain in older adults. Prolonged conservative treatment carries high risks of immobilization, dependency, medical complications, and disabling pain. Given this scenario, fluoroscopy-guided percutaneous sacroplasty presents a minimally invasive alternative with clinical benefits in selected cases with refractory and severe symptoms. **Objective:** To present a detailed and reproducible technical description of a percutaneous sacroplasty integrating its anatomical justification, operative strategy and clinical application in frail patients. **Method:** The surgical procedure is described step by step, including positioning, radiological planning, access selection, preparation and injection of high-viscosity PMMA cement, and postoperative follow-up. Two representative clinical cases are illustrated: one osteoporotic and the other secondary to a sacral metastatic, both with pain

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refractory to conservative management and documented clinical progression. **Results:** Both patients experienced pain relief within 24 hours (VAS reduction ≥ 5 points), allowing for early sitting and walking. No complications or symptomatic leaks were reported. Follow-up showed fracture consolidation and full functional return. In one case, the biopsy identified metastatic disease, which underscores its added diagnostic value. **Conclusion:** Fluoroscopy -guided percutaneous sacroplasty offers a concrete, effective, and reproducible solution for treating disabling pain in patients with sacral insufficiency fractures. It shortens rehabilitation time, prevents complications from immobilization, and restores patient autonomy quickly and safely. This technique represents a high-impact clinical surgical tool that should be incorporated into the standardized management of modern patients with fragile osteoporotic disease.

Keywords: Percutaneous sacroplasty, sacral insufficiency fracture, sacral cement augmentation**,** osteoporotic pelvic fractures, minimally invasive spine surgery.

Introduction

Sacral insufficiency fractures (SIFs) represent an increasingly recognized cause of lumbopelvic pain in older adults, especially postmenopausal osteoporotic women. Initially described by Lourie in 1982, these fractures usually occur spontaneously or after low-energy trauma, and most frequently affect the sacral ala in a vertical or horizontal pattern with an "H" morphology on imaging studies[1]. The true incidence is likely underestimated, with studies reporting their presence in up to 5% of elderly patients with acute low back pain, and up to 30% in those with concomitant pubic ramus fractures[2].

The diagnosis of SIF is challenging. Conventional radiographs have low sensitivity due to the superimposition of pelvic structures and poor bone mineralization. Computed tomography (CT) allows the identification of fracture lines, while magnetic resonance imaging (MRI) is considered the gold standard due to its high sensitivity for early bone edema[3]. The classic finding on bone scan is the "H" sign, a reflex uptake in the sacral wings with a central bridge[4].

Non-operative treatment remains the first line of care, including relative rest, analgesia, and progressive rehabilitation. However, in patients with debilitating pain or at high risk of complications from immobilization, this approach is limited. The morbidity associated with prolonged rest is considerable, with increased events such as deep vein thrombosis, pulmonary embolism, pneumonia, pressure ulcers, and overall functional decline[5]. Furthermore, in many cases, pain persists for weeks or months, preventing recovery to baseline and increasing dependency.

In this scenario, percutaneous sacroplasty has emerged as a minimally invasive alternative to relieve pain and allow early mobilization. This technique, analogous to vertebroplasty, consists of the percutaneous injection of acrylic cement (PMMA) into the fractured sacral wing under fluoroscopic or tomographic control [6]. Since its introduction in the early 2000s, the literature has reported consistent results in terms of rapid pain reduction and early functional improvement [7]. Compared with more invasive surgical techniques, such as iliosacral screw fixation or lumbopelvic stabilization, sacroplasty has advantages in terms of operative time, need for anesthesia, safety profile and functional recovery[8].

The surgical indication for sacroplasty is established in patients with non-displaced Denis I sacral insufficiency fractures, with severe and disabling pain that does not respond to conservative treatment. The intervention is especially indicated in patients with a high risk of complications due to immobilization, functional deterioration or chronic comorbidities that prevent safe recovery through prolonged rest with no neurological compromise[9].

This article aims to provide a detailed description of fluoroscopy guided percutaneous sacroplasty, emphasizing its anatomical foundation, planning, safe execution, and clinical utility. It will also illustrate the application of this technique with a representative clinical case, and discuss its therapeutic role in the current setting, compared with other surgical and conservative strategies.

Surgical technique

Fluoroscopy guided percutaneous sacroplasty

Sacroplasty is performed in the operating room under strict aseptic conditions, with fluoroscopy available in anteroposterior (AP), lateral, and oblique views. Precise preparation and execution of each step is essential to maximize clinical benefits and avoid complications.

1. Patient positioning

The patient is placed prone on a radiolucent table. Soft supports are used on the chest and pelvis to prevent lumbar hyperextension, with care taken to relieve pressure on the abdomen and pelvis. Local anesthesia combined with conscious sedation is recommended in cooperative patients, although general anesthesia may be used in complex cases or cases of marked anxiety[9], with the authors' preference being general anesthesia.

The placement of the C-arm allows the sacrum to be viewed in AP or adjusted AP view (outlet projection), where the S1-S3 foramina are clearly defined, and lateral view, where the needle path towards the body of the sacral wing is visualized[10]. It is essential to have continuous AP and lateral

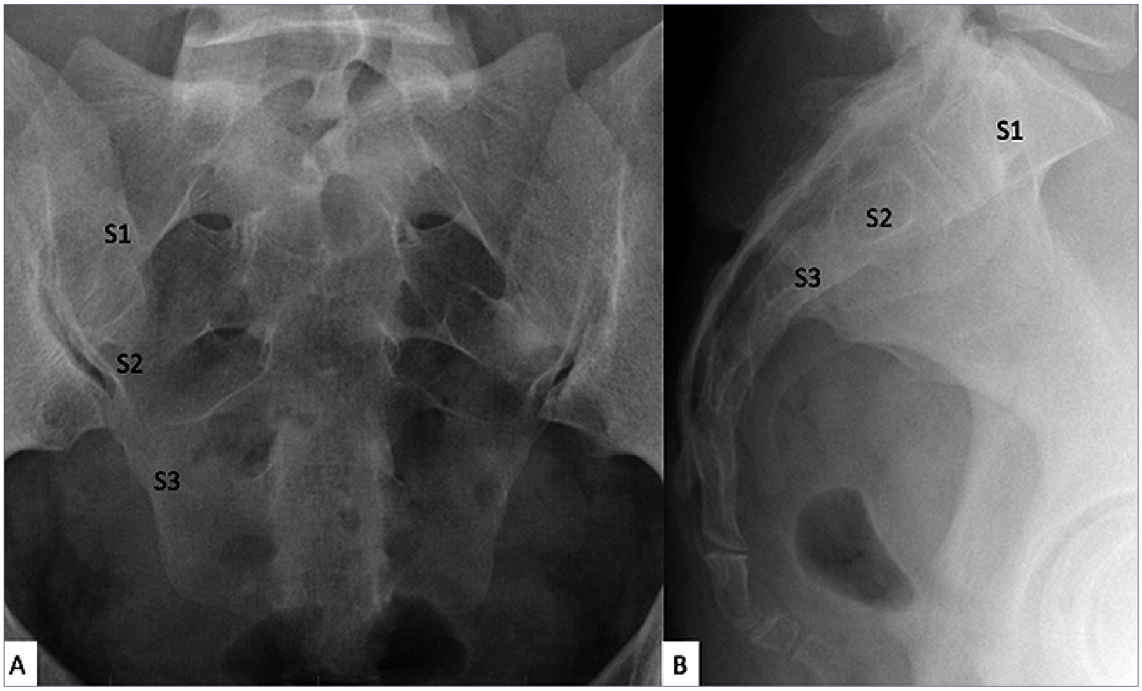

Figure 1. Radiographic projections for planning percutaneous sacroplasty. A: Anteroposterior projection: the sacral foramina S1, S2, and S3 are clearly identified, useful as references for plotting safe trajectories and avoiding foramen violation during trocar placement; B: Lateral projection: allows assessment of the craniocaudal orientation of the sacral vertebrae and planning of the access depth, with direct visualization of the bodies of S1, S2, and S3.

projections; fluoroscopy can also be used, biplanar, which allows dynamic adjustment of access direction and verification of advancement depth in real time (Figure 1).

2. Anatomical identification and radiological planning

The sacral wing is the most common fracture site in SIFS, usually located vertically bilaterally. In the AP view, the foramina appear oval, and the lateral border of the sacral wing is medial to the sacroiliac joint[3]. A line is mentally drawn between the medial margins of the S1, S2, and S3 foramina to avoid violating their trajectories. In the lateral view, the anterior cortical contour of the sacrum, the neural canal, and the L5 plateau are identified[11].

The cutaneous entry point is marked approximately 1.5-2 cm and lateral to the lateral edge of the S2 foramen, lateral to the lateral edge of the S2 foramen is preferred by the authors providing a slightly more caudal access (between S2 and S3) that facilitates the arrival of the trocar to the superior cortex of the sacrum (Figure 2).

3. Trocar insertion

Jamshidi type needles of caliber 11G or 13G are used, preferably with a sharp mandrel to facilitate bone progression. Once the cortical fracture is made, the sheath is introduced approximately 1-2 cm further along with fluoroscopy giving the direction, in the lateral axis maintaining the interforaminal line and in the AP axis towards the middle of the S1 platform, the advancement is performed manually since it is essential to palpate the spongy bone in the advancement, without crossing the cortex[12].

The technique can be adapted according to the fracture pattern:

- *Short-axis technique:* posterolateral access to the sacral wing, most common in vertical fractures.
- *Long axis technique:* craniocaudal trajectory parallel to the wing, useful in extensive or bilateral fractures.
- *Double needle technique:* for simultaneous bilateral treatment, requires careful planning of trajectory crossings[13].

The use of fluoroscopy in AP and lateral projections is essential to avoid unwanted penetration into the sacral canal to the foramina or the pelvic cavity (although we consider blunt access to be quite safe).

4. Preparation of PMMA cement

Once the needles are positioned, high viscosity polymethylmethacrylate (PMMA) bone cement is prepared. It is recommended to wait 3-6 minutes (depending on the type of cement) after mixing to achieve a thick, toothpaste-like consistency, which significantly reduces the risk of extravasation during injection[14]. Cementation should be planned to take less than 10 minutes, but this is relative since the material can have different hardening times.

Some variants include radiofrequency-activated cements, which increase their viscosity and flow control; or the use of balloon expansion (balloon-sacroplasty) that exerts an kyphoplasty effect and creates a previous cavity. However, in simple osteoporotic fractures, the standard technique with dense PMMA offers excellent results without the need for additional complexity[15], but as it is an infrequent technique this decision probably remains at the discretion of the surgeon; at

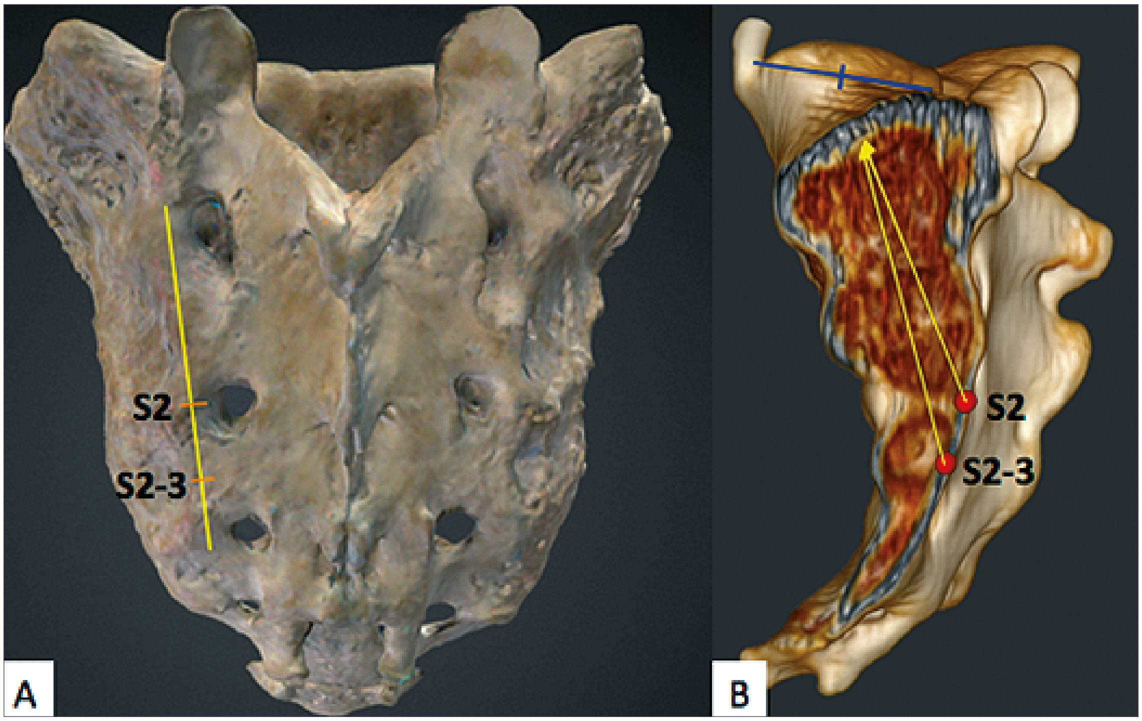

Figure 2. Anatomical projection and access trajectories for percutaneous sacroplasty. A: Posterior anatomical image of a 3D sacrum specimen: the entry points corresponding to the safe projections are indicated at levels S2 and S2-S3, following a path parallel to the lateral border of the sacrum, avoiding the sacral foramina; B: 3D CT reconstruction: lateral visualization of the sacral ala with simulation of the trocar trajectories toward the anterior third of the sacrum. The arrows indicate the safe direction toward the trabecular loading zone, avoiding the spinal canal and anterior cortex.

this moment there is no evidence to say that there is improvement of one technique over another.

5. Injection under fluoroscopy

Injection is performed slowly with 10 mL syringes, or by syringe or cementing cannula. The usual volume ranges from 3-8 mL per sacral wing, although in bilateral fractures up to 12 mL total may be used[16]. During the injection, continuous fluoroscopic control in lateral projection is performed to follow the advance of the cement towards the anterior third of the wing. Simultaneously, the outlet view allows detection of lateral leaks or leaks towards foramina.

Optimal cement spread occurs when it progressively fills the fracture site and surrounds the adjacent trabeculae without escaping the cortical boundaries. If extravasation is observed near foramina, the spinal canal, or pelvic soft tissue, the injection is stopped. According to the series by Andresen et al., clinically significant leakage is not observed in more than 95% of cases when dense, low-volume cement is used[17].

The "stepwise injection" technique can also be applied: ~1 mL is injected , a 20-second wait is followed, and the injection is continued if expansion is concentric. This method increases control in risk areas and improves the quality of bone filling[18]. Furthermore, the injection can be withdrawn slightly distally, ensuring better distribution of the cement.

6. Withdrawal and verification

Once the injection is complete, the needles are carefully withdrawn. To avoid leaving a "tail" of cement adhering to the needle, it is recommended to rotate it slightly during extraction or allow the residual cement to solidify before final removal. Once the tip is in the cortex, scrape the tip over the cortex to ensure the cement has been cut. Gently compress the puncture site with a sterile dressing.

Final follow-up includes images in AP, lateral, and oblique projections. Ideally, cement is evident in the sacral ala in a shape that outlines the sacral ala without penetration of the spinal canal. In some centers, an intraoperative CT scan is performed to more precisely verify the distribution of the material; although it is not mandatory if fluoroscopic control has been adequate[19], we do recommend performing a postoperative CT scan to verify the surgical procedure.

7. Discharge and post-procedure care

The patient can ambulate within the first 4-6 hours, as tolerated. Pain relief is usually immediate or within the first few hours, with significant changes occurring 24 hours post-procedure. In follow-up studies, the visual analogue scale (VAS) decreased on average from 8.3 preoperatively to 2.7 the following day and 0.9 at 12 months[7]. It is advisable to continue osteoporosis treatment, initiate early rehabilitation, and perform clinical follow-up within 2 weeks.

Clinical cases

Case 1

We present the case of a 68 year old man with severe Parkinson's disease of 20 years of evolution with severe

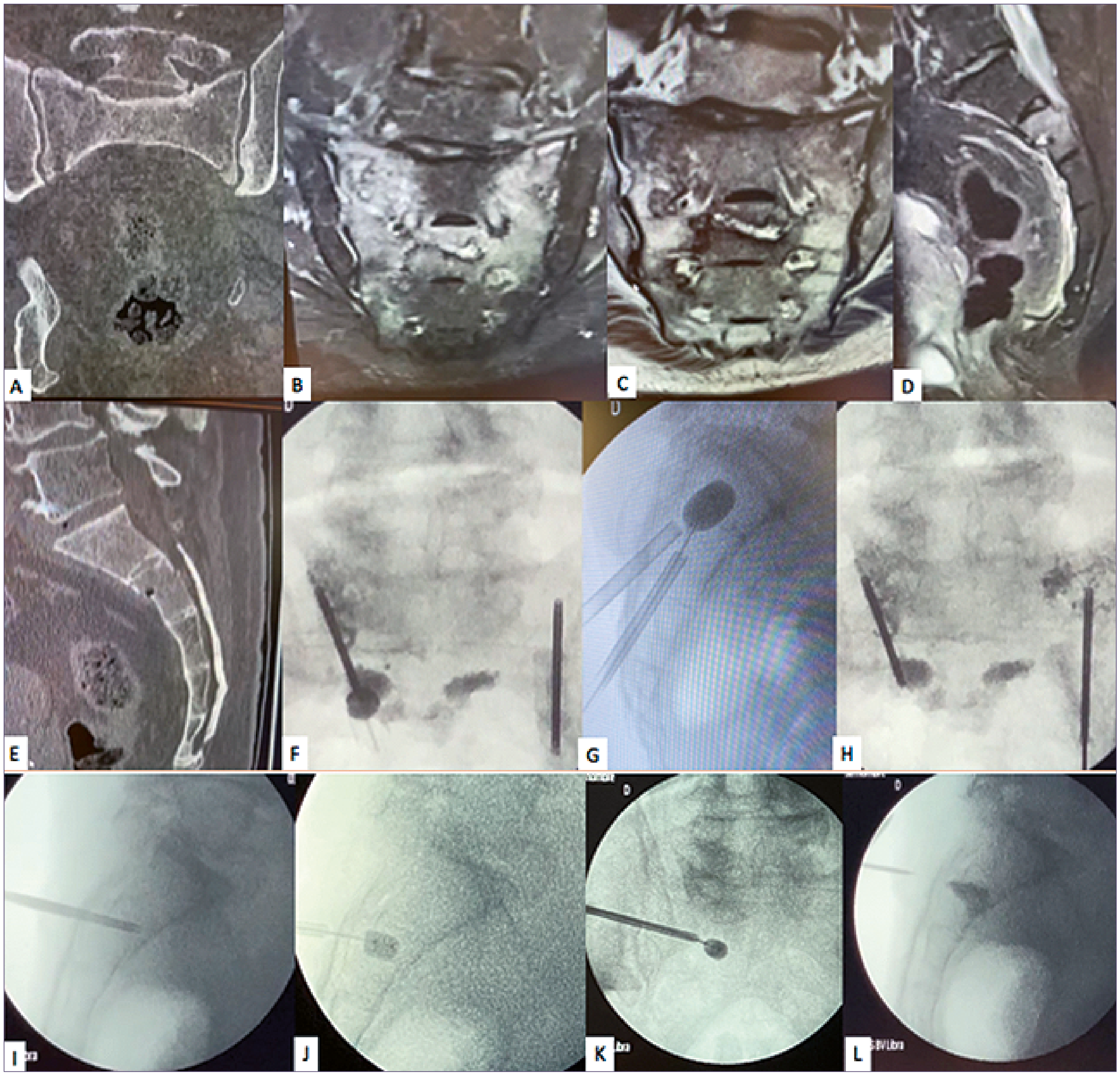

Figure 3. Preoperative evaluation and intraoperative follow-up of percutaneous sacroplasty. A: Coronal computed tomography (CT): bilateral vertical fractures in the sacral wings; B-D: Magnetic resonance imaging (MRI): diffuse bone edema compatible with insufficiency fractures; Coronal section in B and C, sagittal section in D with edema in S2; E. Sagittal CT: evident fracture line in the body of S2; F. Fluoroscopic control: bilateral cementation in S2 and vertebroplasty in right S1; G: Sagittal fluoroscopy: balloon kyphoplasty, evidence of expansion, and trajectory of two trocars (one through the S2 foramen, the other at the S2-S3 junction); H: Post-injection control: vertebroplasty completed in the left sacral ala; I: Lateral fluoroscopy: trocar positioned within the body of S2; J-K: Balloon inflation (J: lateral; K: AP) to create a cavity prior to filling; L: Controlled introduction of PMMA cement under fluoroscopic guidance.

osteoarthritis of the spine and lumbosacral joint without traumatic history, he comes to an outpatient consultation with mixed lumbar pain, both axial and in the perineal area, the pain radiated to both gluteal regions, VAS 8/10 dynamic when standing and preventing sitting, consumption of opioids as analgesic, the examination highlights axial pain in addition to subgluteal pain in the perineal region, CT of the spine shows sacral fracture of S3 and fracture due to sacral insufficiency due to insufficiency of both wings, a neurectomy facet and sacroiliac joint with significant reduction in axial pain but persistent subgluteal pain that made sitting impossible. Given the persistence of disabling pain and progressive functional limitation, it was decided to perform percutaneous sacroplasty and S3 sacral cementation with significant improvement in postoperative VAS 2/10, and she was able to sit and ambulate with minimal assistance. At the 14-day outpatient follow-up, the patient was walking unaided, reported mild sporadic pain (VAS 2/10) and had discontinued opioids. 1-year postoperative follow-up of the patient, without perineal pain and CT scan showing fusion of S3 fracture (Figure 3).

Case 2

A 74-year-old female patient with no known medical history presented with severe lumbosacral pain (VAS 8/10), no history of trauma, radiating to the perineal region, with inability to sit and difficulty walking with the use of opioid patches. Computed tomography revealed insufficiency fractures in both sacral wings and an osteoporotic fracture at L5. Due to the disabling pain, bilateral percutaneous sacroplasty

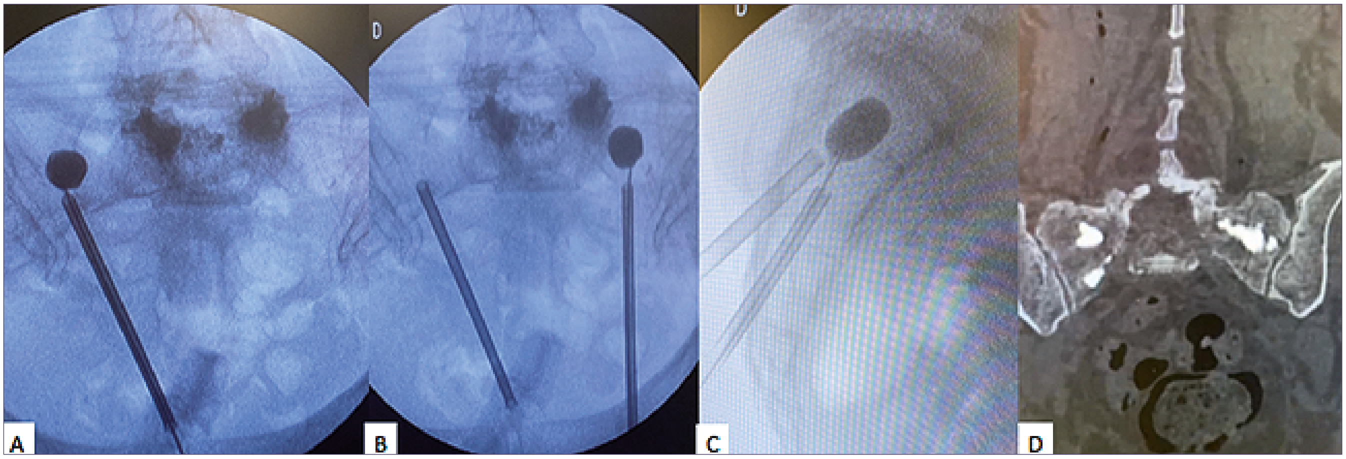

Figure 4. Intraoperative control and outcome. A-B: Fluoroscopy in anteroposterior (AP) projection: bilateral positioning of trocars in divergent trajectories toward the sacral wings; C: Lateral fluoroscopy: balloon insufflation to create a pre-cavity in the left sacral wing before cement injection into the S2 and S2-3 trajectory; D: Postoperative CT scan: adequate distribution of PMMA cement in both sacral wings, without significant extravasation or compromise of neural structures.

with intraoperative biopsy was performed, with significant improvement in pain (VAS 2/10). Histopathological analysis showed metastatic infiltration of pulmonary adenocarcinoma, with a diagnosis of bone metastasis as the underlying cause. The patient showed significant clinical improvement in the immediate postoperative period (Figure 4).

Discussion

Percutaneous sacroplasty has been shown to be an effective technique for the treatment of sacral insufficiency fractures in osteoporotic patients. In contrast to traditional conservative management, which often involves prolonged immobilization and risk of medical complications, sacroplasty allows for early rehabilitation, rapid pain relief, and reduced opioid use[9].

In the meta-analysis by Chandra et al., which included 861 patients, the clinical success rate was 95.7%, with an average reduction in VAS from 8.3 preoperatively to 0.9 at 12 months[7]. This sustained benefit of the procedure is in line with other studies showing immediate pain improvement and short- and medium-term functional recovery[16].

Iliosacral screw fixation, although effective in mechanical stabilization, has a higher complication rate and requires a period of restricted weightbearing, which may be detrimental in frail patients[22]. A prospective study comparing various therapeutic options for fragility fractures of the sacrum showed that subjective patient satisfaction was highest with sacroplasty, followed by internal fixation, with conservative treatment providing the worst clinical and functional outcome[8].

The main advantages of sacroplasty are:
Minimally invasive procedure.

- Early pain relief (in < 48 h in most cases).
- Accelerated rehabilitation and reduced hospital stay.
- Very low rate of serious complications (0.3%) such as symptomatic cement leaks[7].

However, the technique is not without complications. The most important risk is cement extravasation into sacral foramina or vascular structures, which can cause radiculopathy or neurological compression, although these complications are rare if safe techniques and high-viscosity cement are used[18]. The available evidence is mostly based on retrospective studies or case series; there are no randomized clinical trials that directly compare sacroplasty with other therapeutic modalities[7,21].

The ideal indication includes insufficiency fractures or non-displaced Denis type 1 fractures with pain refractory to conservative treatment. Cases with pelvic instability, neurological compromise, or displacement of bone segments should be excluded, in which a different surgical approach would be indicated[22].

From an anatomical point of view, the technique requires a precise understanding of the course of the sacrum and its orientation . The use of simple fluoroscopy is sufficient in most cases, although some authors recommend the use of double C-arm, assisted intraoperative tomography or navigation for complex anatomies or high risk of leakage[19].

In summary, sacroplasty is positioned as a useful, reproducible tool with growing evidence for the treatment of FSI in selected patients. Its main future challenge lies in the standardization of protocols, comparative studies, and evaluation of its long-term functional impact.

Conclusion

Fluoroscopy guided percutaneous sacroplasty represents a minimally invasive, relatively safe, effective, and underutilized technique for the treatment of sacral insufficiency fractures in selected osteoporotic patients. Current evidence supports its ability to provide immediate pain relief, accelerate rehabilitation, and reduce the risk of medical complications associated with prolonged immobilization.

Although its safety and efficacy profile is favorable, the indication should be carefully established, reserving it for nondisplaced fractures with pain refractory to conservative management or with the intention of early rehabilitation. Correct technical execution, based on a detailed understanding of sacral anatomy and precise fluoroscopic control, is essential to minimize risks and optimize outcomes.

The analgesic response is good. Its increasing use in spinal units reflects a consolidated trend toward targeted percutaneous therapies tailored to the frail patient.

In the future, prospective controlled studies with long-term follow-up are required, comparing sacroplasty with percutaneous osteosynthesis and conservative management, to validate its definitive place in the therapeutic algorithm for osteoporotic sacral fractures .

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