Case Report

Second generation robotic-assisted percutaneous balloon sacroplasty

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Abstract

Sacroplasty is one of the surgical modalities described in the treatment of sacral insufficiency fractures that don't respond to non-operative treatment. While the percutaneous procedure is generally done under sedation, complications can arise from cement leakage into the spinal canal and sacral foramina. We present a case of Robotic-Assisted Percutaneous Balloon Sacroplasty in a patient with unilateral sacral insufficiency fracture using the MazorX stealth edition.

A 55-year-old female presented with a left-sided sacral insufficiency fracture which was not responding to non-operative treatment. She underwent Robotic-Assisted Percutaneous Balloon Sacroplasty using the robotic arm and navigation capabilities of the MazorX stealth edition.

About 9 mL of bone cement with hydroxyapatite was injected into the S1 body and left ala. The patient was mobilized post-operatively with minimal pain, 2 h after the procedure. Robotic assistance in percutaneous balloon sacroplasty ensures proper tracks for injection of bone cement with reduced chances of cement leakage.

Keywords: Robotic-assisted spine surgery, sacral fracture, sacroplasty

Introduction

Insufficiency fractures of the sacrum are increasingly common, often underdiagnosed, and cause significant morbidity in the elderly [1-3]. Rest, lifestyle modification and non-steroidal anti-inflammatory drugs are used initially, and surgery is reserved for those unresponsive to non-operative treatment [4]. Percutaneous procedures like placement of ilio-sacral screws and sacroplasty have been described, with similar results [5-6]. Sacroplasty, first described by Grant in 2002, involves injection of bone cement into the sacral ala, and has been reported to provide significant pain relief allowing for early ambulation and return to activity [7]. The procedure is not without complications like cement leak which can cause neural compression [8]. Spine robots are useful in planning and drilling accurate trajectories, and the previous generation of spine robots have been used effectively in performing sacroplasty [9,10]. We describe a case in which the robotic arm and navigation capabilities of the MazorX stealth edition (MXSE) (Medtronic limited, Dublin, Ireland) were used to perform sacroplasty.

Case Report

A 55-year-old female presented with a history of lower back ache and difficulty in walking bearing weight on the left lower limb for 3 weeks. She did not give any history of fall or trauma and did not have any comorbidities. Radiographs and magnetic resonance imaging of the sacrum revealed an insufficiency fracture in the left ala [Figure 1a-c]. She had consulted her family physician who

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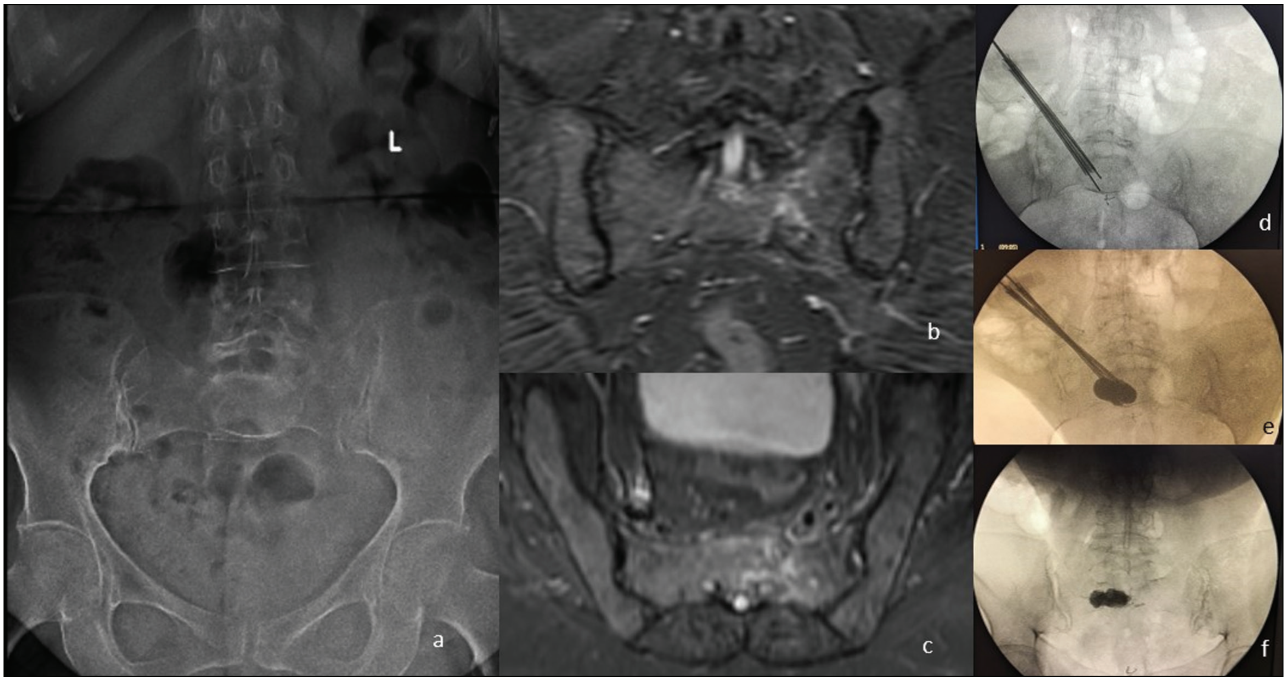

Figure 1: Antero-posterior radiograph (a) and axial STIR magnetic resonance imaging (b, c) showing left sacral insufficiency fracture. Intra operative flouroscopic images showing trocars being placed over guidewires (d), balloons inflated with radioopaque dye (e), and final placement of bone cement (f)

had treated her with non-steroidal anti-inflammatory drugs, but her pain persisted, and she found it difficult to perform activities of daily living, reporting a visual analogue scale (VAS) score for pain of 7 on 10. In view of her non-responsiveness to non-operative treatment, a decision to perform percutaneous balloon sacroplasty, with robotic assistance using MXSE, was taken.

The patient was placed prone on the radiolucent operating table under general anesthesia, with the robot attached to the table. The "scan and plan" workflow was used, wherein the O-arm and robot registration were done immediately prior to the procedure. Two "longest possible trajectories from below and lateral to the neural foramen, directed medially and superiorly into the sacral promontory crossing the fracture line" tracks for cement placement were planned on the left side through the bony corridors, avoiding the sacral foramen and spinal canal. These trajectories were drilled and tapped through the robotic arm of the MXSE. Balloons were inflated with urograffin dye under fluoroscopic guidance. Nine mL of bone cement with hydroxyapatite was injected into the sacrum through both predrilled tracks [Figure 1]. The position of bone cement was verified on the O-arm scan and there was no cement leak into the spinal canal or sacral foramen [Figure 2]. The procedure time was 45 min and the total radiation dose of the patient during the surgery was 28 mGy. The patient tolerated the procedure well and was allowed to ambulate 2 h after the surgery, reporting a VAS score of 2 on 10. She reported a 90% reduction in pain following the procedure. Patient consent was obtained for the purpose of research with due care taken to preserve her privacy.

Discussion

With an increasing geriatric population, the disease burden of sacral insufficiency fractures is on the rise, with reported incidence of 1–11% in at-risk population[1-3]. While non-operative treatment has a high chance of success, the remaining patients suffer from difficulty in ambulation and are often bed bound. The lack of ambulation in the elderly results in complications such as orthostatic pneumonia and deep vein thrombosis. These patients benefit from surgical stabilization of the fracture either by percutaneously placed screws or by injection of bone cement [4].

The complex three-dimensional anatomy of the sacrum is poorly represented in two-dimensional fluoroscopy. This can result in an increased radiation exposure to ensure correct placement of trocar for injection of cement. In robotic-assisted sacroplasty, a single 3D fluoroscopy of 13 mGy for robotic planning followed by two to three fluoroscopy images while inflating balloons and injecting cement is sufficient [9]. Short axis and long axis techniques have been described in injection of cement. The long axis technique has a higher risk of anterior breach and cement leaking into the sacral foramen. In the current case we planned long axis trajectories [10].

The use of first-generation robotic assistance in sacroplasty has yielded favorable results [9]. In the current case, we used MXSE, a second generation spine robot to place short axis

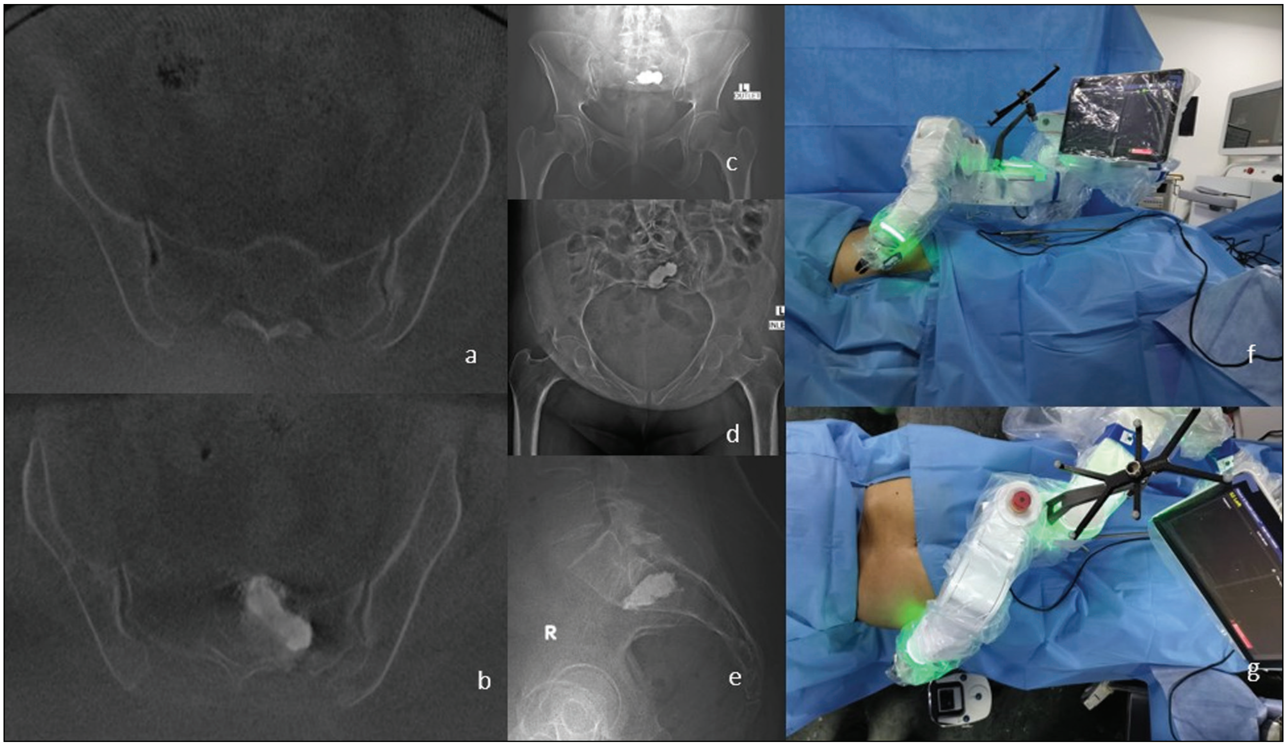

Figure 2: Pre procedure O-arm scan showing left sacral insufficiency fracture (a) and post procedure O-arm scan showing cement placement with no leak into canal (b). Post-operative outlet (c), inlet (d) and lateral (e) radiographs of pelvis showing site of bone cement injection. Clinical photographs (f, g) showing the robot draped in a sterile manner with the surgical field

trajectories in the sacrum, which improves upon the previous generation of spine robots with added navigation capabilities. The current generation of spine robot's "scan and plan" work flow allows for intraoperative robot registration and image acquisition. After robot-navigation registration with "snapshot," the four beads of the "star marker" fiduciary array is adequately visualized on 2D and subsequently 3D scans. The acquired image is then sent to the workstation of the MXSE where the exact location of the fracture and precise planning of trajectories can be done. This allows injection of bone cement with minimal risk of cement leaking into the canal or sacral foramen. Biomechanical studies have shown that 4 mL of bone cement did not sufficiently restore strength and stiffness of the cadaveric sacrum [10]. Earlier studies reported injection of 4–6 mL of bone cement, accuracy of the robotic guided trajectory also allows larger volume of cement injection, without worrying about leak [4]. Additionally, the use of balloons to inflate and compress the surrounding cancellous bone theoretically reduces the risk of cement leaking into the foramen as well as the fracture line, hindering fracture healing. Further comparative studies, on a larger sample will be needed to determine effectiveness of robotic-assisted sacroplasty.

Conclusion

Percutaneous Balloon Sacroplasty using the MXSE is a novel procedure in the treatment of osteoporotic sacral fractures. Further prospective interventional trials can shed light on effectiveness of robotic assistance in surgical treatment of sacral insufficiency fractures.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Conflict of interest

The authors did not receive support from any organization for the submitted work. All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

Authors' contributions

All authors contributed substantially to the write-up of the article. All authors reviewed and approved the final draft of the manuscript and all take responsibility of the content of the publication.

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