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Evaluating the Necessity of Screw Replacement in Sacral Bone Loosening: A Percutaneous Approach to Bridging the Bone-Screw Gap

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Abstract

Objectives: Bone loosening is a widespread challenge faced by patients who have undergone posterior spinal fusion surgery. While replacing the loosened screw with a larger one is a possibility, this approach necessitates a significant surgical intervention that requires general anesthesia and involves the complete disassembly of the instrument.

Methods: This study included patients who had undergone posterior transpedicular stabilization but showed signs of sacral bone loosening in follow-up. The gap between the screw and the bone was filled using polymethyl methacrylate, performed under local anesthesia. The preoperative and postoperative visual analog scale (VAS) scores were compared at 1, 3, and 12 months after the procedure.

Results: The study involved 28 procedures performed on 17 patients, with 11 patients receiving bilateral procedures and 6 receiving unilateral procedures. The postoperative VAS scores demonstrated a marked decrease compared to the preoperative scores.

Conclusion: By filling the cavity with cement through a minimally invasive procedure performed under fluoroscopy and local anesthesia, screw movement can be prevented, leading to a reduction in pain.

Keywords

Bone loosening, Screw loosening, Polymethyl methacrylate, Fusion insufficiency

Introduction

Spinal instrumentation is a widely used approach for treating various conditions of the spine, including degenerative diseases, trauma, and tumors. In adult spinal deformities, fixation is critical to maintain proper vertebral alignment and achieve optimal bone fusion [1-3]. The techniques used for lumbosacral fixation are patient-specific, and may include iliac screws, S1 and S2 pedicle screws, S2 alar screws, and L5/S1 interbody fusion [4]. However, post-operative follow-up may reveal complications such as instrument breakage, dislocation, or bone fractures [5]. One of the most commonly encountered issues without trauma is bone loosening and loss of screw fixation [1]. Despite advancements in surgical techniques and instruments, inadequate solid fixation remains a challenge, especially in cases of osteoporosis or long-term fixation. These weaknesses can result in realignment of the vertebral column, negatively impact sagittal balance, and lead to poor clinical outcomes [6]. Revision surgery may become necessary, leading to increased morbidity, cost, and decreased patient satisfaction [7]. Minimally invasive options, such as filling the vertebral corpus with cement before pedicular screw insertion, are used when possible to address instrumentation-related deficiencies, particularly in cases of osteoporotic or tumor-related fractures [7-13].

When bone loosening occurs around the screw, it can cause instability in the system and severe pain for the patient. Filling the corpus with cement can increase bone density, but it does not address the loosened screw. This

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study aims to evaluate the efficacy of a percutaneous screw fixation technique that uses cement application between the loosened screw and bone in our patient population. The results of this technique will be presented and analyzed.

Material and Methods

The present study included patients who had undergone posterior transpedicular stabilization in our hospital and reported recurrence of symptoms during their follow-up. Radiographs and spinal computed tomography scans were obtained for all patients to assess the sagittal balance and the status of the screws. These images were reviewed by a single radiologist who defined a radiolucent area (circumference greater than 1 mm) around the screw as evidence of screw/bone loosening. Only patients with sacral screw/bone loosening were included in the study, while patients with instability due to screw breakage, bone fracture, or adjacent segment pathologies but without evidence of screw/bone loosening were excluded. Informed consent was obtained from all participants.

Surgical procedure

The patients were positioned prone on the operating table, and the procedure was performed under sterile conditions with the administration of local anesthesia and sedation. A single dose of prophylactic intravenous antibiotic (cefazolin, 2g) was administered one hour prior to the procedure. Fluoroscopy was used to guide the procedure, with anteroposterior and lateral images obtained. In cases where patient anatomy made visualization difficult, oblique images were used. The insertion site was targeted approximately 2 cm lateral to the S1 pedicle, and the area was anesthetized with a lidocaine injection. A 10-gauge stylet was guided to the S1 screw at an angle of approximately 45 degrees lateral to the S1 pedicle, and the meeting of the stylet and pedicle screw was confirmed with fluoroscopy. The presence of the needle in the space between the screw and bone was confirmed by injecting radiopaque material. Polymethyl methacrylate (PMMA) was then injected around the screw and monitored with real-time fluoroscopy, and filling of the gap with PMMA was confirmed. The cannula was removed, and the patient was transferred to bed in stable condition (Figure 1).

Follow-up

Patients were mobilized on the same day after the sedative effect had worn off. The visual analog scale (VAS)

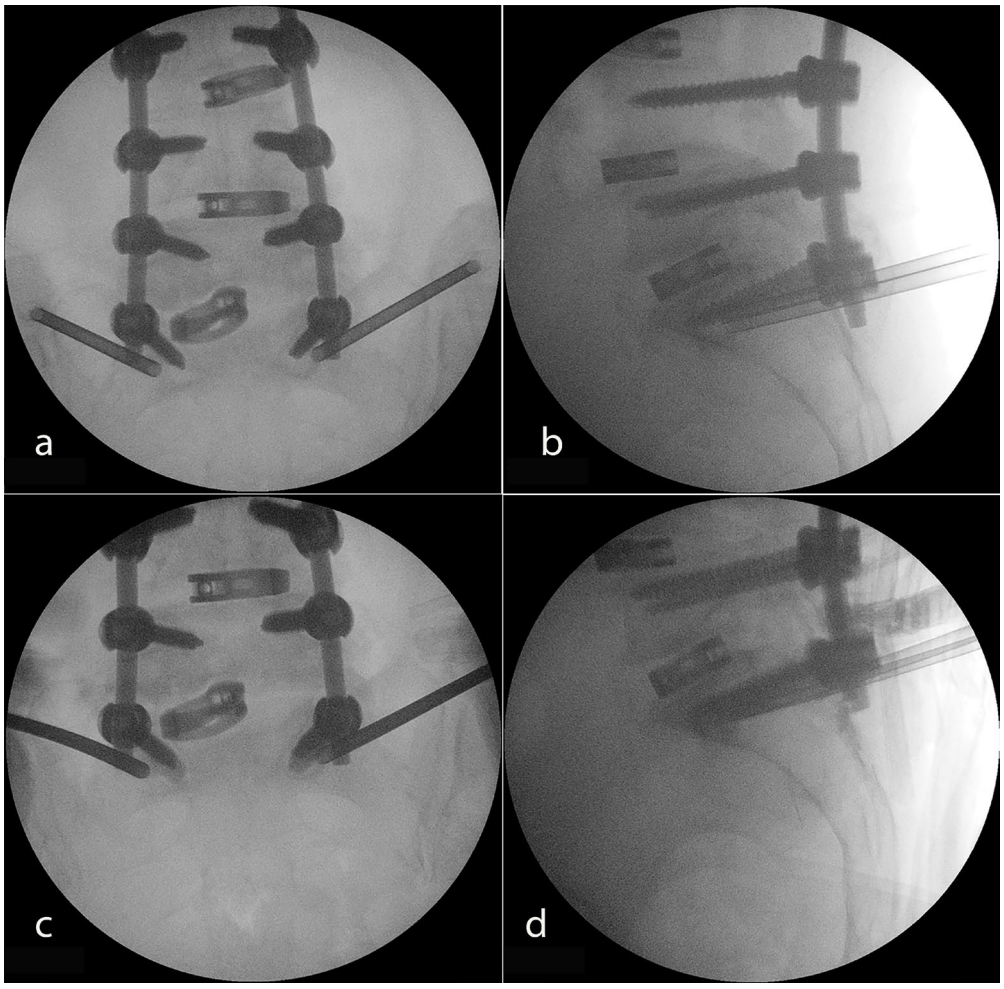

Figure 1: Fluoroscopy images of the procedure. A) Antero-posterior view of the loosened S1 screw before PMMA augmentation. The cannula was placed into the gap between the bone and the screw; B) Lateral view of the cannula; c,d) The PMMA was augmented into the gap, and the procedure was observed in real-time with coronal and sagittal fluoroscopy images.

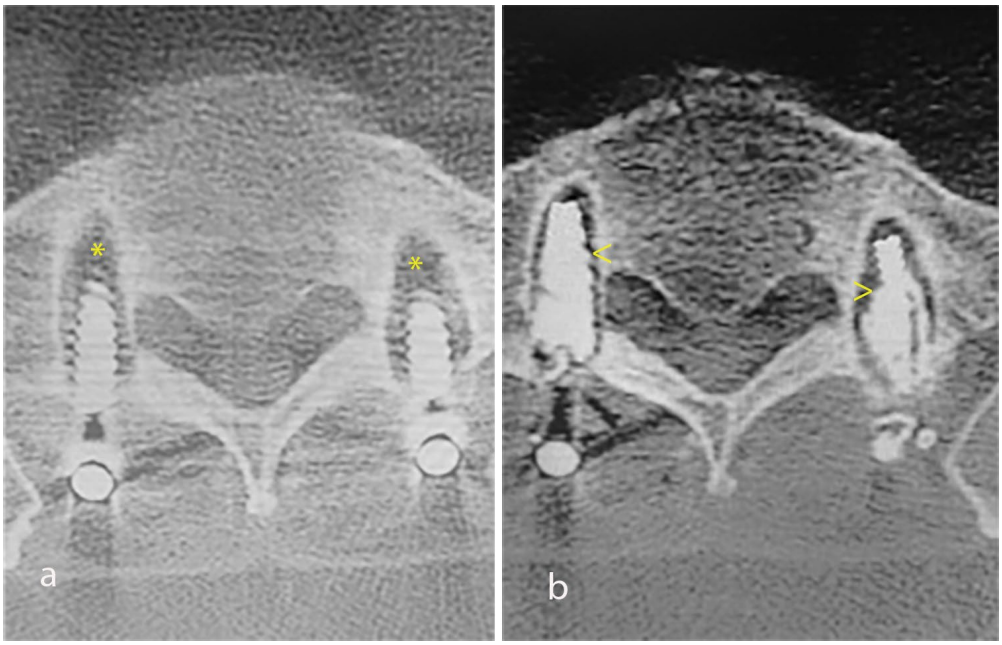

Figure 2: The CT scans were used to evaluate if the proper filling was acquired. (*: bone loosening around the screw, ><: The gap was filled with PMMA)

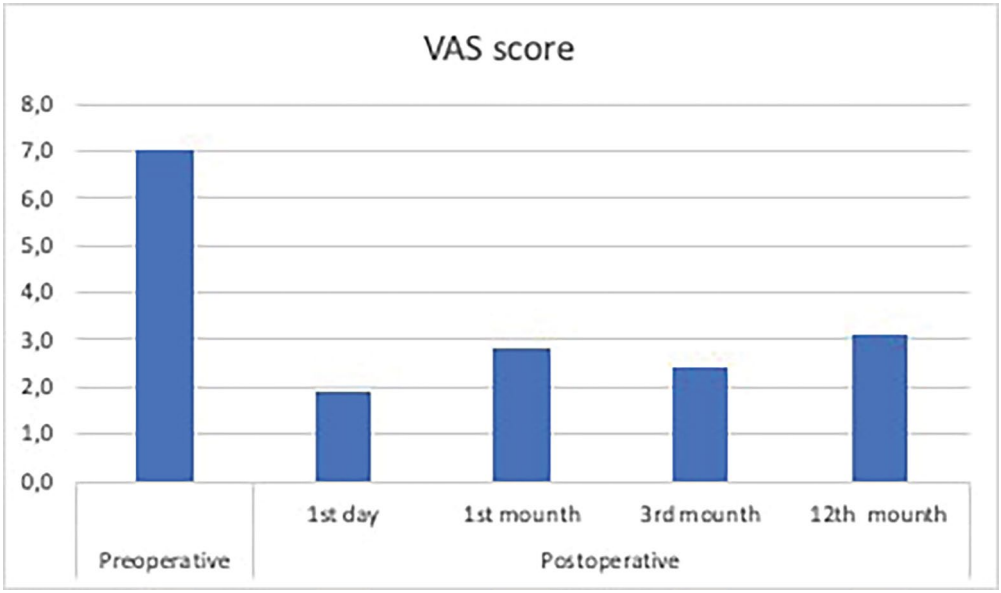

Figure 3: The graph illustrates the significant decrease between the preoperative and postoperative VAS scores. There was no significant change between the follow-up VAS score.

score was used to compare the patients' low back pain before and after the operation, and X-ray and CT scans were performed at 1, 3, and 12 months post-operatively to assess for screw loosening. The VAS scores were compared at these time points (Figure 2).

Statistics

The Man-Whitney U test was utilized to compare the preoperative VAS score with the postoperative VAS scores on the first day, first month, third month, and twelfth month. Statistical analysis was performed using SPSS version 13.0 (SPSS Inc., Chicago, IL), and a P-value less than 0.05 was considered statistically significant (Figure 3).

Results

A total of 28 surgical procedures were conducted on 17 patients, with 11 of them receiving bilateral procedures and 6 receiving unilateral procedures. One patient underwent a procedure that was eventually abandoned due to adverse effects of the sedation medication. The study population

comprised of 8 female patients and 9 male patients, with a mean age of 57 ± 2 years. Four patients were classified as overweight, while 5 were underweight and 8 were of average weight. The preoperative mean visual analog scale (VAS) score was 7 ± 2, with pain being the most common complaint. The VAS scores significantly decreased on the first postoperative day (VAS = 3 ± 1, $p < 0.05$) and continued to decrease in significance during the first, third, and twelfth-month follow-up visits. No significant changes were observed in the follow-up VAS scores.

Discussion

The loosening of screws is a critical issue that patients who have undergone spinal fusion surgery frequently encounter. Such loosening can cause pain, particularly during movement, and may also put a load on the other healthy segments of the spine, leading to further loosening, protrusion, or fractures over time [1]. The incidence of sacral screw loosening after long-segment spinal fusion is relatively high, ranging from 7.5-52% [14]. Low bone density and quality are the most significant factors that contribute to screw loosening, with osteopenia caused by aging, hormonal factors, and disuse after surgery being the major contributing factors [15,16]. Other significant factors include deformations on the bone and screw surface, high static stress, and loading. High pelvic incidence (PI), failure to correct lumbar lordosis (LL), and postoperative sagittal imbalance have also been identified as risk factors for lumbosacral fixation failure and bone loosening [14,17].

Numerous strategies have been suggested to prevent screw loosening, including the use of expandable screws, thicker screws, and cannulated screws. Despite these efforts, screw loosening continues to be a challenge, and surgical revision is often required, where the loosened screw is replaced with a larger diameter screw and additional screws and rods are added if necessary. While filling the bone loss area with PMMA and adding a screw to the same site has gained popularity, it still requires general anesthesia and disassembly and reattachment of the entire system [6,15].

Minimally invasive options are preferable for resolving instrumentation failure. Vertebral cement reinforcement has been used for the treatment of painful osteoporotic and tumor-associated compression fractures [7,11]. Several studies have described the use of PMMA during primary surgery to reinforce pedicular screws [5,8-10,12].

In this study, the aim was to prevent screw movement by filling the space between the loosened screw and the bone with PMMA. The filled cavity was found to simulate a surgical intervention, with the thickness of the screw being the equivalent. Results indicated that the filled cavity, acting like a thick screw, prevented screw movement and reduced patient pain. The advantage of this method was that it did not require general anesthesia and was performed percutaneously without significant surgical intervention. Additionally, since there were no issues with the proximal screws, there was no need to disassemble the entire system to replace just the distal screw. This approach offers advantages over surgical revision, including shorter hospital stays and a lower impact on the patient's work capacity. All patients were able to mobilize and were discharged from the hospital on the same day and were able to return to their normal activities on the third day.

Conclusion

Bone loosening is a common issue arising from the use of sacral screws following posterior instrumentation. This results in pain for the patient due to the movement of the screw within the gap between the screw and the bone. Percutaneous intervention utilizing cement filling under fluoroscopy guidance and local anesthesia can effectively mitigate screw movement and alleviate patient pain. This approach is considered more favorable than revision surgery, as it entails fewer surgical risks, shorter hospital stays, and higher patient satisfaction in long-term follow-up evaluations.

Statements and Declarations

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Competing interest

All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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