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Case Report Open Access

Complications of Artificial Bone Powder in Lumbar Spinal Fusion Surgery: Intraspinal Heterotopic Ossification

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Abstract

Purpose: Artificial bone grafts have been widely used in lumbar decompression and fusion surgery, but intraspinal heterotopic ossification (HO) as a complication is rarely reported. This study presents a rare case of intraspinal HO associated with bioactive glass-based artificial bone powder, leading to restenosis of the spinal canal after lumbar fusion.

Method: A 61-year-old male underwent L4/5 minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF) for lumbar spinal stenosis. During surgery, the intervertebral space was filled with autologous facet joint bone, bioactive glass artificial bone powder, and an interbody cage. Five months postoperatively, the patient developed bilateral lower limb numbness, pain, and walking difficulty. CT scans revealed heterotopic ossification and recurrent spinal canal stenosis. Revision surgery was performed to remove the heterotopic bone mass.

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Results: Intraoperative findings showed dense adhesion between the intraspinal HO and the dura mater, nerve roots. The ectopic ossified bone was removed and sent for pathological examination to confirm the bone tissue. Postoperatively, the patient's symptoms significantly improved, the visual analog scale (VAS) score for pain decreased from 7 to 2, motor function gradually recovered, and independent walking ability was restored.

Conclusion: This case suggests that bioactive glass artificial bone powder may contribute to intraspinal HO following lumbar fusion. Precise surgical techniques to prevent bone powder extravasation into the spinal canal are critical for avoiding such complications. Enhanced postoperative monitoring and surgeon awareness are essential for early detection and timely intervention, thereby reducing the risk of severe neurological deficits.

Keywords: *Artificial bone, intraspinal heterotopic ossification (HO), minimally invasive transforaminal lumbar interbody fusion (MIS-TLIF), lumbar spinal fusion surgery*

1. Introduction

MIS-TLIF is a common surgical approach for degenerative lumbar diseases [1]. In TLIF procedures, the choice of bone graft material significantly influences fusion efficacy and surgical outcomes [2]. Although autologous bone grafts remain the gold standard, limitations such as donor site morbidity, infection risks, and limited graft availability persist [3]. To overcome these problems, artificial bone has gradually been widely used in clinical practice as an alternative material in recent years [4]. However, the clinical use of artificial bone carries potential risks, with intraspinal HO being a notable complication. Currently, reports linking artificial bone to intraspinal HO are scarce, particularly for bioactive glass materials. Here, a case of intraspinal HO caused by bioactive glass artificial bone powder after MIS-TLIF surgery is presented.

2. Case Presentation

A 61-year-old man was experiencing low back pain accompanied by right lower limb pain and soreness for over 1 year, which had worsened in the preceding month, and was admitted for the first time on November 3, 2024. After admission, a comprehensive physical examination was conducted. Combined with imaging examinations such as lumbar CT and MRI, the diagnosis of lumbar spinal stenosis at the L4/L5 segment was confirmed. After preoperative evaluations, the patient underwent L4/5 decompression with bone grafting and fusion fixation. During surgery, the intervertebral space was filled with autologous facet joint bone, bioactive glass artificial bone powder, and an interbody cage. The procedure was uneventful, and routine postoperative anti-inflammatory and symptomatic treatments were administered. The surgical drain was removed on postoperative day 3, with follow-up X-rays showing

no abnormalities. The patient reported significant relief of low back and leg pain, gradually resumed ambulation, and was discharged one week postoperatively.

At the 3-month follow-up, the patient exhibited satisfactory recovery without complaints. However, at 4 months postoperatively, he returned with bilateral lower limb numbness and pain. X-ray imaging revealed no evidence of screw/cage malposition, loosening, or fracture. Symptoms partially improved with anti-inflammatory and analgesic therapy. By the fifth postoperative month, the patient experienced rapid progression of bilateral lower limb numbness, severe pain, and walking difficulty, prompting rehospitalization. Lumbar CT scans demonstrated intraspinal heterotopic ossification at the L4/5 level, leading to secondary spinal canal stenosis (Figure 1).

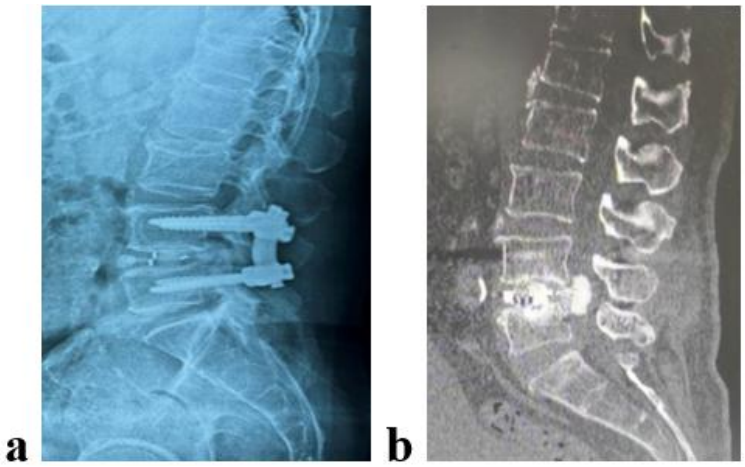

FIGURE 1: Imaging findings at 5-month postoperative follow-up. **a)** X-ray demonstrates ossification in the intervertebral foramen region. **b)** CT scan reveals HO at the L4/5 level.

Following multidisciplinary consultation, the patient underwent revision surgery. Intraoperative microscopic examination revealed whitish heterotopic ossification tissue within the spinal canal at the L4/5 level (Figure 2a), which exhibited a hard texture and compressed the dural sac. The heterotopic bone was carefully dissected and completely excised, with the resected specimen sent for pathological examination (Figure 2b). The surgery procedure was successfully completed. Postoperatively, the patient received symptomatic management, including anti-infection prophylaxis, dehydration therapy for edema reduction, and neurotrophic support. The patient's bilateral lower limb numbness and pain were effectively alleviated, with no postoperative complications observed.

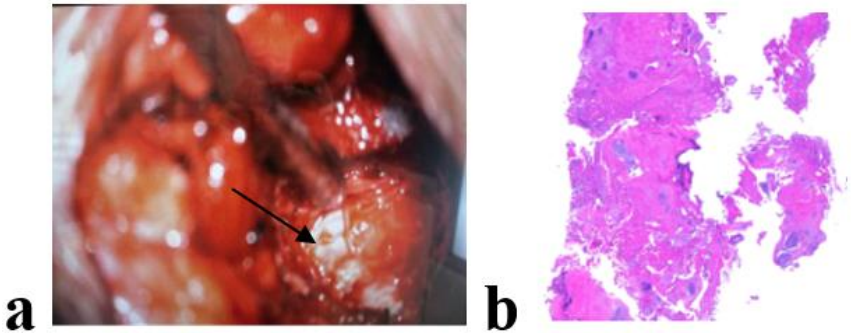

FIGURE 2: a) Microscopic view of intraspinal heterotopic ossification tissue. **b)** Histopathological section of the resected HO mass.

3. Discussion

Artificial bone grafts are widely used in lumbar fusion surgery to promote osseointegration, with common types including calcium phosphate cement, calcium sulfate-based synthetic bone, and bioceramic bone substitutes [5]. These materials are fabricated in various morphologies such as strip-like, granular, and powdered forms. In this case, bioactive glass composed of SiO_2, CaO, Na_2O and P_2O_5 was utilized. Studies indicate that bioactive glass undergoes time-dependent surface dynamics upon contact with biological fluids, inducing calcium and phosphate ion deposition from surrounding tissue fluid, ultimately forming a highly reactive carbonated HA (HCA) layer. The HCA layer, which closely resembles the inorganic composition of human bone, provides an ideal scaffold for bone tissue engineering (BTE) [6, 7]. Intraoperative extravasation of bioactive glass particles into the spinal canal may serve as the primary cause of HO, where local microenvironmental factors of hemorrhage and inflammation stimulate ectopic bone formation [8].

In this case, the potential causative factors include: i) Post-implantation migration of the artificial bone powder into proximity with the epidural space, or early postoperative mobilization induced displacement of artificial bone particles into spinal canal tissues, which may trigger intraspinal HO. ii) Surgical trauma leads to the formation of an epidural hematoma. During hematoma organization, the combined stimulation from degradation byproducts of the artificial bone and inflammatory cytokines promotes accelerated osteogenesis, thereby facilitating the development of intraspinal HO.

Intraspinal HO predominantly occurs 6-12 months postoperatively. Most patients remain asymptomatic in the early stages, and radiographic follow-up is sufficient for asymptomatic cases. However, in some patients, compression of nerve roots or the dural sac by ossified lesions may lead to delayed-onset lower limb radiculopathy or intermittent claudication, often necessitating revision surgery [9]. To avoid such complications occurring, meticulous intraoperative hemostasis is critical. Additionally, application of absorbable hemostatic agents to seal the implantation site may act as a physical barrier against particle migration. Beyond evaluating the osteogenic properties and biocompatibility of artificial bone materials, their physical morphology should be carefully considered. We recommend utilizing larger granular forms rather than powdered formulations to minimize unintended dispersion.

This case report highlights a complication still considered rare in the existing literature, yet its incidence may rise with the increasing clinical adoption of artificial bone grafts in recent years. These findings suggest that heightened vigilance is warranted as novel bone substitutes become mainstream in spinal surgery.

4. Conclusion

This case highlights the potential risk of bioactive glass artificial bone powder in triggering intraspinal HO following lumbar fusion surgery. While it demonstrates significant advantages in promoting osseointegration, the risk of intraspinal HO development within the spinal canal after its application warrants heightened clinical vigilance. To mitigate the risk of intraspinal HO, modifications to bioactive glass materials combined with refined surgical techniques to prevent intraoperative particle migration are imperative. Furthermore, standardized

postoperative follow-up should be carried out to achieve early warning of intraspinal HO.

Data Availability

No datasets were generated or analyzed during the current study.

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Competing Interests

None.

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