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Minimally invasive non-fusion vertebral body stabilization in severe benign and malignant fractures. Stent-screw Assisted Internal Fixation: the SAIF technique

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Abstract

This short review focuses on clinical and therapeutic issues posed by severe osteoporotic and neoplastic insufficiency vertebral fractures and on the potential use of a new technique to obtain minimally invasive vertebral body reconstruction, augmentation, and stabilization in such severe fractures, combining two preexisting procedures. The implant of vertebral body stents is followed by insertion of percutaneous, fenestrated, cement-augmented pedicular screws that act as anchors to the posterior elements for the cement–stent complex. This procedure results in a 360° nonfusion form of vertebral internal fixation that may empower vertebral augmentation and potentially avoid corpectomy in challenging osteoporotic and neoplastic fractures.

Keywords

Vertebral augmentation, stent, kyphoplasty, screw

Introduction

Cement vertebral augmentation has been extensively used for pain palliation and stabilization of vertebral body (VB) fractures due to trauma, osteoporosis, and tumors.[1–3]

Osteoporotic fractures

In osteoporotic vertebral fractures, the spectrum of severity ranges from mild and stable compression fractures,[4] affecting the disc-endplate region and leading only to minor deformity, to unstable fractures with a high-degree of osseous fragmentation, collapse deformity, middle column involvement, pediculo-somatic junction fracture, and kyphotic deformity[5,6] (Figure 1(a) to (b)).

Cement vertebral augmentation is widely used to treat fragility fractures, to palliate pain, restore axial load capability of the VB, and arrest fracture progression.[7] Nevertheless, standard vertebral augmentation is intended to reinforce the anterior column and usually leaves the middle column nonaugmented (Figure 1(c) to (d)). The injection of cement is in fact halted when polymethyl methacrylate (PMMA) approaches the posterior third of the VB, to avoid the feared cement leak in the epidural space. Vertebral augmentation performed with vertebroplasty or balloon kyphoplasty might therefore represent an under-treatment in severe osteoporotic fractures with middle column involvement.

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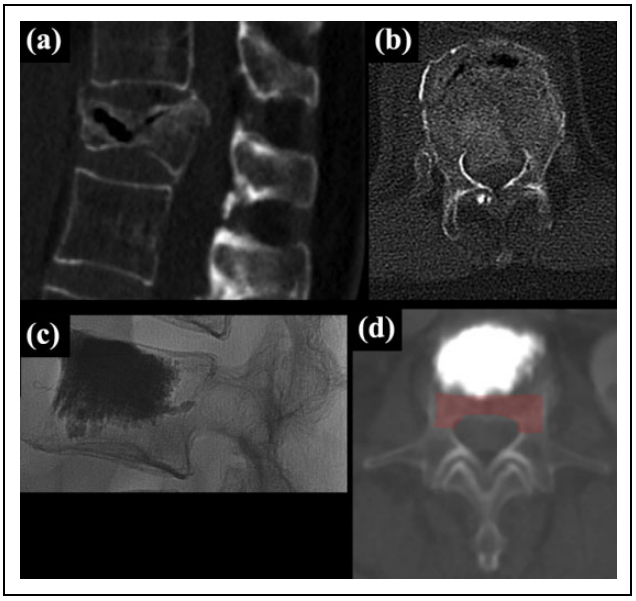


Figure 1. Osteoporotic fracture. (a, b) An osteoporotic T12 compression fracture involving anterior and middle columns, with gas-filled cleft, and posterior wall retropulsion in the central canal. (c) A lumbar VB cement-augmented with vertebroplasty: cement injection was interrupted as it was approaching the posterior wall. Axial CT image (d) of the same vertebra shows the nonaugmented middle column (highlighted in transparent red). VB: vertebral body.

Neoplastic osteolysis

Spinal osteolysis may cause severe instability, leading to fractures and neural compression.[8] Stability restoration is therefore of paramount importance in the treatment of lytic spinal tumors. Posterior surgical fixation is widely used but should be accompanied by anterior column stabilization, either with corpectomy and grafting or with cement augmentation.[9,10] Posterior fixation, however, may not be feasible in patients with advanced disease, multilevel lesions, and poor bone quality. Corpectomy and grafting is highly invasive and carries significant morbidity risk especially in fragile neoplastic patients.[11] Finally, vertebroplasty and kyphoplasty, when osteolysis causes extensive destruction of the cortical boundaries of the VB, may be challenging or impossible.[12,13] Cement distribution in these highly destroyed VBs might be unpredictable, uneven, or result in early extra-vertebral leaks leading to insufficient augmentation and stabilization or to clinical complications including vascular migration or neural compression.

SAIF technique

To address the limitations of standard vertebral augmentation in the most severe osteoporotic fractures and neoplastic lytic lesions, we have recently proposed the use of a new technique, called "stent-screw-assisted internal fixation (SAIF)."[14]

We use SAIF in osteoporotic spinal fractures with wedge, biconcave, and burst morphology from moderate to severe degree of deformity (Genant grades II and III)[5] and with high level of osseous fragmentation (Mc Cormack grades II & III)[6]; for neoplastic spinal fractures, we treat wide lytic lesions, also with cortical involvement, fractured or with impending collapse (Tomita extracompartmental lesion type IV–VI).[15]

The SAIF is performed by combining the use of vertebral body stent (VBS) (De Puy Synthes—Johnson&Johnson®) augmentation and insertion of percutaneous cannulated fenestrated transpedicular screw (Injection pin—2B1, Milan-Italy).

The VBS is a balloon-expandable barrel-shaped metallic device, which is inserted unilaterally or bilaterally via a transpedicular access. Upon expansion, the VBS keeps the created cavity open after balloon deflation until cement is injected. Introduced for treatment of vertebral compression fractures,[16–22] VBS has also been used in neoplastic fractures.[23] Most recently, it has been tested in cases of extensive osteolysis of the VB in order to reconstruct the anterior column.[24]

VB stenting has several potential advantages over traditional augmentation in that the rigid stent remains expanded after balloon deflation thus maintaining the restored VB height.[19] The barrel shape of the VBS, with its large support-surface, provides mechanical support, scaffolds the VB from within, and when necessary as in cases of fragmented cortical boundaries or osteolysis recreates VB walls. The metallic mesh helps confine the injected cement within the created cavity. These characteristics potentially favor the use of VBS in the most severe vertebral fractures, such as highly fragmented osteoporotic fractures, or neoplastic fractures with prominent cortical osteolysis.

We have implemented the VBS technique, combining the VBS implant with the insertion of percutaneous transpedicular cannulated fenestrated screws, followed by cement deposition through the screw (Figure 2). The intent is to anchor the VBS–cement implant to the posterior elements thereby reducing the risk of VBS mobilization, bridging middle column and pedicular fractures.

This SAIF technique, as opposed to the standard surgical external fixation achieved with screws and bars bypassing the index level, might represent a minimally invasive image-guided 360° nonfusion form of vertebral reconstruction and stabilization that would be viable even in patients with severe osteoporotic or neoplastic thoraco-lumbar vertebral fractures. When deemed necessary, the SAIF technique could be combined with a posterior surgical approach, including decompressive laminectomy, dorsal open or percutaneous instrumentation. The SAIF procedure can be performed in a day-surgery setting, invasiveness is minimized, the patient is mobilized early and can stand and walk the same day; most importantly, in neoplastic patients, SAIF does not interfere with ongoing radiation or chemotherapy treatments.

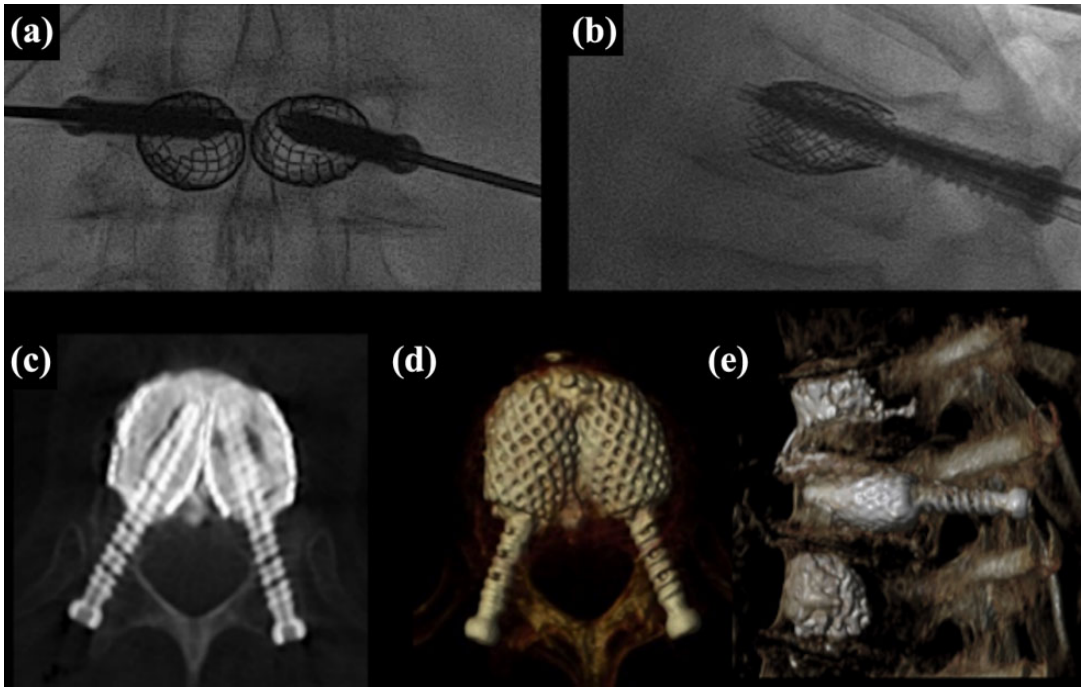


Figure 2. SAIF technique. After bilateral transpedicular trocar placement, VBSs are inserted into the VB and balloon expanded. The trocars are removed by exchanging them over k-wires and percutaneous fenestrated and cannulated pedicular screws are inserted inside the stents' lumen (a, b). The stents are then augmented with cement injected through the fenestrated screws, as shown on axial (c) and 3-D volume rendering (d, e) post-procedural images. SAIF: stent-screw-assisted internal fixation; VBS: vertebral body stent.

Conclusion

SAIF can be performed as a stand-alone procedure or be combined with surgical posterior stabilization, potentially obviating the need for corpectomy and grafting or other invasive surgical procedures on the anterior column.

The SAIF technique remains a percutaneous minimally invasive image-guided procedure but ensures effective VB reconstruction via an internal VB prosthesis that allows a 360° nonfusion stabilization. This technique may be used in fractures in which height restoration, kyphosis correction, VB reconstruction, and middle column protection are clinical concerns.

Declaration of conflicting interests

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