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COMPARATIVE ASSESSMENT OF SURGICAL TREATMENT OUTCOMES FOR OSTEOPOROTIC COMPRESSION FRACTURES OF THE THORACOLUMBAR SPINE USING BALLOON KYPHOPLASTY AND PERCUTANEOUS VERTEBROPLASTY

Sh.Sh. Shatursunov
D.I. Eshkulov
Khuzhanazarov I.E
RSNPMCTO of Traumatology and Orthopedics.
Tashkent State Medical University Tashkent, Uzbekistan.

Abstract

Percutaneous vertebroplasty consists of the transcutaneous injection of bone cement (usually polymethylmethacrylate, PMMA) into the body of the damaged vertebra under fluoroscopic control. A needle is introduced through a posterior approach into the neural arch and vertebral pedicle. The cement fills cracks and voids, reinforcing the bone and restoring its strength.

Introduction

Balloon kyphoplasty involves an additional step: before cement injection, a specialized balloon is introduced into the vertebral body. It is gradually inflated with a radiopaque solution under pressure, which allows restoration of the vertebral body height and partial correction of the deformity (kyphosis). After inflation, the balloon is removed and bone cement is injected into the created cavity.

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Progressive population aging is currently considered a global problem according to WHO experts [2]. Vertebral body injuries in elderly and senile patients are generally considered to be a consequence of low-energy trauma due to concomitant osteopenic syndrome [1–2]. However, increasing social activity among older age groups leads to a rise in the number and energy of injuries.

The absolute indication for instrumental stabilization of uncomplicated spinal injuries is their unstable character. Currently, the question of fixation of stable osteoporotic vertebral body fractures has no definitive answer. The use of transpedicular systems in the setting of osteoporosis carries the risk of implant instability and migration in the early postoperative period. The widely used puncture-based stabilization techniques (vertebroplasty and kyphoplasty) are currently not considered 'standard treatment' by most orthopedic surgeons [7, 8].

Comparison of Methods

Advantages of vertebroplasty

- Simpler technique;
- Shorter operation duration;
- Potentially lower cost.

Advantages of kyphoplasty

- Correction of spinal deformity;
- More pronounced restoration of vertebral height;
- Potentially better prevention of further deformity.

Limitations of the methods:

Vertebroplasty does not always provide long-term pain relief, particularly in the presence of pronounced deformities. Kyphoplasty is effective only for fresh fractures (within 8 weeks), as after this period the bone fragments may consolidate in a distorted position.

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Indications and Choice of Method

The choice of method depends on the clinical situation. Vertebroplasty is preferred for minor fractures without pronounced vertebral deformity. Kyphoplasty is indicated for pronounced vertebral compression, reduction of vertebral height, and the presence of kyphosis. Both methods are most commonly used in patients with severe pain syndrome that cannot be controlled by conservative means. However, thorough diagnostic evaluation (MRI, CT) and assessment of the patient's general condition are mandatory before surgery.

Current Recommendations

Current expert guidelines emphasize the need for informed choice and cautious application of both methods. Surgical interventions are advisable primarily in a strictly selected group of patients with severe, poorly controlled pain and functional disability, especially in the early period after fracture. For complicated fractures with instability and neurological deficit, more radical surgeries are indicated (decompressive-stabilizing procedures with transpedicular fixation). It is important to note that neither method eliminates osteoporosis itself; therefore, anti-osteoporotic therapy must be continued after surgery.

Today, most orthopedic surgeons prefer conservative treatment approaches. However, it should be noted that conservative treatment of osteoporotic compression vertebral fractures does not always achieve good clinical results. Prolonged bed rest and the use of external fixation devices (corsets, postural correctors) may lead to hypostatic complications (pneumonia, thromboembolic events, etc.) and decompensation of existing somatic pathology.

At the same time, early patient mobilization and early axial loading in the injury zone frequently leads to kyphotic deformity and chronic vertebrogenic pain syndrome. Another unfavorable outcome of non-compliance with conservative treatment protocols for such injuries is the development of mobile deformities and associated pain syndrome.

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Conservative treatment of compression fractures in elderly patients carries risks from pharmacological side effects, and prolonged immobilization in a corset may lead to muscle atrophy and immobilization osteoporosis with progression of sarcopenia, worsening disability, and increased fall risk.

Thus, treatment of patients with spinal injuries in the context of multiple and combined trauma is a complex task requiring strict adherence to management protocols and careful formulation of indications for surgical treatment considering the polymorphism of injuries.

Vertebral body compression fractures are the most common complication of osteoporosis: approximately 1.5 million osteoporosis-related fractures are registered annually in the United States, with an annual incidence of vertebral compression fractures of approximately 700,000 cases. The true prevalence is likely even higher, as such injuries are diagnosed in only 1/3 of cases. Surgical treatment of compression fractures has gained wide acceptance, as it promotes rapid, pronounced, and sustained back pain relief, functional improvement, and enhanced quality of life.

However, the choice of optimal surgical stabilization method in the setting of reduced bone mineral density and concomitant diseases in elderly patients remains a subject of debate [1, 4, 9]. Conventional surgical approaches for thoracolumbar fractures — transpedicular fixation via a posterior midline approach, anterior spinal fusion, or their combination — are inappropriate for elderly patients due to high invasiveness, risk of implant instability in osteoporotic bone, and high anesthetic risk [10]. Minimally invasive surgical techniques allow stabilization of the injured spine with minimal trauma. Vertebroplasty and kyphoplasty have gained the widest adoption for treatment of osteoporotic compression fractures, providing effective pain relief, functional improvement, and prevention of further vertebral body compression [3, 5, 6].

Balloon kyphoplasty was first introduced by American neurosurgeons led by M. Reiley in collaboration with the company 'Kyphon' in 1998, and the scientific

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report was published by W. Wong et al. in 2000. Kyphoplasty is essentially a modified vertebroplasty, its principal distinction being the preliminary introduction of a balloon-tipped guide through a specialized bone needle into the vertebral body; the balloon is inserted in a deflated state and then inflated to restore the height of the affected vertebra. Furthermore, an important advantage of kyphoplasty is the reduction of the risk of extravertebral bone cement leakage.

Aim of the Study

To analyze the outcomes of surgical treatment of osteoporotic fractures of the thoracolumbar vertebral bodies using percutaneous balloon kyphoplasty with bone cement.

Materials and Methods

A retrospective analysis was performed of surgical treatment in 38 patients aged over 50 years with osteoporotic compression fractures of the thoracic and lumbar vertebral bodies who received inpatient treatment in the vertebrology department of the RSNPMCTO, Tashkent, between 2019 and 2023. Of these, 21 were male (55.2%) and 17 female (44.7%). The mean age was 60.5 years.

All patients underwent clinical and instrumental examination: laboratory investigations, specialist consultations, plain radiography of the thoracolumbar spine, MSCT, MRI, densitometry, Doppler ultrasound, and others. The degree of reduction in bone mineral density was determined by indirect radiological signs and by attenuation coefficient assessment using MSCT and MRI data. Additionally, the probability of osteoporosis and risk factors were identified during history taking. Signs confirming the presence of osteoporosis included prior typical low-energy fractures of the distal radius, proximal humeral metaepiphysis, proximal femoral metaepiphysis, glucocorticosteroid use for somatic diseases, early menopause (before 45 years), surgical menopause, and the presence of other endocrine diseases.

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Pain intensity was assessed using the Visual Analogue Scale (VAS), and the degree of disability (functional capacity) was determined using the Oswestry Disability Index (ODI).

Among 38 patients, 54 vertebral body fractures were identified: single vertebral body fracture in 65.7% of cases (25 patients); fractures at 2 levels in 18% (7 patients); multilevel injuries of 3, 4, and 5 vertebrae in 15.7% (6 patients). Fractures at the thoracolumbar junction were most common due to the biomechanical characteristics of this segment. The Magerl and AO/ASIF classification was used to determine fracture morphology. Type A compression fractures were found in the majority of cases (87.6%), type B fractures were observed in 16 patients (12.4%). Patients with type C fractures and complicated fractures were excluded from the study.

Prior to the procedure, anesthetic and surgical risks were assessed, preoperative preparation was performed, and somatic pathology was compensated.

Balloon kyphoplasty was performed mainly under local anesthesia and in some cases under intravenous general anesthesia with mechanical ventilation. In several patients with a unipedicular approach, combined anesthesia (local anesthesia combined with intravenous sedation) was used. The procedural technique complied with the manufacturer's recommendations. 'Allevo', 'Kyphon', and 'Medinaut' kits were used.

The patient was positioned prone with extension bolsters. All stages of the operation were performed under C-arm fluoroscopic control: transpedicular approach with working cannula placement, balloon insertion and inflation, injection of bone cement into the created cavities. Postoperative control spondylography was performed; in some patients — MSCT. Drug therapy included antibacterial and anti-inflammatory agents, osteotropic therapy in the form of bisphosphonates, calcium supplements, and vitamin D, as well as prophylaxis of thromboembolic complications.

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Results and Discussion

A total of 47 segments were operated upon. After the intervention, a significant reduction in pain severity, improvement of functional status, and early patient mobilization were observed. Mean VAS pain scores decreased from 7.1 to 2.1 points. The majority of patients achieved restoration of anterior vertebral height and correction of local kyphosis. No infectious or neurological complications were observed.

Clinical Example No. 1

Patient A., 57 years old. Diagnosis: compression fracture of the LI vertebral body, without spinal cord dysfunction. CT and X-ray prior to surgery: compression fracture of LI vertebral body, grade II–III. Postoperative spondylography demonstrates restoration of the height of the wedge-shaped vertebral body deformity by 75%.

Clinical Example No. 2

Patient S., 64 years old. Diagnosis: compression fracture of the LI vertebral body, without spinal cord dysfunction. MRI and X-ray prior to surgery: compression fracture of LI vertebral body, grade III. Postoperative X-ray following stabilization of the fractured LI vertebra with bone cement. Leakage of methacrylate into the disc space can be prevented by using high-viscosity cement and controlling its injection under fluoroscopy.

In the analysis of short-term and long-term treatment outcomes, clinical examination was used, quality of life was assessed using the adapted Oswestry questionnaire, and pain syndrome was studied using the Visual Analogue Scale (VAS). MSCT and plain two-projection spinal radiography with subsequent X-ray morphometric analysis of the injury character and long-term outcome were used to study the anatomical bony structures of the spine.

Wedge-shaped vertebral body deformity before surgery was 25–50% (39.7±8.7%). During kyphoplasty, restoration of anterior height of the fractured vertebra was achieved at 15.0±6.2%. Correction of the local kyphosis angle was

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achieved within 5–10° (7.3±2.5°). Pain syndrome decreased from 7.1±1.9 to 2.1±1.7 on the Visual Analogue Scale. In the long-term period, no increase in pain syndrome, progression of the local kyphosis angle, or vertebral body deformity was noted. An advantage of balloon kyphoplasty is the minimal number of complications related to extravertebral bone cement spread.

Thus, percutaneous puncture kyphoplasty allows minimally invasive, low-trauma stabilization of thoracolumbar vertebral body fractures in the setting of osteoporosis, restoring the strength characteristics of the damaged vertebra. Restoration of vertebral body height leads to restoration of the biomechanics of the spinal motion segment, thereby reducing the likelihood of 'adjacent level' fractures.

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