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Surgical Management of Fragility Fractures of Thoraco-lumbar Spine

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Abstract

Osteoporotic fractures of the spine are an increasing and important health care issue because these fractures can result in significant morbidity and potential mortality. The incidence of osteoporosis in the elderly population continues to rise constantly. Osteoporotic vertebral fractures mostly affects elderly patients and is complicated because of existing comorbidities, impeded functional reserves, cognitive dysfunction, and often multi pharmacy. The annual incidence of new vertebral fractures accounts for about 1.4 million fractures all over the world. An estimated one quarter of the population above 50 years old will suffer a vertebral fracture throughout their lifetime. Fragility fractures of the spine is a common cause of back pain that interferes with the life style of elderly patients and may need surgical intervention which is becoming a major burden on the healthcare system.

Keywords: Surgical Management, Fragility Fractures, Thoraco-lumbar Spine.

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1. Introduction

Osteoporosis is a common disease that is characterized by low bone mass with micro architectural disruption and skeletal fragility, resulting in an increased risk of fracture, particularly at the spine, hip, wrist, humerus, and pelvis. Osteoporotic fractures (fragility fractures, low-trauma fractures) are commonly defined as those occurring from a fall from a standing height or less, without major trauma such as a motor vehicle accident [1]. Vertebral fragility fractures (VFFs) are the most common type of osteoporotic fractures. The prevalence of these fractures is significantly higher, when considering patients aged 80 or older. These data, however, could be significantly underestimated, since approximately 60% of VFFs are clinically silent. It is remarkable that, although asymptomatic, VFFs could have a significant impact on the patient's health by causing height loss, trunk deformity, impaired mobility and an overall decreased quality of life [2].

X-ray examination provides visualization of the fracture site and type, allowing assessment of the fracture direction and extent of displacement, all of which is valuable information with respect to diagnosis and treatment. Aside from providing radiological evidence of the presence of fracture, X-ray films also offer clues towards osteoporosis diagnosis, including reduced bone density, thinning of trabecular and cortical bone, and expansion of the bone marrow cavity [3]. Nowadays, percutaneous vertebra \plasty (PVP) is an alternative option. It is a minimally invasive procedure that has been used worldwide for the treatment of symptomatic vertebral compression fractures. The procedure involves injection of poly-methyl-methacrylate (PMMA) bone cement into the vertebral body aiming at stabilizing the fracture and immediate improvement of pain [4].

A. Conservative Treatment

- ***Introduction***

The acute pain of a new OVF is usually relieved after 6–12 weeks. The most common course of treatment for a patient with an acute OVF is a conservative manner. It focuses on pain management through short-term bed rest, analgesic medicine, anti-osteoporotic medication, exercise (physiotherapy), and a brace (spinal orthosis). Because conservative treatment is highly beneficial and should be actively practiced in general, it has remained a successful primary therapeutic approach even if there are no conclusive results [5].

1. Medical treatment

- ***Pain control***

Analgesic medicine is the first line of treatment. Acute pain control may include non-steroidal anti-inflammatory drugs (NSAIDs), muscle relaxants, narcotic pain medication, neuropathic pain agents (i.e., tricyclic antidepressants), local analgesic patch, intercostal nerve blocks, and transcutaneous nerve stimulation units [6-7]. NSAIDs are often first-line drugs for back pain as they do not have sedating effects. However, they do have gastric toxicity and an increased risk of cardiac events for patients with hypertension and coronary artery disease [8]. There is also a theoretical inhibitory effect of NSAIDs on bony healing, though this has not case in actual studies [9-10]. Opioids such as oxycodone can be combined with paracetamol for patients

who do not respond well to first-line pain relievers. Opioids and muscle relaxants may provide strong relief when NSAIDs are inadequate but have significant sedative effects as well as the risk of dependency. As such their use needs to be carefully balanced in the geriatric patient [6]. Opioids not only have a significant impact on management of acute pain but also have significant adverse effects (AEs), including addiction, decreased gastrointestinal motility and respiratory function, cognitive impairments with a corresponding increase in falls, and depression [11].

- ***Anti-osteoporosis drugs***

Preventing and treating osteoporosis is the most important aspect of managing OVF. Baseline treatments (calcium and vitamin D), conventional medications (BP and selective estrogen receptor modulators), and newer drugs (denosumab and TPD) can all be used to reduce the number of subsequent vertebral fractures [12]. Anti-osteoporotic medications may be used to treat pain in OVF patients. It contains anabolic substances and conventional antiresorptive drugs, such as intravenous teriparatide (TPD) and bisphosphonates (BPs). TPD, an injectable form of parathyroid hormone (PTH), has been shown in meta-analyses to significantly reduce back pain, improve bone mineral density (BMD), and lower the risk of subsequent fracture. Although it is recommended, there is little evidence that calcitonin is effective for treating persistent back pain in recent OVF patients [13].

- ***Fracture healing***

In terms of biology, Biphosphonates (BPs) cause a delay in maturation during endochondral repair, which results in a less developed fusion mass and a marked reduction in the union, as well as an increase in fracture callus size. According to the author, BPs may inhibit bone remodeling and maturation during fracture healing. However, a 1-year study of 40 osteoporosis patients found that BP therapy increased the rate of interbody fusion [14]. Intermittent injection of TPD (recombinant human PTH 1–34) stimulates bone formation by stimulating osteoblast proliferation, inhibiting osteoblast apoptosis, and increasing osteoblast activity. TPD greatly improved fusion and fracture healing in an animal study, and it has been observed that patients with OVF who receive conservative treatment with TPD can anticipate outcomes that are on par with those of VA treatments. The TPD group had a much greater 6-month union rate than the BP group, according to a retrospective comparison study, which raised the possibility that TPD might promote the healing of OVF fractures. In reducing mechanical problems following posterior instrumented fusion for OVF, TPD outperformed BP [15].

2. Brace (spinal orthosis)

Patients with OVF should wear traditional three-point contact braces, hyperextension orthoses, or thoracolumbar sacral orthoses (TLSO) There are numerous advantages to using a brace, including being less invasive, relatively safe, and inexpensive. The goals of the braces are to promote fracture healing by stabilizing, to allow for faster mobilization, to reduce pain and fatigue, and to prevent postural forward flexion. A TLSO was found to have significant effects on trunk muscle strength, posture, quality of life, activities of daily life, and pain in one prospective randomized study. Spinal orthoses significantly improved functional outcomes in neurologically intact patients 60 years of age and older, reducing kyphotic deformity, improving postural stability, and increasing muscular strength [16]. However, studies in patients with non-OVFs provide evidence for the effectiveness of a spinal orthosis. Inadequate immobilization, sores, decreased pulmonary function and compliance, and core muscle weakness are drawbacks of spinal orthoses. Clinicians lack sufficient information regarding the particular type of brace, indications, and time to remove. Additionally, a number of papers claimed that there is poor compliance and wide variation in the use of spinal orthoses [17].

3. Exercise (physiotherapy)

After the acute pain subsides, core muscle strengthening exercises are frequently recommended to reduce chronic pain, improve posture and gait, improve quality of life, and strengthen the back extensors. Additionally, it might reduce edema, the need for painkillers, and the danger of further falls and fractures. Continuous physical activity was linked to a lower risk of osteoporotic fractures in a nationwide population-based cohort study [18]. A tailored rehabilitation program based on balance and muscle strength tests has recently been proposed as an effective treatment option for basic motor function improvement and disability reduction. A retrospective observational study found that compliance with a home exercise program was 62.86%, with several causes of non-compliance, including the absence of supervision by health personnel and a lack of motivation [19].

B. Surgical Treatments

Approximately 15%–35% of patients will experience persistent pain, decreased pulmonary function, spinal deformity, and neurological deficits that will necessitate surgical intervention [20].

- ***Surgical indication***

Surgery is recommended for individuals who have:

- Significant vertebral instability (unstable fractures).
- Clinical symptoms (persistent intractable back pain or neurological deficit).
- Radiological deformity (kyphosis or pseudarthrosis).

The incomplete or delayed neurological deficit is believed to be the result of progressive kyphosis or dynamic instability, which repeatedly causes micro trauma. Dynamic MRI can be a useful tool in making an accurate diagnosis for these patients [21].

- ***Surgical methods***

Because perioperative complications and implant failures were observed in 18.1% and 41.2% of cases, respectively, specific surgical approaches for OVF are required. The following surgical fusion methods are commonly used: anterior spinal fusion, posterior spinal fusion, combined anterior and posterior spinal fusion, posterior three-column osteotomy with shortening osteotomy or vertebral column excision, and VP with posterior spinal fusion. All five methods produced comparable neurological recovery, functional improvements, and complication rates. Because the load-sharing concept can cause an implant failure in a flexion moment during a standing or sitting

position, longer instrumented fusion constructs are required in the posterior alone instrumentation, along with pedicle screw fixation (PSF) and more anchors [22]. Recent reports from several authors describe so-called hybrid stabilization, a minimally invasive fixation for OBF that combines KP.

- ***Surgical strategies and techniques***

1) Screw characteristics

In general population, a larger screw diameter can increase pullout strength. However, osteoporotic bone conditions should be considered when performing PSF in OVF patients. The thin cortex of the pedicle in OVF patients can negate enhanced fixation strength provided by larger diameter screws and increase risk of pedicle fracture if screw diameter is greater than 70% of pedicle diameter. Increasing screw length improves screw pullout strength, though this effect may be less pronounced in OVF patients [23].

2) Screw fixation techniques

Superior fixation strength and resistance to screw pullout may be provided by pedicle screws (PS) when they are inserted with a triangulation trajectory and engaged subchondral bone. According to some authors, a minimum of three fixation points should be placed above and below the deformity's apex. The ideal fusion length, meanwhile, is still up for debate [24].

3) Bone–screw interface

Because the bone–screw interface is critical for preventing screw pullout, expandable PS and VA have been the subject of extensive research. Representative materials include PMMA bone cement and hydroxyapatite cement (HAC). PMMA bone cement has a two-fold to three-fold improvement in pullout strength. The disadvantage of non-PMMA cement is that it takes 4–24 hours to reach maximum stiffness, whereas PMMA reaches stiffness immediately [25].

4) Sublaminar wire and hooks

Combining PS and additional offset sublaminar hooks, also known as pediculolaminar fixation, can increase stiffness and pullout strength by up to 100%. PSF should not be used in patients with BMD less than 0.3 g/cm^2 in a biomechanical investigation. The cortices of the laminae are significantly more powerful than the marrow within pedicles in OVF patients. Laminae also have a higher proportion of cortical bone than cancellous bone, making them less susceptible to osteoporosis. Although spinal loop rectangle and sublaminar wiring construct are viable options for stabilizing OVF, sublaminar hooks are believed to be more resistant to posteriorly directed stresses. Hooks, however, should not be used as the sole means of fixation [26].

5) Supplementary interbody fusion

Lumbar interbody fusion may result in anterior column support. To avoid cage subsidence, endplate damage, delayed fusion, or pseudarthrosis, meticulous and thorough cartilaginous endplate removal is crucial. A suitable-sized interbody spacer or cage and enough amount of bone graft are also necessary for a successful fusion [27].

6) Vertebral Augmentation

There have been numerous studies published on vertebral augmentation (VA), which includes kyphoplasty (KP) and vertebroplasty (VP). VA has several advantages, including local anesthesia, mechanical stabilization with cement injection, and analgesic effect from the thermal reaction of polymethyl methacrylate (PMMA) cement. According to several studies, treating local kyphosis and relieving pain with VA may have significantly improved sagittal imbalance [28]. Short segment fixation combined VA (hybrid procedure) has been introduced as a different treatment approach for OBF. However, because these studies have limited surgical indications, then VA should be performed through a comprehensive evaluation for vertebral instability to avoid serious complications [29]. Although VA has low reported complication rates in general, it is important to discuss the serious nature of these problems (2% in KP and 3.9% in VP). The likelihood of major AEs, including infection, neural tissue damage, thecal sac compression, pulmonary embolism, and respiratory failure, was identified in five trials (821 VP cases). Cement extravasation is a common severe complication. In 473 VA cases, 87.5% for VP and 49.2% for KP were found.

In comparison with 1.6% to 3.0% for VP, two meta-analyses determined that the symptomatic leakage rate for KP is between 0% and 0.3%. Precautions have been suggested to reduce the risk of cement leakage, including (1) careful preoperative evaluation, (2) a total cement injection volume less than or equal to the void left by the balloon, (3) a small volume of cement (0.2–0.5 mL) each time, (4) regular evaluation by fluoroscopic imaging, (5) use of high-viscosity cement in a doughy state, and (6) injection time of 3–4 minutes after cement mixing [30]. Re-fractures (VA index level) or subsequent fractures (adjacent level) have also been mentioned as a cause for concern. Risk factors for index level re-fracture include intravertebral cleft and severe kyphosis, increased psoas muscle fatty infiltration, thoracolumbar level, solid lump cement distribution pattern, and higher restoration of body height [31]. A common complication is adjacent-segment fracture (ASF), which has a risk of 2% to 23% in KP and up to 52% in VP. The majority of ASFs were observed within two months of VA. The following are hypotheses regarding the potential causes of the rising ASF rate. By increasing the stiffness of the cemented vertebra, it is possible to produce 35 times harder and 12 times stiffer than those in the control group.

Unusual loading distribution can result in a 13%–18% increase in adjacent-level pressure. Until recently, the impact of VA on later ASF was not well understood. According to some authors, restoring sagittal balance and physiologic loading by VA may reduce ASF, which was primarily caused by underlying osteoporosis and altered mechanical load caused by spinal deformity [32]. Percutaneous vertebroplasty (PVP) is a treatment for patients with one or more symptomatic vertebral fractures caused by a bone tumor, osteoporosis, or trauma. In a PVP, bone biopsy needles are inserted into the fractured vertebra with the patient under local anesthesia; bone cement made of polymethyl methacrylate (PMMA) is injected through the needles, and then symptoms such as walking difficulty or back pain are immediately alleviated. A PVP procedure requires only 2 h of treatment time and 2 h of postoperative bed rest; it can be performed through a 5-mm skin incision for the insertion of each bone biopsy needle, it has a low frequency of serious adverse events, it can be performed without special preoperative preparation or intensive

postoperative care, and the only absolute contraindications are an uncontrollable infection and bleeding tendency [33].

7) Indications and contraindications of PVP

While both pain and QOL are subjective no matter what measurement system is adopted, the modified Yokoyama's activities of daily living (ADL) scoring system, which is an ADL measurement, is noteworthy. This system is as follows:

0 points = complete independence, independent walking;
1 point = light assistance is needed, walking with a walking aid;
2 points = moderate assistance, needing a wheelchair for locomotion;
3 points = major assistance, mostly staying in bed or sitting upright at 60°–90°;
4 points = total assistance, mostly staying in a bed-ridden state or sitting upright at less than 60°.

This scoring system has several advantages, including ease of use, simple and objective estimates by any medical staff, and a direct relationship between the mobility scores and the physical condition of patients with vertebral fractures. Clinical problems are also easy to predict with this system. For example, patients who score 3 or 4 points usually stay in bed, urinate/defecate in a bedridden state, require frequent medical staff assistance, and are at increased risk of secondary illness and long-term hospitalization. Patients with 2 points are normally in a wheelchair, urinate and defecate in a bathroom, undergo advanced rehabilitation for walking but still need assistance, and go on limited outings. Patients with 0 points or 1 point can walk, return home, and expand their activities [34].

Clinicians should also be aware of the exclusion criteria for PVP as proposed in the guidelines for PVP for osteoporotic vertebral fracture [35]:

(1) Uncontrollable local or systemic infections,
(2) Uncontrollable bleeding tendency,
(3) Allergies to bone cement or opacification agents,
(4) Back pain from a condition other than a vertebral fracture,
(5) Major organ dysfunction,
(6) Under 55 years of age,
(7) Difficulty in the prone position,
(8) 4 or more vertebral fractures, and
(9) Vertebral posterior wall damage.

(1)– (3) And (4)–(9) are considered to be absolute and relative contraindications to PVP, respectively.

C. Surgical outcomes and the prognosis

Although there are numerous surgical procedures, it is too difficult to obtain positive results in OVF patients. The sagittal balance that had been restored following surgery could not always be kept. Patients with Parkinson's disease or rheumatoid arthritis frequently showed significant correction loss during follow-up (recurrence of severe local kyphosis or vertebral collapse that existed before surgery). The moderate-to-severe grade of preoperative neurological deficit, perioperative morbidity, and lack of postoperative PTH administration were strongly associated with postoperative impaired ADL [29]**.** Because no single method can guarantee the best surgical outcomes in OVF patients, customized surgical approaches are required. Surgeons must stay current on developments in the osteoporotic spine field and be open to new treatment options.

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