



FUNCTIONAL OUTCOMES AND TREATMENT EFFICACY OF CONSERVATIVE, PERCUTANEOUS VERTEBROPLASTY, AND SPINAL RECONSTRUCTION IN OSTEOPOROTIC VERTEBRAL COMPRESSION FRACTURES: A COMPARATIVE STUDY

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Abstract

Introduction: Osteoporotic vertebral compression fractures (OVCF) are a common and debilitating condition that causes significant pain, functional limitations, and reduced quality of life, particularly among the elderly. With several treatment options available, including conservative management, percutaneous vertebroplasty (PVP), and spinal reconstruction, there is a need to compare the clinical and functional outcomes of these modalities to optimize treatment strategies for OVCF patients.

Methodology: This prospective study included 96 patients with symptomatic OVCF, who were treated between June 2014 and December 2016. Patients were divided into three groups: 30 treated with percutaneous vertebroplasty, 32 with decompression and spinal transpedicular screw reconstruction, and 34 receiving conservative management. Pre-operative evaluations included Visual Analog Scale (VAS), Oswestry Disability Index (ODI), and SF-36 scores, along with imaging studies such as X-rays, MRI, and dual-energy X-ray absorptiometry (DEXA). Patients were assessed at six weeks, three months, six months, and one year follow-up.

Results: The results showed significant improvement in pain, disability, and quality of life across all groups. The vertebroplasty group demonstrated the greatest improvement, with a reduction in ODI from 67.97 ± 5.96 to 17.20 ± 2.20 ($p < 0.001$) and VAS scores from 7.6 to 0.43 ($p < 0.001$). The spinal reconstruction group also showed significant improvements in ODI and VAS scores, while the conservative treatment group exhibited moderate improvements. Complications such as dural tear, cement leakage, and persistent pain were observed but managed successfully without significant long-term neurological deficits.

Conclusion: The study concludes that both vertebroplasty and spinal reconstruction are highly effective in improving pain, functional outcomes, and quality of life in OVCF patients, with minimal complications when performed in appropriate candidates. Conservative management provides moderate improvement, but surgical interventions offer superior outcomes in terms of pain relief and functional recovery. Treatment selection should be individualized, with careful consideration of the patient's condition, fracture severity, and potential for recovery.

Keywords: Osteoporotic vertebral compression fractures, percutaneous vertebroplasty, spinal reconstruction, conservative management, functional outcomes, pain relief, Oswestry Disability Index, Visual Analog Scale, SF-36.

Introduction

Osteoporotic vertebral compression fractures (OVCF) are a significant cause of morbidity in the elderly population, particularly affecting women over 50 years of age. These fractures are often associated with severe pain, reduced mobility, and a decline in quality of life, making effective management crucial. Osteoporosis, characterized by decreased bone density and impaired bone structure, increases the risk of fractures due to minimal trauma or even normal daily activities. The spine, being a weight-bearing structure, is highly vulnerable to these fractures, leading to instability, pain, and functional impairment. Approximately 26% of women over 50 years and up to 40% of women over 80 years experience osteoporotic vertebral fractures, and the majority of these patients develop chronic back pain that often persists despite conservative treatment [1][2].

The management of OVCF typically includes conservative measures such as analgesics, bed rest, external bracing, and rehabilitation. However, these treatments often fail to provide long-term relief and can lead to further complications such as immobility, pulmonary issues, and increased risk of subsequent fractures [3][4]. In recent years, minimally invasive procedures such as percutaneous vertebroplasty (PVP) and spinal reconstruction surgery have emerged as viable treatment options. PVP, which involves the injection of polymethylmethacrylate (PMMA) cement into the fractured vertebra, aims to stabilize the fracture, alleviate pain, and allow for early mobilization. Spinal reconstruction surgery, typically indicated for more severe fractures with neurological deficits or spinal instability, involves decompression and instrumentation to restore spinal stability [5][6].

While various studies have assessed the effectiveness of these treatments individually, there is a lack of consensus on the optimal treatment strategy, especially when comparing conservative management with surgical interventions. The goal of this study is to evaluate and compare the functional outcomes, pain relief, and overall quality of life improvements associated with conservative management, percutaneous vertebroplasty, and spinal reconstruction in patients with osteoporotic vertebral compression fractures. This study will provide valuable insights into the effectiveness and safety of these treatment modalities, guiding clinical decisions for the management of OVCF.

Methodology

This was a prospective, comparative study conducted between June 2014 and December 2016, involving 96 consecutive patients diagnosed with symptomatic osteoporotic vertebral compression fractures (OVCF). These patients were recruited from a single institution and were classified into three treatment groups: group 1 (vertebroplasty), group 2 (spinal reconstruction), and group 3 (conservative management). The study was approved by the institutional review board, and all patients provided informed consent prior to participation.

The inclusion criteria for the study were patients aged 50 years and above who had symptomatic OVCF. For the conservative management group, patients had fractures classified as grade 1 (according to the Genant classification), whereas patients in the vertebroplasty and spinal reconstruction groups had fractures classified as grade 2 or 3. The patients in the surgical groups were those who had not responded to at least 6 weeks of conservative treatment, had neurological deficits, or displayed spinal instability. Patients were excluded if they had severe cardiopulmonary comorbidities, untreated coagulopathy, systemic or local infections, pathological fractures due to primary or metastatic tumors, or had previously undergone spinal surgery.

Pre-operative evaluation for all patients involved a thorough medical history and clinical examination, which included pain severity, neurological status, and overall health assessment. Pain severity was assessed using the Visual Analog Scale (VAS), where patients rated their pain from 0 (no pain) to 10 (worst possible pain). Disability and functional outcomes were evaluated using the

Oswestry Disability Index (ODI) and the SF-36 questionnaire. Imaging studies, including X-rays, MRI, and dual-energy X-ray absorptiometry (DEXA) scans, were performed to assess the severity of the fractures and the bone mineral density of the patients.

Following the pre-operative evaluations, patients were assigned to one of three treatment groups based on their clinical presentation. The vertebroplasty group (group 1) consisted of patients who had significant pain unresponsive to conservative management but without neurological deficit or spinal instability. The spinal reconstruction group (group 2) was composed of patients with severe pain, neurological deficits, or spinal instability, requiring decompression and transpedicular screw spinal reconstruction. The conservative treatment group (group 3) included patients with fractures classified as grade 1 and no significant neurological deficits or spinal instability. All patients were followed for a minimum of one year post-treatment to assess clinical outcomes.

Surgical Procedures :

Vertebroplasty

Operative Technique- In prone position and under local anaesthesia with help of C-arm fluoroscopies, a biopsy needle is guided into the fractured vertebra .With the aid of a fluoroscope (a special X-ray machine), two large diameter needles are inserted into the vertebral body through the pedicles. The needles are advanced through the bone using either a twisting motion or a tapping mallet. The needles are angled to avoid the spinal cord. Specially formulated acrylic bone cement is injected under pressure directly into the fractured vertebra, filling the deepest area first, then withdrawing the needle slightly to fill top areas . The pressure and amount of cement injected will be closely monitored to avoid leakage into unwanted areas. The needle is removed and the cement hardens quickly (about 10 minutes), congealing the fragments of the fractured vertebra and stabilizing the bone.

Figure 1 Patient in prone position with bone needle

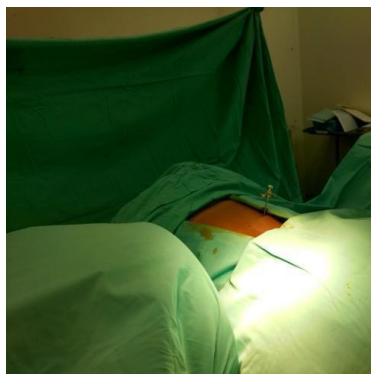


Figure 2 Bone needle passed through pedicle



Figure 3 Injected PMMA cement



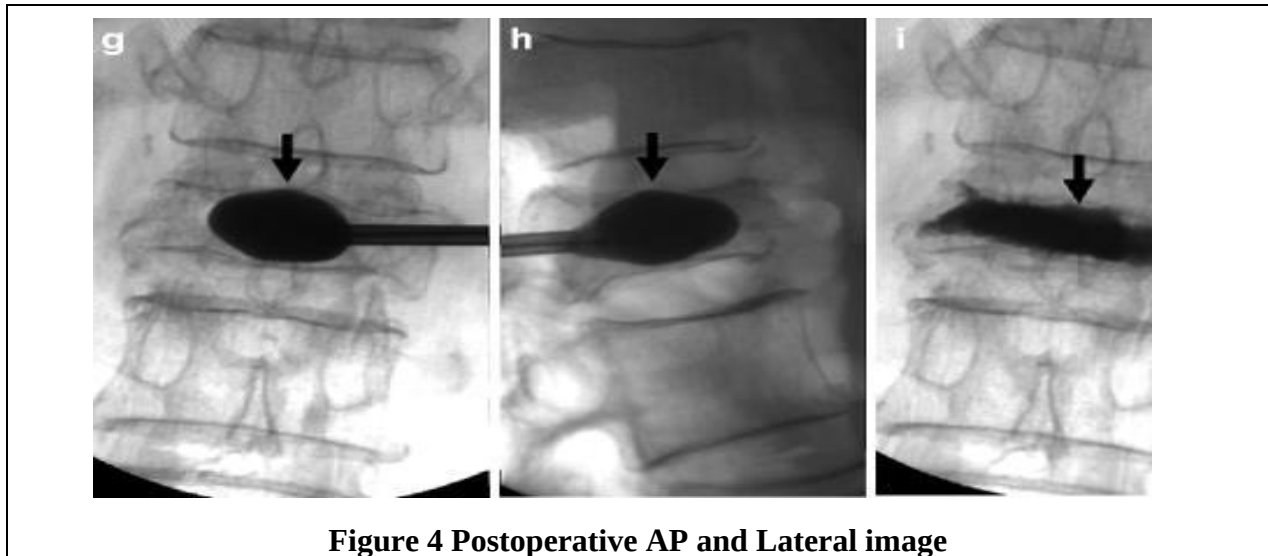


Figure 4 Postoperative AP and Lateral image

Decompression and spinal transpedicular screw reconstruction surgery

Operative Technique - In prone position ,under general anesthesia, long midline incision was taken over the area to be exposed. Dissection is deepened in the midline.Radiograph is obtained to confirm proper localization of the intended level. Short segment pedicle screw instrumentation construct includes the adjacent vertebrae immediately above and below the collapsed vertebra. When the adjacent vertebra suffered from concomitant compression fracture, we extended the instrumentation to one further level above or below. When more than two vertebrae had collapsed, the fixation level included two above and two below the collapsed vertebrae. Laminectomy of the affected vertebra was performed. When the affected vertebra were severely collapsed and neural compression due to retropulsed bony fragments remained severe even after laminectomy, the collapsed vertebral body was decancellated through the pedicles. After the medial part of both pedicles was resected using an air drill and rongeurs, cancellous bone and soft tissue within the vertebral body was removed. Then the cancellous bone of the body was pushed anteriorly into the body to create a cavity in the vertebra. After thinning the posterior wall, the remaining posterior cortex was pushed into the body and dissected from the adherent dura so as to decompress the spinal canal. If higher the deformity, we need larger constructs.

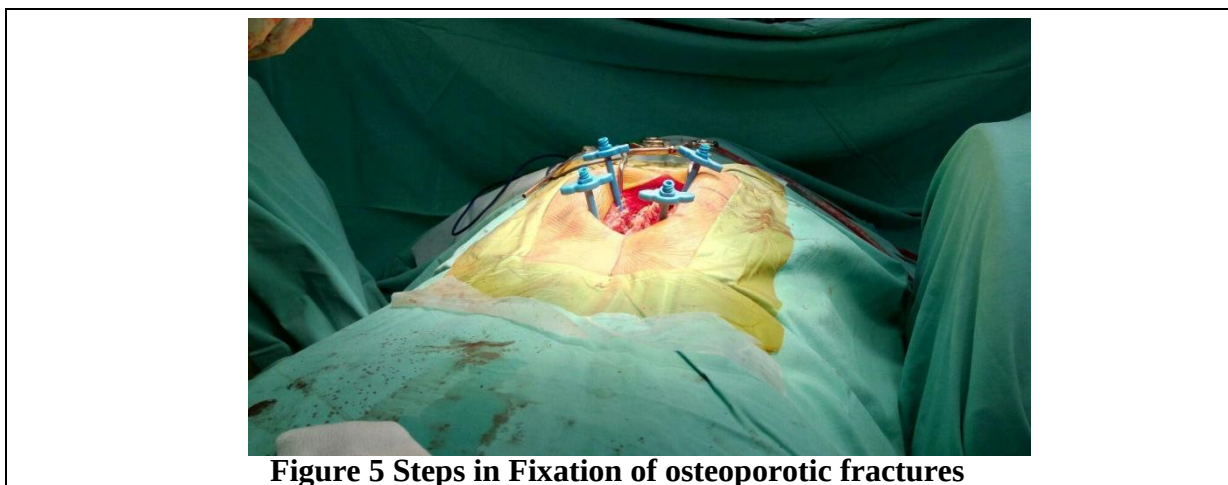


Figure 5 Steps in Fixation of osteoporotic fractures

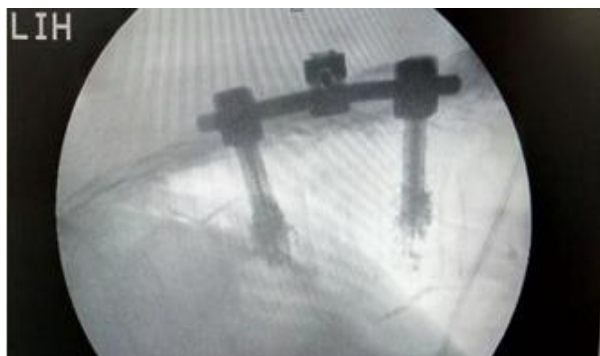


Figure 6 Intraoperative X ray images



Figure 7 Post operative X ray showing spinal reconstruction in Osteoporotic vertebral fracture

Follow up post-operatively:

All patients were evaluated for their clinical, neurological, and radiological parameters along with VAS score, ODI score and SF-36 score at presentation, at six weeks, three months, Six months and 1 year follow-up.

Results

Table 1: Demographic Characteristics of Patients by Treatment Group

Demographic Characteristic	Group 1: Vertebroplasty (n=30)	Group 2: Spinal Reconstruction (n=32)	Group 3: Conservative Management (n=34)
Total Patients (n)	30	32	34
Male (n)	7	13	9
Female (n)	23	19	25
Age (Mean $\pm$ SD)	63 $\pm$ 8 years	65 $\pm$ 8 years	62 $\pm$ 8 years
Age Range	55-71 years	57-73 years	54-70 years
Fracture Severity (Genant Grade)	Grade 1	Grade 2/3	Grade 1

The table summarizes the demographic details of the 96 patients across three treatment groups. The majority of participants were female in all groups. The mean age was similar across groups, with the vertebroplasty group averaging 63 years, the spinal reconstruction group 65 years, and the conservative group 62 years. The fracture severity varied: the vertebroplasty and conservative groups had Grade 1 fractures (mild compression), while the spinal reconstruction group had more severe fractures, classified as Grade 2 or 3. These differences in fracture severity were the basis for assigning patients to the appropriate treatment group.

Table 2: VAS Scores by Treatment Group

Outcome Measure	Group 1: Vertebroplasty (n=30)	Group 2: Spinal Reconstruction (n=32)	Group 3: Conservative Management (n=34)
Pre-operative VAS	7.6 ± 0.65	7.8 ± 0.55	7.6 ± 0.56
1-Year Follow-up VAS	0.43 ± 0.50	0.53 ± 0.51	0.88 ± 0.54
P-value	<0.001	<0.001	<0.001

This table shows the Visual Analog Scale (VAS) pain scores before and after treatment for the three patient groups. The pre-operative VAS scores were similar across all groups, with the vertebroplasty and conservative management groups having a score of 7.6, and the spinal reconstruction group slightly higher at 7.8. At the 1-year follow-up, there was a significant reduction in pain across all groups. The vertebroplasty group showed the greatest pain relief, with a mean VAS score of 0.43, followed by the spinal reconstruction group (0.53) and the conservative management group (0.88). The p-values for all comparisons were <0.001, indicating that the pain reduction was statistically significant in all groups.

Table 3: ODI Scores by Treatment Group

Outcome Measure	Group 1: Vertebroplasty (n=30)	Group 2: Spinal Reconstruction (n=32)	Group 3: Conservative Management (n=34)
Pre-operative ODI	67.97 ± 5.96	68.72 ± 10.24	45.88 ± 6.21
1-Year Follow-up ODI	17.20 ± 2.20	19.69 ± 2.97	21.62 ± 3.93
P-value	<0.001	<0.001	<0.001

This table presents the Oswestry Disability Index (ODI) scores, which measure the level of disability in patients with osteoporotic vertebral compression fractures. The pre-operative ODI scores were similar for the vertebroplasty (67.97), spinal reconstruction (68.72), and conservative management (45.88) groups, with the latter group showing lower pre-operative disability. After one year, all groups showed significant improvement in their ODI scores. The vertebroplasty group had the most significant improvement, with an ODI reduction to 17.20, followed by the spinal reconstruction group (19.69) and the conservative management group (21.62). The p-values for all comparisons were <0.001, indicating that the improvements in disability were statistically significant across all treatment groups.

Table 4: SF-36 Scores (PCS and MCS) by Treatment Group

Outcome Measure	Group 1: Vertebroplasty (n=30)	Group 2: Spinal Reconstruction (n=32)	Group 3: Conservative Management (n=34)
PCS Pre-operative	25.6 ± 6.3	24.9 ± 6.48	26.1 ± 5.90
PCS 1-Year Follow-up	59.83 ± 3.46	57.36 ± 3.28	55.99 ± 2.88
P-value	<0.001	<0.001	<0.001
MCS Pre-operative	33.6 ± 11.6	34.9 ± 9.95	33.5 ± 10.42
MCS 1-Year Follow-up	60.78 ± 3.25	58.55 ± 9.71	56.88 ± 3.08
P-value	<0.001	<0.001	<0.001

For the PCS, the pre-operative scores were similar across all groups: 25.6 for the vertebroplasty group, 24.9 for the spinal reconstruction group, and 26.1 for the conservative management group. At the 1-year follow-up, all groups showed significant improvement, with the vertebroplasty group showing the highest increase (59.83), followed by spinal reconstruction (57.36) and conservative management (55.99). The p-values for all groups were <0.001, indicating statistically significant improvements in physical health.

For the MCS, the pre-operative scores were also similar across the groups: 33.6 for vertebroplasty, 34.9 for spinal reconstruction, and 33.5 for conservative management. After 1 year, the scores improved significantly in all groups. The vertebroplasty group again showed the greatest improvement (60.78), followed by spinal reconstruction (58.55) and conservative management (56.88). The p-values for all comparisons were <0.001, demonstrating significant improvements in mental health across all treatment groups.

Discussion

Osteoporotic vertebral compression fractures (OVCF) represent a significant clinical problem, particularly among the elderly population. These fractures not only contribute to considerable pain and functional impairment but also significantly affect the quality of life of affected individuals. Conservative management, including pain relief through analgesics, bed rest, and bracing, remains the most common initial treatment for OVCF. However, for patients with more severe pain, neurological deficits, or spinal instability, surgical interventions such as percutaneous vertebroplasty (PVP) or spinal reconstruction surgery are often considered [7][8]. This study provides an important comparison of the effectiveness of these treatment options.

The results of this study demonstrate that both vertebroplasty and spinal reconstruction offer significant improvements in pain relief and functional recovery in patients with OVCF, with better outcomes than conservative treatment. The vertebroplasty group showed the most significant reduction in pain, with the Visual Analog Scale (VAS) scores dropping from 7.6 pre-operatively to 0.43 at one-year follow-up. This is consistent with previous studies that have highlighted the effectiveness of vertebroplasty in reducing pain, with improvements seen within weeks post-procedure [9][10]. In a similar context, Buchbinder et al. (2009) found that vertebroplasty provided superior pain relief compared to conservative treatments in patients with painful vertebral compression fractures [11].

In terms of disability, as measured by the Oswestry Disability Index (ODI), the vertebroplasty group demonstrated the greatest improvement, with scores decreasing from 67.97 pre-operatively to 17.20 at the one-year follow-up. The spinal reconstruction group also showed significant improvements,

although not as marked as those seen in the vertebroplasty group. The conservative management group showed the least improvement in disability, with the ODI score reducing from 45.88 to 21.62, which is still clinically significant but considerably lower than the surgical groups. This finding aligns with the research of Reginster et al. (2000), who emphasized that surgical options tend to offer more pronounced improvements in functionality compared to conservative care [12].

The SF-36 scores, which assess the quality of life in terms of both physical and mental health, further support these findings. In the vertebroplasty group, the Physical Component Summary (PCS) improved from 25.6 to 59.83, and the Mental Component Summary (MCS) improved from 33.6 to 60.78, reflecting substantial improvements in both physical function and mental well-being. Similarly, the spinal reconstruction group showed marked improvement in both PCS and MCS scores. These results are consistent with the findings of Kado et al. (1999), who demonstrated the positive impact of surgical intervention on both pain relief and quality of life in patients with vertebral compression fractures [13].

Notably, the study also reveals that conservative treatment, although resulting in less dramatic improvements, still provides notable benefits in terms of pain relief and functionality. The conservative management group saw improvements in both VAS and ODI scores, indicating that this approach remains a viable option for patients with less severe fractures or those contraindicated for surgery. However, as shown by the improved VAS and ODI scores in the surgical groups, vertebroplasty and spinal reconstruction are more effective for patients with significant pain, neurological deficits, or spinal instability [14].

One of the key findings in this study is the low incidence of complications, particularly in the vertebroplasty and spinal reconstruction groups. While complications such as dural tears, cement leakage, and persistent pain were observed, these were manageable, and no patients developed neurological deficits. This is consistent with other studies, which have demonstrated that the complication rates for these procedures are low when performed by experienced surgeons [16][17]. However, it is important to note that complications such as cement leakage, while relatively rare, remain a concern in vertebroplasty, as highlighted in several studies [18].

Conclusion

This study highlights that both vertebroplasty and spinal reconstruction offer significant improvements in pain relief, disability reduction, and quality of life for patients with osteoporotic vertebral compression fractures, with vertebroplasty showing the most pronounced benefits. The Visual Analog Scale (VAS) and Oswestry Disability Index (ODI) scores demonstrated substantial reductions in both surgical groups, with the vertebroplasty group exhibiting the greatest improvements. The SF-36 scores further indicated improvements in physical and mental health, particularly in the vertebroplasty and spinal reconstruction groups. Conservative management, while effective, resulted in less dramatic improvements. The low incidence of complications in the surgical groups further supports the use of these interventions for appropriate candidates. Ultimately, the findings underscore the importance of patient selection in determining the optimal treatment strategy for OVCF.

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