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ORIGINAL STUDY

Cement augmentation for vertebral fractures in patients with multiple myeloma

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Objective of our study was to assess the outcome of cement augmentation in patients with multiple myeloma. We reviewed 12 patients with 48 vertebral fractures. Mean age was 62.5 years. Average length of follow-up was 27.5 months. Expected survival was less than 12 months in 2 patients and more than 12 months in the remaining patients. After surgery mean survival was 32.5 months. Mean correction in vertebral angle was 3.6°. Karnofsky score was more than 70 in 5 patients, 50-70 in 6 and less than 50 in 1 patient preoperatively, while it was more than 70 in all patients postoperatively. Preoperative mean ODI was 72%. After surgery it was 46% at 6 weeks and 14% at 12 months. All patients reported improvement in their pain status after surgery. Cement augmentation is a safe and effective way of treating symptoms of multiple myeloma, which occur due to vertebral metastases. It results in excellent pain control and improvement in quality of life.

Keywords : kyphoplasty ; vertebroplasty ; vertebral stents ; metastatic spine disease ; plasmacytoma.

Abbreviations

ODI ; Oswestry Disability Index
MTS ; Modified Tokuhashi Score
VA ; Vertebral Angle
VAS ; Visual Analogue Scale
PMMA ; Polymethyl methacrylate

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INTRODUCTION

Vertebral compression fractures are common sources of morbidity in cancer patients. Compression is the result of axial loading or hyperflexion of vertebral column. Vertebral fractures may be asymptomatic, may present with variable severity of pain and are not typically associated with neurological deficit. Multiple myeloma is the most common malignancy affecting the skeletal system. The main symptoms in multiple myeloma are caused by skeletal destruction that results from a shift in the normal balance between bone formation and bone resorption towards increased bone loss. These symptoms include bone pain, malaise, anaemia,

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renal insufficiency, hypercalcemia and physical deformity due to recurrent vertebral fractures. Vertebral fractures secondary to multiple myeloma may not be painful, but they are associated with impaired quality of life, increased mortality and significant morbidity. In addition, severe physiological and functional disabilities have negative impacts on pulmonary capacity, nutritional status, psychological wellbeing and overall quality of life (*1*). Painful vertebral fractures also increase the risk of new fractures and the number of hospitalizations (*3,4*). Contrary to other metastatic tumours, the lytic process observed in myeloma is different, as the bone destruction is not followed by new bone formation (*17*). Treatment for multiple myeloma includes chemotherapy and radiotherapy to control the disease and bisphosphonates to deter bone destruction. These treatment modalities are associated with variable outcome. Unfortunately, multiple myeloma is still incurable ; however, survival rates and quality of life are steadily improving due to advancements in medical treatment and more frequent use of cement augmentation techniques (kyphoplasty, vertebroplasty and vertebral body stents). Cement augmentation has shown the benefits of early pain relief and improved functional status in patients with painful pathological spinal fractures. Studies have shown that balloon kyphoplasty also provides long-term benefits to improve pain and disability (*1*). Cement leakage outside the vertebral body has always been the main concern in vertebroplasty. Kyphoplasty on the other hand, has been associated with loss of vertebral height once the balloon was deflated. Vertebral body stents were developed recently and introduced into clinical practice after experimental studies on cadaveric spines and animal models (*15*). The objective of our study was to analyse the efficacy and safety of cement augmentation techniques and to assess the survival and outcome of patients with vertebral fractures secondary to multiple myeloma.

PATIENTS AND METHODS

We performed a retrospective review of patients with vertebral body fractures secondary to multiple myeloma, treated with cemented augmentation techniques. Patients with myeloma who had instrumented stabilization were not included. Data were collected over 3 years' duration (2009 to 2011). Patients included in this study were non-consecutive admissions in a large teaching hospital. They were referred from other specialties including oncology, haematology, medical specialty and orthopaedic units from district general hospitals in the local area. Medical records review included demographic details, duration of symptoms, functional assessment using Karnofsky performance score and Oswestry disability index (ODI). Expected survival analysis was done using Modified Tokuhashi score (MTS). Vertebral body angle (VA) was recorded preoperatively as well as postoperatively to assess the correction achieved. Visual analogue scale (VAS) was used to assess pain level. All patients had magnetic resonance imaging (MRI) scans of the whole spine prior to surgery along with routine blood investigations and skeletal survey to identify other lytic lesions. Nine patients also had computed tomography (CT) scans to assess the integrity of the posterior wall of the concerned vertebrae. Surgery was performed under general or spinal anaesthesia depending on the level involved and co-morbidities. All patients were operated on in laminar flow theatres using biplanar fluoroscopic guidance by 2 senior spinal surgeons (ZK and RB). Careful intraoperative monitoring was done to prevent and identify cement leakage. Haemodynamic status of the patients was monitored during surgery while infiltrating the cement into the vertebral body. PMMA (Polymethyl methacrylate) cement was used for all patients. We restricted the number of levels of vertebral bodies to a maximum of 4 during a single session of surgery in a single patient in order not to exceed the total amount of cement more than 20 ml. Postoperatively, sensory, motor and circulatory functions of the lower extremities were monitored on the ward. The patients were allowed to mobilize without any restriction with the help of physiotherapists. After discharge from hospital, they were then followed up at 6 weeks, 6 months and 12 months stages with up to date x-rays and assessments of their pain score and functional status using standardised questionnaires. We applied chi square test to analyze the significance of expected outcome and used confidence interval to analyze the improvement in functional status and pain score.

RESULTS

We reviewed 12 patients with 48 vertebral compression fractures including 9 male and 3 female patients. Average age was 62.5 years (41 to

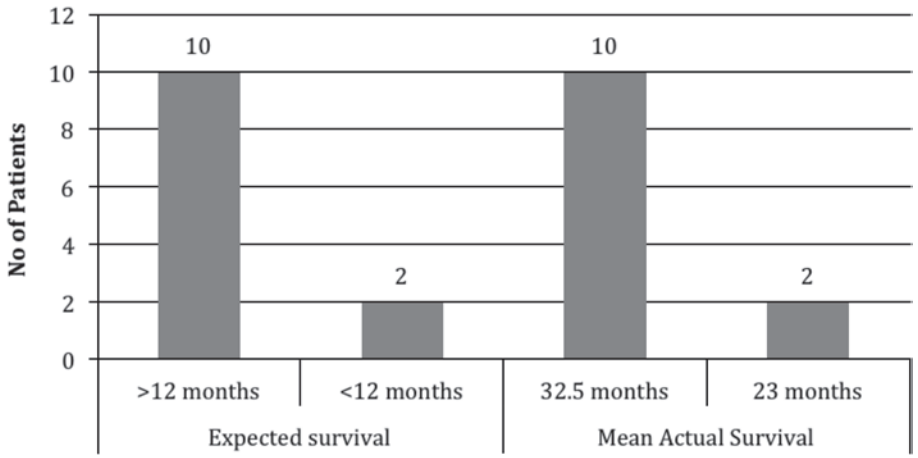

Fig. 1. — Expected and actual survival

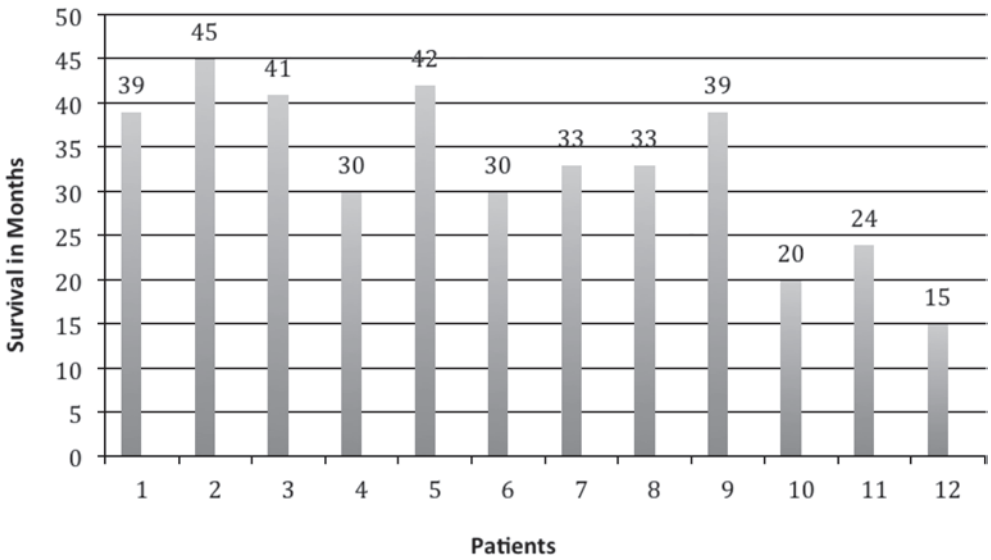

Fig. 2. — Actual survival in months in all patients

85 years). Five patients had single level vertebral fracture while 7 patients had multiple fractures at different levels in thoraco-lumbar spine. Average length of follow-up was 27.5 months (12 to 42 months).

Based on Modified Tokuhashi score, the expected survival was less than 12 months in 2 patients and more than 12 months in the remaining patients. Ten patients are alive with an average duration of 32.5 months (15 to 45 months) after their surgery. None of these patients were lost to follow up and are being reviewed at one yearly interval for an intended long-term follow up. Two patients died, with mean survival of 23 months after their initial surgery (Fig. 1, 2). We found these results to be clinically significant, however, base on calculated p value of 0.54 ($p > 0.05$), the results did not reach statistical significance.

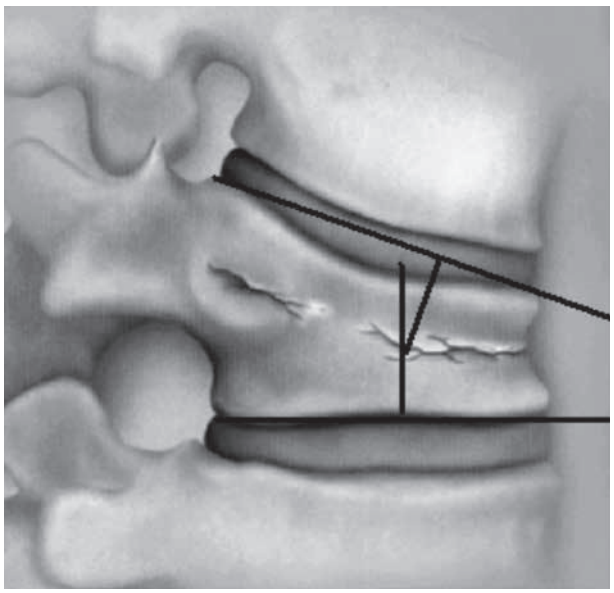

Fig. 3. — Vertebral body angle

Vertebral body angle was measured by drawing a line across the superior and inferior end plate of the concerned vertebral body. The angle subtended by two lines drawn perpendicular to the end plate lines was the vertebral angle (Fig. 3). Prior to correction, mean vertebral angle (VA) was 10.6° (2.3° to 25.2°) and after cement augmentation it was 7.0° (1.6° to 22.8°). The mean correction achieved was 3.6° (Fig. 4). There was no loss of vertebral height in any patient until their last follow up.

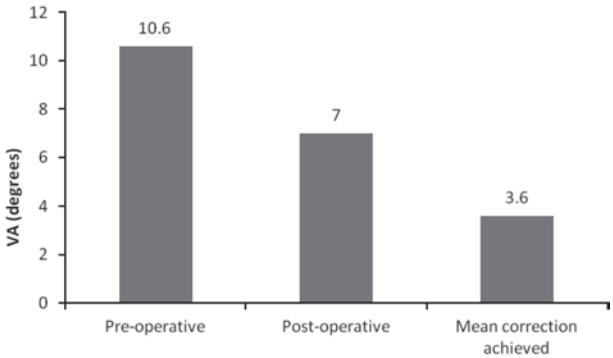

Fig. 4. — Mean vertebral body angle

Preoperative assessment of functional status and disability showed Karnofsky performance score of more than 70 in 5 patients, 50-70 in 6 and less than 50 in 1 patient indicating worsening functional status with decreasing score. Postoperatively, it improved to more than 70 in all patients (Fig. 5). Preoperatively the mean Oswestry disability index score was 72%. After surgery it was 46% at 6 weeks, 30% at 6 months and 14% at 12 months follow up (95% confidence interval : 5.39-13.49), indicating gradual improvement in the functional status of our patients (Fig. 6).

All patients reported improvement in their pain status after surgery. Prior to correction, mean VAS was 8.7. Postoperatively mean VAS was 4.0 at 6 weeks, 2.9 at 6 months and 1.5 at 12 months follow up (95% confidence interval : 0.81-2.19), indicating gradual improvement in pain status (Fig. 7).

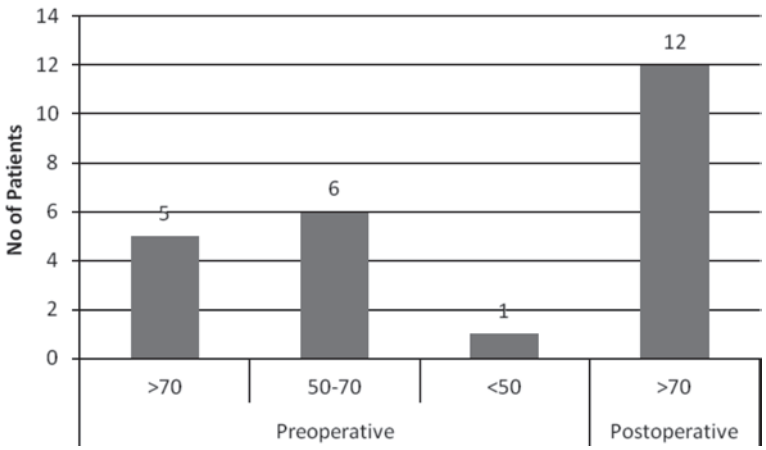

Fig. 5. — Karnofsky performance score

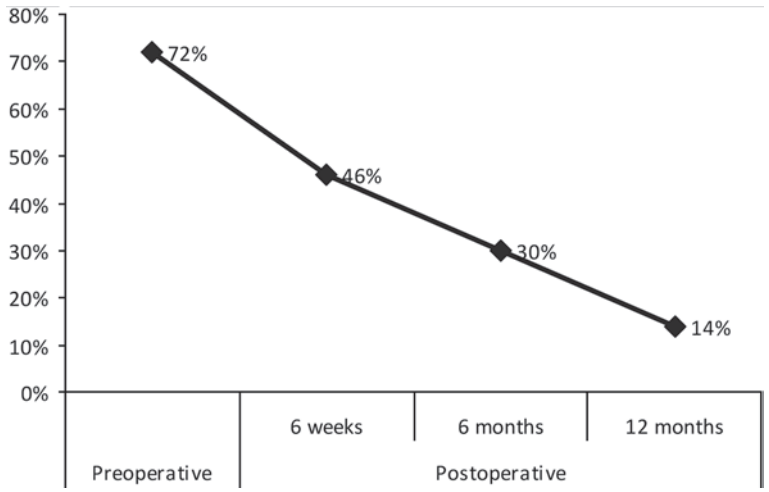

Fig. 6. — Oswestry disability index

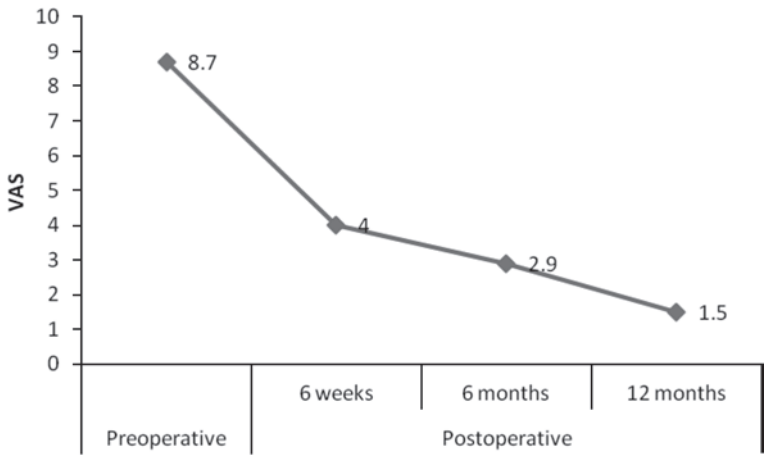

Fig. 7. — Visual analogue scale

Kyphoplasty was the main cement augmentation technique used in our patients, however, 1 patient had vertebroplasty and 1 had vertebral body stenting performed for compression fracture. All patients had chemotherapy and radiotherapy, either before or after surgery, depending on the extent of their disease. No major procedure-related complications were seen during or after surgery ; however there was a minor leakage of cement in 1 patient without leading to any clinical consequence. There was no episode of haemodynamic instability in any of our patients during or immediately after the surgical procedure. Mean volume of cement injected for a single vertebral body was 7.7 ml. Mean radiation time in theatre was 2 minutes and 43 seconds per patient and 56 seconds per vertebral level. Cement leakage was excluded by evaluation both intra-operative and postoperative plain radiographs of the operated sites in all patients.

DISCUSSION

The incidence of multiple myeloma is estimated to be between 0.9 and 9.5 per 100,000 per year worldwide (*2,8,9*). The first patient with multiple myeloma was reported by Solly in 1844 and was treated with rhubarb pills, orange peel infusions, and opiates (*16*). Deramond *et al* reported the first

successful application of cement augmentation (vertebroplasty) for a patient with vertebral fracture secondary to multiple myeloma (*6,7*).

Surgical treatment for pathological spinal fractures secondary to multiple myeloma has progressed rapidly over last 3 to 4 decades. In the 1970s and 1980s, acrylic and ceramic vertebral prostheses were used to replace the painful osteolytic vertebrae (*5,10,13*). Macroscopically, multiple myeloma is a very soft vascular tumour, as evidenced by the backflow of blood from the working cannulae during kyphoplasty. The near fluid consistency of the tumour makes it easy for thick cement to displace it and results in impressive cement filling of the vertebra.

Vertebroplasty has been in practice for the last 3 decades. It involves injecting low viscosity cement under high pressure, with risk of cement leakage outside vertebral body, potentially leading to nerve root symptoms, paralysis and pulmonary embolism ; however in clinical practice the frequency of these complications is very rare. Other complications include local or systemic reactions to cement. Kyphoplasty, on the other hand, involves creating a cavity in vertebral body by balloon inflation followed by filling of high viscosity cement under much smaller pressure. Kyphoplasty aims to restore vertebral body height in case of recent collapse and provides an increased resistance to compressive strength resulting in prevention of further compression fracture (*11*). This helps in immediate weight bearing and prevention of worsening of the pathological fractures. In addition, the exothermic reaction developed during the polymerization of the cement exerts a local cytotoxic action against the tumour also resulting in the reduction of pain. Cement leakage can still occur during kyphoplasty, the incidence however is between 4% and 9%, being lower than vertebroplasty. To overcome this potentially concerning problem, eggshell technique has been developed to fill the cavity appropriately and complete the procedure safely rather than aborting it (*9*). This technique can be used whenever indicated during kyphoplasty in cases of brittle bones in order to minimize the risk of cement leakage. Kyphoplasty has also been associated with loss of vertebral height once the balloon was deflated. To overcome this potential problem, recently vertebral body stents were introduced into clinical practice. The results of this technique in myeloma as well as other metastatic tumours are preliminary but have been found to be encouraging as they have provided

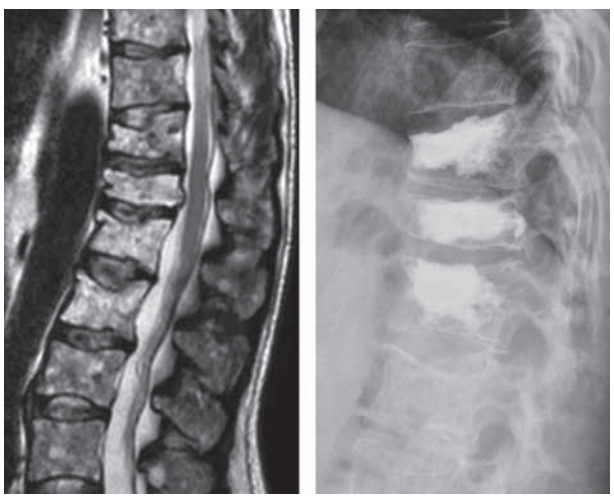

Fig. 8. — 57 years male who presented with intractable pain and disability, had kyphoplasty at T12, L1, L2 and had excellent outcome.

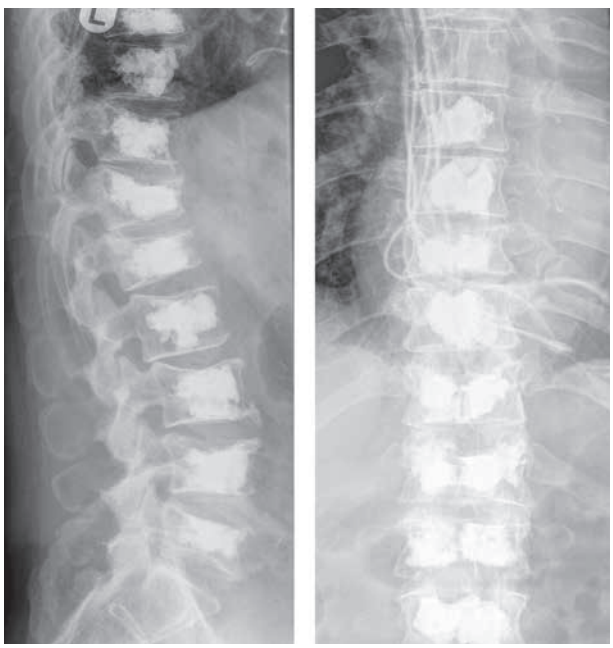

Fig. 9. — 69 year old male who presented with multiple fractures at different intervals and had kyphoplasty at multiple levels with satisfactory outcome.

excellent pain relief and have maintained the vertebral height in contrast to balloon kyphoplasty (*12*).

In our study, the efficacy and safety of cement augmentation was assessed. Efficacy of the procedure was evident by the improvement in the functional status of our patients. Patients who required assistance in their daily needs including mobilization due to intractable pain and physical deformity, improved after surgery to independent mobility status and self-care, while the remaining patients were able to maintain their independent mobility status. Cement augmentation led to steady improvement in the pain status postoperatively when patients were assessed at regular intervals. Kyphotic angle was found to be better after surgery, which improved physical deformity caused by vertebral compression (Fig. 8, 9). These factors resulted in improvement in overall quality of life. Safety of the procedure was observed at each step, taking into account, all the necessary precautions. The procedure did not result in haemodynamic instability or clinically significant cement leakage in any of our patients. The adjuvant treatments including radiotherapy, chemotherapy, bisphosphonates and analgesics helped synergistically, resulting in better overall survival of these patients. Unlike some authors who adhere to conservative treatment until vertebral collapse occurs, we advocate early intervention, even with insignificant collapse, to avoid acute onset of deformity with rare but possible major deformity or even with neurological deficit.

CONCLUSION

Cement augmentation of vertebral fractures secondary to myeloma results in improvement of pain, functional status, overall quality of life and survival. It is safe and effective way of helping the patients' symptoms suffering from an incurable disease. With recent advancements in this technique, the potential shortcomings of traditional method can be overcome ; however prospective review with more cases is required for further analysis.

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