

Minimally Invasive Treatment of Osteoporotic Vertebral Compression Fracture

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Background: The use of percutaneous vertebroplasty (PV) to treat osteoporotic vertebral fractures is increasing. This investigation assesses the efficacy and safety of PV for refractory pain owing to osteoporotic vertebral compression fractures.

Methods: A retrospective investigation of PV was conducted with a minimal of 1 year follow up. PV with polymethylmethacrylate (PMMA) was performed on 75 patients with osteoporotic vertebral compression fractures that responded poorly to the conservative therapy. Patients were asked to quantify their degree of pain using Huskisson's visual analogue scale to assess the clinical results.

Results: Eighty-seven vertebrae treated using PV in 70 patients were evaluated with a minimal of 1 year follow up. Pain, as assessed on the VAS, decreased from 80 ± 16 mm before PV to 36 ± 28 mm at 1 month after PV and 30 ± 19 mm at the most recent follow up. The reduction in pain from the baseline to 1 month ($p=0.031$) and to final follow up ($p=0.023$) were both statistically significant. Sixty-two patients (85.5%) quickly returned to their pre-injury activity level and achieved better quality of life.

Conclusions: PV is effective in pain reduction for painful vertebral compression fractures. It provided significant pain relief. Skillful techniques and careful safeguards can minimize the risks of PMMA migration.

(*Chang Gung Med J* 2004;27:261-7)

Key words: percutaneous vertebroplasty, osteoporosis, vertebral compression fracture.

Vertebral compression fracture is the most common complication of osteoporosis. Vertebral fractures may result in persistent severe pain, limited mobility and significantly impact the quality of life. Conservative therapy using external bracing, bed rest and analgesic are necessary for pain control in these patients. However, some patients may experience protracted or ongoing pain even with these measures.⁽¹⁾

Augmentation of vertebral compression fracture

with polymethylmethacrylate (PMMA), percutaneous vertebroplasty (PV) was first described by Galibert in 1987 for vertebral hemangiomas.⁽²⁾ Recently, this new method was introduced as a therapeutic alternative for treating other pathological entities, such as vertebral metastases, myelomas, and osteoporotic compression fractures.⁽³⁻⁷⁾

We began to treat osteoporotic compression fractures with PV in March 2001. The current study presents the therapeutic technique, complications,

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Received: Jul. 26, 2003; Accepted: Jan. 15, 2004

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and treatment outcomes as well as reviews of the relevant literatures.

METHODS

Patients with definite evidence of a recent vertebral compression fracture along with severe back pain and failed to receive management using conservative treatment were recruited. The pain frequently radiated along the ribs to the chest or abdomen. Neurological evaluations were performed to assess possible radiculopathy. Radiological evaluations included plain radiography and magnetic resonance image (MRI) of the spine. Exclusion criteria included coagulopathy, infection, evidence of radiculopathy from a retracted fracture, and pain unrelated to the compression fracture. The surgical procedures, indications, benefits, risks, and possible complications of PV were explained to the patients and their families.

Surgical technique

At first, the procedure was performed with the patient under general anesthesia. However, as the technique evolved and our experience increased, we

began to employ local anesthesia and conscious sedation. The anesthesiologist constantly monitored the patient's clinical status including blood pressure, EKG, and oxygen saturation. Intravenous neuroleptic anesthesia using small doses of narcotic (fentanyl) may be required for some patients. The patient was put in prone position. The skin was prepared and draped in standard aseptic fashion. The fracture level was visualized fluoroscopically and the needle entry site overlying its pedicles was localized. A small skin incision was made over the center of the pedicle using an 11 # scalpel blade. A 10-gauge bone biopsy needle (Stryker Instrument, Kalamazoo, Mich, USA) was positioned with its tip at the center of the pedicle and advanced until the stylet tip abutted the bone. Under biplane fluoroscopic guidance, the needle was advanced with a mallet through the mid-portion of the pedicle and into the collapsed vertebral body. The needle placement clearly required frequent checking using a fluoroscope to ensure maintenance of its optimal location. The needle tip ultimately advanced to reach the anterior third of the fractured vertebral body.

The PMMA cement was prepared once the needle placement was satisfactory. Twenty grams of the

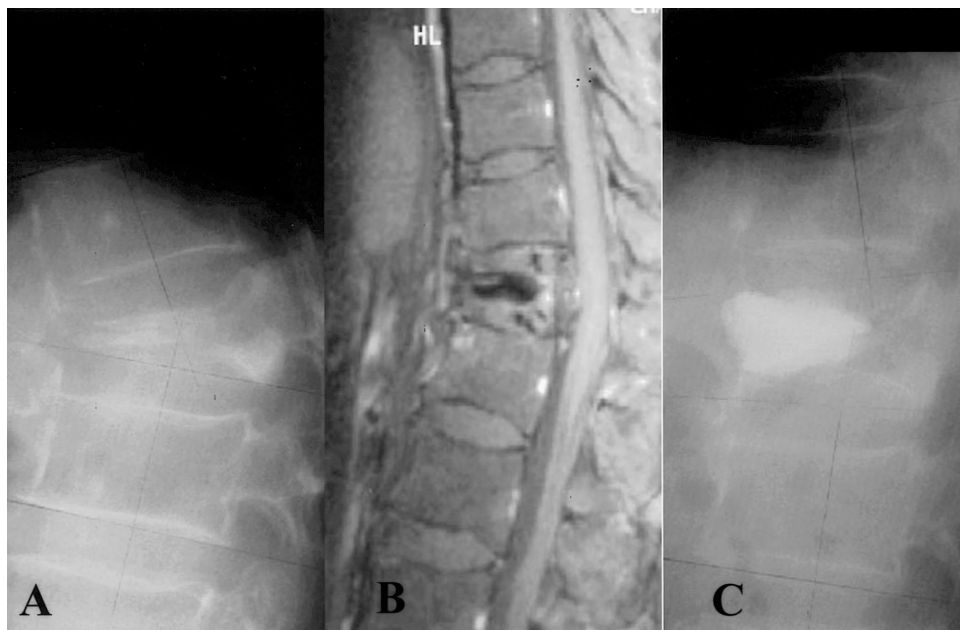


Fig. 1 (A) and (B) Lateral view of plain X ray and MRI showed T12 vertebral compression fracture with nonunion (C) PMMA cement in the vertebral body after vertebroplasty

PMMA polymer powder was used with 3 additional grams of barium sulfate for adequate fluoroscopic monitoring during delivery. The cement mixture was allowed to polymerize at room temperature until it had a paste-like consistency necessary for controlled injection. The mixture was transferred to a 10-ml plastic syringe. Using a special screw syringe compressor, the PMMA in the 10-ml plastic syringe could be slowly and steadily applied. Continuous fluoroscopic monitoring during injection prevented overfilling or extension into the spinal canal or neural foramen. Injection was stopped when the cement occupied the posterior one-third of the vertebral body, or if epidural venous filling was suggested. When sufficient PMMA crossed the midline of the vertebral body, the opposite pedicle did not require exploration. However, when filling did not occur across the midline, then the contralateral pedicle was localized and the procedure was repeated. Upon the completion of the PV, the needle was removed and hemostasis at the puncture site was achieved by the applying gentle pressure to the wound. After the procedure, the patient ambulated with a thoracolumbar brace support and was discharged within 24 hours of the procedure. Clinical follow-up examinations involved a spinal X-ray evaluation (Fig. 1) and a questionnaire to assess pain and mobility. Surgical results were assessed by asking patients to quantify their degree of pain on Huskisson's visual analogue scale (VAS: 0 mm=no pain; 100 mm=the most pain possible) on three separate occasions: before PV, 1 month after PV, and at final follow-up after PV. The group's VAS values were compared using the Wilcoxon signed rank non-parametric test. The patients were also asked to compare their ambulatory status, the ability to sleep comfortably, and analgesic requirements before and after PV. After PV, they selected one of three possible responses for each including significantly improved, worse, or approximately the same. As an overall assessment of well being, patients were asked whether they thought that the procedure had significantly enhanced their quality of life.

RESULTS

Seventy-five patients were treated using PV during a 15-month period. Five cases did not finish at least 1 year of follow up. One case died of cancer,

two cases suffered from cardiovascular accident and two cases were lost to follow up. Thus, 87 vertebrae (45 lumbar, 42 thoracic) treated using PV in 70 patients (62 women, 8 men), with at least 1 year of follow up were available for evaluation. The ages of these patients ranged from 62 to 91 years (mean, 70.2 years). All of the patients with osteoporotic compression fractures suffered from disabling pain that limited their mobility and substantially altered their quality of life. The mean duration of symptoms was 8 months (range, 2.5 to 20 months) and symptomatic levels were identified using correlated the clinical data with spinal MRI findings in these patients.

The fractured vertebrae extended from T6 to L4, and were predominantly located around the thoracolumbar junction. The most common fracture site was T12. The quantity of PMMA injected per vertebral body varied from 2.5 to 13 milliliters. The volume depended on the level of the fracture site and the severity of the compression fracture. Sixty-eight vertebrae (80%) in this study were treated via unicpular puncture.

The patients were asked to quantify their degree of pain on the Huskisson's visual analogue scale (VAS; 0 mm=no pain, 100 mm=most pain possible) before PV, on the first day after PV, 1 month after PV and at the time of the study. Pain scale decreased from 80 ± 16 mm at the baseline to 38 ± 24 mm on the first day after PV, 36 ± 28 mm at 1 month after PV, and 30 ± 19 mm at the final follow-up. The reductions in pain from the baseline to 1 month ($p=0.031$) after PV and at the final follow up ($p=0.023$) were both statistically significant. However, no statistical differences existed between the degree of pain at 1 month after PV and at the final follow up. Six (8.6%) patients had no significant pain relief, but no patient reported worsening of pain post-operatively. Sixty-two cases (85.5%) quickly returned to their pre-injury activity level and achieved improved life quality.

Complications

For 32 vertebra (37.6%), radiographs revealed evidence of PMMA leakage through the end plate fracture site into either the disc space or paravertebral space, without evidence of clinical symptoms except for one patient that required surgical decompression (Fig. 2). Cement embolism was demonstrated on the chest radiograph of one patient with

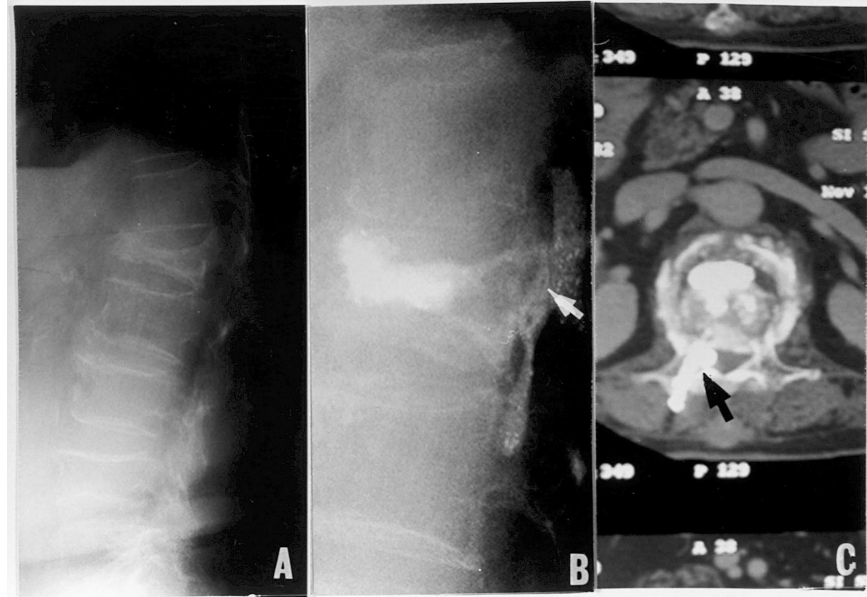


Fig. 2 (A) Lateral view of L1 compression fracture for 5 months after minor trauma (B) and (C) Arrows showed PMMA cement leakage on plain X-ray and CT after vertebroplasty

mild cough symptoms but no dyspnea occurred, and cough had subsided after symptomatic treatment. Ten patients developed adjacent fracture at the proximal vertebra. Four of these patients required further vertebroplasty to treat back pain after the failure of conservative therapy.

DISCUSSION

PV is a new procedure with the percutaneous injection of PMMA into a fractured vertebral body. It provides pain relief and bone strengthening of weakened vertebral bodies. PV is effective in treating aggressive hemangiomas, bone metastases, and multiple myeloma with fast and significant pain relief. Due to large number of benefits, vertebroplasty has been proposed for use in treating vertebral compression fractures. The European experience declared 90 to 100% of pain relief.⁽⁴⁻¹¹⁾

The mechanism of PMMA injection with pain relief is not understood. Several hypotheses have been suggested. The mechanical, vascular, chemical, and thermal effects of cement might account for the destruction of nerve endings. Stabilization of microfractures and the reduction in mechanical stress

may also play a role.^(4,8,9) In the present study, the patients' symptoms were significantly improved. Vertebroplasty had a favorable influence on the patients' quality of life.

Patients with osteoporotic vertebral compression fractures and spinal kyphotic deformity have reduced pulmonary function (forced vital capacity and forced expiratory volume). Pulmonary function is most commonly compromised with thoracic fractures, but also can be compromised with lumbar fractures.⁽¹²⁾ General anesthesia with endotracheal tube may increase numerous co-morbid conditions in these elderly patients. Consequently, PV under local anesthesia should be considered. A conscious patient allows for the neurological monitoring during the PV. Almost all the patients in this series tolerated the procedure well under local anesthesia with or without conscious sedation.

The unipedicle approach is the preferred method for several reasons. It requires less time, and it is simple. Thus, the risk of complications is reduced. Biomechanical studies on cadavers have shown that PMMA immediately improves the vertebral body strength regardless of single or bilateral pedicle injection.⁽¹³⁾ Biomechanical studies also suggested

that strengthening of the vertebral body was independent of the amount of PMMA used. Indeed, our study showed that the surgeon achieved filling across the midline of the vertebral body in 80% of cases using unipedicle injection. If the cement cannot be delivered across the midline via a single pedicle, the opposite pedicle approach is needed.

However, minimally invasive PV does not imply minimal complications. PV inherits potential dangers from the leakage of PMMA into the venous system or through a gap of the fractured vertebra into the spinal canal. The present techniques cannot consistently eliminate the leakage of PMMA into unwanted locations. Extravertebral cement leakage has been reported in up to 65% of vertebrae treated with vertebroplasty, but mostly has not been clinically significant.^(5,7,8,14,15) Reported complications include radiculopathies, pulmonary embolism from PMMA, and infection. Cement leakage outside the vertebral body was observed in 37.6% of the treated patients in this study. One patient with a cement leak into the spinal canal warranted surgical decompression.

It is safe to perform PV at approximately 3 to 4 weeks after a fracture.^(16,17) The interval allows for consolidation of the fractured posterior elements and clotting of the venous plexus that helps to decrease the risks of leakage related to the introduction of relatively liquid cement. If the fracture is acute, there is a greater risk of bleeding and cement leak, because of the pressure necessary for injection may disrupt small vessels and may lead to extrusion of the cement through crevices in the bone.

The procedures used contain many safety measures.⁽¹⁸⁻²⁵⁾ The measures include image guidance with closed fluoroscopic monitoring is very important to ensure a precise transpedicular approach and cement injection. Mixing PMMA with barium for opacification is essential for early detection of leakage. The injection must be stopped immediately if cement leaks into the posterior 1/3 of the body under fluoroscopic guidance. A screw syringe compressor allows slow and steady injection of the cementing material. Over filling of the vertebral space is risky and should be avoided to reduce the possibility of cement extravasations. Cement of the appropriate viscosity should be injected with a paste like consistency being preferred to a liquid mobile consistency. These modifications can minimize unintentional migration of PMMA.

Adjacent fractures after percutaneous vertebroplasty are commonly reported. Grados reported a slight but significantly increased risk of vertebral fracture in the vicinity of a cemented vertebrae compared with an uncemented one.⁽¹⁷⁾ Increased stiffness of the cement-augmented vertebrae alters the biomechanics of the load transfer to the adjacent vertebrae.⁽²⁶⁾ a stress- riser effect and significant disparity in biomechanical properties between the two involved vertebral bodies may cause the early failure of the adjacent non-augmented level.

In conclusion, PV is an effective procedure for painful osteoporotic compression fractures. It provided significant pain relief. However, significant complications can occur and they are likely underreported. Skillful techniques and careful safeguards can minimize the risks of PMMA migration.

REFERENCES

1. Melton LJ. Epidemiology of spinal osteoporosis. *Spine* 1997;22:2S-11S.
2. Galibert P, Deramond H, Rosat P, Legars D. Note preliminaire sur le traitement des angiomes vertebraux par vertebroplastie percutanee. *Neurochirurgie* 1987;33:166-8. *Rachis* 1989;2:143-53.
3. Deramond H, Galibert P, Debussche C. Vertebroplasty. *Neuroradiology* 1991;33(Suppl.):177-8.
4. Deramond H, Galibert P, Debussche-Depriester C, Pruvo JP, Heleg A, Hodes J. Percutaneous vertebroplasty with methylmethacrylate: technique, method, results. *Radiology* 1990;177P:352.
5. Weill A, Chiras J, Simon J, Rose M, Sola-Martinez T, Enkaoua E. Spinal metastases: indications for and results of percutaneous injection of acrylic surgical cement. *Radiology* 1996;199:241-7.
6. Cotten A, Dewatre F, Cortet B, Assaker R, Leblond D, Duquesnoy B. Percutaneous vertebroplasty for osteolytic metastases and myeloma: effects of the percentage of lesion filling and the leakage of methyl-methacrylate at clinical follow up. *Radiology* 1996;200:525-30.
7. Cortet B, Cotten A, Boutry N, Dewatre F, Flipo RM, Duquesnoy B. Percutaneous vertebroplasty in patients with osteolytic metastases or multiple myeloma. *Rev Rhum Engl Ed* 1997;64:177-83.
8. Cortet B, Cotten A, Boutry N, Flipo RM, Duquesnoy B, Chastanet P. Percutaneous vertebroplasty in the treatment of osteoporotic vertebral compression fractures: an open prospective study. *J Rheumatol* 1999;10:2222-8.
9. Debussche-Depriester C, Deramond H, Fardellone P, Heleg A, Sebert JL, Cartz C. Percutaneous vertebroplasty with acrylic cement in the treatment of osteoporotic vertebral crush fracture syndrome. *Neuroradiology* 1991;

- 33S:149-52.
10. Gangi A, Kastler BA, Dietemann JL. Percutaneous vertebroplasty guided by a combination of CT and fluoroscopy. *AJNR Am J Neuroradiol* 1994;15:83-6
 11. Bird SB, Dickson EW: Clinically significant changes in pain along the visual analog scale. *Ann Emerg Med* 38: 639-43.
 12. Leech JA, Dulberg C, Kellie S, Porttee L, Gay J. Relationship of lung function to severity of osteoporosis in women. *Am Rev Respir Dis* 1990;140:68-71.
 13. Tohmeh AG, Mathis JM, Fenton DC, Levine AM, Belkoff SM. Biomechanical efficacy of unipedicular versus bipedicular vertebroplasty for the management of osteoporotic compression fractures. *Spine* 1999;24:1772-6.
 14. Padovani B, Kasriel O, Brunner P, et al. Pulmonary embolism caused by acrylic cement: A rare complication of percutaneous vertebroplasty. *AJNR Am J Neuroradiol* 1999;20:375-7
 15. Barr JD, Barr MS, Lemley TJ, McCann RM. Percutaneous vertebroplasty for osteoporotic vertebral compression fractures. *Bone* 1998;5(Suppl.):617.
 16. Garfin SR, Reilley MA. Minimally invasive treatment of osteoporotic vertebral body compression fracture. *The Spine Journal* 2000;2:76-80.
 17. Grados F, Depriester C, Cayrolle G. Long-term observations of vertebral osteoporotic fractures treated by percutaneous vertebroplasty. *Rheumatology* 2000;39:1410-4.
 18. Jensen ME, Evans AJ, Mathis JM, Kallmes DF, Cloft HJ, Dion JE. Percutaneous polymethylmethacrylate vertebroplasty in the treatment of osteoporotic vertebral body compression fractures: technical aspects. *AJNR Am J Neuroradiol* 1997;18:1897-904.
 19. Mathis JM, Petri M, Naff N. Percutaneous vertebroplasty treatment of steroid-induced osteoporotic compression fractures. *Arthritis Rheum* 1998;41:171-5.
 20. Mathis JM, Barr JD, Belkoff SM. Percutaneous vertebroplasty: A developing standard of care for vertebral compression fractures. *AJNR Am J Neuroradiol* 2001;22: 373-81.
 21. Moreland DB, Landi MK, Grand W. Vertebroplasty: techniques to avoid complications. *The Spine Journal* 2001; 66-71.
 22. O'Brien JP, Sims JT, Evans AJ. Vertebroplasty in patients with severe vertebral compression fractures: A technical report. *AJNR Am J Neuroradiol* 2000;21:1555-8.
 23. Harrington KD. Major neurological complications following percutaneous vertebroplasty with polymethylmethacrylate: A case report. *J Bone Joint Surg Am* 2001; 83:1070-3.
 24. Jang JS, Lee SH, Jung SK. Pulmonary embolism of polymethylmethacrylate after percutaneous vertebroplasty -- a report of three cases. *Spine* 2002;27:E416-8.
 25. Lee BL, Lee SR, Yoo TY. Paraplegia as a complication of percutaneous vertebroplasty with polymethylmethacrylate - a case report. *Spine* 2002;27:E419-22.
 26. Belkoff SM, Mathis JM, Erbe EM. Biomechanical evaluation of a new bone cement for use in vertebroplasty. *Spine* 2000;25:1061-4.

微創手術以椎體修補術治療骨質疏鬆所造成的脊椎椎體骨折

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背景： 使用椎體修補術治療骨質疏鬆引起脊椎骨折，在國內外風行增加中，本報告提出這種微創手術治療成效及其安全性的臨床經驗。

方法： 這是經皮膚穿刺椎體修補術的回溯性臨床研究，以此種微創手術，用來治療因骨鬆症造成椎體骨折保療方法失敗的病人，共有75位。我們根據病人疼痛的減輕描述並評估臨床結果。

結果： 其中70位病人（共87個椎體以經皮膚穿刺椎體修補術治療），接受至少一年以上的追蹤研究。病人疼痛指數由術前為 80 ± 16 mm到術後一個月為 36 ± 28 mm，這種程度的疼痛減輕具統計意義；至於病後追蹤疼痛指數則為 30 ± 19 mm。62位病人（85.5%）術後疼痛有明顯有效減輕而回復一般日常行走和活動以維持更好的生活品質。

結論： 當然此微創手術仍有其危險性如感染、導針錯置及骨水泥外漏引起神經功能損傷。但如由專業的醫師診斷，篩選適當病人作此新療法—脊椎椎體修補術，在可能最少併發症下，使骨鬆症引起壓迫性骨折的病人獲得最佳臨床滿意結果。
(長庚醫誌 2004;27:261-7)

關鍵字： 經皮膚椎體修補術，骨質疏鬆症，脊椎壓迫性骨折。