Percutaneous Vertebroplasty Using Hydroxyapatite Blocks for the Treatment of Vertebral Body Fracture

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Abstract

Vertebroplasty with hydroxyapatite blocks through a modified percutaneous approach was used to treat 30 patients with vertebral body fractures in 32 vertebral bodies between February 2003 and March 2007. The mean follow-up period was 16.6 months. The pain associated with this procedure, effects on adjacent vertebral bodies, and other complications were evaluated. The rate of recollapse after vertebroplasty was examined in 26 patients with 26 vertebral bodies treated and followed up for more than 3 months. Mean time of operation was 57 minutes and mean number of blocks used per vertebral body was 104. The mean visual analogue scale score was 7.0 preoperatively and 1.6 postoperatively. The mean decline in postoperative vertebral body height was 13%. New vertebral body fractures occurred postoperatively in 3 vertebral bodies in 2 patients. Leakage of blocks outside the vertebral body occurred in 2 patients during the operation, and after the operation in one patient, and the hydroxyapatite plug broke postoperatively in one patient. Hydroxyapatite blocks yielded good pain relief comparable to bone cement, with no serious complications such as a pulmonary embolism or leakage into the spinal canal, and are effective for percutaneous vertebroplasty.

Key words: percutaneous vertebroplasty, hydroxyapatite block, vertebral body fracture, vertebral body collapse

Introduction

Percutaneous vertebroplasty for vertebral body fracture is increasingly performed in Japan, although still less than in Europe and the United States. Liquid materials such as polymethylmethacrylate (PMMA) and calcium phosphate paste are commonly used as fillers for vertebral bodies. The conventional method provides adequate pain relief, but leakage of filler into the spinal canal may result in paraplegia, and rarely liquid flowing into a vein has caused pulmonary embolism. Vertebroplasty using solid hydroxyapatite blocks (Fig. 1 upper) was developed to avoid these serious complications. In the original method, the vertebral lamina is exposed with an approximately 5 cm midline skin incision at the level of the vertebral body, and the blocks are applied using originally designed instruments. Vertebroplasty using hydroxyapatite blocks achieves a high degree of pain relief equivalent to that obtained using PMMA. The mechanism of pain relief appears to involve improvement of the instability of the fractured vertebral body by the addition of blocks to the vertebral body.

We have developed a new percutaneous procedure for vertebroplasty, using both existing and new instruments with hydroxyapatite blocks. The present procedure is indicated for patients who have no neurological deficits but limits to their activities...
of daily living due to pain.

Materials and Methods

I. Patient population

Thirty patients, 23 females and 7 males aged 56 to 87 years (mean 72.3 years), were treated for compression fracture (bone fracture involving only the anterior wall of the vertebral body) or burst fracture (bone fracture involving both the anterior and posterior walls of the vertebral body) in 32 vertebral bodies between February 2003 and March 2007. New vertebral body fractures occurred in two patients during follow up, and the procedure was performed twice in one patient. Twenty-three patients had a clear history of injury such as falls and seven had osteoporosis. The cause of vertebral fracture was unidentified in one patient with dementia. Nineteen patients had 20 compression fractures, and 11 patients had 12 burst fractures. The interval between injury and operation ranged from 2 to 367 days (mean 32 days, median 9 days).

Two patients during the early period of this study were treated with the original method with an open wound. The new percutaneous method was performed in 30 vertebral bodies of 28 patients. The follow-up period was 0.7–49.7 months (mean 16.6 month). The numbers of bodies treated at each level of the vertebral column were as follows: T11 in 2, T12 in 9, L1 in 9, L2 in 4, L3 in 4, and L4 in 4. The indications for surgery were pain, tolerance of general anesthesia, vertebral pedicle greater than 7 mm at the narrowest point measured by computed tomography (CT), and no other neurological symptoms. The diagnosis was based on findings of low intensity on T1-weighted magnetic resonance imaging in all patients.

II. Surgical procedure

Vertebral fractures were examined on the 3-mm CT slice where the vertebral pedicle was largest to determine the direction of insertion of the hydroxyapatite blocks. The direction of insertion was oriented through the center of the vertebral pedicle at an angle inclined at 10–15 degrees to the inside of the sagittal plane (Fig. 2).

Under general anesthesia, the patient was placed in the prone position and the upper part of the body was elevated slightly. Fluoroscopy was used to confirm the fractured vertebral body, and the fluoroscope was set to the angle determined by CT. Then a skin incision of 1.2 cm was made over both vertebral pedicles, and a Kirschner wire 1.5 mm in diameter was inserted manually into the vertebral pedicle (Fig. 3-1). The fluoroscope was moved to obtain a lateral view and the inner and outer dilators of the Vertebroplasty Guidance System (Medtronic Sofamor Danek, Memphis, Tenn., U.S.A.) were inserted along the Kirschner wire in the muscular layer. The inner dilator was replaced with a reamer, and a hole to the cortical bone of the vertebral lamina was opened just above the pedicle by turning the reamer manually (Fig. 3-2). The reamer and outer dilator were retracted, leaving the Kirchner wire, and the portal was established in the thickness of the muscular layer with a TRIK System Dilator (Koshiya, Inc., Kanazawa, Ishikawa). This portal functioned as the sheath for the tool for block insertion (Fig. 3-3). A guide stick for the vertebral body was inserted and the hole in the cortical bone was widened to 5-mm diameter along the Kirchner wire (Fig. 3-4). The guide stick was pulled out with the Kirchner wire and a larger guide stick was inserted into the vertebral body to enlarge the hole in the cortical bone to 6-mm diameter. Under fluoroscopy guidance, an inserter (Fig. 1 middle) was introduced into the center of the vertebral body and the inner pipe was removed to insert hydroxyapatite blocks into the vertebral body through the inserter (Fig. 3-5). The block was applied by removing the inserter and tapping an impacter with a nylon hammer (Fig. 3-6). This maneuver was performed several times to insert hydroxyapatite blocks into the vertebral body until 1/2–2/3 of the vertebral body was filled. A newly devised pedicle marker was inserted into the vertebral pedicle to compact the blocks, and the procedure was repeated on the opposite side of the vertebral body to achieve slightly greater packing of the blocks. When the vertebral body was filled with
Fig. 3 Diagrams illustrating the procedure of vertebroplasty using hydroxyapatite blocks. 1: A Kirschner wire is inserted into the pedicle under fluoroscope guidance. 2: The vertebroplasty guidance system is used for making a hole into the pedicle. The Kirschner wire is the guide for this procedure. 3: A portal is inserted using the TRIK System as a sheath. 4: A wider hole is made with the guide stick. 5: The inserter is guided into the vertebral body, then the lead hydroxyapatite blocks are inserted into the vertebral body using the inserter. 6: The vertebral body is filled with hydroxyapatite blocks with the impacter. 7: Procedures 5 and 6 are repeated to place more hydroxyapatite blocks into the vertebral body. A hydroxyapatite plug is led into the pedicle using the Kirschner wire. 8: The hydroxyapatite plug is forced into the pedicle deeply with the plug impacter.

hydroxyapatite blocks, the sound made by tapping of the impacter became low pitched, indicating that the body was adequately packed. Finally the vertebral pedicle was corked with a hydroxyapatite plug (Fig. 1 lower) using a plug impacter and returned to the left again, at the same level as on the right side to add more blocks and cork them with a hydroxyapatite plug (Fig. 3-7, 8). The portal was then withdrawn on both sides, and the fascia and skin were sutured with absorbable thread to complete the operation (Fig. 4).

III. Postoperative evaluation

A hard corset was constructed preoperatively for the patient and then applied after the procedure to allow walking. The anterior wall height of the vertebral body was measured on lateral radiographs before and after surgery to examine the change in height of the vertebral body. Pain was evaluated using a visual analogue scale (VAS) (maximum pain 10, painlessness 0) before and after surgery in all 30 patients who underwent vertebroplasty, as well as the effects of the procedure on adjacent vertebral bodies and any complications. Radiography was performed more than 3 months after surgery in 26 vertebral bodies in 26 patients to determine the degree of recollapse of the vertebral body after vertebroplasty. The independent two-sample t-test was used for statistical analysis, with probability values less than 0.05 considered significant.

Results

The procedure took from 33–99 minutes (mean 57 minutes) for all patients, but 33–52 minutes (mean 43 minutes) for the 10 most recent cases. The amount of bleeding was 5–240 ml (mean 85 ml, not including patients treated with the open method or with multiple vertebroplasties). A total of 34–240 (mean 104) blocks were used per vertebral body. VAS changed from 4.0–10 (mean 7.0) preoperatively to 0–7.0 (mean 1.6) postoperatively (Fig. 5). Patients who were able to walk before the injury could all stand up on the day after surgery.

The anterior wall of the vertebral body had recollapsed in many cases (Fig. 6), most frequently during...
2 months after operation, with the height of the vertebral body maintained afterwards. The postoperative rate of decline in height of the vertebral body was 0–41% (mean 13%) when measured after the 3rd postoperative month, compared to the height of the vertebral body just after surgery. No patient experienced recurrence of pain, even if loss of vertebral body height was marked. The rate of collapse after vertebroplasty was significantly higher (p < 0.05) in the burst fracture group (10 cases; 4–41%, mean 18%) than in the compression fracture group (16 cases; 0–29%, mean 9%). Rate of collapse was not correlated with either the number of blocks inserted into the vertebral body or the time between injury and surgery. The postoperative change in height of the vertebral body plateaued at 84–138% (mean 103%) of the height just before surgery, and collapse tended to occur to the height of the vertebral body just before surgery (Fig. 7).

New vertebral body bone fracture occurred in 3 vertebral bodies of 2 patients, caused by osteoporosis in both patients, and an old fracture of another vertebral body was also present from before the first operation. In addition, one of the two patients had undergone long-term use of steroids for other diseases. The times to new vertebral body fracture were 18 months, 18 months, and 5 months. Two of the three fractures occurred in an adjacent vertebral body after 18 months. The procedure was performed again on one vertebral body.

The hydroxyapatite plug fractured postoperatively in one case (Fig. 8). Hydroxyapatite blocks leaked from the vertebral body during the procedure in 2 cases and afterwards in one case, associated with paravertebral emphysema outside the vertebral body wall on CT just after surgery (Fig. 9).

**Discussion**

The final vertebral body height after vertebroplasty tended to be the same as that before vertebroplasty, and was not correlated with the quantity of filler added to the vertebral body. Clearly, only the hydroxyapatite blocks cannot maintain the height of the vertebral body, but the fractured vertebral body wall may contribute to maintenance of height. New fractures occurred at mean 13.7 months after vertebroplasty in 3 vertebral bodies of 2 patients. New bone fracture occurs after 1–3 months in 10–20% of patients postvertebroplasty using PMMA. New vertebral body fractures also occurred spontaneously after 1 year in about 18% of patients with old fractures.
Vertebral body fracture. In our series, since other old vertebral body fractures were recognized before first operation in all patients with a new fracture, the procedure is unlikely to have caused the new vertebral body fractures.

Leakage of hydroxyapatite blocks from the vertebral body was observed in 3 of the 32 vertebral bodies treated in this series, during the operation in 2 cases, and postoperatively in one case. Insertion of the blocks at the center of the vertebral body in the beginning of the procedure and then filling blocks anteriorly under fluoroscope guidance is important to avoid block leakage. Postoperative leakage of blocks was associated with paravertebral emphysema outside the vertebral body wall just after surgery, and required prolonging the postoperative period of rest. However, no symptoms were encountered and the patients were followed conservatively. The hydroxyapatite plug was broken in one case, probably caused by a facet joint when a plug was inserted insufficiently to a lacuna made for block filling.

The present percutaneous vertebroplasty procedure using hydroxyapatite blocks provided adequate pain relief, without serious complications such as pulmonary embolism or leakage into the spinal canal. Hydroxyapatite blocks appear to be an effective filling material for vertebroplasty and can be introduced percutaneously, similar to PMMA.

References

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In spite of recent articles from Europe and Australia, vertebroplasty is useful and effective in patients with compression spinal vertebral body fractures. Once techniques are adopted, many are looking for ways to improve a relatively safe procedure. There are up to 10 different ways to accomplish vertebral body support. Nishioka et al. have shown us a new technique using hydroxyapatite blocks. Such blocks seem to be very stable and are unlikely to migrate. In the future, multi-center clinical studies are needed where we truly compare some of these newer procedures. But that study could be expensive. Most likely, we will simply have to accept Class III data like this article. So we will have to encourage the authors to continue their work. Cost effectiveness may influence what procedures we adopt in the future.

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Nishioka and colleagues present a novel approach to percutaneous vertebroplasty using solid hydroxyapatite blocks as an alternative to liquid materials such as polymethylmethacrylate (PMMA) and hydroxyapatite paste. The rationale for this approach is to reduce and possibly eliminate rare but potentially devastating complications that can result when liquid materials extravasate beyond their intended margins. Neurologic complications such as pain, weakness, sensory changes, changes in bowel and bladder function, and paraplegia may result when liquid cement extends into the neural foramina or spinal canal. Cement leakage into the disk space has been proposed to increase the risk of adjacent level vertebral fractures, although recent evidence disputes this claim. Cement extravasation into the circulatory system can cause pulmonary embolism and death. Lee, in a recent meta-analysis of complications of percutaneous vertebroplasty for vertebral compression, found that the incidence of symptomatic cement leakage with vertebroplasty is 1.48%. The incidence of asymptomatic cement leakage may be as high as 75%. In this manuscript, Nishioka and colleagues have demonstrated that their procedure relieves pain related to vertebral fractures reducing mean visual analogue scale scores from 7.0 preoperatively to 1.6 postoperatively in thirty patients with thirty-two vertebral body fractures. The procedure can be done safely via a percutaneous technique (twenty-eight of the thirty patients; thirty vertebral bodies) with no incidents of major procedure-related complications such as neurologic decline secondary to block leakage into the spinal canal. Hydroxyapatite blocks leaked anteriorly from the vertebral body during the procedure in two cases and afterwards in one case thus in 3 out of the 32 vertebral bodies treated or 9.375%. Block leakage resulted in a prolonged period of postoperative rest without other clinical sequela. Some degree of loss of vertebral body height occurred after the procedure when evaluated by x-ray at 3 months. This was not associated with recurrence of pain, even with significant body collapse. The mean rate of loss of vertebral body height occurred significantly more rapidly in patients treated for burst fractures 18% vs. compression fractures 13% (p < 0.05). Two adjacent level fractures occurred in two patients with osteoporosis at 18 months. The average time need to perform the procedure was 43 minutes in the ten most recently performed cases by the authors. All patients underwent general anesthesia and mean blood loss was 85 ml.

The authors have shown their procedure to be a feasible and safe alternative to vertebroplasty with liquid materials. A randomized prospective trial is needed to determine if outcomes from the procedure are truly comparable to standard vertebroplasty or kyphoplasty procedures and if the apparent risk reduction outweighs the risk of other complications, i.e. those associated with general anesthesia, and increased operative times.

References


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