Clinical observations of osteoporotic vertebral compression fractures by using mineralized collagen modified polymethylmethacrylate bone cement

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Abstract

To investigate the clinical outcomes of the treatment of osteoporotic vertebral compression fractures (OVCFs) by using mineralized collagen (MC) modified polymethylmethacrylate (PMMA) bone cement. 52 cases (52 vertebras) who sustained OVCF treated with MC modified PMMA bone cement from July 2014 to December 2015 were reviewed retrospectively. All the cases (52 patients, 52 vertebras) included 8 males and 44 females with an average age of 74.83 (ranging from 57- to 90-years old). The visual analogue scale (VAS), vertebral body height, Cobb angle, CT values preand post-operation as well as incidence of complications were used to be observed. All the patients underwent the surgery were successfully followed-up with an average period of 13.54 months (ranging from 6 to 23 months). The patients can ambulate at the second day after the operation. The VAS scores 2 days after the operation and during the last follow-up were significantly decreased compared with that before the operation (P < 0.05); the average vertebral height and local Cobb angle had significant recovery (P < 0.05); the CT value of the treated vertebra significantly increased compared with that before the operation (P < 0.05). MC with good osteogenic activity and degradation properties can effectively improve the mechanical properties and biocompatibility of the PMMA bone cement, thus obtain better clinical results.

Keywords: mineralized collagen; PMMA bone cement; osteoporosis; vertebral compression fractures

Introduction

Percutaneous vertebroplasty (PVP) and percutaneous kyphoplasty (PKP) have been becoming commonly used surgeries for the treatment of osteoporotic vertebral compression fractures (OVCF) [1–4]. An idea bone filling material with good operating performance, biomechanical properties and biological characteristics (biocompatibility, osteointegration ability, osteoconductivity etc.) is expected by those surgeons performing PVP and PKP [5, 6]. Nowadays, polymethylmethacrylate (PMMA) bone cements with good injectability and high contrast effect have been widely applied in PVP and PKP [7–9].

However, many disadvantages influenced clinical performance of these PMMA bone cements. The compressive modulus is relative higher than that of the natural vertebral bone, the suddenly increased intensity of the treated vertebral body may induce secondary fracture on adjacent ones, especially for those osteoporotic bodies [10–13]. On the other hand, PMMA is a bioinert material that
cannot form osteointegration with the host bone at the implant site [14]. The implanted PMMA bone cement may loosen or even dislodge inside the vertebral body [15, 16]. Such complications need further surgeries, which increase illness and economic burden for the patients.

Many efforts were tried to modify existing PMMA bone cements in terms of biomechanical and biological properties. In a general way, biomaterials were added into the PMMA bone cements to improve their performance [17–19]. Such biomaterials include calcium phosphate, chitosan, sodium hyaluronate and so on. However, there were no reports indicate that both biomechanical properties and osteointegration ability could be improved by using a single component.

In recent years, a biomimetic mineralized collagen (MC) material ‘Bongold’ with similar chemical components and microstructures of the natural bone tissue was developed by Tsinghua University, China and has been commercialized by Beijing Allgens Medical Science and Technology Co., Ltd., China [20–23]. With good biocompatibility, biodegradability and osteoconductivity, this biomaterial could be used to repair bone defects at various body sites [24–30]. Such MC products been approved by both Chinese Food and Drug Administration and US food and drug administration as implantable medical devices [31]. In this clinical observation, in order to improve the properties of the commercially available PMMA bone cement, we used the MC ‘Bongold’ for the modification of the PMMA bone cement. On the basis of previous studies, such modification could effectively reduce the hardness and improve its biocompatibility, so as to reduce the occurrence of either secondary fracture at the adjacent vertebrae or dislodgement of the implanted bone cement for the treatment of patients with OVCF.

### Clinical data and methods

#### Clinical data

The patients with OVCF treated with vertebroplasty with MC modified PMMA bone cement between July 2014 and December 2015 in our department were screened. Patients’ clinical data is listed in Table 1. Pre-operative vertebral X-ray, MRI and CT examinations were performed for each patient, except those with vertebral lesions, disc disease, spinal stenosis caused by dural sac and nerve root compression caused by pain. CT examinations confirmed the integrity of the vertebral posterior wall with fractures, whether unilateral or bilateral pedicle is intact, and the lower part of the vertebral body and the lower endplate did not burst (Table 1).

#### Surgical techniques

Patients were treated at prone position with abdomen hung. Local or general anesthesia was selected according to the general condition of the patient. The surface projection of the pedicle was positioned

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Data</th>
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<tbody>
<tr>
<td>Number of patients</td>
<td>52</td>
</tr>
<tr>
<td>Mean age (years)</td>
<td>74.83 ± 7.85 (from 57 to 90)</td>
</tr>
<tr>
<td>Gender (male/female)</td>
<td>8/44</td>
</tr>
<tr>
<td>Treated vertebral body</td>
<td>T7: 1, T8: 2, T10: 1, T11: 5, T12: 17, L1: 11, L2: 10, L3: 5</td>
</tr>
<tr>
<td>Operation time (min)</td>
<td>32 ± 13</td>
</tr>
<tr>
<td>Follow-up period (months)</td>
<td>12.19 ± 3.75 (from 6 to 18)</td>
</tr>
</tbody>
</table>

### Results

All 52 patients were followed up for 6–18 months, with an average follow-up of 12.19 months. Mean operative time was (32 ± 13) minutes. One case occurred vertebral bone cement leakage, two cases occurred vertebral paraspinal soft tissue leakage. No bone cement was injected into the vertebral body from the trailing edge of the neural canal, and there were no clinical symptoms caused by leakage of bone cement. Intraoperative lateral X-ray films showed vertebral height of the central part of the vertebral body recovered, without bone cement leakage. Surgery slander anteroposterior X-ray showed vertebral bone cement distributed well (Fig. 2a and b). For the post-operative follow-ups, VAS scores, vertebral height, Cobb angle and T value of CT were significantly improved compared with those pre-operative values (P < 0.05). One-year follow-up showed the MC modified PMMA bone cement was stable within the treated vertebral body without loosening or dislodgement. Although after
the first 2 days, all the values still improved, there were no signifi-
cant differences between the 2 days post-operation and the last follow-up ($P > 0.05$), (Table 2).

**Discussion**

The stiffness of the vertebral body treated with traditional PMMA bone cement becomes significantly higher than the adjacent ones, thus resulting stress concentration and may cause new fracture on those adjacent vertebral bodies [10, 11]. It was reported that the occurrence of the new fracture on the adjacent vertebral bodies after PVP and PKP was 7–20% [12]. The bioinert PMMA cannot form osteointegration with the bone tissue within the vertebral body [14]. Apparent interface will exist between the bone cement and the host bone, and the combination strength will be very weak. Micro motion between the bone cement and the bone is inevitable, osteolysis and further aseptic loosening or even dislodgement of the bone cement inside the vertebral body may be produced [14, 15].
Table 2. The average VAS score, the average height of the vertebral, Cobb angle and the T value of CT before and after surgery (x ± S)

<table>
<thead>
<tr>
<th>Evaluation time</th>
<th>VAS score</th>
<th>Average height of the vertebral (mm)</th>
<th>Cobb angle (°)</th>
<th>T value of CT (HU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-operation</td>
<td>8.6 ± 2.4</td>
<td>10.7 ± 4.8</td>
<td>32.7 ± 12.3</td>
<td>76.3 ± 11.5</td>
</tr>
<tr>
<td>After 2 days</td>
<td>2.8 ± 2.2</td>
<td>12.5 ± 5.1</td>
<td>21.6 ± 9.7</td>
<td>93.2 ± 12.9</td>
</tr>
<tr>
<td>Last follow-up</td>
<td>2.9 ± 2.6</td>
<td>12.4 ± 5.3</td>
<td>22.5 ± 11.5</td>
<td>98.7 ± 10.3</td>
</tr>
</tbody>
</table>

*When compared with the pre-operative values, P < 0.05.

We use MC good osteogenic activity and degradation in vivo absorption characteristics of the conventional PMMA bone cement composite, can effectively control the mechanical properties and biocompatibility [33–35], MC will also enable the degradation of bone cement and autogenous bone to form a good osteointegration, better clinical results. Herein were followed up by the discovery of bone cement MC modified after vertebral, fractures can effectively improve the pain caused to the patient by injecting PVP, while the vertebrae play a good role in supporting and securing the postoperative follow-up, the vertebral front height and Cobb angle compared with that obtained significant recovery was not found in the vertebral bone cement loose and fall off. There are an average follow-up time after the end of the CT values of vertebral significantly improved compared with the operative, the difference was statistically significant, indicating that the ability to promote local bone fracture healing by MC modified cement thereby increasing bone density. In summary, we believe that after MC modified bone cement has good mechanical properties and biocompatibility of the organization, worthy of clinical patients choose to use.

Conclusion

By adding biomimic MC, PMMA bone cement was improved to have better mechanical properties and biocompatibility than traditional PMMA bone cements. In this clinical observation, by using MC modified PMMA bone cement, all the patients obtained good clinical effects. VAS scores of the patients were significantly improved, as well as vertebral height and Cobb angle recovered well.

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Conflict of interest statement. None declared.

References


