The treatment of metastasis to the femoral neck using percutaneous hollow perforated screws with cement augmentation

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We have developed a hollow perforated cannulated screw. One or more of these was implanted percutaneously in 11 patients with an osteolytic metastasis in the femoral neck and multiple metastases elsewhere. They were supplemented by one or two additional standard 6.5 mm cannulated screws in nine patients. Polymethylmethacrylate bone cement was injected through the screw into the neck of the femur using small syringes, as in vertebroplasty. The mean amount of cement injected was 23.2 ml (17 to 30). Radiotherapy was started on the fourth post-operative day and chemotherapy, on average, was resumed a day later.

Good structural stability and satisfactory relief from pain were achieved in all the patients. This technique may be useful in the palliation of metastases in the femoral neck.

In the treatment of metastatic bone tumours combined percutaneous vertebroplasty and cementoplasty1-3 which involve the injection of polymethylmethacrylate (PMMA) into lesions of the vertebral body,4-7 pelvis8-12 and femur12,13 are minimally invasive and give good results. Percutaneous cementoplasty combined with radiofrequency ablation has also been used14-16 for osteolytic metastatic bone tumours, but its use in long bones may be complicated by pathological fracture. Recently, MR-guided ultrasound surgery for the palliation of pain in patients with bone metastases has been described by Catane et al.17

The conservative treatment of metastatic tumours of the femoral neck is difficult because of the frequency of intractable pain and impending or established pathological fracture. Any of the aforementioned methods of treatment may be considered, but do not contribute significantly to the stability of the femoral neck. Until recently, we treated such patients by either joint replacement, internal fixation or palliation.

We report our experience of palliative surgical stabilisation of metastatic tumours of the femoral neck using hollow perforated screws and injection of cement or intra-operative adjuvant materials.

Patients and Methods

The study was approved by our Institutional Review Board and informed consent was obtained both from the patients and their families. The procedure and its possible complications were fully explained before the operation and we obtained specific permission to use our specially-designed hollow perforated screw.

We treated 11 patients with an osteolytic metastatic tumour of the femoral neck by combined percutaneous hollow perforated screw fixation and cementoplasty, with or without the intra-operative injection of an adjuvant agent (Table I). There were five men and six women with a mean age of 64.4 years (46 to 82). Each had stage-IV18 cancer with multiple metastases in bone or other organs. The primary tumours were carcinoma of the bronchus in seven, hepatocellular carcinoma in one, cholangiocarcinoma in one, carcinoma of the colon in one, and B-cell lymphoma in one. Each patient suffered from intractable pain and had difficulty in walking because of the metastasis to the femoral neck. Major surgery such as total joint replacement or open internal fixation were contraindicated because of the patient’s poor general condition and short life expectancy. Of the 11 patients, five had an undisplaced pathological fracture, three of the femoral neck and two of the intertrochanteric area. Two patients received radiotherapy pre-operatively and three post-operatively. Every patient received chemotherapy before and after surgery.

The severity of pain was measured using a numerical rating scale (NRS) which ranged from 0 (no pain) to 10 (worst pain imaginable).19 Measurements were taken on
the day before surgery and on the second and seventh post-operative days. The patient’s general condition and ability to walk were reviewed in the third post-operative month.

**The perforated hollow screw.** A perforated hollow screw was devised by modifying a 6.5 mm cannulated screw (SOLCO, Seoul, Korea). The medical engineering department of our institution added multiple, side holes measuring 2 mm in diameter and placed 10 mm apart. The patient’s radiographs were measured pre-operatively so that screws with the appropriate length and number of holes could be prepared (Fig. 1).

**Operative technique.** The procedure was performed in the lateral decubitus position under spinal anaesthesia except in two patients in whom local anaesthesia was used because they were unable to assume the posture for spinal anaesthesia. First, we placed two or three 2.2 mm guide wires in the lesion in the femoral neck percutaneously under image intensification. A small skin incision was made around the puncture site of each wire, and the near cortex was drilled using a cannulated drill. One or two hollow perforated screws were then introduced over the wires (Fig. 1). In the nine patients who had a large osteolytic lesion, a high body-weight, a high risk of impending fracture or an undisplaced pathological fracture, we used one or two extra screws. In the two who had an ipsilateral diaphyseal osteolytic lesion, one or two Ender’s nails (Smith and Nephew, London, United Kingdom) were driven from the distal femoral condyle across the site of the lesion. After checking the location of all implants fluoroscopically, we introduced a percutaneous vertebroplasty (PV) needle (10 gauge, 11 cm) (Kyung-won Medical, Seoul, Korea) through the hollow perforated screw (Fig. 1). This PV needle was driven into the silicone tube before insertion, which was made temporarily by segmentally cutting a hemovac line for preventing leakage of injected materials at the connecting site with the multiholed screw. The guide wire was removed and high viscosity polymethylmethacrylate bone cement (Depuy International

### Table I. Details of the 11 patients with metastasis to the femoral neck

<table>
<thead>
<tr>
<th>Case (yrs)</th>
<th>Gender (y)</th>
<th>Primary tumour</th>
<th>Ipsilateral accompanied metastatic area</th>
<th>Pain grade (NRS)</th>
<th>Fixator for femoral neck HPS/CS</th>
<th>Cement for femoral neck (nil total)</th>
<th>Intra-operative adjuvant</th>
<th>Pre-operative</th>
<th>Post-operative</th>
<th>Post-operative start day, CTx/RTx†</th>
<th>Patients’ condition (3 mths)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 69 M</td>
<td>Hepatocellular carcinoma Pelvis</td>
<td>-</td>
<td>2/0</td>
<td>25 (15/10) Ethanol</td>
<td>9</td>
<td>3</td>
<td>63/7</td>
<td>Stick</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 53 M</td>
<td>Cholangiocarcinoma Intertrochanter</td>
<td>-</td>
<td>2/0</td>
<td>27 (16/11) -</td>
<td>8</td>
<td>2</td>
<td>2/pre-op</td>
<td>Walk WS‡</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 58 M</td>
<td>Carcinoma of the bronchus Diaphysis, pelvis</td>
<td>-</td>
<td>2/0</td>
<td>24 (13/11) Ethanol</td>
<td>9</td>
<td>2</td>
<td>46/5</td>
<td>Crutch</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 63 F</td>
<td>Carcinoma of the bronchus Diaphysis, pelvis</td>
<td>-</td>
<td>1/1</td>
<td>18 Ethanol</td>
<td>10</td>
<td>6</td>
<td>2/pre-op</td>
<td>Died</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 82 M</td>
<td>Carcinoma of the bronchus Intertrochanter, pelvis</td>
<td>-</td>
<td>2/1</td>
<td>18 (10/8) -</td>
<td>10</td>
<td>5</td>
<td>1/-</td>
<td>Wheelchair</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 69 F</td>
<td>Carcinoma of the bronchus Pelvis</td>
<td>-</td>
<td>2/1</td>
<td>17 (11/6) -</td>
<td>10</td>
<td>4</td>
<td>4/-</td>
<td>Died</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 57 F</td>
<td>Carcinoma of the bronchus Pelvis</td>
<td>-</td>
<td>1/2</td>
<td>18 Ethanol</td>
<td>10</td>
<td>4</td>
<td>-/-</td>
<td>Wheelchair</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 76 M</td>
<td>Carcinoma of the colon Intertrochanter</td>
<td>-</td>
<td>1/2</td>
<td>17 Ethanol</td>
<td>10</td>
<td>3</td>
<td>1/-</td>
<td>Walking frame</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 75 F</td>
<td>Malignant lymphoma Pelvis</td>
<td>-</td>
<td>2/1</td>
<td>19 Ethanol</td>
<td>10</td>
<td>7</td>
<td>13/-</td>
<td>Bedridden</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 60 F</td>
<td>Carcinoma of the bronchus Pelvis</td>
<td>-</td>
<td>2/1</td>
<td>30 (16/14) Gemcitabine 10</td>
<td>2</td>
<td>5/-</td>
<td>Walk WS‡</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 46 F</td>
<td>Carcinoma of the bronchus Pelvis</td>
<td>-</td>
<td>2/1</td>
<td>19 (11/8) Gemcitabine 8</td>
<td>2</td>
<td>35/3</td>
<td>Walk WS‡</td>
<td></td>
<td></td>
<td></td>
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</table>

* HPS, hollow perforated screw; CS, cannulated screw
† CTx, chemotherapy; RTx, radiation therapy
‡ without support
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Ltd, Blackpool, United Kingdom) was injected through 1 ml syringes. The volume of cement is about 20 ml per pack (20 g). We used one or two mixes of bone cement as is usually used in vertebroplasty. A single mix was introduced into a 30 ml syringe as quickly as possible. An assistant then divided the cement mixture into 1 ml syringes and passed them to the surgeon for prompt injection so that a sufficient amount of bone cement could be introduced.

Case 1 – A 69-year-old man with hepatocellular carcinoma who had multiple bone metastases in the left pelvis and femoral neck underwent percutaneous hollow-perforated screw fixation and cement augmentation; a) pre-operative radiograph (left) and MR scan (right) showing osteolytic metastatic lesions in the left femoral neck and ilium, b) intra-operative fluoroscopic views showing the placement of two hollow perforated screws (left) and injection of cement (right), c) post-operative radiograph (left), CT scan (middle) and MR scan (right) showing good filling of cement in the osteolytic lesions.
was no additional operation or fracture at the operation site. Her pain was successfully controlled with medication. There was discomfort and had no limitation of movement of the hip. because of her poor general condition, but was only in mild radiotherapy a mean of four days in three patients. We achieved satisfactory relief from pain and good structural stability in all cases (Fig 2, Table I).

Discussion
Metastatic carcinoma is the most common malignancy treated by orthopaedic oncologists. Post-mortem studies have shown that up to 85% of patients who die of lung, breast and prostate cancer have metastases to bone at the time of death.20,21 The femoral neck is a common site and this may cause marked deterioration in the quality of life because of intractable pain, impending or pathological fracture, and restricted mobility. Although radiotherapy is the standard method of palliation it cannot restore bone which has been destroyed or increase the strength of that which remains. Moreover, relief from pain following radiotherapy to the femoral neck may be less predictable than that suggested by a previous report which stated that partial or complete relief from pain was achieved in 75% to 90% of patients with metastases.20

In our series, eight of 11 patients underwent surgical intervention for metastasis in the femoral neck before receiving radiotherapy, which is different from patients with other bone metastases who are usually treated by radiotherapy first. Patients with a metastasis in the femoral neck require surgery to regain structural stability. However, they are usually in a poor general condition with a limited life expectancy. Percutaneous surgical techniques have been developed to treat osteolytic lesions by the injection of PMMA cement into the pelvis,8,12 sacrum22 and spine4,7 with or without prior treatment by ablative methods. The latter include the use of ethanol,23 laser-induced interstitial thermoablation,24 cryoablation25 and radiofrequency ablation.16,26 Gangi et al23 have described the use of CT-guided percutaneous administration of 95% ethanol for the palliation of pain in metastatic bone tumours. In three of our patients we injected dehydrated alcohol through a multiholed screw after mixing it with contrast dye which we used to check for distribution and extraosseous leakage by image intensification.

Gemcitabine, a deoxynucleotide analogue, is an excellent radiosensitiser both in vivo and in vitro,27 and is widely used for the treatment of solid tumours of the lung, breast, ovary, bladder and pancreas.28 One of our patients (case 10) received 1670 mg of gemcitabine and 100 mg of cisplatin intravenously before operation and again afterwards. Another (case 11) received radiotherapy post-operatively, but no definite therapeutic effect was observed. Further studies are needed to determine the therapeutic effect of topically administered chemotherapeutic agents with PMMA cement.

Bone cement (PMMA) has been one of the most useful agents in the treatment of bone tumours since it provides immediate mechanical stability and generates heat which may have some tumouricidal effect. In most previously reported cases the amount of cement injected was between 2 ml and 15 ml3,8,12,14 whereas we were able to inject a relatively large amount (18 ml to 30 ml) to maximise mechanical stability. Introducing cement through a multiholed cannulated screw augments the resistance against pull-out of screws from osteoporotic or osteolytic lesions. It also has a tendency to delay local intramedullary recurrence.

This procedure is simple enough to be undertaken using local anaesthesia. Any pain induced by the injection of the cement can be controlled by the use of intravenous analgesics. Sciubba et al22 reported a case in which a transiliosomal...
rod with cement augmentation was sited percutaneously for a sacral insufficiency fracture. The fixation and cement augmentation were performed individually. However, we carried out percutaneous screw fixation with cement augmentation and/or the injection of adjuvants through a single portal. We prefer to use a silicone tube longer in length than the PV needle to prevent the leakage of the injected substances. By applying this tube, we could seal the periphery of the screw entrance when we pushed a PV needle into its central canal. We are currently developing a new injection needle and a multiholed screw which should prevent leakage without the need for a silicone tube. The interruption period of chemotherapy was shortened relative to that of a major operation by our percutaneous method in which chemotherapy would be delayed until approximately two weeks of wound healing.29,30 A newly devised multiholed cannulated screw was useful in the palliative surgical intervention of femoral neck metastasis for relieving pain.

References