ONCOLOGY

Fixation of pathological humeral fractures by the cemented plate technique

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Pathological fractures of the humerus are associated with pain, morbidity, loss of function and a diminished quality of life. We report our experience of stabilising these fractures using polymethylmethacrylate and non-locking plates. We undertook a retrospective review over 20 years of patients treated at a tertiary musculoskeletal oncology centre. Those who had undergone surgery for an impending or completed pathological humeral fracture with a diagnosis of metastatic disease or myeloma were identified from our database. There were 63 patients (43 men, 20 women) in the series with a mean age of 63 years (39 to 87).

All had undergone intrallesional curettage of the tumour followed by fixation with intramedullary polymethylmethacrylate and plating. Complications occurred in 14 patients (22.2%) and seven (11.1%) required re-operation. At the latest follow-up, 47 patients (74.6%) were deceased and 16 (25.4%) were living with a mean follow-up of 75 months (1 to 184). A total of 54 (86%) patients had no or mild pain and 50 (80%) required no or minimal assistance with daily living. Of the 16 living patients none had pain and all could perform activities of daily living without assistance.

Intralvesional resection of the tumour, filling of the cavity with cement, and plate stabilisation of the pathological fracture gives immediate rigidity and allows an early return of function without the need for bony union. The patient’s local disease burden is reduced, which may alleviate tumour-related pain and slow the progression of the disease. The cemented-plate technique provides a reliable option for the treatment of pathological fractures of the humerus.

The humerus is the second most common long bone to be affected by metastatic cancer, and the most common in the arm.1,2 Pathological and impending fractures of the humerus are associated with pain and disability. Conservative treatment is unpredictable, with poor functional results and failure to relieve pain.2-4 The guiding principles of the stabilisation of pathological humeral fractures include the preservation of normal bone and soft tissues whenever possible, relief from pain, immediate, durable, rigid fixation and the ability to use the affected arm immediately.5

Various methods of management have been described including non-operative treatment,4 amputation,6 intra- and extramedullary fixation,1,4-17 cement fixation,1,4,5,7,14,16-18 the use of intercalary spacers18,19 and endoprosthetic reconstruction.1,2,6 A popular method of stabilisation is closed intramedullary (IM) nailing. Reported advantages are that it is minimally invasive and allows a large segment of the humerus to be stabilised.2 However, there are several disadvantages to this method: damage to the rotator cuff with residual shoulder pain and weakness; prominence of the nail at the shoulder; inability to achieve rigid fixation due to poor bone quality and relatively few points of fixation; failure to reduce the local tumour burden with a high rate of progression of local disease; 29% in one series.13

Frassica and Frassica2 in their review of metastatic disease of the humerus described a technique of curettage of the tumour and plating augmented with cement. This gave immediate rigidity and allowed unrestricted function in the early post-operative period. Extensive curettage of the tumour can be undertaken to reduce the risk of local progression. It also avoids violating the rotator cuff. These advantages make it a useful option for the management of impending and completed pathological humeral fractures. Our aims were to describe a retrospective series of patients who received this treatment for pathological humeral fracture and to evaluate their clinical and functional outcome.
Patients and Methods

After gaining permission from our institutional review board, a retrospective review was undertaken of all patients treated at our tertiary musculoskeletal oncology referral centre between 1989 and 2009. Only patients who had undergone cemented plate stabilisation of an impending or pathological fracture of the humerus because of metastases or multiple myeloma were included. A minimum follow-up of one month was required as such patients often have a very short life expectancy and we wished to assess whether early relief from pain and restoration of function had been achieved. The patients’ records and radiographs were reviewed. Clinical details, the surgical reconstruction, peri- and post-operative complications and subsequent follow-up data including relief from pain and function were extracted.

The records were available for 63 patients (43 men and 20 women) with a mean age at the time of initial surgery of 63 years (39 to 87). In 48 patients (76.2%) there was an established pathological fracture at presentation, while in 15 (23.8%) it was impending. In 40 patients (63.5%) the right humerus was involved and in 23 (86.5%) the left. The cause was multiple myeloma in 14 patients (22.2%), renal and lung adenocarcinoma in 13 (20.6%) each, thyroid carcinoma in four (6.4%) and breast carcinoma in two (3.2%). The remaining nine patients had, respectively, lymphoma, melanoma, metastatic sarcoma and carcinoma of the bladder, colon, tongue, oesophagus, nasopharynx and prostate. In eight patients (12.7%) the primary source could not be identified.

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Operative technique. Tumours with high vascularity were embolised pre-operatively. The humerus was exposed through standard surgical approaches. In most cases an extensile anterolateral Henry approach was used. If the bone was intact, a cortical window was made, generally at the site of maximum bone destruction to allow thorough curettage of the tumour mass. Flexible hand or power reamers were often used to remove the tumour tissue beyond the reach of curettes. If the bone had already fractured, the tumour was removed via the fracture and a trial reduction was performed. Antibiotic bone cement (Simplex; Stryker, Mahwah, New Jersey) containing 1 mg of tobramycin per 40 mg of polymethylmethacrylate was then placed into the humeral canal and bone defect using a cement gun with a flexible nozzle to inject it proximal and distal to the defect, supplemented by digitally packing the bone defect with cement. If there was a fracture, the bone ends were held in place by hand or with bone clamps as the cement polymerised. The humerus was then stabilised using non-locking plates fixed with screws inserted through the composite of bone and hardened cement. Ideally, the plates spanned the defect by at least two cortical diameters and often the entire length of the bone (Fig. 1). A variety of plates was used according to the preference of the surgeon and the number was dictated by the degree of bony destruction. Absolute rigidity of the construct was confirmed by inspection and manipulation. The wounds were irrigated and closed in layers, and drains were placed according to the preference of the surgeon. A soft dressing and sling were applied. Gentle range-of-
movement exercises were begun immediately, but patients were encouraged to use the affected arm without restriction once they were comfortable.

**Measurement of outcome.** Assessment of meaningful outcomes in these patients is difficult for several reasons. Ideally, pre- and post-operative pain and function should be measured by a validated scoring system, but approximately 75% of our patients presented after pathological fracture, precluding the possibility of comparing meaningful pre- and post-operative assessments. We therefore quantified the patient’s pain level as none, mild, severe and unknown, based on the patient’s most recent contact with our unit or with another medical practitioner elsewhere.

In terms of function, patients were stratified based on their ability to perform all activities of daily living (ADLs) independently at the time of last contact. They were divided into those who were completely independent, those requiring assistance in at least one but not all ADLs, those who required comprehensive care and those whose functional level could not be ascertained from the records.

The incidence of peri-operative complications and reconstructive failure were noted. The cumulative probability of reconstruction failure was estimated using the cumulative incidence function to account for competing risks as this is a better estimator than Kaplan-Meier survivorship in a setting of competing risks. Revision of the reconstruction for any reason was the endpoint of interest. Patient survival was estimated by the Kaplan-Meier product limit method with 95% confidence intervals (CI).

**Results**

In all, 45 (71.4%) patients had one plate at the initial operation, 16 (25.4%) had two, and one patient each (1.6%) had three and four plates. The most common pattern of stabilisation was that of the head and diaphysis which was performed in 45 patients (71.4%), the trochlea and diaphysis were stabilised in eight patients (12.7%) and simple diaphyseal fixation excluding the head and trochlea in ten (15.9%).

At the time of this review, 47 patients had died and 16 were still alive at a mean follow-up of 75 months (1 to 184). Post-operative survival was 61% (95% CI 50 to 75) at six months, 42% (95% CI 31 to 57) at 12 months, 28% (95% CI 18 to 44) at two years and 12% (95% CI 5 to 28) at five years (Fig. 2).

**Fixation complications.** The cumulative incidence of revision for any reason was 4% (95% CI 0 to 9) at one year, and 13% (95% CI 1 to 21) at five years (Fig. 3). A total of five patients underwent revision for locally progressive disease, one for infection and one for mechanical failure of the construct.

The mechanical failure occurred in a man whose level of pain and functional status improved to the point that he began a home-improvement project. His plate failed while he was hammering repetitively using the affected arm. The reconstructions requiring revision were treated by resection and insertion of a tumour endoprosthesis in three patients, repeated cement-plating in three, and forequarter amputation in one. To date there have been no repeat revisions.

**Other complications.** Overall, there were 14 (22.2%) complications (Table I). The most common, in five patients, was local progression of disease requiring revision of the construct. There were three peri-operative deaths. One patient died on the eighth post-operative day from pulmonary embolism, one on the ninth post-operative day from superior vena cava syndrome and one on the 16th post-operative day after becoming confused and developing a coagulopathy. There were two cases of nerve palsy, one of
the anterior and one of the posterior interosseous nerve, one recurrence of carcinoma in the soft tissues and one non-fatal pulmonary embolism.

**Pain and function.** In all, 40 patients (63.5%) reported that they had no pain, 14 (22.2%) mild pain and one (1.6%) severe pain. The level of pain of the remaining eight patients (12.7%) was not available.

A total of 42 patients (66.7%) were completely independent for all ADLs with eight (17.7%) needing assistance with at least one ADL and five (7.9%) requiring comprehensive care. The ADL status of the remaining eight patients (12.7%) could not be determined from the records. Of those patients who were considered to be fully independent, 11 were described as having exceptional function. They reported engaging in recreational sports and high-level physical activities.

**Discussion**

Metastatic carcinoma to bone and multiple myeloma represent the most common examples of bone malignancy. Incidences of skeletal metastases reported in the literature have been as high as 83% for carcinoma of the breast, 85% for that of the prostate, 30% for that of the thyroid, 30% for that of the kidney, and 40% for that of the lung. Involvement of bone is ubiquitous in multiple myeloma. Bone pain is the most common presenting symptom and may be due to structural weakness, periosteal irritation, production of prostaglandin by tumour cells, nerve entrapment or a combination of these. In addition to considerable pain, bone metastases cause decreased functional status, hypercalcaemia and pathological fracture. All of these contribute to a severely reduced quality of life. Treatment such as cytotoxic chemotherapy, the use of bisphosphonates, radiation, hormonal therapy and stem-cell transplantation have improved the survival of patients with metastatic disease. Despite this, pathological fractures and impending pathological fractures still occur. Moreover, their incidence is expected to rise as the proportion of elderly in the population increases bringing with it a higher incidence of cancer. It is essential that both orthopaedic oncologists and community orthopaedic surgeons are conversant with treating pathological and impending pathological fractures.

With respect to our series, the mean age of 63 years was similar to that reported in other series of humeral metastases. In ours, the most frequent neoplasms were multiple myeloma, renal carcinoma and lung carcinoma, together accounting for 64% of the total. In other series, breast and/or prostate carcinoma predominated. This difference is likely to reflect local practice with patients with breast and prostate carcinoma being treated at community hospitals and associated oncology centres whereas those with myeloma, lung and renal carcinoma are referred to our tertiary oncology centre.

Our complication rate of 22% was comparable with those published elsewhere of 23% for IM nailing, 29% for intercalary spacers, and 20% for isoelastic polyacetal resin prostheses. Our revision rate of 11% was similar to that for other forms of surgical management. Our complication rate and revision rate were both higher than those recently reported by Spencer et al, who, out of a series of 35 patients treated by IM fixation, reported one case of palsy of the posterior interosseous nerve and no revisions. In five patients progression of disease caused instability of the construct which led to revision. In one a short plate was used with recurrent disease causing another pathological fracture distal to the plate. In order to avoid this complication, we recommend stabilisation of the entire humeral diaphysis by a cement-plate construct. In a series of 21 patients reported by Vail and Harrelson there was an incidence of tumour progression of 29% and fixation failure of 23%. In this series 90% of patients had IM fixation. We believe that thorough curettage of the diseased bone and filling of the defect with cement significantly lowers the local tumour burden and may explain the lower incidence of tumour progression in our patients.

In the absence of progression of disease we encountered only one mechanical failure, in comparison with failure ranging from 10% to 29% in other series. Augmentation of fixation with bone cement has been advocated previously. Additionally, biomechanical studies have shown that the pull-out strength of screws augmented with cement is superior to cementless fixation. A recent study of the fixation of pathological humeral fractures reported a mortality of 94% at the end of the period of study with a mean survival of 7.1 months.
short survival would limit the period of risk for the construct used and contribute to a low rate of revision. The survival of our patients was somewhat greater and more consistent with the life expectancy reported elsewhere.23,27 Few studies on this condition have included the measurement of objective outcome data. Although we used a non-mild-severe3 description of pain and an ADL-based functional assessment which was not a validated scoring system, we feel that these accurately and appropriately described the outcome in our patients. We have shown that most of our surviving patients had no pain and were independent in terms of ADLs.

The method of stabilisation which we have adopted has several advantages. Most importantly, it provides immediate, absolute rigidity producing prompt relief from pain and unrestricted return of function without the need for bony union. Although our overall rate of complications was not significantly different from that of other series in the literature, our incidence of palsy of the radial nerve (one case) and implant failure in the absence of progression of the disease (one case) was much lower than that in other series.9,12,13,16,19

As oncological treatments continue to improve, so will the life expectancy of patients with metastatic disease and maintenance of the quality of life in these patients is of the utmost importance. The technique which we have described meets the treatment goals for patients with metastatic bone disease and should be considered in the surgical management of impending or completed pathological fractures of the humerus.

References