Comparative analysis of the surgical treatment results for multiple myeloma bone disease of the spine and the long bone/soft tissue

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Abstract. The present retrospective study was designed to compare the pain relief, surgery duration, life quality, survival time and relative prognostic factors in multiple myeloma (MM) bone disease patients with different surgical sites. A total of 65 cases were enrolled and divided into two groups. Group A included patients with lesions located in the spine, while Group B included patients with lesions located in the long bone or soft tissue. Pain relief was measured by the visual analogue scale (VAS), neurological impairment was determined according to Frankel classification, and survival was assessed by the Kaplan-Meier method. Cox regression analysis was also used to estimate the effect of factors on the prediction of survival. The hospitalization time, preoperative duration of symptoms, method of surgery, complications, recurrence and survival time were evaluated and compared retrospectively. Pain relief and improvement of life quality were observed in all the patients in groups A and B. No significant differences were detected for the majority of parameters compared between groups A and B, with the exception of the surgery duration, as well as the postoperative VAS score at 1 and 6 months after surgery. The multivariate Cox regression analysis revealed several risk factors significantly associated with survival, including the preoperative VAS score, postoperative chemotherapy, prothrombin time activity (PTA), albumin, lactate dehydrogenase and urine protein level. In conclusion, surgical treatment was an effective therapeutic method in patients with MM. Postoperative analgesic use should be individualized according to the different surgical sites and postoperative periods. Furthermore, preoperative pain, PTA, albumin, urine protein level and postoperative chemotherapy are associated with prognosis.

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Introduction

Multiple myeloma (MM) is a hematologic malignancy characterized by the development of a destructive and progressive osteolytic bone disease, which is mainly associated with severe bone pain, pathological fractures, osteoporosis, hypercalcemia and spinal cord compression (1). Although there have been numerous significant improvements in the understanding of the pathophysiologic changes of MM, it remains an incurable disease (2). Destructive skeletal-related events (SREs) are the main clinical manifestations in patients with MM (1,3). It was demonstrated that 70-80% of patients presented with osteolytic bone lesions at diagnosis, and during the course of MM, >90% of patients developed lytic lesions (1-5). If no effective treatment was provided, >50% of patients with Durie-Salmon (D-S) stage III MM would suffer at least one SRE within 2 years (6). Frequently, one or more vertebral bodies are detected to be affected by vertebral collapse and/or osteolytic lesions, and long bone fractures more commonly occur in the proximal locations of the upper arm and femora (7). In addition, occasionally soft tissue mass appears in extramedullary tissue, resulting in severe pain and reducing the quality of life. In recent years, surgical consultation has been recommended for MM patients with intractable pain, spinal instability and pathological fractures (8); however, the results of the surgery performed on different sites are not definite. To date, no previous studies have conducted a comparative analysis of different surgical sites of MM patients.

To the best of our knowledge, the present study is the first to compare the results of MM patients receiving surgery for lesions located in the spine with those surgically treated for long bone and soft tissue lesions.

Patients and methods

Patients and specimens. A total of 65 patients diagnosed with MM were recruited in the present study, including 40 males and 25 females with a mean age of 57.23 years (age range, 20-79 years). The participants were consecutively surgically treated in our institution (Beijing Chao-yang Hospital, Capital Medical University, Beijing, China) over a 5-year period (January 2010 to January 2015). Survival time was recorded from the date of surgery to the last follow-up in June 2016.

Informed consent was obtained from the subjects for participation into the present study. Ethical approval was obtained from The College Research Ethics Committee of Beijing Chao-yang Hospital, Capital Medical University (Beijing, China).

In this study, the cases were divided into two groups. Group A comprised 33 patients (21 males and 12 females; mean age, 58.32 years; age range, 20-79 years) with surgical sites located in the spine, while Group B included 32 patients (19 males and 13 females; mean age, 56.21 years; age range, 44-74 years) whose surgical sites were in the long bone or soft tissue. The 8 soft tissue cases were initially diagnosed with MM at the Department of Hematology, Beijing Chao-yang Hospital, Capital Medical University (Beijing, China), and subsequently soft tissue masses appeared with the progression of the disease. The D-S stage, International Staging System (ISS) stage and type of MM were recorded, and these data are listed in Table I (9,10). Type of MM was determined using the classification system of the European Society for Medical Oncology, according to the type of monoclonal immunoglobulin secreted by multiple myeloma cells (11). Initially, 2 of the patients were assessed at the Department of Orthopedics at Beijing Chao-yang Hospital, Capital Medical University (Beijing, China) due to experiencing severe pain, and were diagnosed with MM subsequent to surgery and chemotherapy based on specimen examination. The remaining 63 patients were diagnosed with MM upon admission, and accepted treatment by surgery and chemotherapy at the Department of Hematology at Beijing Chao-yang Hospital, Capital Medical University (Beijing, China).

Treatments. In group A, 23 patients (69.7%, 23/33) received chemotherapy prior to surgery, while 27 patients (84.4%, 27/32) received chemotherapy prior to surgery in group B. The remaining 10 patients in group A and 5 patients in group B accepted surgical treatment without preoperative medical therapy. A total of 20 patients (60.6%, 20/33) in group A and 29 patients (90.6%, 29/32) in group B continued to receive chemotherapy during the postoperative course. The remaining 13 patients in group A and 3 patients in group B did not accepted further medical treatment due to limited economic capacity or other reasons. The main chemotherapy schedule was PCD (bortezomib + cyclophosphamide + dexamethasone) or PAD (bortezomib + adriamycin + dexamethasone) in the present study, as previously described (12,13). All the cases receiving preoperative or postoperative chemotherapy completed their chemotherapy courses. In addition, all patients were informed of the benefits of pre- or postoperative radiation therapy, however, the patients participating in the current study selected only pre- or postoperative chemotherapy due to limited understanding of the MM disease and their economic capability.

Lesion locations. In group A, the most common location of bone lesions was in the spine (thoracic, 20 cases; lumbar spine, 5 cases; sacrum, 3 cases; lumbar spine and sacrum, 3 cases; thoracic and lumbar spine, 2 cases). In group B, the lesions were located in the long bones and soft tissue (femur, 12 cases; humerus, 7 cases; clavicle, 2 cases; tibia, 2 cases; radial bone, 1 case; soft tissue, 8 cases).

Surgical procedures. The surgical approach and detailed procedure performed were recorded in the surgeon's operative documents. Patients involved by MM were all medically stable for surgery and complied with the selection criteria for surgical intervention, with the exception of 3 patients in group A (lesions located in T7-9, T4-5 and T5, respectively) who were in a serious condition with irreversible neurological impairment when admitted to the hospital. The preoperative condition of these patients was evaluated via X-ray examination, computed tomography (CT), magnetic resonance imaging (MRI) and blood tests, while ultrasound examination was also required in certain cases with soft tissue lesions.

Different surgical techniques were performed according to the sites of lesions and the surgeon's preference. In group A, 24 patients were treated by lesion resection, posterior decompression and dorsal stabilization with pedicle screw systems. In addition, lesions located in the vertebral body were resected as much as possible, and the defect was filled with bone cement (Fig. 1); a total of 3 patients received this treatment. A total of 5 patients were diagnosed with a vertebral body compression fracture, and percutaneous kyphoplasty (PKP) was performed on the lesion levels. There were 3 patients whose lesions were located in the sacrum causing cauda equina compression; of these, 2 cases were treated by lesion resection and reconstruction with bone cement and a pedicle screw system, while radiofrequency ablation, tumor resection and reconstruction with bone cement was performed in the other case. Furthermore, 1 case with a lesion located in the ventral vertebral body of the first thoracic was treated by vertebral body resection and reconstruction with a titanium cage and bone cement, as well as instrumentation with a vertebral body screw through the anterior approach (Fig. 2). In group B, surgical procedures including tumor resection and reconstruction with bone cement, titanium plates and screws were performed in 20 patients. In addition, 1 patient with a lesion located near the proximal humerus was treated by tumor resection and reconstruction with bone cement and intramedullary nailing (Fig. 3). In 2 cases, a lesion in the femoral head was resected, and replacement of endoprosthesis was performed. Furthermore, 1 case with an intertrochanteric fracture was treated by implantation of intramedullary nailing. There were 8 patients whose surgical sites were in the soft tissue (lower limb, 2 cases; upper limb, 2 cases; buttock, 2 cases; groin, 1 case; back, 1 case). Among these 8 cases, tumor resection alone was performed in 6 patients, and the remaining 2 patients were treated with both tumor resection and nerve decompression.

Follow-up and assessments. The follow-up investigation was conducted by phone or out-patient review. The mean follow-up time was 24.7 months (ranging from 3 to 60 months). Neurological impairment was assessed according to the Frankel classification which provided an assessment of spinal cord function and was used as a tool for spinal cord injury (14). It was defined as five grades (Frankel A, B, C, D and E) according to different motor and sensory function following spinal cord injury. Postoperative radiographs were judged based on local tumor recurrence and the stability of instrumentations. The preoperative visual analogue scale (VAS) score (15), as well as the postoperative VAS scores at

Table I. Common demographics of the enrolled patients.

Characteristic	Group A (n=33)	Group B (n=32)	P-values
Male: female	21:12	19:13	
Age[a] (years)	58.3±12.7	56.2±8.2	0.429
D-S stage of MM			
I A/B	0	0	
II A/B	3	4	
III A/B	27	26	
Missing information	3	2	
ISS stage of MM			
I	2	2	
II	13	12	
III	15	16	
Missing information	3	2	
Type of MM[c]			
IgA-κ	5	5	
IgA-λ	2	8	
IgG-κ	13	5	
IgG-λ	8	7	
IgD-λ	2	3	
Nonsecretory	0	2	
Missing	3	2	
Preoperative chemotherapy			
Yes	23	27	
No	10	5	
Postoperative chemotherapy			
Yes	20	29	
No	13	3	
Hospitalization time[a], days	19.6±8.2	18.6±13.4	0.721
Preoperative duration of symptoms[a] (months)	18.4±16.3	20.5±17.1	0.623
Surgery duration[a] (min)	180.0±74.6	119.7±45.0	<0.001[b]
Peri-operative bleeding[a] (ml)	343.7±74.1	253.2±73.0	0.108
Survival time[a] (months)	24.3±20.2	20.6±14.4	0.397
Preoperative VAS[a] (points)	8.3±1.2	7.7±1.9	0.102
VAS at 1 month after surgery[a] (points)	5.5±1.9	3.3±1.3	<0.001[b]
VAS at 6 months after surgery[a] (points)	2.8±2.5	1.4±0.6	<0.001[b]
Platelets[a] ($x10^9$/l)	197.1±64.7	182.8±98.3	0.498
Hemoglobin[a] ($x10^{12}$/l)	112.0±21.1	109.8±30.1	0.736
Albumin[a] (g/l)	31.8±5.0	33.1±5.5	0.344
Lactate dehydrogenase[a] (U/l)	352.7±40.4	239.1±59.5	0.143
Urine protein[a] (mg/dl)	24.4±7.6	14.3±6.6	0.332

[a]Data are shown as the mean ± standard deviation. [b]P<0.05. MM, multiple myeloma; D-S, Durie-Salmon; ISS, International Staging System; VAS, visual analogue scale; [c]Type of MM, the classification system of multiple myeloma according to the type of monoclonal immunoglobulin secreted by multiple myeloma cells (13).

1 and 6 months after surgery were retrospectively compared between the two groups.

Statistical analysis. Groups A and B were compared in terms of the age, hospitalization time, preoperative duration of symptoms, surgery duration, peri-operative bleeding, survival time and laboratory examinations, with differences between the two groups assessed by independent sample t-test and correlation analysis. The postoperative complications and mortality rate between groups A and B were analyzed using an χ^2-test. The survival time was estimated using the Kaplan-Meier method. Cox regression analysis was used to estimate the effect of

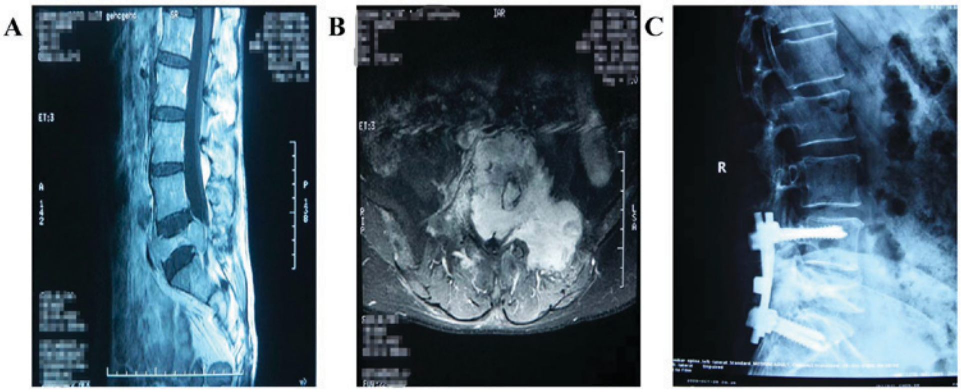

Figure 1. Magnetic resonance imaging and X-ray plain film were used to examine one patient from group A. (A) Magnetic resonance imaging examination revealed that the lesion was located in the spine, the vertebral body of L5 was severely destroyed, and the lumbosacral dural sac was evidently compressed. Image obtained prior to surgery. (B) In this coronary scanning of magnetic resonance imaging examination, lesions were observed to be protruded towards the left and back. Image obtained prior to surgery (C) A postoperative X-ray plain film scan indicated that the fixation devices were implanted successfully. Image obtained following surgery.

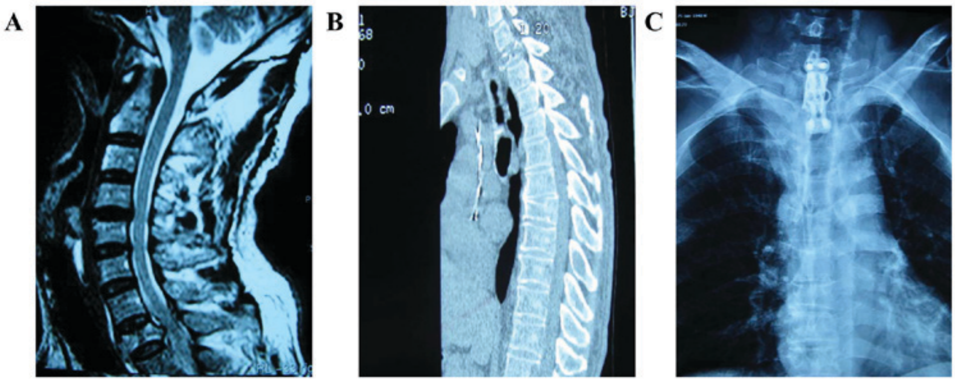

Figure 2. Images from one patient from group A. (A) Magnetic resonance imaging examination demonstrated that the lesion was located in the ventral vertebral body of the first thoracic, and the destroyed part of the vertebral body bulged backward and compressed the dural sac. Image obtained prior to surgery. (B) Computed tomography scan revealed that the majority of the first thoracic vertebrae had been destroyed. Image obtained prior to surgery. (C) The lesion and the destroyed vertebral body were removed via an anterior approach, and were reconstructed with a titanium cage, bone cement and instrumentation with a vertebral body screw. Image obtained following surgery.

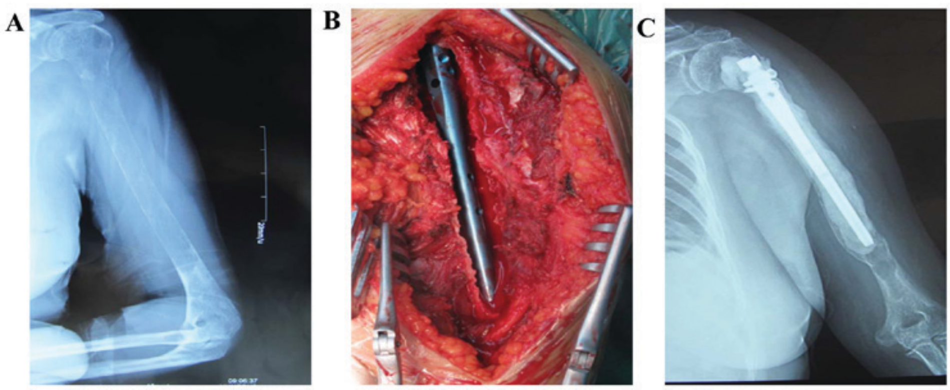

Figure 3. Images from one patient from group B. (A) Myeloma cells invaded in the middle/upper part of the humerus, and the cortical bone became thinner. Image obtained prior to surgery. (B) During surgery, the tumor was removed as much as possible, and proper intramedullary nails were then implanted and fixed with screws. Image obtained during surgery. (C) Postoperative imaging examination demonstrated that the internal fixation devices and bone cement were implanted successfully. Image obtained following surgery.

factors on the prediction of survival. The threshold for a statistically significant difference was set at $P<0.05$. Statistical analysis was performed with SPSS version 17.0 (SPSS, Inc., Chicago, IL, USA).

Results

Patient characteristics. The clinicopathological data of patients in groups A and B are presented in Table I. No statistical significance was observed in the age, hospitalization time, preoperative duration of symptoms, peri-operative bleeding, survival time, preoperative VAS score, and in the levels of platelets, hemoglobin, albumin, lactate dehydrogenase (LDH) and urine protein between the two groups. However, there was a statistically significant difference in the surgery duration (P<0.001), as well as in the postoperative VAS scores at 1 and 6 months after surgery (both P<0.001) between groups A and B.

Treatment outcome and survival. In group A, 18 patients succumbed to the disease and 15 patients were alive at the last follow-up, while 14 patients succumbed and 18 were alive in group B. The mortality rate of groups A and B was analyzed by χ^2-test, and no significant difference was detected (χ^2=0.552, P=0.458). Among the 8 soft tissue cases, 4 patients succumbed and 4 patients were alive at the last follow-up. Pain relief and improvement in the quality of life were obtained in all the patients. The mean VAS scores for the 65 enrolled patients decreased from 7.97 prior to surgery to a value of 4.34 at 1 month after surgery and 2.08 at 6 months after surgery. However, the decrease in the VAS score was significantly greater in group A when compared with that in group B (P<0.001; Table I).

Furthermore, the neurological function improved by different degrees subsequent to the surgical intervention in the majority of patients in group A. Among the 33 MM patients with preoperative neurological dysfunction, 27 patients improved from grade D to E after surgery according to the Frankel classification, while 3 patients improved from Frankel grade C to D. In addition, 3 patients remained at the same state as that upon admission (Frankel grade C), as their neurological function was already severely and irreversibly impaired, and these patients finally succumbed to the disease at 10, 10 and 23 days after surgery, respectively. In group A, 30 out of the 33 patients (90.9%, 30/33) demonstrated improvement in neurological impairment following surgery, and no patient developed progressive neurological impairment.

Following surgical intervention, local recurrence was not detected in these patients via associated postoperative imaging examinations, including X-ray plain film, CT and MRI examinations. In group A, 2 patients (6.1%, 2/33) were complicated with pulmonary infection and 1 case (3.0%, 1/33) was complicated with septic shock, resulting in a complication rate of 9.1% (3/33) in group A. In group B, only 1 patient (3.1%, 1/32) was complicated with cerebral infarction, pulmonary infection and urinary infection continuously. The total complication rate in the present study was 6.2% (4/65). In addition, there was no significant difference in the postoperative complications between groups A and B (χ^2=0.338, P=0.561; Table II). The median postoperative survival time in groups A and B was 36 and 60 months, respectively, as determined by the Kaplan-Meier method. When the 8 soft tissue cases were analyzed separately, the median postoperative survival time appeared to be 28 months. The overall survival time of the 8 soft tissue cases was 51.4 months, whereas that of the total 65 cases was 60.2 months. Furthermore, the postoperative 1- and 3-year overall survival rates of group A were 67.2 and 59.5%, respectively, while these were 68.9 and 58.3%, respectively, in group B. The survival curves of the two groups were compared, as shown in Fig. 4. There was no significant difference in mortality rate of groups A and B (χ^2=0.552, P=0.458).

Table II. Postoperative complications in the two groups.

Postoperative complication	Group A	Group B	Total
Pulmonary infection	2	0	2
Septic shock	1	0	1
Cerebral infarction, pulmonary infection and urinary infection	0	1	1
Total	3	1	4

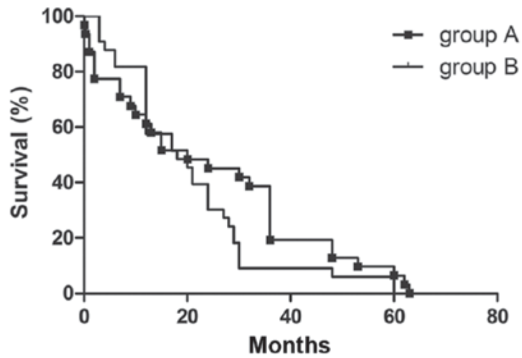

Figure 4. Survival curves of groups A and B of the multiple myeloma patients were compared.

Risk factors. Multivariate Cox regression analysis revealed the significant survival risk factors, and these included the preoperative VAS score (RR=1.731, P=0.025), postoperative chemotherapy (RR=5.241, P=0.048), prothrombin time activity (PTA; RR=0.63, P=0.008), albumin (RR=0.586, P=0.006), LDH (RR=1.000, P=0.037) and urine protein level (RR=1.037, P=0.026; Table III). Evidence of instrumentation failure and local recurrence was not found in the patients enrolled during the follow-up period.

Discussion

MM is the most common primary tumor of the spine, and its typical localization in the vertebral body is in the lower thoracic or lumbar spine (16). Among the SREs secondary to MM, spinal pathologic fractures are considered to be the most common complication (17). However, MM also occurs in the long bone and the soft tissue. Tumor enlargement, pathologic fractures and neurological symptoms are relatively common in MM patients. Apart from treatment approaches including radiotherapy, chemotherapy, bisphosphonates and supportive treatment that are useful (18,19), Dimopoulos *et al* (11) reported a case with acute bony spinal cord compression and neurological impairment in which the patient was successfully treated with a non-operative approach. However, surgical treatment is also proven to be effective in pain relief and improvement of the life quality for the majority of MM patients with SREs and soft tissue mass. The aim of the present study was to compare

Table III. Multivariate Cox regression analysis.

Parameter	Risk ratio	95% confidence interval	P-value
Sex	3.459	0.190-62.984	0.402
Age	0.914	0.798-1.048	0.197
Preoperative VAS score	1.731	1.070-2.800	0.025[a]
Hospitalization time	0.964	0.884-1.052	0.409
Preoperative duration of symptoms	1.086	0.976-1.209	0.132
Preoperative chemotherapy	1.218	0.042-35.379	0.908
Postoperative chemotherapy	5.241	1.017-27.014	0.048[a]
Stage (D-S)			
I	0.000	0.000-1.095	0.053
II	23367	0.000-1.142	0.377
III	2.128	0.014-315.35	0.767
Bleeding during operation	0.999	0.995-1.002	0.438
PTA	0.63	0.447-0.886	0.008[a]
PT	0.205	0.014-2.990	0.247
APTT	0.858	0.715-1.029	0.098
TT	1.112	0.621-1.990	0.720
Albumin	0.586	0.401-0.857	0.006[a]
Hemoglobin	0.966	0.904-1.033	0.312
LDH	1.000	0.997-1.003	0.037[a]
Urine protein	1.037	1.004-1.071	0.026[a]

[a]P<0.05. VAS, visual analogue scale; D-S, Durie-Salmon; PTA, prothrombin activity; PT, protrombin time; APTT, activated partial thromboplastin time; TT, thrombin time; LDH, lactate dehydrogenase.

MM patients with different presentation sites who were surgically treated.

Based on recent progress (1,20,17), the understanding of the osteoclastogenic and osteoblastic factors involved in the development of myeloma bone disease has improved. The myeloma cells are located adjacent to sites of active bone resorption, which suggests that the mechanism for osteoclastic bone destruction in myeloma bone disease is locally mediated (21). In cases of neurological impairment, radiation therapy and chemotherapy are often effective to diminish the local tumor lesion; however, these strategies do not sufficiently treat spinal instability. It is evident that the combination of surgical and adjuvant treatment is necessary to promote promising outcomes, whether the location of the lesion is in the spine, long bone or soft tissue. Therefore, a primary target in the treatment of MM bone disease is the preservation or restoration of spinal stability, which is similar to the goal in the treatment of metastasis (22,23).

To date, only a few studies have been published reporting a comparative analysis of MM patients with different surgical sites. For instance, Zeifang *et al* (24) reported that a tumor in long weight-bearing bones was associated with a reduced survival rate as compared with a spinal tumor location (21 vs. 66 months, respectively). However, in the present study, the median survival time of patients with lesions located in the long bone and soft tissue was longer in comparison with that of patients with lesions located in the spine (60 vs. 36 months, respectively), which is not consistent with previous findings reported in the literature. A statistical difference was not evident in MM patients with different anatomical sites of osteolytic bone lesions in the present study. It can be assumed that plasma cells initially infiltrate the axial skeleton, leading to the compression of marrow. With increased cellular proliferation, extensive bone destruction, pathological fractures, hypercalcemia and osteolyses in long weight-bearing bones become evident, indicating an advanced stage of the disease (25). However, in our opinion, the surgery conducted on the spine is a larger invasive procedure compared with procedures on the long bone and soft tissue, which leads to a longer period of time before the patient is able to walk. Thus, it may result in more postoperative complications, including pulmonary infection, deep venous thrombosis and bedsores among others. Finally, patients undergoing surgery on the spine exhibited a shorter median survival time when compared with those undergoing surgery on the long bone and soft tissue. In addition, studies have demonstrated that the presence or absence of extramedullary lesions in MM patients is closely correlated with the prognosis (26,27). The present study revealed that the prognosis of MM patients with extramedullary lesions was worse in comparison with that of patients without extramedullary lesions, which may also explain why the soft tissue cases had a shorter survival time. Other important considerations, including an advanced tumor stage, health condition of the patients, preoperative duration of symptoms, other accompanying diseases and interruption of other treatments, such as chemotherapy, should also be analyzed.

The surgical outcome of lytic bone lesions in MM is frequently compared with that of bone metastases. In earlier reports, the overall survival time in metastatic bone disease ranged between 6 and 22 months (28,29), depending on the type of primary tumor. Recent studies concluded that the median survival time of MM patients is longer as compared with that of patients with bone metastases (24,30). This explains the fact that, in myeloma patients requiring orthopedic surgery, a treatment decision should be made comprising a stable reconstruction of the bone defects. Recently, minimally invasive stabilization using bone cement, such as the PKP and percutaneous vertebroplasty (PVP) methods, have been demonstrated to be an effective and safe strategy for vertebral body pathologic fractures in MM patients (31,32). Pain relief was apparent in the early stages following PKP/PVP treatment (20). In the present study, 30 out of the 33 patients (90.9%, 30/33) in group A exhibited improved neurological impairment subsequent to surgery. However, in a previous study, only 14 out of 49 patients (29%) exhibited improved neurological function after surgery, and 10 of them were treated by dorsal decompression and stabilization (24). Other authors have reported that up to 81% of patients with spinal neoplasm experienced neurological improvement following surgery combining anterior-posterior approaches (33,34). The prognosis for neurological recovery is adversely affected by the degree and duration of canal narrowing, demonstrating that patients may benefit from earlier decompression regardless of the selected surgical procedure (35). The surgical sites of the majority of cases included into the present study were in the spine or in the long bone/soft tissue, and patients benefited significantly from surgery. The post-surgical complication rate was low (9.1% in group A vs. 3.1% in group B). A study by Pascal-Moussellard *et al* (36) reported a complication rate of 19% (17/145) following vertebral metastasis surgery. The complication rates in groups A and B in the current study were lower compared with that reported following surgery in patients with metastases. Refractures in operated limbs were not identified in the present study.

A study including 84 MM patients who were surgically treated reported a recurrence rate of 6% (24). In the study by Hannisdal *et al* (25), the total local recurrence rate was 11.1%, which was similar to the recurrence rate of 6-22% reported in spinal metastases (37-39). In the current study, local recurrence was not reported in any of the 65 patients to date. This may be contributed to the destruction of the MM microenvironment during the surgical procedure and the effect of adjuvant treatment, as well as the limited length of follow-up. Terpos *et al* (40) reported that, although MRI is superior to positron emission tomography (PET)/CT in the detection of marrow involvement, the PET/CT examination was regarded as the best technique for the follow-up of patients with MM. PET/CT was also proven to be an independent prognostic value at diagnosis and subsequent to treatment. However, in the patients of the present study, only X-ray plain film examination was performed during follow-up and out-patient review due to the financial ability of patients, which should be taken into account. Certain other unknown reasons must also be considered.

Albumin and serum LDH were regarded as markers of the tumor burden and aggressive disease biology, respectively, in the revised ISS classification (41). LDH may be regarded as one of the adjuvant indexes to reflect the prognostic and tumor burden of MM patients (42). In the present study, albumin and LDH were identified as two of the prognostic factors via multivariate Cox regression analysis. The advanced age, site of lytic bone lesions and D-S stage III were indicated as negative prognostic factors for survival in an earlier study (43). However, no significant difference in these three factors was identified for all the patients and between the two groups in the current study. The selection bias of MM patients and grouping of patients should be considered for this. Besides, although no significant difference in the indication of prognosis was detected for the preoperative duration of symptoms in the present study, this factor serves an important role in improving the quality of life of patients and decreasing complications, such as bone disease, anemia and renal failure in MM (44). General practitioners decision-making aids and public education campaigns are required to reduce the time-to-diagnosis (45). Furthermore, it was observed herein that the VAS score decreased gradually in the two groups between the time prior to surgery and at 1 or 6 months following surgery. Notably, a statistically significant difference was observed in the postoperative VAS score at 1 and 6 months after surgery between groups A and B (both $P<0.001$). Thus, it is suggested that the MM patients should be treated individually subsequent to accepting surgery, particularly regarding the postoperative analgesic use. The postoperative pain in MM patients could be controlled effectively by using the appropriate dose of analgesic drugs.

In conclusion, based on the literature and the current findings, it is suggested that surgical treatment is an effective method in MM patients whether the lesion is located in the spine or in the long bone and soft tissue. Preoperative pain, PTA, albumin, urine protein and postoperative chemotherapy are associated with the patient prognosis. Postoperative analgesic use should be individualized according to the different surgical sites and postoperative periods. Finally, studies depicting the outcomes of MM patients with different surgical sites are limited, thus, further investigation need to be undertaken in the future.

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Availability of data and materials

The datasets generated and analyzed in the present study are included in this published article.

Authors' contributions

All these authors contributed equally to this work. JTS and XRD conceived and designed the study. LXZ, HL, ZYX and XRD acquired, analyzed and interpreted the information. JTS and XRD wrote, reviewed and/or revised the manuscript. XRD, ZYX and JTS proofread and formatted the manuscript.

Ethics approval and consent to participate

Informed consent was obtained from the subjects for participation into the present study. Ethical approval was obtained from the The College Research Ethics Committee, Beijing Chao-yang Hospital, Capital Medical University (Beijing, China).

Consent for publication

Consent for publication of this article has been obtained from all patients included in the study.

Competing interests

The authors declare that they have no competing interests.

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