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Research Article

Clinical outcomes and complications of surgical interventions for multiple myeloma lesions in the extremities and pelvis: A retrospective clinical study

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ABSTRACT

Objective: This study aimed to assess the pain and functional status of patients who underwent various surgical interventions for the stabilization of selected multiple myeloma (MM) lesions in the extremities and pelvis and to investigate the rate of complications requiring reintervention.

Methods: Patients with MM who underwent various surgical interventions for the extremity or pelvic lesions were retrospectively reviewed. Change in the pain intensity was assessed using visual analogous scale (VAS) preoperatively, at the time of discharge, and at the final follow-up. Functional status was assessed using the musculoskeletal tumor society (MSTS) scoring system for both upper and lower extremities preoperatively and at the final follow-up. Postoperative complications requiring reintervention, including dislocation, loss of fixation/aseptic loosening of prosthesis, mechanical insufficiency, periprosthetic fracture, infection, or progression of the local disease, were recorded.

Results: A total of 49 (20 men and 29 women) previously (23) or newly (26) diagnosed patients with a mean age of 60.8±18.2 years were included in this study. Of these, 6 patients underwent multiple surgeries for different skeletal sites; in total, 57 procedures were performed. The mean follow-up was 47.7±21.63 months. The lesions were localized to the humerus (19), radius (1), pelvis (4), femur (30), and tibia (3). The surgical indications included therapy-refractory pain for 17 patients and pathological fractures due to progression of pre-existing lesions for 12 patients or newly diagnosed lesions with extensive bone destruction at initial presentation for 28 patients. Surgical procedures included prosthetic reconstruction in 32 patients, cement-augmented osteosynthesis in 9, and closed intramedullary nailing in 16. The mean VAS score decreased from 8.75±1.2 preoperatively to 3.21±1.56 at the time of discharge and 1.2±0.42 at the final follow-up. Although a significant decrease was detected between the preoperative and postoperative VAS scores at the time of discharge (p=0.0001), the decrease between the time of discharge and the final follow-up was statistically insignificant (p=0.086). The mean MSTS score significantly improved from 9.1%±6.4% (range: 0%–40%) preoperatively to 76%±14.9% (range: 40%–93.3%) at the final follow-up (p=0.0001). Significantly higher MSTS scores were obtained in the upper extremity than lower extremity/pelvis (p=0.04) and in isolated diaphyseal involvement than metaphyseal or articular involvement (p=0.032). A total of 11 complications requiring reintervention (19.2%) were observed, which included dislocation (3.5%), loss of fixation (5.2%), mechanical insufficiency (3.5%), infection (5.2%), and local tumor progression (1.7%). The rate of complications requiring reintervention was lower but statistically insignificant in the upper extremity (5%; 1/20) than lower extremity/pelvis (27%; 10/37) (p=0.076) and in isolated diaphyseal involvement (6.2%; 1/16) than metaphyseal or articular involvement (24.3%; 10/41) (p=0.079).

Conclusion: Although different types of surgeries can achieve pain relief and good function in different anatomical localizations, better functional results with lower complication rates may be obtained following surgical management of MM lesions in the upper extremities and in diaphyseal localizations.

Level of Evidence: Level IV, Therapeutic Study

Introduction

Multiple myeloma (MM) is a B-lymphoid cell neoplasm characterized by clonal proliferation of plasma cells within the bone marrow. Infiltration of bones with plasma cells leads to osteolysis and shifts the normal balance of bone formation toward bone resorption. Diffuse osteopenia, focal lytic lesions, pathological fractures, and bone pain are frequently seen as the major causes of morbidity (1, 2).

Primary treatment modality of MM is nonoperative, including multiagent chemotherapy and bisphosphonates (3). Radiation treatment is also effective for relieving intractable bone pain, especially if the pain is localized (1, 4-6). Surgical interventions should be reserved for therapy-refractory pain or pathological fractures due to the progression of pre-existing lesions or newly diagnosed lesions with extensive bone destruction (1, 2, 7-13). An active approach is needed to keep the patients with MM ambulatory and independent. The surgical treatment should provide immediate pain reduction, stabilization of pathological fractures, restoration of function of the affected extremity, and return to mobility with full-weight bearing as soon as possible (1, 2).

There are a limited number of studies focusing on the skeletal manifestations of MM requiring surgical intervention (7-10, 12, 13). Although chemotherapy is the mainstay of treatment and skeletal lesions are very sensitive to radiotherapy, we believe that a selected group of patient with MM still requires surgical treatment for stabilization of the involved extremity, with the least operative morbidity to retain a satisfactory quality of life. In this study, we aimed to reveal the improvement

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in pain and functional status of the patients after endoprosthetic reconstruction, cement-augmented osteosynthesis, and closed intramedullary nailing, which were all performed for stabilization of MM lesions in the extremities and pelvis. The rate of complications necessitating reoperation was also searched for each surgical modality. In addition, the effects of localization of the lesion, upper versus lower extremity, and diaphyseal versus metaphyseal or articular involvement, on functional results and complication rates were analyzed.

Materials and Methods

Patients with MM who underwent surgical treatment for extremity or pelvic lesions between 2010 and 2017 were reviewed retrospectively in this study. A computer search of our database revealed that the study population included 20.6% of patients with MM admitted to our orthopedic oncology unit, as a consultation or direct admission to an outpatient clinic or emergency department, in the time of this study. The patients whose musculoskeletal problems could be managed by chemotherapy and radiation were excluded. The patients with spinal involvement, managed by bracing or occasional spinal fixation, were also not the subject of this study.

Data were collected from our extensive orthopedic oncology records, patient archiving and communication systems, and pathology reports. The following variables were recorded: age and sex of the patients, location of the lesions, the type and duration of symptoms, previous oncological treatment, the indications and types of surgeries, postoperative clinical and radiological follow-up, complications that necessitate a reoperation, and overall patient survival. Ethical approval for this study was granted by the local ethics committee of Marmara University School of Medicine (decision no: 09.2014.0209).

All patients in this study were treated with a multidisciplinary approach according to the decision of the bone and soft tissue tumors council of Marmara University, Pendik, training and research hospital. The surgical indications for previously diagnosed patients with MM were therapy-refractory pain and progression of pre-existing bone lesions, sometimes despite radiation therapy, leading to a pathological fracture. Extensive bone destruction with an impending or actual pathological fracture at presentation was the main indication for immediate surgery for newly diagnosed patients. The Mirels' scoring system for predicting pathological fracture risk in bone metastasis was used similarly to define the impending fracture in this study; MM lesions with a score of 8 or higher were considered to have a fracture risk (14). Bone marrow aspiration was performed in all patients with a new diagnosis.

HIGHLIGHTS

- In the current study, progressive MM lesions of the extremities and pelvis were managed by various surgical interventions including prosthetic reconstruction, cement augmented osteosynthesis or closed intramedullary nailing, due to the localization and local extension of the lesions.
- Although different types of surgeries achieved pain relief and good function in different anatomical localizations, better functional results with lower complication rates were possible following surgical management of myeloma lesions in the upper extremities and in diaphyseal involvement.
- We recommend intramedullary nailing as the method of choice for diaphyseal myeloma lesions in the extremities. Even for less aggressive lesions, a prosthetic replacement can be preferred to cement augmented osteosynthesis in the metaphyseal and articular regions.

The surgical interventions included prosthetic reconstruction, cement-augmented osteosynthesis and closed intramedullary nailing owing to the localization (diaphyseal versus metaphyseal or articular), and severity of local extension of the lesions. Closed intramedullary nailing was preferred for isolated diaphyseal lesions, regardless of tumor extension. Femoral (cephalomedullary) and tibial nails were routinely locked on both ends; however, distal locking was occasionally required in humeral nails. Metaphyseal or articular lesions were treated by an arthroplasty or cement-augmented osteosynthesis depending on the local extension of the tumor. A prosthetic replacement was chosen if the involved part was destructed extensively and if the tumor extended to soft tissues. If the tumor was confined within the boundaries of the bone without significant cortical destruction, osteosynthesis using a plate or nail and cement augmentation was performed. Pelvic/acetabular lesions were routinely managed by total hip arthroplasty (THA) with or without pelvic reconstruction. Acetabular reconstruction included retrograde threaded pins with cemented acetabular reinforcement ring and/or polyethylene cup (15).

Cemented stems were preferred in all prosthetic replacements; antibiotic (gentamycin)-containing bone cement was used in these procedures. In segmental hip reconstructions with tumor endoprosthesis, capsular and abductor repair was reinforced by an attachment tube (polyethylene terephthalate "Trevira tube," MUTARS, Implantcast, Buxtehude, Germany) surrounding the prosthesis. The attachment tube was also used in proximal humeral reconstructions. Antibiotic prophylaxis was administered at induction and continued until all drains were removed by the second to fourth postoperative day.

A musculoskeletal oncology team including 4 orthopedic surgeons performed the preoperative and postoperative clinical and radiological follow-up evaluations. Clinical and radiological follow-up was performed by 3-month intervals in the first 2 years, 6-month intervals in the following 3 years, and then annually. Clinical follow-up mainly included evaluation of improvement in pain and functional status of the patients in the postoperative period. Visual analogous scale (VAS) scores were measured preoperatively and postoperatively at the time of discharge and last follow-up. Functional evaluation was performed by the musculoskeletal tumor society (MSTS) scoring system for both upper and lower extremities; preoperative and postoperative last follow-up MSTS scores were used to demonstrate the functional improvement.

Postoperative complications that necessitate a reoperation, including dislocation, loss of fixation/aseptic loosening of the prosthesis, mechanical insufficiency, periprosthetic fracture, infection, and progression of the local disease, were searched. Patient survival was recorded.

Data obtained in this study were analyzed statistically using Statistical Package for the Social Sciences version 11 software (SPSS Inc.; Chicago, IL, USA). The compatibility of the data with a normal distribution was evaluated with histograms and the Kolmogorov–Smirnov test. The descriptive statistics were presented as means, standard deviations, and medians. The Mann–Whitney U test was used for the pair-wise comparison of nonparametric variables. In addition, localization of the lesion, upper versus lower extremities and diaphyseal versus metaphyseal or articular involvement, was statistically analyzed by the Mann–Whitney U test. The Chi-square test (Fisher's exact test) was used for complication rates. The paired *t*-test was used for the difference between preoperative and postoperative VAS (at the time of discharge and last follow-up) and MSTS (last follow-up) scores. $p<0.05$ was accepted as statistically significant.

Results

There were 49 (20 men and 29 women) previously (23) or newly (26) diagnosed patients with a mean age of 60.8±18.2 years. A total of 6 patients had multiple surgeries for different skeletal sites; therefore, 57 procedures were performed. The age at the first surgery was considered for patients with multiple surgeries. The mean follow-up was 47.7±21.63 months. At the time of this study, 27 patients were still alive, with a mean follow-up of 50.8±23.42 months after surgery.

The lesions that required surgery were localized in the humerus (19), radius (1), pelvis (4), femur (30), and tibia (3). Moderate to severe pain was the main symptom, present in all patients either with a known or new diagnosis, for a mean duration of 4 months (range, 1–9 months). A total of 48 (84.2%) out of 57 lesions were associated with actual (32) or impending (16) pathologic fractures, which frequently led to limited motion of the involved extremity (Figure 1). The Mirels' score was 8 or higher for all lesions, which were defined as associated with an impending fracture. Bone marrow aspiration demonstrated a plasma cell infiltration in all patients with a new diagnosis.

All the 23 patients with a previous diagnosis of MM were under chemotherapy before surgery and continued chemotherapy postoperatively. Of these, 17 patients received preoperative radiation treatment for their bone lesions. The patients with a new diagnosis had immediate surgery, which was followed by chemotherapy and radiation. The entire length of the involved bone, regardless of the procedure performed, was irradiated in patients who did not receive radiation treatment before. Patients who had multiple surgeries were managed according to the same principles.

The indications for surgery are described in a flowchart in Figure 1. A total of 57 surgical procedures, including prosthetic reconstruction, cement-augmented osteosynthesis, and closed intramedullary nailing, were performed. Table 1 demonstrates the distribution of surgical interventions in different skeletal sites (Figures 2. a-c, 3. a, b, and 4. a-d).

All the patients improved postoperatively, with respect to pain, extremity motion, and mobility. The mean VAS score, which was 8.75±1.2 preoperatively, had a tendency to decrease postoperatively and was measured as 3.21±1.56 and 1.2±0.42 at the time of discharge and last follow-up, respectively. A statistically significant decrease was detected between the preoperative and postoperative VAS scores at the time of discharge (p=0.0001). The mean time for discharge was 6.7±3.4 days. The VAS score did not show a significant decrease between the time of discharge and the last follow-up (p=0.086).

The mean preoperative MSTS functional score of the whole study group was measured as 9.1%±6.4% (range: 0%–40%). The mean MSTS scores owing to the last follow-up of all patients and of those surviving were 76%±14.9% (range: 40%–93.3%) and 76.4%±15.3% (range: 40%–93.3%), respectively. A statistically significant overall functional improvement was achieved postoperatively (p=0.0001). The mean MSTS scores after upper and lower extremities/pelvis surgeries were 85.8%±7.5% (range: 70%–93.3%) and 70.8%±15.4% (range: 40%–93.3%), respectively. Management of the isolated diaphyseal lesions revealed an MSTS score of 87.9%±6.2% (range: 73.3%–93.3%) compared with 70.1%±14.5% (range: 40%–93.3%) for metaphyseal or articular lesions, including the pelvis. Statistically, localization of the lesions correlated with the MSTS scores; higher MSTS scores were obtained in the upper extremity than the lower extremity/pelvis (p=0.04) and in isolated diaphyseal involvement than metaphyseal or articular involvement (p=0.032). Closed intramedullary nailing of diaphyseal lesions was associated with higher MSTS scores than those of prosthetic reconstruction and cement-augmented osteosynthesis of metaphyseal or articular lesions (p=0.002). The postoperative improvement in MSTS scores of previously and newly diagnosed patient groups was not statistically significant (p=0.226).

Table 2 gives the summary of complications necessitating reoperation after prosthetic reconstruction, cement-augmented osteosynthesis, and closed intramedullary nailing. The rate was lower but statis-

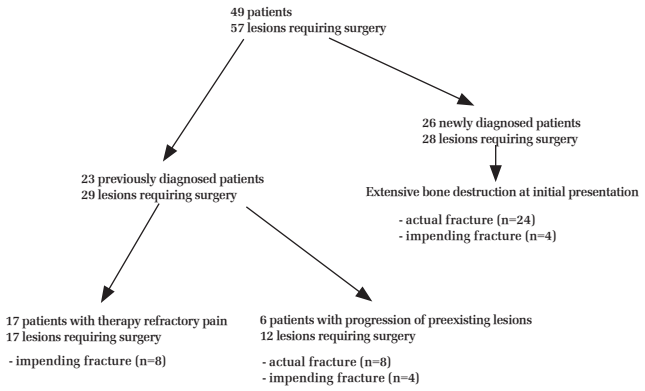

Figure 1. Surgical treatment indications for previously and newly diagnosed MM patient

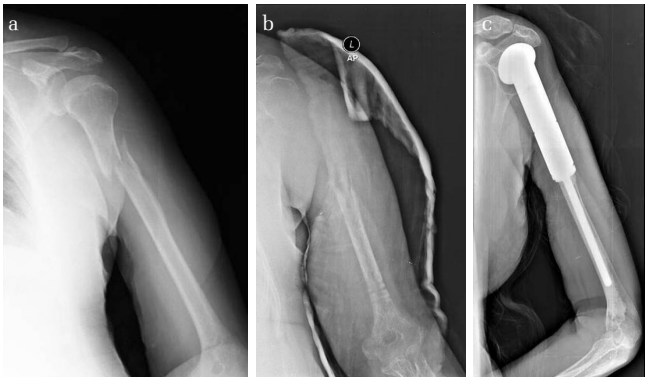

Figure 2. a-c. A 64-year-old male with a progressive lytic lesion of the proximal part of the left humerus (a-b). This patient had a pathological fracture and was initially treated with an external fixator in another institution. Then he was diagnosed as MM in the author's institution and underwent resection and endoprosthetic reconstruction, followed by chemotherapy and radiotherapy (c)

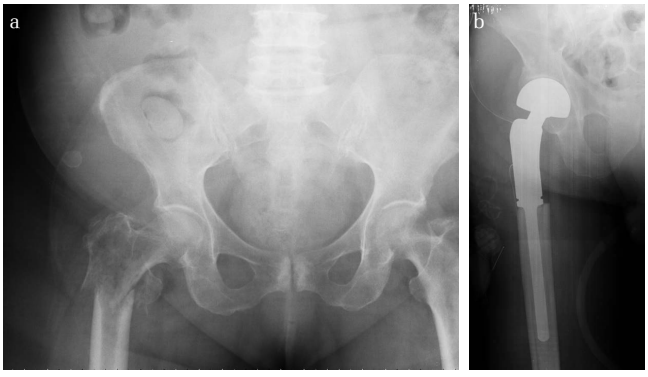

Figure 3. a, b. A 57-year-old male with a pathological fracture of the proximal femur due to MM (a). The patient underwent resection and endoprosthetic reconstruction due to extensive bony involvement (b)

Table 1. The distribution of the surgical interventions in different skeletal sites

		EPR ° (n=32)	PMMA +IF ° (n=9)	Closed IMN ° (n=16)
Humerus (n=19)	Proximal metaphysis or articular	10	2 (1 PMMA + plate, 1 PMMA + IMN)	
	Distal metaphysis or articular	1	1 (PMMA + plate)	
	Diaphysis			5
Radius (n=1)	Diaphysis			1
Pelvis (n=4)	Periacetabular	4 *		
Femur (n=30)	Proximal metaphysis or articular	15 **	2 (1 PMMA + plate, 1 PMMA + IMN)	
	Distal metaphysis or articular	2	2 (2 PMMA + plate)	
	Diaphysis			9
Tibia (n=3)	Proximal metaphysis or articular		1 (PMMA + IMN)	
	Distal metaphysis or articular		1 (PMMA + plate)	
	Diaphysis			1

° EPR:endoprosthetic reconstruction; PMMA + IF: cement augmented osteosynthesis; Closed IMN: Closed intramedullary nailing
* (2) patients; cementation of the defect + THA, (2) patients; preoperative embolization + acetabular reconstruction + THA
** (5) patients; conventional hip prosthesis, (10) patients; tumour endoprosthesis. Hip articulation was bipolar in 13 and THA in 2.

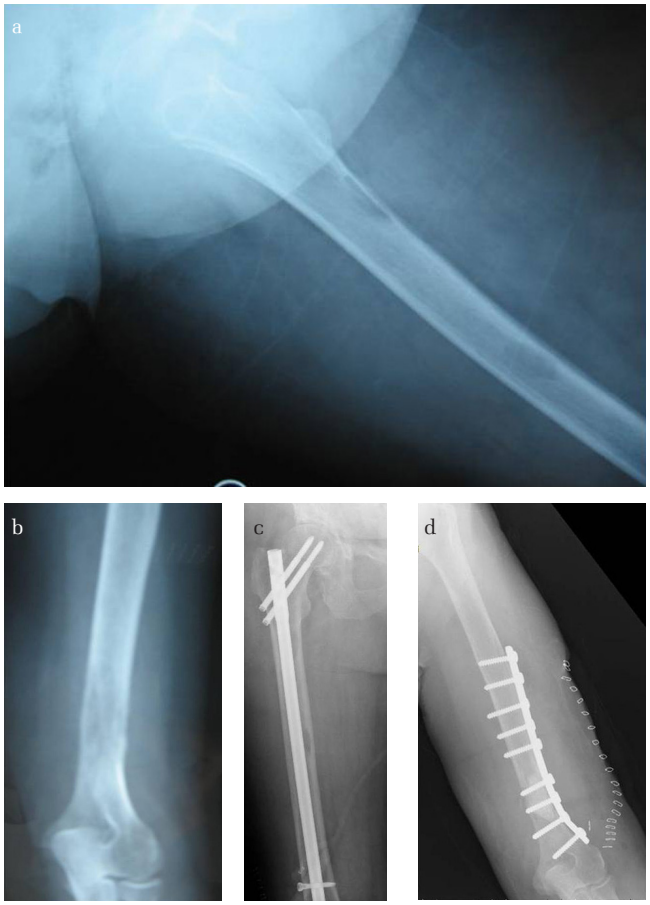

Figure 4. a-d. A 68-year-old female had multiple surgeries for skeletal manifestations of MM (a-b). The patient had closed intramedullary nailing for multiple lesions in the femoral diaphysis and cement augmented osteosynthesis for a solitary lesion in the distal humeral metaphysis (c-d)

tically insignificant in the upper extremity (5%; 1/20) than the lower extremity/pelvis (27%; 10/37) (p=0.076) and in isolated diaphyseal involvement (6.2%; 1/16) than metaphyseal or articular involvement (24.3%; 10/41) (p=0.079). The previously and newly diagnosed patient groups did not show a significant difference in terms of complications necessitating reoperation (p=0.142).

There were 2 (3.5%) dislocations around the hip after resection and reconstruction, seen within 2 months of the initial procedure; 1 dislocation occurred in THA and the other in bipolar articulation. Dislocations were managed by closed reduction (1) or open reduction and soft tissue reconstruction (1), followed by a period of abduction bracing and physical therapy, without any further dislocation.

Table 2. Complications necessitating re-operation following different types of surgeries performed for skeletal manifestations of MM

Complications necessitating re-operation (19.2%)	EPR ° (n=32)	PMMA +IF ° (n=9)	Closed IMN ° (n=16)
Dislocation: 2 (3.5%)	2 (6.25%)	-	-
Loss of fixation: 3 (5.2%)	-	3 (33.3%)	-
Mechanical insufficiency: 2 (3.5%)	1 (3.12%)	1 (11.1%)	-
Infection: 3 (5.2%)	2 (6.25%)	1 (11.1%)	-
Local tumor progression: 1 (1.7%)	-	-	1 (6.25%)
Complication rate (X%)	15.5% (5/32)	55.5% (5/9)	6.25% (1/16)

° EPR: endoprosthetic reconstruction; PMMA + IF: cement augmented osteosynthesis; Closed IMN: Closed intramedullary nailing

Internal fixation was loosened between 6 and 18 months in 3 (5.2%) patients who underwent cement-augmented osteosynthesis for proximal humeral, distal femoral, and proximal tibial lesions. Loosened distal femoral plate was revised with a cement-augmented retrograde intramedullary nail. Remaining 2 failures were managed by resection and endoprosthetic reconstruction.

Mechanical insufficiency was observed in 2 (3.5%) patients between 2 and 3 years. Stem fracture of the proximal femoral endoprosthesis was managed by revising the whole reconstruction. In another patient, the broken distal femoral blade plate was revised with a cement-augmented retrograde intramedullary nail.

The most common complication resulting in reoperation was deep infection observed in 3 (5.2%) patients; 1 infection was seen 9 months after the endoprosthetic reconstruction of a proximal femoral lesion and managed by 2-staged surgery. The implants were removed, and the defect was temporarily fixed with an antibiotic-loaded cement spacer. The endoprosthesis was reimplanted following a period of antibiotherapy. This patient is still alive without any event for a total follow-up of 24 months. Remaining 2 early infections were associated with a proximal femoral endoprosthesis and a proximal tibial cement-augmented plate and were managed by mechanical debridement and antibiotherapy, without a recurrent infection. Mobile components of endoprosthesis were also exchanged.

Moreover, 1 (1.7%) patient with a femoral diaphyseal lesion, which was managed by closed intramedullary nailing followed by adjuvant chemotherapy and radiation, had local tumor progression 2 years

postoperatively. This patient had a segmental distal femoral resection and endoprosthetic reconstruction.

Discussion

MM is the most common malignant neoplasm of plasma cells, and it primarily involves the bone and bone marrow (16). The lytic process observed in MM is very different from other cancers that metastasize to the bone in which bone destruction is followed by new bone formation. Systemic chemotherapy is the primary treatment modality for MM, and novel agents and bone marrow transplantation have improved the survival outcomes in recent years (1-3, 17). Local radiotherapy is a readily available modality that can be useful for the treatment of symptomatic bone lesions (1, 6). Although MM frequently responds to chemotherapy and radiation treatment, skeletal lesions may still progress without the healing of osteolytic lesions. These certain groups of patients with therapy-refractory bone pain and pathological fracture may require surgical intervention for mobility and pain control (1, 7-10, 12, 13). However, the extent of surgical treatment should be minimized to decrease morbidity and possible infection, with an early postoperative return to chemotherapy whenever possible. In this study, various surgical interventions provided a significant clinical improvement for MM lesions with therapy-refractory pain or pathological fracture owing to extensive involvement in the extremities or pelvis. All patients improved postoperatively with respect to pain, extremity motion, and mobility. A comparison of the functional results revealed significantly better results after surgical management of lesions in the upper extremities and in diaphyseal localizations. The complications requiring reoperation were also seen less in the upper extremity and in diaphyseal involvement, although this was not statistically significant.

Prognostic factors affecting the functional outcomes and complication rates of surgical procedures and survivorship of implants and patients have been investigated in large heterogeneous series, including patients with primary or metastatic bone tumors (18, 19). In a heterogeneous series of 3,049 patients, the pathological fracture rate was 43% in 513 patients with MM (20). Except for lung cancer, the pathological fracture was associated with a significant increase in the risk of death.

Zeifang et al. reported 84 patients with MM who were treated surgically for spinal and extremity lesions (8). Although 2 different chemotherapy protocols were compared in terms of long-term survival, the authors described the outcomes and complications of surgical treatment in MM. Indications for surgical treatment in the extremities were intractable bone pain and actual or impending pathological fractures. The preferred surgical treatment modalities included endoprosthetic reconstruction for femoral or humeral articular or metaphyseal fractures and compound plate osteosynthesis for diaphyseal osteolytic lesions. The complication rate after extremity and pelvic surgery was 10.7% (9 in 84 patients), including infection, hematoma, mechanical problems, dislocations, and local recurrence. The authors concluded that surgical treatment could provide a long-term stable reconstruction of the affected bone, with a low complication rate.

Utzschneider et al. performed 83 surgical interventions to 75 patients with MM with axial skeleton or proximal extremity involvement (9). The mean follow-up was 5.4 years. Patients with a single bone lesion, a negative bone-marrow biopsy, and postoperative radiation had a better survival probability. Localization of the bone lesion, regardless of the presence of a fracture, did not influence the prognosis. The authors concluded that survival time was better in MM than metastatic bone disease, and surgical treatment should be considered for skeletal lesions with pathological fractures.

Pelvic and periacetabular bony involvement of MM is associated with some unique characteristics regarding the biomechanics of this specific anatomical region, morbidity, overall survival, and prognosis, which all reflect impairment of quality of life. Sakellariou et al. reviewed the special features of MM lesions around the pelvis and acetabulum and presented an algorithm of surgical management (7). The authors emphasized disabling the functional pain, despite analgesics and/or radiotherapy, as the most cited surgical indication and recommended stabilization surgery when life expectancy is longer than 3 months. The authors put forward the Harrington classification (15) to describe the extent of the periacetabular lesion and an appropriate type of reconstruction.

In this study, an isolated series of patients with MM with pelvic and extremity lesions were treated surgically. The proximal end of the femur was involved most commonly because of its weight-bearing role and the high stress applied to that region. Symptomatic femoral diaphyseal lesions were also commonly seen. Although it is not a weight-bearing bone, the humeral lesions associated with pathological fractures were frequently encountered.

The main indications for surgery in previously diagnosed patients were therapy-refractory pain and progression of destructive lesions, with impending or actual pathological fractures. A considerable number of lesions in this series (30%; 17/57) had been irradiated before surgical intervention, which indicates that although irradiation is a well-established and effective local treatment of bony lesions in MM, some patients may still require surgery for pain control and function. It should also be recognized that a painful, extensive bony lesion with an actual or impending fracture may be the presenting symptom in MM and that surgical treatment is required before chemotherapy and radiation.

Pathological fractures are frequently associated with progressive myeloma lesions and constitute a major cause for surgical treatment. Some studies suggest that pathological fractures reduce survival and increase mortality in patients with MM (21). Actual or impending pathological fracture rate was 84.2% in this series. Because of this high rate of patients with pathological fracture, it was difficult to compare the subjects of this study with or without pathological fracture in terms of postoperative functional outcomes and complication rates.

The localization and local extension of the lesions are the main factors in determining the type of surgical treatment modality in patients with metastatic bone disease and MM (7, 9-13, 22). Pelvic/acetabular lesions can be managed by cementation of the defect with or without pelvic reconstruction and THA. For a lesion confined to the femoral head, a conventional hip replacement may suffice. Extensive articular and metaphyseal lesions frequently weaken the proximal femur, tibia, or humerus and require replacement by tumor endoprosthesis (13). Less destructive metaphyseal lesions in both the extremities can be managed by cement-augmented osteosynthesis. In addition, for selected long bone metaphyseal lesions, new-generation multilocked intramedullary nails can be used without bone cement because MM lesions are prone to healing and sensitive to radiotherapy (23). Intramedullary nails are preferred for diaphyseal lesions (10-12). Stabilizing the entire bone by cephalomedullary nails, locked proximally and distally for maximum stability, is recommended for diaphyseal

lesions of the femur (10). The aforementioned principles were applied throughout this series, and MM lesions, with or without a pathological fracture, were managed by different surgical procedures depending on localization and local aggressiveness of the tumor.

Postoperative irradiation improves the functional outcomes and reduces the rate of repeat surgery, needed after surgical stabilization of the long bone lesions in MM (10, 24). Historically, postoperative radiotherapy encompassed the full length of the surgical hardware, usually entire length of the affected bone, regardless of the preoperative extent of disease along the bone. Previous studies have shown that greater coverage of surgical hardware is associated with improved local disease control (25); however, these studies explored the use of radiotherapy after surgical bone fixation in patients with metastatic bone disease. Unlike many solid tumors, MM is a systemic disease that is highly chemo- and radiosensitive, and current studies favor a different approach by reducing both the radiation dose and the field size after surgical stabilization (26). Considering the time frame of our study, the entire length of the involved bone, regardless of the procedure performed, was irradiated in those patients who did not receive radiation treatment before. However, in recent years, the trend in our institution is also evolving to a limited postoperative radiation therapy involving a reduced dose and field size. Another issue related to postoperative radiotherapy is the use of cemented implants because the radiation may affect bone ingrowth or ongrowth in uncemented prostheses (22). Cemented stems were used in all prosthetic replacements in this series.

The surgical management of symptomatic, extensive myeloma lesions, mostly associated with a pathological fracture, provided a significant clinical improvement throughout this series; all the patients improved postoperatively with regard to pain, extremity motion, and mobility. Although different types of surgeries achieved pain relief and good function in different localizations, better functional results with lower complication rates were possible after surgical management of lesions in the upper extremities and in diaphyseal localizations. The rate of complications requiring reoperation (19.2%) was slightly higher than the limited number of reported studies in the literature (8). Closed intramedullary fixation of isolated diaphyseal lesions provided better functional results and lower complication and reoperation rates than endoprosthetic reconstruction or cement-augmented osteosynthesis of metaphyseal or articular lesions.

It is difficult to explain these results objectively because different surgical techniques were used in different anatomical localizations. We believe that the technique used and the lesion site should be considered interrelated for subjective conclusions. Because it is a less invasive technique and the diaphyseal lesions are far from the articular/periarticular region, an early and reliable functional restoration and return to mobility was possible after closed intramedullary fixation of diaphyseal lesions in both the extremities. In addition, this minimal intervention achieved decreased patient morbidity and early postoperative return to chemotherapy and, when required, early use of postoperative radiotherapy. In contrast, although endoprosthetic replacement or cement-augmented osteosynthesis of metaphyseal or articular lesions provided immediate pain relief and a stable extremity, the functional recovery time was longer and frequently interrupted by possible complications. A relatively high complication rate also had a negative effect on the use of adjuvant treatments following these more aggressive interventions.

We recognize the limitations in this study. First, it is a retrospective study including a limited number of patients. However, MM lesions that require surgery are relatively rare, limiting the overall number of interventions performed for skeletal manifestations of MM. Second, different types of surgical procedures were performed for the same anatomical site (endoprosthetic reconstruction or cement-augmented osteosynthesis for metaphyseal or articular lesions). Although the type of surgery was determined depending on the localization and the local extent of the lesions, this prevented achieving a standard approach throughout the series. Thus, the overall functional improvement and complication rate of the whole study group and different localizations were evaluated without the support of a standard approach. Third, there is no control group for comparison in this study; hence, similar series in the literature were discussed to evaluate our results. Fourth, the preoperative and postoperative clinical and radiological follow-up evaluations were performed by the surgeons in the orthopedic oncology team instead of an independent observer. In contrast, all the procedures were performed by the same surgeon in the same institution. In addition, the patients were followed extensively with detailed clinical, functional, and oncological records.

Surgical stabilization of extensive bony lesions and pathological fractures should be considered to keep the patients with MM ambulatory and independent. Depending on the localization and the local extent of the bony lesions, various surgical techniques were used to provide a stable long-term reconstruction in the pelvis and extremities. Overall, good functional results and, except for cement-augmented osteosynthesis, acceptable complication and reoperation rates were obtained. The results of this study support that intramedullary nailing should be the method of choice to fix diaphyseal myeloma lesions in the extremities.

Even for less-aggressive lesions, a prosthetic replacement can be preferred for cement-augmented osteosynthesis in the metaphyseal and articular regions.

Ethics Committee Approval: Ethics committee approval was received for this study from the Ethical Committee of Marmara University, School of Medicine (decision no: 09.2014.0209).

Informed Consent: Written informed consent was obtained from the patients who participated in this study.

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