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Application of acrylic spacers for long bone defects after tumoral resections

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Abstract. – INTRODUCTIONS: Tumoral resections pose serious challenges because sufficient removal has to be balanced against function preservation. A particular type of resection is encountered when the tumor is located in the diaphysis. It can lead to an important gap which cannot always amend to bone grafting in the same procedure.

PATIENTS AND METHODS: The aim of the paper is to evaluate the long term outcome of segmental bone loss in patients with malignant tumors removed from diaphyseal regions and treated by intramedullary nailing and polymethylmethacrylate spacer. The limb function was then evaluated using a range of motion by the Musculoskeletal Tumor Score (MSTS) and the perceived quality of life measured by the EORTC QLQ-C30.

RESULTS: There were no immediate postoperative local or systemic complications and no failures of the nail/cement construct. All cases were allowed immediate weight bearing (lower limb) and none were immobilized (upper limb). The average length of the bone defect was 9 (6-14) centimeters. The average follow-up was 2.5 (1-4) years.

CONCLUSIONS: Polymethylmethacrylate cement spacers, over intramedullary nailing, have statistically proved a feasible and inexpensive procedure with limited complications, low surgical stress and favorable functional outcomes. It can be a definitive therapy for advanced cases, as well as temporary solution which can be successfully converted to secondary bone grafting.

Key Words:
Polymethylmethacrylate spacers, Tumoral resections, Long bone defects, Fibula autograft, Treatment outcome.

Introduction

Segmental bone resection, after tumoral establishment, poses serious options because of a sufficient removal in balance with a preservation of the function. Radical treatment – amputation – has been found to provide comparable therapeutic outcomes for limited resections but with less favorable functional results. In addition, in the tumoral setting, amputation severely alters the quality of life of the patients, especially when performed above the knee or the dominant arm. When the tumoral mass is located at metaphysis level, the adjacent joint is usually involved and the treatment requires a tutoral prosthesis. Without such complex and expensive implants, only little progress can be done to preserve the function. Another particular type of resection is encountered when the tumor is located at the diaphysis of the long bones. When the radicalness of the procedure or the overall status of the patient (high probability or confirmation of multiple metastases) is questionable, the surgery may lead to a palliative procedure. However, the local disease could still be contained for a long time with adjunctive chemotherapy. On this principle, we have observed favorable evolution in a previous retrospective study on pathologic fractures associated with osteosarcoma. Limb sparring procedures, in conjunction with adjuvant chemotherapy, could lead to favorable functional outcomes and survival[1]. If the tumor appears to be a secondary dissemination, surgical removal can also attempt a favorable long term outcome. Furthermore, the presentation with a pathologic diaphyseal fracture, obliges to a surgical treatment even if the overall conditions are uncertain. After the tumor removal, the gap is often important and thus distraction osteosynthesis or cancellous autograft (such as iliac crest) do not suffice. Free fibular grafts could be a good option but, very often, these patients need supplemental challenges. Patients can be too weak to undergo a single lengthy and complex procedure. For such cases a

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marginal or radical resection of the tumor can be followed by locked intramedullary nailing and the segmental defect filled with an acrylic cement spacer. Biewener et al[2] have shown that combination osteosynthesis is a suitable mean to stabilize segmental bone defects in cases with poor lifetime prognosis or as temporary stabilization during chemotherapy. Polymethylmethacrylate (PMMA) is one of the most versatile and inexpensive substance used as bone cement. It has been used in orthopedics along many decades with relative little modifications. It serves as adhesive in arthroplasty, vertebral augmentation, spacer which delivers antibiotics in bone and joint infections or just for filling osseous defects. It has virtually no local adverse effects and very limited cardiopulmonary complications[3,4]. The use of PMMA to improve fixation in pathologic bone is not new. Miller et al[5] have proposed injection of polymethylmethacrylate through the intramedullary nail with retrograde filling of the space between the rod and the inner cortex. Masquelet et al[6] found that, when a segmental bone loss is temporarily occupied by a PMMA spacer, a reactive inflammatory membrane creates around it in as little as 6 weeks. In a second step, when the cement block is removed and replaced by cancellous bone, this membrane somewhat acts like a periostium, prevents resorption and secretes growth factors. Apard et al[7] modified the above technique and used internal fixation – intramedullary nails instead of external fixation. In this way, their patients resumed weight-bearing more quickly. All these techniques were applied to tibial bone loss resulting from trauma or infection. Given these premises, we aimed to evaluate the long term outcomes of segmental bone loss after tumoral resection treated with intramedullary nailing and a polymethylmethacrylate spacer.

Patients and Methods

In a prospective observational study we followed 12 patients who had malignant tumors removed from diaphyseal regions with internal stabilization using intramedullary nails and gap filling done by acrylic cement. The cases were enrolled over a period of 5 years in a University Hospital, out of a pool of 47 cases with long bone malignancies. The anatomical location, length of the defect, pathologic fracture as initial presentation, patient demographics, histology of the tumor, follow-up period, final outcome, local recurrence, secondary surgery for bone grafting and postoperative chemotherapy of the studied 12 patients are summarized in Table I.

The limb function was evaluated using Musculoskeletal Tumour Score (MSTS)[8]. The per-

Table I. Synthetic data of the patients.

	Level	Length of the defect	Pathologic fracture	Age	Gender	Histology	Follow-up	Local recurrence	Secondary bone grafting	Chemo-therapy
1	Humerus	6	Yes	60	Male	Metastatic adenocarcinoma	1/Death	No	No	Yes
2	Humerus	7	No	57	Female	Condrosarcoma G2	3/Alive	No	Yes	No
3	Humerus	7	Yes	71	Female	Malignant fibrohistyocitoma	3/Alive	No	No	Yes
4	Radius	10	No	24	Female	Osteosarcoma	2/Death	No	No	Yes
5	Radius	6	No	59	Female	Fibrosarcoma	2/-	No	Yes	Yes
6	Ulna	12	No	52	Male	Leiomyosarcoma	4/Alive	No	Yes	No
7	Femur	9	Yes	64	Male	Metastatic carcinoma	2/Alive	No	No	Yes
8	Femur	9	Yes	51	Female	Mieloma	3/-	No	Yes	Yes
9	Femur	7	Yes	75	Male	Metastatic adenocarcinoma	2/Death	No	No	Yes
10	Tibia	14	No	26	Male	Parosteal osteosarcoma	1/Death	No	No	Yes
11	Tibia	8	No	64	Female	Metastatic carcinoma	3/-	No	No	Yes
12	Tibia	13	No	68	Male	Giant cell (malignant)	4/Alive	No	Yes	No

ceived quality of life was measured using the EORTC QLQ-C30 (30-item multi-dimensional validated questionnaire developed to assess the quality of life)[9]. Also ROM (Range Of Motion: distance and direction a joint can move between the flexed position and the extended position) was finally evaluated. In Table II the upmentioned scores were analyzed as percentage of the preoperative score (considered before the fracture). For all outcome measures, one month included evaluation done between 4 and 6 weeks after surgery and one year for evaluations made between 11 and 13 months postoperatively. All cases were unilateral and, therefore, passive range of motion (ROM) was determined as percentage of the contra lateral side. To give a single measure for overall mobility, we used the average of percentages compared to contra lateral in all planes. For the humerus, shoulder and elbow joints were evaluated and for radius and ulna the elbow and wrist were assessed. For the femur were valuated hip and knee while for tibia were assessed knee and ankle, respectively. At the shoulder were evaluated standing lateral adduction/abduction, flexion/extension at 90 degrees (or maximum), abduction and external rotation at 0 degrees of abduction with the elbow at 90 degrees (or maximum) of flexion. At the elbow level flexion/extension were recorded. Regarding the wrist, were comparatively evaluated palmar and dorsal flexion with both hands touching the front of the patient. A single forearm pronosupination was recorded with the elbows at 90 degrees of flexion. For the lower limb all measurements were assessed in supine position: passive flexion of the hip with the knee bent and abduction with the leg straight. Internal and external rotation were judged with the hip and knee flexed at 90 degrees. Passive flexion of the knee was recorded in the same position. For the ankle, only combined flexion/extension was evaluated. The amplitudes of motion were compared as percentage of contra lateral and then averaged.

Two representative cases are depicted in Figures 1 and 2.

Results

There were no immediate postoperative local or systemic complications and no failures of the nail/cement construct. All cases were allowed immediate weight bearing (lower limb) and none were immobilized (upper limb). The average length of the bone defect was 9 (6-14) cm. The average follow-up was 2.5 (1-4) years.

Two representative cases are depicted in Figures 3 to 6.

Discussion

A recent literature review, done by Taylor et al[10], detailed the benefits of polymethylmethacrylate spacers in the staged treatment of segmental bone defects. They point out that cement behaves

Table II. Evolution of quality of life (QLQ-C30), Muscle Skeletal Tumor Score (MSTS) and Range Of Motion (ROM) for each patient. Scores are shown as percentage between 1 month and 1 year postoperative compared to preoperative results (considered before the fracture). ROM values are presented as average of percentage results comparative to contra lateral (see text for detailed explanation) for the proximal and distal adjacent joints. Due to the limited number and heterogeneity of cases, the evaluation was performed using descriptive statistics.

	QLQ-C30%		MSTS%		ROM%	
	1 month	1 year	1 month	1 year	1 month	1 year
1	69	84	70	81	44	56
2	59	90	65	90	38	78
3	60	85	67	83	40	72
4	46	81	62	79	55	75
5	53	89	52	87	51	59
6	58	92	60	85	50	83
7	64	78	59	66	41	60
8	57	72	56	69	54	62
9	54	75	55	71	47	66
10	50	73	64	72	39	70
11	42	76	63	84	52	71
12	45	87	61	88	43	79

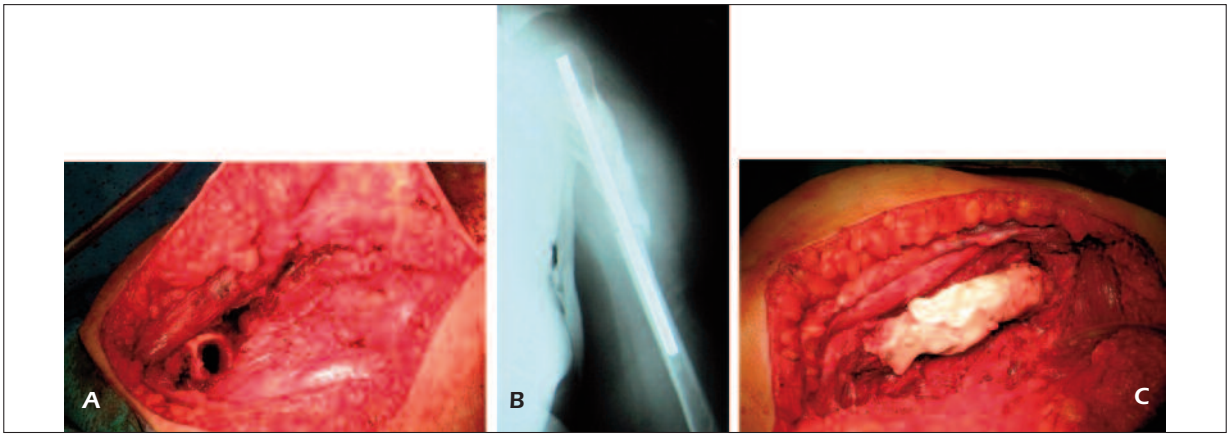

Figure 1. ***A,*** Intraoperative aspect of a removed fibrosarcoma of the left humerus. ***B,*** AP radiograph with the cement spacer in situ over a short intramedullary nail. ***C,*** Final intraoperative view with the PMMA in place.

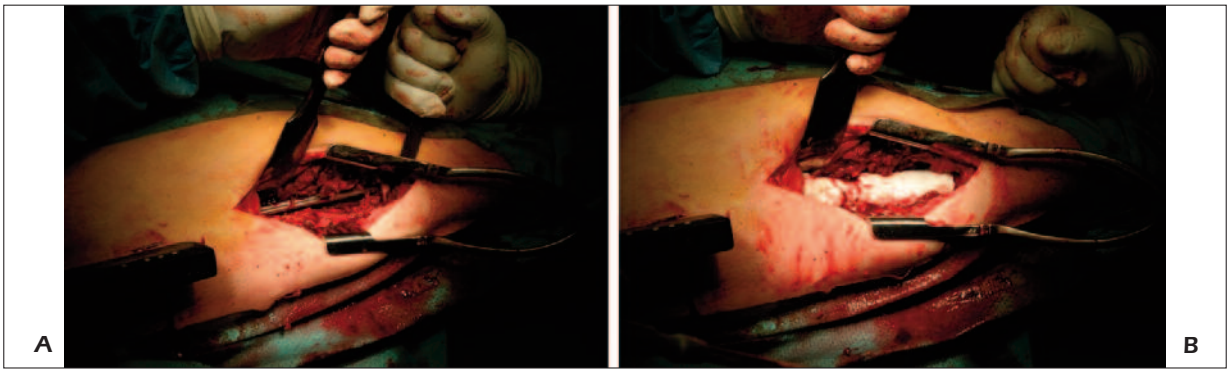

Figure 2. ***A,*** Intraoperative aspect of the right femur with a large metastasis of a uterine cervical adenocarcinoma. ***B,*** After removal and internal stabilization with intramedullary nail, an additional support was obtained by polymethylmethacrylate filling.

Figure 3. AP and lateral X-ray views of a uterine cervical carcinoma metastasis at the level of the right tibial diaphysis removed and replaced with PMMA spacer over a locked nail.

Figure 4. The same case 18 months after surgery; the radiographic images show no signs of degradation of the nail/cement construct.

Figure 5. Right forearm leiomyosarcoma which invaded the proximal ulna; after tumor removal, a large bony defect was filled with PMMA spacer over a thick Kirschner wire.

as a biologic membrane that will nurture the definitive bone graft. The mechanism is multifactorial. 4 to 8 weeks after spacer placement the protective shell is matured. This prevents graft dispersal and resorption, promotes revascularization and induces growth factors which lead to the excellent clinical results being reported[11].

The inductive potential of such membranes has been histological proved in animal models[12] with better results in comparison to recent artificial bioresorbable polylactide membranes that boast single step procedures[13]. Pelissier et al[14] showed production of growth factors (VEGF, TGFbeta1) and osteoinductive factors (BMP-2) with a peak at about 4 weeks. This immunochemistry analysis can support a more rapid conversion to bone grafting. Viateau et al[15] expanded autologous mesenchymal stem cells onto granulated scaffold. After implantation into an induced membrane formed by a previous polymethylmethacrylate spacer, they conclude that particulate bone constructs can be used to repair large defects and that their osteogenic ability approaches that of bone autograft.

Our results favor limited resections. This somewhat contradicts with data in the literature which find limb salvage procedure to lead to secondary surgeries and comparable long term outcomes to amputations[16].

All patients were very reluctant to radical procedures such amputations. Even in the setting of metastases, when there were no other apparent lesions, we performed limited resections offering similar outcomes with better residual quality of life.

Figure 6. The same case 7 months after surgery index with no local reoccurrence; the cement block is seen surrounded by a thick membrane which was left in situ to support a vascularized fibular autograft.

Conclusions

Polymethylmethacrylate cement spacers, over intramedullary nailing, have proved, in our opinion, a feasible and inexpensive procedure with limited complications, low surgical stress and favorable functional outcomes. It can be a definitive therapy for advanced cases as well as temporary solution which can be successfully converted to secondary bone grafting.

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Conflict of Interest

The Authors declare that they have no conflict of interests.

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