Treatment of Giant-Cell Tumors of Long Bones with Curettage and Bone-Grafting*

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Abstract

Background: **The use of curettage, phenol, and cement is accepted by most experts as the best treatment for giant-cell tumor of bone. The present study was performed to evaluate whether equivalent results could be obtained with curettage with use of a high-speed burr and reconstruction of the resulting defect with autogenous bone graft with or without allograft bone.**

Methods: **The prospectively collected records of patients who had a giant-cell tumor of a long bone were reviewed to determine the rate of local recurrence after treatment with curettage with use of a high-speed burr and reconstruction with autogenous bone graft with or without allograft bone. All of the patients were followed clinically and radiographically, and a biopsy was performed if there were any suspicious changes.**

Results: **Fifty-nine patients met the criteria for inclusion in the study. According to the grading system of Campanacci et al., two patients (3 percent) had a grade-I tumor, twenty-nine (49 percent) had a grade-II tumor, and twenty-eight (47 percent) had a grade-III tumor. Seventeen patients (29 percent) had a pathological fracture at the time of presentation. The mean duration of follow-up was eighty months (range, twenty-eight to 132 months). Seven patients (12 percent) had a local recurrence. Six of these seven were disease-free at the latest follow-up examination after at least one additional treatment with curettage or soft-tissue resection (one patient). One patient had resection and reconstruction with a prosthesis after a massive local recurrence and pulmonary metastases.**

Conclusions: **Despite the high rates of recurrence reported in the literature after treatment of giant-cell tumor with curettage and bone-grafting, the results of the present study suggest that the risk of local recurrence after curettage with a high-speed burr and reconstruction with autogenous graft with or without allograft bone is similar to that observed after use of cement and other adjuvant treatment. It is likely that the adequacy of the removal of the tumor rather than the use of adjuvant modalities is what determines the risk of recurrence.**

A variety of treatments have been advocated for giant-cell tumor of bone, including curettage, curettage and bone-grafting, cryotherapy of the cavity after curettage, application of phenol after curettage, radiation, embolization of the feeding vessels, insertion of methylmethacrylate cement in the cavity after curettage, distraction osteogenesis, insertion of hydroxyapatite, and resection followed by allograft or prosthetic reconstruction[1,4,7,9,15,16,22,23,26,28,34,38,39]. Most experts currently recommend the use of adjuvant agents, such as phenol or liquid nitrogen, to destroy any tumor cells remaining after curettage, and they advocate filling the defect with methylmethacrylate cement[1,6,8,11,15,24,25,29,30,34,35]. In fact, a recent report on giant-cell tumors suggested that treatment with curettage and bone-grafting does not reflect modern standards of care[36].

Despite the acceptance of phenol application and cementing of the defect for the treatment of giant-cell tumors, we are not aware of any randomized trials comparing this method with reconstruction with bone graft. Because of concern regarding the level of evidence available to confirm the superiority of cement compared with bone graft for the reconstruction of giant-cell-tumor defects, our unit has maintained a policy of treating most periarticular giant-cell tumors of long bones with extensive curettage with use of a high-speed burr. After all evident tumor has been removed, the defect is reconstructed with autogenous graft alone or with autogenous graft and allograft bone, supported when necessary with standard internal fixation devices. The outcome of the technique has been documented prospectively since 1986. The purpose of the present study was to describe the rate of recurrence and the complications associated with this technique.

Materials and Methods

Inclusion and Exclusion Criteria

One hundred and twenty-five patients who had a histologically proved giant-cell tumor of bone were managed at the University Musculoskeletal Oncology Unit at Mount Sinai Hospital in Toronto, between January 1986 and April 1996, and the data on these patients

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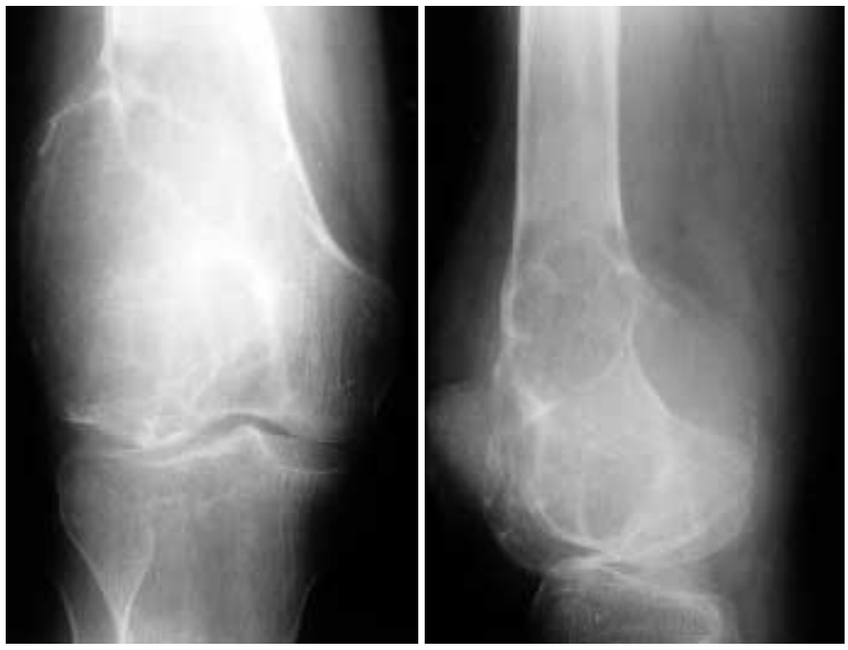

FIG. 1-A FIG. 1-B

Figs. 1-A through 1-D: A thirty-six-year-old man who was first seen in our unit with a biopsy-confirmed recurrent giant-cell tumor in the distal end of the right femur. The primary tumor had been treated two years earlier at another institution with curettage, phenol, and bone-grafting. The patient was referred for resection and prosthetic replacement.

Figs. 1-A and 1-B: Anteroposterior and lateral preoperative radiographs showing the recurrent giant-cell tumor in the distal end of the femur.

were prospectively documented in a computerized database. The inclusion criteria were a histologically confirmed giant-cell tumor involving a long bone that was treated with curettage with a high-speed burr and autogenous bone graft with or without allograft bone, with internal fixation as necessary, and a minimum of two years of follow-up.

Of the 125 patients, 100 had a tumor that involved a long bone. Forty-one of these 100 patients were excluded from the study. Twelve patients (eight who had a tumor in the proximal end of the fibula and four who had a tumor in the distal end of the ulna) were excluded because the tumor was treated with *en bloc* excision alone (complete resection of the tumor with the plane of resection outside the pseudocapsule of the tumor). Six patients who had a tumor in the distal end of the radius with extraosseous extension were managed with *en bloc* excision and arthrodesis of the wrist with the use of autogenous bone graft. Ten patients had a tumor defect that was not amenable to reconstruction and necessitated replacement with an allograft or a prosthesis; two of these tumors were in the proximal end of the humerus, two were in the proximal end of the tibia, and six were in the distal end of the femur. One patient was excluded because a high-speed burr was not used during removal of the tumor because of equipment failure. Twelve patients (nine who had a tumor in the proximal end of the tibia, three who had a tumor in the distal end of the femur, and one who had a tumor in the distal end of the radius) were excluded because they were managed with phenol or cement, or both. Four of these twelve were managed with 5 percent phenol in 1986 and 1987. The use of phenol was discontinued after the fourth patient sustained a chemical burn to the skin when phenol was inadvertently spilled on the soft tissues. Eight of the twelve patients had a grade-I tumor[5] distant from the joint surface, and cement was used in the defect. These eight patients had a small tumor that did not extend into the subchondral bone, and they elected not to have a bone graft after discussion of the treatment options.

The remaining fifty-nine patients were managed with the described technique of extensive curettage with use of a high-speed burr and bone-grafting, and these patients make up the present study. There were twenty-six male patients (44 percent) and thirty-three female patients (56 percent). The average age at the time of diagnosis was thirty-two years (range, sixteen to sixty-four years). Thirty tumors (51 percent) were in the distal end of the femur, fifteen (25 percent) were in the proximal end of the tibia, eight (14 percent) were in the proximal end of the femur, three (5 percent) were in the distal end of the tibia, two (3 percent) were in the proximal end of the humerus, and one (2 percent) was in the distal end of the radius.

According to the grading system developed by Campanacci et al.[5], two lesions (3 percent) were grade I, twenty-nine (49 percent) were grade II, and twenty-eight (47 percent) were grade III. Twelve of the grade-II

tumors and five of the grade-III tumors were associated with a pathological fracture.

Of the fifty-nine patients, seven (12 percent) were first seen in our unit for the treatment of a first local recurrence (Figs. 1-A through 1-D) and two (3 percent) were first seen for the treatment of a second local recurrence; the primary lesion had been treated elsewhere with simple curettage and bone-grafting or cement.

Fifty patients were treated with both autogenous graft and allograft bone, and nine were treated with autogenous graft only. Internal fixation was used in thirty-five patients.

The histological findings were confirmed by one of us (R. K.), an experienced musculoskeletal pathologist. The histological grade was not analyzed because it has been reported to have little relation to local recurrence[5,23].

Operative Technique and Rehabilitation

The operative technique of extensive curettage requires a large cortical window that provides straightforward visualization of the entire tumor cavity. If there is extension of the tumor into the soft tissue, the entire pseudocapsule is dissected circumferentially and is excised completely. The intraosseous tumor bulk is removed with an intralesional technique, with use of a large curet, back to normal-appearing bone; the cavity is then enlarged in all directions with a high-speed burr under direct vision. This technique involves removal of an additional one to five millimeters of bone lining the exposed cavity, including the subchondral plate if necessary. Meticulous care is taken to ensure that all bone and soft tissue that is possibly involved is excised and that contamination of the surrounding soft tissues is minimized. The cavity is irrigated with sterile water, but no chemical adjuvant is used. The subchondral region of the cavity is then packed with autogenous bone graft obtained from the iliac crest. After the autogenous graft is inserted, irradiated (with 2.5 megarad [25,000 gray]) corticocancellous allograft bone obtained from our hospital bone bank is used, when necessary, to fill the defect completely. (The allograft bone is obtained and stored according to established criteria[3,13,37].) When

FIG. 1-C

FIG. 1-D

Fig. 1-C: Anteroposterior radiograph made immediately after extensive curettage, application of autogenous iliac-crest bone graft and allograft, and internal fixation.

Fig. 1-D: Anteroposterior radiograph made seven years postoperatively. The patient was active and worked full-time with no restrictive symptoms.

TABLE
DATA ON THE PATIENTS WHO

Case	Gender, Age (yrs.)	Site	Grade[5]	Pathological Fracture	Status of Tumor*
1	F, 41	Proximal end, tibia	III	Y	Primary
2	F, 28	Distal end, femur	III	Y	Primary
3	M, 18	Proximal end, femur	III	N	First local recurrence
4	F, 19	Distal end, radius	III	N	Primary
5	F, 23	Proximal end, tibia	III	Y	Second local recurrence
6	M, 51	Distal end, tibia	II	Y	Primary
7	M, 28	Distal end, femur	III	N	Primary

*When seen at the University Musculoskeletal Oncology Unit of Mount Sinai Hospital.

necessary, standard internal fixation devices are used to buttress the bone.

Immediately after the procedure, patients who had a tumor of the lower extremity are allowed to walk with crutches with partial weight-bearing (thirty to seventy pounds [sixteen to thirty-two kilograms]). Between six and twelve weeks postoperatively, these patients (including those who had a pathological fracture) are allowed to bear weight as tolerated. Patients who had a tumor of the upper extremity begin gravity-resisted range-of-motion exercises immediately.

Collection of the Data

The age and gender of the patient, the location of the tumor, the presence of a pathological fracture, and the grade of the tumor at presentation according to the system of Campanacci et al.[5] were recorded. The grade was determined from conventional radiographs and operative findings in conjunction with the results of computerized tomography or magnetic resonance imaging. Grade-I tumors have a well marginated border consisting of a thin rim of mature reactive bone, and the cortex is intact or slightly thinned but not deformed. Grade-II tumors have no reactive bone at the periphery and some cortical thinning or erosion with expansion but no cortical breakthrough. Any fractures associated with a grade-II tumor in the present study were recorded separately. Grade-III tumors have a permeative border and loss of cortical continuity with extension into the soft tissue.

Postoperative complications were recorded. All patients had routine follow-up with a physical examination and radiographs of the involved limb every three months for two years, then every six months for three years, and then annually thereafter. The radiographs were reviewed by the surgeon and a radiologist independently and were compared with previous radiographs. Any progressive osteolytic changes noted on the radiographs were investigated with an open biopsy.

Statistical Analysis

The time to local recurrence was evaluated with use of the method of Kaplan and Meier[21]. The 95 percent confidence interval was calculated with use of the method of Greenwood[17].

Results

The mean duration of follow-up after operative treatment of the fifty-nine patients in our unit was eighty months (range, twenty-eight to 132 months; median, seventy-five months). Forty-five patients (76 percent) were followed for more than five years; only two were followed for less than three years.

Local Recurrence

Seven (12 percent) of the fifty-nine patients had a local recurrence (Table I), at a mean of twenty-two months (range, seven to sixty-one months). All but one recurrence occurred within three years after the index operation. The Kaplan-Meier curves confirmed that the highest proportion of recurrences were in the first twenty-four months after the operation (Fig. 2).

Two of the nine patients who were initially seen in our unit for treatment of a first or second local recurrence had an additional local recurrence compared with five (10 percent) of the fifty patients who were seen for a primary tumor.

Of the seven patients who had a local recurrence, one (Case 4), who had initially been seen for a primary

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HAD A LOCAL RECURRENCE

Treatment*	Time to Recurrence *(mos.)*	Treatment of Recurrence	Duration of Follow-up After Treatment of Recurrence *(mos.)*	Status at Latest Follow-up
Autogenous graft, allograft bone, internal fixation	15	Curettage, cementing	89	Disease-free
Autogenous graft, allograft bone, internal fixation	61	Curettage, cementing	6	Disease-free
Autogenous graft, allograft bone, internal fixation	7	Wide excision, soft tissues; radiation therapy	48	Disease-free
Autogenous graft, allograft bone	8	Curettage, autogenous graft		
	16	Excision, soft tissues; autogenous graft; radiation therapy		
	28	Curettage, cementing	60	Disease-free
Autogenous graft, allograft bone, internal fixation	30	Curettage, cementing, radiation therapy	36	Disease-free
Autogenous graft, allograft bone, internal fixation	18	Curettage, allograft bone	48	Disease-free
Autogenous graft, allograft bone, internal fixation	12	Excision; prosthesis; excision, lung metastases	26	Disease-free

tumor in the distal end of the radius, had a second local recurrence after repeat extensive curettage and bone-grafting. The second local recurrence was complicated by a large soft-tissue mass, which was treated with postoperative radiation therapy in addition to a repeat operation. A third local recurrence subsequently developed and was treated with curettage and cementing. At the time of follow-up, sixty months after the last procedure, the patient had remained disease-free with preservation of the distal end of the radius.

Another patient (Case 3) had a large soft-tissue mass at the time of recurrence, and he too was managed with postoperative radiation therapy in addition to a repeat operation. At the time of follow-up, at forty-eight months, he had had no additional recurrence.

Four of the patients who had a recurrence (including Case 4) were managed with repeat curettage and cementing, whereas one (Case 6) was managed with repeat curettage and repeat allografting. One of the four patients (Case 5), who had a tumor in the proximal end of the tibia, was pregnant. It was thought inadvisable to obtain an autogenous graft from the pelvis because of the risk of inducing labor, and the patient refused the use of allograft bone. Because this was the third recurrence (the patient had had two recurrences before she was seen in our unit), the patient was also managed with radiation five months after the repeat operation (two months post partum). In the other three patients, cement was used as filler because the tumor was small and distant from the surface of the joint.

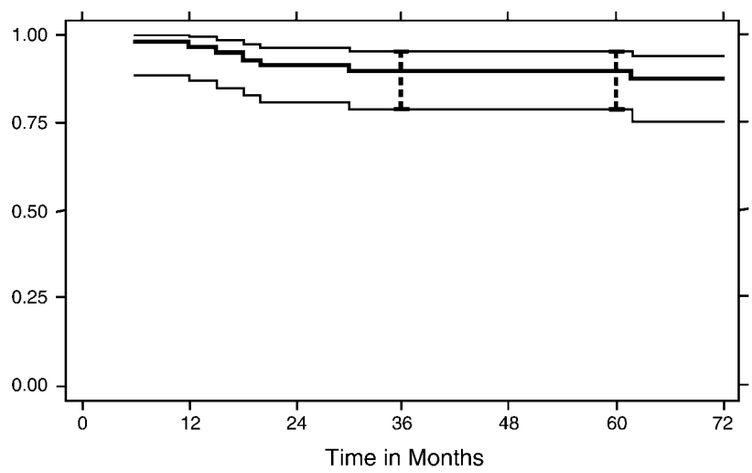

FIG. 2

Kaplan-Meier plot with 95 percent confidence limits, showing that most of the local recurrences were within the first twenty-four months after the procedure.

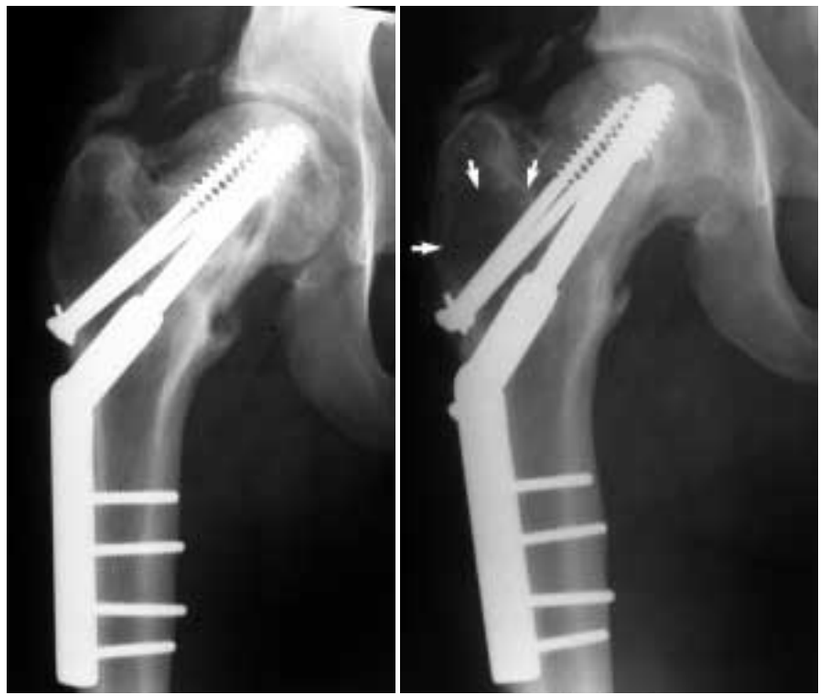

FIG. 3-A FIG. 3-B

Figs. 3-A, 3-B, and 3-C: A thirty-year-old man who had a radiographically suspicious lesion after curettage and bone-grafting to treat a giant-cell tumor of the proximal end of the right femur.

Fig. 3-A: Anteroposterior radiograph made six months postoperatively, showing incorporation of the graft.

Fig. 3-B: Anteroposterior radiograph made two years postoperatively, showing a suspicious lesion (arrows) in the greater trochanter, which was treated with open curettage biopsy and autogenous graft. There was no evidence of recurrent giant-cell tumor.

Metastases occurred in one patient (Case 7), and a massive recurrence involving soft tissue and bone developed in the distal end of the femur twelve months after the initial operation. The recurrence was treated with excision and insertion of a prosthesis (Kotz Femoral Tibial Replacement System; Howmedica, Rutherford, New Jersey). At the time of the operation, the patient was noted to have two pulmonary lesions that were identified histologically as giant-cell tumors on resection. As of the time of writing, this was the only patient who needed excision of osteoarticular bone to treat a recurrence.

In general, operative treatment of the recurrences in bone was straightforward as the bone graft that had been previously inserted in the defects was removed easily with use of a high-speed burr. Soft-tissue recurrences were more difficult to treat, and radiation was used in the two patients (Cases 3 and 4) who had such a recurrence. Most patients who were managed for a recurrence remained disease-free for a prolonged period (mean, forty-five months; range, six to eighty-nine months) afterward.

Postoperative Complications and Negative Biopsies

In addition to the local recurrences, seven patients had a postoperative complication. Stiffness of the knee developed in two patients after treatment of a distal femoral grade-III lesion associated with a pathological fracture. Both patients were managed with open arthrotomy and quadricepsplasty six months postoperatively, and both recovered more than 90 degrees of flexion of the knee.

A nonunion developed at the site of a pathological fracture in a thirty-one-year-old patient who had a grade-III tumor in the distal end of the femur. The nonunion was successfully treated with replacement of the plate and bone-grafting ten months after the index operation. Five years after the second operation, the patient was fully active but had some mild pain in the lateral aspect of the knee associated with mild radiographic subchondral sclerosis and osteophytic lipping as well as a limited range of motion (10 to 80 degrees). Neither the symptoms nor the radiographic changes progressed during the three years before the most recent follow-up examination. The fracture had healed in valgus angulation, which probably predisposed the patient to pain in the lateral aspect of the knee.

One patient, a fifty-six-year-old woman who had a grade-II metaphyseal lesion in the distal end of the femur, had radiographic evidence of tricompartmental degenerative arthritis three years postoperatively. The symptoms were well controlled with anti-inflammatory medication. The patient had similar symptoms in the

FIG. 3-C

Anteroposterior radiograph made five years after the curettage and bone-grafting of the apparent lesion in the greater trochanter. The was no evidence of recurrence.

contralateral knee; therefore, it is possible that the arthritic changes were not related to the operation for the tumor.

Two patients had prominent hardware removed, and a superficial wound infection developed in one after the removal. The infection resolved with oral administration of antibiotics. A sterile pretibial wound hematoma developed in another patient and was treated with operative drainage. There were no deep infections.

Two patients had an open biopsy performed because of a radiographically suspicious lesion, which proved to be negative for recurrence of giant-cell tumor. These lesions were filled with autogenous graft after the biopsy showed no sign of tumor. The patients were disease-free more than four years after the biopsies, and no additional changes were noted on the radiographs (Figs. 3-A, 3-B, and 3-C).

Discussion

The acceptance of the phenol-and-cement method for the treatment of giant-cell tumor has likely been the result of two factors: comparison of the outcomes of this technique with those in historical series of patients managed with bone graft, and the results of a nonrandomized, multicenter study that compared the methods of treatment used by different institutions for the treatment of giant-cell tumor[8,34].

The lack of a randomized, controlled trial comparing the efficacy of phenol and cement with that of bone graft for the treatment of giant-cell tumor introduces several possible sources of bias into the comparison of these two treatments. The use of cement, with or without chemical adjuvants, is a more recent method of treatment than bone-grafting, and it is possible that improved imaging methodologies, such as cross-sectional imaging with computerized tomography or magnetic resonance imaging, might contribute to better outcomes after treatment of tumor defects with cement. Shorter follow-up after treatment with cement might also bias the results in favor of this technique, especially if the use of cement delays but does not reduce the overall rate of recurrence of giant-cell tumor. Finally, the comparison of outcomes from various centers in which different techniques were used might reflect the experience and skill of the practitioners in the various centers as much as the method of treatment.

When the outcomes of intralesional treatment of giant-cell tumors are described, it is important that investigators present the total number of patients who were managed in addition to the results for patients who were managed with intralesional therapy. If this is not done, the effect of patient selection on the outcome cannot be determined. For example, if a large proportion of patients who had a grade-II or III tumor was managed with resection, one can assume that the authors are reporting the results of treatment of smaller lesions in their description of the outcomes of intralesional treatment of giant-cell tumor. In the present study, fifty-seven (85 percent) of the sixty-seven grade-II and III tumors (in the entire group of 125 tumors) that were not in the distal end of the radius were treated with intralesional curettage and bone graft. The remaining ten tumors were treated with complete excision because the defects were not amenable to repair. Six of the seven tumors of the distal end of the radius were excluded from the study because we, like Vander Griend and Funderburk[40] as well as Kocher et al.[22], tend to use *en bloc* resection for most radial tumors with extraosseous extension. The fact that only one patient in the present study had a tumor of the radius introduces a selection bias as the prevalence of local recurrence is known to be high at this anatomical site[40].

When developing a treatment protocol for giant-cell tumor of bone, a surgeon must decide whether to perform an intralesional or *en bloc* resection, whether to use adjuvant therapy to eradicate residual microscopic disease, and what material to use to fill the resultant defect in the bone. The first of these considerations is relatively straightforward. The risk of local recurrence after an *en bloc* resection involving the joint followed by prosthetic or allograft reconstruction is lower than that after an intralesional procedure[5,15,23]. However, the

long-term complications related to prosthetic or allograft reconstruction make this treatment generally inappropriate for most giant-cell tumors of bone[11,12,15,23,28,34] unless a pathological fracture or progression of the disease has resulted in a clinical situation that prevents skeletal reconstruction after intralesional curettage.

Once the decision has been made to treat most tumors with intralesional therapy, the surgeon must decide whether to use adjuvant therapy to eliminate microscopic remnants of the tumor from the cavity after curettage. Surgeons began using adjuvant therapy (insertion of methylmethacrylate cement with or without liquid nitrogen or phenol) because of dissatisfaction regarding the outcome of curettage and bone-grafting. Historically, curettage, with or without bone-grafting, has been associated with a high rate of recurrence. Goldenberg et al.[16] reported that fifty (52 percent) of ninety-seven tumors originating in the distal end of the femur, the proximal end of the tibia, and the distal end of the radius recurred after such treatment, Larsson et al.[19] reported that fourteen (47 percent) of thirty patients had a recurrence, and Campanacci et al.[5] reported that thirty-eight (29 percent) of 130 tumors recurred. Many clinicians have rejected this technique because of the reported high risk of local recurrence.

The high risk of recurrence after bone-grafting led to the technique of intralesional curettage followed by packing of the defect with methylmethacrylate cement, which was first described in 1969 by Vidal et al.[41]. It has been suggested that free radicals and the thermal effects of the polymerization reaction may cause as much as two to three millimeters of necrosis in cancellous bone[27,34]. Additional advantages of the use of cement include low cost, ease of use, lack of donor-site morbidity, elimination of the risk of transmission of disease associated with allograft bone, immediate structural stability, and potential for earlier detection of local recurrence. The results of initial studies of the use of cement after curettage of giant-cell tumors were favorable, with no recurrences reported in two studies of only two tumors each[2,5] and one recurrence reported in a study of seven patients[29]. However, in two larger series, five of seventeen patients[10] and eight of nineteen patients[28] had recurrence after management with cement, rates that are equivalent to those reported after treatment without cement.

Additional adjuvant treatment of the bone bed with liquid nitrogen or phenol after removal of the tumor has been advocated to decrease the risk of local recurrence when cement is used alone. Liquid nitrogen results in effective osteonecrosis to a depth of one to two centimeters[18]. Marcove[26] reported a 2 percent rate of recurrence in the latter stages of a seventeen-year review of 100 giant-cell bone tumors, and Malawer and Dunham[24] reported a 4 percent rate of recurrence (one in twenty-five patients). However, because the depth of the osteonecrosis induced by liquid nitrogen is difficult to control, there is a high risk of fracture[24,25]. In one study, six fractures occurred in five of twelve patients who were treated with liquid nitrogen[20].

Phenol has been advocated as a safer agent than liquid nitrogen for adjuvant therapy[34]. Phenol causes protein coagulation, damages DNA, and causes necrosis[31,32,34]. Schiller et al.[35] reported local recurrence in 10 percent (three) of thirty-one patients who had been managed with curettage and phenol for a variety of benign bone tumors, including giant-cell tumor. The advantage of phenol compared with liquid nitrogen is its reduced penetration, which results in only one to one and a half millimeters of bone injury[32] and hence a reduced rate of fracture. However, phenol used alone without cement after removal of giant-cell tumors has generally been less effective than phenol used with cement, with reported rates of recurrence of 21 percent (thirty-one of 147 patients)[34] and 34 percent (twenty-nine of eighty-five patients, five of whom were managed with curettage without phenol)[23].

The results of combined use of phenol and cement reported in several relatively small series have been promising. Gitelis et al.[15] reported one recurrence in seventeen patients after three to nine years. The authors of a larger, multicenter study reported that a subset of thirty-three patients had a 3 percent rate of recurrence (one recurrence) at a mean of seventy-five months after management with phenol and cement[8]. However, O'Donnell et al.[28] reported recurrence in three of seventeen patients at a mean of four years after they were managed with phenol and cement.

Treatment Issues

The use of 5 percent phenol was discontinued at our unit after a patient sustained a chemical burn. Most of the patients in the present study had extensive cortical disruption. Preventing leakage of phenol in this situation while at the same time allowing adequate saturation of the bone with the chemical would had been difficult and the leakage would have been potentially harmful. Phenol is toxic to the nervous system, the heart, the kidneys, and the liver and is readily absorbed through skin, mucosa, and open wounds. Death has occurred following skin exposure, and there is a theoretical concern of phenol toxicity following rapid absorption through cancellous bone[32]. Quint et al.[32] supported the safety of 5 percent phenol only. However, the use of higher concentrations, including 75 percent phenol in one study[32], has been reported[34]. The use of concentrations higher than 5 percent may be hazardous.

The 12 percent rate of local recurrence (seven of fifty-nine patients) in the present study is comparable with the clinical results reported after the use of chemical adjuvants and cement. Our patients did not have the high rate of recurrence reported in earlier studies of curettage with bone-grafting[5,16,19], and we attribute this improvement to the extensive use of a high-speed

burr as well as the availability of allograft bone from a hospital-based tissue bank, which allows the surgeon to resect involved bone extensively without concern for how to fill the defect. It is likely that a major factor in the success or failure of curettage is related to how completely the tumor is removed[11].

The data presented in the present report should not be interpreted as suggesting that bone-grafting is better treatment than the insertion of cement after removal of giant-cell tumors. Indeed, other factors may militate against the use of bone graft, including the donor-site morbidity associated with removal of bone for an autogenous graft, the risk of disease transmission from allograft bone[3,37], and the difficulty of visualizing recurrences within the bone graft at the time of radiographic follow-up[33]. However, there are long-term concerns other than local recurrence related to the use of cement, including the difficulty associated with removal of acrylic material in the case of local recurrence or fracture and the risk of long-term osteoarthritis when the cement is placed in proximity to articular cartilage[43]. The risk of subchondral cement causing damage to cartilage and subsequent degenerative arthritis has been alluded to in the literature but remains unproved[32]. Articular degeneration with associated biochemical changes after treatment with cement has been noted in the weight-bearing area in animal studies[42], whereas other studies have demonstrated the superior ability of subchondral autogenous bone grafts to restore the subchondral osseous anatomy to normal[14]. In a combined European and American study, degeneration of the joint occurred in fourteen (7 percent) of 204 patients who had been managed with cement compared with only two (0.7 percent) of 280 patients who had been managed with bone-grafting[6]. Degeneration of the joint was also inversely related to the distance of the tumor from the articular cartilage[6]. Osteoarthritic changes developed in one patient in the present study, but these were most likely related to valgus malunion of a fracture.

We do not believe that there is good evidence in the literature that the use of cement with or without phenol or liquid nitrogen is better than the use of bone-grafting if care has been taken to remove the tumor completely. A comparison of the efficacy of cement and bone-grafting in the treatment of giant-cell tumor of bone therefore is an appropriate focus for a randomized clinical trial. However, the event rates for both forms of treatment are so low that it would be difficult to enroll the hundreds of patients needed to attain adequate power to detect differences between the two treatments. It is unlikely that such a randomized trial will be undertaken, especially since most centers obtain adequate results with either therapy.

Finally, one additional issue, related to the reporting of results of intralesional treatment of giant-cell tumors of bone, must be addressed. Recent reports have emphasized the use of adjuvant therapy, particularly phenol, as part of the treatment of giant-cell tumors. We have noticed a recent increase in the number of patients referred to our unit with recurrence of giant-cell tumor after the use of cement, with or without chemical adjuvants. Because we believe that the low risk of recurrence associated with the use of adjuvant phenol or cement, or both, in the treatment of giant-cell tumors is related not only to the adjuvant treatment but also to how thoroughly the tumor is removed, it is important that the orthopaedic community recognize that adjuvant agents cannot prevent recurrence if the tumor has not been adequately removed.

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