Giant Cell Tumor of the Hand: Superior Results With Curettage, Cryosurgery, and Cementation

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At our institution giant cell tumors arising in all locations are treated with curettage, cryosurgery, and cementation to avoid resection or amputation, increase local tumor control over curettage alone, and avoid the morbidity associated with immobilization. We report the oncologic and functional results of 3 patients with giant cell tumors arising from the tubular bones of the hand who were treated in this manner. At a mean follow-up period of 54 months there were no local recurrences. No patient complained of pain. Digital range of motion and grip strength were within normal limits for all 3 patients. All patients returned to their previous occupational and recreational activities. One instance of minor wound necrosis was successfully treated conservatively. There were no other complications (fractures, infections, neuropraxias, or vascular damage). Curettage, cryosurgery, and cementation performed by experienced surgeons appears to be a safe, effective, and reliable method for treating selected giant cell tumors of the hand. (J Hand Surg 2001;26A:546–555. Copyright © 2001 by the American Society for Surgery of the Hand.)

Key words: Giant cell tumor, cryosurgery, hand tumor, curettage, cementation.

Giant cell tumors of the hand account for approximately 2% to 5% of all giant cell tumors.[1–4] The metaphyseal region of the metacarpals and phalanges is the site of origin for most of these tumors.[5–7] Compared with giant cell tumors arising at more proximal locations, tumors of the hand more commonly present at advanced stages with major bony destruction and diaphyseal extension, which complicates treatment.[1,2,5–8]

The goals in treating giant cell tumors of the hand are to obtain local tumor control, restore hand function, and maintain good cosmesis. Historically, traditional procedures, such as curettage and bone grafting, wide local resection and reconstruction, and single- or double-ray amputation, have frequently failed to achieve these goals. Curettage and bone grafting preserve bone stock and articular integrity; however, local recurrence rates as high as 90% have been reported.[1,2,7,9] Wide resection and reconstruction with structural bone graft, although theoretically removing the entire tumor, also has been associated with high local recurrence rates (up to 40%).[1] In addition, structural bone grafts may not reliably heal and prolonged postoperative immobilization can result in stiffness and contractures. Single- or double-ray resection for primary and recurrent tumors has been reported.[1,2,7,9] Even with these radical procedures, local tumor control has not been absolute.

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Hand function is compromised and the procedures are cosmetically mutilating.

Cryosurgery using liquid nitrogen is an effective adjunct to curettage for treatment of giant cell tumors in more proximal locations.[10–16] Local recurrence rates are as low as 2% to 3%, comparing favorably to the rates of 17% to 60% achieved with curettage alone.[17–24] In these cases reconstruction using polymethylmethacrylate combined with metallic internal fixation provides immediate stabilization that prevents postoperative fracture.[10,12,15,16] Early postoperative weight bearing and rehabilitation are facilitated, and complete functional restoration is achieved in most cases.

We have routinely used curettage, cryosurgery, and cementation in the treatment of giant cell tumors of the hand. Our goals have been to preserve native bone stock and articular integrity, eliminate local tumor recurrence, and secure immediate, stable fixation for early motion and rehabilitation. We report the oncologic and functional results and complications associated with curettage, cryosurgery, and cementation in 3 patients with giant cell tumors arising from the tubular bones of the hand. Emphasis is placed on the surgical technique for optimization of local tumor control and to minimize the risk of complications.

Materials and Methods

Patients

Four patients with giant cell tumors arising from the tubular bones of the hand were treated between 1992 and 1997 with curettage, cryosurgery using liquid nitrogen, and a reinforced cementation technique for stabilization. One patient was lost to follow-up evaluation immediately following the procedure. The remaining 3 patients form the basis of this report (Table 1). The patients' ages ranged from 16 to 33 years at the time of initial presentation. All 3 patients were males. The follow-up period ranged from 49 to 62 months (mean, 54 months). There was 1 stage 2 tumor and 2 stage 3 tumors. Two patients (cases 1 and 3) presented with primary tumors. Case 2 presented with a recurrent tumor that had been treated with curettage and cancellous bone grafting at another institution 6 weeks before presentation (Fig 1). All patients complained of pain in the affected digit at the time of presentation and all had restricted motion of the affected digit secondary to pain. The exact range of motion of the affected digit at presentation was not recorded in the patients' medical charts. Tumor origins were the fifth digit distal phalanx, third digit middle phalanx, and second digit metacarpal. Preoperative evaluation consisted of physical examination, plain radiography, magnetic resonance imaging or computed tomography scanning of the lesion, chest computed tomography, and triple-phase bone scan. Intraoperative frozen-section pathology and final pathology results were consistent with giant cell tumor in each patient.

The patients were monitored with serial physical examination, plain radiography of the digit, and chest computed tomography at least every 3 months for the first 2 years after surgery. After the first 2 years the patients were evaluated every 6 months and a chest x-ray was substituted for the chest computed tomography. A retrospective review of each patient's chart and sequential radiographs was conducted. The development of local recurrence, metastatic disease, complications, the presence of pain, and limitations in activities or work were evaluated at the latest follow-up examination. At that time, range of motion

Table 1. Clinical Data From Three Patients Treated by Curettage, Cryosurgery, and Cemented Internal Fixation

Case No.	*Age (yr)/ Gender*	*Occupation*	*Location*	*Stage*	*Length of Follow-Up Period*	*ROM (MCP, PIP)*	*ROM (DIP)*	*Complications*
1	22/M	Police officer	L little finger, distal phalanx	II	49 mo	≥90°	≥70°	Skin necrosis
2	16/M	Cashier	R long finger, middle phalanx	III	62 mo	≥90°	≥70°	None
3	33/M	Salesperson	L index finger, metacarpal	III	50 mo	≥90°	≥70°	None

ROM, range of motion; MCP, metacarpophalangeal joint; PIP, proximal interphalangeal joint; DIP, distal interphalangeal joint.

Figure 1. (A) Posteroanterior radiograph of the giant cell tumor of the long finger middle phalanx obtained at the initial presentation. This patient had undergone curettage and bone grafting at another institution 6 weeks earlier (case 2). (B) Lateral radiograph of the same patient obtained at the initial presentation. *(Figure continues)*

of the metacarpophalangeal joint, proximal interphalangeal joint, and distal interphalangeal joint of the affected digit was estimated by visual inspection and was compared with the contralateral hand. Grip strength was evaluated by manual examination and was compared with that of the opposite hand.

Surgical Procedure

Incision. After tourniquet inflation a longitudinal incision was made over the dorsal or dorsolateral aspect of the affected phalanx or metacarpal. All stage 3 tumors in this series presented with dorsal extraosseous components; a dorsal approach was therefore performed. Full-thickness skin flaps including the neurovascular bundles on each side of the digit were constructed to allow for wide retraction to protect from the freezing effects of cryosurgery. Extensor tendons were either split longitudinally or retracted away from the bone.

Exposure of the Tumor Cavity. The entire tumor cavity must be adequately exposed to facilitate a thorough curettage and enable the liquid nitrogen to permeate every aspect. An elliptical cortical window, approximating in size the length and width of the tumor, was cut with a knife or high-speed burr, depending on cortical thickness. The window should be as large as the tumor for complete visualization and thorough curettage. For stage 3 lesions, the extraosseous component was excised *en bloc* with the cortical window. This is important to prevent soft tissue recurrence. Cortical destruction may be extensive with large stage 3 tumors and minimal additional enlargement of the hole through the cortex may be needed.

Curettage. Hand curettage of the tumor cavity was performed to remove all gross tumor. This was followed by high-speed burring (resectional curettage) of the cavity wall in areas in which sufficient cortical

C

Figure 1. *(Cont)* (C) Lateral radiograph obtained 2 months after initial presentation demonstrating increased radiolucency, resorption of bone graft, and diaphyseal expansion indicative of a local recurrence.

bone remained. Burring extended the hand curettage an additional millimeter. Areas of the tumor cavity in which the cortical bone was very thin or where periosteum was visible were not subjected to high-speed burring. Intraoperative pathologic analysis was performed and confirmed the diagnosis of giant cell tumor.

Cryosurgery. We used the open-pour technique as originally described by Marcove and colleagues.[11–13] An appropriately sized stainless steel funnel was inserted into the tumor cavity. The funnel and cavity were surrounded with Gelfoam (Upjohn; Kalamazoo, MI) to form a seal; this would prevent extravasation of liquid nitrogen and thus protect the adjacent neurovascular structures and the skin (Fig. 2). Thermocouples were used to monitor the temperature of the cavity wall and the outer soft tissues. The skin was continuously irrigated with warm saline to protect the skin and neurovascular bundle from thermal damage. Liquid nitrogen was poured into the funnel until the tumor cavity was filled. The liquid nitrogen remained in the tumor cavity until it evaporated. Additional liquid nitrogen was poured into the cavity until the temperature in the cavity reached –21°C. This was followed by a slow 3- to 5-minute thaw until the cavity reached 0°C. These steps comprised 1 freeze-thaw cycle. All patients in this study were treated with 2 freeze-thaw cycles.

Reconstruction With Reinforced Polymethylmethacrylate. Two 1-mm K-wires were inserted to span the tumor cavity and were anchored into the remaining bone proximally and distally. In the phalanges the wires were crossed for additional stability. In the metacarpal the wires were placed longitudinally within the cavity. Polymethylmethacrylate was used to fill the tumor cavity (Fig. 3). Care was taken to ensure that no cement extruded beyond the outer limit of the cortices. The wound was closed with 3–0 interrupted nylon sutures.

Postoperative Management. All patients received a 3-to 5-day course of prophylactic antibiotics. Dressings were changed on the third postoperative day, at which time active and passive range of motion exercises of the digits and wrist were instituted. After full motion was achieved, gradual hand strengthening was initiated. Patients were instructed to refrain from contact sports and lifting heavy objects for 3 months.

Results

There was no clinical or radiographic evidence of local recurrence in any patient at the most recent follow-up examination (mean, 54 months; range, 49–62 months). No patient developed pulmonary metastases or evidence of multicentricity. Grip strength was grade 5 and comparable to that of the opposite hand for all patients. Digital range of motion was also similar to that of the opposite hand (Fig. 4). In the involved digit of each patient, the active motion at the metacarpophalangeal and prox-

Figure 2. Surgical technique for cryosurgery in the hand. Wide retraction of the skin flaps is important for protection from the freezing effects of liquid nitrogen.

imal interphalangeal joints was at least 0° to 90°; at the distal interphalangeal joint, range of motion was at least 0° to 70°. There were no limitations in strength or motion of the uninvolved digits or wrist. No patient complained of pain, numbness, weakness, or limitations in recreational activities or activities of daily living (feeding, personal hygiene, grooming, or household chores). One patient (case 1) developed minor wound necrosis (2 × 3mm) after surgery that was treated successfully with dressing changes. There were no postoperative fractures, infections, vascular complications, neuropraxias, or joint contractures. All patients returned to work. Patient 2 resumed recreational baseball and used the affected hand to catch the ball.

Discussion

Giant cell tumors are generally considered benign, locally aggressive bone tumors. They may metastasize in up to 10% of patients, but usually do so only after repetitive local recurrences.[25,26] When they occur in the hand they frequently cause severe bony destruction and extend into the surrounding soft tissues.[1,2,5,7,9] Historically, the major problem with treating giant cell tumors of the hand has been achieving local tumor control without the need for radical resection or amputation.

Giant cell tumors of the hand have been treated with curettage and cancellous bone grafting, wide resection, and structural bone grafts or ray amputation (Table 2). A review of the literature shows that treatment by curettage or wide resection has been associated with high local recurrence rates.[1,2,7,9] Single- or double-ray amputation has not guaranteed local control and could be functionally debilitating and cosmetically mutilating. Bone grafting procedures require prolonged immobilization with the inherent risks of nonunion, stiffness, tendon adhesion, and contractures. In addition, when cancellous bone graft has been used to fill the tumor cavity, it has

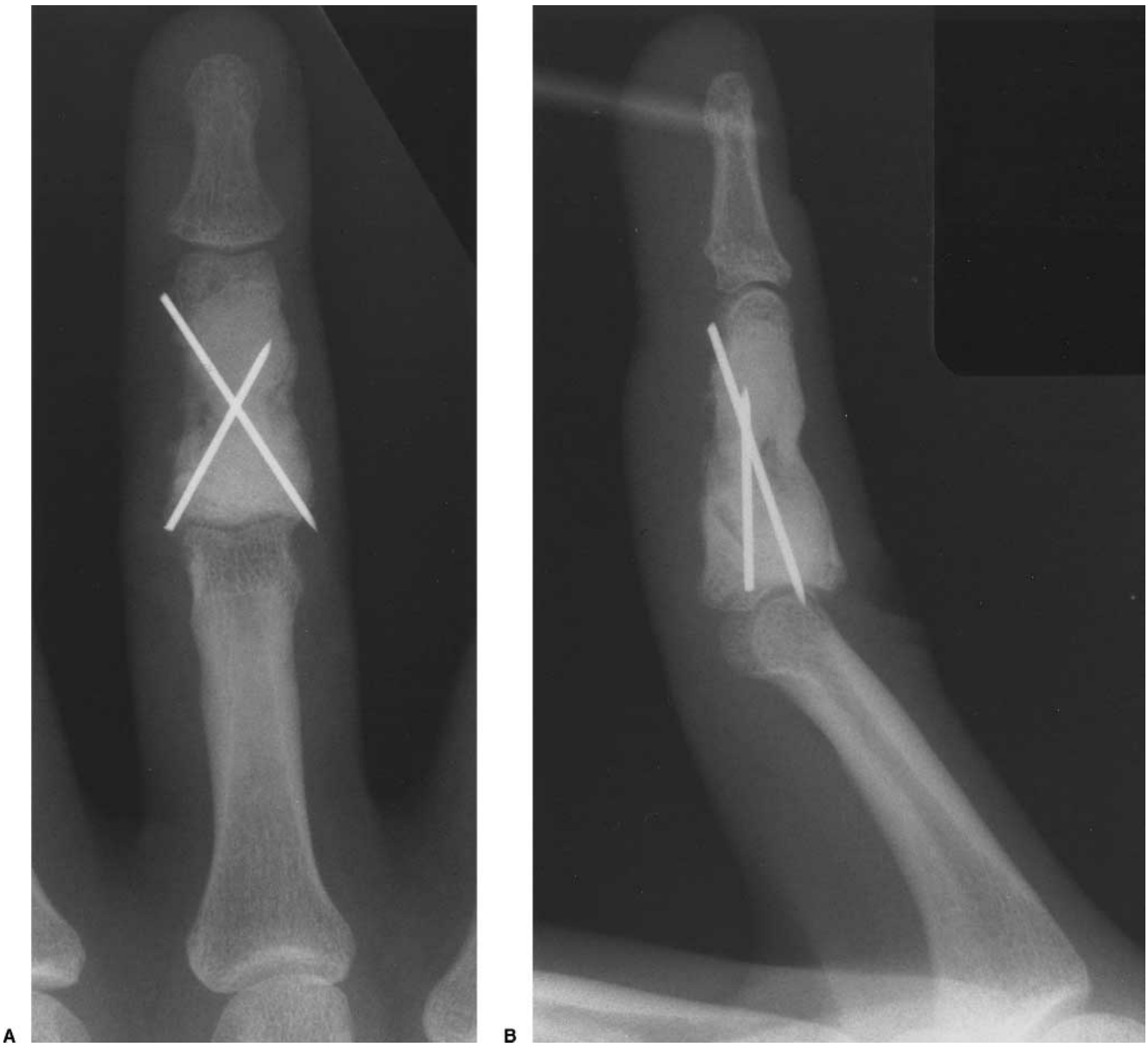

Figure 3. (A) Posteroanterior and (B) lateral radiographs of the long finger middle phalanx 62 months after curettage, cryosurgery, and cemented internal fixation for recurrent giant cell tumor (case 2).

been difficult to detect local recurrence at an early stage on plain radiographs. Thus, many local recurrences following curettage and cancellous bone grafting have become quite large before being detected and have required single- or double-ray amputation in lieu of resection.

Averill et al[2] reported one of the largest series of giant cell tumors of the hand (Table 2). This was a multi-institutional study consisting of 21 patients with 28 lesions. The local recurrence rate associated with curettage alone or curettage and bone grafting was 90%. Three of 7 patients experienced local recurrence following wide local resection. Most patients with recurrent tumor required ray amputation for local control. Two of 4 patients who underwent successful wide resection and reconstruction with structural bone graft experienced tendon adhesion and contracture. Patel et al[9] reported 5 cases of giant cell tumor of the hand. Three patients were treated with curettage and bone grafting. Two patients developed local recurrence and required ray resection. Athanasian et al[1] reviewed 14 patients who presented

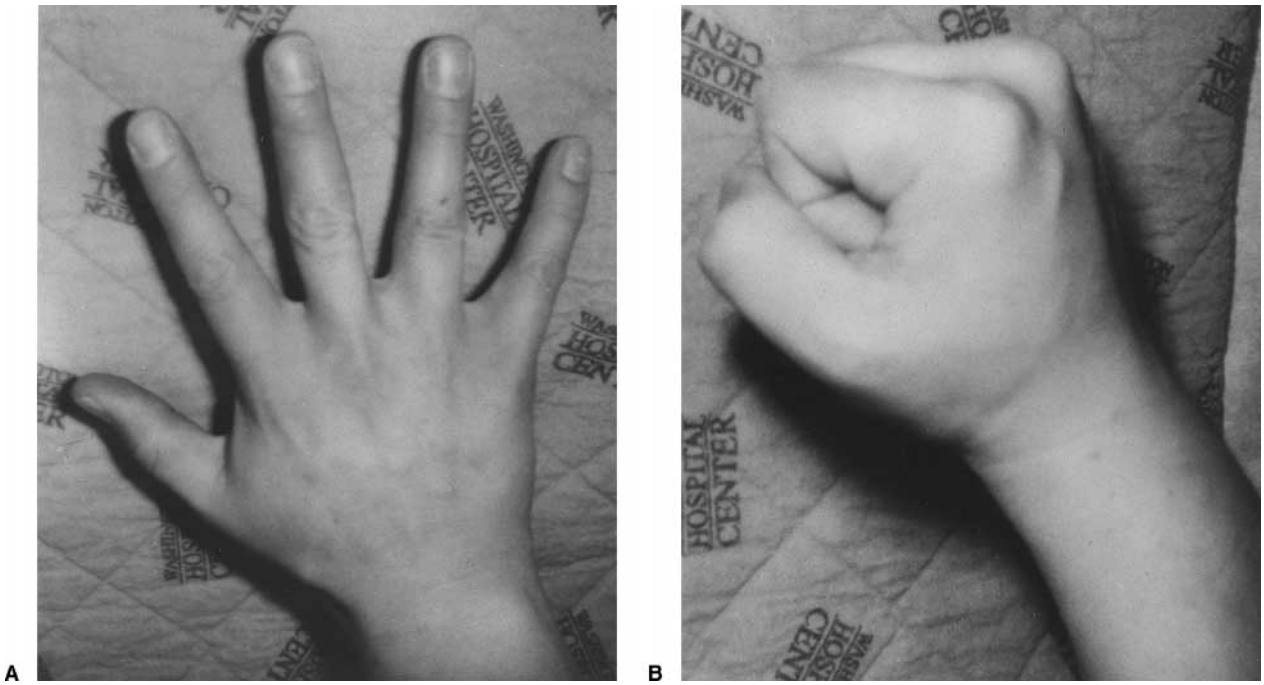

Figure 4. Demonstration of full range of motion 62 months after curettage, cryosurgery, and cemented internal fixation for recurrent giant cell tumor of the long finger middle phalanx. This patient is a recreational baseball player and uses this hand to catch (case 2).

at the Mayo Clinic over a 50-year period. Local recurrence occurred in 79% of patients whose tumors were treated with curettage and in 36% of patients whose lesions were treated with resection or ray amputation. Pulmonary lesions developed in 2 patients following local recurrence of the primary tumor. Similarly, Wold and Swee[7] reported an overall 75% local recurrence rate after curettage with or

Table 2. Literature Review of Local Recurrence Rates After Curettage, Resection, Amputation, and Cryosurgery for Giant Cell Tumor of the Hand

		Curettage ± Graft		*Resection or Amputation*		*Cryosurgery*			
Source	*No. of Cases*	*n*	*LR*	*n*	*LR*	*n*	*LR*	*Recurrence Rate*	*Recommended Treatment*
Averill et al[2] (1980)	28	15	13	7	3	—	—	90%	Resection or amputation
Wold et al[7] (1984)	34	29	20	9	1	—	—	75%	Resection or amputation
Patel et al[9] (1987)	5	3	2	2	0	—	—	40%	Resection or amputation
Athanasian et al[1] (1997)	14	14	11	14	5	—	—	79%	Resection or amputation
Marcove et al[12] (1978)	1	—	—	—	—	1	0	0%	Cryosurgery
Meals et al[3] (1989)	1	—	—	—	—	1	0	0%	Cryosurgery
This study	3	—	—	—	—	3	0	0%	Cryosurgery
Overall results (LR rate)		61	46 (75%)	32	9 (28%)	5	0 (0%)		

LR, local recurrences.

without bone grafting for giant cell tumors arising from the tubular bones of the hand and foot. To summarize, our review of the literature (Table 2) showed an overall 75% local recurrence rate in 61 patients treated with curettage with or without bone graft. Of 32 patients (many presenting with recurrent lesions) treated with resection or amputation, 9 (28%) developed a local recurrence.

Cryosurgery in the treatment of bone tumors involves the instillation of liquid nitrogen into the tumor cavity following thorough curettage of the tumor. It induces cellular necrosis and destroys residual tumor cells in the reactive zone and therefore biologically extends the margins of an intralesional procedure, thus increasing local tumor control.[8,10–15] The technique was first reported by Marcove and Miller[11] in 1969 for the treatment of metastatic lung carcinoma to bone and was soon adapted to the treatment of giant cell tumors and other benign, aggressive bone tumors.[13,19] Malawer et al[15] recently reported a 2% to 3% local recurrence rate in a series of 86 primary giant cell tumors of bone treated with curettage, cryosurgery, and cementation and monitored for an average of 6.5 years (range, 4–15 years). These investigators compared their results to an average local recurrence rate of 40% with curettage alone (a percentage derived from an extensive literature review).

The risk of postoperative fracture has been one of the main concerns with using cryosurgery in the treatment of bone tumors. In the earliest reports, at a time when cryosurgery was still considered experimental, patients had repeat biopsies 3 to 6 months after treatment to detect any potential local recurrence.[12,13] For this reason, there was little attempt at the initial surgery to reconstruct the bony deficiency. Frequently, the tumor cavity was left empty or was filled with bone graft without internal fixation. This, in combination with bony necrosis induced by cryosurgery, led to a high fracture rate (25%) following surgery.[13] In later series, however, the high fracture rate was reduced by filling the tumor cavity with polymethylmethacrylate (reinforced with metallic internal fixation).[12] In a recent series of 73 patients with giant cell tumors treated with cryosurgery and reconstructed in this manner, no fractures occurred after cementation with internal fixation.[15]

Two earlier reports describe cryosurgery for treating a giant cell tumor of the hand.[3,13] Each report was based on a single patient and both groups of investigators used bone graft without internal fixation to fill the tumor cavity. In 1978 Marcove et al[12] reported 52 cases of giant cell tumors treated with cryosurgery. The study population included 1 patient with a giant cell tumor of the third digit middle phalanx who presented with a recurrent lesion following curettage at another institution. After a 106-month follow-up period the patient was without evidence of disease. Functional outcome was not discussed; however, the patient did experience a postoperative fracture that healed with conservative treatment. In 1989 Meals et al[3] reported cryosurgery of a fourth metacarpal giant cell tumor. At 33 months after surgery the patient was without evidence of disease and had full range of motion of all digits and normal grip strength.

The senior author of this report (M.M.) has treated giant cell tumors of the hand with the same method of curettage, cryosurgery, and cementation used at other anatomic sites. No patient in the series reported here has developed a local recurrence. The mean follow-up period (54 months) is ample time for assessing local tumor control, since most local recurrences of giant cell tumors of the hand occur within 1 year of surgery.[1,2] All 3 patients were pain free and returned to their premorbid level of function. Digital range of motion and grip strength were within normal limits at the most recent follow-up examination. Although based on a small number of patients, these oncologic results and functional outcomes compare favorably with those previously cited for curettage alone or wide resection. The procedure appears safe and reliable; however, it must be emphasized that these patients were treated by a surgeon with extensive experience in the technique. The complication rate and magnitude of complications may be more extensive and the procedure may not be as effective if it is performed by surgeons who are inexperienced with cryosurgery.

This study used cement to fill a tumor cavity in the hand. There have been no complications related to the use of cement in these patients. We prefer cementation over bone grafting because the immediate stability conferred by cement protects against postoperative fracture, it obviates the need for external immobilization, and it allows early rehabilitation. Cement also provides visual contrast material for plain radiographic detection of local recurrence so that local recurrences may be detected while they are still minor.[19]

The exact indications for curettage, cryosurgery, and cementation for giant cell tumor of the hand remain a matter of debate. We believe that most giant cell tumors arising in the hand can be treated with

this method. For functional reasons every attempt should be made to preserve the native articular surfaces. Resection should be reserved only for rare cases in which there is severely deficient bone stock. The definition of adequate bone stock is somewhat subjective; however, we recommend this method of reconstruction for the tubular bones of the hand as long as the native articular surface is preserved at both ends of the bone and the epiphyses are attached to each other by at least a portion of the cortical shaft. If it is questionable whether adequate bone stock will persist following curettage, we recommend that the decision be made during surgery after exploring the tumor; the procedure can always be converted to a resection. All stage 1 and 2 lesions that by definition are entirely confined by the bony cortices can be treated in this manner. Select stage 3 tumors, which erode through the cortical bone, also may be treated with this method provided there is enough bone proximally and distally to ensure secure fixation of the K-wires and cement. With reference to the 2 stage 3 tumors reported here, at least 50% of the circumference of the cortical shaft and both epiphyses remained following curettage and cryosurgery. In areas where there was severely deficient bone, the cement was contoured into the shape of the bone and made smooth so it would not interfere with tendon gliding.

The biologic effects of liquid nitrogen on bone include the production of local bone necrosis with subsequent regeneration from endosteum and periosteum via creeping substitution.[14,27] As noted by several investigators, liquid nitrogen may cause cytotoxicity by several mechanisms, including intracellular ice crystal formation and cell membrane destruction, microvascular thrombosis, electrolyte changes, and intracellular protein denaturation.[14,28] It is the rate of cooling and thawing that is most responsible for direct cellular destruction: rapid, almost instantaneous, freezing to at least –21°C followed by a slow thaw is most effective in killing cells.[29]

Several steps are crucial for obtaining an adequate curettage, ensuring the entire tumor cavity is frozen with liquid nitrogen, and minimizing complications. A long incision should be made to allow wide retraction of skin flaps, including the neurovascular bundle. The cortical window should be the length of the tumor and the width of the bone. The soft tissue component of stage 3 lesions should be excised *en bloc* with the cortical window to prevent soft tissue recurrence. In our experience most stage 3 giant cell tumors, independent of anatomic location, remain covered with periosteum that facilitates *en bloc* resection of the soft tissue component.[15] While freezing the tumor cavity the surrounding skin (not tumor cavity) is continuously irrigated with warm saline to prevent the skin from freezing. Reconstruction of the bony deficiency with the combination of cement and metallic wires helps prevent postoperative fractures, possibly because the cement resists compressive forces well while the wires resist bending and torsional forces.

One of the basic tenets of hand surgery is to initiate range of motion exercises as early as possible following surgery. We recommend that rehabilitation (range of motion followed by strengthening exercises) be initiated as soon as the dressing is changed, usually by 3 days after surgery, provided there are no wound complications. The stable fixation provided by cement and K-wires permits early aggressive rehabilitation so that patients can return to work and most activities within 6 weeks. Heavy lifting or contact sports should be restricted for 3 to 6 months after surgery, depending on the amount of native cortical bone preserved at the time of the procedure.

Curettage, cryosurgery, and cementation reinforced with metallic internal fixation appears relatively safe, effective, and reliable for the treatment of select giant cell tumors of the tubular bones of the hand when used by surgeons with experience with this technique. Normal motion and grip strength can be restored and complications minimized when performed by experienced surgeons. We recommend this method of treatment for most lesions in which sufficient bone remains following curettage to enable a stable reconstruction. Further investigation is necessary before definitive conclusions can be made regarding the precise indications for this method.

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