ORIGINAL ARTICLE

Local recurrence of giant cell tumour of bone after intralesional treatment with and without adjuvant therapy, a single institution case series

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Abstract

Background: Giant cell tumour (GCT) of bone is generally a benign tumour composed of mononuclear stromal cells and characteristic multinucleated giant cells that exhibit osteoclastic activity. It usually develops in long bones but can occur in unusual locations. The typical appearance is a lytic lesion with a well-defined but non-sclerotic margin that is eccentric in location, extends near the articular surface, and occurs in patients with closed physes.

Objective: The current study was planned to summarise our experiences with GCTB, and to evaluate individual effect of bone cement, high-speed burring and hydrogen per oxide (H2O2) on local recurrence. GCT can mimic or be mimicked by other benign or malignant lesions at both radiological evaluation and histological analysis. In the past, the mainstay of treatment was surgical, primarily consisting of curettage with cement placement, with recurrence rates of 15%-25%. Recurrence is suggested by development of progressive lucency at the cement-bone interface.

Results: Of the 21 patients who started the study, 4(19%) were lost to follow-up, and 17(81%) represented the final study sample. Of them, 16(94.11%) patients underwent the curettage procedure with adjuvant therapy and reconstruction with bone grafts taken from iliac crest. In 3(26.3%) patients, no adjuvant was used. Total of 6 (42.1%) patients had local recurrence and 3(50%) of them were those who were treated without any adjuvant; 2(33.3%) with phenol and 1(16.6%) with PMMA.

Conclusion: The results of the present study suggest that an "aggressive curettage" with the use of adjuvant reduces the recurrence rate in a disease whose aggressiveness is not easy to predict.

Keywords: Bone tumour, Giant cell tumour, Extremity, Surgery, Curettage, Resection, Wide excision. (JPMA 65: S-105 (Suppl. 3); 2015)

Introduction

Giant cell tumour of bone (GCTB) is an intermediate, locally aggressive but rarely metastasising tumour, representing 5% of primary bone tumours and 20% of benign bone tumours.[1] It occurs mostly between the ages of 30-50 years and rarely arises in the immature skeleton. There is a slight predominance for female patients.[1,2] At presentation, 15%-20% of patients have a pathologic fracture due to substantial cortical destruction followed by relatively minor trauma. GCTB is typically seen solitary, mostly located in the meta-epiphyseal region of long bones (85%), but may also occur in the axial skeleton (10%) or occasionally in the small bones of hands and feet (5%).[2,3] At the latter location, so-called giant cell lesion of the small bones — a different entity — should be considered.[4] Approximately 1%-4% of otherwise conventional patients develop pulmonary metastases.[3,5-9] These metastases often have relatively indolent behaviour. Multifocal GCTB is rare, appearing either simultaneously or metachronously. In these presentations, so-called brown tumours associated with hyperparathyroidism should be ruled out by blood biochemistry because they are histologically barely distinguishable from GCTBs. Malignant transformation has been described in less than 1% of all GCTBs and may be either primary (i.e., sarcomatous progression) or, more commonly, secondary (mostly radiation induced).[1]

The main problem in the management of GCTB is local recurrence after surgical treatment: 27%-65% after isolated curettage;[2,3] 12%-27% after curettage with adjuvants such as high-speed burr, phenol, liquid nitrogen, or polymethylmethacrylate (PMMA);[2,10-12] and 0%-12% after en bloc resection.[2,13] In clinical practice, the choice of surgical treatment depends mostly on the feasibility of curettage and local adjuvants versus resection, but also in part on the expected risk for local recurrence in each individual patient. Soft tissue extension, for example, is commonly present and increases the risk for local recurrence.[14,15] Pathological fractures are also common, and although this does not in itself increase recurrence risk, it may render curettage technically more difficult. In general, the aim for joint preservation is justified, considering the benign but

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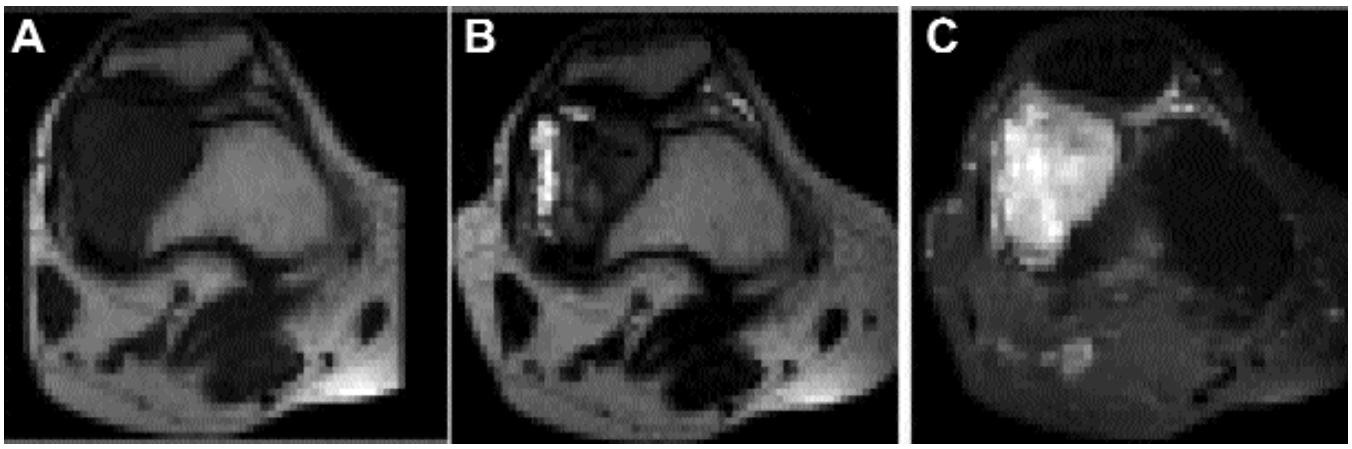


Figure-1: Different radiological modalities in the diagnosis of giant cell tumour of bone. (A): Plain radiograph shows a lytic lesion with extensive cortical destruction and a pathological fracture in the distal radius. (B-D): T1- and T2-weighted magnetic resonance imaging (MRI) shows low signal intensity through hemosiderin depositions and high signal intensity through secondary cystic changes. (C): T1-weighted MRI with fat suppression after intravenous gadolinium administration demonstrates marked, relatively homogeneous enhancement.

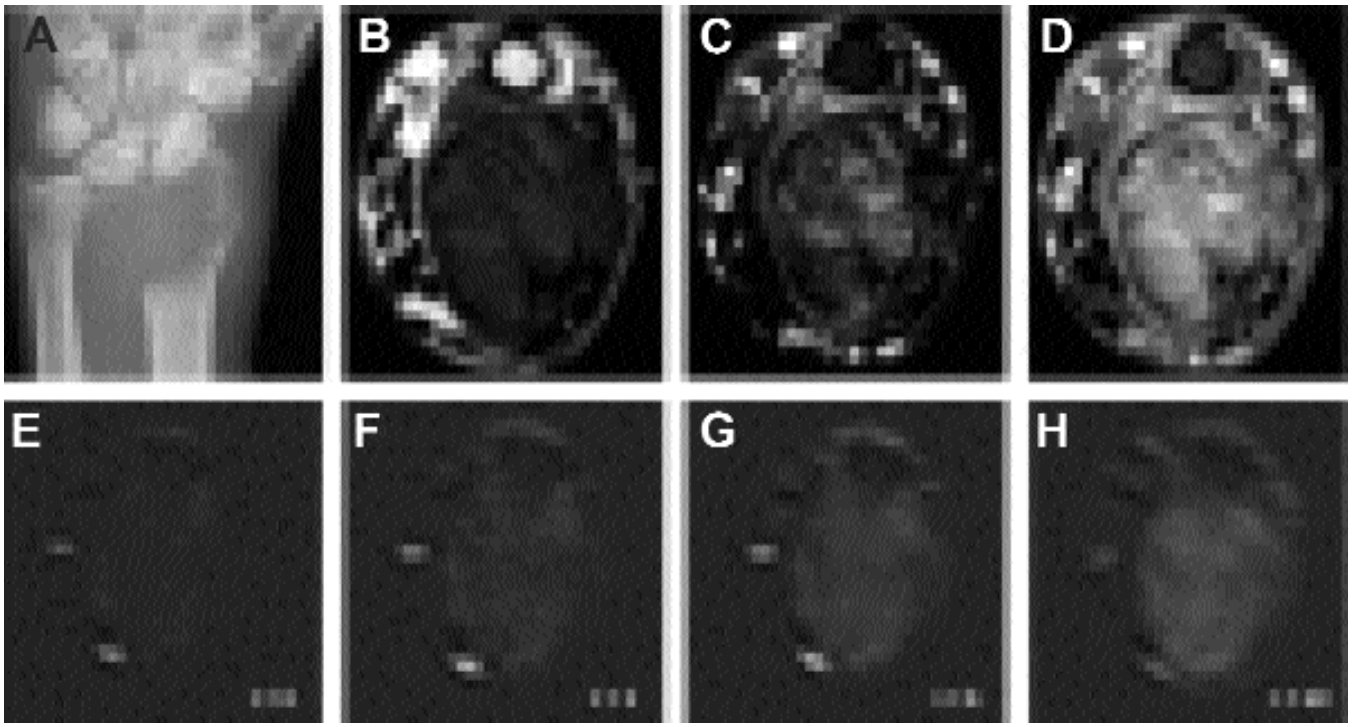


Figure-2: Different radiological modalities in the diagnosis of giant cell tumour of bone. (A): Plain radiograph shows a lytic lesion with extensive cortical destruction and a pathological fracture in the distal radius. (B-D): T1- and T2-weighted magnetic resonance imaging (MRI) shows inhomogeneous low to high signal intensity and marked enhancement after gadolinium administration. (E-H): Dynamic contrast-enhanced MRI (DCE-MRI) shows homogeneous enhancement within 6 seconds after gadolinium administration. DCE-MRI can provide functional information on tumour angiogenesis and permeability but will not be part of standard imaging protocols in many centres.

locally aggressive nature, young patient population, and significant complications including need for revision surgery after resection and reconstruction with tumour prostheses.[16-19]

The current study was planned to summarise our experiences with GCTB, and to evaluate individual effect of bone cement, high-speed burring and hydrogen per oxide (H_2O_2) on local recurrence.

Materials and Methods

The descriptive case series was conducted at the

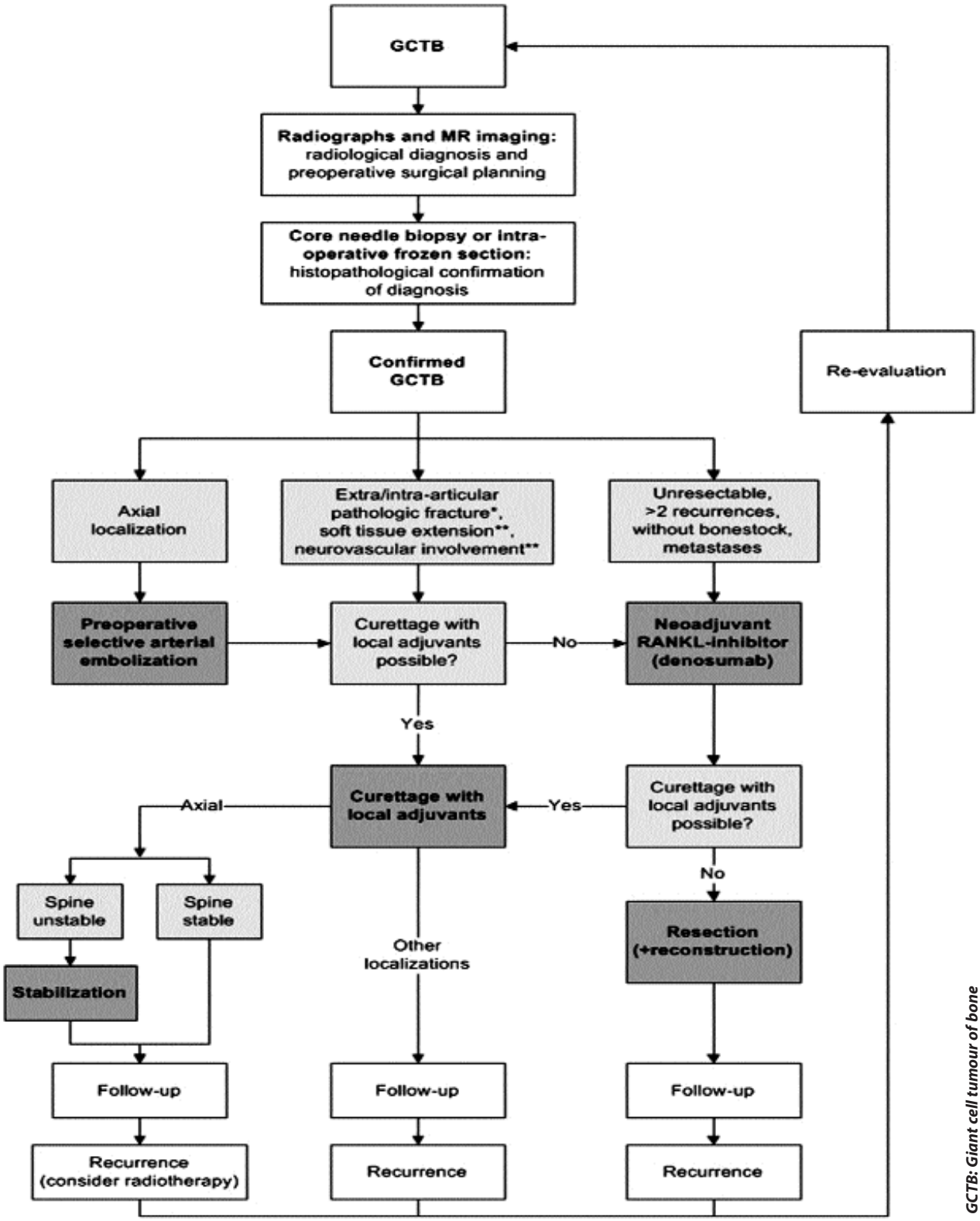


Figure-3: Multidisciplinary treatment recommendations for giant cell tumour of bone (GCTB).*, With extra-articular pathologic fractures, preoperative fracture healing may be delayed, whereas immediate surgery is required with intra-articular pathological fractures.**, Caution is warranted with local adjuvants (e.g., phenol, alcohol, liquid nitrogen) in case of involvement of soft tissues or neurovascular structures because it may induce (severe) necrosis.

Table-1: Adjuvant therapies for GCT.

Local chemical and physical adjuvants	
Cryosurgery (liquid N)	With the use of liquid nitrogen, the tumor is subjected to a freeze/thaw cycle in an attempt to cause cellular necrosis.
Alcohols	An organic compound used for antiseptic purposes. Anhydrous alcohols have been reported to be a safe adjuvant for the treatment of GCT.
Phenol	A chemical which has antiseptic properties and removes microscopic tumor residuals
Hydrogen peroxide	Oxidizing effervescent which is used to clean and removal tumor cell residues
Zinc chloride	A chemical compound, which causes cell necrosis and is used to inhibit reoccurrence of GCT
Argon beam coagulation	Cryotherapy that causes thermal necrosis of GCT and is used to lower the local recurrence
Mechanism-based drugs	
Denosumab	Human monoclonal antibody which targets RANKL, thereby inhibiting the formation and function of giant osteoclast-like cells of the tumor
Bisphosphonates	A series of drugs that strongly attaches to hydroxyapatite of the bone and are then ingested by resorptive cells, leading to apoptosis of these cells. Bisphosphonates also have activity against cancerous cells.
IFNα	A protein produced by leukocytes and is involved in immune response. IFNα is an antiangiogenic inhibitor, which obstructs angiogenesis and tumor growth by targeting growth factors (e.g., bFGF, VEGF).

GCT: Giant cell tumour
RANKL: Receptor activator of nuclear factor kappa-B ligand
IFNα: interferon alpha
bFGF: Basic fibroblast growth factor
VEGF: Vascular endothelial growth factor.

Department of Orthopaedics, Punjab Medical College, Faisalabad, Pakistan, and affiliated hospitals from July 2011 to June 2014. Patients meeting the inclusion criteria were admitted through the outpatient department (OPD) and those lost to follow-up were excluded. Non-probability but purposive sampling technique was used. Risks and benefits were discussed. We analysed the differences in local recurrence rates, functional results, and complications between wide excision and curettage with adjuvant therapy in management of the patients diagnosed with primary lesions after follow-up.

The data collected consisted of clinical notes, operative notes, radiographic images, pathological reports, as well as gross and microscopic imaging. They were asked to sign an informed consent form for surgery and allow the use of data for research purposes. The lesions were graded according to Campanacci et al.[6] as Grade I, Grade II, or Grade III. Any pathological fractures were noted. Intra-compartmental or extra-compartmental tumour growth was identified on the basis of preoperative imaging studies, including computed tomography (CT) and magnetic resonance imaging (MRI) and on the basis of intraoperative findings. The compartmental extension was graded T1 or T2 according to the system of Enneking et al.[12,13] and Wolf and Enneking.[14] All surgical specimens were reviewed by a consultant pathologist specialising in bone and soft tissue pathology and histologically classified as benign GCT.

For intralesional procedures, a wide cortical window was created to observe the tumour cavity. The tumour tissue was removed with a curette. The borders of the tumour cavity then were cleared away with a high speed burr. The tumour cavity was inspected with a dental mirror or an endoscope to verify the removal of all tumour tissue. Further, 89 per cent phenol was applied in the borders of the cavity with cotton-tipped applicators and then neutralised with alcohol in 16 patients. Finally, the tumour cavity was packed carefully with autologous and/or allogenic bone grafts and PMMA. Procedures in which polymethylmethacrylate packing was combined with bone grafting were subsumed into PMMA treatment groups.

For follow-up, patients were contacted via phone and serial radiographs of primary site and chest were taken every 3-4 months for the first 2 years and every 6 months for the next year and annually thereafter.

Data was analysed via SPSS 19 to find percentages and

frequencies of study variables. Descriptive statistics were used to calculate mean and standard deviations.

Results

Of the 21 patients who started the study, 4(19%) were lost to follow-up, and 17(81%) represented the final study sample. Of them, 16(94.11%) patients underwent the curettage procedure with adjuvant therapy and reconstruction with bone grafts taken from iliac crest. In 3(26.3%) patients, no adjuvant was used. Total of 6 (42.1%) patients had local recurrence and 3(50%) of them were

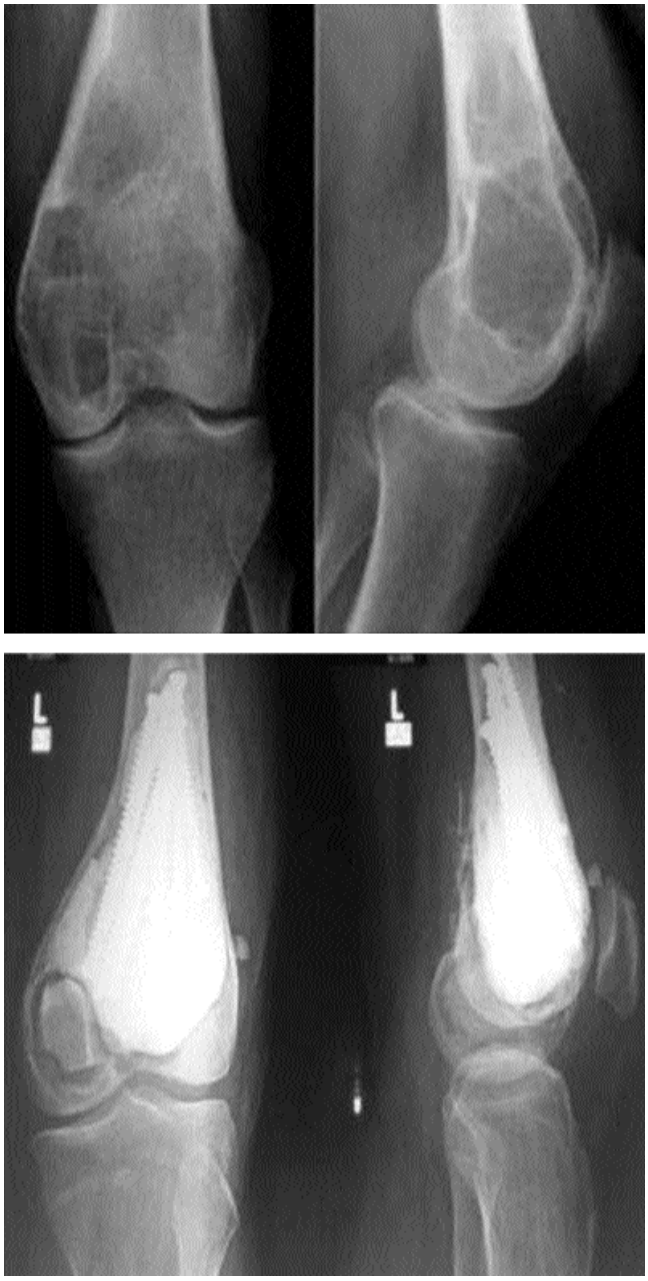


Figure-3: Radiological appearance of giant cell tumour of bone (GCTB) of distal femur in one of our patients. (A, B): Radiographs demonstrating an eccentric, sharply demarcated lytic lesion in the distal femur metaphysis extending to the epiphysis without tumor mineralisation. And Post-Op radiograph of the same patient treated with bone cement and a bone graft augmented with screws.

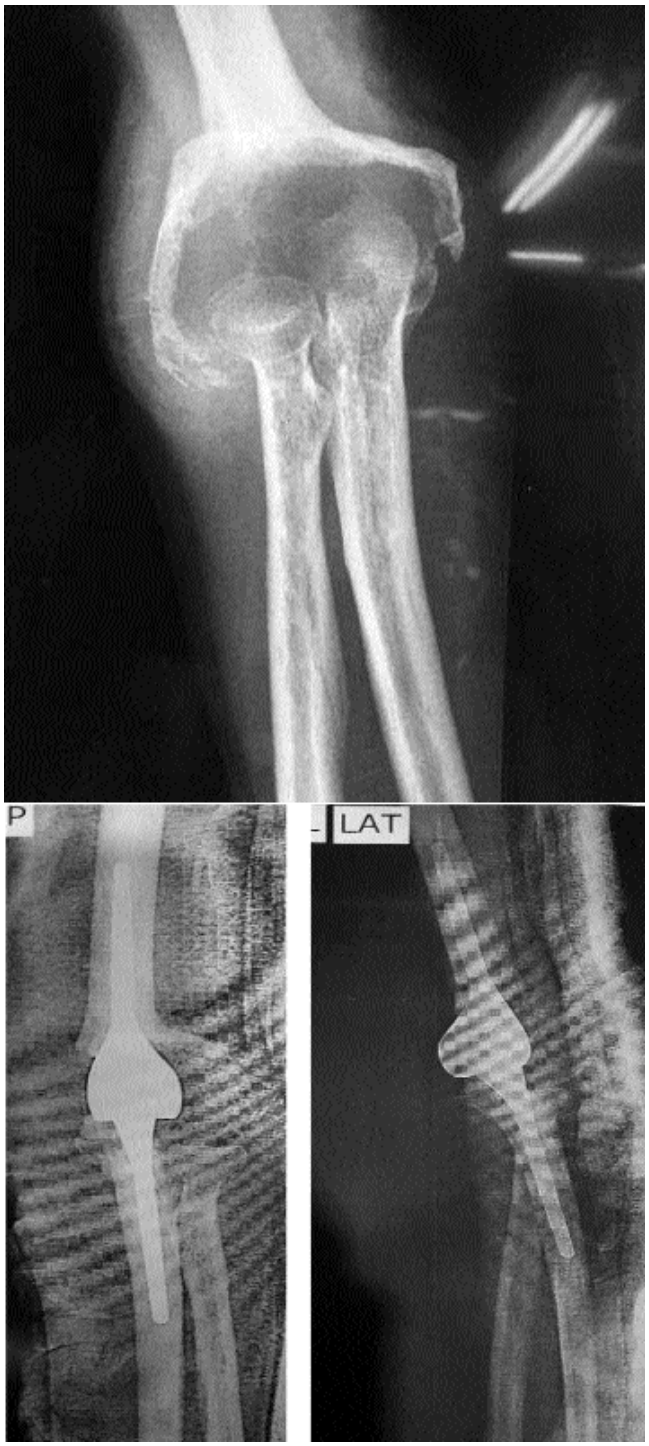


Figure-4: Another patient with Giant Cell Tumour of Distal Humerus that was treated with wide excision and Elbow Arthroplasty afterwards.

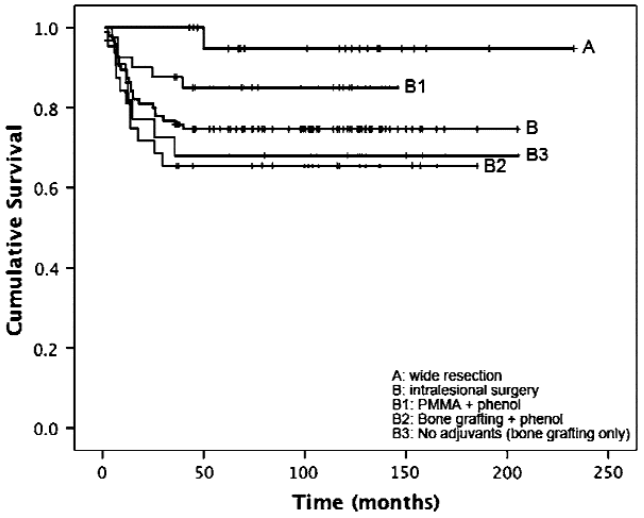
Table-2: Descriptive patient demographics and treatment data in our study.

Parameter	Mean	SD
Patient age at diagnosis (years)	35.4	15.8
Time to recurrence (months)	16.4	12.3
Followup (months)	27.9	34.1
	Number	**Percent**
Gender		
Male	08	47
Female	09	52.9
Location		
Distal femur	9	52.9
Distal tibia	2	11.7
Proximal tibia	2	11.7
Distal humerus	3	17.6
Proximal humerus	1	5.88
Grade (Campanacci)		
Grade I	5	29.4
Grade II	4	23.5
Grade III	8	47.0
Tumor extension		
T1	9	52.9
T2	8	47.1
Pathologic fracture	13	76.4
Treatment		
Wide resection	01	5.88
Intralesional surgery	16	94.11
Adjuvants		
No Adjuvant	03	18.75
Bone grafting + phenol	04	25
PMMA+ Bone graft	6	37.5
PMMA+Phenol	3	18.75
Recurrences-total	06	37.5
Recurrences-bone	5	83.3
Soft tissue implantations	4	3.4

those who were treated without any adjuvant; 2(33.3%) with phenol and 1(16.6%) with PMMA (Table-2). Using the Musculoskeletal Tumour Society system to evaluate average function,[17] the results were 25.56 points for the wide excision group and 25.64 points for the curettage group, respectively.

Intralesional procedures were the most common surgical treatment and of the 16(94%) patients treated with intralesional surgery and PMMA void filling, 7(43.7%) received additional local phenol and alcohol treatment; 3(43%) with PMMA and 4(57%) with phenol alone. Six (37.5%) patients were treated solely with PMMA and no additional adjuvants. Wide resections were performed in 1(5.88%) patient (Figure-3, 4),

Reconstructions after wide resections included



Kaplan -Meier survival analysis.[18]

Figure-5: Recurrence-free survival for patients with primary giant cell tumour (GCT) treated with wide resection (A) and intralesional surgery (B) is shown. Treatment subgroups for patients were intralesional surgery included the use of polymethylmethacrylate (PMMA) and phenol (B1), the use of bone grafting and phenol (B2), and intralesional surgery without adjuvants (B3). The estimated cumula- tive recurrence free survival (95% confidence interval) rates were 0.947 (0.847-0.999) for Group A, 0.747 (0.659-0.835) for Group B, 0.851 (0.741-0.961) for Group B1, 0.656 (0.491-0.821) for Group B2, and 0.682 (0.488-0.876) Group B3.

arthroplasties 1(5.88%), (Figure-4) The mean interval between surgery and recurrence was 16.3±12.4 months (range: 4-36 months) (Figure-5).

Discussion

Giant cell tumour of bone (GCTB) is a benign but locally aggressive tumour that usually involves the end of long bone. Its histogenesis remains unclear. It is characterised by a proliferation of mononuclear stromal cells and the presence of many multinucleated giant cells with homogenous distribution. The name giant cell tumour was suggested by Cooper and Travers[19] in 1818. Virchow[19,20] suggested a malignant potential in 1846. Ne´laton,[20] a French doctor, was the first to recognise the similarities of the multinucleated giant cell with osteoclasts in 1860. In 1912, Bloodgood[21] reported on the benign nature of GCT. Most of current knowledge of this specific bone tumour has come from Jaffe et al.[22]

GCT has a significant incidence, accounting for 20% of all benign bone tumours and 5% of all bone tumours.[23] Higher incidence has been reported for Chinese population, in which it can be up to 20% of all bone tumours.[24] Although some series show a slight female predominance,[25] but most support that there is no gender predilection in GCT. GCTB most frequently occurs

Table-3: Recurrence rates after different types of surgical treatment for giant cell tumour of bone (GCTB). [Lizz et al.2014 (Tab 1)]

Study	Year	Follow-up, mo (range)	Total	Resection			Curettage without local adjuvants			Curettage with phenol			Curettage with phenol and PMMA			Curettage with PMMA			Curettage with liquid nitrogen			Curettage with liquid nitrogen and PMMA		
			n	*n*	rec	%	*n*	rec	%	*n*	rec	%	*n*	rec	%	*n*	rec	%	*n*	rec	%	*n*	rec	%
Marcove et al.[a] [77]	1978	43 (3–120)	52	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	52	12	23	—	—	—
Jacobs et al. [78]	1985	(26–132)	12	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	12	2	17	—	—	—
Capanna et al. [67]	1990	NR	667	—	—	—	280	126	45	147	28	19	33	1	3	187	36	19	20	4	19	—	—	—
Marcove et al.[b] [75]	1994	147 (24–170)	7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7	2	29	—	—	—
O'Donnell et al. [71]	1994	48 (24–120)	60	—	—	—	—	—	—	—	—	—	17	3	18	43	12	28	—	—	—	—	—	—
Alkalay et al. [79]	1996	(24–48)	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	0	0
Dürr et al. [68]	1999	61 (6–178)	26	—	—	—	7	3	43	11	1	9	—	—	—	—	—	—	—	—	—	—	—	—
Mallawer et al. [74]	1999	78 (48–180)	102	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	86	8	8	—	—	—
Schreuder et al. [76]	1999	34 (18–79)	13	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	13	4	31	—	—	—
Trieb et al. [69]	2001	121 (48–516)	47	—	—	—	14	3	21	12	3	25	—	—	—	—	—	—	—	—	—	—	—	—
Wittig et al.[c] [81]	2001	54 (49–62)	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	0	0
Boons et al. [62]	2002	84 (24–372)	36	11	0	0	—	—	—	—	—	—	—	—	—	4	1	25	12	5	42	5	1	20
Ghert et al. [63]	2002	62 (24–224)	75	24	3	12	—	—	—	—	—	—	9	3	33	38	6	16	—	—	—	—	—	—
Turcotte et al.[d] [64]	2002	57 (24–192)	186	38	6	16	—	—	—	37	NR	18	U	U	18	62	NR	18	10	0	0	—	—	—
Wada et al. [73]	2002	46 (24–188)	15	—	—	—	—	—	—	—	—	—	—	—	—	15	1	7	—	—	—	—	—	—
Ward et al.[e] [65]	2002	59 (12–115)	31	7	0	0	—	—	—	9	1	11	14	1	7	1	0	0	—	—	—	—	—	—
Salz et al. [72]	2004	76 (28–175)	40	—	—	—	—	—	—	—	—	—	40	5	13	—	—	—	—	—	—	—	—	—
Su et al. [66]	2004	62 (28–138)	87	31	1	3	—	—	—	56	10	18	—	—	—	—	—	—	—	—	—	—	—	—
Abdelrahman et al. [80]	2008	34 (24–40)	28	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	28	1	4
Balke et al.[c] [2]	2008	60 (8–281)	214	18	0	0	55	32	65	—	—	—	42	5	12	91	26	29	—	—	—	—	—	—
Becker et al. [10]	2008	64 (1–440)	256	48	1	2	65	32	49	—	—	—	50	13	27	69	15	22	—	—	—	—	—	—
Kivioja et al. [11]	2008	60 (3–216)	294	92	11	12	47	24	51	—	—	—	—	—	—	147	32	22	—	—	—	—	—	—
Errani et al. [13]	2010	91 (36–204)	349	149	18	12	—	—	—	136	24	18	64	8	13	—	—	—	—	—	—	—	—	—
Gaston et al. [70]	2011	77 (2–319)	330				246	73	30							84	12	14						
Klenke et al. [14]	2011	108 (36–233)	118	22	1	5	22	7	32	32	11	34	40	6	15	1	0	0	—	—	—	—	—	—
Lin et al. [84]	2011	58 (36–156)	26	—	—	—	—	—	—	26	3	12	—	—	—	—	—	—	—	—	—	—	—	—
Benevenia et al. [129]	2012	55 (10–184)	93	—	—	—	—	—	—	18	4	22	—	—	—	—	—	—	—	—	—	—	—	—
van der Heijden et al. [15]	2012	96 (24–288)	93	—	—	—	—	—	—	—	—	—	75	20	27	18	5	28	—	—	—	—	—	—
Recurrence rate, mean (range)				6 (0–16)			42 (21–65)			19 (9–34)			17 (3–33)			17 (0–29)			21 (8–42)		6 (0–20)		

[a]PMMA was used instead of bone grafts only in later cases, but it is not stated in how many patients.

[b]In this study, only GCTB of the sacrum was reported.

[c]In this study, only GCTB of the small bones of the hand was reported.

[d]In this study, only the overall recurrence rate was given after curettage with different adjuvants (18%) including phenol, PMMA, liquid nitrogen, and combinations thereof. The recurrence rate was further specified only for the use of liquid nitrogen (0%).

[e]H2O2 was used as alternative to phenol as the local adjuvant.

Abbreviations: --: no data; GCTB: Giant Cell Tumor of Bone; NR: Not Reported; PMMA: Polymethlmethacrylate; rec: recurrence; U: Unknown.

Table-4: Kaplan-Meier survival analysis of recurrence free survival 10 years after surgery.

Surgical treatment	Recurrence-free survival	Standard error	Mean recurrence-free survival (months)	95% confidenc interval	p (versus wide resection)	p (versus PMMA+phenol)
Wide resection	0.955	0.051	116	109–123	–	–
Intralesional surgery	0.747	0.045	93	84–103	0.036	–
PMMA+phenol	0.854	0.056	105	93–116	0.209	–
Bone grafting+phenol	0.656	0.084	83	66–101	0.009	0.044
No adjuvants (bone grafting)	0.682	0.099	87	67–107	0.018	0.107

in young adults between 20 and 40 years of age.[26] Occurrence before epiphyseal plate closure is exceptional.[27] GCT can be seen in patients over 50 years old. Though less frequent, this disease needs to be included in the differential diagnosis process of a lytic bone lesion.[28]

Intralesional curettage has been established as the preferred treatment for most GCTs. Wide resection is reserved for tumours with extensive destruction, impossible joint salvage, and when expendable bones like fibular head or distal ulna are affected.[14,16,23,27,28] We analysed the recurrence-free survival after treatment of GCT with an emphasis on the impact of surgical approach, adjuvant therapy, tumour presentation and demographic factors on the risk of recurrence.

Similar to previous reports,[1,3,6,15,22,28] we found that wide resection was associated with a lower risk of recurrence than intralesional surgery. When intralesional procedures are performed, local adjuvants (PMMA, phenol, H_2O_2, and cryotherapy) have been reported to improve tumour control.[1,3,5,11,28,29] Campanacci et al. showed a rate of recurrence of 27% out of all intralesional procedures, 8% in mariginal excisions and 0% in wide excisions, and 90% of recurrences occurred in the first three years after surgery.[29] We found that PMMA's use decreased the risk of local recurrence. Similar risk reductions have been observed by others,[1,3,22] and have been attributed to thermal and toxic effects on tumour cells.[33] Additionally, PMMA may decrease the risk of collapse and allow for more aggressive tumour removal as a result of its mechanical properties. Considering the importance of thorough tumour removal, this capacity may overshadow the effects of heat-mediated tumour effects; a suggestion that was also made by Gher et al.[33] Similar results were reported by Klenke et al.[34] in their retrospective study of 46 patients. The use of PMMA with intralesional curettage lowers the recurrence rate from the average of 32% to 14%. The recurrence rates seen for wide resection are near 5-6%, but they entail considerable loss of function. In another series, Klenke et al. reported on the recurrence rates of GCT in 118 patients treated with wide resection and intralesional curettage and the rates are 5% and 25%, respectively. However, they suggested the use of curettage with PMMA, since this procedure lowers the recurrence rate and it provides equivalent tumour control compared to resection.[36,40] Phenol is a commonly used adjuvant for GCT treatment. Phenol induces tumour necrosis[24,36,37,41] with few adverse effects.. However, tissue penetration is poor and limits tumour necrosis to superficial cell layers.[34] Balke et al. found a negligible necrotising effect of phenol and discounted it as an adjuvant after curettage of bone tumours.[2,19,21,33] Others have also reported little effect of phenol on recurrence.[1,35-38] However, Durr et al. did report decreased local recurrence with the use of phenol.[39] We did not find any effect of adjuvant phenol treatment on GCT recurrence. Age at diagnosis independently predicted recurrence regardless of the status of the disease and the aggressiveness of the chosen treatment: recurrence rate decreased as the patient's age increased. The greater risk of young patients having recurrence has been reported [40] and may be associated with increased bone turnover in young people.[21,34,40,41] This hypothesis is supported by studies showing inhibition of bone turnover with bisphosphonates reducing the risk of recurrence.[7,9,17,43] Other demographic and disease-related variables (gender, location, tumour grade, soft tissue extension, and pathologic fracture) had no influence on local recurrence in our patients. Previous studies have also shown that gender, location, and tumour grade did not influence recurrence.[1,3,43] The prognostic relevance of soft tissue expansion and pathological fractures is controversial.[1,3,15,22,31,38,40,43] Becker et al. found that the prevalence of soft tissue extension influenced the risk of local recurrence[41] and O'Donnell et al. reported that pathological fractures were associated with an increased recurrence rate.[43]

The aggressiveness of the treatment should be considered when interpreting the correlation of soft tissue expansion or pathological fractures and local recurrence. In tumours with and without pathological

fractures, wide resections were performed in 47% and 14%, respectively. Thus, patients with pathological fractures more commonly received resections. In this retrospective study, this may underestimate the risk of recurrence in patients with pathological fractures. The rate of pulmonary metastases in our study patients was 0%, similar to previous studies reporting ranges from 0% to 4%.[3,4,8,10,15,20,30,39,42,44] Although GCT is classified as a benign lesion [44], but few patients develop progressive lung metastases with poor outcomes.[2,6,44] It is difficult to quantify the real morbidity (physical and emotional) of patients who experience recurrence and require repeat surgery. Based on the results of this study, we recommend intralesional surgery for treating most GCTs; the selection of bone graft versus PMMA remains individualised. Because young age is a risk factor for local recurrence, we favour the use of PMMA in young patients as the best way to minimise recurrence and preserve the native joint. Similarly, when little bone stock remains or for patients with questionable compliance for a limited weight-bearing rehabilitation, methylmethacrylate is favoured for its immediate stability.

Conclusion

The combination of adjuncts (PMMA, burring, H_2O_2) reduces the likelihood of recurrence compared to curettage alone and therefore should be recommended as the standard treatment. If the tumour reaches close to the articulating surface, a strut/cancellous bone graft can be performed without risking a higher recurrence rate. Use of PMMA as an adjuvant significantly reduces the recurrence rate following intralesional treatment of benign GCT, and it appears to be the therapy of choice for primary as well as recurrent Giant Cell Tumour of Bone.

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