Extended curettage and reconstruction with bone grafting or combined bone graft and cement (Sandwich Technique) in giant cell tumors (GCT) of bone – Prospective study of Functional Outcome

Yogesh Panchwagh[1], Pankush Arora[1], Suheil Khan[1], Ashok K Shyam[1,2], Parag Sancheti[1].

ABSTRACT

Background: Treatment of giant-cell tumors (GCTs) of bone is generally either curettage with bone-grafting or combined bone grafting and cementing (sandwich technique) or wide en bloc resection of the lesion. This study aims to find out the early functional outcomes after extended curettage and reconstruction using either bone graft sandwich technique with or without internal fixation.

Methods: Seventeen patients who had giant-cell tumor of bone and were managed with extended curettage and reconstruction using either bone grafting or sandwich technique between July 2007 and April 2009 were studied. Aggressive curettage was done with the use of various adjuvants like high speed burr, hydrogen peroxide, and phenol and alcohol application in suitable cases.

Results: After a median duration of follow-up of 14.5 months, the average MSTS score at final follow up was 24.59. Age, gender, grade of tumor, technique and recurrence had no significant effect on the eventual functional outcome achieved by the patients. There was 1 patient with GCT of the lower end of radius who had a unicortical fracture post-operatively which was managed conservatively in cast. There was one recurrence in these 17 patients (6%); however a longer follow up will be required to comment on the recurrence rate.

Conclusions: We concluded a good to excellent functional outcome without compromise of prognosis, can be achieved by using a bone graft or sandwich technique following extended curettage. Most patients could resume their previous work and reach the earlier level of physical activities. Age, gender, grade of tumor, technique had no significant effect on the eventual functional outcome achieved by the patients .A longer duration of follow-up of a larger group of patients is necessary to study the recurrence rates.

Keywords – giant cell tumor, extended curettage, functional oolcone.

[1]Department of Orthopaedics, Sancheti Institute for Orthopaedics and rehabilitation, Pune Maharashtra, India.
[2]Indian Orthopaedic Research Group, Maharashtra, India

Address for correspondence: Dr Yogesh Panchwagh, Sancheti Institute for Orthopaedics and Rehabilitation, first floor, Shivaji nagar, Pune, Maharashtra, India.
Email: drpanchwagh@gmail.com

INTRODUCTION

Giant cell tumor of bone is benign1 though [1]ocally aggressive tumor[2,3,4,5], of bone may undergo malignant transformation.[6] It represents 4–5% of primary bone tumors and 20% of biopsy concluded benign bone tumours.7 There is a slight female predominance8 with a peak incidence in young adults aged 20–40 years.[2 ,8, 9, 10] The most frequent sites are lower end femur, proximal tibia, lower end radius11 and proximal humerus.[8,12] The treatment of GCT aims to eradicate the tumor tissue, reconstruct the bone defect, and restore a functional limb. When formulating a plan for local control of GCT, the treatment options are extended curettage [2, 4, 12 , 13 ,14] and reconstruction with bone graft or sandwich technique [15,16] and an en-bloc resection.[2,4, 13, 17, 18] En-bloc resection11 is carried out if the tumor is large enough to involve a wide area of surrounding soft tissue or when the articular cartilage is largely damaged, there is inadequate bone stock post curettage and when resection results in no significant morbidity as proximal fibula and flat bones.[18,19]

To reduce local recurrence after curettage, various methods have been tried like the use of burr[20], phenol[3, 7, 21 , 22], electrocautery[23], cryotherapy [5, 22], hydrogen peroxide[3, 23], ringer lactate and argon laser[24] as adjuvant therapies. Reconstruction of the bone void is done using either autograft bone[20, 25, 26, 27]; allograft bone[20, 25, 26, 27] and polymethyl methacrylate bone cement (PMMA).[4, 21, 26, 28, 29, 30,31] However it is very well documented that local tumor control depends on how thoroughly the tumor tissue has been excised.[20] Although a marginal or wide excision of the involved bone is curative if contamination is avoided with reported recurrence rate of 0-32 % [32,33,34]. It is associated with reconstruction and disability problems. Recurrence rates after intralesional procedures have ranged from 30 -52% irrespective of use of adjuvants.[20, 23, 25, 26, 27, 28, 29, 32, 33, 35]

Although a lot of studies do define the cure rate and focus on the recurrence and other surgical variables, there exists a lack of studies on the functional outcome after treatment of GCT. This study aims to find out the early functional outcomes after extended curettage and reconstruction using either bone graft or sandwich technique with or without internal fixation.

MATERIALS AND METHODS

Between June 2007 and April 2009, 17 patients managed with extended curettage and reconstructions were included in our

study. Amongst these, 6 patients had GCT in the upper end of femur, 3 in upper end tibia, 3 in lower end tibia, 2 in lower end radius, 1 in upper end femur, 1 in first metacarpal and 1 in proximal phalanx of ring finger. There were 9 males and 8 females with mean age of 28.94 years (range 18 to 54 years). Of these, 10 patients were aged less than 30 years (58.82%), making this a significantly young cohort. According to the grading system of GCTs as described by Campanacci, there were four grade 1, nine grade 2, and four grade 3 tumors. There were 14 primary tumors and 3 recurrences. All recurrent cases (n=3) patients were operated primarily at other institutes. At our institute, all surgeries were done by the senior author (YP)

Technique: Under appropriate anaesthesia, incision was taken to include the scar of biopsy. Adequate exposure was achieved by making a large cortical window to access the tumor so as to avoid having to curette under overhanging shelves or ridges of bone. A dental mirror was used which helped for better visualization. The part of the wall of the cavity which is composed of soft tissue or a thin bony shell was excised. Multiple angled curettes helped to identify and access small pockets of residual disease which may otherwise result in recurrence. The remaining cristae and septa in the cavity were excised. When the wall of the cavity contains many small holes caused by local invasion of the tumour, each hole should be meticulously cleared. They usually do not penetrate the periosteum, but a dead space may be found between them and the periosteum. A high power burr may be used to break the bony ridges. A pulsatile jet lavage system was used after curettage to bare the raw cancellous bone and physically wash out tumor cells. Adjuvants such as hydrogen peroxide were used routinely, but the use of alcohol and phenol was restricted to those patients whose lesions had adequate cortical wall post curettage without any significant risk to the neuro-vascular bundle and other soft tissues (n=12). Reconstructing the defect after curettage was done with either bone graft alone or using a Sandwich technique depending on the thickness of the subchondral bone. In cases with thin subchondral bone or where the cartilage was eroded were treated with sandwich technique (n=8) and remaining cases were treated with bone grafting only (n=9). Sandwich technique included using a sheet of morselised bone graft to cover the articular cartilage. Gel foam was placed over the bone graft and cement was then used to fill the entire cavity so as to restore the anatomical shape of the bone. Any internal fixation required was decided intra- operatively. In six cases, no fixation was required, K wires were used in 5 cases, cannulated cancellous screws were used in two cases and plating was used in 4 cases. Closure of the soft tissue, subcutaneous tissue and skin was done in layers. Post-operatively patients were given immobilization in the form of plasters.

Functional evaluation of these patients was performed according to the most recent system of the Musculoskeletal Tumor Society (MSTS) .[22] The pre- operative and post-operative MSTS Score was determined and compared to study the functional outcome of the patients. The patients were followed for twelve to thirty-one months (mean: 17.76 months).

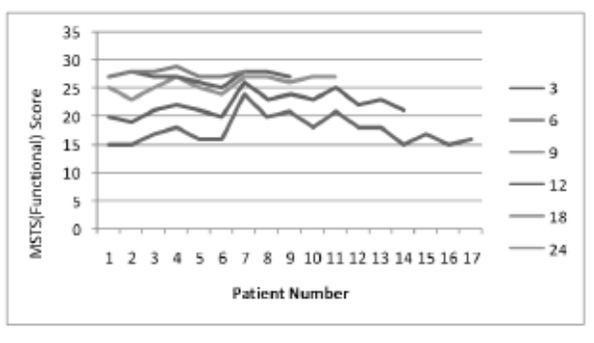
Subgroup analysis was done by classifying the group according to age (<30,>30), gender (male, female), grade of tumor, technique (bone grafting alone or sandwich technique) and primary of recurrent lesion. Statistical analysis was done using online calculators. Mann Whitney 'U' test and ANOVA test were used for subgroup analysis. Since five subgroups were analysed, the normal allowed beta error of 5% was divided by 5 and p value <0.01 was taken to be significant.

RESULTS

The mean follow up was 17.76±4.38 months (range 12 to 31 months). The functional score pre-operatively was 10.82 ± 3.43 (range: 0-16). At 3 months post-operative follow up, it was 17.64 ± 2.57 (range, 15-24). At 6 months, it improved to 22.14 ± 1.99 (range, 19-26), which further improved to 25.73 ± 1.42 (range, 23-27) at 9 months. The functional score at 1 year was 27 ± 1 (range, 25-28) and at 1 ½ year follow up was 27.71 ± 0.76 (range, 27-29). There was only 1 patient with a follow up of more than 2 years with a functional score of 28 points as per the MSTS Score.

The data revealed that there was significant improvement in the functional scores at each follow up visits.

Figure 1: Line Diagram showing improvement in functional score over time



Of the 17 patients included in the study, the functional outcomes were evaluated using the MSTS score. The mean score was 24.7±4.75 with mean rate of 81%. 11 patients had rate >90%, 3 patients had rate between 70 to 90% and three had between 50 to 60%. No patient had score below 50%. Since all patients answered all the questions, further description is according to the absolute score of the patients out of maximum score of 30. This made the subgroup analysis simpler when the patients were analysed with respect to age, gender, technique used, radiological grade of the tumor, and whether the tumor was primary or recurrent

Table 1: Comparative analysis of factors affecting the functional outcome.

Variable		No. of patients	MSTS Score		p value
			Mean	SD	
Age	<=30 years	10	24.5	5.21	0.92
	>30 years	7	24.71	4.23	
Gender	Male	9	24.89	4.46	0.65
	Female	8	24.25	5.23	
Grade of tumor	Grade 1	3	25.33	2.89	0.87
	Grade 2	10	24.80	5.16	(ANOVA)
	Grade 3	4	23.5	5.45	
Technique	Bone graft only	9	25.8	4.05	0.19
	Sandwich technique	8	23.12	5.19	
Primary or Recurrence	Primary	14	24.29	5.04	0.58
	Recurrence	3	26.00	2.65	

p value is for Mann Whitney 'U' test, value <0.01 was taken as significant

ANOVA: In comparing functional outcome with reference to grades of tumor, ANOVA test was used.

Age, gender, grade of tumor, technique and recurrence did not significantly affect the eventual functional outcome achieved by the patient, as evaluated by the MSTS Score (p>0.01), (Table 1).

During the study period, one patient had post-operative fever which lasted for 3 days and settled on medications. There was 1 patient with unicortical fracture in a case of lower end radius GCT which was seen in the radiograph done 6 weeks post-operatively after which the above elbow cast was removed. Cast was continued for 3 weeks more followed by wrist support and intermittent wrist range of motion (ROM) exercises. There was no infection at the surgical site and none of the patients developed deep infection. There were no cases of implant back out or implant breakage during the study period. None of the patients required any additional surgery. There was one recurrence (6%) at one year follow-up seen in a 28 year old male with lower end radius lesion. He was a case of recurrent GCT primarily treated with extended curettage and bone grafting. No other patient had recurrence till latest follow up visits.

DISCUSSION

Diagnosis of cancer severely affects the quality of life and emotional status of any individual. Assessment of functional score measures this aspect of tumor management and is a verdict by the patient about how well he has been treated. This study, along with presenting the details and reviewing the literature on GCT aims to focus on this aspect of assessment.

The demographics of the current study were similar to previous studies. [29, 34, 37] In our series, the most common site of predilection was also around the knee joint (52.9%), and most patients were in their third and fourth decade; men slightly outnumbered women. Long recognized as a benign[1,11], but potentially aggressive neoplasm [2, 3, 4, 5, 11] , GCT has historically been approached in a suitably aggressive manner. With the advent of bulk cortico-cancellous and massive osteoarticular allografts and later with the increased availability of endoprosthetic devices, en bloc resection [2, 4] often comes to replace intralesional procedures for local control of long bone GCT. Gitelis et al[33] reported no local recurrences after the treatment of 20 long bone GCT patients with en bloc resection after a mean follow-up of 92 months. Most recently, Mankin and Hornicek et al [38] reported a local recurrence rate of 6% in such cases. Nonetheless, allograft usage is associated with high rates of infection, fracture, and non-union, with approximately one third of patients suffering at least one major complication[38, 39] Similarly, massive prosthetic implants are also subject to complications such as aseptic loosening and deep infection often necessitating revision, and sometimes even amputation.[40]

Because of the relatively high rate of major complications and the adverse functional effects of en bloc resection, intralesional treatment of long bone GCT gained renewed interest after the widespread introduction of PMMA [5, 31] packing for this clinical situation in 1969, by Vidal et al[41], O'Donnell et al[21] reported a 25% local recurrence rate after the treatment of 60 GCT patients with curettage and packing with PMMA. However, acceptable rates of local control are still reported with allograft or autograft packing [20,25,26,27] or

even no packing.[35] In a recent study, Prosser et al[35] retrospectively reviewed 137 GCT patients treated primarily with curettage without adjuvant therapy over a 27-year period and reported an overall 19% local recurrence rate. In another recent study of 38 patients by Kafichitsas et al[30] in 2010, they reported a recurrence rate of 23.8% in bone cementing after curettage which was significantly lower than 52.9% recurrence rate of patients treated with cancellous bone filling or curettage alone. The benefits of decreased morbidity and improved function associated with intralesional procedures have been in general, thought to outweigh the disadvantage of a higher local recurrence and re-operation rate than was traditionally associated with en bloc procedures.[4,5,31,42]

A variety of adjuvant measures have been employed and reviewed for effectiveness.[4] These additional steps include: mechanical burring, electrocautery, and/or the application of a variety of substances like hydrogen peroxide, phenol, and liquid nitrogen.[4] Ward et al[23] reported a 6.4% rate of local recurrence after intralesional resection of GCT consisting of curettage, burring, hydrogen peroxide application, electrocautery, phenol irrigation, and reconstruction with PMMA. The adjuvants used varied in our cases depending on the grade of GCT. We used high speed burr and H2O2 as adjuvants in all our cases. But the use of alcohol and phenol was restricted to patients with grade 2 and 3 tumors i.e. those without a breach in cortex and without any soft tissue extension. There is a theoretical concern of phenol toxicity following rapid absorption through cancellous bone.[43] In all our cases, a pre-operative biopsy was performed which reported GCT in all 17 cases. Post operatively, all excised masses were sent for histopathological examination which confirmed it as GCT indicating 100% accuracy in confirming the diagnosis following a J needle biopsy. The soft tissue which could have been contaminated with tumor cells during the biopsy should be included in the excision surgery.

The early functional results were very encouraging with 11/17 having a rating of >90% (>27/30). This indicates significant improvement in quality of life, emotional status and functional ability of the patients. Three patients had lower scores while three had intermediate score. An analysis of the various subgroups helps us to understand the factors affecting the variation in functional outcome.

AGE:

The common age group for GCT has traditionally been 20-40 years.2,5 There have not been studies showing the effect of age on functional outcome. In our study, there was no significant difference in the functional outcome in relatively younger subjects (Group <= 30 years) with higher level of physical demands than those over 30 years of age. This indicates that improvement in quality of life was equally appreciated by patients of all age groups.

GENDER:

Tain-Hsiung Chen et al[44] in 2005 found that there was no statistically significant difference in the functional outcome between the male and the female groups. In our study group too, there was no statistically significant difference in the functional result achieved between the male and female groups.

GRADE OF TUMOUR:

Campanacci and co-workers[29,45] and Enneking44 have developed similar staging systems for GCTs. Campanacci's radiographic grades I, II and III correspond to Enneking's surgical stages 1, 2 and 3 which represent the latent, active and aggressive clinical presentations respectively [46] Jones et al[36] found no cellular atypia with Stage 3 tumors; however, the radiographically aggressive tumors demonstrated more aggressive features on histology. Moreover, they could not find any predictable features of recurrence or metastasis. Gitelis et al[33] found no correlation between Campanacci's grading and local recurrence. In contrast, Rock[47], in a multi-institutional study, found a weak correlation between Campanacci's and Enneking's stages and the rate of local recurrence. Also Tain-Hsiung Chen et al[44] in 2005 found no correlation between the grade of the tumor and functional outcome. T Morii et al[48] in 2008 also found no significant difference between the Campanaccis grades and the functional result. In our study too, there was no statistically significant difference in between the 3 grades of tumor with respect to functional outcomes.

PRIMARY AND RECURRENT TUMOUR:

T Morii et al48 in 2008 showed that the risk factors for poor functions were recurrence and joint instability. F. Vult Von Steyern et al21 observed that of the patients who had their local recurrence treated with curettage and cement, two had a second local recurrence which was successfully treated with a repeated curettage and cementing and they had a full range of movement, no pain and no evidence of disease at latest follow-up, 30 and 41 months after the last operation. Similar results with acceptable re-recurrence rate of 21.7 % were documented by Balke et al in 2009.44 In our series, we observed no statistically significant difference between the 2 groups as regards to functional outcome.

Technique: Localized lesion are said to be best treated with curettage with bone grafting.[52] Use of appropriate fixation method is recommended whenever bone stock is adequate.[52] We used fixation in 11 cases with 4 cases fixed with plates. This adds stability to the bone graft and permits early mobilisation. Use of sandwich technique has definite indications and has been used by several authors.[15,16] The main aim in this technique is to preserve the surviving articular cartilage by preventing damage by cement hyperthermia. We used this technique in 8 patients. There was no case of collapse of the sandwich and the results were similar to cases treated with bone grafting alone. Thus, this technique can be safely used in selected cases.

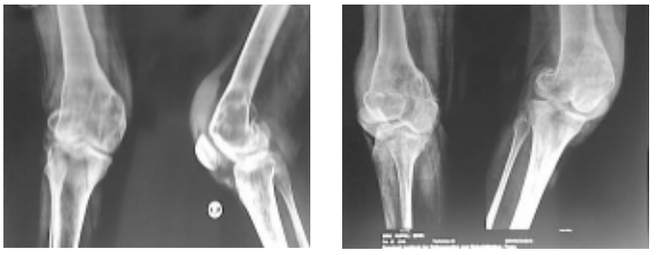
Figure legend

Figure 1: Line Diagram showing improvement in functional score over time

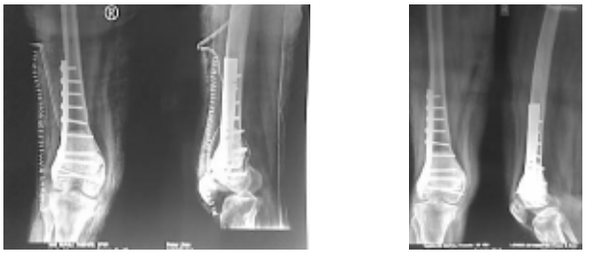
Figure 2: Case 1: Curettage and Reconstruction with sandwich technique and Fixation with Cobra plate

CASE 2: Excision and curettage and Reconstruction with bone grafting and Fixation with Two Cannulated Cancellous Screws

CASE 1: Curettage and Reconstruction with sandwich technique and Fixation with Cobra plate



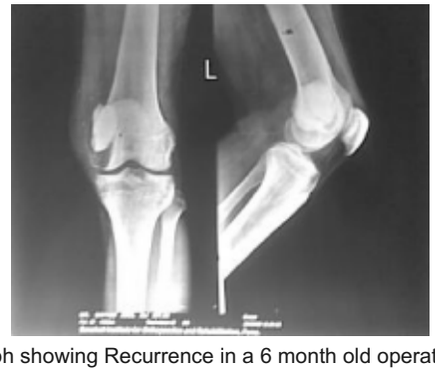
Radiographs showing GCT lower end femur with a pathological supracindylar fracture



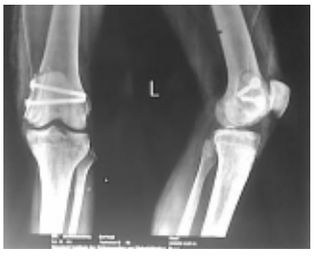
Immediate post op radiograph

At 12 months follow up

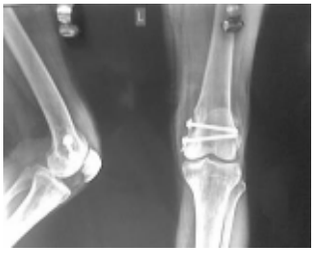
CASE 2: Excision and curettage and Reconstruction with Sandwich technique and Fixation with Two Cannulated Cancellous Screws



Radiograph showing Recurrence in a 6 month old operated case of GCT L/E Femur. Recurrence is very well visualized in this case where Bone Cement was used



Immediate post op



12 months follow up

CONCLUSION

The results of this study suggest that a definite and subjectively appreciable improvement in quality of life of the patient can be achieved by using a bone graft or sandwich technique reconstruction following aggressive curettage with the use of various adjuvants. Patients of various ages and both gender equally benefitted from surgery in terms of functional improvement. The tumor grade as per the Campanacci's grading system and surgery on primary or recurrent cases too did not affect the functional outcome. We had one case (6%) of recurrence in our series of 17 patients at an average follow-up of 14.6 months. However, a longer follow- up is required to comment if these outcomes are enduring and to assess the recurrence rates. Also a larger case series is needed to report if similar results are reproducible in majority of patients.

REFERENCES

1 Turcotte RE, Wunder JS, Isler MH, Bell RS, Schachar N, Masri BA, Moreau G, Davis AM; Canadian Sarcoma Group. Giant cell tumor of long bone: a Canadian Sarcoma Group study. Clin Orthop Relat Res. 2002 Apr; (397): 248-58.

2. Campanacci M. Giant cell tumor. In: Gaggi A (ed) Bone and soft- tissue tumors. Springer, Bologna; 1990; 117–153

3. Unni KK. Dahlin's bone tumors: general aspect and data on 11087 cases, 5th edn. Lippincott-Raven, Philadelphia. 1998

4. Blackley HR, Wunder JS, Davis AM, White LM, Kandel R, Bell RS. Treatment of giant-cell tumors of long bones with curettage and bone-grafting. J Bone Join Surg Am. 1999 Jun;81(6):811-20.

5. O'Donnell RJ, Springfield DS, Motwani HK, Ready JE, Gebhardt MC, Mankin HJ.

Recurrence of giant-cell tumors of the long bones after curettage and packing with cement. J Bone Joint Surg Am. 1994 Dec; 76(12): 1827-33.

6. Present D, Bertoni F, Hudson T, Enneking WF. The correlation between the radiologic staging studies and histopathologic findings in aggressive stage 3 giant cell tumor of bone. Cancer. 1986 Jan 15; 57(2): 237-44.

7. Ward WG Sr, Li G 3rd. Customized treatment algorithm for giant cell tumor of bone: report of a series. Clin Orthop Relat Res. 2002 Apr; (397): 259-70.

8. Lewis VO, Wei A, Mendoza T, Primus F, Peabody T, Simon MA. Argon beam coagulation as an adjuvant for local control of giant cell tumor. Clin Orthop Relat Res. 2007 Jan; 454:192-7.

9. Richardson MJ, Dickinson IC. Giant cell tumor of bone. Bull Hosp Jt Dis. 1998; 57(1): 6-10.

10. Saglik Y, Yildiz Y, Karakas A, Ogüt H, Erekul S. Giant cell tumor of bone. Bull Hosp Jt Dis. 1999; 58(2): 98-104.

11 Sung HW, Kuo DP, Shu WP, Chai YB, Liu CC, Li SM. Giant-cell tumor of bone: analysis of two hundred and eight cases in Chinese patients. J Bone Joint Surg Am. 1982 Jun; 64(5): 755-61.

12. Bini SA, Gill K, Johnston JO. Giant cell tumor of bone. Curettage and cement reconstruction. Clin Orthop Relat Res. 1995 Dec; (321): 245-50.

13. Campanacci M, Baldini N, Boriani S, Sudanese A. Giant-cell tumor of bone. J Bone Joint Surg Am. 1987 Jan; 69(1): 106-14.

14 Dreinhöfer KE, Rydholm A, Bauer HC, Kreicbergs A. Giant-cell tumours with fracture at diagnosis. Curettage and acrylic cementing in ten cases. J Bone Joint Surg Br. 1995 Mar; 77(2): 189-93.

15 Lackman RD, Hosalkar HS, Ogilvie CM, Torbert JT, Fox EJ. Intralesional curettage for grades II and III giant cell tumors of bone. Clin Orthop Relat Res. 2005 Sep; 438:123-7.

16. Wada T, Kaya M, Nagoya S, et al. Complications assocated with bone cementing for the treatment of giant cell tumors of bone. J Orthop Sci 2002; 7: 194-8.
17. von Steyern FV, Kristiansson I, Jonsson K, Mannfolk P, Heinegård D, Rydholm A. Giant-cell tumour of the knee: the condition of the cartilage after treatment by curettage and cementing. J Bone Joint Surg Br. 2007 Mar; 89(3): 361-5.
18. Capanna R, Fabbri N, Bettelli G. Curettage of giant cell tumor of bone. The effect of surgical technique and adjuvants on local recurrence rate. Chir Organi Mov. 1990; 75(1 Suppl): 206.
19. Gitelis S, Mallin BA, Piasecki P, Turner F. Intralesional excision compared with en bloc resection for giant-cell tumors of bone. J Bone Joint Surg Am. 1993 Nov; 75(11): 1648-55.
20. Goldenberg RR, Campbell CJ, Bonfiglio M. Giant-cell tumor of bone. An analysis of two hundred and eighteen cases. J Bone Joint Surg Am. 1970 Jun; 52(4): 619-64.
21. Prosser GH, Baloch KG, Tillman RM, Carter SR, Grimer RJ. Does curettage without adjuvant therapy provide low recurrence rates in giant-cell tumors of bone? Clin Orthop Relat Res. 2005 Jun; (435): 211-8.
22 Enneking WF, Dunham W, Gebhardt MC, Malawar M, Pritchard DJ. A system for the functional evaluation of reconstructive procedures after surgical treatment of tumors of the musculoskeletal system. Clin Orthop Relat Res. 1993 Jan; (286): 241-6.
23 Larsson SE, Lorentzon R, Boquist L. Giant-cell tumor of bone. A demographic, clinical, and histopathological study of all cases recorded in the Swedish Cancer Registry for the years 1958 through 1968. J Bone Joint Surg Am. 1975 Mar; 57(2): 167-73
24. Mankin HJ, Hornicek FJ. Treatment of giant cell tumors with allograft transplants: a 30-year study. Clin Orthop Relat Res. 2005 Oct; 439: 144-50.
25. Masui F, Ushigome S, Fujii K. Giant cell tumor of bone: a clinicopathologic study of prognostic factors. Pathol Int 1998; 48(9): 723–729
26. Ward WG Sr, Dory F, Kelly C, Kabo JM, Wirganowicz PZ, Eckardt JJ. Lessons from massive tumor endoprostheses: Implications for future tumor and total joint endoprostheses. Seminars in Arthroplasty 1999; 10(3): 124–132
27. Vidal J, Mimran R, Allieu Y, Jamme M, Goalard G. Plastie de Complement par Metacrylate de Methyle Traitment de Certaines Tumerus Osseuses Benignes. Montepellier Chir 1969; 15: 389–397
28. Campanacci M, Giunti A, Olmi R. Giant-cell tumors of bone. A study of 209 cases with long-term follow-up in 130. Ital J Orthop Traumat 1975; 1: 249-77
29. Enneking WF. Staging of musculoskeletal tumors. In: Enneking WF, editor. Musculoskeletal Tumor Surgery. New York: Churchill Livingstone.1983; 69-88.
30. Tain-Hsiung Chen, Yu-Ping Su, Wei-Ming Chen. Giant Cell Tumours of the knee: subchondral bone integrity affects the outcome: International Orthopaedics (SICOT) 2005; 29: 30-34
31. Morii T, Yabe H, Morioka H, Suzuki Y, Anazawa U, Toyama Y. Curettage and allograft reconstruction for giant cell tumours. J Orthop Surg (Hong Kong). 2008 Apr; 16(1): 75-9.
32. Eckardt J J, Jeffrey J, Grogan T J, Thomas J. Giant Cell Tumour of Bone : Clinical Orthopaedics Related Research ; 1986; (204): 45-58
33. Shih H N, Chen Y J, Huang T J, Ho W P, Hsueh S, Hsu RW (): Changgeng Yi Xue Za Zhi; 1996 Mar; 19(1): 16-23
34. Bassiony AA, Abdelrahman M, Abdelhady A, Assal MK. Resection arthrodesis for the management of aggressive giant cell tumor of the distal femur. Indian J Orthop. 2009 Jan; 43(1): 67-71
35. Kafchitsas K, Habermann B, Proschek D, Kurth A, Eberhardt C. Functional results after giant cell tumor operation near knee joint and the cement radiolucent zone as indicator of recurrence. Anticancer Res. 2010 Sep; 30(9): 3795-9
36. Jones KB, DeYoung BR, Morcuende JA, Buckwalter JA. Ethanol as a local adjuvant for giant cell tumor of bone. Iowa Orthop J. 2006; 26: 69-76.
37. Rastogi S, Prashanth I, Khan S, Trikha V, Mittal R. Giant cell tumor of bone: Is curettage the answer?. Indian J Orthop 2007; 41: 109-14
38. Errani C, Ruggieri P, Asenzio MA, Toscano A, Colangeli S, Rimondi E, Rossi G, Longhi A, Mercuri M. Giant cell tumor of the extremity: A review of 349 cases from a single institution. Cancer Treat Rev. 2010 Feb; 36(1): 1-7.
39. Fraquet N, Faizon G, Rosset P, Phillipeau JM, Waast D, Gouin F. Long bones giant cells tumors: treatment by curretage and cavity filling cementation. Orthop Traumatol Surg Res. 2009 Oct; 95(6): 402-6..
40. Lin N, Ye ZM, Li WX, Tao HM, Yang DS. Long-term result of fibula grafting for reconstruction of the distal radius after giant cell tumor excision. Zhonghua Wai Ke Za Zhi. 2009 Jul 15; 47(14): 1079-82.
41. Mays CJ, Steeg KV, Chowdhry S, Seligson D, Wilhelmi BJ. Wrist joint reconstruction with a vascularized fibula free flap following giant cell tumor excision in the distal radius. Eplasty. 2010 May 22; 10: e38.
42. Donati D, Wafa H, Di Bella C, Colangeli M, Colangeli S, Bertoni F. Management of pelvic giant cell tumours involving the acetabular bone. Acta Orthop Belg. 2008 Dec; 74(6): 773-8.
43. Balke M, Streitbuerger A, Budny T, Henrichs M, Gosheger G, Hardes J. Treatment and outcome of giant cell tumors of the pelvis. Acta Orthop. 2009 Oct; 80(5): 590-6.
44. Balke M, Ahrens H, Streitbuerger A, Koehler G, Winkelmann W, Gosheger G, Hardes J. Treatment options for recurrent giant cell tumors of bone. J Cancer Res Clin Oncol. 2009 Jan; 135(1): 149-58.
45. Arbeitsgemeinschaft Knochentumoren, Becker WT, Dohle J, Bernd L, Braun A, Cserhati M, Enderle A, Hovy L, Matejovsky Z, Szendroi M, Trieb K, Tunn PU. Local recurrence of giant cell tumor of bone after intralesional treatment with and without adjuvant therapy. J Bone Joint Surg Am. 2008 May; 90(5): 1060-7.
46. Beebe-Dimmer JL, Cetin K, Fryzek JP, Schuetze SM, Schwartz K. The epidemiology of malignant giant cell tumors of bone: an analysis of data from the Surveillance, Epidemiology and End Results Program (1975-2004). Rare Tumors. 2009 Dec 28; 1(2): e52.
47. Ayerza MA, Aponte-Tinao LA, Farfalli GL, Restrepo CA, Muscolo DL. Joint preservation after extensive curettage of knee giant cell tumors. Clin Orthop Relat Res. 2009 Nov;467(11):2845-51.
48. Turcotte RE. Giant cell tumor of bone. Orthop Clin North Am. 2006 Jan; 37(1): 35-51.
49. Karpik M. Giant Cell Tumor (tumor gigantocellularis, osteoclastoma) - epidemiology, diagnosis, treatment. Ortop Traumatol Rehabil. 2010 May-Jun; 12(3): 207-15
50. Zhang Z, Zhu B, Sun T. [Case analysis on treatment and recurrence of giant cell tumor of bone]. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi. 2006 Oct; 20(10): 1007-10.
51. Oda Y, Miura H, Tsuneyoshi M, Iwamoto Y. Giant cell tumor of bone: oncological and functional results of long-term follow-up. Jpn J Clin Oncol. 1998 May; 28(5): 323-8.
52. Panchwagh Y, Puri A, Agarwal M, Anchan C, Shah M. Giant cell tumor - distal end radius: Do we know the answer?. Indian J Orthop 2007; 41: 139-45
53. Salgia A, Biswas S, Agrawal R, Goyal V. Multicentric giant cell tumor around the knee. Indian J Orthop. 2007 Apr; 41(2): 151-3.
54. Puri A, Agarwal M. Treatment of giant cell tumor of bone: Current concepts. Indian J Orthop 2007; 41: 101-8

Source of Support: Nil, Conflict of Interest: none