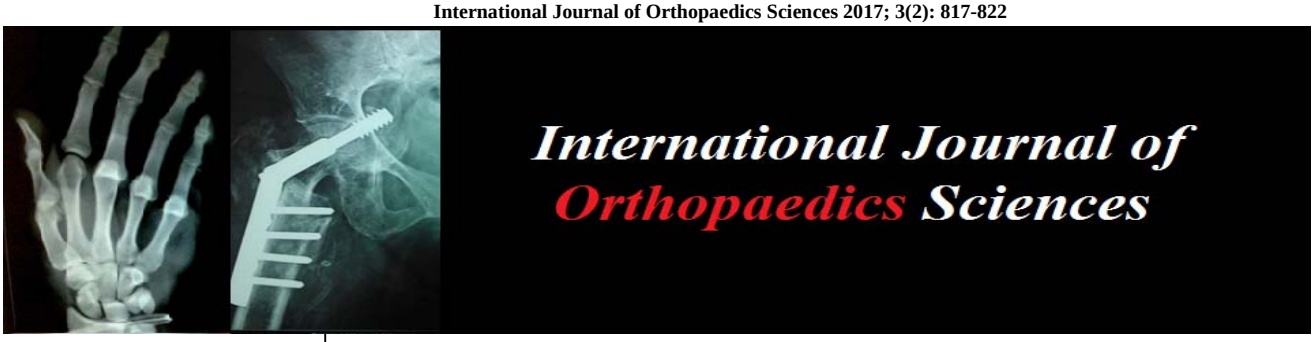

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Retrospective study of function outcome in giant cell tumor treated by sandwich technique with internal fixation

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Abstract
Purpose: To evaluate outcomes of 27 patients who underwent curettage, use of phenol, and reconstruction using the sandwich technique with internal fixation with plate or k wires for giant cell tumor (GCT) of bone around the knee and ankle.
Methods: 15 women and 12 men aged 19 to 46 (mean, 29.6) years underwent intralesional curettage, use of phenol, and reconstruction using the sandwich technique with internal fixatation with plate or k wires for GCT of the proximal tibia (n=12) or distal femur (n=13) or distal tibia (n=2). 1, 16, and 10 tumors were classified as grade I, grade II, and grade III, respectively. Four of the grade III tumors were associated with an extra-articular pathological fracture. Patients underwent intralesional curettage, use of phenol, and reconstruction with autograft (iliac crest), gel foam, and cement (the sandwich technique) with internal fixation with plates or k wires. Pathological fractures were fixed with plates. Results were based on serial radiographs showing consolidation of the lesion along with a subjective clinical examination and functional evaluation noted in the patient's records. Functional outcome was evaluated using the Musculoskel *et al* Tumor Society (MSTS) score.
Result: The mean follow-up period was 75.4 (60- 108) months. The mean MSTS score was 27.4 out of 30 (standard deviation, 3; range, 19–30). No patient had recurrence. No patient had malignant transformation.
Conclusion: Intralesional curettage, use of phenol, and reconstruction with allograft, gel foam, and cement (the sandwich technique) for GCT of bone achieved good functional outcome and a low recurrence rate.

Keywords: Curettage, giant cell tumor of bone, sandwich technique, phenol

Introduction
GCT represents approximately 5% of all primary bone tumors [1, 2, 3]. More than half of these lesions occur in the third and fourth decades of life age group 15 to 40 year and there is slight female predominance (1.5:1) [3]. GCTs are benign tumors with potential for aggressive behavior and capacity to metastasize [4].

Although rarely lethal, benign bone tumors may be associated with a substantial disturbance of the local bony architecture that can be particularly troublesome in peri-articular locations and has a relatively high recurrence rate.

Treatment by curettage alone has a high risk of recurrence (2, 3). Use of adjuvants (phenol, cement, cryosurgery, or a combination of these) is recommended, followed by reconstruction with autograft, allograft, cement, and/or hydroxyapatite. In our hospital, the treatment of GCT of bone has been intralesional curettage followed by the use of phenol and reconstruction using the sandwich technique, in which the autograft in the subchondral region is overlaid with a layer of gel foam, and the rest of the cavity is filled with cement. This study evaluated outcome of 27 patients who underwent curettage, use of phenol, and reconstruction using the sandwich technique with internal fixation with plates or k wire for GCT of bone around the knee and ankle. This study retrospectively evaluates our experience of sandwich technique with internal fixation following intralesional curettage for the treatment of giant cell tumors of the long bones of lower limbs.

Materials and methods

We performed a retrospective analysis of clinical records, radiographs and outcomes of histologically proven cases of giant cell tumor lesions of the long bones of lower limbs that had undergone sandwich technique with internal fixation between 2006 to 2016. 15 women and 12 men (f:m= 1.25:1) aged 20 to 45 (mean +SD 26.59+ 5.83) years underwent intralesional curettage, use of phenol, and reconstruction using the sandwich technique. There were GCT of the proximal tibia (n=12), distal femur (n=13), distal tibia (n=2). According to the Campanacci grading system [4] 1 tumors were classified as grade I, 16 were grade II, and 10 were grade III. 4 of the grade III tumors were associated with an extra articular pathological fracture of the femur (n=3) or tibia (n=1). Inclusion criteria were histologically proven giant cell tumor lesions around joint treated by sandwich technique with internal fixation and a minimum follow up of 5 years.

Most of the cases were Campanacci grade II or III 16 and 10 respectively. Written consent was obtained from patients before starting treatment. As a rule, pre-operative confirmation of diagnosis was performed using J-needle aspiration biopsy or open biopsy in all patients except for 5 patients who had been biopsied at another laboratory and were later referred to us for definitive management. 2 case are recurrence which are primarily treated somewhere else.

The surgical technique of sandwich technique was contemplated by entering either from the limiting cortex or the side of erosion, as appreciated on a radiograph or MRI and then gradually enlarging the entry to a wide cortical window that provides visualization of the entire tumor cavity and permits digital palpation of the inner tumor walls. In recurrent lesion 2 case old surgical scar mark was also excised. The surgical mark planning also took consideration for future surgery for recurrence.

The intraosseous tumor bulk was scooped out completely with a large curette until smooth cortical bony surface with punctate bleeding was visible, ensuring the undersurface of window. The cavity was then enlarged in all directions using a high-speed burr, with care to avoid contamination of the surrounding soft tissues. Meticulous care was taken to ensure that all the involved bone and the possible contaminated surrounding soft tissue was excised. The curetted material was re-sent for histopathological examination.

The cavity is cleaned multiple time with gauge soaked with H2O2 and later cavity was cleaned with phenol, and phenol soaked gauze was placed inside the cavity for 2 minutes. In case of pathological fracture we use hydrogen peroxide. Care was taken not to spill the phenol to the surrounding tissues. Adjuvant was keep around the margin of bony window. This possibly help in avoid contamination of surrounding soft tissue. Iliac crest is prepared for tricortical corticocancellous structural autografts. Largest fitting size of graft were placed at subchondral level and rest of graft placed under it. All major pieces were fixed with multiple k wires. A layer of gel foam was laid over the allograft, and the remaining cavity was Hand packed with cement. Internal fixation is done with help of locking plate or k wires. K wire or plate placed under IITV guidance.

Plain radiographs were taken post-operatively. Appropriate antibiotics were administered and sutures were removed after 2 weeks. Range of motion exercises of the joint above and below the lesion were started after suture removal. Non weight bearing with a pair of axillary crutches was allowed as soon as pain subsided on the third or fourth post-operative day and continued for 4 weeks and later on shifted on partial weight bearing. Depending upon fixation cane support for next 3-4 weeks. After a total period of 12-16 weeks, full weight bearing without support was allowed depending upon graft consolidation on x-ray. Patients were followed up every 4 week for 6 months and with radiographs and clinical examination and later on once in 6 month.

Results were based on a subjective clinical examination and functional outcome assessed by MSTS score. Results were categorized as excellent, good, fair, and poor. The results were graded according to the following scale: Excellent – 75% to 100%; good – 70% to 74%; moderate – 60% to 69%; fair – 50% to 59% and poor – <50%. Musculoskel *et al* Tumor Society (MSTS) score, which involves 6 parameters (pain, function, emotional acceptance, use of walking aids, walking ability, and gait). Scores for each parameter range from 0 to 5.

Results

The study group involved biopsy proven giant cell tumor. 27 patients had lesions in the weight-bearing lower extremity long bones. Approximately 92.5% of the lesions were reported around the knee. Various sites of lesions included distal femur in 13 patients, proximal tibia in 12 patients, and distal tibia in 2 patients. The largest lesion measured 10* 9* 6 cm and smallest lesion measured 5 * 4 * 3 cm on plain radiographs. Nearly all lesions showed cortical expansion.

Two patients developed a superficial infection which was managed with prolonged antibiotic therapy. One patients developed skin burn during phenol use intraoperative. Two patients develop knee stiffnes which was managed with knee mobilization exercises.

The mean follow-up period was 75.4 months. Curettage and reconstruction by the sandwich technique for GCT around the joints the mean MSTS score was 27.4 out of 30 (standard deviation, 3; range, 19–30). The results were graded as excellent (92 %) and moderate (8%). No patients had any recurrence.

Pre op immediate post op

After 60 month (plate and k wire removed at 24 months)

Case 1: Curettage and Reconstruction with sandwich technique and Fixation with proximal medial condyle plate

Pre op immediate post op

After 72 months

Case 2: Excision and curettage and Reconstruction with Sandwich technique and Fixation with k wires in distal tiba GCT

Discussion

Diagnosis of tumor 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. While managing patients with a giant cell tumor, the surgeon must decide whether to perform an intralesional or an en bloc resection, whether to use adjuvant therapy, and what material to use to fill the resultant defect in the bone.

The demographics of the current study were similar to previous studies [1, 2, 5]. In our series, the most common site of predilection was also around the knee joint (92.5%), and most patients were in their second and third decade; female slightly outnumbered men.

Intralesional curettage alone has a high recurrence rate of 60% [6]. whereas marginal/wide resection is associated with functional disability. Preservation of joint function is an advantage of intralesional curettage compared to wide resection.

In our study, intralesional curettage and reconstruction with the sandwich technique with internal fixation achieved a good functional outcome (92.3%). To ensure thorough curettage, adequate exposure through a wide cortical window is necessary, followed by breaking the bony ridges in the tumor using a high-power burr. The use of phenol decreases recurrence [7, 8]. as phenol causes protein coagulation and necrosis and damages DNA [7]. Structural auto graft is laid in the subchondral region and overlaid with a layer of gel foam, and the rest of the cavity is filled with polymethylmethacrylate (PMMA) bone cement. The heating effect of cement destroys remaining tumor cells [10]. The bone graft in the subchondral region helps maintain joint function and prevents articular degeneration [11]. Care must be taken to prevent inadvertent cortical breach or removal of the posterior fibro periosteal pseudo capsule during curettage. The posterior periosteum acts as a biological barrier, preventing the escape of bone graft or cement filled in the cavity. The risk of neurovascular injury by phenol increases if the posterior periosteum is deficient. Intact posterior periosteum is crucial for the reconstitution of the posterior cortex, especially after bone grafting [6]. The small crevices within this layer, potentially containing tumor cells, were treated with phenol. The cavity can be reconstructed with auto graft, bone cement. The advantage of auto graft is that if it is successfully incorporated, the reconstruction is permanent, and easily detecting recurrence. The benefits of bone cement include immediate weight bearing and its cytotoxic and thermal effects to minimize the risk of recurrence, but it is associated with degeneration of articular cartilage in the subchondral region of the weight bearing area [12]. Applying a layer of bone graft and gel foam not only protects the underlying articular cartilage from the thermal effect of the curing cement, but also supports the weakened subchondral area. Thus, the sandwich technique appears to be a viable alternative to wide resection.

A variety of adjuvant measures have been employed and reviewed for effectiveness. These additional steps include: mechanical burring, electro cautery, and/or the application of a variety of substances like hydrogen peroxide, phenol, and liquid nitrogen. Ward *et al* [13] 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. We used high speed burr and phenol or H2O2 as adjuvants in all our cases. But the use of phenol was restricted to patients with 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. In one patient skin burn occur during use of phenol.

In all our cases, a pre-operative biopsy was performed which reported GCT in all 27 cases. Post operatively, all excised masses were sent for histopathological examination which confirmed it as GCT indicating 100% accuracy in confirming the diagnosis. 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 a rating of 92% (>25/30). This indicates significant improvement in quality of life, emotional status and functional ability of the patients. Two patient had intermediate score, they were recurrence case operated somewhere else previously.

We used k wires or locking plate in all patients for giving the stabilization of graft and bone cement. Using an internal fixation provided better stability to graft and decreased the chance of graft collapse. In four case of proximal tibia GCT we removed the plate in one patients after 20 months or k wires in 3 patients after average 12 months due to hardware prominence and for sake of patient comfort and in one patients due to low grade infection. We use structural tricortical autograft instead of morselized bone graft because in morselized bone graft resorption rate is high, so there are high chances of articular surface collapse.

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 [1, 2, 14]. 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.

Maurice Balke *et al* [15] found the mean age was 33.3 years in his study. Banerjee, Samik *et al* [16] found average age of the patients was 26.5. Balaji saibaba *et al* [17] found aged 19 to 46 (mean, 29.6) years. S.P. Gupta *et al* [18] found the age of the patients ranged from 18−79 years with a mean age of 38.57 years. In our study age of patients ranged from 20 to 45 (mean, 26.59).

Gender

Tain-Hsiung Chen *et al* [11] 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. Maurice Balke *et al* [15] found female-to-male ratio of 1.2: 1. Balaji saibaba *et al* [17] had 22 women and 14 men (f:m=1.57:1). In our study female to male ratio is 1.25:1.

Grade of tumor

Campanacci and co-workers [14, 19] and Enneking [20] 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. Gitelis *et al* [21] found no correlation between Campanacci's grading and local recurrence. H. R. BLACKLEY *et al* [22] found in his 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. Also Tain-Hsiung Chen *et al* [11] found no correlation between the grade of the tumor and functional outcome. T Morii *et al* [23] 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. Balaji saibaba *et al* [17] 2, 18, and 16 tumors were classified as grade I, grade II, and grade III, respectively. Five of the grade III tumors were associated with an extra-articular pathological fracture and found no correlation between the grade of the tumor and functional outcome. In our study 1, 16 and 10 tumors were classified as grade I, grade II, and grade III, respectively.

Range of motion

Banerjee, Samik *et al* [16] found average range of motion of 122.9° in the knee. In our study average range of motion around knee is 114 degree and around ankle planter flexion is 27.5 degree and dorsiflexion is 20 degree.

Complication

Malveer *et al* [24] found Complications associated with cryosurgery included six (5.9%) pathologic fractures, three (2.9%) cases of partial skin necrosis, and two (1.9%) significant degenerative changes. one patient had post-operative fever which lasted for 3 days and settled on medications. Yogesh Panchwagh *et al* [25] found 1 patient with unicortical fracture in a case of lower end radius GCT which was seen in the radiograph done 6 weeks postoperatively 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 was one recurrence (6%) at one year follow-up seen in a 28 year old male with lower end radius lesion.

S.P. Gupta *et al* [18] Three patients developed a superficial infection which was managed with prolonged antibiotic therapy. Necrosis of the overlying skin in the metadiaphyseal region of the tibia was seen in one patient and treated with repeated debridement and flap cover. Another patient treated for a lesion in the proximal femur developed a fracture of the cement mass 3 weeks post-operatively due to early weight bearing. One patient who was treated for a lesion in the distal femur developed patella-femoral arthritis in the knee joint 10 months post-operatively. The patient was managed conservatively for 6 months and was later advised to undergo total knee arthroplasty. Four patients developed local recurrence during the follow-up period.

In our study one patient develop skin burn during phenol use which heal spontaneously. Two patients develop superficial infection which managed by prolong antibiotic. One patient develop valgus deformity at knee joint. Two patients develop stiff knee, they put on knee mobilization exercise, these two patients are recurrence cases which primary treated somewhere else.

MSTS Score

Keiichi Muramatsu *et al* [26] found Musculoskel *etal* Tumor Society measure were successful, with an average score of 26.6 points (range, 22-30 points). Yogesh Panchwagh *et al* [25] found average MSTS score at final follow up was 24.59. Banerjee, Samik *et al* [16] found The average MSTS score for the lower extremity was 26. Balaji saibaba *et al* [17] The mean MSTS score was 27.7 out of 30 (standard deviation, 3; range, 16–30). In our study the mean MSTS score is 27.4 out of 30.

Functional outcome or result

Malveer *et al* [24] found Overall function was good to excellent in 94 patients (92.2%), moderate in seven patients (6.9%), and poor in one patient (0.9%) with cryosurgery. S.P. Gupta *etal* (18) results were graded as excellent (72 %), good (12.82 %) fair (10.25 %) and poor (5.12 %). In our study result were graded as excellent (92%) and moderate (8%).

Conclusion

The results of our study suggest that a definite and subjectively appreciable improvement in quality of life of the patient can be achieved by using a sandwich technique reconstruction with internal fixation following aggressive curettage with the use of phenol and H_2O_2 as a adjuvants. Patients of various ages and both gender equally benefitted from surgery in terms of functional outcome.

Definitive fixation with plate or k wire along with bone cement has given us good result because it allow early mobilization, early weight bearing, better graft holding so better consolidation and possibly low recurrence rate but for

comment on recurrence we need a large follow up. We had no recurrence in our series of 27 patients at an average follow up of 75.4 months.

Intralesional curettage, use of phenol and H_2O_2, and reconstruction with autograft, gel foam, and cement (sandwich technique) and internal fixation with k wires or plates for GCT of bone achieved good functional outcome and a low recurrence rate.

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