Joint Diseases and Related Surgery

Jt Dis Relat Surg
2025;36(1):31-38

ORIGINAL ARTICLE

Clinical results of knee juxta-articular giant-cell tumors treated with bone cement filling and internal fixation after extensive curettage

Lin Ming, MD[1], Chen Jingqian, MD[2], Xia Zhongyu, MD[1], Guo Meifeng, MD[1], Guo Bingqing, MD[1], Wang Yu, MD[1], Zou Jiaxuan, MD[2]*, Xu Jianda, MD[1]*

[1]Department of Orthopaedics, Changzhou Hospital Affiliated to Nanjing University of Chinese Medicine, Changzhou, Jiangsu Province, China
[2]Nanjing University of Chinese Medicine, Nanjing, Jiangsu Province, China

Giant cell tumors (GCTs) are benign tumors which exhibit a local invasive behavior and a relatively high rate of recurrence, if treated inappropriately.[1] The reported recurrence rate of simple curettage is approximately 30 to 50%, while it is approximately 7% in patients who undergo with *en-bloc* resection.[2,3] *En-bloc* resection can reduce the recurrence rate, but extensive bone resection often sacrifices joint function.[4] Gitelis et al.[5] obtained similar results and reported that wide *en-bloc* resection could achieve a recurrence rate of 0%, but it also diminished the limb function.

Received: May 08, 2024
Accepted: August 20, 2024
Published online: December 18, 2024

Correspondence: Jianda Xu, MD. Department of Orthopaedics, Changzhou hospital affiliated to Nanjing University of Chinese Medicine. Changzhou 213003, Jiangsu Province, China.

E-mail: milidoc3@163.com

** Xu Jianda and Zou Jiaxuan are the co-corresponding authors*
\# Lin Ming and Chen Jingqian are co-first authors.

Citation: Ming L, Jingqian C, Zhongyu X, Meifeng G, Bingqing G, Yu W, et al. et al. Clinical results of knee juxta-articular giant-cell tumors treated with bone cement filling and internal fixation after extensive curettage. Jt Dis Relat Surg 2025;36(1):31-38. doi: 10.52312/jdrs.2024.1801.

©2024 All right reserved by the Turkish Joint Diseases Foundation

This is an open access article under the terms of the Creative Commons Attribution-NonCommercial License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited and is not used for commercial purposes (http://creativecommons.org/licenses/by-nc/4.0/).

ABSTRACT

Objectives: This study was to evaluate the radiological and clinical outcomes of patients with juxta-articular giant-cell tumors (GCTs) around the knee treated with bone cement filling and internal fixation after extensive curettage.

Patients and methods: A total of 15 patients (6 males, 9 females; mean age: 35.3±8.4 years; range, 24 to 53 years) with juxta-articular GCTs around the knee were retrospectively reviewed between January 2010 and June 2020. Wound healing, functional status as assessed by the Musculoskeletal Tumor Society (MSTS) scores, local recurrence, metastasis, and complications were evaluated.

Results: The mean follow-up was 41.3±9.9 (range, 24 to 69) months with an overall survival of 93.3%. The mean distance between tumor and cartilage was 6.29±3.73 mm. Five patients underwent reconstruction with cancellous allografts and the mean distance between tumor and cartilage was 2.20±1.48 mm in these patients. At the final follow-up, three patients had Kellgren-Lawrence Grade 2 tibiofemoral osteoarthritis in the operated knee. Lucent zones around the bone cement with no further progression were found in five patients. One patient experienced recurrence 17 months after surgery and was treated by *en-bloc* resection and reconstructed with a tumor endoprosthesis. The remaining 14 patients had a mean MSTS score of 26.86±2.11 (range, 23 to 30) at the final follow-up. The mean overall range of motion at the final follow-up was 109.20±14.20° (range, 85 to 130°).

Conclusion: Bone cement filling and internal fixation after extensive curettage is a viable strategy for accessing juxta-articular GCTs around the knee. The choice of local adjuvants, subchondral bone grafting, and the thickness of subchondral bone require more attention to preserve the continuity of articular cartilage.

Keywords: Bone cement filling, extensive curettage, internal fixation, Juxta-articular giant-cell tumor.

Juxta-articular GCTs around the knee are common and pose a special problem of reconstruction and joint preservation after tumor excision, which often occur predominantly in the patients aged 30 to 40 years.[6,7] The optimal goal is to achieve complete tumor removal and the maximum preservation of joint function. To date, preserved joint reconstruction of juxta-articular GCTs is still a major clinical challenge for surgeons, particularly in patients with extraosseous extension or less subarticular bone. Considering the local aggressiveness of GCTs, the preferred treatment is intralesional extensive curettage with adjunctive procedures. However, there is no consensus about the optimal adjuvants for minimum recurrence. Kivioja et al.[8] analyzed 294 patients with GCTs and suggested intralesional surgery as the first choice for GCTs, even for patients with pathological fractures. Bone cement was preferred for reducing the local recurrence rate. Fraquet et al.[9] reported that cementation could reduce the recurrence rate and provide an excellent mechanical and functional qualities. Previous published studies also have reported similar results.[10] However, there is inconsistency that bone cement is associated with a high rate of secondary osteoarthritis. Some remedies have been attempted to prevent secondary osteoarthritis. Wu et al.[11] used subchondral bone grafting combined with bone cement reconstruction for patients with giant-cell tumors around the knee, and the recurrence rate was 3.7%. However, due to the limited number of cases, there are still insufficient functional outcomes associated with this treatment.

To achieve better joint reconstruction of juxta-articular GCTs around the knee, in the present study, we aimed to evaluate the clinical functional outcomes of bone cement filling and internal fixation after extensive curettage and to assess the presence of secondary arthritis during follow-up.

PATIENTS AND METHODS

Study design and study population

This single-center, retrospective case series was conducted at Changzhou Hospital Affiliated to Nanjing University of Chinese Medicine, Department of Orthopaedics between January 2010 and June 2020. A total of 15 patients (6 males, 9 females; mean age: 35.3±8.4 years; range, 24 to 53 years) with unilateral juxta-articular GCTs around the knee were included. Inclusion criteria were as follows: having tumors located near the joint, new cases without prior management, and pathological diagnosis of GCTs. Patients who underwent total knee arthroplasty or bone resection were excluded. A written informed consent was obtained from each patient. The study protocol was approved by the Ethics Review Committee of Changzhou Traditional Chinese Medical Hospital, affiliated to Nanjing University of Traditional Chinese Medicine. (date: 10.02.2020, no: 2020-LL-012(L)). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Surgical technique

At the initial diagnosis, physical examination, plain radiographs, computed tomography (CT), and magnetic resonance imaging (MRI) were performed to assess tumor growth. Fine-needle percutaneous biopsy was performed to confirm the diagnosis of GCTs, but the biopsy track could be available for resection in future surgery.

All surgeries were performed under general anesthesia by a single experienced surgeon. The patients were placed in the supine position. The surgical approach was designed based on the lesion. After adequate exposure of the tumor, surgical gauze was placed around the tumor to prevent surrounding tissue contamination. A cortical window was opened by Coriolis needle drilling, and the intraosseous tumor tissues were removed completely by a hand-held curette. The amount of removed lesion was based on the extent seen on CT and MRI preoperatively. It is of utmost importance to preserve ligamentous structures to maintain limb function.[12] Radical curettage was performed till the healthy bone margin. A high-speed burr was used to grind the paratumorous bone to enlarge the cavity. The remnant margin was cauterized by an electrotome and, then, denatured by 5% phenol-soaked gauze. The phenol was removed by ravaging with 99% alcohol. The main goal of all these procedures was to achieve radical marginal excision. If leisure destroyed partial articular cartilage, a 0.5-cm thick allograft bone was paved under the surface of cartilage surface to the increase the endurance of the subchondral bone.[13,14] If the tumor extended into soft tissues, all the contaminated surrounding soft tissue and pseudo-capsule could be completely removed. Intraoperative images were taken to confirm a clear margin of intralesional curettage.

Polymethylmethacrylate (PMMA) cementing combined with a plate was chosen for skeletal support. The bone defect was, then, filled with PMMA cement. The plate was placed at the bone defect to provide sufficient mechanical stability before the

cement was about to be set. Next, the wound was sutured in layers after adequate hemostasis.

The rehabilitation regime was tailored based on the individual needs of each patient. If tolerable, the patients were encouraged to perform isometric muscle strength training after surgery. The range of motion (ROM) exercise varied among individuals. A non-weight-bearing stand with two crutches was permitted four weeks after the operation, and the patients gradually transitioned to partial and full weight-bearing stands.

Definitions and outcome measures

The follow-up duration was defined as the interval between the date of the operation and the date of the final visit. Postoperative follow-up included clinical and radiographic assessments at one, three, six, and 12 months and, then, annually thereafter. Chest CT was performed every six months. Physical examination and plain radiographs were needed at each visit to assess failure of cement filling[15] or internal fixation, tumor recurrence, and metastasis.

The radiographic staging system of Campanacci et al.[16] was used to classify GCTs based on their radiographic appearance.

The Musculoskeletal Tumor Society (MSTS) score[17] was employed to evaluate functional outcomes, including pain, functional limitations, walking distance, support use, emotional acceptance, and gait.

Compared to that of the contralateral knee, secondary arthritis was staged using the Kellgren-Lawrence (KL) classification.[18]

The ROM of the knee was measured in the supine position using a goniometer.[19]

The degree of pain was measured by the Visual Analog Scale (VAS). The patients were asked to mark their level of pain on a 10-cm VAS.[20]

Complications, such as infection, local recurrence, fracture and joint narrowing, were also recorded.

Statistical analysis

Statistical analysis was performed using the SPSS version 24.0 software (IBM Corp., Armonk, NY, USA). The distribution of the data was evaluated using the Kolmogorov-Smirnov test. Continuous variables were expressed in mean ± standard deviation (SD) or median and interquartile range (IQR), while categorical variables were expressed in number or frequency.

RESULTS

Table I shows baseline characteristics of the patients. The mean follow-up was 41.3±9.9 (range, 24 to 69) months with an overall survival of 93.3%. Five of 15 patients underwent reconstruction with

TABLE I
Baseline characteristics of patients

No	Age/Sex	Laterality	Campanacci radiographic system	Surgical time (min)	Complication	Follow-up time (m)	MSTS	Recurrence	Metastasis
1	26/F	R	II	90	None	35	23	None	None
2	24/M	L	I	90	None	24	28	None	None
3	38/F	R	II	80	DWH	39	27	None	None
4	30/F	L	I	80	None	40	20	Yes	None
5	41/M	R	III	110	None	69	25	None	None
6	26/F	L	II	90	None	36	27	None	None
7	30/M	R	II	85	None	34	30	None	None
8	32/F	R	I	90	Pain	42	28	None	None
9	29/M	L	II	90	None	48	28	None	None
10	37/F	R	II	90	None	40	25	None	None
11	36/M	L	I	90	None	45	29	None	None
12	38/F	R	II	100	None	50	30	None	None
13	53/F	L	II	90	DWH	36	26	None	None
14	42/F	R	II	105	None	43	25	None	None
15	49/M	R	II	100	None	38	25	None	None

MSTS: Musculoskeletal Tumor Society; L: Left; R: Right; DWH: Delayed wound healing.

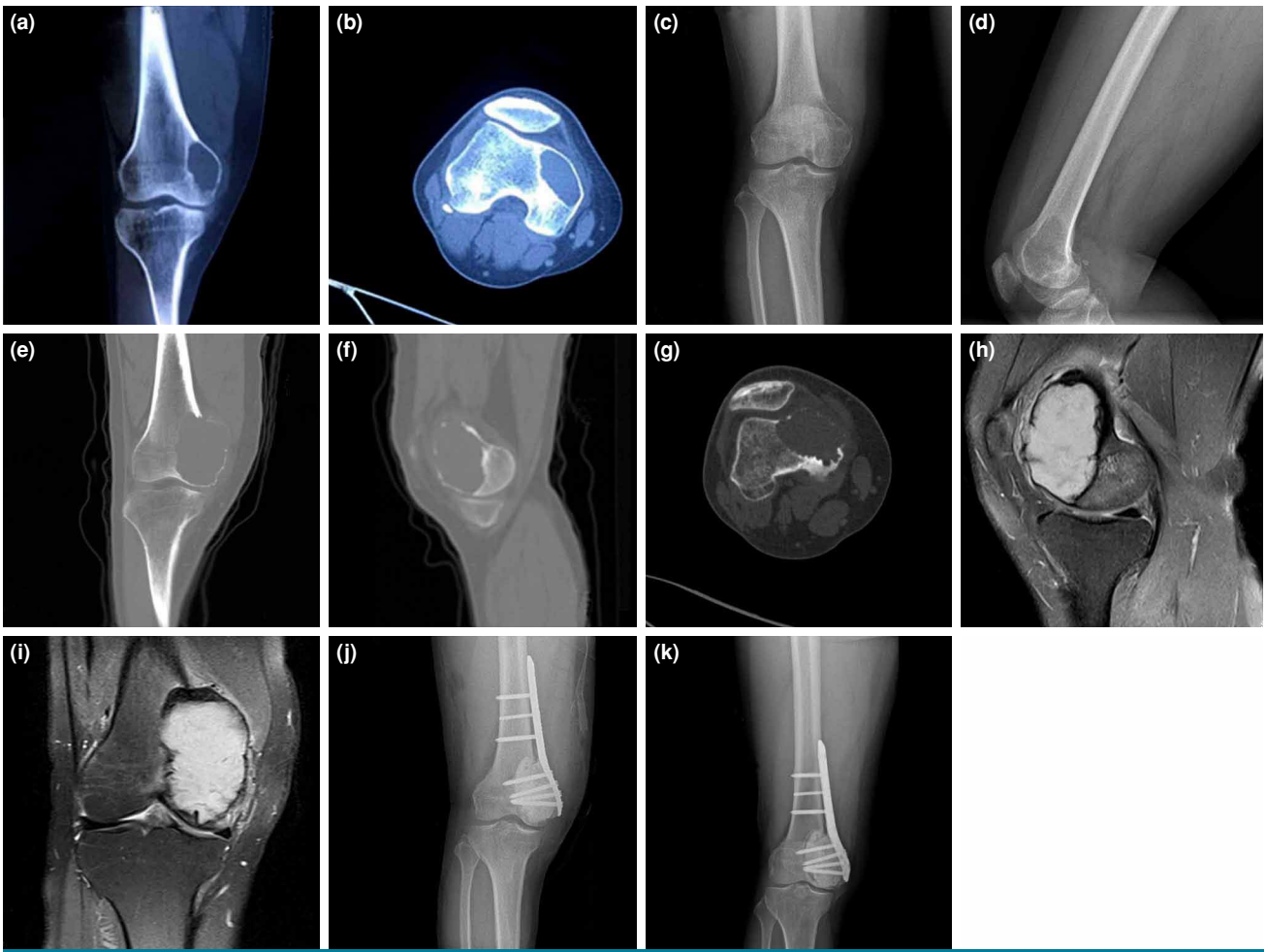


FIGURE 1. A 41-year-old man with the knee juxta-articular giant-cell tumor, complaining pain in the right knee for nine months. **(a, b)** The initial CT examination showed bone destruction lesion with sclerotic margin and misdiagnosed as bone cyst at the first visit hospital. **(c-i)** About nine months later, an expansile radiolytic lesion with non-sclerotic margin was found in medial femoral condyle in the plain film. CT and MRI confirmed the hyperintense lesion in the epimetaphyseal region of medial femoral condyle. Some lesions destroyed partial articular cartilage and bulged into soft tissue. **(j)** the postoperative plain film showed preserved joint reconstruction with bone cement filling and internal fixation. **(k)** After five years postoperatively, the plain film showed no signs of recurrence. Lucent zones around the bone cement with no further progression was found.
CT: Computed tomography; MRI: Magnetic resonance imaging.

cancellous allografts and mean distance between the tumor and cartilage was 2.20±1.48 mm.

According to the Campanacci et al.'s.[16] classification, four patients had Grade 1, 10 had Grade 2, and one had Grade 3 GCTs.

All patients resumed their daily life and jobs pain-free (Figure 1). Thirteen of 15 patients could walk without any aid at the final follow-up. One patient experienced recurrence 17 months after surgery and was treated by *en-bloc* resection and reconstructed with a knee joint tumor prosthesis. It had the lowest MSTS score (23 points). The remaining 14 patients had a mean MSTS score of approximately 27.07±1.82 (range, 25 to 30) at the final follow-up. For all patients, the mean ROM at the final follow-up was 109.20±14.20° (range, 85 to 130°). Twelve of 15 patients could extend completely and flex more than 100°, and three patients could extend completely but flex no more than 90°.

None of the patients had signs of knee OA according to preoperative X-ray, and all the contralateral knees had no signs of OA (KL-0 or KL-1) at the final follow-up. The mean distance between the tumor and cartilage was 6.29±3.73 mm. Lucent zones around the bone cement with no further

progression were found in five patients. At the final follow-up, three patients had KL Grade 2 tibiofemoral OA in the operated knee. Of them, two patients underwent reconstruction with cancellous allografts. The distance between tumor-cartilage was 0, 2, and 7, mm respectively.

No serious complications such as failure of internal fixation, deep infection, or fracture occurred in any patients. Two patients experienced delayed wound healing after dressing changes. One patient complained of pain which was relieved after oral painkillers.

DISCUSSION

The management of juxta-articular GCTs around the knee remains a major clinical challenge for surgeons to maintain native joint function with minimum recurrence. In the present study, we showed that bone cement filling and internal fixation after extensive curettage was a viable strategy for accessing juxta-articular GCTs around the knee. The continuity of articular cartilage was a key factor contributing to degenerative arthritis. Therefore, more attention needs to be given to subchondral bone grafting and the thickness of subchondral bone to restore the continuity of articular cartilage.

It is challenging to achieve complete removal of the tumor in the cavity. Local adjuvants are used to destroy microscopic tumor foci and minimize the recurrence rate. Adjuvant treatment followed by curettage could prevent morbidities associated with decreased recurrence.[21]

Many physical and chemical methods have been used to effectively remove tumor tissues and decrease local recurrence after curettage. Algawahmed et al.[22] proposed that a high-speed burr was an effective method for reducing the local recurrence rate. Intralesional curettage with high-speed burring results in a low recurrence rate of approximately 12 to 25%.[22] Electrocautery can destroy tumor cells beyond 6 mm and provides a relatively safe margin.[23] Chemical adjuvants include phenol, alcohol, hydrogen peroxide, and liquid nitrogen.[24] As a local adjuvant, phenol must be used with great care to protect soft tissues. It could improve local control by chemical burns on the surgical margin.[25] In the present study, a high-speed bur, an electrotome and phenol were combined to achieve radical marginal excision. In contrast, Blackley et al.[26] proposed that adequate removal of tumor tissues was a key step for reducing local recurrence, but was not related to adjuvant modalities. Ruggieri et al.[27] also analyzed the effects of different local adjuvants and proposed that any local adjuvant did not reduce recurrence, but increased the rate of complications.

A meta-analysis investigating the efficacy of bone cementation and allogeneic bone grafting suggested that adjuvant bone cementation was preferable with lower local recurrence.[28] The polymerizing heat during bone cement solidification can reach 80 to 90°C, and the heat penetration during the setting of the cement is approximately 3 mm in depth. The exothermic reaction of PMMA can kill local remaining tumor cells to reduce recurrence.[29,30] Bone cement can easily fill irregular defects at a relatively low cost. Bone cement filling immediately reconstructs bone defects and exhibits good mechanical strength for early weight-bearing.[31] Subchondral bone replaced by cement can alter the biomechanics, but does not influence knee function or quality of life. It helps the subchondral stiffness recover to 98% of that of the healthy limb.[32]

In our center, PMMA cementing combined with a plate was chosen for skeletal support after adjuvant treatments. All patients were followed for a mean of 41.27±9.90 months with an overall survival of 93.3%.[33] Previous studies have confirmed similar results. The combined use of the burr down technique, phenolization and polymethyl methacrylate is a safe method with a reduced local recurrence of 5.1%.[34] Satisfactory functional results can also be achieved when GCTs are treated with intralesional curettage with high-speed burr, electrocauterization and bone cement. A tumor with a large soft tissue extension usually increases the risk of local recurrence.[35] We also added other adjuvants to widen surgical margins to reduce recurrence.

Little is known about the risk factors for degenerative changes. Wada et al.[36] reported that the continuity of articular cartilage was the main factor contributing to degenerative arthritis. If the continuity of the articular cartilage is preserved, intralesional curettage with cement filling does not increase the rates of recurrence or degenerative osteoarthritis.[37] The incidence of secondary osteoarthritis is low after a median follow-up period of 131 months.[38] Therefore, more attention is needed to protect the articular cartilage during surgery. Some researchers are concerned that the high polymerization temperature may be harmful to cartilage. In the present study, no serious degenerative changes were found. This finding

indicates that concerns about secondary arthritis may be superfluous. However, concern about the increased risk of long-term degenerative changes still exists due to the weight-bearing nature of bone cement.[11]

Some authors have shown that bone cement results in further damage to subchondral bone. To prevent thermal damage to articular cartilage, subchondral bone grafting is used to reduce secondary osteoarthritis. The allograft was paved under the surface of the cartilage surface to increase the endurance of the subchondral bone and prevent heat necrosis. Suzuki et al.[39] reported that the incidence of second osteoarthritis was only 11% after the combination of PMMA and subchondral cancellous bone graft. Allogeneic bone grafting is a widely accepted method for filling lesions under the articular surface. To maintain the disrupted articular cartilage, we interposed bone chips under the cartilage to prevent harm from the cement. The interposed chips could maintain the joint shape with better functional results. The distance between the tumor and cartilage and the area taken up by the tumor were the main risk factors for developing OA. Van der Heijden et al.[40] reported the similar results and proposed that the risk of OA increased 4.2 times, if the remaining subchondral bone was less than 3 mm. Currently, there is no consensus about the relation of thickness of remaining healthy subchondral bone and arthrosis. In contrast, Caubère et al.[41] conducted a study of patients with GCTs in the knee area treated by curettage-cement packing. They concluded that the small quantity of subchondral bone remaining after curettage was correlated with the development of knee OA. However, replacing subchondral bone with cement did not affect the functional outcomes or quality of life.

Cementation offered immediate stability for earlier weight bearing with less morbidity.[42] Another study showed that bone cement also reduced the relapse rate after surgery.[8] In present study, a plate was used to provide early stability and control the micro-motion between the cement and bone. The composite fixation of bone cement and internal fixation provides sufficient stability to reduce subsequent postoperative fracture and reconstruction failure. Similarly, Yu et al.[43] suggested that oral bisphosphonates were also needed after patients treated with aggressive curettage, cement filling and internal fixation. However, there is still a lack of sufficient evidence regarding the benefits of additional oral bisphosphonates.[43]

The loss of appropriate cortical bone may increase the risk of fracture. During the preoperative plan, it is a key step to prepare materials with potential for residual defects after intralesional curettage. Bone cement combined with internal fixation exhibited better biomechanical strength than that of bone cement alone.[44] In addition, internal fixation is needed to avoid further stress-induced resorption of bone around the cement.[45] The radiolucent zone is believed to be associated with thermal injury of bone cement fillings. In present study, radiolucent zones at the bone-cement interface existed in most patients, but they were non-progressive. The progressive osteolysis of the radiolucent lines may result in gross loosening.

Nonetheless, there are several limitations to this case series. First, it has a retrospective design with a small sample size. Second, it has a relatively short follow-up and long-term follow-up is needed to definitively evaluate the prognosis including recurrence and joint degeneration. Third, we used the Campanacci system which is solely based on interpretation of complex morphologies in two-dimensional radiographs and in which identification of tumor borders precisely is difficult.[46] This may have led to a potential observer bias. Further multi-center, large-scale, long-term prospective studies are needed to evaluate the effects of different adjuvant methods.

In conclusion, bone cement filling and internal fixation after extensive curettage provide a fine joint function. However, to preserve the continuity of articular cartilage, some issues still require attention, including the choice of local adjuvants, subchondral bone grafting and the thickness of subchondral bone.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Wrote the main manuscript: L.M., C.J.; Undertook data management and statistical analysis: X.Z., G.M.; Contributed to data management and literatures review: G.B., W.Y.; Designed the study and managed overall process: X.J., Z.J. All authors have approved the final manuscript.

Conflict of Interest: The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding: The authors received no financial support for the research and/or authorship of this article.

REFERENCES

1. Montgomery C, Couch C, Emory CL, Nicholas R. Giant cell tumor of bone: Review of current literature, evaluation, and treatment options. J Knee Surg 2019;32:331-6. doi: 10.1055/s-0038-1675815.
2. Sakamoto A. Joint preserved reconstruction after curettage in giant cell tumor of bone arising in the distal radius: Case report. Int J Surg Case Rep 2015;16:181-3. doi: 10.1016/j.ijscr.2015.10.007.
3. Liu HS, Wang JW. Treatment of giant cell tumor of bone: A comparison of local curettage and wide resection. Changgeng Yi Xue Za Zhi 1998;21:37-43.
4. Turcotte RE. Giant cell tumor of bone. Orthop Clin North Am 2006;37:35-51. doi: 10.1016/j.ocl.2005.08.005.
5. 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;75:1648-55. doi: 10.2106/00004623-199311000-00009.
6. Lin F, Hu Y, Zhao L, Zhang H, Yu X, Wang Z, et al. The epidemiological and clinical features of primary giant cell tumor around the knee: A report from the multicenter retrospective study in china. J Bone Oncol 2016;5:38-42. doi: 10.1016/j.jbo.2016.02.001.
7. Natarajan MV, Prabhakar R, Mohamed SM, Shashidhar R. Management of juxta articular giant cell tumors around the knee by custom mega prosthetic arthroplasty. Indian J Orthop 2007;41:134-8. doi: 10.4103/0019-5413.32045.
8. Kivioja AH, Blomqvist C, Hietaniemi K, Trovik C, Walloe A, Bauer HC, et al. Cement is recommended in intralesional surgery of giant cell tumors: A Scandinavian Sarcoma Group study of 294 patients followed for a median time of 5 years. Acta Orthop 2008;79:86-93. doi: 10.1080/17453670710014815.
9. Fraquet N, Faizon G, Rosset P, Phillipeau J-, Waast D, Gouin F. Long bones giant cells tumors: Treatment by curretage and cavity filling cementation. Orthop Traumatol Surg Res 2009;95:402-6. doi: 10.1016/j.otsr.2009.07.004.
10. Becker WT, Dohle J, Bernd L, Braun A, Cserhati M, Enderle A, et al. Local recurrence of giant cell tumor of bone after intralesional treatment with and without adjuvant therapy. J Bone Joint Surg [Am] 2008;90:1060-7. doi: 10.2106/JBJS.D.02771.
11. Wu M, Yao S, Xie Y, Yan F, Deng Z, Lei J, et al. A novel subchondral bone-grafting procedure for the treatment of giant-cell tumor around the knee: A retrospective study of 27 cases. Medicine (Baltimore) 2018;97:e13154. doi: 10.1097/MD.0000000000013154.
12. Li JM, Yang ZP, Li ZF, Li X, Carter SR. Knee reconstruction with preservation of the meniscus in tibial giant cell tumor. Clin Orthop Relat Res 2008;466:3101-7. doi: 10.1007/s11999-008-0542-7.
13. Benevenia J, Rivero SM, Moore J, Ippolito JA, Siegerman DA, Beebe KS, et al. Supplemental bone grafting in giant cell tumor of the extremity reduces nononcologic complications. Clin Orthop Relat Res 2017;475:776-83. doi: 10.1007/s11999-016-4755-x.
14. Teng W, Lin P, Li Y, Yan X, Li H, Li B, et al. Bone combined cement grafting in giant cell tumor around the knee reduces mechanical failure. Int Orthop 2019;43:475-82. doi: 10.1007/s00264-018-3939-2.
15. 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;286:241-6.
16. Sobti A, Agrawal P, Agarwala S, Agarwal M. Giant cell tumor of bone - An overview. Arch Bone Jt Surg 2016;4:2-9.
17. Kellgren JH, Lawrence JS. Radiological assessment of osteo-arthrosis. Ann Rheum Dis 1957;16:494-502. doi: 10.1136/ard.16.4.494.
18. 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;30:3795-9.
19. Gogia PP, Braatz JH, Rose SJ, Norton BJ. Reliability and validity of goniometric measurements at the knee. Phys Ther 1987;67:192-5. doi: 10.1093/ptj/67.2.192.
20. Stubbs DF. Visual analogue scales. Br J Clin Pharmacol 1979;7:124. doi: 10.1111/j.1365-2125.1979.tb00911.x.
21. Gupta SP, Garg G. Curettage with cement augmentation of large bone defects in giant cell tumors with pathological fractures in lower-extremity long bones. J Orthop Traumatol 2016;17:239-47. doi: 10.1007/s10195-016-0397-8.
22. Algawahmed H, Turcotte R, Farrokhyar F, Ghert M. High-speed burring with and without the use of surgical adjuvants in the intralesional management of giant cell tumor of bone: A systematic review and meta-analysis. Sarcoma 2010;2010:586090. doi: 10.1155/2010/586090.
23. Aydin M, Basarir K, Armangil M, Yildiz HY, Saglik Y, Bilgili H, et al. Thermal necrosis induced by electrocauterization as a local adjuvant therapy in local aggressive bone tumors, what is the safe limit for surgical margins? An experimental study. Arch Orthop Trauma Surg 2015;135:1071-6. doi: 10.1007/s00402-015-2262-2.
24. van der Heijden L, van der Geest IC, Schreuder HW, van de Sande MA, Dijkstra PD. Liquid nitrogen or phenolization for giant cell tumor of bone?: A comparative cohort study of various standard treatments at two tertiary referral centers. J Bone Joint Surg Am 2014;96:e35. doi: 10.2106/JBJS.M.00516.
25. Gortzak Y, Kandel R, Deheshi B, Werier J, Turcotte RE, Ferguson PC, et al. The efficacy of chemical adjuvants on giant-cell tumour of bone. An in vitro study. J Bone Joint Surg [Br] 2010;92:1475-9. doi: 10.1302/0301-620x.92b10.23495.
26. 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 Joint Surg [Am] 1999;81:811-20. doi: 10.2106/00004623-199906000-00008.
27. Ruggieri P, Mavrogenis AF, Ussia G, Angelini A, Papagelopoulos PJ, Mercuri M. Recurrence after and complications associated with adjuvant treatments for sacral giant cell tumor. Clin Orthop Relat Res 2010;468:2954-61. doi: 10.1007/s11999-010-1448-8.
28. Zuo D, Zheng L, Sun W, Fu D, Hua Y, Cai Z. Contemporary adjuvant polymethyl methacrylate cementation optimally limits recurrence in primary giant cell tumor of bone patients compared to bone grafting: a systematic review and meta-analysis. World J Surg Oncol 2013; 11:156.
29. Gaston CL, Bhumbra R, Watanuki M, Abudu AT, Carter SR, Jeys LM, et al. Does the addition of cement improve the rate of local recurrence after curettage of giant cell tumours in bone? J Bone Joint Surg [Br] 2011;93:1665-9. doi: 10.1302/0301-620X.93B12.27663.
30. Nelson DA, Barker ME, Hamlin BH. Thermal effects of acrylic cementation at bone tumour sites. Int J Hyperthermia 1997;13:287-306. doi: 10.3109/02656739709023537.

31. Frassica FJ, Sim FH, Pritchard DJ, Chao EY. Subchondral replacement: A comparative analysis of reconstruction with methyl methacrylate or autogenous bone graft. Chir Organi Mov 1990;75(1 Suppl):189-90.
32. 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;89:361-5. doi: 10.1302/0301-620X.89B3.18604.
33. Atik OŞ. Writing for Joint Diseases and Related Surgery (JDRS): There is something new and interesting in this article! Jt Dis Relat Surg 2023;34:533. doi: 10.52312/jdrs.2023.57916.
34. Gillani SFUHS, Iqbal Y, Taqi M, Ahmad Blouch T, Iqbal M, Siddiq A. Recurrence rate of giant cell tumor with the treatment of scooping curettage, burr down technique, phenolization, and bone cement. Cureus 2020;12:e11953. doi: 10.7759/cureus.11953.
35. Şirin E, Akgülle AH, Topkar OM, Sofulu Ö, Baykan SE, Erol B. Mid-term results of intralesional extended curettage, cauterization, and polymethylmethacrylate cementation in the treatment of giant cell tumor of bone: A retrospective case series. Acta Orthop Traumatol Turc 2020;54:524-9. doi: 10.5152/j.aott.2020.19082.
36. Wada T, Kaya M, Nagoya S, Kawaguchi S, Isu K, Yamashita T, et al. Complications associated with bone cementing for the treatment of giant cell tumors of bone. J Orthop Sci 2002;7:194-8. doi: 10.1007/s007760200033.
37. Araki Y, Yamamoto N, Hayashi K, Takeuchi A, Miwa S, Igarashi K, et al. Secondary osteoarthritis after curettage and calcium phosphate cementing for giant-cell tumor of bone around the knee joint: Long-term follow-up. JB JS Open Access 2020;5:e19.00068. doi: 10.2106/JBJS.OA.19.00068.
38. Persson BM, Ekelund L, Lövdahl R, Gunterberg B. Favourable results of acrylic cementation for giant cell tumors. Acta Orthop Scand 1984;55:209-14. doi: 10.3109/17453678408992339.
39. Suzuki Y, Nishida Y, Yamada Y, Tsukushi S, Sugiura H, Nakashima H, et al. Re-operation results in osteoarthritic change of knee joints in patients with giant cell tumor of bone. Knee 2007;14:369-74. doi: 10.1016/j.knee.2007.05.008.
40. van der Heijden L, van de Sande MA, Heineken AC, Fiocco M, Nelissen RG, Dijkstra PD. Mid-term outcome after curettage with polymethylmethacrylate for giant cell tumor around the knee: Higher risk of radiographic osteoarthritis? J Bone Joint Surg [Am] 2013;95:e159. doi: 10.2106/JBJS.M.00066.
41. Caubère A, Harrosch S, Fioravanti M, Curvale G, Rochwerger A, Mattei JC. Does curettage-cement packing for treating giant cell tumors at the knee lead to osteoarthritis? Orthop Traumatol Surg Res 2017;103:1075-9. doi: 10.1016/j.otsr.2017.06.013.E
42. Saikia KC, Bhattacharyya TD, Bhuyan SK, Bordoloi B, Durgia B, Ahmed F. Local recurrences after curettage and cementing in long bone giant cell tumor. Indian J Orthop 2011;45:168-73. doi: 10.4103/0019-5413.77138.
43. Yu X, Xu M, Xu S, Su Q. Clinical outcomes of giant cell tumor of bone treated with bone cement filling and internal fixation, and oral bisphosphonates. Oncol Lett 2013;5:447-51. doi: 10.3892/ol.2012.1036.
44. Hu X, Lu M, Zhang Y, Wang Y, Min L, Tu C. A biomechanical comparison between cement packing combined with extra fixation and three-dimensional printed strut-type prosthetic reconstruction for giant cell tumor of bone in distal femur. J Orthop Surg Res 2022;17:151. doi: 10.1186/s13018-022-03039-y.
45. Toy PC, France J, Randall RL, Neel MD, Shorr RI, Heck RK. Reconstruction of noncontained distal femoral defects with polymethylmethacrylate and crossed-screw augmentation: A biomechanical study. J Bone Joint Surg Am 2006;88:171-8. doi: 10.2106/JBJS.D.02313.
46. Costelloe CM, Madewell JE. Radiography in the initial diagnosis of primary bone tumors. AJR Am J Roentgenol 2013;200:3-7. doi: 10.2214/AJR.12.8488.