# Functional Results after Giant Cell Tumor Operation near Knee Joint and the Cement Radiolucent Zone as Indicator of Recurrence

K. KAFCHITSAS[1], B. HABERMANN[1], D. PROSCHEK[1], A. KURTH[1] and C. EBERHARDT[2]

[1]*Center of Musculoskeletal Surgery, Department of Orthopaedic Surgery, University Medical Center Johannes Gutenberg University Mainz, 55131 Mainz, Germany;*
[2]*Klinikum Hanau GmbH Department for Orthopaedic Surgery and Traumatology, 20, 63450 Hanau, Germany*

**Abstract.** *Background: Giant cell tumor of bone near the knee joints is a dilemma for the operating surgeon. Curettage and bone grafting have a high recurrence, whereas wide resection has a reduced recurrence rate with the compromise of limb function. Materials and Methods: Thirty-eight patients with histologically proven giant cell tumor near the knee joint were treated. All patients were reviewed with regard to the operative method, recurrence rate, postoperative arthritis and functional results of the joint. In cases of cement filling, the radiolucent zone and the sclerotic rim were assessed as possible markers for recurrence. Results: 14 male and 24 female patients were included in this study (mean age 28 years, range 13-56 years). All patients underwent surgery, 21 patients were treated with a bone cement filling and additional osteosynthesis after curettage. Seventeen patients were filled with cancellous bone or curettage alone. In the group with bone cement filling after curettage, the recurrence rate was 23.8%, whereas a recurrence rate of 52.9% was detected in the group with cancellous bone filling or curettage alone. The average time to recurrence was two years (5 months to 6 years). An increase of the radiolucent zone was seen in 80% of all patients with a recurrence. Conclusion: Cement filling after extensive curettage does not increase the recurrence rate and does not induce osteoarthritis, as long as the continuity of articular cartilage is maintained. Patients with giant cell tumor of bone near the knee joint can be treated satisfactorily with intralesional resection and bone cement packing. The extension of the radiolucent zone after bone cement filling is a reliable indicator for a possible local recurrence.*

*Correspondence to:* Dr. Konstantinos Kafchitsas, Department of Orthopaedic Surgery, University Hospital Mainz, Langenbeckstrasse 1, 55131 Mainz, Germany. Tel: +49 6131170, e-mail: Kafchitsas@em.uni-frankfurt.de

*Key Words:* Giant cell tumor, knee joint, bone cement, radiolucent zone, recurrence.

Giant cell tumor (GCT) is one of the most common primary tumors of the bone. It represents approximately 10% of all primary musculoskeletal tumors. It affects slightly more women than men (3:2), typically between the age of 20 and 50 years (1, 2). Radiographically, GCTs are lytic, excentric, epiphyseal and subchondral lesions with non-sclerotic borders. GCT was classified by Enneking (3) and is described as tumor of low-grade malignancy (4).

Curettage and packing with polymethylmethacrylate (PMMA) cement has gained wide acceptance for the treatment of GCTs of bone, which are often large, juxta-articular tumors with a historically high rate of local recurrence (5, 6). PMMA alone significantly reduces the likelihood of recurrence (6). Bone cementing is the most straightforward way to reconstruct a large cavity and simultaneously restore the structural integrity (7). According to a biomechanical study by Frassica *et al*. (8), subchondral stiffness was restored to within 98% of the control contralateral limb after the defects were reconstructed using PMMA. In addition, PMMA is potentially tumorcidal, allows easy recognition of tumor recurrence, is easy to work with in filling irregular defects, and is essentially in unlimited supply, as well as being relatively inexpensive (7, 9, 10).

On the other hand, primary curettage without filling agents has also been recommended in the literature (11, 12). The primary disadvantage of acrylic cementation has been the concern over the long-term biomechanical effects of a large, stiff mantel of cement adjacent to subchondral bone and articular cartilage (13, 14). The risk of subchondral cement causing damage to cartilage and subsequent degenerative arthritis has been alluded to in the literature but remains inevident (15). Another concern about the use of PMMA is the radiolucent line at the bone–cement interface (16). It is still unclear whether the radiolucent line is progressive and leads to loosening of the cement. Radiolucent lines frequently appear at the bone–cement interface following arthroplasty. Sometimes they are progressive and quickly expand to become an obvious area of osteolysis, resulting in a gross loosening (17-19).

Table I. *Recurrence after each treatment*.

| Method | Cement filling and/or osteosynthesis (group 1) | Curettage and/or cancellous bone (group 2) |
|---|---|---|
| N | 21 | 17 |
| Recurrence | 5 | 9 |
| % | 24% | 53% |

Given the controversial recommendations provided in the literature, we summarize our experience with GCT of bone treated at our hospitals and analyze the recurrence rate after curettage with or without cement filling, the development of arthritis and the joint function. Finally, we assessed the possibility of using the radiolucent zone at the bone–cement interface as an indicator of local recurrence. The assessment of the radiolucent zone has not yet been reported in the literature.

## Materials and Methods

Thirty-eight patients with a histologically proven GCT of the bone underwent surgical intervention at our departments. Patient files from 1981 until 2004 were examined and the records of the 38 patients treated at our institution were reviewed retrospectively. Only patients operated and with a completed follow-up (operation, X-ray control, histological examination and postoperative clinical and radiological control) in our unit were included in the study. Patients either with a primary treatment elsewhere or after referral to our unit with local recurrence after treatment elsewhere were not included in the study. None of the patients had synchronous tumors at the initial presentation. No metachronous lesions were identified within two years after the first tumor. Radiographs of tumors were available for all patients and were reviewed to determine the location and characteristics of the tumors by an independent radiologist. The GCTs were graded using the grading system described by Campanacci (4, 20). None of the patients had tumor with extraosseus extension (Grade III). Local recurrence was diagnosed clinically, radiologically, and histopathologically. Clinical information and follow up data were obtained from medical records, original pathology reports, and correspondence letters. All patients had curettage of the GCT. The further intraoperative treatment procedure was divided into group 1: filling of the defect zone with bone cement and additional osteosynthesis, and group 2: filling with cancellous bone or no filling (Table I).

Patients were generally followed with routine periodic plain radiography of the affected bone to look for tumor recurrence. The radiological assessment of the defect filling with regard to arthritis and knee joint function fulfilled the following criteria: a. Maintenance of the anatomical and functional integrity of the bone; b. Defect filling should be near joints; c. Clinical follow-up for at least 1½ years following the operation.

The conventional radiographic examinations in frontal and lateral exposures (postoperative, half-year, one-year and two-year assessment) were reviewed by an independent radiologist with regard to the width of the radiolucent zone in the cement filling and the development of a sclerotic rim. The radiological method used for the assessment of the radiolucent zone and the sclerotic rim in frontal and lateral exposures is described by Hovy (21). The width of the radiolucent zone was measured at eight points around an optical centre of the cement filling defined in terms of a compass using the a.p. and lateral radiograph as shown in Figure 1.

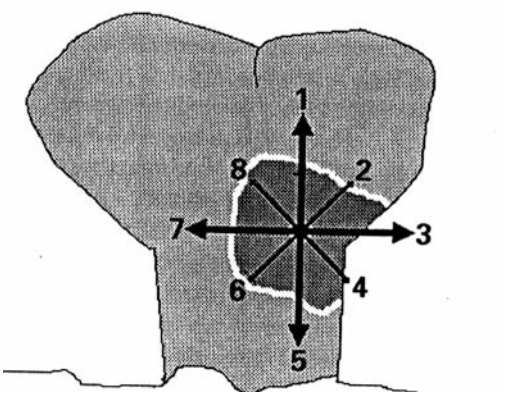


Figure 1. *Method of assessment of the radiolucent zone as described by Hovy et al. (21).*

Rank Sum analysis and proportional comparison of small samples (Fisher-Test) of independent variables was performed. For all tests, a $p$-value $<0.05$ was considered to be significant. All analyses were conducted with SPSS statistical software for Windows 14.0 (SPSS, Chicago, IL, USA) and Sigma Scan Version Software 3.90 (Jandel Scientific, Corte Madera, CA, USA). The results of this study were compared with the review data found in the literature.

## Results

The study included 24 female (63%) and 14 male patients (37%). The average patient age at the time of presentation of the first tumor was 28 years (range 13-56 years): 24 of the patients (63%) were younger than 30 years of age, 5 of the patients (13%) were in the third decade of life, 6 patients (16%) were in the fourth decade and only three patients (8%) were older than 40 years of age at the time of the initial presentation. The follow-up period was from the discovery of the initial tumor and ranged from 2 years and 2 months to 16 years (average 8.7 years).

In all cases the tumors developed around the knee with almost equal involvement of the distal part of the femur (17 out of 38) and the proximal part of the tibia (21 out of 38). None of these tumors extended across the knee joint. Group 1 included 21 patients with a bone cement filling and additional osteosynthesis after curettage. Group 2 included 17 patients of which 10 were treated with curettage and filling with cancellous bone and 7 were treated with curettage alone (Table II). 16 patients from group 1 and only 3 patients from group 2 (Table II) had fully documented clinical examination results as far as joint function for the follow-up period is concerned.

Table II. *Tumor localization, development of arthritis after treatment and functional results of the joint.*

| Tumor localization | n | Cement filling | Cancellous bone filling | Arthritis | | ROM | |
|---|---|---|---|---|---|---|---|
| | | | | Yes | No | Decreased | Normal |
| Subchondral | 3 | 3 | | | 3 | | 3 |
| Epimetaphyseal | 5 | 5 | | | 5 | | 5 |
| Pathology fracture | 7 | 6 | 1 | 6 | 1 | 3 | 4 |
| Subchondral & Pathology fracture | 3 | 2 | 1 | 3 | | 1 | 2 |
| Soft tissue penetration | 1 | | 1 | | 1 | | 1 |

Table III. *Radiolucent zone and sclerotic rim after 6, 12 and 24 months.*

| | | Radiolucent zone/sclerotic rim | | | |
|---|---|---|---|---|---|
| | Localisation | 0 months | 6 months | 12 months | 24 months |
| Cement filling (CF) | Prox. tibia | 0/0 | 0.2/0.4 | 0.8/0.2 | (R) |
| | Prox. tibia | 0/0 | 0.1/0.2 | 0.1/0.2 | 0.1/0.2 |
| | Dist. femur | 0/0 | 1.2/0.4 | 1.8/0.2 | (R) |
| | Prox. tibia | 0/0 | 0.6/0.8 | 0.6/0.8 | 0.6/0.8 |
| CF and osteosynthesis | Prox. tibia | 0/0 | 1.1/0.6 | 1.1/0.6 | 1.5/0.2 (R) |
| | Dist. femur | 0/0 | 0.2/0.6 | 0.2/0.6 | 0.2/0.6 |
| | Dist. femur | 0/0 | 0.5/0.5 | 0.5/0.5 | 0.5/0.5 |
| | Dist. femur | 0/0 | 0.4/0.5 | 0.4/0.5 | 0.4/0.5 |
| | Prox. tibia | 0/0 | 0.3/0.6 | 0.3/0.6 | 0.3/0.6 |
| | Dist. femur | 0/0 | 0.6/0.8 | 0.6/0.8 | 0.6/0.8 |
| | Prox. tibia | 0/0 | 0.8/0.7 | 0.8/0.7 | 0.8/0.7 |
| | Prox. tibia | 0/0 | 1.3/0.6 | 1.3/0.6 | 1.3/0.6 |
| | Dist. femur | 0/0 | 1.0/0.5 | 1.0/0.5 | 1.0/0.5 |
| | Dist. femur | 0/0 | 1.4/0.6 | 1.4/0.6 | 1.4/0.6 |
| | Dist. femur | 0/0 | 1.2/0.7 | 2.0/0.5 | (R) |
| | Dist. femur | 0/0 | 1.1/0.3 | 1.1/0.3 | 1.1/0.3(R) |
| | Prox. tibia | 0/0 | 0.2/0.2 | 0.3/0.3 | 0.3/0.3 |
| | Prox. tibia | 0/0 | 1.3/0.4 | 1.4/0.3 | 1.4/0.3 |
| | Prox. tibia | 0/0 | 0.9/0.5 | 1.0/0.5 | 1.0/0.5 |
| | Prox. tibia | 0/0 | 0.4/0.5 | 0.5/0.6 | 0.5/0.6 |
| | Prox. tibia | 0/0 | 0.4/0.6 | 0.6/0.7 | 0.6/0.7 |

R, Recurrence observed after change of the width of the radiolucent zone.

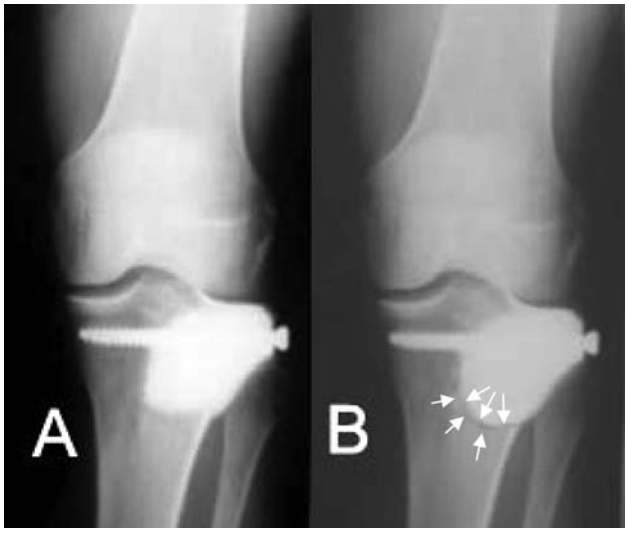


Figure 2. *Recurrence (B) 12 months after curettage, cancellous bone and osteosynthesis (A). The increase of radiolucent zone (arrows) has to be taken into consideration (recurrence).*

Four out of the 14 male patients (28.5%) and 10 out of the 24 female patients (41.5%) showed a local recurrence (Table I). The recurrence rate in all patients was 36.8%. The average time to recurrence was two years (range 5 months to 6 years). Six of the patients had a recurrence in less than two years. In 59% of the patients with a localization of the GCT in the distal femur, a recurrence was seen, whereas the recurrence rate in patients with a localization of the GCT in the proximal tibia was 19%.

In group 1 (bone cement filling and osteosynthesis), the recurrence rate was 24% (5 out of 21 patients, Table I). Further treatment of the recurrence included another curettage and bone cement filling (3 patients), a wide resection (1 patient) and amputation after soft tissue recurrence (1 patient). In group 2 (cancellous bone filling or curettage alone), the recurrence rate was 52.9% (9 out of 17 patients, Table I). Further treatment in this group included curettage and bone cement filling (8 patients) and a wide resection in 1 patient. The difference in recurrence rate was not statistically significant ($p>0.05$).

The joint function was examined in all patients and included the possibility of arthritis after treatment and the range of motion (ROM). The results are presented in Table II. In 19 out of 38 patients the complete clinical examination results have been documented whereas conventional radiography was documented in all patients. The follow-up period for these patients ranged from 3 years and 3 months to 13 years and 3 months (mean 4.5 years). Depending on the criteria published by Enneking (3), 78.9% of the patients showed good or excellent functional results.

The development of a radiolucent zone and a sclerotic rim was detected in 80% of the patients with a local recurrence (4 out of 5 patients with a local recurrence in group 1). The results are presented in Table III. In the follow-up, after 6 months no radiolucent zone surrounding the cement filling was observed in any of the patients (Table III). One year after treatment, an increase of the radiolucent zone (Figure 2) and a reduction of the sclerotic rim was observed in three cases (14.3%). In one patient, an increase was detected after 2 years.

## Discussion

In this study, we have compared the treatment methods of GCT of the bone, and questioned the possibility of using the radiolucent zone of the cement as an indicator for the development of local recurrence. An isolated correlation between the surgical margins and the rate of recurrence might influence one to prefer wide resection (recurrence rate of 0%) over intralesional curettage (recurrence rate of between 8 and 40% in several studies). However, wide resection at the typical metaphyseal-epiphyseal location would have led to deficits in function and would have required more complicated and difficult reconstruction because of joint involvement (22, 23).

A significant correlation between tumor staging and recurrence rate could not be verified in our study. While Campanacci *et al*. (4, 20) and McDonald *et al*. (24) also found no a correlation either, Rock (25) showed a recurrence rate of 10%, 28% and 40% respectively for stage 1, stage 2 and stage 3 tumors. According to Hoch *et al*. (26) the risk of recurrence depends on the type of surgery that is performed. The majority of patients with GCTs of bone can be treated satisfactorily with intralesional resection techniques. Cement packing after extensive curettage decreases the recurrence rate and does not induce osteoarthritis as long as the continuity of articular cartilage is maintained. Additionaly, the function of the neighbour joint is fully maintained without significant loss of range of motion. Wide resection should be reserved for patients with local bone loss that is too extensive for intralesional procedures and for patients with GCTs in those bones where the functional deficit after complete excision of the involved portion of the bone is anticipated to be minimal.

The curettage of GCT with or without application of bone cement apparently decreases the local recurrence rate in comparison to cancellous bone filling. It has been suggested that free radicals and the thermal effects of polymerization reaction may affect tumor cells left in the curetted cavity. Khan *et al*. showed (27) that curettage alone for GCTs of the distal radius is an adequate treatment for the majority of patients with such tumors (local recurrence rate of 17%). By contrast, Blackley *et al*. (28) reported that the risk of local recurrence after curettage with a high speed burr and reconstruction with autogenous bone graft was similar to that observed after the use of cement and other adjuvant treatments. This study also suggests that additionally to the cement packing the adequacy of the removal of the tumor is an important factor that determines the risk of recurrence. We believe that low local recurrence of GCT is related not only to tumorcidal effects of the cement but also to the use of a large cortical window for meticulous and aggressive debridement.

Bini *et al*. (29) reported that 11% of patients experienced degenerative arthritis after subchondral cementing. However, the factors that attributed to the degenerative changes remain unproven. In the present study, 87.5% of the patients treated with cement packing after curettage showed very good functional results with normal range of motion of the treated joint, which reflects the results presented by Fraquet *et al*. (14). These results suggest that subchondral cement does not cause degenerative arthritis if the continuity of articular cartilage is maintained under surgery and that subchondral cementation in the presence of disrupted articular cartilage may have a greater risk of osteoarthritis. For GCTs with intra-articular fracture, the two-stage operation advocated by Alkalay *et al*. (30) may be indicated. The first stage includes curettage, open reduction, autologous bone grafting and temporary bone cement filling. Following bone union, the second operation includes recurettage, cryosurgery and cementing with stable internal fixation.

Another concern for the use of PMMA is a radiolucent zone at the bone–cement interface. In the present study, the radiolucent zone increased in width up to 1.4 mm during the first six months and was surrounded by a sclerotic rim. Such zones were not progressive and did not affect fixation. Wada *et al*. (31) showed a positive correlation between the maximum width of the zone and the volume of cement fillings. These observations are in accordance with those of Mjoberg *et al*. (16) and Radev *et al*. (7) and suggest that the radiolucent zone surrounding the bone cement is caused by thermal injury. A large volume of cement filling produces a wide radiolucent zone, which might allow micromotion between bone and cement. After cement filling, a growing of the width of the radiolucent zone is an indicator of possible recurrence of the tumor. An increasing radiolucent zone indicates the recurrence and a reoperation is mandatory.

## Conclusion

Patients with GCT of the bone near the knee joint can be treated satisfactorily with intralesional resection and bone cement packing. Cement filling after extensive curettage does not increase the recurrence rate and does not induce osteoarthritis, as long as the continuity of articular cartilage is maintained. We suggest that the procedure of choice is curettage with cement packing and X-ray follow-up every 3 months. The assessment of the radiolucent zone in the case of cement filling could be used additionally as an indicator of local recurrence.

## References


1 Carrasco C and Murray J: Giant cell tumors. Orthop Clin North Am *20*: 395-405, 1989.
2 Dahlin DC: Bone Tumors. General Aspect and Data on 6221 Cases, 3rd edition. Springfield, Illinois, Charles C. Thomas, p. 76, 1978.
3 Enneking W: Surgical Staging of Musculoskeletal Neoplasms. Current Concepts of Diagnosis and Treatment of Soft Tissue Tumors. Springer Verlag, Berlin-Heidelberg, 1984.
4 Campanacci M: Giant-cell tumor and chondrosarcomas: grading, treatment and results (studies of 209 and 131 cases). Recent Results Cancer Res *54*: 257-261, 1976.
5 Kivioja AH, Blomqvist C, Hietaniemi K, Trovik C, Walloe A, Bauer HC, Jorgensen PH, Bergh P and Follerås G: 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 *79(1)*: 86-93, 2008.
6 Balke M, Schremper L, Gebert C, Ahrens H, Streitbuerger A, Koehler G, Hardes J and Gosheger G: Giant cell tumor of bone: treatment and outcome of 214 cases. J Cancer Res Clin Oncol *134*: 969-978, 2008
7 Radev BR, Kase JA, Askew MJ and Weiner SD: Potential for thermal damage to articular cartilage by PMMA reconstruction of a bone cavity following tumor excision: A finite element study. J Biomech *42*: 1120-1126, 2009.
8 Frassica F, Sim F, Pritchard D and Chao E: Subchondral replacement: a comparative analysis of reconstruction with methyl methacrylate or autogenous bone graft. Chir Organi Mov *75*: 189-190, 1990.
9 Errani C, Ruggieri P, Asenzio MA, Toscano A, Colangeli S, Rimondi E, Rossi G, Longhi A and Mercuri M: Giant cell tumor of the extremity: A review of 349 cases from a single institution. Cancer Treat Rev *36*: 1-7, 2010.
10 O'Donnell R, Springfield D, Motwani H, Ready J, Gebhardt M and Mankin H: Recurrence of giant-cell tumors of the long bones after curettage and packing with cement. J Bone Joint Surg Am *76*: 1827-1833, 1994.
11 Remedios D, Saifuddin A and Pringle J: Radiological and clinical recurrence of giant-cell tumour of bone after the use of cement. J Bone Joint Surg Br *79*: 26-30, 1997.
12 Datta NK, Ahamed SU, Miah MM and Nessa A: Application of mixed bone graft (autograft+allograft) in the management of giant cell tumor of bone. Mymensingh Med J *19*: 225-231, 2010.
13 Prosser GH, Baloch KG, Tillman RM, Carter SR and Grimer RJ: Does curettage without adjuvant therapy provide low Recurrence rates in giant-cell tumors of bone? Clin Orthop Relat Res *435*: 211-218, 2005
14 Fraquet N, Faizon G, Rosset P, Phillipeau JM, Waast D and Gouin F: Long bones giant cells tumors: treatment by curretage and cavity filling cementation. Orthop Traumatol Surg Res *95*: 402-406, 2009.
15 Szalay K, Antal I, Kiss J and Szendroi M: Comparison of the degenerative changes in weight-bearing joints following cementing or grafting techniques in giant cell tumour patients: medium-term results. Int Orthop *30(6)*: 505-509, 2006.
16 Mjoberg B, Pettersson H, Rosenqvist R and Rydholm A: Bone cement, thermal injury and the radiolucent zone. Acta Orthop Scand *55*: 597-600, 1984.
17 Jones L and Hungerford D: Cement disease. Clin Orthop Relat Res *225*: 192-206, 1987.
18 McGrath P: Giant-cell tumour of bone: an analysis of fifty-two cases. J Bone Joint Surg Br *54*: 216-229, 1972.
19 Smith S, Naima V and Freeman M: The natural history of tibial radiolucent lines in a proximally cemented stemmed total knee arthroplasty. J Arthroplasty *14*: 3-8, 1999.
20 Campanacci M, Baldini N, Boriani S and Sudanese A: Giant-cell tumor of bone. J Bone Joint Surg Am *69*: 106-114, 1987.
21 Hovy L: Experimentelle Untersuchungen zur lokalen Knochentumor-Therapie. Habilitationsschrift für das Fach Orthopädie. J-W Goethe Universität Frankfurt a.M., 1993.
22 Mnaymneh W and Ghandur-Mnaymneh L: Giant-cell tumor of bone. Prog Clin Cancer *3*: 245-280, 1967.
23 Nelaton E : D´une Nouvelle Espece de Tumerous Benignes des Os, ou Tumerous a Myeloplaxes. Adrien Delahaye, 1960.
24 McDonald D, Sim F, McLeod R and Dahlin D: Giant-cell tumor of bone. J Bone Joint Surg Am *68*: 235-242, 1986.
25 Rock M: Curettage of giant cell tumor of bone. Factors influencing local recurrences and metastasis. Chir Organi Mov *75*: 204-205, 1990.
26 Hoch B, Inwards C, Sundaram M and Rosenberg AE: Multicentric giant cell tumor of bone. Clinicopathologic analysis of thirty cases. J Bone Joint Surg Am *88(9)*: 1998-2008, 2006.
27 Khan M, Gray J, Carter S, Grimer R and Tillman R: Management of the giant-cell tumours of the distal radius. Ann R Coll Surg Engl *86*: 18-24, 2004.
28 Blackley H, Wunder J, Davis A, White L, Kandel R and Bell R: Treatment of giant-cell tumors of long bones with curettage and bone-grafting. J Bone Joint Surg Am *81*: 811-820, 1999.
29 Bini S, Gill K and Johnston J: Giant cell tumor of bone. Curettage and cement reconstruction. Clin Orthop Relat Res *321*: 245-250, 1995.
30 Alkalay D, Kollender Y, Mozes M and Meller I: Giant cell tumors with intraarticular fracture. Two-stage local excision, cryosurgery and cementation in 5 patients with distal femoral tumor followed for 2-4 years. Acta Orthop Scand *67*: 291-294, 1996.
31 Wada T, Kaya M, Nagoya S, Kawaguchi S, Isu K, Yamashita T, Yamawaki S and Ishii S: Complications associated with bone cementing for the treatment of giant cell tumors of bone. J Orthop Sci *7*: 194-198, 2002.


*Received March 1, 2010*
*Revised June 16, 2010*
*Accepted June 28, 2010*