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Is Prophylactic Fixation Necessary After Extended Curettage and Cementation of Lower Extremity Cartilage Tumors? A Retrospective Analysis of Fracture Risk and Functional Outcomes

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ABSTRACT

Objective: Extended intralesional curettage followed by cementation is widely accepted for the treatment of low-grade cartilaginous tumors of the long bones. However, the necessity of prophylactic internal fixation to prevent post-operative fractures remains controversial. The aim of this study is to assess fracture risk and functional outcomes in patients undergoing extended curettage and cementation for lower extremity cartilaginous tumors without prophylactic fixation.

Materials and Methods: This retrospective study included 98 patients with lower extremity cartilaginous tumors treated with extended curettage and polymethylmethacrylate cementation without prophylactic fixation between 1996 and 2024. Fracture incidence, oncological outcomes, and functional results assessed by Musculoskeletal Tumor Society, Harris Hip Score, Knee Society Score, and American Orthopaedic Foot and Ankle Society Score were analyzed over a mean follow-up of 56 months.

Results: Post-operative fractures occurred in five patients (5%), four of which were incomplete and managed successfully with conservative treatment or limited fixation. All fractures achieved union without long-term functional compromise. No local recurrence, metastasis, or infection was observed. At final follow-up, all patients were classified as having no evidence of disease. Functional outcomes were excellent, with mean scores exceeding 90% across all scoring systems.

Conclusion: Extended curettage and cementation without prophylactic fixation provides oncologically safe treatment, acceptable fracture risk, and excellent functional outcomes for selected lower extremity cartilaginous tumors. Avoiding routine fixation eliminates implant-related complications and imaging artifacts while preserving mechanical stability when meticulous surgical technique and controlled post-operative rehabilitation are applied.

Keywords: Bone cements, cartilage neoplasms, curettage

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INTRODUCTION

Cartilaginous tumors constitute a distinct subgroup of bone lesions in orthopedic oncology, characterized by unique diagnostic challenges and tailored therapeutic strategies. Extended intralesional procedures such as curettage followed by cementation are widely employed to achieve local tumor control while preserving joint integrity and maximizing post-operative function. Despite their efficacy in local tumor control, these procedures inherently create a structural defect in the bone, which may predispose patients to post-operative complications, particularly increasing the fracture risk.[1]

Although previous studies have demonstrated the oncological safety of extended curettage and cementation for these lesions, evidence regarding mechanical stability and functional outcomes in the absence of prophylactic fixation remains limited. Factors such as lesion size and anatomical location play a critical role in determining the risk of local recurrence and may also influence biomechanical integrity; therefore, fracture risk should be considered as a distinct endpoint.[2] Moreover, even relatively small lesions have the potential to compromise structural stability, depending on their position within the bone.[3]

The primary objective of this study is to assess fracture risk and functional outcomes in patients undergoing extended curettage and cementation for lower extremity cartilaginous tumors without prophylactic fixation, providing evidence to inform surgical decision-making and optimize patient management.

MATERIALS AND METHODS

Patient Cohort

A retrospective institutional database review was conducted to identify patients managed for lower extremity cartilaginous tumors at our tertiary musculoskeletal oncology center between 1996 and 2024. Inclusion was restricted to individuals who underwent extended intralesional curettage and cementation without concomitant prophylactic internal fixation. To maintain cohort homogeneity, exclusion criteria comprised a follow-up duration of <24 months, the utilization of local adjuvants other than polymethylmethacrylate (PMMA), and the presence of multicentric lesions.

The study was conducted in accordance with institutional guidelines, and written informed consent for the use of clinical data for research purposes was obtained from all participants at hospital admission. This study was conducted in full compliance with the principles of the Declaration of Helsinki. The research protocol was approved by the Institutional Ethics Committee of Acibadem Mehmet Ali Aydinlar University (date/number: January 08, 2026/2026–01/11).

Surgical Technique and Post-operative Care

Surgical planning was tailored individually for each patient based on their clinical presentation and comprehensive pre-operative imaging, with particular attention to features indicative of malignancy. All cases were reviewed and discussed in a multidisciplinary tumor board to establish an evidence-based operative strategy. All patients underwent intralesional extended curettage and cementation without plate augmentation. All tissue specimens were examined and verified by an experienced musculoskeletal pathologist to ensure diagnostic accuracy. All surgical procedures were performed by the senior author (Prof. Özger), providing uniformity in operative technique and intraoperative decision-making. No patient received neoadjuvant or adjuvant chemotherapy or radiotherapy.

All surgical procedures were performed under general anesthesia. The tumor was precisely localized preoperatively using high-resolution imaging studies, including magnetic resonance ımaging (MRI), to delineate its full extent. Based on these findings, a patient-specific incision was planned and executed to provide optimal exposure while minimizing soft-tissue disruption or contamination. A targeted corticotomy was then performed using a high-speed micromotor system (e.g., Midas Rex Legend Triton, Medtronic, Dublin, Ireland), ensuring preservation of surrounding bone and soft-tissue structures. Extended curettage was carried out meticulously, addressing both the intramedullary space and the inner surface of the excised cortical window with a high-speed burr to remove microscopic residual tumor tissue. Intraoperative fluoroscopy was employed to confirm the adequacy of tumor removal and to guide the subsequent steps. Once complete, the cavity was filled with high-viscosity PMMA cement (Versabond®, Smith and Nephew, UK) as a local adjuvant. In our surgical practice, we extend cementation beyond the tumor cavity into the intramedullary space, thereby increasing the cement-filled volume, improving load distribution and the overall mechanical stability of the bone.

The cortical window was repositioned carefully to restore anatomical continuity and facilitate osteointegration, without the use of additional fixation. Hemostasis was ensured, and meticulous soft-tissue closure was performed to optimize post-operative healing.

Although PMMA cement generally provides mechanical stability, rotational movements were strictly avoided until cortical window integration and sufficient radiological healing were achieved, in order to prevent torsional stresses on the bone. Post-operative care followed a structured rehabilitation program patients began with bedside sitting, then assisted ambulation with walkers or crutches. Weight bearing advanced

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from toe-touch to partial, and finally full load after radiological evidence of bone healing.

Follow-up and Outcome Assessment

Patients were monitored according to a structured follow-up protocol, which included monthly imaging for the first 3 months for cortical window integration, every 3 months for the subsequent 2 years, every 6 months for the following 3 years, and annual evaluations up to 10 years postoperatively. Functional outcomes were systematically assessed using the Musculoskeletal Tumor Society (MSTS) scoring system.[4] In addition, the Harris Hip Score (HHS),[5] Knee Society Score (KSS),[6] and the American Orthopaedic Foot and Ankle Society Score (AOFAS)[7] were applied to assess hip, knee, and ankle functions, respectively. Oncological outcomes were classified in accordance with the International Society of Limb Salvage (ISOLS) criteria.[8]

The primary endpoint of the study was to evaluate the occurrence of post-operative fractures prior to complete osseous consolidation, confirmed through both clinical evaluation and radiographic assessment. Hence, the incidence of post-operative fractures and their respective management strategies were meticulously documented throughout the follow-up period.

Statistical Analysis

Data were analyzed using the Statistical Package for the Social Sciences software (version 25.0, IBM Corp., Armonk, NY, USA). Descriptive statistics were reported as means with ranges for continuous variables and as frequencies with percentages for categorical variables. Patients who developed post-operative fractures were compared with those without fractures in terms of tumor volume using the Mann–Whitney U test, while the association between fracture occurrence and tumor location was analyzed using the Chi-square test. $P<0.05$ was considered as statistically significant.

RESULTS

The study cohort included 98 patients (76 females and 22 males) with a mean age of 42 years (range, 13–73) at the time of surgery. Histopathological diagnoses consisted of atypical cartilaginous tumors (52%; n=51), low-grade chondrosarcomas (36%; n=35), and enchondromas (12%; n=12). The mean tumor volume was 30 cm^3 (range, 6–68). Regarding anatomical distribution, lesions were predominantly located in the distal femur (n=43), followed by the proximal femur (n=22), femoral diaphysis (n=20), proximal tibia (n=11), and tibial diaphysis (n=2). The mean post-operative follow-up was 56 months (range, 26–240). Post-operative fractures were observed in five patients. In a patient with a femoral head lesion treated with extended curettage and cementation, an incomplete fracture developed at post-operative week 7 due to rotational stress, despite prescribed activity restrictions, and was subsequently stabilized with cannulated screw fixation. Two additional patients with distal femoral metaphyseal lesions, along with one patient with a femoral diaphyseal lesion, sustained incomplete fractures through the cortical window following minor rotational trauma in the third post-operative month. Conservative management with restricted weight-bearing ultimately resulted in successful bone healing (Fig. 1). In another patient with an enchondroma in the distal femoral diaphyseal-metaphyseal region, a displaced femoral fracture occurred 1 month postoperatively after a low-energy fall and was treated with plate-and-screw osteosynthesis (Fig. 2). Radiographic bone union was achieved in all cases, with no subsequent complications.

Throughout follow-up, no cases of local recurrence or distant metastasis were identified. According to the ISOLS criteria, all patients were classified as no evidence of disease at their final evaluation. In addition, no superficial or deep infections, nor wound-related complications, were encountered. The functional outcomes are summarized in Table 1.

Comparative analysis revealed no statistically significant differences in tumor volume between patients with and without post-operative fractures (p>0.05). In addition, fracture occurrence was not significantly associated with tumor location within the lower extremity (p>0.05).

DISCUSSION

Our findings demonstrate that extended intralesional curettage followed by cementation, even without prophylactic internal fixation, provides excellent functional outcomes and acceptable fracture risk in lower extremity cartilaginous tumors. The absence of plate augmentation did not compromise mechanical stability or patient-reported function, aligning with the fracture incidence and oncologic safety rates previously reported in the literature.[9-13] In our series, only five post-operative fractures were observed (5%), a frequency comparable to those in studies that included

Table 1. Functional outcomes of the patients (n=98)

Outcome measure	Mean	Range
MSTS (%)	93	(83–96)
HHS	95	(93–98)
KSS	93	(90–98)
AOFAS	96	(94–100)

MSTS: Musculoskeletal tumor society; HHS: Harris hip score; KSS: Knee society score; AOFAS; American orthopaedic foot and ankle society score.

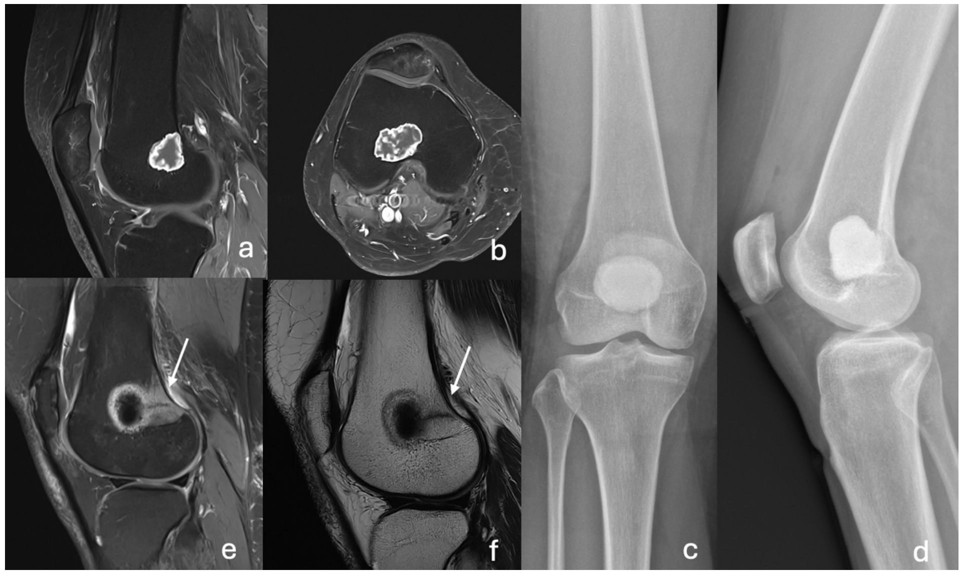

Figure 1. (a, b) Contrast-enhanced sagittal and axial magnetic resonance (MR) images of a 40-year-old female patient demonstrating an intramedullary cartilaginous lesion in the distal femur. **(c, d)** Early post-operative anteroposterior and lateral radiographs obtained following extended curettage and cementation. **(e, f)** Sagittal T1- and T2-weighted MR sequences at 3 months postoperatively, revealing a fissure line (white arrow) extending to the cortical window with surrounding bone marrow edema.

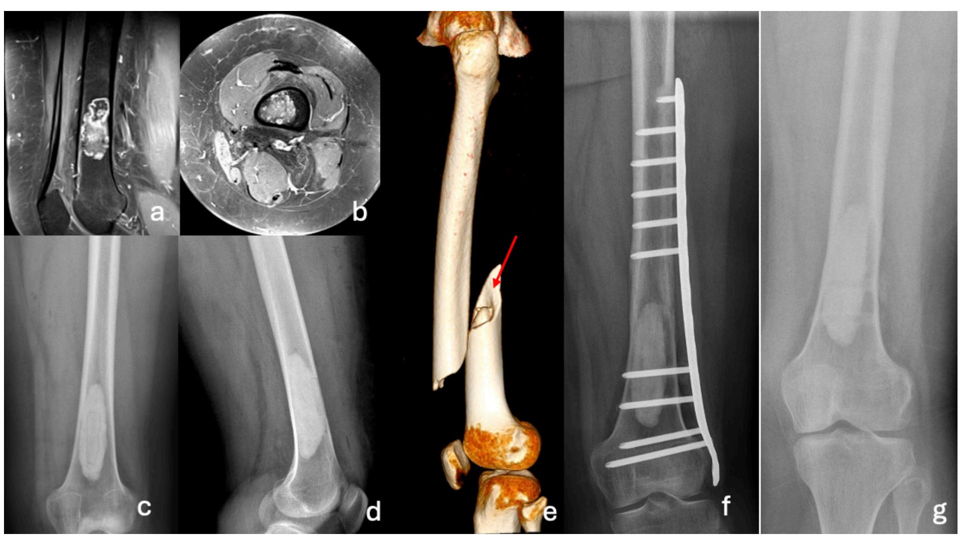

Figure 2. (a, b) Contrast-enhanced sagittal and axial magnetic resonance images of a 23-year-old female patient demonstrating an intramedullary cartilaginous tumor in the distal femur. **(c, d)** Early post-operative anteroposterior and lateral radiographs of the same patient. **(e)** Three-dimensional computed tomography image obtained at 1 month postoperatively following a fall, showing a fracture at the proximal margin of the cement (red arrow). **(f)** Anteroposterior (AP) radiograph at 4 years postoperatively after minimally invasive plate osteosynthesis. **(g)** AP radiograph of the femur after removal of the implants due to irritation of the soft tissues

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patients treated with prophylactic osteosynthesis.[9,10,14] This reinforces that prophylactic plating may not be necessary when meticulous curettage and optimized cementation techniques are employed.

A pivotal technical nuance of our approach involves extending the cement mantle beyond the lesion into adjacent intramedullary segments, thereby increasing the effective cement volume and optimizing load distribution across a broader surface area. This technique appears to enhance the biomechanical stiffness of the bone and may compensate for the absence of fixation hardware, particularly in diaphyseal or metaphyseal locations where torsional forces predominate. Previous biomechanical studies have similarly suggested that the principal determinants of fracture risk are the residual cortical thickness and cement volume, rather than the presence of fixation plates.[15] Accordingly, our strategy of extended cementation likely contributed to the low rate of mechanical complications observed.

The reported fracture rates after curettage and cementation in the literature vary between 3% and 10%, depending on lesion size, cortical involvement, and post-operative rehabilitation.[9,10,14] Krebbekx et al.[9] identified lesion size greater than 38 mm and male sex as independent predictors of fracture, while Errani et al.[2] noted that cortical thinning was a major factor influencing both local recurrence and mechanical failure. Our findings are consistent with these reports; however, given that none of our patients with larger lesions required secondary fixation due to instability, we believe that a carefully controlled mobilization protocol and rotational movement restriction in the early post-operative period play an essential role in reducing fracture risk. Specifically, torsional stresses through the cortical window may precipitate incomplete fractures, as observed in a small number of our cases, but conservative management with weight-bearing modification resulted in complete union without functional compromise.

Importantly, avoiding prophylactic metallic implants offers substantial advantages for post-operative imaging surveillance. Metallic fixation devices create susceptibility and beam-hardening artefacts on MRI and computed tomography, which can significantly obscure the evaluation of cortical integrity and potential local recurrence.[16-19] Despite recent advances in metal artefact reduction sequences, these technologies are not universally accessible and remain time-consuming.[16-19] By obviating the need for metallic hardware, our strategy facilitates artifact-free imaging, thereby enhancing the diagnostic sensitivity for early local recurrence and providing a more precise assessment of osseous consolidation. This represents a distinct advantage in managing low-grade cartilaginous lesions that require long-term surveillance.

Functional outcomes in our series were uniformly excellent, with mean MSTS, HHS, KSS, and AOFAS scores exceeding 90%. These findings are consistent with prior reports of superior post-operative function after intralesional procedures compared to wide resections.[11-13] However, there remains a notable paucity of studies directly comparing functional outcomes between fixation and non-fixation groups. The literature includes over 2,000 cases treated with intralesional curettage since 2015, yet only a limited subset provides validated MSTS or Toronto Extremity Salvage Score (TESS) data.[11-16,20-23] Our results, therefore, contribute novel evidence supporting that functional recovery can be excellent even in the absence of plate fixation, provided that mechanical stabilization through extended cementation and structured rehabilitation protocols is achieved. Future prospective comparative studies are warranted to confirm these findings and further elucidate the biomechanical and functional benefits of avoiding unnecessary fixation.

In conclusion, our experience supports that extended curettage and cementation without prophylactic fixation is both oncologically safe and mechanically sound for the management of lower extremity cartilaginous tumors. When cementation is extended beyond the tumor cavity to increase load distribution and post-operative mobilization is appropriately restricted, fracture risk remains within the range reported in the literature. Moreover, the elimination of metal artefacts during follow-up imaging significantly enhances surveillance accuracy. Considering these mechanical, functional, and imaging advantages, we advocate for fixation-free extended curettage and cementation as a sufficient and effective strategy in appropriately selected patients.

Limitations

This study has several limitations inherent to its retrospective design. The relatively small number of post-operative fracture events limits the statistical power to identify specific predictive factors. Moreover, the absence of a control group treated with prophylactic fixation precludes direct biomechanical comparison between fixation and non-fixation strategies. Although a single-surgeon series provides uniformity, it may introduce selection bias

Finally, larger multicenter cohorts would provide greater external validity and strengthen the generalizability of our findings.

CONCLUSION

Extended curettage and cementation without plate augmentation for lower extremity cartilage tumors, supported by meticulous surgical technique and carefully supervised post-operative rehabilitation, minimize fracture risk, ensure excellent functional outcomes, and optimize radiologic surveillance while avoiding implant-related complications.

Disclosures

Ethics Committee Approval: The study protocol was approved by the Acibadem Mehmet Ali Aydinlar University Ethics Committee (No: 2026/2026–01/11, Date: 08/01/2026).

Informed Consent: Written informed consent for the use of clinical data for research purposes was obtained from all participants at hospital admission.

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REFERENCES

1. Omlor GW, Lohnherr V, Lange J, Gantz S, Merle C, Fellenberg J, et al. Enchondromas and atypical cartilaginous tumors at the proximal humerus treated with intralesional resection and bone cement filling with or without osteosynthesis: retrospective analysis of 42 cases with 6 years mean follow-up. World J Surg Oncol 2018;16:139.
2. Errani C, Tsukamoto S, Ciani G, Akahane M, Cevolani L, Tanzi P, et al. Risk factors for local recurrence from atypical cartilaginous tumour and enchondroma of the long bones. Eur J Orthop Surg Traumatol 2017;27:805–11.
3. Hong ED, Carrino JA, Weber KL, Fayad LM. Prevalence of shoulder enchondromas on routine MR imaging. Clin Imaging 2011;35:378–84.
4. 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;241–6.
5. Harris WH. Traumatic arthritis of the hip after dislocation and acetabular fractures: treatment by mold arthroplasty. An end-result study using a new method of result evaluation. J Bone Joint Surg Am 1969;51:737–55.
6. Insall JN, Dorr LD, Scott RD, Scott WN. Rationale of the Knee Society clinical rating system. Clin Orthop Relat Res 1989;13–4.
7. Kitaoka HB, Alexander IJ, Adelaar RS, Nunley JA, Myerson MS, Sanders M. Clinical rating systems for the ankle-hindfoot, midfoot, hallux, and lesser toes. Foot Ankle Int 1994;15:349–53.
8. Henderson ER, O'Connor MI, Ruggieri P, Windhager R, Funovics PT, Gibbons CL, et al. Classification of failure of limb salvage after reconstructive surgery for bone tumours: a modified system Including biological and expandable reconstructions. Bone Joint J 2014;96-B:1436–40.
9. Krebbekx GGJ, Fris FJ, Schaap GR, Bramer JAM, Verspoor FGM, Janssen SJ. Fracture risk after intralesional curettage of atypical cartilaginous tumors. J Orthop Surg Res 2023;18:851.
10. Scholte CHJ, Van de Sande MAJ, Van der Wal RJP, Broekhuis D, Van Langevelde K, Dorleijn DMJ. Clinical outcome of curettage in atypical cartilaginous tumors of the long bones: a descriptive cohort study. Acta Orthop 2024;95:752–7.
11. Görgün B, Özşahin MK, Tok O, Davulcu CD, Karaismailoğlu B, Hız M. Intralesional curettage and cementation of low-grade chondrosarcomas of the appendicular skeleton: Long-term results from a single center. Acta Orthop Traumatol Turc 2022;56:402–7.
12. Chen YC, Wu PK, Chen CF, Chen WM. Intralesional curettage of central low-grade chondrosarcoma: A midterm follow-up study. J Chin Med Assoc 2017;80:178–82.
13. Deckers C, van Zeijl NT, van Hooff ML, Veldman-Goossen PI, Schreuder HWB, Dierselhuis EF, et al. Active surveillance of atypical cartilaginous tumours of bone: short term quality of life measurements. J Orthop Surg Res 2023;18:208.
14. Coke E, Ben-Gal O, Mahendra A, Pietrzycki J, Vaughan S, Gupta S. Transformation and Management of Long-Bone Atypical Cartilaginous Tumours. Cancers (Basel) 2025;17:3178.
15. Ghouchani A, Rouhi G, Ebrahimzadeh MH. Post-operative fracture risk assessment following tumor curettage in the distal femur: a hybrid in vitro and in silico biomechanical approach. Sci Rep 2020;10:21319.
16. Feuerriegel GC, Sutter R. Managing hardware-related metal artifacts in MRI: current and evolving techniques. Skeletal Radiol 2024;53:1737–50.
17. Lee EM, Ibrahim EH, Dudek N, Lu JC, Kalia V, Runge M, et al. Improving MR image quality in patients with metallic implants. Radiographics 2021;41:E126–37.

18. Andersson KM, Nowik P, Persliden J, Thunberg P, Norrman E. Metal artefact reduction in CT imaging of hip prostheses—an evaluation of commercial techniques provided by four vendors. Br J Radiol 2015;88:20140473.
19. Choi SJ, Koch KM, Hargreaves BA, Stevens KJ, Gold GE. Metal artifact reduction with MAVRIC SL at 3-T MRI in patients with hip arthroplasty. AJR Am J Roentgenol 2015;204:140–7.
20. El Masry AM, Azmy SI, Mustafa MAR, Abdel Aal MM. Long-term follow up of patients with low-grade chondrosarcoma in the appendicular skeleton treated by extended curettage and liquid nitrogen. Orthop Traumatol Surg Res 2023;109:103410.
21. Ipponi E, Cordoni M, DE Franco S, Campo FR, D'Arienzo A, Andreani L. Hand enchondromas treated with curettage: a single ınstitution experience and literature review. Acta Chir Orthop Traumatol Cech 2024;91:331–8.
22. Horstmann PF, Hettwer WH, Petersen MM. Treatment of benign and borderline bone tumors with combined curettage and bone defect reconstruction. J Orthop Surg (Hong Kong) 2018;26:2309499018774929.
23. Sampath Kumar V, Tyrrell PN, Singh J, Gregory J, Cribb GL, Cool P. Surveillance of intramedullary cartilage tumours in long bones. Bone Joint J 2016;98-B:1542–7.