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Clinical efficacy of allograft bone combined with calcium phosphate bone powder in repairing bone defects of benign bone tumors: A retrospective controlled study

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Abstract

Objective To evaluate the clinical efficacy of repairing bone defects caused by benign bone tumors using allograft bone combined with calcium phosphate bone powder.

Methods A retrospective analysis was conducted on 55 patients (aged 10–61 years, mean 35 ± 13.2) with benign bone tumors treated at our hospital from June 2020 to December 2022. The bone defects in these cases were created after surgical curettage of the tumor lesions, which included common benign tumors such as osteochondroma, giant cell tumor of bone, and enchondroma. Patients were divided into two groups based on bone graft materials: a simple allograft bone group ($n = 30$) and a combined group using allograft bone with calcium phosphate bone powder ($n = 25$). Preoperative data, surgical time, intraoperative blood loss, postoperative complications, imaging findings, limb function, and quality of life (KPS scores) were analyzed.

Results All 55 patients were followed for 12–30 months (mean 13.45 ± 5.18). All incisions healed by primary intention without complications such as graft nonunion, fractures, or tumor recurrence. The combined group showed a significantly shorter healing time ($t = 4.280$, $P < 0.05$) and higher KPS scores at 6 months postoperatively ($X^2 = 3.646$, $P < 0.05$) compared to the simple group. However, no significant differences were observed between groups in healing rate, residual bone defects, or limb function at 12 months postoperatively ($P > 0.05$).

Conclusion Allograft bone combined with calcium phosphate bone powder is superior to allograft bone alone for repairing bone defects following curettage of benign bone tumors, promoting faster healing and better postoperative functional recovery.

Keyword Benign bone tumor; allograft bone; calcium phosphate bone powder; bone defect repair

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Background

Benign bone tumors, including bone cysts, osteoid osteoma, fibrous dysplasia, and enchondroma, can compromise bone integrity and increase the risk of pathological fractures [1–3]. Surgical excision of these tumors often results in bone defects that necessitate reconstruction to restore normal bone structure and function [4]. Autologous bone grafting is considered the "gold standard" for such reconstructions [5]; however, its application is limited by donor site morbidity and limited availability. Allogeneic bone grafts offer an alternative [6], but their use raises concerns regarding immunogenicity. Despite processing methods intended to reduce antigenicity, allogeneic bone can still elicit immune responses in recipients. Studies have reported that up to 48% of patients may develop sensitization after receiving allogeneic bone grafts, indicating a significant immunological response [7]. To mitigate these issues, synthetic bone substitutes, such as calcium phosphate bone powder, have been developed. While these materials avoid the risks of infection and immune rejection associated with allografts, they can degrade rapidly when used alone [8]. Combining different graft materials aims to leverage their respective advantages and offset their limitations [9]. In clinical practice, the application of allogeneic bone grafts can lead to the dispersion of bone graft particles into surrounding soft tissues. Coating the graft with a paste-like mixture of calcium phosphate bone powder may prevent this scattering; however, the impact of such combinations on bone healing remains to be fully elucidated. This study aims to compare the outcomes of bone defect repairs using allogeneic bone alone versus a combination of allogeneic bone and calcium phosphate bone powder in patients with benign bone tumors.

Materials and methods

General information

Inclusion criteria included patients diagnosed via histological examination with primary benign bone tumors, such as bone cysts, osteoid osteomas, fibrous dysplasia, or enchondromas, who were undergoing initial surgical intervention, available for follow-up exceeding 12 months, and had provided informed consent. Exclusion criteria encompassed concurrent diagnosis of other malignant tumors, severe diseases affecting vital organs including the heart, lungs, or kidneys, presence of traumatic fractures, tumor lesions located in the spine or axial skeleton, history of malignant bone tumors, tumor recurrence within two years post-surgery, loss to follow-up, and diagnosed mental disorders. The study comprised 55 patients: 29 males and 26 females, aged between 10 and 61 years (mean age: 35 ± 13.2 years). Diagnoses included 18 cases of enchondroma, 18 cases of fibrous dysplasia, 9 cases of bone cysts, 4 cases of giant cell tumors of bone, 4 cases of non-ossifying fibroma, and 2 cases of aneurysmal bone cysts. Tumor locations were distributed as follows: femur (23 cases), tibia (7 cases), phalanges (6 cases), humerus (5 cases), clavicle (3 cases), phalanx(3 cases), pelvis (2 cases), ulna (2 cases), calcaneus (2 cases), radius (1 case), and metacarpal (1 case). The follow-up period ranged from 6 to 30 months, with an average of 11 months. All surgical procedures were performed by the same experienced orthopedic oncologist. Baseline characteristics between the two groups were comparable (refer to Table 1).

Inclusion and exclusion criteria

Inclusion criteria: patients diagnosed via histological examination with primary benign bone tumors, such as bone cysts, osteoid osteomas, fibrous dysplasia, or enchondromas, who were undergoing initial surgical intervention, available for follow-up exceeding 12 months, and had provided informed consent.

Exclusion criteria: concurrent diagnosis of other malignant tumors, severe diseases affecting vital organs including the heart, lungs, or kidneys, presence of traumatic fractures, tumor lesions located in the spine or

Tab 1 General information of patients in both groups

Characteristics	Combination group ($n = 25$)	Simple group ($n = 30$)
Age (years)	39.13 ± 15.46	41.53 ± 15.76
Gender(Male/female)(cases)	16/9	13/17
Type of pathology (cases)		
osteochondroma	8	10
Fibrous dysplasia	9	9
Bone cyst	5	4
Giant cell tumor of bone	1	3
Nonossifying fibroma	1	3
Aneurysmal bone cyst	1	1
Site of lesion (cases)		
Femur	13	10
Shin bone	3	4
Phalanx	1	5
Humerus	3	2
Clavicle	0	3
Phalanx	3	0
Pelvis	0	2
Ulna	0	2
Calcaneus	1	1
Radius	0	1
Metacarpal bone	1	0

axial skeleton, history of malignant bone tumors, tumor recurrence within two years post-surgery, loss to follow-up, and diagnosed mental disorders.

Surgical methods

After the lesion was fully exposed and the surrounding tissues were protected with gauze, the bone cortex was opened, and the tumor was carefully curetted using a spatula. The tumor wall was smoothed and prepared using a high-speed burr drill, followed by cauterization with an electric knife. To further reduce the risk of recurrence, chemical inactivation of the tumor cavity was performed by applying anhydrous ethanol. Finally, bone grafting was conducted as follows.

In the **simple group**, allogeneic cancellous bone particles (Shanxi Aorui Biomaterials Co., Ltd.) were packed into the medullary cavity and compacted to fill the defect. Bone grafting rods were used to further stabilize the graft.

In the **combined group**, approximately 3/4 of the cavity was first filled with allogeneic cancellous bone particles, while the remaining 1/4 was filled with calcium phosphate bone powder (Shanghai Ruibang Biomaterials Co.) mixed to a paste-like consistency. The paste was applied to the surface of the bone graft to plasticize and secure it, effectively preventing the allogeneic bone particles from spilling into the surrounding soft tissues.

The incision was thoroughly irrigated, and the surgical site was closed in layers. A negative pressure drainage tube was routinely placed to facilitate postoperative recovery.

Postoperative treatment

Postoperative care involved changing dressings every three days to monitor the incision site for signs of infection or complications. Sutures were removed two weeks after surgery. The drainage tube was removed when the drainage volume was less than 50 mL over a 24-h period. Patients were advised to avoid weight-bearing on the affected limb until sufficient bone healing was confirmed. Follow-up X-rays were performed at 1, 3, 6, and 12 months post-surgery to assess bone healing progression. Based on radiographic findings, patients were gradually introduced to joint mobility exercises and muscle-strengthening rehabilitation programs tailored to their recovery status.

Postoperative follow-up

Clinical observation

The operation duration and intraoperative blood loss were documented for each patient. Postoperative complications, such as surgical site infections and adverse reactions, were meticulously monitored. Adverse reactions were identified by the presence of incision redness, swelling, dehiscence, or purulent discharge during the follow-up period. At the final follow-up, limb functionality was assessed using the Enneking functional scoring system, which evaluates factors like pain, function, and emotional acceptance, assigning numerical values to each category. Additionally, the Karnofsky Performance Status (KPS) scale was employed to determine the patients' postoperative quality of life, with scores ranging from 0 to 100, indicating the patient's ability to perform daily activities.

Imaging observation

Preoperative imaging, including X-rays, CT, and MRI, was performed to evaluate the bone lesion. Postoperative imaging consisted of immediate X-rays, as well as follow-up X-rays at 1, 3, 6, 12, and 18 months after discharge from the hospital, and a CT scan at the 12th postoperative month time to assess bone graft healing and regression of the bone defect. The criteria for bone graft healing [10] were as follows: 1) **Complete healing**: The implanted bone particles are fully fused with no visible original structure or gap between the implanted bone and the recipient bone bed. The patient experiences no pain during normal activities even after the removal of internal fixation. 2) **Healing**: The implanted bone particles are fully fused with no visible original structure or gap between the implanted bone and the recipient bone bed. The patient can bear full weight and experiences no clinical pain, even after the removal of internal or external fixation. 3) **Partial healing**: The original structure of the implanted bone particles becomes blurred, showing gradual fusion with the bone bed. Partial weight bearing is possible without clinical pain. 4) **Non-healing**: The original structure of the implanted bone particles remains distinct, with an obvious gap between the implanted bone and the bone bed. Weight bearing is not possible, or pain occurs with weight bearing.The healing rate was calculated using the formula: Healing rate = (Number of cases with complete healing + healing + partial healing) / Total cases × 100%.

For CT evaluation, transverse images were taken at three levels (upper edge, middle, and lower edge) of the bone graft sites. The bone defect area before grafting was defined as **A**, and the residual bone defect void in any cross-sectional image was defined as **a**. The residual bone defect rate was calculated using the formula:

Residual bone defect rate = (a / A) × 100%, with the mean value derived from the three transverse planes."

Statistical methods

Statistical analysis was conducted using SPSS 26.0 software. Continuous variables were first tested for normality using the Shapiro–Wilk test. Data that followed a normal distribution were expressed as mean ± standard deviation (SD) and analyzed using an independent samples t-test for two-group comparisons. For data that did not satisfy normal distribution, results were described using the median (interquartile range, IQR) and analyzed with the Mann–Whitney U test. Categorical variables were expressed as frequencies and percentages (%). Group comparisons of categorical data were performed using the chi-square test (χ^2 test) or Fisher's exact test when appropriate. For small sample sizes or when expected counts in contingency tables were less than 5, the continuity correction chi-square test was applied. A *p*-value of less than 0.05 was considered statistically significant for all analyses."

Results

Intraoperative situation of the two groups

Comparison of operation time and intraoperative bleeding between the two groups, the difference is not statistically significant ($P > 0.05$) (Table 2).

Comparison of postoperative healing between the two groups of patients

The healing rate of the combined group and the simple group at 12 months after surgery was 97.5% and 92.5%, respectively, and the difference between the groups was not statistically significant ($X^2 = 0.110, P > 0.05$); the initial healing time of the homograft bone combined with calcium phosphate group was significantly shorter than that of the homograft bone group, and the difference was statistically significant ($t = 4.280$, $P < 0.05$), and the rate of residual bone defect in the combined group was less than that in the simple group (Fig. 1, Fig. 2), but the difference was not statistically significant ($X^2 = 1.136$, $P > 0.05$). However, the difference was not statistically significant ($X^2 = 1.136$, $P > 0.05$).

Recovery of patients' postoperative limb function

At 12 months after surgery, the excellent rates of limb function in the combined group and the simple group were 96.0% and 93.3%, and the difference between the groups was not statistically significant compared with each other ($X^2 = 0.000$, $P > 0.05$) (Table 3).

Tab 2 Intraoperative condition of patients in both groups [cases($\bar{x} \pm s$)]

groups	n	Operation time (min)	Intraoperative blood loss (ml)
combine group	25	130 ± 65.15	155 ± 150.72
single group	30	107 ± 41.46	162 ± 122.44
Statistic		$t = 1.501$ $P = 0.139$	$t = 0.169$ $P = 0.867$

Comparison of patients' postoperative quality of life (KPS score)

The KPS scores of the two groups were significantly higher than those of the simple group at 6 months postoperatively ($t = 3.646$, $P < 0.05$), and the differences between the KPS scores of the two groups were not statistically significant at 3 months postoperatively and 12 months postoperatively ($P > 0.05$) (Table 4).

Typical cases

Figure 1: A 62-year-old female patient with an endogenous chondroid tumor of the lower end of the left femur underwent "Curettage surgery for a tumor in the left femur, bone grafting of the left femur, and internal fixation of the left femur." "a, b Preoperative orthopantomograms and lateral radiographs showed an elliptical lesion in the distal left femur with internal calcified gravelly patches. c, d Preoperative CT scans showed a speckled calcified lesion in the bone marrow cavity of the left femur. Follow-up radiographs and CT at 24 months postoperatively demonstrated satisfactory fusion of implants and stable internal fixation.

Figure 2Male patient, 11 years old, with an aneurysmal-like bone cyst in the distal left fibula, underwent "Curettage surgery for a tumor in the left fibula and left fibula bone grafting". a, b, Preoperative frontal and lateral X-rays showed a cavity-like cystic lesion in the distal left fibula. c, d, Preoperative MRI showed fibrous septal-like changes in the distal left fibula. e, f, Immediate postoperative X radiographs show that the bone graft is well positioned in the cavity. Good position; g, h, i, j, k, l Follow-up radiographs at 3, 6, and 12 months postoperatively showed gradual fusion of the implant with satisfactory results; m, n CT at 24 months postoperatively showed good fusion of the implant and good local cortical continuity of the bone.

Discussion

Surgical treatment for benign bone tumors typically involves tumor resection followed by cavity filling with bone graft materials to restore bone structure and function [11–13]. The ideal bone grafting material should possess characteristics such as good histocompatibility, mechanical strength, controlled degradability, porosity to support new bone formation, and osteoinductive, osteoconductive, and osteogenic properties [14]. Autologous bone grafts provide osteogenesis through the framework of osteogenic cells, growth factors, and bone matrix production. Allogeneic bone grafts, in contrast, induce osteoinduction through the differentiation of osteogenic cells, aided by osteoinductors such as bone morphogenetic proteins (BMPs). Osteoconduction occurs through

Fig. 1 A 62-year-old female patient with an endogenous chondroid tumor of the lower end of the left femur underwent "Curettage surgery for a tumor in the left femur, bone grafting of the left femur, and internal fixation of the left femur." "a, b Preoperative orthopantomograms and lateral radiographs showed an elliptical lesion in the distal left femur with internal calcified gravelly patches. c, d Preoperative CT scans showed a speckled calcified lesion in the bone marrow cavity of the left femur. Follow-up radiographs and CT at 24 months postoperatively demonstrated satisfactory fusion of implants and stable internal fixation

the use of biological scaffolds that allow for bone formation and revascularization, integrating with the host bone tissue [15, 16].

Artificial bone materials, particularly calcium phosphate (CAP), have gained attention due to their resemblance to the inorganic components of natural bone. CAP materials have been shown to promote integration with the host bone and exhibit favorable biocompatibility and osteogenic properties, particularly through their porosity, which facilitates interaction with osteoclasts and osteoblasts. This interaction enhances bone formation, providing a framework for cell proliferation and osteogenic differentiation. Furthermore, calcium phosphate materials, loaded with biological factors and trace elements, can promote both vascularization and bone formation, making them valuable in clinical applications for bone tissue repair and regeneration [17, 18].

However, despite its advantages, calcium phosphate material is prone to early degradation and does not provide long-lasting mechanical support. To address this, the combination of calcium phosphate with allogeneic bone grafts has been explored in recent years. Allogeneic bone offers several advantages, including abundant availability, avoidance of donor site complications, and a proven capacity for osteoconduction and osteoinduction. Advances in allogeneic bone processing, disinfection, and storage methods, particularly through the establishment of bone banks, have facilitated its clinical use [19].

In the present study, we aimed to investigate the synergistic effect of combining calcium phosphate with allogeneic bone grafts. The results indicated a lower rate of residual bone defects in the combined group at 12 months postoperatively compared to the simple allogeneic bone group. We hypothesize that the calcium

Fig. 2 Male patient, 11 years old, with an aneurysmal-like bone cyst in the distal left fibula, underwent "Curettage surgery for a tumor in the left fibula and left fibula bone grafting". a, b, Preoperative frontal and lateral X-rays showed a cavity-like cystic lesion in the distal left fibula. c, d, Preoperative MRI showed fibrous septal-like changes in the distal left fibula. e, f, Immediate postoperative X radiographs show that the bone graft is well positioned in the cavity. Good position; g, h, i, j, k, l Follow-up radiographs at 3, 6, and 12 months postoperatively showed gradual fusion of the implant with satisfactory results; m, n CT at 24 months postoperatively showed good fusion of the implant and good local cortical continuity of the bone

Tab 3 Bone graft healing results of the two groups of patients [case (%) ($\bar{x} \pm s$)]

Groups	Complete healing	Fuse	Initial healing	Non-healing	Initial healing time (months)	Residual bone defect	Rate of residual bone defects	Healing rate
Combine group ($n=25$)	6	11	7	1	10.32±0.99	1	4.0%	96.0%
single group ($n=30$)	6	15	6	3	11.60±1.19	5	16.7%	90.0%

Tab 4 Postoperative KPS scores in both groups ($\bar{x}\pm s$)

groups	n	preoperative	3 months after surgery	6 months after surgery	12 months after surgery
Combine group	25	73.20±6.90	76.40±5.69	84.00±5.00	86.00±5.00
single group	30	72.67±6.91	76.00±4.98	78.67±5.71	85.33±5.71
Statistic		t=0.285 *P* =0.777	t=0.278 *P* =0.782	t=3.646 *P* =0.001	t=0.456 *P* =0.650

phosphate bone powder prevented the scattering of allogeneic bone particles within the tumor cavity, which likely contributed to a reduction in bone defects. This finding aligns with previous reports on the use of calcium phosphate in combination with other graft materials in bone tumor repair, though no studies have directly compared it with allogeneic bone grafting [17–19].

Although no significant difference in the overall healing rate was observed between the combined and simple groups, the initial healing time in the combined group was significantly shorter. This is consistent with the well-established osteogenic properties of calcium phosphate bone powder, which is known to promote osteoblast activity and enhance bone formation. The ability of calcium phosphate to accelerate bone healing, particularly in the initial phase, was supported by our results, which showed faster bone regeneration compared to the simple group. This is in line with previous studies that have highlighted the biocompatibility, biodegradability, and low immunogenicity of calcium phosphate, which collectively contribute to its superior healing effects [20, 21].

Furthermore, the functional recovery of the patients in both groups was comparable, with no significant difference in the rate of good limb function at 12 months post-surgery. This suggests that both grafting methods allowed for effective recovery of limb function. However, the quality of life improved more rapidly in the combined group, likely due to the quicker bone healing and reduced bone defect formation.

Before concluding, we acknowledge certain limitations of this study. First, the sample size was relatively small, which may have affected the statistical power and limited the detection of potential differences. Second, the follow-up period was relatively short, covering only 12 months postoperatively, which prevented us from evaluating long-term bone integration and functional recovery. Therefore, further large-scale clinical studies with extended follow-up periods are needed to validate our findings and assess the long-term efficacy of this combined grafting strategy. Additionally, the physicochemical properties of bone grafting materials, such as porosity, mechanical strength, and degradation rate, may significantly influence bone regeneration [22, 23]. Future research should focus on optimizing these characteristics to enhance bone repair and functional recovery outcomes.

In conclusion, the combination of allogeneic bone grafts with calcium phosphate bone powder offers several advantages over allogeneic bone grafts alone, including faster healing, reduced bone defects, and improved postoperative quality of life.

Abbreviations

KPS	KarnofskyPerformance Status
CT	Computer Tomography
MRI	Magnetic Resonance Imaging
SPSS	Statistical Product and Service Solutions

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Not applicable

Authors' contributions
Shi Jiandang and Yang Zongqiang: design of the study protocol, review and guidance of the article; Liu Qiang: statistical analysis and paper writing; Zheng Jianping、Niu Ningkui: critical review of the intellectual content of the article; Ma Long and Chu Dawei: case follow-up and data collection.

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Availability of data and materials
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
The study protocol was approved by the Research Ethics Committee of the General Hospital of Ningxia Medical University(KYLL-2023–0467); All patients agreed and signed an informed consent form.

Consent for publication
All patients agreed and signed an informed consent form

Competing interests
The authors declare no competing interests.

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References
1. Liu W, Zong YQ. Research progress in the treatment of patients with limb bone defects. Med Equipment. 2022;016:035.
2. Wu JS. CORR insights®: is core needle biopsy reliable in differentiating between aggressive benign and malignant radiolucent bone tumors? Clin Orthop Relat Res. 2018;476(3):578–9.
3. Ni M. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi. 2021;35(9):1186–91.
4. Tian YF, Liu JQ, Hu YS, et al. Clinical study of recombinant human BMP-2 calcium phosphate-loaded calcium phosphate-loaded antibiotic-loaded artificial bone in the treatment of chronic osteomyelit. 2021;35(5):573–8.
5. Jia RP. Observation on the efficacy of autologous bone combined with allogeneic bone in the treatment of malignant bone tumors of the extremities. Basic and Clinical Tumor. 2018;31(06):497–9.
6. Yang P, Xing J, Liu J, et al. Individual tissue-engineered bone in repairing bone defects: a 10-year follow-up study. Tissue Eng Part A. 2020;26(15–16):896–904.
7. Mishchenko O, Yanovska A, Sulaieva O, Moskalenko R, Pernakov M, Husak Y, Korniienko V, Deineka V, Kosinov O, Varakuta O, et al. From synthesis to clinical trial: novel bioinductive calcium deficient HA/beta-TCP bone grafting nanomaterial. Nanomaterials (Basel). 2023;13(12):1876.
8. Song XN, Ji ZG, Zhou ZB, et al. Observation on the clinical effect of applying nano hydroxyapatite/collagen composite artificial bone to repair bone defects after scraping of benign bone tumors. Journal of Clinical Military Medicine. 2023;51(01):15–8.
9. Wang SZ, Zhou J, Li RR, et al. Experimental study of calcium phosphate-modified titanium implants combined with platelet-rich plasma to promote implant osseointegration in osteoporotic rats. Journal of Clinical and Experimental Medicine. 2023;22(03):237–42.
10. Lu SY, Xu YQ, Li FB, et al. Clinical study of new artificial bone repair materials in bone defect repair. Bio-Orthopaedic Materials and Clinical Research. 2021;18(04):24–8.
11. Ma ZR, Wang WJ. Efficacy of different bone graft materials in bone graft reconstruction in patients with benign bone tumors. Chinese Journal of Surgical Oncology. 2018;10(05):323–6.
12. 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(4):331–6.
13. Puthoor D, Francis L, Ismail R. Is sclerotherapy with polidocanol a better treatment option for aneurysmal bone cyst compared to conventional curettage and bone grafting? J Orthop. 2021;25:265–70 Published 2021 May 21.
14. Gava NF, Engel EE. Treatment alternatives and clinical outcomes of bone filling after benign tumour curettage. A systematic review. Orthop Traumatol Surg Res. 2022;108(4): 102966.
15. Ma ZR, Wang WJ. Efficacy of different bone grafting materials for bone graft reconstruction in patients with benign bone tumors. Chinese Journal of Surgical Oncology. 2018;10(05):323–6.
16. Ca C, Guo D, et al. Chinese journal of orthopaedics and traumatology. 2021;2021(4):382–8.
17. Wubneh A, Tsekoura EK, Ayranci C, Uludağ H. Current state of fabrication technologies and materials for bone tissue engineering. Acta Biomater. 2018;80:1–30.
18. Jia HZ, Lu QD, Liu ZX, et al. A case of chondroblastoma of the femoral head in adolescents treated by transsurgical dislocation approach and literature review. China Clinical Case Outcome Database. 2023;05(01):E00391–E00391.
19. Li JN, Zeng QF, Yu SY, et al. Preparation and properties of biphasic calcium phosphate coated hydroxyapatite porous scaffolds. Chinese Tissue Engineering Research. 2023;27(16):8.
20. Qin CH, Zhou CH, Ren Y, et al. Extensive eggshell-like debridement technique plus antibiotic-loaded calcium sulphate for one-stage treatment of chronic calcaneal osteomyelitis. Foot Ankle Surg. 2020;26(6):644–9.
21. Wen RY, Fang HX, Xi LC. Effects of lesion scraping combined with filling with different materials on patients with giant cell tumor of limb bone. Medical theory and practice. 2023;36(7):4.
22. Department of Orthopaedics & Traumatology, Nanfang Hospital, Southern Medical University, Guangzhou, PR China, et al. Chinese expert consensus on diagnosis and treatment of infection after fracture fixation. Injury. 2019;50(11):1952–8.
23. Mishchenko O, Yanovska A, Kosinov O, Maksymov D, Moskalenko R, Ramanavicius A, Pogorielov M. Synthetic calcium-phosphate materials for bone grafting. Polymers (Basel). 2023;15(18):3822.

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