Use of purified beta-tricalcium phosphate for filling defects after curettage of benign bone tumours

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Abstract Fifty-three patients with benign bone tumours were treated with curettage and filling with a purified beta-tricalcium phosphate (β -TCP). Recurrences occurred in two cases. There was neither a postoperative infection nor adverse reaction due to the material. Postoperative fractures did not occur in any patients. Radiographically, complete resorption of the material and bone remodelling were achieved in 23 cases (43%). Of these 23 cases, there was a statistical correlation between the filling volume and the time taken for complete resorption ($p<0.05$). We concluded that purified β -TCP was an ideal bone graft substitute for the treatment of benign bone tumours because of its good biocompatibility and resorption characteristics.

Résumé 53 patients présentant une tumeur bénigne des os ont été traités par curetage et greffe par du beta-tricalcium phosphate (β -TCP) pur. La récurrence de la tumeur n'a été observée que dans deux cas. Il n'y a eu aucune infection et aucune réaction négative dues au matériel. Nous n'avons pas constaté de fractures post-opératoires. Sur le plan radiographique, nous avons assisté à une résorption complète de la tumeur et remodelage osseux chez 23 patients (43%). Pour ces 23 patients, il existe une corrélation statistique non significative entre le volume du substitut et le temps pour sa complète résorption ($p<0.05$).

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Nous pouvons en conclure que le β -TCP est un substitut osseux idéal pour le traitement des tumeurs osseuses bénignes qu'il présente une bonne bio compatibilité et des caractéristiques satisfaisantes en terme de résorption.

Introduction

Autogenous bone graft is well known as the standard means to fill bone defects. However, there are still some complications, such as infection, haematoma, nerve injury, donor defect herniation, and iliac wing fracture, from bone harvesting [2, 3, 15]. Moreover, the supply of autogenous bone is restricted. Recently, beta-tricalcium phosphate (β -TCP) was clinically used in orthopaedic surgery as an alternative agent [4, 7, 9]. This ceramic has both osteoconductive and resorbable properties. The aim of this study was to assess the efficacy of purified β -TCP as a bone graft substitute to fill the defects after curettage for benign bone tumours.

Patients and methods

Fifty-three patients with benign bone tumours underwent operative treatment. The mean age of the patients was 31 years (range: 6–76 years). A total of 32 were male and 21 were female. There were 21 patients under 20 years old and 32 over 20 years old. The exact distribution of the 53 reported cases was follows: femur 15 cases, phalanx 12 cases, humerus 10 cases, tibia 7 cases, calcaneus 3 cases, radius 2 cases, ilium 2 cases, metacarpal bone 1 case, and metatarsal bone 1 case. The tumours included 18 enchondromas, 14 aneurysmal bone cysts, 10 fibrous dysplasias, 5 intraosseous lipomas, 3 solitary bone cysts, 1 nonossifying

Fig. 1 Graph showing the correlation between the filling volume of the β -TCP and the time taken for complete resorption

fibroma, 1 benign chondroblastoma, and 1 osteofibrous dysplasia. After complete curettage of the tumour, the defect was filled with purified β -TCP (Osferion, Olympus, Tokyo, Japan) in granule form or block form. The porosity of this material was 75%, the average pore size was from 100 to 400 μ m in diameter, and the sintering temperature was 1,050°C. A corticocancellous autograft was not used. The patients with lesions of the upper limb were postoperatively immobilised in splints for 2–4 weeks. The patients with lesions of the lower limb spent 4–6 weeks in non-weight-bearing splints. Full weight bearing was allowed

after 8 weeks. The mean follow-up period was 21 (6–41) months. The clinical findings were assessed at the latest examination. Postoperative limb function was evaluated by the criteria of Enneking et al. [6].

To evaluate the resorption of β -TCP, a radiographic analysis was performed. The lengths and the widths of the lesion filled with β -TCP were measured.

The filling volume of β -TCP could be calculated using the formula $(A \times B^2)/2$, where A is the shorter figure of the measured values and B is the longer one. The resorption rate could be calculated using the formula $(C-D)/C \times 100$, where C is the volume of β -TCP just after surgery and D is the volume at the final examination.

For the statistical analysis of the data, we used Spearman's rank correlation coefficient. A *p* value less than 5% was considered as statistically significant.

Results

There was neither a postoperative infection nor adverse reaction due to the material. No postoperative fractures were seen in any patients. In the young patients, neither deformity nor growth arrest was observed. Recurrences of the tumour were seen in only two cases, one benign chondroblastoma and one solitary bone cyst. No further surgical intervention was needed at the final examination. The average limb function was 100%. All patients were pain free and were satisfied with their limb function. Radiographically, the mean filling volume of β -TCP

Fig. 2 Radiographs of an 11-year-old boy with an aneurysmal bone cyst in the calcaneus. **a** Lateral view of the calcaneus with clear osteolysis, **b** biodegradation of β -TCP 4 months after operation, and **c** complete resorption of it after 15 months. The resorption rate was 100%

Fig. 3 Radiographs of a 19-year-old woman with an intraosseous lipoma in the tibia. **a** Osteolysis of the diaphysis, **b** clear contour of the β -TCP 15 months after operation, and **c** delayed resorption of β -TCP 42 months after operation. The resorption rate was 12.5%

immediately after operation was 18.4 (0.06 – 121.5) cm^3 . Complete resorption of β -TCP and bone remodelling was observed in 23 cases (43%). The mean period to complete resorption of the material was 12.7 (5–26) months. The mean filling volume was 9.0 (0.06 – 38.4) cm^3 . In these 23 cases, there was a statistical correlation between the filling volume and the time taken for complete resorption ($p < 0.05$) (Fig. 1). In the 32 patients over 20 years old, complete resorption was seen in 13 cases (40.6%); in the 21 patients under 20, complete resorption was seen in 10 cases (47%) (Fig. 2).

Signs of the grafted β -TCP still remained radiographically at the final examination in 30 cases (57%), but the material in the bone marrow was incorporated and being gradually resorbed. The expanded cortex caused by tumour growth had been restored to its original shape. The mean filling volume was 35.5 (1.4 – 121.5) cm^3 . There were seven delayed resorption cases, in which the resorption rate was less than 50% at 13 months after operation; four involved fibrous dysplasia of the femur, one intraosseous lipoma of the femur, one intraosseous lipoma of the tibia (Fig. 3), and one aneurysmal bone cyst of the femur.

Discussion

The present study showed that purified β -TCP was useful for filling defects after curettage of benign bone tumours. This bioactive ceramic was safe, non-toxic, lacked disease transmission or immunogenic response properties, and its

use avoided morbidity at bone graft donor sites. Furthermore, handling and storage of β -TCP was easy. Two cases exhibited local recurrence after operation in this study. This was not due to the selection of the material, but by the biological behaviour of the tumour itself. The recurrence rate of this study was smaller than that of other reports [9].

Radiographically, the grafted β -TCP showed good incorporation into the host bone and new bone formation. A recent study reported that there was histologically new bone formation in the pores of β -TCP and no fibrous tissue between β -TCP and the new bone at an early stage in human adult bone [10]. In small defects, lesions healed rapidly and there was a correlation between the filling volume and the time taken for complete resorption. Nicholas and Lange also reported that healing was dependent upon the defect size [9]. Galois et al. mentioned that the implant size, the implant volume, bone stock quality, and patient age were important factors affecting implant integration [7]. In our results, the resorption of β -TCP depended on both filling volume and patient's age. Altermatt et al. reported on the usefulness of TCP used to fill defects after curettage of solitary bone cysts. The grafted TCP was well incorporated but still remained 7 years after surgery [1]. In our series, rapid resorption and new bone formation were observed with the benefit of purified porous TCP. For the delayed resorption cases, long-term follow-up is needed.

Hydroxyapatite (HA), has already proved a good bone graft substitute in surgery for benign bone tumours [8, 12, 14]. The grafted HA exhibited good incorporation radio-

graphically and histologically, but still remained due to its poor resorbability. Therefore, postoperative fractures were seen in the HA or at the interface with its surroundings. Matsumine et al. reported that postoperative fractures had occurred in two patients [8]. In our study, no postoperative fractures occurred in any patients, because the material was gradually resorbed into the host bone. Ohyama et al. showed that there were no significant differences in functional stiffness between autograft and β -TCP used for packing interbody fusion cages in the canine lumbar spine [11].

β -TCP itself possessed neither intrinsic osteogenic nor osteoconductive properties. To promote biodegradation, the osteogenic activity of a composite graft of TCP and bone marrow-derived osteoprogenitor cells was examined. β -TCP blocks combined with marrow-derived osteoprogenitor cells exhibited good osteogenic activity [5]. Yamada et al. found that mesenchymal stem cells and β -TCP fibrin glue injectable admixtures resulted in bone formation [13]. If these tissue engineering techniques were applied to human bone, large bone defects could be healed quickly and less invasively.

We conclude that purified β -TCP is an ideal bone graft substitute for the treatment of benign bone tumours because of its good biocompatibility and characteristics of resorption.

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