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Research Article

Use of Hydroxyapatite Crystals to Fill the Curetted Bone Cavity in Benign Bone Tumours - A Case Series

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Abstract

We treated 11 patients with benign bone tumours by curettage and filling the defect with calcium hydroxyapatite (HA). There were 5 females and 6 males with a mean age of 24 years (8 to 55). The mean follow-up was for 9 months. Postoperative radiological assessment revealed that the implanted HA was well incorporated into the surrounding host bone in all patients. None of patients suffered any fractures in the postoperative period. One patient complained of pain associated with HA in the soft tissues, but this diminished within three months. No patient had local pain at the final follow-up. No recurrence noted in any patients. Follow up radiographs showed formation of much appositional bone. We conclude that HA is an excellent bone-graft substitute in surgery for benign bone tumours.

Keywords: Hydroxyapatite (HA); Benign; Tumour; Curettage; Lesion; Incorporation

Introduction

Pathological fractures are commonly seen in patients having benign bone tumors or tumour-like lesions because these lesions frequently deteriorate bones. There are no clear guidelines for management and follow-up for benign bone tumours. There are various treatment options such as steroid injection, surgery, or conservative management for painless benign bone lesions but still it remains a controversial issue. Nevertheless, results of a latest systematic review indicated that surgical management provided better outcomes than conservative treatment. Even though the healing rates were variable, and favourable results were seen [1]. Prevention of tumor recurrence and allowing the restoration of bone strength are the two important goals of surgery. Bigger tumours need to be filled with a graft to reduce the risk of pathological fractures [2]. A lot of controversy regarding the optimum material to fill the bone defects following curettage of bone tumors. Types of commonly used materials include cement [3], autograft [4], allograft [5-8], and bone substitutes [9-13]. Nonetheless, the pros and cons of different types of bone grafts applied during the surgery have been demonstrated. Many of basic research studies on calcium hydroxyapatite (HA) has concerned its clinical use as a bone-graft substitute. There has been excellent osteoconductive properties reported with the use of calcium hydroxyapatite in various histological [14-22]. biological [23,24]. and biomechanical surveys of its implantation into bone [25-57]. It is also used as a coating for prostheses. as well as to fill defects in bone [28-30]. However, there are few reports on the clinical outcome of its use in surgery for bone tumours [31,32].

The objective of this study was to assess the functional and radiological outcome following the use of hydroxyapatite crystals for filling the bone defects after curettage. Two major outcomes associated with bone restoration were assessed: the quality (radiographic healing status) and the efficiency (healing time) of final graft incorporation.

Patients and Methods

We conducted a retrospective study on a total of 14 patients with benign bone lesions over limbs were diagnosed at our hospital or referred from other hospitals between August 2021 and March

2022. Of those, patients undergoing surgical treatment were included in this study.

In our series, indications for surgery included the following: [1]. Patients who were at high risk for a pathological fracture; [2]. The presence of pain and disability following a pathological fracture (with a Visual Analog Scale [VAS] score greater than 5 points); [3]. Bone malignancy could not be ruled out based on imaging studies. Only 11 of 14 patients (11.95%) fulfilled the criteria were included for analysis. All patients underwent intralesional curettage procedure followed by filling the bone cavity with hydroxyapatite crystals. There were 6 males and 5 females, with a mean age of 24 (range: 8 to 55 years). The average follow-up was 9 months (range: 6 to 14 months). The most common location of tumours was the distal femur in 5 patients (45.6%), followed by the proximal humerus in 3 patients (27.3%), Fibula shaft in 2 patients (18.2%), Clavicle in 1 patient (9.1%). Various clinical parameters acquired were age, gender, tumour location, tumour length, and use of graft. Preoperatively plain films were obtained for all patients which was used to evaluate the tumour length. All the lesions were imaged by plain radiography, CT and MRI. All patients had curettage of the tumour and filling of the resulting bone defect with HA, without autologous bone.

Surgery involved intralesional curettage through a cortical window. After removal of the fluid, the fibrous membrane lining the cyst wall was curetted. Specimens were sent for histopathological analysis. After thorough curettage and pulse lavage of the lesion, packing of bone cavity with HA crystals done in a random pattern. If any sclerotic margins were identified it was drilled to establish a connection to healthy bone marrow. The cortical window was replaced after filling of the bone defect with HA. No other adjuvant treatment such as phenol or cryotherapy was used after curettage. One patient with aneurysmal bone cyst in proximal humerus developed pathological fracture for which it was supplemented with titanium elastic nail internal fixation.

The material which we used consists of hydroxyapatite compound ([Ca10(PO4)6(OH)2]) with tricalcium phosphate (TCP). The porosity was 3% to 55% and the pore size 1 to 15 m. Variously shaped pieces of HA were available in various shapes which were used in the surgeries, depending size and location of the tumour. The mass of implanted HA ranged from 5 to 60 g. Post operative radiographs were analysed to check the changes in the radiolucent zone around HA and the amount of incorporation and displacement of HA. The mean follow-up was 9 months (6 to 12). Of the 4 patients with lesions of the upper limb, all were immobilised in a sling or a splint. The mean period of immobilisation was 3 weeks. Of the 7 patients with lesions in the lower limb, 5 were immobilised in splints. The mean period of immobilisation was 3.5 weeks.

Partial weight bearing was started in the first post-operative month in those patients who had tumour in lower limbs. Serial improvement in weight bearing force was monitored and assessed through sequential X-rays during the follow-ups. Passive range-of-motion training immediately after the surgery. Postoperative follow-ups were conducted every 4 to 6 weeks, depending on the location of tumour. X-ray evaluation continued until the bone graft incorporation reached a stable status. And then, a suggested schedule for follow-up evaluation was at 12 months later.

All the post-operative radiographs were assessed for the degrees of graft filling of the bone defects. This was classified into four types based on postoperative radiographs. Grade I was defined as less than 50% filling of the graft within the bone defect. In Grade II filling was between 50% and 75%; Grade III and Grade IV were 75% to 90% and greater than 90% of filling of the bone defect.

The primary outcome was quality of bone healing status which was evaluated by X-ray imaging studies at the last follow up [33,34]. The efficiency of bone healing was on the basis of time to stable healing. Figure 1 shows an example of radiographic assessment in determining the degree of bone healing for an 15-year-old girl with fibrous dysplasia of clavicle.

Results

There were no postoperative infections reported. In all the cases, the post operative radiographs (Figure 2 and Figure 3) there was good incorporation of the implanted HA to the surrounding host bone. There was a radiolucent zones seen between the implanted HA and the surrounding cancellous bone in the radiographs obtained immediately after surgery. During the regular follow up visits of patients, it was seen that, over time, the radiolucent zones disappeared and new bone formed (Figure 4 and Figure 5). The mean period required for the zones to disappear was 5 months. There was increased density of material during the post-operative follow up x-rays, and gradually the radiolucent areas faded and margins became indistinct. No degenerative changes were noted in nearby joints during the final follow up, even in giant-cell tumours of bone in which the HA was implanted beneath the subchondral bone. In all the patients, post-operative period was uneventful and none of the patient reported of local pain at the final follow-up. Range of movement of adjacent joints were completely normal in all the patients and there were no restrictions. All patients in which lower limb was involved started full weight bearing in 6 weeks. X-rays at six months or more after surgery depicted good osteogenic activity surrounding the HA. There was no post-operative complications reported in any of the patients. One, with a solitary bone cyst in the humerus, fell eight days after surgery, and the other, a patient with a non-ossifying fibroma in the distal tibia, sustained a fracture while playing football two weeks after operation. There was no recurrences of tumour in any of the case.

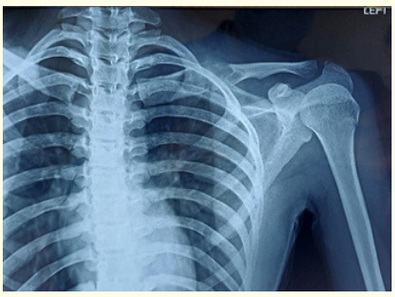

Figure 1: Preoperative image showing the lytic lesion in the clavicle.

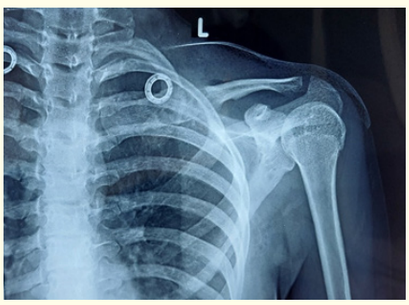

Figure 2: Post-operative X-ray after curettage and filling with HA crystals.

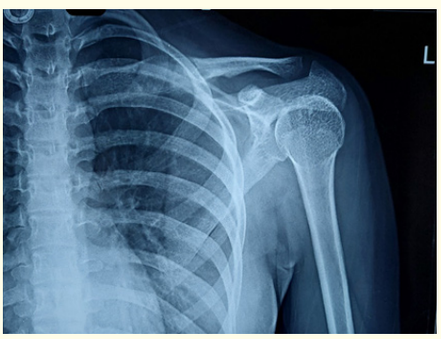

Figure 3: 6 Weeks post-operative X-ray of clavicle.

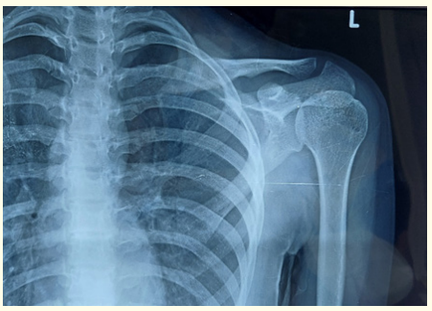

Figure 4: 3 months post-operative X-ray of clavicle showing good incorporation of HA into bone.

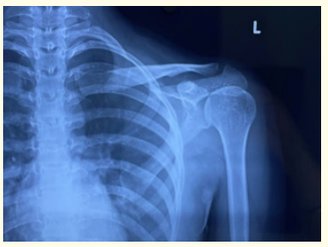

Figure 5: 6 months post-operative X-ray showing that HA has almost disappeared from the bone.

Discussion

The main fears associated with benign tumour excision are postoperative recurrence rate and bone strength [1]. Steroid injection is a method of managing a simple bone cyst, which can result in a good bone healing rate (e.g., 77.4% by methylprednisolone acetate) [35]; however, studies also reported high failure rates [36-38]. Curettage alone without an allograft or bone substitute may be used [2]. Historically, surgical curettage with bone grafting were the best choices to curtail the risk of recurrence. Two main goals after intralesional curettage and bone grafting for benign bone tumors were high quality and efficient healing. Good quality of bone healing means that the bone has healed adequately for full weight bearing and prevent from any pathological fractures. There is one published research article that declared that most bone defects after excision of benign bone tumors will consolidate without any supplementation; [2] however, this has raised the concerns about the healing quality and healing time. An autograft is an excellent material to fill the bone defect after tumour excision. The advantages of autografts have been well established. However, the only reason that limits its use to fill bone defect is insufficiency in the origin of this material. Also, increased postoperative mobility of donor site is another concern with autografts [39]. There is a study that reported reduced pain, blood loss, operating time and complication in synthetic substitutes compared with iliac crest grafts [40]. We didn't used autograft in any patient in our study. Alternatively, allografts and bone substitutes are readily available and we preferred to used them for filling large bone defects. There are several disadvantages of allografts which are reported such as transmission of disease and a relatively poor ability of incorporation [8]. Although, the bone substitute has high cost, it is widely used due to their convenience. A systematic review [11] established that the bone healing outcome were comparable between bone substitute and bone graft following surgical curettage. It is observed that the healing rate of 90% could be achieved with the use of autograft, allograft or any bone substitution material. The main challenge for orthopaedic surgeon is to treat a patient with a large tumour volume or tumour length. There are two main factors which cause this difficulty. First is curettage is performed through a small bone window. It would be very challenging to do complete excision for large

or deep-seated tumour, that subsequently could cause rise in local recurrence rate. Second, increased tumour length also could lead to more risk of preoperative pathological fracture and make the surgery more difficult. Also, the surgical time and cost will rise due to filling of a larger bone defect. There is a study by Glancy., *et al.* [4]. which reported an increased "no healing" rate for tumours with greater size after curettage and grafting for bone tumours, associated with more complications like as bone growth arrest and stress fractures. However, tumour length was not related to the time to attain a stable healing. There are many studies which reported that the longer follow up period is needed because of the higher rate of recurrence [41-43]. Minimum follow up period of at least two years will be required to report the recurrence rates and compare between the two groups of graft types [43].

There are many authors that have demonstrated that bone ingrowth into HA implanted into bone marrow in animal experiments and in biopsy specimens from patients [14-22]. Uchida., *et al.* [14]. found that bone ingrowth is better into HA with TCP than that with calcium aluminate. Holmes., *et al.* [15]. studied HA implanted into diaphyseal defects in dogs. They found that there is good incorporation of the HA and bone ingrowth into the material and there were no sign of biodegradation. In a study done by Sartoris., *et al.* [44], assessment of the radiological changes of HA used to fill the defect was done. They showed that the incorporation was excellent in most cases. Also, it was demonstrated that the intrinsic architecture of the HA was well preserved on radiographs, however the margins had become indistinct, suggestive of incomplete biodegradation of the material. There are various applications of HA in orthopaedics such as in spinal surgery, bone defects resulting from severe fractures and arthroplasty. In our series, HA was well incorporated into the surrounding host bone in all cases within a average time period of 4.5 months. The X-ray changes in the implanted HA were similar to those previously reported [16,31,44]. There was increase in density with indistinct margins on radiology after several months. The HA had not totally disappeared in any case at final follow-up. This suggests that although HA is biodegradable, it is only very slowly replaced by new bone. We implanted HA into the cavities of 5 distal femur, 3 proximal humerus, one fibula and one clavicle. Although follow-up period was short, there were no degenerative changes noted in any joint in any patients.

We found that HA is equivalent and effective compared to autologous bone grafting for tumours adjacent to joints in order to support the articular cartilage. There were no complications reported in our study. None of our patient sustained a fracture after full weight-bearing had begun. A study by Piecuch., *et al.* [27]. found that once HA became incorporated, mechanical testing demonstrated it to be as strong as normal bone. Hamson., *et al.* [26]. stated that there is no substantial difference in mechanical strength between HA and autologous cortical bone, six months after implantation. Vuola., *et al.* [25]. suggested that the compressive strength of HA was greater than bone marrow after 12 weeks. In our study, no recurrence of tumour was noted during 1 year follow up period. None of patients in our study complained of local pain at the final follow up. HA incorporation into the soft tissues can be a cause of mechanical irritation while only rarely does it cause a histological foreign-body reaction [21]. It was seen that the scattered HA vanished within few months.

Conclusion

We conclude that HA is an effective bone-graft substitute for filling the void in the surgery for benign bone tumours. Its implantation provides good osseointegration with no complications reported in our series. However, we acknowledge that the sample size of this study is small and would recommend carrying out more studies to corroborate the efficacy of the treatment.

Bibliography

1. Wu PK., *et al.* "Freezing nitrogen ethanol composite may be a viable approach for cryotherapy of human giant cell tumor of bone". *Clinical Orthopaedics and Related Research* 90 (2017): 1060e4.

2. Martti Hirn., *et al.* "Bone defects following curettage do not necessarily need augmentation". *Acta Orthopaedica* 80.1 (2009): 4-8.

3. Bini SA., *et al.* "Giant cell tumor of bone. Curettage and cement reconstruction". *Clinical Orthopaedics and Related Research* (1995): 245e50.

4. Glancy GL., *et al.* "Autograft versus allograft for benign lesions in children". *Clinical Orthopaedics and Related Research* (1991): 28e33.

5. Dion N and Sim FH. "The use of allografts in musculoskeletal oncology". *Instructional Course Lectures* 51 (2002): 499e506.

6. Lerner T., *et al.* "A level-1 pilot study to evaluate of ultraporous beta-tricalcium phosphate as a graft extender in the posterior correction of adolescent idiopathic scoliosis". *European Spine Journal* 18 (2009): 170e9.

7. Moenning JE and Wolford LM. "Coralline porous hydroxyapatite as a bone graft substitute in orthognathic surgery: 24-month follow-up results". *The International Journal of Adult Orthodontics and Orthognathic Surgery* 4 (1989): 105e17.

8. Pelker RR and Friedlaender GE. "Biomechanical aspects of bone autografts and allografts". *Orthopedic Clinics of North America* 18 (1987): 235e9.

9. Botez P. "Modern surgical treatment of aneurysmal bone cyst using a synthetic bone substitute (Ceraform, a calcium phosphate ceramic)]". *Revista Medico-Chirurgicala a Societatii de Medici si Naturalisti din Iasi* 107 (2003): 913e20.

10. Grimes JS., *et al.* "Collagen and biphasic calcium phosphate bone graft in large osseous defects". *Orthopedics* 29 (2006): 145e8.

11. Kadhim M., *et al.* "Treatment of unicameral bone cyst: systematic review and meta analysis". *Journal of Children's Orthopaedics* 8 (2014): 171e91.

12. Mankin HJ., *et al.* "The use of frozen cadaveric allografts in the management of patients with bone tumors of the extremities". *Orthopedic Clinics of North America* 18 (1987): 275e89.

13. Theologis AA., *et al.* "Spinal Deformity Study G. Type of bone graft or substitute does not affect outcome of spine fusion with instrumentation for adolescent idiopathic scoliosis". *Spine (Phila Pa 1976)* 40 (2015): 1345e51.

14. Uchida A., *et al.* "The use of ceramics for bone replacement: a comparative study of three different porous ceramics". *The Journal of Bone and Joint Surgery. British* 66-B (1984): 269-275.

15. Holmes RE., *et al.* "Porous hydroxyapatite as a bone graft substitute in diaphyseal defects: a histometric study". *Journal of Orthopaedic Research* 5 (1987): 114-121.

16. Holmes R., *et al.* "A coralline hydroxyapatite bone graft substitute: preliminary report". *Clinical Orthopaedics* 188 (1984): 252-262.

17. Shimizu T., *et al.* "Bone ingrowth into porous calcium phosphate ceramics: influence of pulsing electromagnetic field". *Journal of Orthopaedic Research* 6 (1988): 248-258.

18. Takaoka T., *et al.* "Histological and biochemical evaluation of osteogenic response in porous hydroxyapatite coated alumina ceramics". *Biomaterials* 17 (1996): 1499-1505.

19. Sempuku T., *et al.* "Osteogenic potential of allogeneic rat marrow cells in porous hydroxyapatite ceramics: a histological study". *Journal of Orthopaedic Research* 14 (1996): 907-913.

20. Buma P., *et al.* "Histological and biomechanical analysis of bone and interface reactions around hydroxyapatite-coated intramedullary implants of different stiffness: a pilot study on the goat". *Biomaterials* 18 (1997): 1251-1260.

21. Suominen EA., *et al.* "Hydroxyapatiteglass composite as a bone substitute in large metaphyseal cavities in rabbits". *International Orthopaedics* 19 (1995): 167-173.

22. Overgaard S., *et al.* "Hydroxyapatite and fluorapatite coatings for fixation of weight loaded implants". *Clinical Orthopaedics* 336 (1997): 286-296.

23. Takahashi T., *et al.* "Use of porous hydroxyapatite graft containing recombinant human bone morphogenetic protein-2 for cervical fusion in a caprine model". *Journal of Neurosurgery* 90 (1999): 224-30.

24. Sun JS., *et al.* "The influence of hydroxyapatite particles on osteoclast cell activities". *Journal of Biomedical Materials Research* 45 (1999): 311-321.

25. Wilke A., *et al.* "Biocompatibility analysis of different biomaterials in human bone marrow cell cultures". *Journal of Biomedical Materials Research* 40 (1998): 301-306.

26. Vuola J., *et al.* "Compressive strength of calcium carbonate and hydroxyapatite implants after bonemarrow-induced osteogenesis". *Biomaterials* 19 (1998): 223-227.

27. Hamson KR., *et al.* "Preliminary experience with a novel model assessing *in vivo* mechanical strength of bone grafts and substitute materials". *Calcified Tissue International* 57 (1995): 64-68.

28. Piecuch JF., *et al.* "Compressive strength of implanted porous replamineform hydroxyapatite". *Journal of Biomedical Materials Research* 18 (1984): 39-45.

29. D'Lima DD., *et al.* "Omnifit-HA stem in total hip arthroplasty: a 2- to 5-year follow-up". *Clinical Orthopaedics* 363 (1999): 163-169.

30. Tonino AJ., *et al.* "Hydroxyapatite-coated femoral stems: histology and histomorphometry around five components retrieved at postmortem". *The Journal of Bone and Joint Surgery. British* 81-B (1999): 148-154.

31. Regner L., *et al.* "Ceramic coating improves tibial component fixation in total knee arthroplasty". *The Journal of Arthroplasty* 13 (1998): 882-889.

32. Uchida A., *et al.* "The use of calcium hydroxyapatite ceramic in bone tumour surgery". *The Journal of Bone and Joint Surgery. British* 72-B (1990): 298-302.

33. Uchida A., *et al.* "Slow release of anticancer drugs from porous calcium hydroxyapatite ceramic". *Journal of Orthopaedic Research* 10 (1992): 440-445

34. Cho HS., *et al.* "Minimal invasive surgery for unicameral bone cyst using demineralized bone matrix: a case series". *BMC Musculoskeletal Disorders* 13 (2012): 134.

35. Kaczmarczyk J., *et al.* "Complete twelve-month bone remodeling with a bi-phasic injectable bone substitute in benign bone tumors: a prospective pilot study". *BMC Musculoskeletal Disorders* 16 (2015): 369.

36. Oppenheim W and Galleno H. "Operative treatment versus steroid injection in the management of unicameral bone cysts". *Journal of Pediatric Orthopaedics* 4 (1984): 1e7.

37. Scaglietti O., *et al.* "Final results obtained in the treatment of bone cysts with methylprednisolone acetate (depo-medrol) and a discussion of results achieved in other bone lesions". *Clinical Orthopaedics and Related Research* (1982): 33e42.

38. Sung AD., *et al.* "Unicameral bone cyst: a retrospective study of three surgical treatments". *Clinical Orthopaedics and Related Research* 466 (2008): 2519e26.

39. Shih HN., *et al.* "Reconstructing humerus defects after tumor resection using an intramedullary cortical allograft strut". *Chang Gung Medical Journal* 25 (2002): 656e63.

40. Campanacci M., *et al.* "Unicameral and aneurysmal bone cysts". *Clinical Orthopaedics and Related Research* 204 (1986): 25e36.

41. Lerner T., *et al.* "A level-1 pilot study to evaluate of ultraporous beta-tricalcium phosphate as a graft extender in the posterior correction of adolescent idiopathic scoliosis". *European Spine Journal* 18 (2009): 170e9.

42. Aboulafia AJ., *et al.* "Begnign bone tumors of childhood". *Journal of the American Academy of Orthopaedic Surgeons* 7 (1999): 377e88.

43. Copley L and Dormans JP. "Benign pediatric bone tumors. Evaluation and treatment". *Pediatric Clinics of North America* 43 (1996): 949e66.

44. Gibbs Jr CP., *et al.* "Aneurysmal bone cyst of the extremities. Factors related to local recurrence after curettage with a high-speed burr". *Journal of Bone and Joint Surgery America* 81 (1999): 1671e8.

45. Sartoris DJ., *et al.* "Coralline hydroxyapatite bone graft substitutes: preliminary report of radiographic evaluation". *Radiology* 159 (1986): 133-137.