

Fate Of Hydroxyapatite Crystals Used As Bone Graft Substitute In Benign Lytic Lesions Of Long Bones

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Abstract

Background: Benign lytic lesions of bone most commonly treated with curettage which creates defect. Defects are usually filled with autogenous bone graft. Alternatively hydroxyapatite crystals may be used to overcome the donor site morbidity of autogenous bone grafting. Our purpose of study was to depict the fate of hydroxyapatite crystals in these lesions.

Method : We treated 5 cases of giant cell tumour, 5 cases of simple bone cyst and 2 case of aneurysmal bone cyst, who presented with lytic lesion of long bones, by curettage alone and application of hydroxyapatite crystals. The patients were selected according to inclusion and exclusion criteria's. These patients were followed up for 36 month. Radiographic evaluation was done according to IRWIN grading, stage I (obvious margins), stage II (hazy margins) and stage III (obvious incorporation).

Observation: We found no rejection of implanted hydroxyapatite crystals. In maximum of 13 month all cases show incorporation of hydroxyapatite crystals to host bone. Out of 12 cases final Irwin grading was III in 10 cases(83.33%) and II in 2(16.67%) cases. Absorption of hydroxyapatite crystals is very slow process, even in three year follow up, very little hydroxyapatite crystals was absorbed. Union and remodelling of bone in pathological fracture was normal. There was no collapse of graft on weight bearing. During followup period, haematological and blood biochemical parameters stayed within normal limit. No long term complication seen in any case with hydroxyapatite crystals except recurrence of tumour seen in two cases. Conclusion: Hydroxyapatite crystals are slowly absorbed by body. Bone ingrowth and bone formation around the hydroxyapatite crystals are excellent. Hydroxyapatite crystals have great biological safety, good biocompatibility & good bone conduction.

INTRODUCTION

Smaller benign lytic lesion which are not causing symptom may be left as such with regular follow up or may be merely treated with curettage alone. In moderate size lesion after curettage significant volume of bony defect may be produced, if left uncared may lead to complications like pathological fracture. Then it become essential to fill the defect with bone graft, bone graft substitute or bone cement with internal fixation if required.

Bone graft may be autogenous or allogenic .Autogenous bone graft is an ideal bone graft having osteogenic, osteoconductive and osteoinductive potential. Donor site morbidity such as hernia, neurovascular injury, infection, haematoma formation and chronic pain are well known complication of autogenous bone graft as well as it is limited in quantity ^{7,8} Allogenic bone graft after processing is used in large scale with very good results. It also has osteoconductive and osteoinductive potential. Allogenic

bone graft use associated with significant resorption and remodeling of graft and has high infection rate.

In adult skeleton bone cement provide good instant stability but doesn't provide biological reconstruction. Bone cement appears to be well tolerated in long bone¹² , but problem may occur in case of osteolysis, tumour recurrence or if the patient develops osteoarthritis and joint arthroplasty becomes necessary¹³. In growing bones, use of non resorbable cement affects skeletal growth. So in paediatric age group autologous bone graft or biocompatible bone graft substitute resembling physiological bone should be used such as hydroxyapatite.⁶

Hydroxyapatite crystals are cheap, easily available bone graft substitute. It has pure osteoconductive property, there by creating suitable environment for new bone formation. The large surface area provided by it enhances ingrowth and new bone formation. For osteoinduction potential (Bone

Morphogenic Protein, Pletlets Derived Growth Factors etc) it depends on the host which are provided by haemopoetic cells of surrounding marrow. They are increasingly used as an alternative to fill tumor defect, tibial platue fracture, spinal fusion, scoliosis surgery etc.⁸

The study was conducted to observe the fate and sequential changes occurring in hydroxyapatite crystals during its incorporation to host bone, and time taken to achieve different stages of incorporation

METHOD & MATERIAL

Between 2005 -2010, 12 patient with benign lytic lesion of long bone were treated by curettage and hydroxyapatite crystal grafting.. The patients of benign lytic lesion were selected as per inclusion and exclusion criteria:

INCLUSION CRITERION

1. Benign tumors confined to the bone with without pathological fracture.

EXCLUSION CRITERIA

1. Very large benign tumor,
2. Diagnosed or suspected malignant tumour
3. Bone loss due to traumatic event
4. Active infection

Patient was evaluated clinicoradiologically. FNAC and biopsy was done to confirm the diagnosis. Standard surgical principles & approach were used to expose the site. Cortical window in the defect were made equal to size of defect to facilitate through intralesional curettage with minimal disturbance to periosteum. Defect was packed completely with hydroxyapatite crystals blocks. 1 case of pathological fracture was internally fixed. Postoperatively limb was individualized on the basis of site and size of lesion.

Radiographic evaluation was done on following criteria:

1. Changes in radiolucent line around hydroxyapatite crystals,
2. Incorporation of hydroxyapatite crystals block
3. Displacement or dislocation of implant
4. Restoration of cortical integrity

Radiographic staging of graft done according to IRWIN

grading¹⁰:

- Stage I (obvious margin),
- Stage II (hazy margin) and
- Stage III (obvious incorporation)

Patients were followed at 6 weeks, 3 months, 6 months and yearly interval thereafter. Findings were noted as per improvement in radiological status and Irwin staging¹⁰.

RESULTS

12 cases were enrolled out of which 5 were giant cell tumour, 5 of simple bone cyst, and 2 of aneurysmal bone cyst s. Maximum patients were in the age group of 0-10 years (33.33%). 75% the patients were males and 25% were females. Most common site of involvement was femur (41.67%) All the patients were treated by curettage and hydroxyapatite crystal grafting. External support was given as per requirement on case to case basis. The total follow up period was 36 month. Radiolucent zone around the hydroxyapatite crystals tended to decrease with time... Blocks and granule of hydroxyapatite crystals seem to become attached to each other with time. These finding were interpreted as evidence of bone regeneration around and within the hydroxyapatite crystals. There was no disturbance of growth plate even if the hydroxyapatite crystals were implanted in very close proximity. In maximal of 13 months followup all cases showed very good incorporation of hydroxyapatite crystals to host bone. 9 out of 12 cases (75%%) achieved Irwin grading of III, rest 3 were graded as II (75%)

Hydroxyapatite crystals resorption and biodegradation was very slow process. In three year follow-up very little hydroxyapatite crystals were absorbed. Many cases show no obvious evidence of biodegradation of hydroxyapatite crystals. No remodeling of hydroxyapatite crystals occurred. There was no collapse of graft on weight bearing.

There was no rejection of implanted hydroxyapatite crystals . In 2 cases there was discharge from wound in post operative period which subsided on antibiotic treatment. No toxic effect of implant was detected and there was no abnormal laboratory finding.

Cases with pathological fracture united well with no delay in actual expected union time. Remodeling was excellent in most of cases.

Two cases, one of aneurysmal bone cyst and other of giant cell tumour show recurrence of tumor. No other long term complication seen

DISCUSSION

Bone defect caused by curettage of benign lesion of bone have been filled with autogenous or allogenic bone graft for long time . The disadvantages of both can be eliminated by biocompatible bone graft substitute with its limitation¹⁴. The aim of filling defect is to reestablish skeletal stability and bone morphology without compromising axial growth, joint function and overall morbidity.

Once the hydroxyapatite crystals are placed in the cavity, the process of calcium sulphate resorption is initiated leaving behind 3-dimensional construct of hydroxyapatite crystals. It is believed that calcium sulphate is replaced by newly formed bone , in a process called CREEPING SUBSTITUTION, by which resorption takes place at same rate as consecutive bone ingrowth. Calcium sulphate which is known to support the ingress of blood vessels and osteogenic cells, act as space filler, and by doing so prevent the ingrowth of fibrous tissue¹. During the process hydroxyapatite crystals function as scaffolding, which provide temporary structural stability. The highly crystalline porous hydroxyapatite crystals scaffolding is brittle and carries little tensile strength .⁹ But ingrowth and overlay of new bone on the trabeculae of these render a more dense structure and once incorporated these become actually stronger than bone they replace.¹⁶

Radiographic observation after implantation show evidence of abundant bone formation , around the hydroxyapatite crystals with good incorporation to host bone. In maximum of 13 month all cases show good incorporation to host bone. These radiographic results are generally consistent with the studies of Sartorius et al 1986¹⁵, Bucholz et al 1987² and Yamamota et al 2000.²⁰

It has been shown that hydroxyapatite crystals is essentially a non-degradable, with resorption rate of only 5-15 % per year¹⁹. In our study the rate hydroxyapatite crystals resorption was very slow and no remodeling of implant occurred. In three year follow-up very little hydroxyapatite crystals resorbed. And in many cases, there was no obvious evidence of biodegradation of hydroxyapatite crystals. Uchida et al (1990)¹⁸ in there study found no obvious sign of biodegradation of hydroxyapatite crystals even in five year followup.

Yamamota et al 2000²⁰ also observed that it is only very slowly replaced by new bone. In the study of Saikia et al (2008)¹⁷ hydroxyapatite crystals never completely disappeared and remained un-remodeled even after long period of implantation.

We did not observe any immunogenic reaction or foreign body reaction to hydroxyapatite crystals. Hydroxyapatite crystals are non toxic substance which provoke little reaction from tissue and have many properties, both chemical and physical, that make them suitable alternative to bone graft. The biological compatibility of hydroxyapatite crystals to bone and bone marrow has been demonstrated in animal experiments of Bhaskar et al 1971⁴, Cameron et al 1977⁵, and Jarcho 1981¹¹.

Recurrence of bone tumor was seen in two cases. In our series we did not used any adjuvant therapy, it may be reason of recurrence of lesions.

CONCLUSION

Our conclusions are that hydroxyapatite crystals is non degradable, with very low resorption rate. We should be expectant of bony reunion till 13-14 weeks in case the radiographs are showing regression. Bone ingrowth and bone formation around the hydroxyapatite crystals is usually excellent. Hydroxyapatite crystals have great biological safety, good biocompatibility and good bone conduction.

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