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A CLINICO-RADIOLOGICAL STUDY OF ROLE OF HYDROXY APATITE (G -BONE) AND MIXED GRAFT (AUTOGRAFT+G-BONE) IN TREATMENT OF BENIGN LYTIC LESION OF BONE

Orthopaedics

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ABSTRACT

Benign lytic bone lesions, though non-malignant, can cause significant morbidity if left untreated .These lesions represent approximately 79.3% of musculoskeletal tumors, with a slight female predominance. Surgical intervention is often required to prevent pathological fractures and manage persistent pain or functional impairment .This study investigates the effectiveness of hydroxyapatite (G-Bone) and mixed grafts (auto graft + G-Bone) in managing these lesions. Conventional treatment includes curettage and bone grafting, often using auto grafts or allografts. However, the limitations associated with these grafts, such as limited availability and donor site morbidity, have led to the exploration of synthetic alternatives like hydroxyapatite (G-Bone). This study aims to evaluate the clinical and radiological outcomes of using hydroxyapatite and mixed grafts in the management of benign lytic bone lesions. Evaluation and assessment of curettage and bone grafting [G bone and mixed graft] outcomes in the treatment of benign lytic lesions of bone. In this prospective study, 20 patients (11 males, 9 females) aged 2-50 years, with a mean age of 15.05 years, diagnosed with benign lytic bone lesions underwent curettage followed by implantation of hydroxyapatite granules or a mixed graft. The choice of graft was randomized. The lesions included giant cell tumors, aneurysmal bone cysts, simple bone cysts, fibrous dysplasia, chondromyxoid fibroma, and chronic fibrotic lesions. The outcomes were assessed radiologically and functionally over an average follow-up of 8.53 months using standard clinical and imaging criteria. The majority of patients regained normal activity without pain at the surgical site after an average of three months. Radiological healing was observed in most cases, with functional outcomes rated as excellent or good. The most common complication was joint stiffness. Of the 20 patients, 1 patient in the hydroxyapatite group and 4 in the mixed graft group showed early radiological healing (stage 1). Most patients returned to normal activities within three months, with no pain at the surgical site. Functional outcomes were excellent in 1 hydroxyapatite and 8 mixed graft cases, good in 3 hydroxyapatite and 3 mixed graft cases, and fair in 4 hydroxyapatite and 1 mixed graft cases. Joint stiffness was the most common complication. The study demonstrates that hydroxyapatite and mixed grafts are effective in promoting bone healing and restoring function in patients with benign lytic bone lesions. The mixed grafts, combining the benefits of autografts and synthetic materials, showed particularly promising results in terms of functional outcomes. However, the incidence of joint stiffness suggests that further optimization of surgical techniques may be necessary. Hydroxyapatite and mixed grafts offer reliable options for the treatment of benign lytic bone lesions, with both showing favorable radiological and functional outcomes. These grafts are safe, effective, and may reduce the complications associated with traditional auto grafting.

KEYWORDS

Benign Lytic Bone Lesions, Hydroxyapatite, Bone Graft, Autograft, Orthopedic Surgery

1. INTRODUCTION

1.1 Background

Even in today's advanced surgical landscape, bone tumors present the most formidable challenge for orthopedic surgeons.[1]Bone tumors, though rare with only 0.5% of total cancer cases worldwide, have a profound impact on the quality of life of those affected. Benign bone tumors make up approximately 79.3% of total musculoskeletal tumors, slightly having females predominance. Conversely, malignant tumors represent 20.7% of cases, with a higher prevalence among males. This impact is exacerbated in developing countries due to restricted access to diagnostic and treatment resources, as well as delayed diagnosis and presentation.[2]

The biological behaviour of benign bone tumors might be latent, active, or aggressive which determines the course of treatment. The most crucial diagnostic tool is conventional radiology, and comprehensive systemic analysis is required for final confirmation. Options for treatment vary from surgery to observation. The biological activity and the histological kind determine how benign lytic lesions of the bone should be treated..[4]Biological reconstruction requires a significant volume of bone transplant..[5] Numerous therapeutic approaches have been documented to reduce the likelihood of recurrence following surgical excision of benign bone cysts. Using curettage and a local autologous cancellous bone graft or mixed graft as treatments, we assessed the local tumour control, recurrence rate, and bone healing of benign bone cysts in this study. .[10] The purpose of this study is to evaluate the effectiveness of hydroxyapatite crystals alone and in combination with autogenous bone graft to treat benign lytic lesions of the bone. Benign lytic bone lesions are frequently observed in clinical practice and frequently provide difficulties for a precise diagnosis and efficient treatment. On radiographs, these lesions, which can result from a number of benign disorders like giant cell tumours, fibrous dysplasia, or unicameral bone cysts, can seem like patches of destroyed bone.[12]. Despite their benign nature, these lesions can lead to significant complications, including pain, pathological fractures, and impaired function, thereby necessitating appropriate management strategies [13].The current approaches to managing benign lytic bone lesions vary widely, ranging from observation and activity modification to surgical interventions like curettage and bone grafting [14]. This variability in treatment is influenced by several factors, including the lesion's type, size, location, patient age, and risk of fracture [15].

1.2 Problem Statement

Consequently, the lack of standardized guidelines can result in inconsistent outcomes and challenges clinicians in selecting the most appropriate management strategy for each patient.Despite advancements in imaging and surgical techniques, there is still no consensus on the optimal management of these lesions. Critical questions remain, such as when surgical intervention is necessary, which lesions are at the highest risk for fracture, and what are the long-term outcomes of different treatment modalities [16]. There is a pressing need for more standardized guidelines to assist clinicians in making informed decisions that effectively balance the risks and benefits of various management options [17].This research aims to address these challenges by reviewing the current literature on the management of benign lytic bone lesions, evaluating the effectiveness of different treatment approaches, identifying factors that influence treatment decisions, and developing evidence-based guidelines to improve patient outcomes. By doing so, the research hopes to provide clearer pathways for clinicians and enhance the quality of care for patients with these lesions

2. Objectives

1. Primary Objective: Evaluation and assessment of curettage and bone grafting [G bone and mixed graft] outcomes in the treatment of benign lytic lesions of bone.

2. Secondary Objective: To observe the acceptance of graft (Clinical and radiological assessment of two group) and Observation of complications between two group.

3. MATERIAL AND METHODS

3.1 Study Design

This study was designed as a prospective observational study conducted over a period from Dec 2022 to July 2024 in the Department of Orthopedics, GSVM Medical College, Kanpur.

Sample Selection:

A) Inclusion Criteria:

- All the cases of Benign tumor confined to anatomical limits of bone with / without pathological fracture from 2 to 50ys

B) Exclusion Criteria:

- Age <2yrs and >50yrs,Suspected /Diagnosed malignancy, Traumatic bone defect and Active infection.

3.2 Study Population

3.3 Treatment Protocols

After taking informed written consent, the patient was operated using standard approaches and principles. Cortical window of a size equal to the largest dimension of the lytic lesion was created over the lesion. The cavity and the walls were thoroughly curetted to remove all the tumor tissue. The shape and size of HA blocks were modified according to the need. After curettage, the cavity was treated with hydrogen peroxide,[11] thus making curettage an extended one. No other adjuvant[12,13] was used to treat the cavity. Defect was packed completely with HA blocks, and the periosteum was opposed. Wherever periosteal coverage was not sufficient, the soft tissues were opposed to cover the grafted material. Every attempt was made to prevent granules from spilling into the subcutaneous tissue. Internal fixation was not done for immobilization except in one case

Figure 1:12yr Male GCT With Disatl Tibia Left Side Post Curettage And Filling With G Bone

Figure 2: Intra Op Image Of 12yr Male With GCT Disatl Tibia Left Side Post Curettage And Filling With G Bone

Postoperative immobilization was individualized according to site and size of the lesion in the form of plaster cast or internal fixation if need. All the patients were protected from weight bearing for 6–16 weeks. Regular postoperative followup was done clinically and radiologically at 0, 1, 3, 6, 12, months and annually thereafter. The following observations were made: (a) Healing of fracture site (b) Architecture of amorphous HA blocks which include margin definition (c) Number of surfaces in contact with the surrounding bone (which correlated with osteointegration) (d) Radiological evaluation of graft incorporation was done according to the criterion of Irwin et al. (2001)

Table 3- IRWIN'S Radiological Staging.

STAGE	Radiological zone between the bone cavity and graft	Intrinsic graft indistinctiveness	Graft margins
I	Present	Distinct	Obvious
II	Indistinct	Indistinct	Hazy
III	Indistinct/ Disappearance	Indistinct/ disappearance	Obvious incorporation

Functional assessment was done as per natrajan et al

Final assessment will be done the basis of following criteria:

Table 4- Natrajan Clinical Criteria

GRADE	REQUIREMENT
EXCELLENT	Normal Strength / Functional Limb, Normal activity / Life style. Pain free complete healing
Good	United / Strength, Mild Incapacity, daily activities.
FAIR	Pain free / Partial healing. Severe limitations Strength brace / Cane / Crutches required Restricted capacity Daily Activities.
FAILURE	Graft Rejection / Amputation / Non – Union / Recurrence

3.5 Statistical Analysis

Data were analyzed. Categorical variables were expressed as frequencies and percentages and analyzed using chi-square tests . A p-value of <0.05 was considered statistically significant . Multivariate logistic regression was employed to identify predictors of union and functional outcomes .

4. RESULTS

Of the 20 patients, 1 patient in the hydroxyapatite group and 4 in the mixed graft group showed early radiological healing (stage 1). Most patients returned to normal activities within three months, with no pain at the surgical site. Functional outcomes were excellent in 1 hydroxyapatite and 8 mixed graft cases, good in 3 hydroxyapatite and 3 mixed graft cases, and fair in 4 hydroxyapatite and 1 mixed graft cases. Joint stiffness was the most common complication.

Diagnosis : GCT Distal Humerus Right Side

Table 11- Analysis Of Radiological Outcome.

	IRWIN STAGE I	IRWIN STAGE II	IRWIN STAGE III
G BONE	1	3	7
MIXED GRAFTING	4	3	2

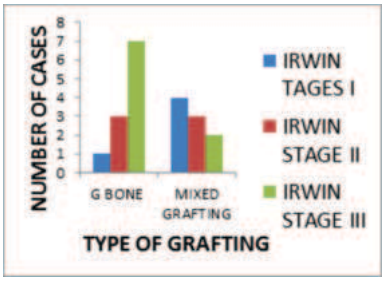

Figure 11- Analysis Of Radiological Outcome.

Table 12- Analysis Of Functional Outcome.

HEALING STATUS	COMPLETE	INCOMPLETE
G BONE	8	4
MIXED GRAFTING	1	7

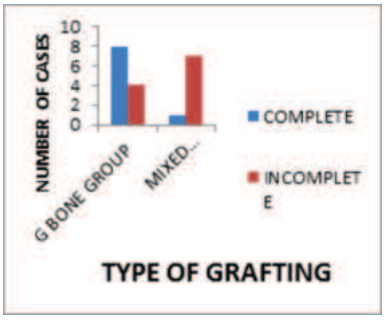

Figure 12- Analysis Of Functional Outcome.

In maximal of 12 months followup, all cases showed very good (combined Irwin grade II and III in different areas) incorporation of HA crystals to host bone.

Local recurrence occurred in 10.0% cases (n = 4). Infection rate was 7.5% (n = 3). Deformity occurred 2.0% cases (n = 1). No case of graft rejection, graft collapse or nonunion was found. Knee joint motion was restricted in 5.0% cases (n = 2). Extravasation of graft occurred in 5.0% (n = 2) cases at the time of operation which ultimately got incorporated with the main graft.

5. DISCUSSION

5.1 Interpretation of Results and Comparison with Previous Studies

Benign and low-grade malignant lytic bone tumors are typically treated through curettage, followed by filling the defect with a bone graft or synthetic bone void filler. This approach encourages healing and restores bone strength[18],[19]. In some cases, internal fixation is necessary, especially when fractures are imminent. Bone grafting's main goal is to fully fill the defect, facilitating bone growth into the cavity due to the osteogenic, osteoinductive, and osteoconductive properties of the graft materials[20]. Autologous bone grafts, considered the gold standard, offer excellent biological properties but are associated with significant donor-site morbidity, including infections, hematomas, neurovascular injuries, delayed wound healing[25].

The lack of a widely available ideal bone graft substitute continues to hinder advancements in the surgical management of benign bone tumors. In response, biocompatible bone graft substitutes like calcium hydroxyapatite and tricalcium phosphate are increasingly used as alternatives to autogenous bone grafts.[21] These materials are favored due to their ease of use and lack of the adverse effects typically seen with autografts[24]

Demographics

In this study, 20 cases were analyzed, with patient ages ranging from 2 to 50 years (mean age = 15.5 years). Of these, 11 were male and 9 were female. Comparative studies have shown similar distributions, such as those by Saikia et al. (2008)[18] Gupta et al. (2015)[19], and Karem et al. (2018)[20], though age ranges and gender distributions have varied slightly across studies.

Types of Lesions

The study primarily involved Giant Cell Tumors (GCT) (n=6), followed by Aneurysmal Bone Cysts (ABC) (n=4), Simple Bone Cysts (SBC) (n=5), Fibrous Dysplasia (FD) (n=1), Chondromyxoid Fibroma (CMF) (n=1), and Chondroblastoma (CFT) (n=3). Similar patterns have been observed in previous studies by Saikia et al. (2008)[18] and Allam AS (2014)[25].

Site of Lesion

The most common lesion sites in this study were the proximal femur (n=5), followed by the proximal humerus (n=3), distal femur (n=1), and distal tibia (n=3). This aligns with findings from other studies, such as those by Schindler et al. (2008)[24] and Datta NK et al. (2010)[26], where the femur and tibia were frequently affected.

Bone Formation and Radiological Incorporation

Radiological assessment remains the preferred method for evaluating bone growth into graft material, as histological evaluation would require multiple biopsies, which is impractical. In this study, the disappearance of radiolucent zones around the graft material was used to assess consolidation and bony incorporation. However, the dense radiographic appearance of calcium hydroxyapatite can sometimes create a misleading impression of mechanical strength due to its brittle nature.

Adequate stabilization of the surrounding bone is crucial to avoid excessive loading during bone ingrowth. This study kept such considerations in mind by applying protective splintage and delaying weight-bearing activities. Early incorporation was observed in younger patients, while middle-aged and older patients exhibited slower incorporation rates. Most patients reached Irwin's Stage II within 3-9 months and progressed to Stage III over 6-12 months.

Complications

The most common complication was limited joint range of motion, primarily due to soft tissue adhesions rather than hydroxyapatite-induced fibrosis or arthritis. Physiotherapy helped restore joint mobility in most patients. Other complications included mild

infections, managed with antibiotics, and one case of graft fracture due to a fall in a pediatric patient. Previous studies, such as those by Allam AS (2014) [25], reported similar complications, including temporary joint stiffness and low-grade infections.

In summary, while calcium hydroxyapatite and mixed bone grafts provide a viable alternative to autografts in the management of benign bone tumors, their effectiveness and complications vary based on factors like patient age, lesion type, and surgical technique. Proper handling of the graft material and post-operative management, including physiotherapy, are key to optimizing outcome

5.3 Limitations of the Study

- As it was a follow up study high chance of lost to follow up and average duration of follow up is also not comparable

Small Sample Size

- Although extended curettage of the tumour was done using hydrogen peroxide or phenol which deduce recurrence better adjuvant agents like liquid nitrogen, heat cauterisation with electrocutery, argon beam coagulation and polymethyl-methacrylate could have been used.
- Functional outcome will be affected by using internal fixation.

6. CONCLUSION

Results of our study on the role of hydroxyapatite and mixed bone graft in surgical management of benign lytic lesions of bone has led us to conclude that they are both useful and safe bone substitutes in the treatment of benign and locally aggressive bone tumours.

The various reasons behind this are as follows:-

- Hydroxyapatite crystals are easy to manufacture. Its preservation is also very easy. Because of these, it can be made available in abundant quantities.
- It does not cause any adverse reaction like any allergic reaction or any allergic reaction.
- It has excellent biocompatibility. It gets readily incorporated in the bone.
- There is no risk of transmission of disease.
- It has got good adjustment of shape depending on the shape of the bony cavities, left after curettage of the lesion, thereby allowing us to use in various lesions.
- Biodegradation of hydroxyapatite in the body is very low. This allows proper time for osteoconduction and hence osseointegration. A significant association exists between radiological staging at final follow up and duration of follow up and age of the patients.

Because of all the reasons cited above, it is emerging as a good and safe alternative to autografts and allografts.

Mixed bone graft (autogenous bone graft mixed with hydroxyapatite crystals) is however of immense importance in cases requiring large amount of graft since as compared to autograft specially in paediatic group:
Mixed bone graft provides relatively larger amount of graft with lesser morbidity. Also the basic advantages of osteoconduction, osteoinduction as well as osteogenesis are incorporated in mixed bone graft.

Curettage and grafting is an effective and widely accepted treatment method for benign lytic bone lesions. Most patients experience significant pain relief and functional improvement postoperatively. While the recurrence rate is low, it varies depending on the type of lesion. Lesions such as giant cell tumors may have higher recurrence rates, necessitating close follow-up and sometimes additional interventions. The choice between autograft, allograft, and synthetic grafts depends on various factors, including the size of the defect, patient preference, and surgeon experience. Autografts are considered the gold standard due to their osteogenic properties, but synthetic materials and allografts are also widely used with good results. The risk of complications can be minimized through careful surgical technique and appropriate patient selection. Overall, patients tend to have good functional outcomes and satisfaction with the procedure. Rehabilitation and physical therapy play important roles in optimizing recovery and function.

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