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RESEARCH ARTICLE

INJECTABLE BONE GRAFT AND ALLOGRAFT BONE CHIPS IN THE TREATMENT OF BENIGN BONE LESION

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Abstract

This study aimed to compare the efficacy of injectable bone grafts and allograft bone chips in the treatment of benign bone lesions. A total of 34 patients were included, with varying types and locations of lesions. The results showed no significant differences between the two groups in terms of age, gender, lesions type, diagnosis, site of the lesion, and bone leakage. However, the remodelling time was significantly shorter in the injectables group (5+3 months) than in the bone chips group (12+5 months). This study contributes to the understanding of the benefits and limitations of different bone grafting techniques for the treatment of benign bone lesions.

Introduction:-

In a general orthopaedic and orthopaedic oncology practice, benign bone lesionsand cysts are rather common phenomena. Lesions having a wide range of clinical behaviours and natural histories fall within this broad group. Therefore, each patient's treatment needs to be customised based on their unique medical history, specific tissue diagnosis, lesion size, location, accompanying symptoms, and risk of pathological fracture [1].

The typical therapeutic strategy for the surgical treatment of benign bone lesions and tumour-like lesions entails open surgery intralesional curettage with or without the use of adjuvant treatment techniques, such as cavity burring with a mechanical burr, phenolization, sclerotherapy, or cryotherapy, to further reduce potentially lingering tumour cells [2, 3].The remaining bone cavity is typically filled and impacted with either autograft bone—iliac crest autograft being the generally acknowledged gold standard—or an allograft, such as bone chips or bone substitute materials, to avoid potential donor site morbidities and quantity restrictions related to autograft bone retrieval. Calcium phosphates and calcium sulphates are frequently utilised as bone replacements for the restoration of defects. [4].

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Following tumour and tumour like lesions excision, Bone grafting acts as osteocondutive, osteoinductive and structural support. It can be challenging to evaluate the radiological results of grafting. It is unknown how much bone is required for a satisfactory outcome. Although new methods for quantifying bone repair must be developed, a functional evaluation remains the most effective way to judge results [5].

The rate at which the graft is incorporated into the host bone is one of the key elements in assessing the quality of bone graft alternatives. Given that the patient must undergo a separate surgery for a bone sample, histologic assessment is seen to be impracticable even if it offers an effective estimate of the rate of graft integration. Radiographic examination offers an alternative to histology study, however there are no established, standardised assessment criteria for radiographic investigation of bone graft integration in the literature [4, 6].

Study Rationale

Benign bone lesions are frequently treated surgically by intralesional excision with grafting. Injectable bone graft and bone chips both have been both reported in the treatment of benign bone lesions.

Study Objective:-

The current study aims to compare injectable bone graft and bone chips in the treatment of benign bone lesions.

Literature Review:-

Hall et al., conducted a similar study,in (2019), but in a canines, about healing bone lesion defects using injectable CaSO4 /CaPO4 -TCP bone graft substitute compared to cancellous allograft bone chips. The study reported that, after all three time points, defects treated with cancellous bone allograft had less bone than defects treated with the CaSO4/CaPO4-TCP bone graft substitute; the difference after 13 weeks, however, was statistically significant ($p = 0.025$). At 13 ($p = 0.046$) and 26 weeks ($p = 0.025$), the new bone in defects treated with the CaSO4/CaPO4-TCP bone graft substitute was significantly stronger and stiffer than the new bone in defects treated with cancellous bone allograft. At 26 weeks, all defects treated with CaSO4/CaPO4-TCP bone graft substitute had fully healed with new bone, whereas all defects treated with cancellous allograft chips had only partially healed [7].

A Retrospective analysis was performed on 98 patients with benign bone lesions who had undergone intralesional excision using bone graft replacements. At the most recent follow-up, functional scores utilising the International Symposium of Limb Salvage (ISOLS) approach were obtained. 28.3 out of 30 was the average functional score (94%). Three patients had fractures that eventually recovered with treatment. No local recurrences occurred [8].

Another study on 18 patients treated with BCBS for benign bone lesions reported that, 4 individuals reported local recurrence. Nine out of thirteen patients had a characteristic bone remodelling pattern seen on follow-up X-rays and magnetic resonance imaging that showed a double-line phenomena and steadily rising cortical thickness one year following therapy. One patient underwent BCBS removal and lavage due to a septic surgical complication, which is an example of a surgical issue. Two other patients had extended wound secretion, while one patient developed superficial surgical site irritation with redness and swelling [9].

A study conducted to evaluate factors potentially affecting the quality and efficiency of graft healing included 84 patients with simple bone cysts who had undergone lesions excision and filling of the bone defects with grafts reported that, Age and gender had no effect on how quickly bones healed. Neither the radiologic healing status nor the time to stable healing were substantially linked with the graft type. Only two of the assessed variables had a meaningful correlation to the prognosis: (1) Lesions location: Complete healing was substantially more likely for those with lesions at the proximal femur. (Neer I). (2) Lesions length: Complete healing was approximately five times more likely to occur in people with lesions that were less than 6.2 cm in length. Time to stable healing was influenced by the degree to which bone defects were filled with graft. For filling degrees below 90% and over 90%, the average healing periods were 4.86 and 5.94 months, respectively ($p = 0.009$). Refracture after surgery happened in one instance [10].

Methodology:-

A retrospective record-based study was conducted in Riyadh, KSA, during the period from 1st of Jan 2017 to August 2022. Convenience sampling was used, and all valid and complete records of radiology from Prince Sultan Military Medical City were included in the study.

Data collection
Data was collected using a predesigned data collection proforma from the hospital recordsduring the data collection period. The collected data included sociodemographic characteristics of participants (gender, age, marital status, educational and working status), as well as data regarding surgery (type of surgery, type of graft used, intra and post-operative complications, radiological features before and post-surgery).

Selection criteria
The inclusion criteria:
Patients with benign and benign aggressive bone lesions aged 1-70 years old, treated with either injectable bone graft or allograft bone chips.

Exclusion criteria:
Patients with benign bone lesions treated with autograft or without bone graft and patients with malignant bone tumors.

Data management
After data was collected, revised, coded, and fed to statistical software IBM SPSS version 22 (SPSS, Inc. Chicago, IL), all statistical analyses were done using two-tailed tests. A P value less than 0.05 was considered statistically significant. Descriptive analysis based on frequency and percent distribution was done for all variables including demographic data, co-morbidities, and surgical outcomes. Significance of relations in cross tabulation was tested using exact probability test (due to small frequencies).

Ethical considerations
Ethical considerations were taken into account, and approval to conduct the study was obtained from the Research Ethics committee in Prince Sultan Military Medical City. The study was record-based, and no direct interaction with patients was needed. There were no biological samples in this study, and the collected data was totally de-identified since names and specific addresses of the participants were not required. Data was safeguarded until group statistical analysis and publication, and access was only allowed for the authors of the study. There was no conflict of interest.

Results:-
Table 1 summarizes the characteristics of the benign bone lesions in the study population, with a total of 34 patients. The mean age of patients was 24 years with a standard deviation of 12. The majority of the patients were male (73.5%). The most common lesions types were cystic (32.4%) and chondrogenic (20.6%). The most frequent diagnosis was ABC (17.6%) followed by chondroblastoma (14.7%). The femur was the most commonly affected site (32.4%), followed by the tibia (20.6%). Half of the patients received injectable bone grafts during the surgical procedure, while the other half received bone chips. leakage of the bone graft was reported in only 5.9% of all cases, and the mean resorption and remodeling times were 3 weeks and 9 months, respectively. Overall, the study population had a diverse range of benign bone tumors, with varying types and locations.

The results presented in Table 2& figure 1 provide information on the characteristics of benign bone lesions in association with the type of bone graft used. A total of 34 patients were included in the study, and the table presents data on various parameters such as age, gender, lesions type, diagnosis, site of the lesion, leakage, resorption time, and remodelling time.

The age of the patients in the bone chips and injectables groups was 22±11 and 26±13 years, respectively, with no significant difference between the two groups. The gender distribution showed that 82.4% of the bone chips group and 64.7% of the injectables group were male, but this difference was not statistically significant.

Regarding the lesion type, there were no significant differences between the two groups for chondrogenic, cystic, fibrous, misc, and osteoblastoma lesions. The same trend was observed for the diagnosis of the lesions, with no significant differences between the two groups for ABC, chondroblastoma, chondromyxoid fibroma, enchondroma, fibrous dysplasia, ganglion cyst, giant cell tumor, interosseous lipoma, nonossifying fibroma, osteioidosteoma, osteoblastoma, simple cyst, and unicameral bone cyst.

There were also no significant differences between the two groups for the site of the lesion and bone leakage. However, the remodelling time was significantly shorter in the injectables group (5+3 months) than in the bone chips group (12+5 months).

Table 1:- Characters of the benign bone lesions among the study population (n=34).

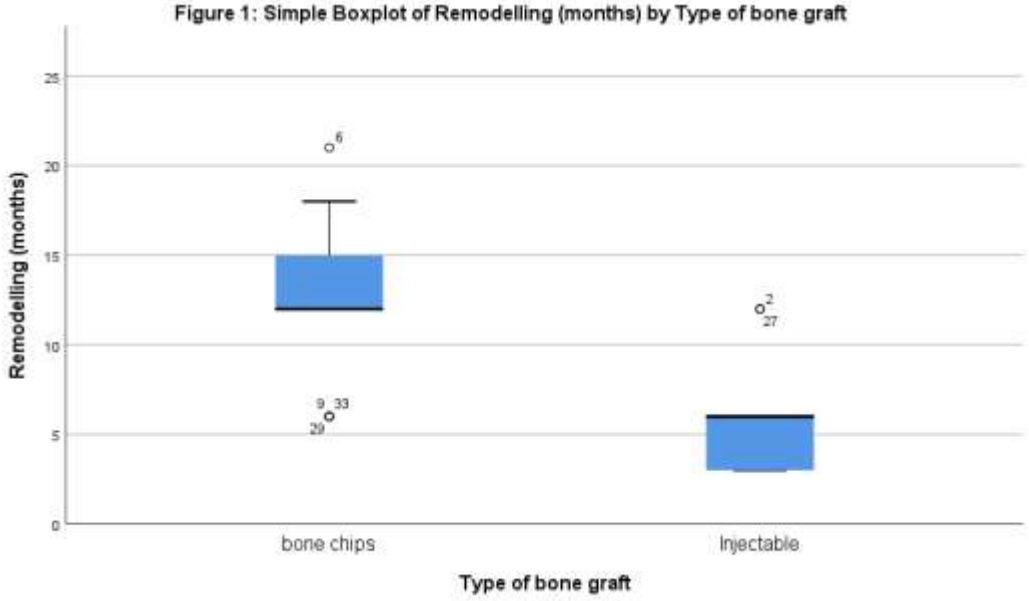
Parameter		**Freq (%) / Mean + SD**
Age		24 + 12
Gender	**Female**	9 (26.5%)
	Male	25 (73.5%)
Tumour type	**Chondrogenic**	7 (20.6%)
	Cystic	11 (32.4%)
	Fibrous	4 (11.8%)
	Misc	5 (14.7%)
	Osteogenic	7 (20.6%)
Diagnosis	**ABC**	6 (17.6%)
	Chondroblastoma	5 (14.7%)
	Chondromyxoid fibroma	1 (2.9%)
	Enchondroma	1 (2.9%)
	Fibrous dysplasia	3 (8.8%)
	Ganglion cyst	1 (2.9%)
	Giant cell tumor	2 (5.9%)
	Interosseous lipoma	3 (8.8%)
	Nonossifying fibroma	4 (11.8%)
	Osteioidosteoma	1 (2.9%)
	Osteoblastoma	3 (8.8%)
	Simple cyst	2 (5.9%)
	Unicameral bone cyst	2 (5.9%)
Site	**Calcaneum**	2 (5.9%)
	Femur	11 (32.4%)
	Fibula	2 (5.9%)
	Humerus	6 (17.6%)
	Metatarsal	1 (2.9%)
	Patella	1 (2.9%)
	Radius	3 (8.8%)
	Talus	1 (2.9%)
	Tibia	7 (20.6%)
Type of bone graft	**Bone chips**	17 (50%)
	Injectables	17 (50%)
Leakage of bone graft	**No**	32 (94.1%)
	Yes	2 (5.9%)
Resorption (weeks)		3 + 2
Remodelling (months)		9 + 5

Table 2:- Characters of the benign bone lesions in association with type of bone graft (n=34).

Parameter		**Type of bone graft**		**P-value**
		Bone chips	**Injectables**	
Age		22 + 11	26 + 13	0.345
Gender	**Female**	3 (17.6%)	6 (35.3%)	0.244
	Male	14 (82.4%)	11 (64.7%)	
Tumour type	**Chondrogenic**	3 (17.6%)	4 (23.5%)	0.966
	Cystic	5 (29.4%)	6 (35.3%)	
	Fibrous	2 (11.8%)	2 (11.8%)	
	Misc	3 (17.6%)	2 (11.8%)	
	Osteogenic	4 (23.5%)	3 (17.6%)	

Diagnosis	**ABC**	3 (17.6%)	3 (17.6%)	0.309
	Chondroblastoma	3 (17.6%)	2 (11.8%)	
	Chondromyxoid fibroma	0 (0%)	1 (5.9%)	
	Enchondroma	0 (0%)	1 (5.9%)	
	Fibrous dysplasia	2 (11.8%)	1 (5.9%)	
	Ganglion cyst	0 (0%)	1 (5.9%)	
	Giant cell tumor	0 (0%)	2 (11.8%)	
	Interosseous lipoma	3 (17.6%)	0 (0%)	
	Nonossifying fibroma	2 (11.8%)	2 (11.8%)	
	Osteioidosteoma	0 (0%)	1 (5.9%)	
	Osteoblastoma	2 (11.8%)	1 (5.9%)	
	Simple cyst	0 (0%)	2 (11.8%)	
	Unicameral bone cyst	2 (11.8%)	0 (0%)	
Site	**Calcaneum**	2 (11.8%)	0 (0%)	0.423
	Femur	7 (41.2%)	4 (23.5%)	
	Fibula	1 (5.9%)	1 (5.9%)	
	Humerus	2 (11.8%)	4 (23.5%)	
	Metatarsal	1 (5.9%)	0 (0%)	
	Patella	1 (5.9%)	0 (0%)	
	Radius	1 (5.9%)	2 (11.8%)	
	Talus	0 (0%)	1 (5.9%)	
	Tibia	2 (11.8%)	5 (29.4%)	
Leakage	**No**	15 (88.2%)	17 (100%)	0.145
	Yes	2 (11.8%)	0 (0%)	
Resorption (weeks)		3 + 2	3 + 2	0.708
Remodelling (months)		12 + 5	5 + 3	0.000
Chi-square test was used for categorical variables. One-way ANOVA test was used for numerical variables.				

Figure 1: Simple Boxplot of Remodelling (months) by Type of bone graft



Discussion:-

Bone grafting is an essential surgical technique in orthopaedic surgery, which is used to treat many conditions such as non-union, bone defects, and spinal fusions [11]. A bone graft is defined as a surgical procedure in which a surgeon transplants bone tissue from one part of the body or from a donor to another site [12]. The bone graft

procedure aims to promote bone growth and regeneration by providing a structural matrix for new bone formation [11. 13]. Bone grafts can be divided into two main categories: autografts, which are derived from the patient's own bone, and allografts, which are derived from donors [14]. Autografts are considered the gold standard, but allografts are widely used due to their availability and lower morbidity rates [15]. Another type of bone graft is synthetic bone grafts, which are made of various materials such as ceramics, polymers, and metals. In recent years, bone graft substitutes have gained popularity due to their ease of use and availability [16].

Bone grafting is used to treat many benign bone lesions such as cystic lesions, enchondromas, and non-ossifying fibromas. These benign bone lesions are common in young adults and children, and they are mostly asymptomatic. However, they can cause pain, deformity, and fractures. Surgical treatment is indicated when the lesion is symptomatic, enlarging, or at risk of fracture [17].

The purpose of this study is to compare the remodelling time of bone grafting using bone chips and injectable bone grafts in the treatment of benign bone lesions. We aimed to evaluate the demographic data, tumour type, diagnosis, site, bone leakage, resorption, and remodelling time in association with the type of bone graft used.

The study population consisted of 34 patients with a mean age of 24 years, and the majority of the patients were male. The most common lesions types were cystic and chondrogenic, and the most frequent diagnosis was ABC. The femur was the most commonly affected site, followed by the tibia. Half of the patients received bone grafts during the surgical procedure, while the other half did not. Bone leakage was reported in only 5.9% of cases, and the mean resorption and remodeling times were 3 weeks and 9 months, respectively. The age of the patients in the bone chips and injectables groups was not significantly different. There were no significant differences between the two groups for chondrogenic, cystic, fibrous, misc, and osteogenic lesions. The same trend was observed for the diagnosis of the lesions. There were also no significant differences between the two groups for the site of the lesion and bone leakage. However, the remodeling time was significantly shorter in the injectables group than in the bone chips group.

Similar to our findings, Hall et al. [7], reported that, at all three time points, there was more bone in lesions treated with the CaSO4 /CaPO4 -TCP bone graft substitute matched to lesions treated with cancellous bone allograft, and the difference at 13 weeks was significant.The new bone was meaningfully stronger and stiffer in lesions treated with the CaSO4 /CaPO4 -TCP bone graft equated to lesions treated with cancellous bone allograft at 13 and 26 weeks. At 26 weeks, all lesions treated with CaSO4 /CaPO4 -TCP bone graft provedwhole healing with new bone, while healing was inadequate in all lesions treated with cancellous allograft chips [7].

A study performed a retrospective analysis of 98 patients with benign bone tumors who had undergone intralesional excision using bone graft replacements[8]. At the most recent follow-up, functional scores utilizing the International Symposium of Limb Salvage (ISOLS) approach were obtained. The average functional score was 28.3 out of 30 (94%), and there were no local recurrences. In comparison, our study aimed to compare the use of injectable bone grafts and bone chips in the treatment of benign bone tumors. While we did not measure functional scores, we did report on various parameters such as age, gender, lesions type, diagnosis, site of the lesion, bone leakage, resorption time, and remodeling time. Our findings showed no significant differences between the two groups for most parameters, except for the remodeling time, which was significantly shorter in the injectables group than in the bone chips group.

The study of Wu et al. aimed to evaluate factors potentially affecting the quality and efficiency of graft healing [10]. The study included 84 patients with simple bone cysts who had undergone lesions excision and filling of the bone defects with grafts. The study found that age and gender had no effect on how quickly bones healed, and the time to stable healing was influenced by the degree to which bone defects were filled with graft. In comparison, our study did not find any significant differences between the two groups based on age, gender, lesions type, diagnosis, site of the lesion, and leakage. However, we did find a significant difference in the remodeling time between the injectables and bone chips groups.

In summary, our study aimed to compare the use of injectable bone grafts and bone chips in the treatment of benign bone tumors, and we reported on various parameters such as age, gender, lesions type, diagnosis, site of the lesion, leakage, resorption time, and remodeling time. We found no significant differences between the two groups for most parameters, except for the remodeling time, which was significantly shorter in the injectables group than in the bone

chips group. Our findings differ from the study of Döring et al. [9], which reported instances of local recurrence, extended wound secretion, and surgical complications. However, our study did report leakage in only 5.9% of cases, and the mean resorption and remodeling times were 3 weeks and 9 months, respectively. Our findings also align with the Wu et al. study, which found that age and gender had no effect on how quickly bones healed, and the time to stable healing was influenced by the degree to which bone defects were filled with graft.

Strengths

The study includes a diverse range of benign bone tumors, providing a more comprehensive understanding of the effectiveness of bone grafting techniques. The sample size is appropriate for this type of study, and statistical analysis was used to evaluate the differences between the two groups.

Limitations

The study is limited by its retrospective design, which may introduce bias and confounding factors. The follow-up period was relatively short, and long-term outcomes could not be evaluated.

Recommendations:-

Future studies should consider a larger sample size and a longer follow-up period to evaluate the long-term efficacy of bone grafting techniques for benign bone lesions.

Conclusion:-

The study found that both injectable bone grafts and bone chips were effective in the treatment of benign bone lesions, with no significant differences in most parameters. However, injectable bone grafts were associated with a significantly shorter remodelling time. This study provides valuable insights into the use of different bone grafting techniques for the treatment of benign bone lesions.

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