Acta Scientific Orthopaedics (ISSN: 2581-8635)

Volume 5 Issue 8 August 2022

Research Article

The Need of Filling of Bone Defects After Curettage of Benign Bone Tumors

Ismail Tawfeek Abdelaziz[1], Ahmed El-Badawy Mahmoud Shahin[1], Ahmed Mohammed Ahmed Fawzy El-Beheiry[1] and Bola Adel Alfy Hakim[2]*

[1]*MD of Orthopedic Surgery, Horus Specialized Hospital, Luxor, Egypt*

[2]*MSc of Orthopedic Surgery, Horus Specialized Hospital, Luxor, Egypt*

***Corresponding Author:** Bola Adel Alfy Hakim, MSc of Orthopedic Surgery, Horus Specialized Hospital, Luxor, Egypt.

DOI: 10.31080/ASOR.2022.05.0533

Received: May 16, 2022

Published: July 15, 2022

Abstract

Background: Benign bone tumors regularly weaken bones and predispose patients to pathological fractures. Benign lytic bone lesions such as Simple Bone Cyst, Non-Ossifying Fibroma, Fibrous Dysplasia, etc. most often affect younger individuals.

Treatment includes observation, injection of bone marrow or demineralized bone matrix, curettage blended with bone or synthetic grafting, decompression with intramedullary nailing or cannulated screw, or a mixture of these approaches.

This study aims to clinical and radiological evaluation of benign bone tumors after curettage with or without filling of bone defects.

Patients and Methods: This is a retrospective study diagnosed as benign bone tumors who underwent curettage (with or without grafting or filling) during the surgical treatment, operated between Jan 2017 and Feb 2021. Lesions' size (length, width, and depth) was measured on plain radiographs using the image j program. When applicable, the degrees of filling of the resultant cavity were classified into four categories according to Modified Neer's classification. Functional evaluation using the musculoskeletal tumor society (MSTS) score was also reviewed

Results: 41 patients were included in this study, 19 male (46.3%) and 22 female (53.7%) ranged from 3 to 53 years old with a mean age of 22.83 ± 13 years.

Extended curettage was done in 32 cases (78%). Hydrogen peroxide was used in 34 cases (82.9%). High-speed burr was performed in 34 cases (82.9%). Filling materials were mainly bone cement in 13 cases (31.7%) and Autograft in 7 cases (17.1%), while 21 cases (51.2%) were without any filling material.

Cystic lesions were mainly centric, while NOFs and GCTs were mainly eccentric. Most benign tumors expressed cortical involvement, while UBCs didn't. The lesion size varies according to its type.

51% of cases were not filled with any type of fillers, 32% were filled with cement, and 17% with autograft. This depends on many variables such as Skeletal maturity, Lesion centricity, Cortical breakdown, curettage, and age.

Conclusion: Filling defects resulting from curettage of benign bone tumors by autograft showed the best results. Better results are obtained while using plate osteosynthesis.

Level of evidence: Level III, retrospective.

Keywords: Enneking; Benign Bone Tumors; Filler; Surgical Interventions; Extended Curettage; Giant Cell Tumor; Simple Bone Cyst; Non-Ossifying Fibroma; Osteolytic; Bone Defects

Introduction

Benign bone tumors regularly weaken bones and predispose patients to pathological fractures [1]. Benign lytic bone lesions such as Simple Bone Cyst (SBC), Non-Ossifying Fibroma (NOF), Fibrous Dysplasia (FD), etc. most often affect younger individuals. Generally asymptomatic, these lesions typically stabilize or resolve after skeletal maturity. Because of this, surgery usually is not required unless the lesion's size predisposes to pathologic fracture, at which point curettage and grafting are the standard treatmentsr [2].

Treatment modalities for painless benign bone tumors such as SBC remain a controversial issue [1]. Currently, treatment of benign bone cysts includes observation, injection of bone marrow or demineralized bone matrix, curettage blended with bone or synthetic grafting, decompression with intramedullary nailing or cannulated screw, or a mixture of these approaches [3].

The goal of the surgical intervention is to prevent tumor recurrence and allow the restoration of bone strength [4]. Jeys., *et al*. reported that tumor carries a high risk for pathological fracture if there's a destruction of more than 54% of the bone cortex [5]. Thus, filling of the bone defects after tumor curettage is currently the most popular approach [6].

Filling of the resultant cavity after removal of the pathological tissues is not continually indispensable and recovery of the cavity can occur within the average time [7].

We hypothesized that in some benign bone tumors, filling the resultant cavity after curettage is not mandatory. Accordingly, this study was conducted to evaluate benign bone tumors after curettage with or without filling of bone defects.

Patient and Methods

This is a retrospective study of patients with benign bone tumors who underwent surgical treatment. The study was conducted after the approval of the institutional review board of our university and written informed consent from patients. Patients diagnosed as benign bone tumors according to the Enneking classification [8] who underwent simple or extended curettage (with or without grafting or filling) during the surgical treatment, operated between Jan 2017 and Feb 2021 with a minimum follow up 6 months were included in the study. Patients with a benign tumor in the axial skeleton, tumor-like condition, or grade one chondrosarcoma and who underwent curettage were excluded. Moreover, patients who received a local injection, radiofrequency ablation, or had no surgical intervention were excluded.

A review of the medical records of the patients was done. The collected data included history and physical examination, demographic data, radiological evaluation (preoperative and postoperative radiographs, CT and MRI if available), tumor diagnosis that was confirmed histologically postoperatively, site of the lesion type, and cause of surgical intervention, methods of fixation if used, type of curettage either simple or extended using a high-speed burr, method of filling of the resultant cavity if done, complications, need of reoperation, any recurrence. Functional evaluation using the musculoskeletal tumor society (MSTS) score was also reviewed.

Extended curettage through a large cortical window to allow full exposure to the lesion. The tumor tissue was removed using different size curettes, further extension using high-speed burr together with lavage of the cavity to dislodge the remaining tumor tissue, the adjuvant and/or filler was used.

Lesions' size (length, width, and depth) was measured on plain radiographs. For those with pathological fractures, measurements were done on the immediate postoperative radiographs. Measurements of the lesion length and width were done on anteroposterior radiographs and the depth of the lesion was measured in lateral view using the widest diameter. Measurements were done on calibrated images using the image j program.

When applicable, the degrees of filling of the resultant cavity were classified into four categories according to Modified Neer's classification [18,19] based on the final postoperative radiographs.

Statistical analysis

IBM SPSS version 25.0 (SPSS Inc., Armonk, NY) was used for the statistical analysis of data. Categorical variables were compared using the Chi-square or Fisher's exact tests, when appropriate. Continuous variables were compared using the student's t-test or one-way ANOVA, when appropriate. Statistical significance was set at a P-value of less than 0.05.

Results

41 patients were included in this study, 19 male (46.3%) and 22 female (53.7%) ranged from 3 to 53 years old with a mean age

of 22.83 ± 13 years. 19 patients were skeletally immature (46.3%), while 22 patients were skeletally mature (53.7%).

The most common presenting symptom was pain in 38 patients (92.68%), followed by swelling in 30 patients (73.17%), then limping in 22 patients (53.66%), and pathological fractures presented in 13 patients (31.7%). Those symptoms are in proportion to the total number of cases in this study, which is 41, hence, to have a more accurate result of limping symptoms it is 22 patients in proportion to 26 patients presented with lower limb tumors which are 84.62%.

Symptom's duration ranged from acute cases; 0 months, up to 6 months, with a mean duration of 2.87 ± 1.89 months. 18 patients were affected on the left side (43.9%), while 23 were on the right side (56.1%). 15 patients were affected in the upper limb (36.6%), while 26 in the lower limb (63.4%).

The most common affected bone was femur in 12 patients (29.3%), followed by tibia and phalanges with 8 patients in each one (19.5% for each one). The most common location within long bones was metaphysis in 29 patients (70.73%), whether alone or in combination with other locations.

Most cases were primary, 40 cases (97.6%), while only 1 case was recurrent (2.4%). Preoperative CT was done in 9 cases (22.5%). Preoperative MRI was done in 28 cases (68.3%). Bone scan was done only in 1 case (2.4%).

Measurements of the lesions on plain radiographs at the time of trauma, or on the immediate postoperative radiographs for those who underwent surgical interventions for displaced fractures. Length and width were measured on anteroposterior radiographs and depth of the lesion were measured in lateral view, widest diameter was taken, measurement was done on calibrated images using the image j program. The mean length of the lesions was 35.39 ± 13.02 mm (range, 10 - 100), the width was 23.88 ± 7.23 mm (range, 6- 70), and the depth was 21.29 ± 8.43 mm (range, 6 - 60).

All cases included in this study were osteolytic lesions. 23 cases had centric lesions (56.1%), while 18 cases were eccentric (43.9%). In 39 cases (95.1%) there was no periosteal reaction, while it was present in only 2 cases (4.9%). In 25 cases (61%), there was cortical involvement, while in 16 cases (39%) there was not any cortical involvement.

Extended curettage was done in 32 cases (78%), while simple curettage in 9 cases (22%). Hydrogen peroxide was used in 34 cases (82.9%), while it wasn't used in 7 cases (17.1%). High-speed burr was performed in 34 cases (82.9%), while it was not performed in 7 cases (17.1%). Filling materials were mainly bone cement in 13 cases (31.7%) and Autograft in 7 cases (17.1%), while 21 cases (51.2%) were without any filling material. The average age of cases managed by filling using bone cement is 30.77 years and which managed by filling with autograft is 19.43 years. The average age of cases managed without filling is 19.1 years.

Methods of fixations were variable according to the lesion characteristics, its site, and additional fillings. We considered non-implant-based treatment when using cast (3 cases), slab (4 cases), or arm sling (1 case), and pinning using K-wires (8 cases) or plates osteosynthesis (11 cases).

Discussion

Filling of bone defects after curettage of benign bone tumors occurs using; bone autografts, bone graft substitutes, allografts, bone cement, or even nothing according to each case [9].

In this study, the epidemiological, clinical, and demographic data of 41 cases we assessed. The type of curettage, the effect of filling a cavity after curettage of benign bone tumor and method of fixation and their relations to the healing process, the MSTS that reflects the patient's satisfaction, and the presence of complications.

The age range for the patients in this study further confirms the belief that benign bone tumors are predominantly a disease of the younger population. The mean age was 22.829 ranged from 3 to 53. 90% of patients were younger than 40 years while only 10% were over 40 years old. This mean age nearly coincides with the study made by J. Kim., *et al*. which was 30.4 years ranged from 2 to 64 [10]. Also coincides with SU Eyesan., *et al*. a study in which the mean age was 26.4 ranged from 2 to 44 [11].

Darwish., *et al*. showed that 66.67% of patients in their study were skeletally immature [12], while in this study only 46.3% of patients were skeletally immature.

The most common presentation was pain (92.68%) followed by swelling (73.17%) which coincides with Moretti [1] and Aboulafia [13], while Bashaireh said that the most common presentation was swelling (43.3%) followed by pain (36.2%) [14].

Limbing represents 84.62% of the presenting symptoms in lower limb patients which gives attention to abnormal gait to request all needed radiological investigations and not to depend on only clinical data.

The most commonly affected bones are the femur and tibia (48.8%) which coincides with the results in the Kindblom study [15]. The most common location of long bone affection was metaphysis which coincides with the results of benign bone tumor locations in Joyce., *et al*. study [16].

In this study, 97.6% of cases were primary which coincides with the results of Darwish., *et al.* [12], a study that shows that 97% of cases were primary.

Preoperative CT was done in 22.5% of cases while preoperative MRI was done in 68.3% of cases this is due to the superiority of MRI over CT in assessing tumors which coincides with Ladd., *et al*. [17], and Klaus., *et al*. [3].

The lesion size in this study nearly coincides with the results presented by other articles, such as; the mean maximum diameter (in mm) of the lesions in this study was 35.39 ± 13.02 and of Limaiem., *et al*. study [28] that was 35 mm. Other articles showed larger size as in Kundu., *et al.* [29], study it was 51 mm. Cystic lesions were mainly centric, while NOFs and GCTs were mainly eccentric which coincides with Sobti., *et al*. [18], and Georg., *et al*. [19], studies.

The lesion size in this study played a major role in our results. We classified our results according to the lesion size (in cm^3) into 2 groups, the 1st one consists of the patients who have lesions larger than 30 cm^3 and the other one of the patients who have lesions smaller than 30 cm^3.

We also divided patients into another 2 groups according to the maximum length diameter (in cm). The 1st one consists of the lesions larger than 4 cm and the other one of the lesions smaller than 4 cm. We could gain very useful results through those classifications.

We noticed that extended curettage was done in all lesions larger than 30 cm^3 and in 75% of lesions less than 30 cm^3. Also, it was done in 89.5% of lesions with maximum length more than 4 cm and in 68.2% of lesions with maximum length less than 4 cm.

No filling after curettage was done in 63.6% of lesions less than 30 cm^3, but it wasn't done in lesions larger than 30 cm^3. No filling of the resultant cavity was done in 68.2% of lesions with maximum length less than 4 cm and in 31.6% of lesions with maximum length more than 4 cm.

Bone cement was used in 15.1% of lesions less than 30 cm^3, and in all lesions larger than 30 cm^3. It was used also in 18.2% of lesions with maximum length less than 4 cm and in 47.4% of lesions with maximum length more than 4 cm.

Utilizing bone graft after curettage was done in 21.1% of lesions less than 30 cm^3, and it wasn't done in lesions larger than 30 cm^3. Bone graft was used in 13.7% of lesions with maximum length less than 4 cm and in 21.1% of lesions with maximum length more than 4 cm.

Filling the resultant cavity either by bone cement, autograft, or even without any filler is statistically significant in accordance to the lesion size whether it's larger or smaller than 30 cm^3 with p-value 0.0004 and nearly significant according to maximum diameter if it's more or less than 4 cm with p-value 0.056.

No implant was used in 57.6% of lesions less than 30 cm^3, and in 37.5% of lesions larger than 30 cm^3. Also, in 54.5% of lesions with maximum length less than 4 cm and in 52.7% of lesions with maximum length more than 4 cm.

Pinning was done in 21.2% of lesions less than 30 cm^3, and in 12.5% of lesions larger than 30 cm^3. Also, in 27.3% of lesions with maximum length less than 4 cm and in 10.5% of lesions with maximum length more than 4 cm.

ORIF using plate and screws was done in 21.2% of lesions less than 30 cm^3, and in 50% of lesions larger than 30 cm^3. Also, in 18.2% of lesions with maximum length less than 4 cm and in 36.8% of lesions with maximum length more than 4 cm.

No complications occurred in 84.8% of lesions less than 30 cm^3, and in 87.5% of lesions larger than 30 cm^3. Also, in 81.8% of lesions with maximum length less than 4 cm and in 89.5% of lesions with maximum length more than 4 cm.

Two cases complained of malunion and both of them had lesions less than 30 cm^3, with maximum length less than 4 cm. Two cases showed recurrence and both of them had lesions less than 30 cm^3, with maximum length of one of them is more than 4 cm and the other was less. Mild osteoarthritis was present in one case that had lesion larger than 30 cm^3, with maximum length more than 4 cm. Partial injury of medial planter nerve was present in one case that had lesion less than 30 cm^3, with maximum length less than 4 cm.

Complete healing in Modified Neer's classification occurred in 76.2% of lesions less than 30 cm^3, also in 66.7% of lesions with maximum length less than 4 cm and in 40% of lesions with maximum length more than 4 cm.

Partial healing in Modified Neer's classification occurred in 22.8% of lesions less than 30 cm^3, also in 33.33% of lesions with maximum length less than 4 cm and in 60% of lesions with maximum length more than 4 cm.

Lesions less than 30 cm^3 weren't filled and showed 19% complications (9.5% recurrence). This is much higher than the results done by Hirn., *et al*. study [3] which was only 3.45%.

Hirn., *et al*. [3], also said that it is better to fill the resultant cavity if it's more than 60 cm^3 to avoid pathological fractures. In our study, all cases more than 30 cm^3 were filled with bone cement without any pathological fracture.

About 51% of cases were not filled with any type of fillers, 32% were filled with cement, and 17% with autograft. This depends on many variables as follows

- Skeletal maturity, in this study, most patients who were skeletally immature were mainly managed either without filling or with autograft filling, While the mature patients were mainly managed with either without filling or with bone cement filling.
- Lesion Centricity, in this study, centric lesions were mainly managed by non-filling or through filling with autograft, while eccentric lesions were mainly managed with bone cement. This result was statistically significant.
- Cortical breakdown, non-filling was done whether there is a breakdown or not. Autograft or cement was used more in the condition of the presence of cortical breakdown.
- Curettage, no case managed with simple curettage was filled with cement.
- Age, the mean age of patients with lesions filled with cement was higher than those with autograft or without any filler.

The mean age of ABC was 16.4 years which almost coincides with the results of Sasaki's results [20] which was 17.9 years. The mean age of UBC was 12.67 years which coincides with Jin Li., *et al.* [21], results which were 12.1years. The mean age of chondroblastoma was 15 years which coincides with Wang., *et al.* [22], results which were 13 years. The mean age of enchondroma was 32.67 years while it was 44.1 years in Pan., *et al*. [23], study. The mean age of GCT was 34.56 years which coincides with Lin., *et al*. results [24], which was 35.1 years.

Most cases were right-sided (56.1%) which doesn't coincide with Bashaireh., *et al.* results [14], which was (53.7%) on the left side.

The most common benign bone tumor in this study was ABC (24.4%), then Enchondroma (22%) and GCT (22%), then UBC (14.6%), which doesn't coincide with David., *et al*. [25], study in which the most common tumor was osteochondroma (35%), followed by GCT (20%), then Osteoblastoma (14%) and partially coincides with the results done in Mexico by Leticia., *et al.* [26], that showed that the most common benign bone tumor was osteochondroma (43.7%) followed by GCT (14.6%) and enchondroma (10.1%).this may be attributed to the inclusion of patients with lesions that received curettage.

In this study, cases presented with pathological fracture were 31.7% of cases which coincides with Leticia., *et al.* [26], study.

Duration of symptoms was variable in this study with an average of 2.87 months. Most of the other studies showed higher results as in Faten., *et al*. study [27], which was 6 months, also Jahanbakhsh et al. study [28], showed an average of 17 months.

The follow-up duration ranged from 6 to 42 months in this study with a mean follow-up of 17.9 months which coincides with June., *et al.* study [10], which showed a follow-up range from 3 to 46 months and a mean of 17.3 months, also with Barry et al. results [29], that was 15.4 months.

The average MSTS at the last follow-up was 28.71 which coincides with the results made by Hazem., *et al*. [30], which was 28.6, and with Walid., *et al*. study [31], that was 27.6.

According to Modified Neer's classification, 13 cases were excluded from the 41 cases in this study. The results showed 57.14% of cases were grade I and 42.86% were grade II which coincide with Wu., *et al*. [6], results showing 60.7% grade I, 29.8% grade II and 7.1% grade III.

In this study, 6 cases (14.63%) expressed complications, 2 of them were recurrence, 2 malunion and deformity, 1 partial injury to the medial plantar nerve, and 1 osteoarthritis. Other literature varies in the incidence of complications Gortzak., *et al*. [32], results showed complications in 5.9% while Gupta., *et al*. [33], showed complications in 23.68%.

There were no complications with simple curettage, while they occurred in 6 cases of 32 cases managed by extended curettage.

Complications occurred in both filling and non-filling with statistical insignificance. But filling with autograft didn't show any complications which don't coincide with the results of Kai., *et al*. study [7], which showed filling with cement has lesser complications than autograft.

Complications did not occur with all cases managed with plates osteosynthesis which indicates that better results are obtained while using ORIF. This coincides with the results obtained from René., *et al*. study [34].

Complications related to enchondroma (2 cases), malunion, and deformity occurred, both of them were in phalanges in which extended curettage was done and high-speed burr was used. This may be due to proximity to the joints with the previous history of pathological fracture and thinning of the cortices after extended curettage.

Modified Neer's classification was grade I (healed) in most cases managed with extended curettage in comparison to simple curettage which coincides with Kar., *et al*. [35], results that showed that more aggressive treatment might be necessary for the management of benign tumors to minimize the risk of recurrence.

Also, it was grade I in most cases managed without filling which coincides with the results of Martti., *et al*. [5] results that focused on the natural healing ability of bone without any adjuvant filling.

Method of fixation has no relation to the healing ability; this may be due to the nature of bone itself that doesn't conflict with the method of fixation.

Most cases managed without implants or using pinning were treated by extended curettage while cases managed using plate osteosynthesis were managed by simple curettage which was statistically significant.

The mean MSTS was lower while using H_2O_2 which doesn't coincide with the results of Georg., *et al*. [36], which shows a higher MSTS while using H_2O_2.

The mean MSTS is much higher with autograft than using bone cement or in case of no filling. This coincides with the results presented by Kai., *et al*. [7].

Conclusion

The type of filling depends on many variables such as 1) Skeletal maturity, 2) Lesion centricity, 3) Cortical breakdown, 4) type of curettage, 5) age, 6) type of tumor, and 7) size of tumor. Also, the larger the lesion size the more need to fill the cavity aiming to gain better results. We found that filling defects resulting from curettage of benign bone tumors by autograft showed the best results.

Demographics and clinical data	patients (n=41)				
	No	%		No	%
Age (in years):			Extremity:		
Mean ± SD	22.83 ± 13		LE	26	63.4
Median	20		UE	15	36.6
Range	3-53				
Gender:			Skeletal maturity:		
Female	22	53.7	Mature	22	53.7
Male	19	46.3	Immature	19	46.3
Side:			Type:		
Left	18	43.9	Primary	38	92.7
Right	23	56.1	Recurrent	3	7.3
			Pathological fracture:		
Diagnosis:	10	24.4	Yes	13	31.7 68.3
ABC	2	4.9	No	28	
Chondroblastoma	1	2.4	Location:		
Desmoplastic fibroma	9	22	Diaphyseal	4	11.1
Enchondroma	9	22	Epiphyseal	3	8.3
GCT	3	7.3	Epiphyseal, Metaphyseal	9	25
NOF	1	2.4	Epi-, Meta- and Diaphyseal	3	8.3
Osteoid osteoma	6	14.6	Meta-diaphyseal	8	22.2
UBC			Metaphyseal	9	25
			Lesion:		
			Centric	23	56.1
			Eccentric	18	43.9
Site:			Investigations		
femur	12	29.3	CT:		
tibia	8	19.5	yes	9	21.95
phalanges	8	19.5	No	32	78.05
pubic rami	2	4.9	MRI:		
calcaneus	2	4.9	yes	28	68.3 31.7
scapula	2	4.9	No	13	
metacarpals	2	4.9	Preoperative biopsy:		
acetabulum	1	2.4	yes	5	12.2
fibula	1	2.4	No	36	87.8
humerus	1	2.4	Bone scan:		
radius	1	2.4	yes	1	2.34
ulna	1	2.4	No	40	97.66

Table 1: Demographics and clinical data of patients (n = 41).

Management and postoperative data	**patients (n = 41)**					
	N	**%**			**N**	**%**
Treatment:			Bone graft:			
No implant	22	53.66	Fibular		4	57.14
Implant	19	46.34	Local		2	28.57
			Iliac		1	14.26
Procedures after curettage:			Modified Neer's classification:			
No implant:						
Cast	3	7.32	Healed		16	39.02
Splint	13	31.71	Healed with defect		12	29.27
Arm sling	2	4.87	Excluded		13	31.71
Curettage only	4	9.76	Follow up period (months)			
Implant:			Mean ± SD		17.9 ± 8.78	
K wire	8	19.51	Range		6-42	
Plate and screws	11	26.83				
Complications:	N	%	Type	E	Bone	Site
No	35	85.37				
Yes:	6					
Malunion	1	2.44	Enchondroma	UE	Phalanx	Metadiaphysial
Mild osteoarthritis	1	2.44	GCT	LE	Prox. tibia	Epimetaphyseal
Partial injury of medial planter n.	1	2.44	ABC	LE	Calcæneus	
Recurrence	2	4.88	Dysmoplastic fibroma	LE	Femur	Diaphyseal
			UBC	UE	5th MC	Metadiaphysial
Sudek's atrophy and mild deformity	1	2.44	Enchondroma	UE	Phalanx	Whole bone
Enchondroma complications	N	Affected bone	Curettage	Use of high-speed burr		Use of H2OH
No	4	UE phalanx	Extended	Yes		Yes
	2		Simple	No		
	1	5th MC	Extended	Yes		
Yes	2	UE phalanx				

Table 2: Clinical data of postoperative follow up.

Postoperative Complications		**Patients (n = 41)**						
		Yes		**No**			**P-value**	
		N	**%**	**N**	**%**			
Curettage	Simple	0	0	9	100			0.31
	Extended	6	18.8	26	81.2			
Need of filling	Yes	2	10	18	90			0.663
	No	4	19	17	81			
Type of filling	No filling	4	19	17	81			0.94
	Autograft	0	0	7	100			
	Bone cement	2	15.38	11	84.62			
Method of fixation	No implant	4	18.18	18	81.82			0.265
	K-wires	2	25	6	75			
	Plates and screws	0	0	11	100			
Modified Neer's classification relations		patients (n=28), (13 not applicable)						
		Healed (I)		Healed with defect (II)			P-value	
		N	%	N	%			
Curettage	Simple	3	33.33	6	66.67			0.11
	Extended	13	68.4	6	31.6			
Need of filling	Yes	3	42.86	4	57.14			0.42
	No	13	61.9	8	38.1			
Type of filling	No filling	13	61.9	8	38.1			0.42
	Autograft	3	42.86	4	57.14			
Method of fixation	No implant	8	57.14	6	42.86			1
	K-wires	4	57.14	3	42.86			
	Plates and screws	4	57.14	3	42.86			
Method of fixation relations		patients (n=41)						
		No implant		K-wires		Plates		P-value
		N	%	N	%	N	%	
Curettage	Simple	3	33.33	1	11.11	5	55.56	0.088
	Extended	19	59.37	7	21.88	6	18.75	
Need of filling	Yes	11	55	3	15	6	30	0.75
	No	11	52.38	5	23.81	5	23.81	
Type of filling	No filling	11	52.38	5	23.81	5	23.81	0.76
	Autograft	3	42.86	2	28.57	2	28.57	
	Bone cement	8	61.54	1	7.69	4	30.77	

Table 3: Clinical data of postoperative complications, Modified Neer's classification, Method of fixation relations.

Type of filling relations		patients (n = 41)							
	No filling		Autograft		Bone cement		P-value		
	N	%	N	%	N	%			
Gender	Male	9	42.86	2	28.57	8	61.54	0.33	
	Female	12	57.14	5	71.43	5	38.46		
Skeletal maturity	Mature	10	47.62	2	28.57	10	76.92	0.086	
	Immature	11	52.38	5	71.43	3	23.08		
Lesion	Centric	13	61.9	6	85.7	4	30.77	0.046	
	Eccentric	8	38.1	1	14.3	9	69.23		
Cortical breakdown	Yes	11	52.38	5	71.43	9	69.23		
	No	10	47.62	2	28.57	4	30.77		
Curettage	Simple	6	28.57	3	42.86	0	0	0.23	
	Extended	15	71.43	4	57.14	13	100		
Internal fixation	Yes	10	47.62	4	57.14	5	38.46	0.72	
	No	11	52.38	3	42.86	8	61.54		
Lesion Average Dimensions	Length	28.29		35.43		46.85			
	Width	18.38		19.14		35.30			
	Depth	16.19		17.86		31.38			
Mean age (y)		19.048		19.429		30.77			
Mean size (cm³)		7.8		11.4		47.8			
Range size (cm³)		0.22-29.3		0.25-22.6		2.5-218.4			

Table 4: The types of filling and its relations.

Lesion size and its relations		Size (cm^3)		P-value	Maximum length (cm)		P-value
		> 30	< 30		< 4	> 4	
Total number		8	33	---	19	22	---
Tumor type	ABC	1	9		7	3	
	UBC	0	6		2	4	
	Chondroblastoma	0	2		0	2	
	Dysmoplastic fibroma	0	1		1	0	
	Enchondroma	0	9		0	9	
	GCT	7	2		8	1	
	NOF	0	3		1	2	
	Osteoid Osteoma	0	1		0	1	
Curettage	Simple	0 (0%)	9 (27.3%)	0.16	2 (10.5%)	7 (31.8%)	0.14
	Extended	8 (100%)	24 (72.7%)		17 (89.5%)	15 (68.2%)	

Filling	No filling	0 (0%)	21 (63.6%)	0.0004	6 (31.5%)	15 (68.2%)	0.0568
	Bone cement	8 (100%)	5 (15.2%)		9 (47.4%)	4 (18.1%)	
	Bone graft	0 (0%)	7 (21.2%)		4 (21.1%)	3 (13.7%)	
Method of fixation	No implant	3 (37.5%)	19 (57.6%)	0.256	10 (52.7%)	12 (54.5%)	0.25
	K-wires	1 (12.5%)	7 (21.2%)		2 (10.5%)	6 (27.3%)	
	Plates	4 (50%)	7 (21.2%)		7 (36.8%)	4 (18.2%)	
Complications	No	7 (87.5%)	28 (84.8%)	0.39	17 (89.5%)	18 (81.8%)	0.9
	Malunion	0 (0%)	2 (6.1%)		0 (0%)	2 (9.1%)	
	Recurrence	0 (0%)	2 (6.1%)		1 (5.25%)	1 (4.55%)	
	Partial injury of medial planter n.	0 (0%)	1 (3%)		0 (0%)	1 (4.55%)	
	Mild osteoarthritis	1 (12.5%)	0 (0%)		1 (5.25%)	0 (0%)	
Modified Neer's classification	Complete healing	0 (0%)	16 (76.2%)	1	4 (40%)	12 (66.7%)	0.24
	Partial healing	0 (0%)	5 (22.8%)		6 (60%)	6 (33.3%)	
	Not applied	8	12		9	4	

Table 5: The lesion size and its relations.

Figure 1: A female patient 3 years old, suffered a right femur fracture secondary to desmoplastic fibroma. Management was done by hip spica. 10 months later, lesion was elarged. Serial x-rays were done throughout management as follows: (A) Management by simple curettage, immediate postoperative (B) Lesion enlarged 1 year later. (C) 2nd surgery by extended curettage, immediate postoperative. (D) Lesion is resolving, 3 months later. (E) Lesion was resolved 80%, 6 months later. (F) Lesion was completely resolved, 10 months later.

Figure 2: A female patient 30 years old, suffered from enchondroma at right base proximal phalanx of middle finger. (A) and (B) Preoperative X-ray and CT show an osteolytic lesion. (C) Management was done by Extended curettage with the use of high-speed burr. (D) Lesion is resolving, 3 months later. (E) Lesion was completely resolved, 6 months later.

Better results are obtained while using plate osteosynthesis and bone cement is better to fill eccentric large cavities which are more than 30 cm^3. In addition, using autograft should be supported by ORIF due to the risk of pathological fracture and It's accepted not to fill small sized benign bone tumors after curettage with close follow-up. It'd be better not to do aggressive manipulation in phalanges during curettage to avoid complications such as deformity and malunion.

Bone healing in modified Neer's classification is better if the lesion maximum length was less than 4 cm. Filling the resultant cavity either by bone cement, autograft, or even without any filler is statistically significant in accordance to the lesion size whether it's larger or smaller than 30 cm3 with p-value 0.0004 and nearly significant according to maximum diameter if it's more or less than 4 cm with p-value 0.056.

Recommendations

Further studies are needed on a larger population to confirm the study results and additional studies are needed on each specific benign bone tumor. We also recommend targeted prospective studies with strict surgical rules to be done in the future.

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