Filling of the resultant cavity after curettage of benign bone tumours is still controversial

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ABSTRACT

Introduction: Benign bone tumours occur most commonly during the first through third decades of life and often weaken the bones, which may predispose them to pathological fractures. Great diversity and debate in the management of primary bone tumours are based on the tumour extent. There has been an increasing trend toward the intra-operative filling of these lesions. We hypothesised that in some benign bone tumours, filling the resulting cavity after curettage was unnecessary. This study was carried out to determine whether it is necessary to fill the resultant cavity after the curettage of benign bone tumours and to represent various fillers.

Materials and Methods: A retrospective study of patients diagnosed as benign bone tumours according to the Enneking classification who underwent simple or extended curettage at Menoufia university-Orthopedic Oncology Division (with or without grafting or filling) during the surgical treatment (Jan 2015 to Feb 2020). A review of the medical records was done. Lesions' size (length, width and depth) was measured on plain radiographs using the image j program. When applicable, degrees of filling of the resultant cavity were classified into four categories, according to Modified Neer's classification. Functional evaluation using the musculoskeletal tumour society (MSTS) score was reviewed.

Results: Overall, 88 patients diagnosed with a primary bone tumour and who received the surgical intervention were included in the study. The mean age of the patients was 22.61+13.497 (3–58) years. There were 48 males and 40 females (54 right and 34 left). The mean follow-up period was 28.09+16.13 months. The most common location was the distal femur in 15 patients, the proximal femur in 10 patients and the proximal tibia in 12 patients. The most common diagnosis was giant cell tumour in 20 patients, followed by UBC in 19 patients, ABC in 15 patients and enchondroma in 13 patients. Twenty-three patients had simple curettage, while 65 patients had extended curettage. Mean MSTS was 28.78±1.68. Fifty-five lesions were classified according to modified Neer's classification.Thirtty-two patients were classified as type 1 with complete healing,22 patient was classified as type 2 with partial healing, and only one was classified as a recurrent lesion. Seven patients (7.9%) developed local recurrences.

Conclusion: Filling the resulting cavity after the removal of the pathological tissues is usually necessary but not always required. This is determined by the type of lesion and the size of the resulting cavity following curettage. Individualised surgery is required; additional fixation should be considered.

KEYWORDS:
Enneking, benign bone tumours, filler, surgical interventions, extended curettage, Giant cell tumour simple bone cyst, non-ossifying fibroma

INTRODUCTION

Benign bone tumours occur most commonly during the first through third decades of life and often weaken the bones, which may predispose them to pathological fractures.[1–3] Benign lytic bone lesions, such as simple bone cyst, non-ossifying fibroma and fibrous dysplasia are asymptomatic, most often affect younger individuals, and these typically stabilise or resolve after skeletal maturity. Because of this, surgery usually is not required unless the lesion's size may cause a pathological fracture, at which point curettage with or without grafting is the preferred treatment to prevent complications.[1,4]

The surgical intervention is controversial and varies according to the anatomic site. The goal is to prevent tumour recurrence, allow the restoration of bone strength and fix fractures already has occurred. Larger lesions need to be filled to decrease the risk of pathological fractures. Thus, filling the bone defects after tumour curettage is currently the most popular approach.[1,5]

Large bone cavities have been reinforced with autologous bone grafts, allografts, bone cement and bone substitutes.[4,6–9] Autologous grafts have an ideal success rate, low risk of disease transmission and histocompatibility; however, there is limited availability and donor site morbidity, especially in children.[10,11] Allografts carry a risk of infection, causing restriction of their use in filling bone cavities, particularly in children, and are no longer used widely as autografts.[12] Calcium phosphate ceramics act as osteoconductive filler of bone defects that completely resorb as newly formed bone remodels and restores structural properties.[13] Many bone substitutes aim to fill these defects,[8] yet there is little evidence

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for their efficacy. There have been very few comparisons with the normal degree of healing expected in bone.[4,14]

Bone cement has been an alternative to the costly allograft and has widely been compared against allografts.[15] It has been studied previously with good results and is the procedure of choice for lesions associated with large defects.[16] Another technique in which cement is added to autograft or allograft also can provide mechanical stability.[17]

Great diversity and debate in the management of primary bone tumours are based on the tumour extent. There has been an increasing trend toward the intraoperative filling of these lesions, especially those in weight-bearing areas.[3,5,6,16-19] The optimal treatment and filling material for these lesions are currently unknown.[19] Currently filling of the cavity is still debatable based on the size of the cavity, availability of filler, cost-effectiveness, and morbidity of autograft harvest, when summated together the decision is determined intraoperatively and surgery is individualised to every patient.[20-22]

We hypothesised that in some benign bone tumours, filling the resulting cavity after curettage was unnecessary. This study was carried out to determine whether it is necessary to fill the resultant cavity after the curettage of benign bone tumours and to represent various fillers.

MATERIALS AND METHODS

This is a retrospective study of patients with benign bone tumours who underwent surgical treatment. The study was conducted after the approval of the institutional review board of Menoufia university and written informed consent from patients. Patients diagnosed as benign bone tumours according to the Enneking classification[23] who underwent simple or extended curettage (with or without grafting or filling) during the surgical treatment, operated between Jan 2015 and Feb 2020 with a minimum follow-up of 1 year were included in the study. Surgeries were conducted by two senior orthopaedic surgeons (ITB&BZ), both orthopaedic consultants at the orthopedic oncology division (Menoufia University, Faculty of Medicine, Orthopedic Department) which is one of the tertiary referral centres of tumour patients in Egypt. Patients with a benign tumour in the axial skeleton, tumour-like condition or grade one chondrosarcoma and who underwent curettage were excluded. Patients who received a local injection, radiofrequency ablation or had no surgical interventionand patients with lost follow-up were excluded.

A review of the medical records of the patients was done. Data collection, extraction and analysis were done by orthopedic surgeons mainly (BAH&AOE), And all radiological parameters were reviewed together with a consultant radiologist (MMM). The collected data included history and physical examination, demographic data, radiological evaluation (pre-operative and post-operative radiographs, CT and MRI if available), tumour 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 tumour society (MSTS) score was also reviewed.

Magnetic resonance (n=56) and computed tomography images (n=25) were revised to see the intraosseous extent and involvement of soft tissue or articular surface. Pre-operative biopsy (n=43) was performed on all locally aggressive lesions (GCT, ABC). Most of the lesions with characteristic radiographic features, for example, non-ossifying fibroma, simple bone cysts, fibrous dysplasia, and enchondromas in the hand, were treated based on radiological appearances.

Curettage was performed through a wide cortical window to give complete exposure to the lesion. The tumour tissue was removed using varied sizes of curettes, further extension using high-speed burr together with lavage of the cavity to dislodge the remaining tumour tissue, and 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 immediate post-operative 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.

According to Modified Neer's classification, the degrees of filling of the resultant cavity were divided into four groups where relevant.[24,25] based on the final post-operative radiographs.Modified Neer classification of radiological evaluation of bone defect healing includesgrade I (Complete Healing) representingcomplete or almost complete filling of the initial lesion with radiological evidence of new bone formation, grade II (Partial Healing) representingincomplete healing and/or graft resorption in an area(s) less than 50% of the initial lesion with enough cortical thickness to prevent fracture, grade III (Persistent Lesion) represent Graft resorption or persistent radiolucent area (s) greater than 50% of the initial lesion and/or with a thin cortical rim potentially at risk for fracture, and grade IV (recurrent lesion) represent progressive lesion reappeared in a previously obliterated area or a residual radiolucent area verified by biopsy.

Statistical Analysis

For statistical analysis, IBM SPSS version 25.0 (SPSS Inc., Armonk, NY) was employed. When appropriate, categorical variables were compared using the Chi-square or Fisher's exact tests. When suitable, continuous variables were compared using the Student's t-test or one-way ANOVA. A p-value of less than 0.05 was used to determine statistical significance.

RESULTS

Overall, 88 patients were diagnosed with a primary bone tumour and received surgical intervention. The mean age of the patients was 22.61+13.497 (3–58) years. Thirty-nine patients (44.3%) were skeletally immature (under 16 years of

age) at the time of treatment. There were 48 males and 40 females. The side of the lesion was right in 54 patients and left in 34 patients. The mean follow-up period was 28.09+16.13 months. Only three patients were presented with previous surgical interventions considered as recurrent lesions, while the others had no previous surgery. The main presentation of the patients was pain, swelling, limping and pathological fractures. Twenty-seven patients (30.7%) presented with pathological fractures (Table I).

Fifty-seven lesions were in the lower extremity, with two lesions located at the posterior acetabular column and superior pubic rami, while 31 lesions were in the upper extremity.

The most common location of the lesions was the distal femur in 15 patients (17%), the proximal femur in 10 patients (11.4%), the proximal tibia in 12 patients (13.6%), the phalanges in 12 patients (13.6%), the proximal humerus in 6 patients (6.8%), the distal tibia in 5 patients (5.7%), three affections fore each(calcaneus, femur mid shaft, metacarpal bone, proximal radius,tibia mid shaft), two affections for each (humerus mid shaft,superior pubic ramus,scapula), and one affection for the remaining (acetabulum posterior column, distal fibula, distal humerus,distal radius,metatarsal bone, proximal ulna). CT was available for 25 patients, while MRI was available for 56 patients.

The most common diagnosis was giant cell tumour in 20 patients (22.7%), followed by UBC in 19 patients (21.6%), ABC in 15 patients (17%), enchondroma in 13 patients (14.8%), NOF in 6 patients (6.8%), chondroblastoma in 4 patients (4.5%), osteoblastoma in 4 patients (4.5%), osteoid osteoma in 3 patients (3.4%), FD in 3 patients (3.4%), desmoplastic fibroma in one patient (Figures 1–3).

Twenty-three patients had simple curettage, while 65 patients had extended curettage. A high-speed burr was used in 68 patients. Extended curettage surgery involved intralesional curettage through a generous cortical window followed by burring, cleansing, and lavage of the lesion. Following surgery, each cavity was either left empty with no filler or filled with autologous bone graft, bone substitute, or bone cement. Forty-two patients had no filling of the defect while the other 46 were packed by either autologous bone graft (10 patients), bone substitute (3 patients), or bone cement (33 patients). Thirty-five patients had fracture fixation or lesion augmentation.

For lower extremity lesions, depending on the size of the lesion and the radiological features, partial weight-bearing was allowed before reaching full weight-bearing. For upper extremity lesions, immobilisation is followed by the resumption of activities based on lesion consolidation.

The mean length of the lesions was 39.23±22.78 mm, the mean width was 25.19±12.18mm, and the mean depth was 21.86±10.87mm. Only 17/27 fractures required fixation, while the remaining was splinted or received bone cement to augment the lesions.

The mean MSTS was 28.78±1.68, there was no statistical significance between those who received filling and those who did not (*p*-value= 0.127) and also no statistical difference between the different fillers used regards the MSTS (*p*-value=0.227)

As the healing and lesion consolidation cannot be evaluated in patients receiving bone cement as a filler, a review of serial radiographs showed 55 lesions were not filled by bone cement and were classified according to modified Neer's classification.Thirty-twopatients were classified as type 1 with complete healing of the lesions,[22] patients were classified as type 2 with partial healing of the lesions, and only one lesion was classified as a recurrent lesion (type 4). The filling pattern began with cortex thickening, followed by the appearance of bone septate through the defect, which progressed to either complete or partial filling of the lesion.

Non-significant relation between the different studied variables and filling of resultant cavity p-value for different variables was (side 0.438, gender 0.096, pathological fracture 0.013,presentation as primary or recurrent 0.646, centricity of the lesion 0.048, use of high-speed burr 0.03,complications 0.374, MSTS 0.127). Only more tendency to non-filling in skeletally immature patients(p-value˃0.005)

Lesions that were filled with bone graft or bone substitute showed the same healing potential as those that were not filled. However, there was no significant relationship between the type of lesion and choice of filling and the healing of the lesion regarding modified Neer's classification p-value = 0.419 (Table II).

Regarding the filling of different lesions, there was a tendency to non-filling of lesions such as enchondroma due to small defects, also in lesions with high potential of bone healing such as NOF and UBC (Table III).

Lesions were evaluated during and after curettage, and if there was still enough strength after the procedure, the decision of non-filling was made, taking into account the lesion size in relation to the affected bone and donor site morbidity, especially in young patients.

Seven patients (7.9%) developed local recurrences during the follow-up period; 4 lesions were UBC, 2 lesions were ABC, and 1 lesion was a desmoplastic fibroma. All patients were controlled by repeated curettage, extending it using a high-speed burr. Only one patient had two recurrences (Figure 1). No case had post-operative wound infection.

During follow-up, two patients had osteoarthritic changes (GCT proximal tibia, GCT distal femur) with occasional pain that responded to conservative measures, three patients had occasional pain and one of these had lower limb edoema, all responded to conservative measures, one patient hadSubdeck's atrophy and mild deformity, the pain was controlled, and range of motion and daily activity was restored fully.

Table I: Patient characteristics, demographic data, diagnoses and treatment outcome

	no	%		no		%
Side			**Type of filling**			
Left	34	38.6	Autograft	10		11.4
Right	54	61.4	Bone cement	33		37.5
Gender			Bone substitute	3		3.4
Female	40	45.5	No filling	42		47.7
Male	48	54.5	**Modified Neer's classification**			
Skeletal maturity status			Not applied	33		37.5
Immature	39	44.3	Complete healing	32		36.4
Mature	49	55.7	Partial healing	22		25.0
Pathological fractures			Recurrent cyst	1		1.1
NO	61	69.3	Curettage			
Yes	27	30.7	Extended	65		73.9
Extremity affection			**Simple**	23		26.1
Lower limb	57	64.7	Duration of symptoms (months) Mean±SD	3.90±4.29		
Upper limb	31	35.2	MSTS(Mean±SD)	28.78±1.68		
Lesion presentation			**Measurements**	Total(n=88)	UE(n=31)	LE(n=57)
Primary	85	96.6	Lesion maximum length in mm (Mean±SD)	39.23±22.8	34±21.61	42±23.3
Recurrent	3	3.4	Lesion maximum width in mm (Mean±SD)	25.19±12.18	18.65±9.3	28.8±12.3
			Lesion maximum depth in mm (Mean±SD)	21.86±10.87	16.19±8.5	25.1±10.8

Table II: Distribution of lesions regards Modified Neer's classification compared to the type of filling

Modified Neer's classification		filling or not			Total
		Filling with BG or BS	no filling	Bone cement	
Complete healing	ABC	2	3		5
	Chondroblastoma	0	2		2
	Enchondroma	1	8		9
	GCT	0	1		1
	NOF	1	2		3
	Osteoblastoma	1	0		1
	Osteoid Osteoma	0	3		3
	UBC	2	6		8
	Total	7	25		32
Recurrent cyst	UBC	1			1
Bone cement	ABC			4	4
	Chondroblastoma			2	2
	Enchondroma			1	1
	FD			3	3
	GCT			19	19
	osteoblastoma			1	1
	Osteoblastoma			2	2
	UBC			1	1
	Total			33	33
Partial healing	ABC	4	2		6
	Dysmoblastic fibroma	0	1		1
	Enchondroma	1	2		3
	NOF	0	3		3
	UBC	0	9		9
	Total	5	17		22
Total	ABC	6	5	4	15
	Chondroblastoma	0	2	2	4
	Dysmoblastic fibroma	0	1	0	1
	Enchondroma	2	10	1	13
	FD	0	0	3	3
	GCT	0	1	19	20
	NOF	1	5	0	6
	osteoblastoma	0	0	1	1
	Osteoblastoma	1	0	2	3
	Osteoid Osteoma	0	3	0	3
	UBC	3	15	1	19
	Total	13	42	33	88

Table III: Different histological diagnoses and their filling and the mean volume of the lesions

	Filling with bone graft or bone substitute		No filling		Filling with bone cement		Total
	NO	Mean volume (CM3)	NO	Mean volume (CM3)	NO	Mean volume (CM3)	
UBC	3	18.8	15	19.4	1	72	19
Enchondroma	2	0.92	10	2.1	1	22.5	13
ABC	6	19	5	34	4	21.6	15
NOF	1	23.8	5	6.7	0	-	6
Osteoid Osteoma	0	-	3	55	0	-	3
Chondroblastoma	0	-	2	7.25	2	20.4	4
Osteoblastoma	1	8	0	-	3	6	4
FD	0	-	0	-	3	104	3
Desmoplastic fibroma	0	-	1	24.5	0	-	1
GCT	0	-	1	1.5	19	89	20
Total	13	15.7	42	17	33	68	88

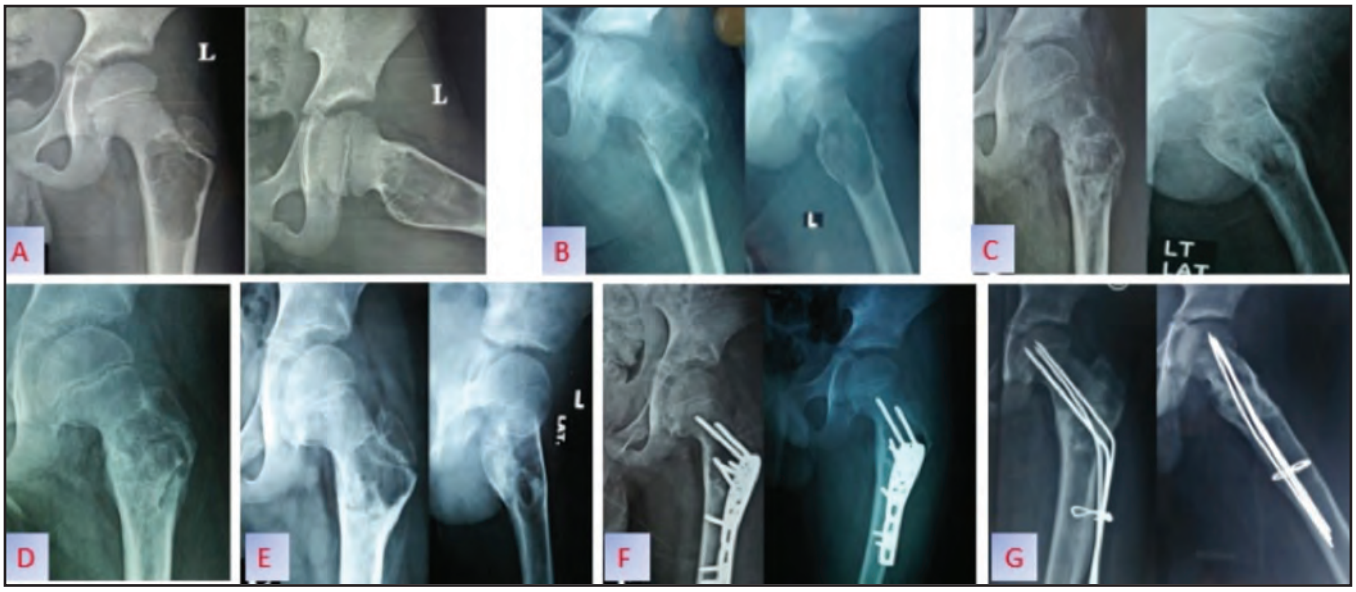

Fig. 1: Male patient 11 years old presented with a unicameral bone cyst of the proximal femur (A), underwent curettage-only surgery and spica cast (B), 3weeks post-operative had a pathological fracture spica cast was applied until the consolidation of the cyst wall (C, D) but with a persistent cyst, after 4 months follow-up (E), re-curettage and plate augmentation was done, but with cyst persistence (F), 6months after the second intervention, extended curettage using a high-speed burr and lesion augmentation with Wagner technique was done with full consolidation of the lesion after 14 months follow-up (G)

DISCUSSION

Benign bone tumours may be found incidentally on imaging for other causes and can present with mild pain and localised swelling.[1] Curettage, alone or in combination with grafting, can relieve pain and reach 95% cure rates in various forms of benign bone tumours.[1,26-28] Whether or not adjuvants are employed, adequate exposure and careful curettage are required to maximise local control.[29] Depending on the tumour diagnosis, the overall recurrence rates can vary significantly.[30] Recurrence rates in giant cell tumours treated with curettage and adjuvant filling have ranged from 7 to 50%, despite numerous attempts to lower this probability of local recurrence, including the use of adjuvants such as phenol, cryotherapy and bone cement.[9,31,32]

The use of bone cement was preferred as a filler for the defect and structural support, also giving benefit through its exothermic property on residual tumour cells. Concern, when used near the surface of a joint, may cause thermal injury and damage to the chondrocyte leading to secondary osteoarthritis.[4,10,16,30] The use of a high-speed burr and adjuvants such as (hydrogen peroxide, alcohol, and the thermal energy of bone cement when used) to extend the destruction of residual tumour cells resulted in a low recurrence rate in this series.

Mechanical insufficiency or microfractures can cause pain in benign lytic bone lesions, which can indicate people are at risk of pathological fracture.[33-35] Shih et al. and Drennan et al. used curettage and grafting along with internal fixation for patients with active lesions of the lower extremity.[35,36] Moretti et al. reported that curettage and grafting of symptomatic benign lytic bone lesions provide adequate mechanical stability and allow a return to full painless activity.[1]

In benign aggressive bone lesions, chemical adjuvants such as phenol, hydrogen peroxide and alcohol have been utilised to expand the curettage margin, minimising recurrence and necrosis.[37,38] Pathological fractures following a benign tumour are not a contraindication to treatment by curettage and cementation.[16,39]

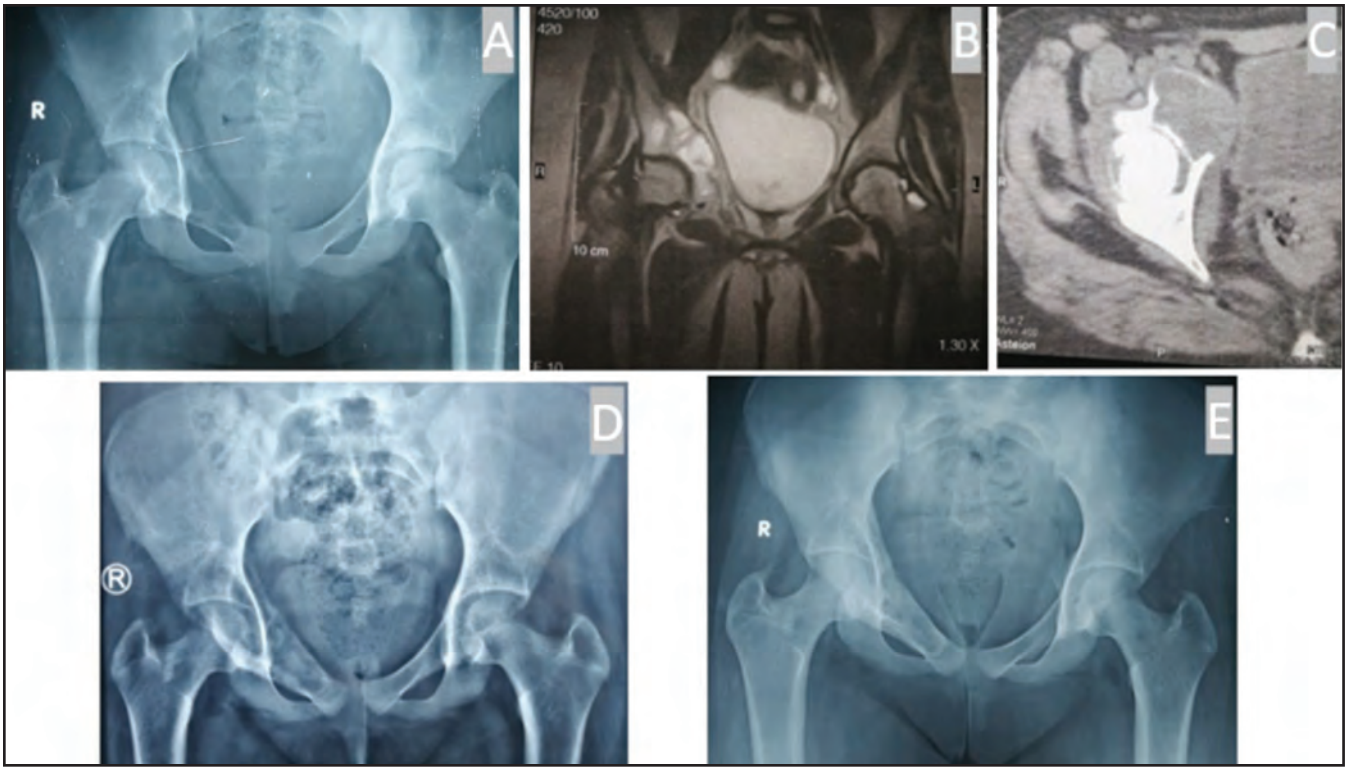

Fig. 2: Female patient presented with ABC of the right superior pubic ramus, (A) Plain radiographs with extensive affection of the right pubic ramus. (B, C) MRI images with multiple fluid-fluid levels, (D) Plain radiograph 2months follow-up after extended curettage surgery using high-speed burr, (E) Follow-up radiographs after 12 months with full consolidation of the lesion

Fig. 3: Female patient 30 years old presented with GCT with pathological fracture, (A, B) plain radiographs with lytic lesion affecting the proximal tibia approaching articular cartilage, (C) CT image with extensive lesion broaching the cortex with pathological fracture. (D, E) MRI images with high signal intensity in T2 images with an expansion of the posterior cortex. (F, G) plain radiographs after extended curettage of the lesion using high-speed burr and cementation and plate osteosynthesis after 2 years follow-up

Wu et al. retrospectively assessed 84 patients with simple bone cysts who had undergone curettage and filling of the bone defects with grafts. Only two of all variables evaluated were significantly correlated with the prognosis: tumour location and tumour length, those at the proximal femur were significantly more likely to achieve complete healing (Neer I). Post-operative re-fracture occurred in one case.[2] Internal fixation was used to supplement fracture fixation or lesion augmentation in 35 patients with defects that may predispose them to a significant risk of fracture.

Most benign bone lesions had a natural tendency to fill the resultant defect following curettage, also filling the defect improves the chances of local control and also had a strong capacity to create new bone after trauma or haematoma created after curettage;there have been some studies reporting on the ability of a surgically created bone defect to fill in if left empty.[4–7,17,38,40,41] Filling of the resultant cavity after curettage was based initially on the lesion size and the ability of these cavities to fill without filling. Minor defects can be left empty. While in large defects, especially those after curettage of GCT filling with bone cement were always considered, as there is a risk of fracture or collapse of the joint surface if the cavity is left with no filling.

The size of the lesion, donor site morbidity of the graft, and type of lesion were the most important factors in the filling and type of filling. Smaller lesions and lesions such as NOFs, enchondromas, and UBCs had a higher likelihood of not filling, which could be attributed to the possibility of bone healing.

Kundu et al. reported that 42 patients with benign bone tumours underwent curettage without grafting or filling of the defect by any other bone substitute. They reported that there is a natural healing ability of bone without filling. In selected sizes and locations of benign lytic tumours and tumour-like lesions, extended curettage alone can be sufficient.[4]

Obtaining a large amount of autograft is quite a large operative procedure, which is likely to lead to significant morbidity.[10] There may be a reluctance to use an allograft; however, particularly in children or young people. Bone substitutes have become more popular with unlimited supply, particularly in defects of large size but with an increased risk of infection.[8]

Factors influencing the quality of bone healing following intralesional curettage and bone grafting are proximal femur location and tumour length. A greater degree of graft filling can contribute to higher bone healing efficiency.[2]

Treatment options for painless benign bone tumours like a simple bone cyst are still up for debate. Currently, treatment of benign bone cysts includes observation, injection of bone marrow or demineralised bone matrix, curettage blended with bone or synthetic grafting, decompression with intramedullary nailing or cannulated screw, or a mixture of these mentioned approaches.[18]

Hirn et al.[6] retrospectively analysed the outcome of 146 benign bone tumours about the knee that had been treated with curettage alone without any augmentation. Following curettage, the mean diameter of the defects was 5.7 (1.3–11) cm. In 88% of the cases, no further intervention after curettage was required and the meantime to full weight-bearing was 6 weeks. They concluded that the most benign defects of bone wouldconsolidate without any adjuvant filling.

The filling of the resulting cavity after GCT treatment affects the patients' curability as well as the structural stability added to the defect. Other benign bone tumour control is unaffected by the type of filling; however, filling of the resulting cavity will remain a point of contention; whether to fill or not to fill will be determined by the extent and size of the lesion, as well as how much structural stability is required for the lesion.The degree of structural stability required determines the need for additional fixation.

Several factors hampered this research. The sample size was limited due to the rarity of these presentations. Also, the difficulty of control as such presentations needs surgical care;the decision is difficult to be determined in advance, to fill or not and to fix or not. The retrospective design with different diagnoses, heterogeneous presentation of the lesions, surgical procedures, curettage method and filling of the resultant cavity may affect the patient outcomes. In future investigations, we will focus on the necessity for filling, further fixation, and consolidation in a specific entity of benign bone tumours.

CONCLUSION

Filling the resulting cavity after removal of the pathological tissues is usually necessary but not always required. This is determined by the type of lesion and the size of the resulting cavity following curettage. Individualised surgery is required; additional fixation should be considered.

ETHICS APPROVAL AND INFORMED CONSENT

The study was conducted after the approval of the institutional review board of Menoufia university-faculty of medicine-EGYPT and written informed consent from patients

COMPETING INTERESTS

No competing interests

FUNDING

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