

Treatment of Unicameral and Aneurysmal Bone Cysts by Minimally Invasive Percutaneous Injection of Grafton[®] DBF Putty Using the Kyphon[®] Cement Delivery System

G. Ulrich Exner¹ , Pascal A. Schai² 

¹Orthopaedie Zentrum Zuerich, Zuerich, Switzerland

²Luzerner Kantonsspital Wolhusen, Wolhusen, Switzerland

Email: exner@orthopaedie-zuerich.ch, pascal.schai@luks.ch

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Abstract

Background: Simple Unicameral and Aneurysmal Bone Cysts are benign lesions that may heal spontaneously especially after fracture which may be the first symptom. However, often size increases causing pain, and complications of fractures can severely compromise the patient. **Aim:** The results in a series of cases treated minimally invasive using a new device for the application of allogenic bone material appear highly promising and shall be presented. **Patients and Methods:** Eight consecutive patients with symptomatic Unicameral Bone Cysts (UBC) were treated by percutaneous instillation of Grafton[®] DBF Putty (demineralised allogenic bone containing fibers) mixed with autologous bone marrow using the Kyphon[®] Cement Delivery System (Medtronic), which allows the injection of this high viscosity paste by controlled high pressure. Five patients with Aneurysmal Bone Cysts (ABC) were treated accordingly after inactivation by Aethoxysclerol 3% and lacking bone formation. Using this approach a high rate of bone regeneration was observed in these patients at 8 months to 5 years follow-up (f/u). **Conclusion:** The presented technique of a minimally invasive biologic treatment led to highly satisfying results using the Grafton[®] DBF Putty with its higher potential for bone regeneration than demineralized bone matrix not containing fibres (DBM).

Keywords

Simple Unicameral Bone Cyst, Aneurysmal Bone Cyst, DBF Putty, Kyphon Cement Delivering System, Bone Marrow, Percutaneous Treatment

1. Introduction

Unicameral Bone Cysts (UBC) are benign lesions with poorly understood etiology. They may resolve spontaneously typically after pathologic fracture and with advancing age; however they can be recalcitrant even after puberty.

Treatment is needed in symptomatic patients depending on size, location and fracture or threatened fracture.

Aneurysmal Bone Cysts (ABC) are neoplasias typically containing *USP6*-rearrangements. Good results and spontaneous healing can be achieved by injection of alcoholic solutions. However, often additional measures are needed for restitution of the bony defect.

We wish to communicate a minimally invasive technique to induce healing of these persistent cystic bone defects injecting the highly viscous paste of Grafton[®] DBF Putty (demineralised allogenic bone containing fibers) mixed with autologous bone marrow (BM), using the Kyphon[®] Cement Delivering System (Medtronic) resulting in a high rate of bone regeneration.

2. Patients and Methods

Eight consecutive patients with symptomatic large UBC (humerus, pelvis, femur, calcaneus, **Table 1**), recurrent after different procedures, were treated since 2016 by the technique presented. Five patients with ABC (pubic bone, femoral neck, tibia, **Table 2**) not showing bone remodeling at a minimum follow-up of 3 months after inactivation by Aethoxysclerol 3% were treated accordingly. Biopsies taken at filling with Grafton[®] DBF Putty in these cases proved no remnants of pathologic tissue. Further details of the otherwise healthy patients aged 15 to 27 years are given in **Table 1** and **Table 2**.

Two 8G Jamshidi needles CareFusion[®] are inserted under fluoroscopy or computer tomography (CT) to have 2 portals—one for injection, the other for “ventilation”. After aspiration of the cystic fluid content radio opaque dye (Iopamiro[®]) is injected to document its distribution within the cavity and to exclude extraosseous leakage as described in detail by Rougraff and Kling [1]. Grafton[®] DBF Putty (3 to 40 cc) was mixed with bone marrow aspirate in the relation of about 2:1 to 1:1 (**Table 1**, **Table 2**). Bone marrow aspirate (each sample maximally 5 cc) is taken from various pelvic locations to provide sufficient osteoblastic progenitor cells [2]. The bone marrow aspirate is mixed with DBF and this highly viscous paste is then injected using the Kyphon[®] Cement Delivering System providing the well controlled high pressure under image intensifier control (CT in special locations) of the extrusion of the contrast dye through the ventilation needle (**Figure 1** and **Figure 2**).

3. Results

There was sufficient incorporation/restitution of bone in 11 patients at a minimum follow-up time of 8 months. In 2 patients a second intervention (1 UBC at 5 years, 1 ABC at 2 years following the first one) was successful. No patients

Table 1. Unicameral bone cysts.

Sex Age	Location	Volume	Treatment DBF/BM	Result follow-up
M 27 y	Humerus, multiple fractures and interventions since age 6 y including plate osteosynthesis	18 cc	DBF 15 cc/BM 5 cc	At 2 years f/u well filled cyst Figure 2
F 22 y	Humerus	18 cc	DBF 10 cc/BM 10 cc	2.5 years f/u restitution
F 16 y	Iliac bone	133 cc	1 st Intervention at age 16 years: DBM 40 cc/platelet rich plasma 12 cc 2 nd intervention at age 21 y DBF 15 cc/BM 5 cc	At 2 years f/u after 2 nd intervention partial bone restitution no pain
F 24 y	Femoral neck	14 cc	DBF 12 cc/BM 8 cc	At 8 months partial restitution
M 21 y	Pathologic fracture femur. Cyst unchanged 3 years after osteosynthesis	102 cc	1 st Intervention at 21 years DBM 10 cc/platelet rich plasma 2 nd intervention at 22 years DBF 20 cc/BM 20 cc	At 4 years f/u complete restitution Figure 5
F 18 y	Calcaneus	20 cc	DBF 12 cc/BM 12 cc	At 1 year f/u well filled cyst
F 19 y	Calcaneus	10 cc	DBF 9 cc/BM 9 cc	At 2 years minimal sclerosis. No symptoms Figure 6
M 15 y	Calcaneus	6 cc	DBF 9 cc/BM 8 cc	At 8 months f/u clinically asymptomatic

DBF—Grafton® DBF Putty, DBM—Demineralized Bone Matrix, BM—Bone Marrow aspirate. Volume calculated based on the radii of an ellipsoid body: $a \times b \times c \times d \times \pi \times 4/3$.



Figure 1. The Grafton® DBF Putty is mixed with the aspirated autologous bone marrow and filled into the applicator of the Kyphon® Cement Delivering System and injected into the calcaneal unicameral bone cyst.

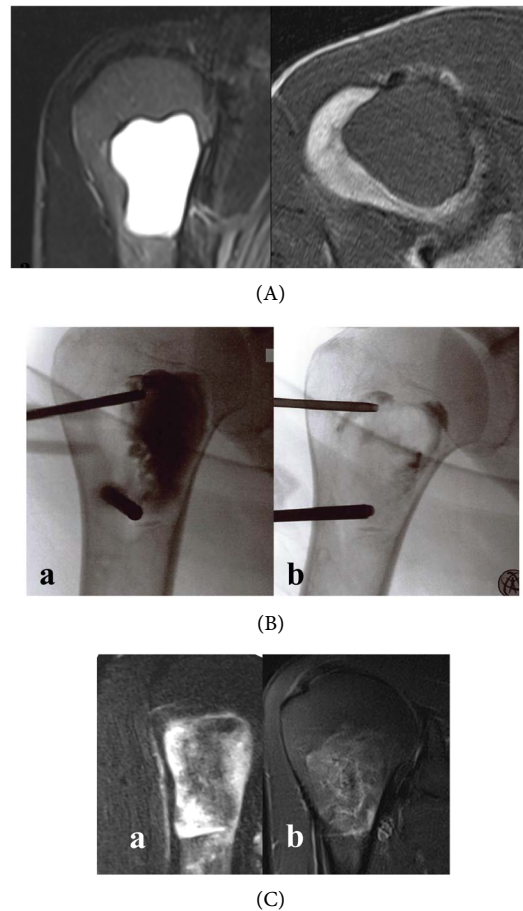


Figure 2. (A) Unicameral bone cyst following repeated fractures and interventions since age 6 years (December 2016); (B) Image intensifier documentation of the cyst filled with Iopamiro (a) and extrusion of the contrast medium by filling with Grafton® DBF Putty/BM (b) (January 2017); (C) MRI at 14 months ((a), March 2018) and 21 months ((b), October 2018) after injection of Grafton® DBF Putty/BM.

Table 2. Aneurysmal Bone Cysts.

Sex/ Age	Location	Volume	Treatment interval after Aethoxysclerol inactivation	DBF BM	Follow-up	Result
F 21 y	Humerus proximal	17 cc	10 mo	DBF 12 cc BM 12 cc	8 mo	incorporation in progress
M 23 y	Trochanter maior	90 cc	4 mo	DBF 40 cc BM 20 cc	3 y	fully restored Figure 4
F 18 y	Femoral neck	6 cc	9 mo	DBF 3 cc BM 3 cc	2 y	restored
F 17 y	Pubic bone/ acetabulum	23 cc	6 mo	DBF 10 cc BM 10 cc	5 y	partial restoration no symptoms ice skating Figure 3
F 22 y	Tibia proximal epiphysis	14 cc	2 y	DBF 12 cc BM 10 cc	8 mo	incorporation in progress

DBF—Grafton® DBF Putty, DBM—Demineralized Bone Matrix, BM—Bone Marrow Aspirate. Volume calculated based on the radii of an ellipsoid body: $a \times b \times c \times d \times \pi \times 4/3$.

suffered fractures and all are pain free at present. Images of selected cases of UBCs und ABCs are presented in **Figures 2-6**; imaging findings at follow-up are given in **Table 1** and **Table 2**.

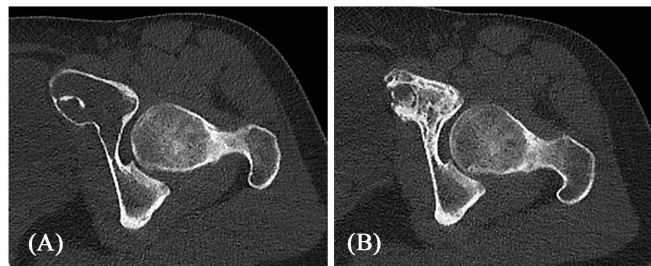


Figure 3. Aneurysmal Bone Cyst of the pubic bone/acetabulum; (A): before intervention December 2013; (B): 2 years after filling with Grafton® DBF Putty/BM June 2016.



Figure 4. (A) Aneurysmal Bone Cyst. MRI showing the extensive intertrochanteric cyst and the fluid sedimentation levels characteristic for Aneurysmal Bone Cysts (November 2013); (B) X-Ray documentation of the Aneurysmal Bone Cyst before treatment (November 2013); (C) The X-Ray 3 years after filling with Grafton® DBF Putty/BM shows the well restructured intertrochanteric region (March 2017).

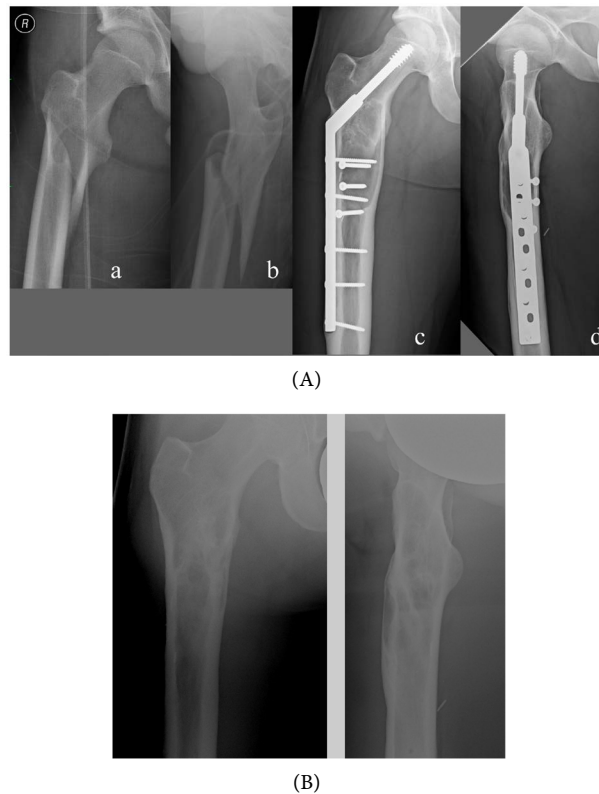


Figure 5. (A) Pathologic fracture through Unicameral Bone Cyst ((a), (b) February 2012). The cyst remained unchanged during 2.8 years f/u after osteosynthesis ((c), (d) November 2014); (B) (November 2019) Reconstitution of bone 5 years after removal of implants and simultaneous filling with Grafton® DBF Putty/BM.

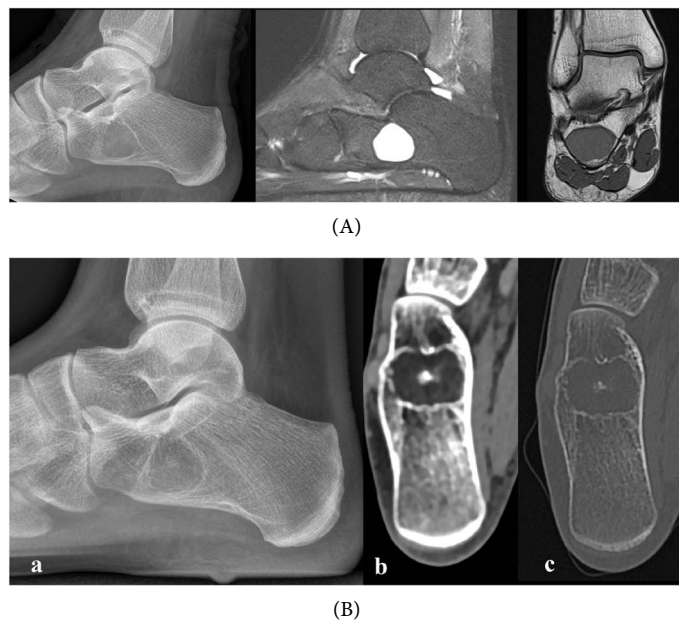


Figure 6. (A) X-Rays and corresponding MRI of calcaneal Unicameral Bone Cyst (April 2018); (B) X-Ray (a) and corresponding CT ((b), soft tissue window; (c), bone window) 2 years after filling with Grafton® DBF Putty/BM (June 2020)-intervention shown in **Figure 1**. Marginal incorporation probably related to non-force-transmitting region.

No adverse reactions to the DBF/BM implant or complications related to technical aspects and the application system were observed.

4. Discussion

The cause of UBC (synonymously used for juvenile bone cysts or simple bone cysts) is poorly understood. Initially UBC was treated mostly by extensive curettage and bone transfer [3]. Since the introduction of intracystic Corticosteroid-Injection by Scaglietti *et al.* [4] less invasive methods are now mostly used; among them are intramedullary nailing and steroid injection [5], injection of bioabsorbable bone cement [6] and artificial bone substitutes [7]. However, so far there is no evidence to determine the best method for treatment [8]. One randomized trial comparing intralesional bone marrow and steroid injections showed superiority of the latter [9].

Good results with the injection of Demineralized Bone Matrix (DBM) mixed with autologous bone marrow aspirate into UBCs were first reported by Rougraff and Kling [1] and confirmed by several studies, e.g. Cho *et al.* [10] and Gundle *et al.* [11].

Grafton® DBF Putty was used in our patients because of its superior osteoinductivity and osteoconductivity compared to DBM [12] [13] [14].

ABCs are lesions unrelated to UBC exhibiting *USP6*-rearrangement, a marker involved in the development and spontaneous regression of neoplastic processes [15]. We add our cases of ABC in this study as we use the same treatment principles as in UBC if the standard treatment with Aethoxysclerol and recently augmented by surgiflo [16] has successfully inactivated the process, but no new bone formation shows up after at least 4 months.

The Kyphon® Cement Delivering System developed for the injection of cement in kyphoplasty proved to be a useful device to inject the pasty mixture of DBF/BM under well controlled pressure.

Drawbacks of this study are the lacking of a control group and the still relatively short f/u.

5. Conclusion

The technique of percutaneous treatment of inactive cysts appears to be effective, minimally invasive and may be considered as a primary choice instead of large open procedures. The use of Grafton® DBF Putty with higher osteoinductive and osteoconductive potential appears to enhance the good results achieved so far with DBM. The minimally invasive injection of the highly viscous paste needs an application system as provided by the Kyphon® Cement Delivering System (Medtronic). The presented system has been useful in other bone defects, e.g. after radiofrequency ablation and cystic degenerative changes of fibrous dysplasia.

Patient Consent

The patients were informed that data from their case would be submitted for

publication, and informed consent was obtained.

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Conflicts of Interest

The authors declare no conflict of interest regarding the publication of this paper.

No benefits in any form have been or will be received from a commercial party related directly or indirectly to the subject of this article.

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