

CHAPTERS

1. Benign Bone Tumors

Background: Benign bone tumours and tumour-like lesions are much more common than primary malignant bone tumours. The majority of the lesions can be diagnosed by the clinical symptoms in combination with radiographs and require no further therapy [1]. Nevertheless some of the benign tumours are capable of distant metastasis (e.g. giant cell tumour) and some tumour-like lesions such as aneurysmal bone cysts or fibrous dysplasia may cause substantial challenges in the treatment [1].

Additionally, larger cysts can cause a bone to weaken, making it more vulnerable to fracture. This can lead to symptoms such as pain, swelling or not being able to move or put weight on a body part [2].

2.
Calcaneus
Fracture

3.
White Wound
Drainage

4.
Acetabular
Revision

5.
Tibia Plateau
Fracture

6.
High Tibial
Osteotomy

A summary of benign bone tumours and tumour-like lesions is shown in table 1 [3, 4].

BENIGN BONE TUMOURS	INCIDENCE (%)
OSTEOBLASTIC TUMOURS	
→ Osteoma	*
→ Osteoid osteoma	10
→ Osteblastoma	3
CHONDROBLASTIC TUMOURS	
→ Cartilaginous exostoses (osteochondroma)	48
→ Chondroma	23
→ Chondroblastoma	5
→ Chondromyxoid fibroma	2
GIANT-CELL TUMOUR	10
VASCULAR TUMOURS	
→ Haemangioma	4
→ Glomus tumour	<1
INTRAOSSEOUS SOFT TISSUE TUMOURS	
→ Fibromatosis	<1
→ Lipoma	<1
→ Benign fibrous histiocytoma	2
INTRAOSSEOUS NEUROGENIC TUMOURS	
→ Neurinoma	<1
→ Neurilemoma (Schwannoma)	<1
TUMOUR LIKE LESIONS	
→ Unicameral (Simple, Solitary, or Juvenile) bone cyst (UBC)	*
→ Aneurysmal bone cyst (ABC)	
→ Fibrous dysplasia	
→ Pigmented villonodular synovitis	
→ M. Paget	

Table 1: Benign bone tumours and tumour-like [3, 4].

➡ Incidences are either too low to note or have not been recorded.

CERAMENT™|BONE VOID FILLER in the management of benign bone tumours or tumour-like lesions which lead to osteolysis or bone cysts (benign bone cysts).

Including:

- ➔ Osteoblastoma
- ➔ Enchondroma
- ➔ Periosteal chondroma
- ➔ Chondroblastoma
- ➔ Chondromyxoid fibroma
- ➔ Giant-cell tumour
- ➔ Unicameral bone cyst (UBC)
- ➔ Aneurysmal bone cyst (ABC)
- ➔ Fibrous dysplasia

Despite the classification of those diseases as “benign”, some of them show aggressive or local destructive growth pattern and even metastases (uncommon, but in giant-cell tumour < 2% of all cases) [5,6]. Therefore some authors suggest curettage and permanent filling of the cysts with Poly Methyl MethAcrylate (PMMA) as a treatment option, especially in osteoblastoma and giant-cell tumor [1,7].

Good indications for CERAMENT™|BONE VOID FILLER are:

- ➔ Unicameral (Simple, Solitary, or Juvenile) bone cyst (UBC)
- ➔ Aneurysmal bone cyst (ABC)
- ➔ Enchondroma

Literature:

1. Tunn PU, Dürr HR. Benign bone tumours and tumour-like lesions of the bone. *Arthritis. and Rheuma.* 2007; 27: 129 – 140.
2. www.nhs.uk/Conditions/Bone-cyst/Pages/Introduction.aspx.
3. Fletcher CDM, Unni KK, Mertens F, Hrsg. World Health Organization Classification of Tumours: Pathology and Genetics of Tumours of Soft Tissue and Bone. Lyon: IARC Press 2002.
4. Freyschmidt J, Ostertag H, Jundt G. Knochentumoren. Klinik, Radiologie, Pathologie. Berlin, Heidelberg, New York: Springer 2003; 9 und 679.
5. Tunn PU, Schlag PM. Der Riesenzelltumor des Knochens. Eine Analyse von 87 Patienten. *Z Orthop Grenzgeb* 2003; 141: 690–698.
6. Mendenhall WM, Zlotecki RA, Scarborough MT, Gibbs CP, Mendenhall NP. Giant cell tumour of bone. *Am J Clin Oncol.* 2006; 29: 96 - 99.
7. Dürr HR, Maier M, Jansson V. Phenol as an adjuvant for local control in the treatment of giant cell tumour of the bone. *Eur J Surg Oncol* 1999; 25: 610–618.

Unicameral (Simple, Solitary, or Juvenile) Bone Cyst (UBC)

Location:

Proximal dia-and metaphysis of long bones, growth in the direction of the diaphysis [1].



Diagnostics:

Clinical examination, X-rays, in some cases MRI, CT-scan or biopsy.

Therapy: Careful observation [1].

☉ active lesion:

in contact with growth plate, can grow large enough to weaken bone and cause fracture.

☉ latent lesion:

no contact to growth plate; as the bone grows the distance between growth plate and cyst becomes greater.

In case of fracture: Spontaneous healing of the cyst in approx. 25% of cases [1].

Radiographic image reproduced by kind permission of Dr Piotr Sowinski and Prof. Jacek A. Kazmarczyk. Dept. of Orthopedic Surgery and Traumatology, Poznan University Hospital, Poznan, Poland.

Treatment options:

There is still a lack of evidence to determine the best method for treating simple bone cysts in long bones [2]. Many different treatment options exist, some are listed below:

- ➔ Aspiration and injection of Methylprednisolone [3].
- ➔ Aspiration and injection of autogenous bone marrow [4,5.]
- ➔ Implantation of cannulated screws [6].
- ➔ Curettage and bone graft or bone graft substitutes, especially in locations at risk of fracture or persisting cysts after fracture [1,2,5,7].

Literature:

1. Tunn PU, Dürr HR. Benign bone tumours and tumour-like lesions of the bone. *Arthritis and Rheuma*. 2007; 27: 129 – 140.
2. Zhao JG, Ding N, Huang WJ, Wang J, Shang J, Zhang P. Interventions for treating simple bone cysts in the long bones of children. *Cochrane database Syst Rev*. 2014; Sept 2; 9 epub ahead of print.
3. Chang CH, Stanton RP, Glutting J. Unicameral bone cysts treated by injection of bone marrow or Methylprednisolone. *J Bone Joint Surg Br*. 2002; 84-B: 407 – 412.
4. Zamzam MM, Abak AA, Bakarman KA, Al-Jassir FF, Khoshhal KI, Zamzami MM. Efficacy of aspiration and autogenous bone marrow injection in the treatment of simple bone cysts. *Int Orthop*. 2009; 33: 1353 – 1358.
5. Hou HY, Wu K, Wang CT, Chang SM, Lin WH, Yang RS. Treatment of unicameral bone cyst: a comparative study of selected techniques. *J Bone Joint Surg Am*. 2010; 92: 855 – 862.
6. Saraph V, Zwick EB, Maizen C, Schneider F, Linhart WE. Treatment of unicameral calcaneal bone cyst in children: review of literature and results using a cannulated screw for continuous decompression of the cyst. *J Pediatr Orthop*. 2004; 24: 568 – 573.
7. Fillingham YA, Lenart BA, Gitelis S. Function after injection of benign bone lesions with a bioceramic. *Clin Orthop Relat res*. 2012; 470: 2014 – 2020.

Unicameral (Simple, Solitary, or Juvenile) Bone Cyst (UBC) Minimal invasive technique

Surgical positioning and preoperative procedures:

- ➔ Mark the site of surgery while informed consent of patient is obtained
- ➔ Position patient on a radiolucent table
- ➔ Prepare mobile C-arm
- ➔ General anesthesia is recommended for this procedure [1]
- ➔ Skin preparation and draping as usual
- ➔ Team time-out



Radiographic image and surgical guidance reproduced by kind permission of Dr Piotr Sowinski and Professor Jacek A.Kaczmarczyk, Dept of Orthopedic Surgery and Traumatology, Poznan University Hospital, Poznan, Poland.

Surgery:

- ➔ Introduce a bone needle (11 Gauge) transcortically into the proximal part of the cyst to act as a ventilation needle under fluoroscopy (Fig. 1).
- ➔ Place a second needle at the distal end of the cyst similarly (Fig. 1).
- ➔ Aspirate the cyst fluid and flush the void several times with 0.9 % saline.
- ➔ Take a sample for histology/cytology.
- ➔ Remove the epithelial lining of the cyst by spot wise scratching with the needle tips to ensure proper contact of CERAMENT™ with cancellous bone.
- ➔ Mix CERAMENT™ as per the Instructions For Use. Wait for three minutes when the material will be more viscous.
- ➔ Inject CERAMENT™ through the distal needle with the opposite needle allowing passive evacuation of the cyst fluid under fluoroscopic control. (The void can be filled with low injection pressure).
- ➔ Aim to completely fill the cyst bone void (sometimes not possible).
- ➔ Introduce the mandrins into the needles after complete filling and leave them for at least seven minutes in place.
- ➔ When slight resistance is felt remove both needles with a rotating movement.

Literature:

1. Nystrom L, Raw R, Buckwalter J, Morcuende JA. Acute intraoperative reactions during the injection of calcium sulfate bone cement for the treatment of unicameral bone cysts: a review of four cases. Iowa Orthop J 2008;28:81-84.

Unicameral (Simple, Solitary, or Juvenile) Bone Cyst (UBC) Minimal invasive technique

Follow Up:

- ➔ Clinical and radiological controls

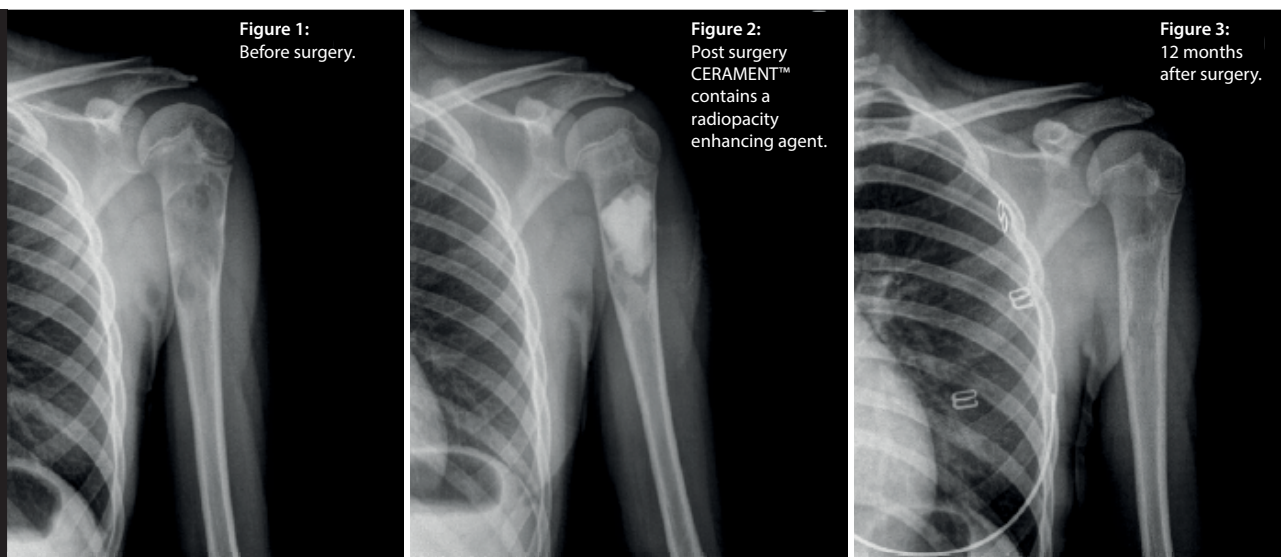
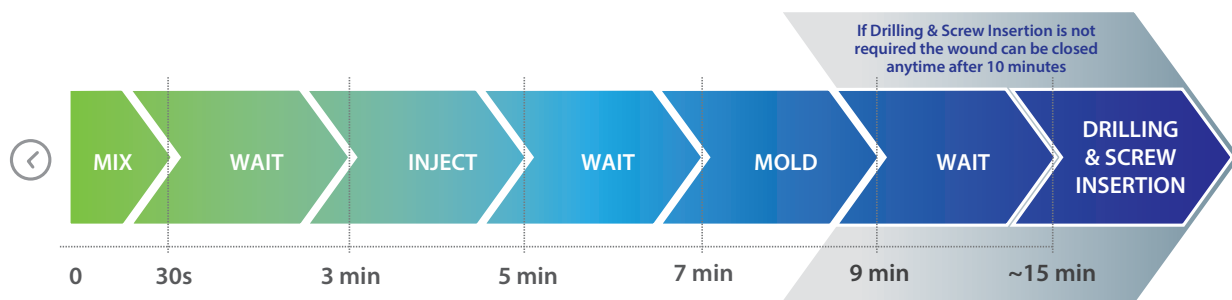


Fig. 1-3: Radiographic images and surgical guidance reproduced by kind permission of Dr Piotr Sowinski and Professor Jacek A.Kaczmarczyk, Dept of Orthopedic Surgery and Traumatology, Poznan University Hospital, Poznan, Poland.



- ➔ Ensure good contact with cancellous bone:
 - Bone cysts may be lined by epithelial tissue
 - This epithelial layer has to be debrided or removed by using the injection/evacuation needles
- ➔ Wait three minutes after mixing before you start to inject CERAMENT™|BONE VOID FILLER ('Spaghetti-test')
- ➔ Control bleeding during surgery
 - Extensive bleeding might result in intermixing of blood with the CERAMENT™ paste
 - Consider using a tourniquet



Unicameral (Simple, Solitary, or Juvenile) Bone Cyst (UBC) Open technique

Surgical positioning and preoperative procedures:

- ➔ Mark the site of surgery while informed consent of patient is obtained
- ➔ The use of a radiolucent table and a mobile C-arm is recommended
- ➔ Antibiotic prophylaxis 30 minutes before incision
- ➔ Place a surgical tourniquet, but do not activate it yet
- ➔ Skin preparation and draping as usual
- ➔ Team time-out



Figure 1:
Pre-operative lateral radiograph
of calcaneal bone cyst.



Figure 2:
Intra-operative radiograph of
fluoroscopic curettage.



Figure 3:
Intra-operative percutaneous
replacement of bone void with
CERAMENT™.

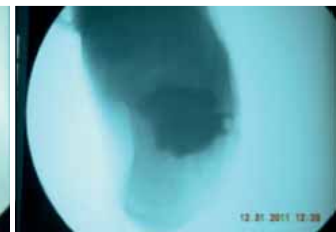


Figure 4:
Axial Radiograph demonstrating
the size of the defect filled with
CERAMENT™.

Fig. 1-4: Radiographic images reproduced by kind permission of Dr Lawrence DiDomenico, Adjunct Professor, Ohio College of Podiatric Medicine, Youngstown, Ohio, USA.

Surgery:

- ➔ Use a standard approach with good soft tissue coverage.
- ➔ Curettage of bone via a small bone window (0.8 x 0.8cm) under fluoroscopy (Fig. 2).
- ➔ Take a biopsy for histological evaluation.
- ➔ Take care for subtle hemostasis.
- ➔ The tourniquet should be activated now.
- ➔ Mix CERAMENT™ as per the Instructions For Use.
- ➔ Wait for three minutes when the material will be more viscous.
- ➔ Inject CERAMENT™|BONE VOID FILLER with a backfill technique under fluoroscopy – starting at the distal part of the void and inject as you withdraw proximally (Fig. 3).
- ➔ Place an abdominal cloth (laparotomy sponges) or a compress on the hardening CERAMENT™ with gentle pressure.
- ➔ Wait for 15 minutes until CERAMENT™ has hardened.
- ➔ Now the tourniquet can be released and hemostasis achieved.
- ➔ Follow normal surgical practice and if applicable use a drain with contact to the hardened CERAMENT™.
- ➔ Close soft tissue and skin carefully in layers.

Literature:

1. Nystrom L, Raw R, Buckwalter J, Morcuende JA. Acute intraoperative reactions during the injection of calcium sulfate bone cement for the treatment of unicameral bone cysts: a review of four cases. Iowa Orthop J 2008;28:81-84.

Unicameral (Simple, Solitary, or Juvenile) Bone Cyst (UBC) Open technique

Follow Up:

- ➔ Clinical and radiological controls

Figure 5:
24-month post-operative lateral radiograph demonstrating complete incorporation of the bone.



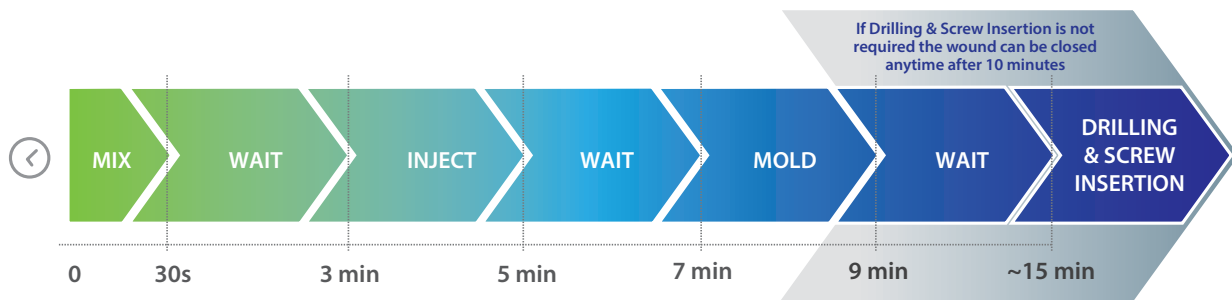
Figure 6:
Final post-operative clinical image demonstrating healthy recovery of soft tissue.



Fig. 5-6: Images reproduced by kind permission of Dr Lawrence DiDomenico, Adjunct Professor, Ohio College of Podiatric Medicine, Youngstown, Ohio, USA.



- ➔ Ensure good contact with cancellous bone:
 - Bone cysts may be lined by epithelial tissue or filled with septa or membranes, they have to be meticulously removed
- ➔ Wait three minutes after mixing till you start to inject CERAMENT™|BONE VOID FILLER ('Spaghetti-test')
- ➔ Control bleeding during surgery
 - Extensive bleeding might result in intermixing of blood with the CERAMENT™ paste
 - Consider using a tourniquet
- ➔ Follow normal surgical practice and if applicable use a drain with contact to the hardened CERAMENT™.
 - The drain may draw white coloured fluid some hours after surgery, which does not endanger or jeopardise the success of surgery
- ➔ Close soft tissue and skin in layers



Aneurysmal Bone Cyst (ABC)

Location:

Central or eccentric lesion in the metaphysis or diaphysis of a long bone. On plain radiographs ballooning with very thin peripheral bone shell can be often be found. Characteristic appearance on MR with fluid-fluid levels due to blood sedimentation [1, 2].



Diagnostics:

Clinical examination, X-rays, MRI, in some cases CT-scan or biopsy.

Therapy:

➤ Curettage and bone graft or bone graft substitutes [1-4].

Treatment options:

➤ In some cases Selective arterial embolization [4, 5] or radiotherapy [3,4,6].

Radiographic image reproduced by kind permission of Dr Piotr Sowinski and Prof. Jacek A. Kazmarczyk. Dept. of Orthopedic Surgery and Traumatology, Poznan University Hospital, Poznan, Poland.

Literature:

1. Tunn PU, Dürr HR. Benign bone tumours and tumour-like lesions of the bone. *Arthritis and Rheuma*. 2007; 27: 129 – 140.
2. Kransdorf MJ, Sweet DE. Aneurysmal Bone Cyst: Concept, Controversy, Clinical Presentation, and Imaging. *AJR* 1995;164:573-580.
3. Mendenhall WM, Zlotecki RA, Gibbs CP, Reith JD, Scarborough MT, Mendenhall NP. Aneurysmal bone cyst. *Am J Clin Oncol*. 2006; 29: 311 - 315.
4. Rapp TB, Ward JP, Alaia MJ. Aneurysmal bone cyst. *J Am Acad Orthop Surg*. 2012; 20: 233 – 241.
5. Cottalorda J, Bourelle S. Current treatments of primary aneurysmal bone cysts. *J Pediatr Orthop B*. 2006; 15: 155 - 167.
6. Feigenberg SJ, Marcus RB Jr, Zlotecki RA, Scarborough MT, Berrey BH, Enneking WF. Megavoltage. Radiotherapy for aneurysmal bone cysts. *Int J Radiat Biol Phys*. 2001; 49: 1243 - 1247.

Aneurysmal Bone Cyst (ABC)

Open technique

Surgical positioning and preoperative procedures:

- ➔ Mark the site of surgery while informed consent of patient is obtained
- ➔ The use of a radiolucent table is recommended
- ➔ Prepare mobile C-arm
- ➔ Antibiotic prophylaxis 30 min before incision
- ➔ Place a surgical tourniquet, but do not activate it yet
- ➔ Skin preparation and draping as usual
- ➔ Team time-out

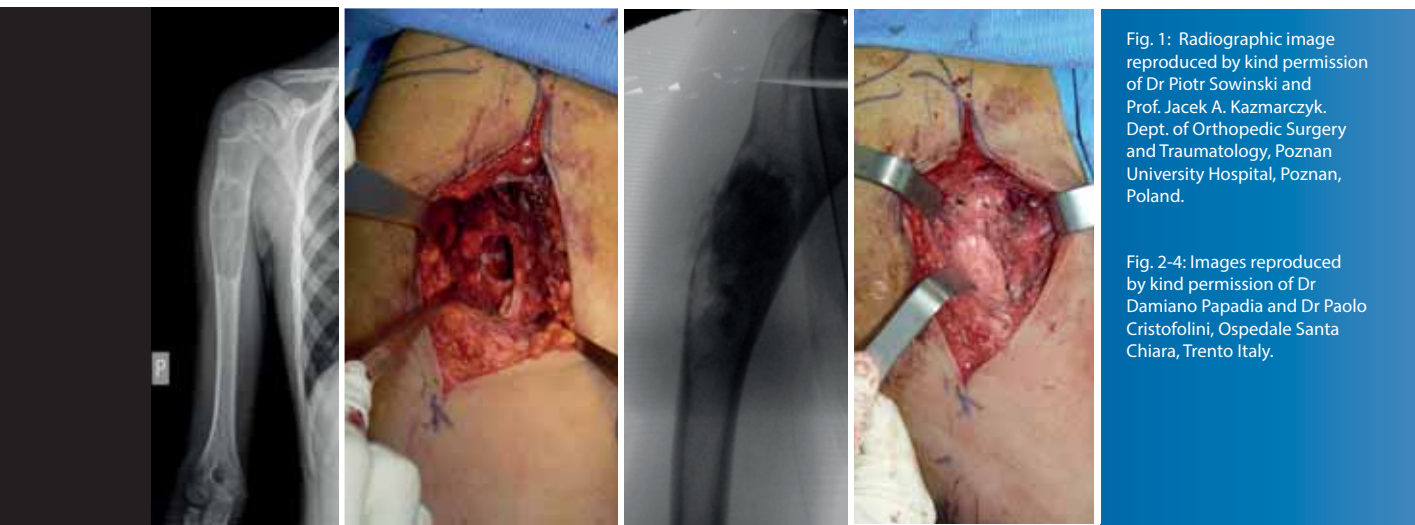


Figure 1

Figure 2:
A small bone window
allows for removal of
the cyst contents.

Figure 3:
Inject CERAMENT™|
BONE VOID FILLER
under fluoroscopy.

Figure 4:
Wait for 15 minutes until
CERAMENT™ has hardened.

Fig. 1: Radiographic image reproduced by kind permission of Dr Piotr Sowinski and Prof. Jacek A. Kazmarczyk. Dept. of Orthopedic Surgery and Traumatology, Poznan University Hospital, Poznan, Poland.

Fig. 2-4: Images reproduced by kind permission of Dr Damiano Papadia and Dr Paolo Cristofolini, Ospedale Santa Chiara, Trento Italy.

Surgery:

- ➔ Use a standard approach with good soft tissue coverage.
- ➔ Curettage bone via a small bone window (0.8 x 0.8cm) under fluoroscopy to remove the cyst membrane and contents (Fig 2).
- ➔ Maintain the thin peripheral bone shell intact.
- ➔ Take a biopsy for histological evaluation.
- ➔ Take care for subtle hemostasis.
- ➔ The tourniquet should be activated now.
- ➔ Mix CERAMENT™ as per the Instructions For Use.
- ➔ Wait for three minutes when the material will be more viscous.
- ➔ Inject CERAMENT™|BONE VOID FILLER with a backfill technique under fluoroscopy – starting at the distal part of the void and inject as you withdraw proximally (Fig. 3).
- ➔ Place an abdominal cloth (laparotomy sponges) or a compress on the hardening CERAMENT™ with gentle pressure.
- ➔ Wait for 15 minutes until CERAMENT™ has hardened. (Fig. 4).
- ➔ Now the tourniquet can be released and hemostasis achieved.
- ➔ Follow normal surgical practice and if applicable use a drain with contact to the hardened CERAMENT™.
- ➔ Close soft tissue and skin carefully in layers.

Literature:

1. Nystrom L, Raw R, Buckwalter J, Morcuende JA. Acute intraoperative reactions during the injection of calcium sulfate bone cement for the treatment of unicameral bone cysts: a review of four cases. Iowa Orthop J 2008;28:81-84.

Aneurysmal Bone Cyst (ABC) Open technique

Follow Up:

- ➔ Clinical and radiological controls

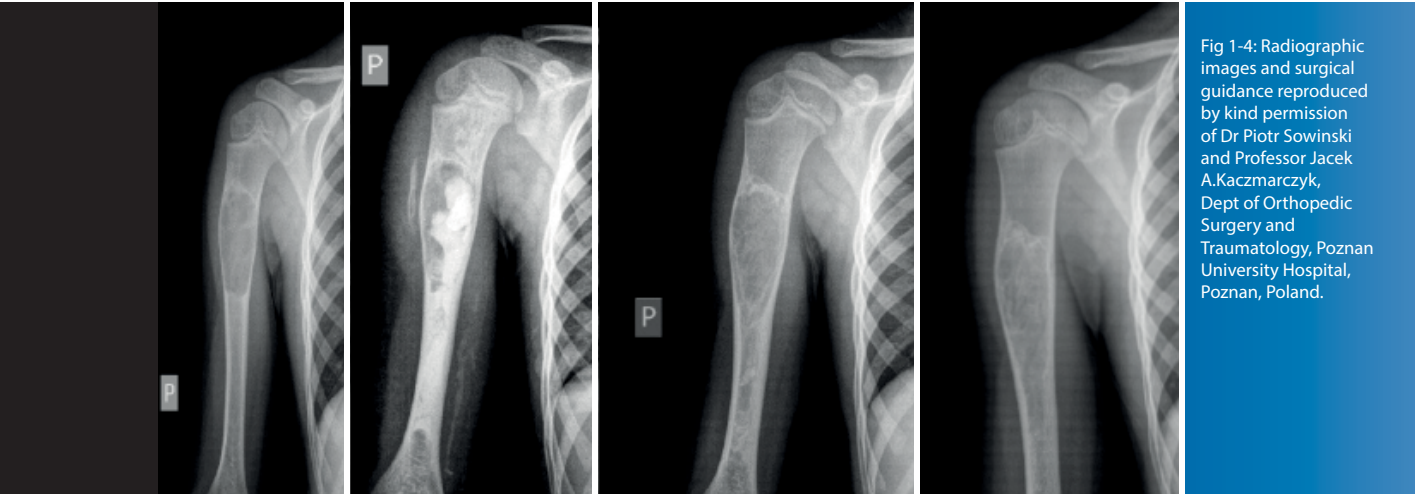


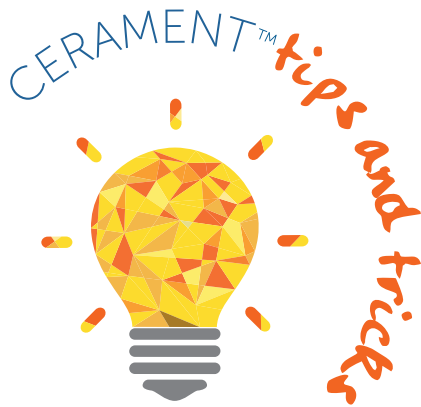
Figure 1:
Before surgery.

Figure 2:
Post surgery CERAMENT™ contains a radiopacity enhancing agent.

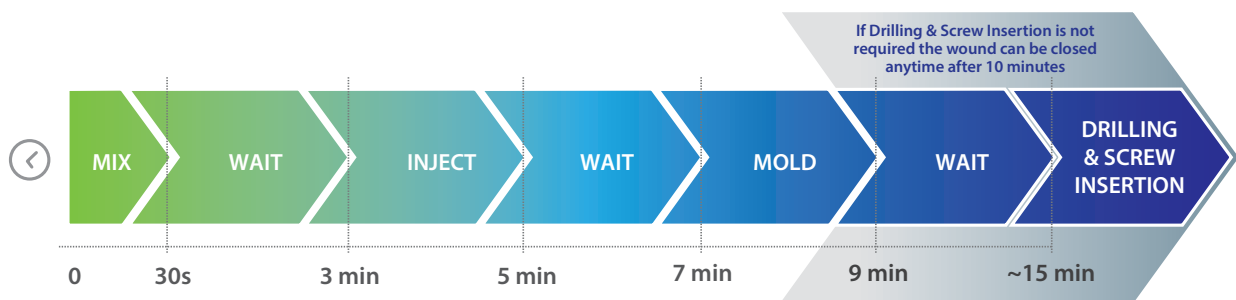
Figure 3:
3 months after surgery.

Figure 4:
12 months after surgery.

Fig 1-4: Radiographic images and surgical guidance reproduced by kind permission of Dr Piotr Sowinski and Professor Jacek A.Kaczmarczyk, Dept of Orthopedic Surgery and Traumatology, Poznan University Hospital, Poznan, Poland.



- ➔ Ensure good contact with cancellous bone:
 - Bone cysts may be lined by epithelial tissue or filled with septa or membranes, they have to be meticulously removed
- ➔ Wait three minutes after mixing till you start to inject CERAMENT™|BONE VOID FILLER ('Spaghetti-test')
- ➔ Control bleeding during surgery
 - Extensive bleeding might result in intermixing of blood with the CERAMENT™ paste
 - Consider using a tourniquet
- ➔ Follow normal surgical practice and if applicable use a drain with contact to the hardened CERAMENT™
 - The drain may draw white coloured fluid some hours after surgery, which does not endanger or jeopardise the success of surgery
- ➔ Close soft tissue and skin in layers



Enchondroma

Location:

Well-defined osteolytic cartilage-forming lesion, most commonly found centrally in the phalanges of hands and feet [1]. In some cases pathologic fractures are seen. Periosteal lesions arise at the surface of the bone. Scalloping of cortical bone is possible, but there is no marrow involvement [2].



Diagnostics:

Clinical examination, X-rays, MRI. Biopsy is not useful (activated histological impression with many mitoses and polymorphism of nuclei makes it difficult to exclude a chondrosarcoma grade 1) [1, 3].

Therapy:

☞ In cases without symptoms careful observation (X-ray controls every 12 or 24 month). If symptoms are present (pain, pathologic fractures or periosteal lesions) Curettage and bone graft or bone substitutes are indicated [2].

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Literature:

1. Tunn PU, Dürr HR. Benign bone tumours and tumour-like lesions of the bone. *Arthritis and Rheuma*. 2007; 27: 129 – 140.
2. Henderson M, Neumeister MW, Bueno RA Jr. Hand tumors: II. Benign and malignant bone tumors of the hand. *Plast Reconstr Surg*. 2014; 133: 814e – 821e.
3. Delling G, Jobke B, Burisch S, Werner M. Knorpelbildende Tumoren: Klassifikation, Voraussetzungen für die Biopsie und histologische Charakteristika. *Orthopäde*. 2005; 34: 1267–1281.

Endochondroma

Open technique

Surgical positioning and preoperative procedures:

- ➔ Mark the site of surgery while informed consent of patient is obtained
- ➔ The use of a radiolucent table and a mobile C-arm is recommended
- ➔ Antibiotic prophylaxis 30 min before incision
- ➔ Place a surgical tourniquet and activate it
- ➔ Skin preparation and draping as usual
- ➔ Team time-out



Figure 1:
Before surgery.

Figure 2:
Curettage of the cyst
via a bone window.

Figure 3:
Curettage of the cyst via a
bone window.

Figure 4:
Cyst is filled
with CERAMENT™|
BONE VOID FILLER.

Figure 5:
Replace the
bone flap.

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Surgery:

- ➔ Use a standard approach with good soft tissue coverage.
- ➔ Curettage of bone via a bone window (2 x 0.8 cm) (Fig. 2 & 3).
- ➔ Keep the bone flap intact.
- ➔ Take a biopsy for histological evaluation.
- ➔ Take care for subtle hemostasis.
- ➔ Mix CERAMENT™ as per the Instructions For Use.
- ➔ Wait for three minutes when the material will be more viscous.
- ➔ Inject CERAMENT™|BONE VOID FILLER with a backfill technique under fluoroscopy – starting at the distal part of the void and inject as you withdraw proximally (Fig. 4).
- ➔ Replace bone flap on hardening CERAMENT™ (Fig. 5).
- ➔ Place an abdominal cloth (laparotomy sponges) or a compress on the bone flap.
- ➔ Wait for 15 minutes until CERAMENT™ has hardened.
- ➔ Now the tourniquet can be released and hemostasis achieved.
- ➔ Use a mini-drain with contact to the bone flap.
- ➔ Close soft tissue and skin carefully in layers.

Endochondroma Open technique

Follow Up:

- ➔ Clinical and radiological controls

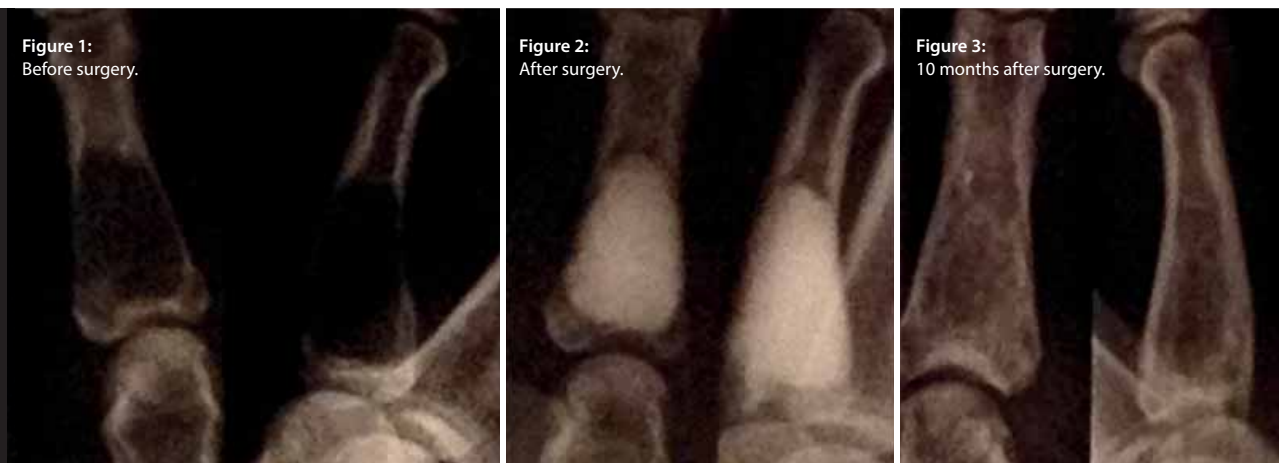


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- ➔ Control bleeding during surgery
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 - Consider using a tourniquet
- ➔ Follow normal surgical practice and if applicable use a drain with contact to the hardened CERAMENT™
 - The drain may draw white coloured fluid some hours after surgery, which does not endanger or jeopardise the success of surgery
- ➔ Replace the bone flap
- ➔ Close soft tissue and skin in layers

