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CASE REPORT

Adjuvant MRI-guided percutaneous cryoablation treatment for aneurysmal bone cyst

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Abstract
Aneurysmal bone cysts are benign, expansile, lytic bone lesions that behave in a locally aggressive manner. Although radiography and computed tomography (CT) can detect the lesion, magnetic resonance imaging (MRI) is ideal for the demonstration of characteristic fluid–fluid levels, extent, and margins. Treatment typically consists of open surgical curettage with the addition of local adjuvants and bone grafting. Residual or recurring lesions may be treated using percutaneous cryoablation. Although CT guidance is often employed for image guidance, visualization and targeting of smaller clusters can be challenging in young children, secondary to the partially mineralized bone matrix in the immature skeleton. In such cases, the higher contrast resolution of interventional MRI affords direct visualization and targeting of small aneurysmal bone cysts, accurate monitoring of the extent of the growing ice ball beyond the lesion's margin, and avoidance of exposure to ionizing radiation. We report a case of a 5-year-old boy with recurrent or remaining aneurysmal bone cysts of the scapula after surgical excision and embolization, which were successfully treated using MRI-guided cryoablation.

Keywords Aneurysmal bone cyst · Treatment · Recurrence · Cryotherapy · MRI guidance

Introduction

Aneurysmal bone cysts are benign, expansile, locally aggressive, lytic bone lesions with an annual incidence of approximately 0.14 per 1 million individuals that typically occur during the 1st and 3rd decades of life with a peak incidence during the 2nd decade [1]. Radiography and computed tomography (CT) can detect the lesion; however, magnetic resonance imaging (MRI) is ideal for the demonstration of characteristic fluid–fluid levels, extent, and margins. The most common locations are the femur (15%), tibia (15%), and spine (14%), whereas only 2% occur in the scapula [2]. An effective treatment regimen is a combination of lesion removal through open surgical curettage followed by local adjuvant treatment, and bone or cement grafting. A number of local adjuvants have been described, including cryoablation, argon beam coagulation, and phenol [3]. Intraoperative cryoablation is an adjuvant treatment that induces tissue necrosis through the formation of ice crystals, osmotic cell injury, disruption of cellular membranes, and vascular injury [4]. Image-guided percutaneous calcitonin injection has been used successfully for the treatment of aneurysmal bone cysts [5].

Percutaneous cryoablation under image guidance can be used to treat remaining or recurrent smaller aneurysmal bone cysts. CT guidance may be used if the lesion is well seen on CT image; however, in the immature skeleton with only partially mineralized bone matrix, small aneurysmal bone cysts may be seen best on MRI. In such cases, cryoablation may be performed under MRI guidance, which comes with the additional advantage of a lack of procedure-related exposure to ionizing radiation [6, 7]. We report a case of a 5-year-old boy with recurrent or remaining aneurysmal bone cysts of the scapula after surgical excision and embolization, which were successfully treated using MRI-guided cryoablation.

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Case report

A 5-year-old boy presented with a 1-year history of nontraumatic right shoulder pain, which had gradually increased to an intensity level of 8 on an 11-point pediatric visual pain scale, whereas 10 indicated maximum pain. Physical examination was notable for fullness over the right shoulder, absent active shoulder range of motion secondary to pain, and normal neurovascular examination of the hand. Radiographs (Fig. 1a) and CT (Fig. 1b) showed expansile lytic lesions of the scapula with partial preservation of a rim of cortical bone. MRI demonstrated two dominant expansile, lytic lesions in the body of the right scapula and coracoid that were characterized by small cystic spaces with fluid–fluid levels (Fig. 1c). CT-guided biopsy and subsequent histopathological examination confirmed the diagnosis of aneurysmal bone cysts (Fig. 2).

Over a period of 6 months, the patient underwent preoperative embolization and subsequent surgical curettage, intraoperative adjuvant cryoablation, and bone grafting. There was reduced but persistent pain. Follow-up MRI showed successful treatment of the larger scapular lesion with no evidence of remaining aneurysmal bone cysts, whereas the coracoid lesion showed partial treatment with two small remaining or recurring aneurysmal bone cysts at the base of the coracoid (Fig. 3a). Given the small size of the remaining disease and the associated morbidity of repeat open surgical intervention, a decision was made to proceed with percutaneous cryoablation. Owing to the low conspicuity of the region of the two remaining or recurring aneurysmal bone cysts at the base of the coracoid (Fig. 3a) on the baseline CT images, we performed the procedure under MRI guidance.

The cryoablation procedure was performed utilizing a 1.5-T MRI system (MAGNETOM Espree, Siemens Healthcare, Erlangen, Germany). General anesthesia was employed. Using a 19-cm loop coil and table element coils, axial intermediate-weighted MRI (turbo spin echo [TSE]; repetition time [TR], 7440; echo time [TE], 24; slice thickness [SL], 3.5 mm; echo train length [ETL], 18; field of view [FOV], 348 × 300 mm; base resolution [BR], 448; phase resolution [PR], 70%; receiver bandwidth [BW], 151 Hz, acquisition time [TA], 3:51 min) identified the two small aneurysmal bone cysts at the coracoid (Fig. 3a). The interventional site was prepped and draped in the usual sterile fashion, after which an 18G introducer needle was advanced to the coracoid under intermittent MRI guidance (TSE; TR, 2480; TE, 23; SL, 3 mm; ETL, 17; FOV, 338 × 300 mm; BR, 384; PR, 70%; BW, 356 Hz). The 18G introducer needle was used for cortical penetration and as an access sheath for intraosseous placement of the cryoablation probe (IceSeed 1.5 MRI Needle; Galil Medical, St Paul, MN, USA). Following successful probe placement into the center of the lesion, cryoablation was performed with two freeze–thaw cycles, each with 6 min of active freezing and 2 min of active thawing at 100% intensity. Continuous MRI at a frame rate of 21 s (TSE; TR, 1,800; TE, 23; SL, 3 mm; ETL, 17; FOV, 338 × 300 mm; BR, 384; PR, 70%; BW, 356 Hz) was used to monitor the ice ball growth to extend beyond the margins of the lesion (Fig. 3b–e). The second lesion was ablated in a similar fashion during

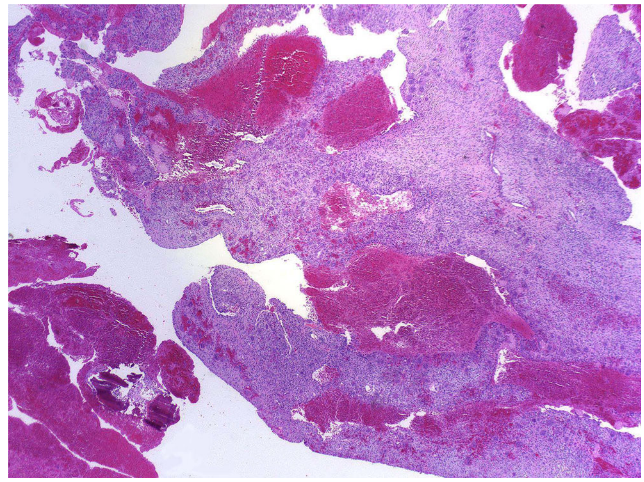

Fig. 2 Low power photomicrograph of a hematoxylin- and eosin–stained section of the right scapular lesion showing large cystic spaces filled with blood that are separated by fibrous areas and contain osteoclast-like multinucleated giant cells, confirmative of an aneurysmal bone cyst

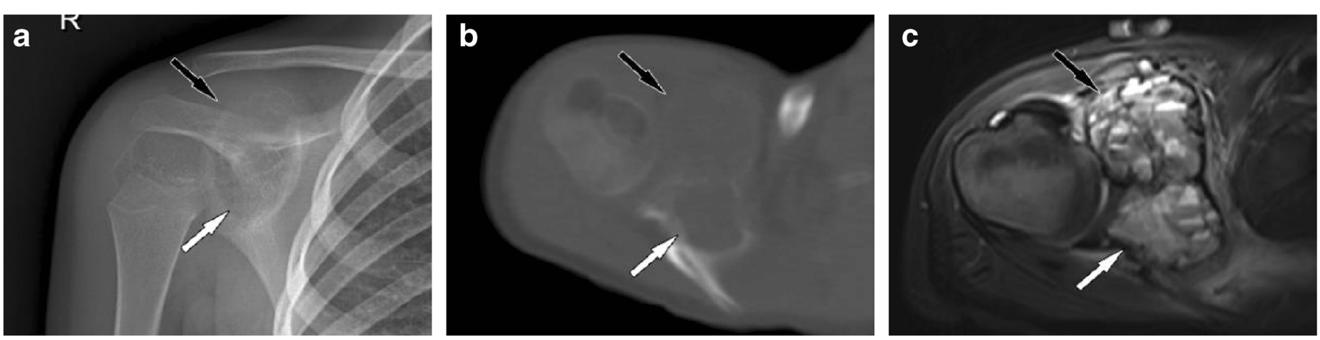

Fig. 1 **a** Anteroposterior radiograph of the right shoulder shows an expansile, lytic lesion (*black arrow*) of the scapular body with preservation of a cortical rim of bone. **b** Axial CT image of the right shoulder shows two lesions in the scapular body (*white arrow*) and coracoid (*black arrow*). **c** Axial T2-weighted MRI with spectral fat suppression shows the many small internal cystic spaces with fluid–fluid levels in the lesions of the scapular body (*white arrow*) and coracoid (*black arrow*)

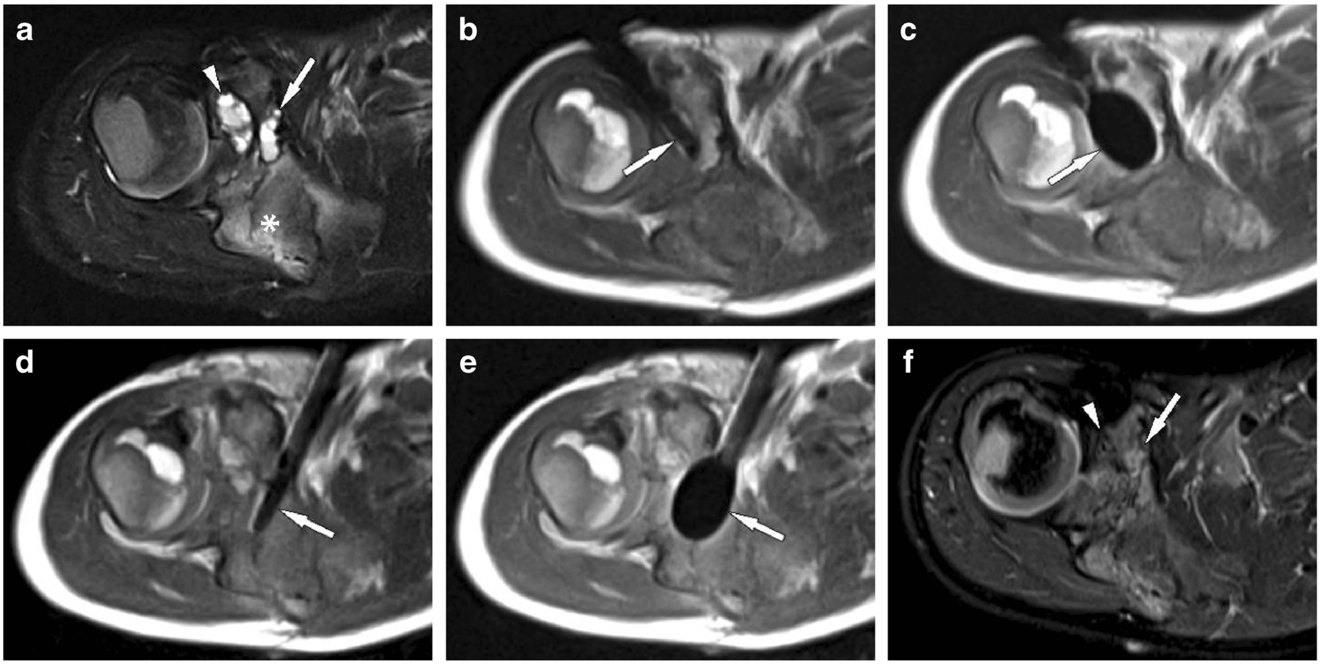

Fig. 3 MRI-guided cryoablation of two small aneurysmal bone cysts at the base of the coracoid in a 5-year-old boy following two treatments of embolization, surgical curettage, intraoperative adjuvant cryoablation, and bone grafting. **a** Axial T2-weighted MRI with spectral fat suppression shows two small aneurysmal bone cysts lateral (*arrowhead*) and medial (*arrow*) to the base of the coracoid. The *asterisk* shows the successfully treated scapular body lesion. **b**, **c** Axial intermediate-weighted MRI shows the cryoablation probe (**b**, *arrow*) in the lateral aneurysmal bone cyst and the 2 × 3 cm ice ball (**c**, *arrow*) ablating the lesion. **d**, **e** Axial intermediate-weighted MRI shows the cryoablation probe (**d**, *arrow*) in the medial aneurysmal bone cyst and the 2 × 3 cm ice ball (**e**, *arrow*) ablating the lesion. **f** At 3 months' follow-up, an axial T2-weighted MRI with spectral fat suppression shows successful ablation of the two lesions

the same session. The maximum ice ball sizes were 2 × 3 cm. There were no complications. The length of time of the entire procedure from entry to exit of the interventional suite was 2 h and 23 min, which included in-room induction and recovery of general anesthesia. At 3-months' follow-up MRI, there was interval resolution of the aneurysmal bone cyst medial and lateral to the coracoid process (Fig. 3f).

The right scapular pain subsequently resolved, and the boy regained full right shoulder motion and function. Three years after the procedure, he remains disease free with no complaints and can undertake full activities without restriction. Serial radiographic follow-up over a 3-year period demonstrates progressive mineralization of the scapula with no evidence for recurrence (Fig. 4).

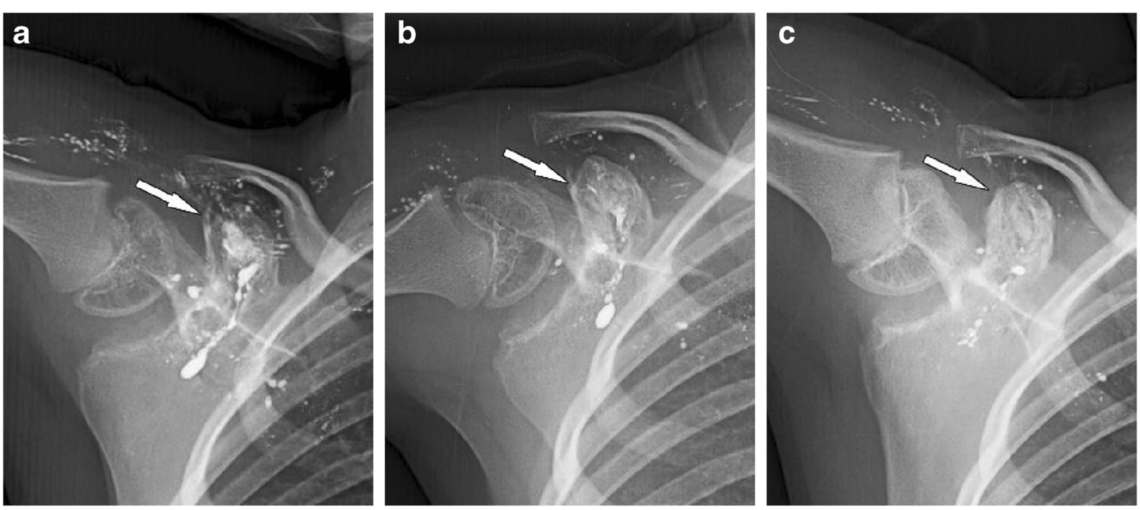

Fig. 4 Annual follow-up over 3 years (**a** 1 year after the procedure; **b** 2 years after the procedure; **c** 3 years after the procedure) with anteroposterior radiographs of the right shoulder shows progressive mineralization of the scapula (*arrows*) with no evidence for recurrence. The linear, radiopaque soft-tissue densities represent embolization agent

Discussion

Aneurysmal bone cysts are benign cystic bone lesions, predominantly consisting of blood-filled cavities interspersed with connective tissue. At the periphery, there may be solid parts of varying dimensions that mostly consist of giant cells and fibroblasts [2]. The radiological appearance is typically an expansile lytic bone lesion with a short transition zone and sclerotic border. On MRI, fluid–fluid levels are a characteristic feature with diagnostic significance as the extent of fluid–fluid levels within a focal bone lesion appears to be inversely related to the degree of malignancy; however, significant differential diagnoses are giant cell tumor and telangiectatic osteosarcoma [8].

The optimal management of aneurysmal bone cysts depends on various factors including the age of the patient, anatomical location, extent of bone and soft tissue, and the size of the lesion. Accordingly, the rate of local recurrence varies [9]. Recurrences are more likely in young children with open growth plates and most often occur within the first 2 years postoperatively [10]. Extended mechanical curettage with a high-speed burr is the treatment of choice [10]. Owing to the high local recurrence rate with curettage alone, many authors have suggested the addition of local adjuvants to kill microscopic disease with the goal of improving local control. The use of adjuvant liquid nitrogen has been reported to provide superior local control with excellent maintenance of function and joint preservation [11]. In addition, the use of additive cryotherapy can result in pain relief, similar to the effect of cryotherapy of bone metastases [12]. Image-guided percutaneous calcitonin and doxycycline injections have been used successfully for the treatment of aneurysmal bone cysts as well [5].

Following the principle of intraoperative cryotherapy, percutaneous cryoablation may be used to treat residual or recurrent aneurysmal bone cysts effectively, with the added benefit of a minimally invasive approach when using cross-sectional imaging guidance [13, 14]. In young children with an immature skeleton and only partial matrix mineralization, such as in our case, CT guidance can be challenging because of the inability to visualize and target small aneurysmal bone cysts accurately. Although CT guidance could result in shorter procedure times owing to faster image acquisition, CT guidance results in exposure to ionizing radiation and nerves, vessels, and the boundaries of the ice ball in soft tissues may be difficult to identify with certainty. In such cases, the higher contrast resolution of MRI guidance can be advantageous as it affords the direct visualization and targeting of small aneurysmal bone cysts, accurate monitoring of the ice ball extent beyond the lesion's margin, and avoidance of exposure to ionizing radiation. Although still in the experimental stage, cementoplasty after cryoablation [14] may also be performed under MRI guidance [15]. During cryoablation, the sparing of vulnerable structures, such as open physes and nerves, is an important factor in avoiding adverse effects, which may also benefit from MRI guidance. Larger studies with appropriate sample size and study design are required to fully determine the full value of percutaneous cryoablation in the treatment of aneurysmal bone cysts.

In conclusion, we report the case of a 5-year-old boy with aggressive aneurysmal bone cysts of the scapula in whom MRI-guided cryoablation was successfully used to treat residual lesions after surgical excision in an additive fashion to achieve a cure. Our patient remains disease free 3 years after the procedure, with no functional deficits.

Compliance with ethical standards

Grant support None.

Conflicts of interest None.

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