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CLINICAL RESEARCH

Aneurysmal Bone Cysts: Do Simple Treatments Work?

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Abstract

Background Primary aneurysmal bone cysts (ABCs) are benign, expansile bone lesions commonly treated with aggressive curettage with or without adjuvants such as cryotherapy, methacrylate cement, or phenol. It has been reported that occasionally these lesions heal spontaneously or after a pathologic fracture, and we observed that some ABCs treated at our center healed after biopsy alone. Because of this, we introduced a novel biopsy technique we call "curopsy," which is a percutaneous limited curettage at the time of biopsy, obtaining the lining membrane from various quadrants of the cyst leading to consolidation (curopsy = biopsy with intention to cure).

Questions/purposes We asked whether (1) a curopsy results in comparable likelihood of healing of the ABC compared with more aggressive approaches involving curettage, (2) the two approaches differ in terms of the likelihood of recurrence after treatment, and (3) the two approaches differ in terms of complications after surgery.

Methods Between January 1, 1999 and June 30, 2012, 221 patients with a diagnosis of primary ABC were registered in our oncology database. Patients presenting with a pathologic fracture and those seeking a second opinion were excluded. One hundred ninety patients were included in the study. One hundred two (54%) were treated with curopsy and 88 (46%) were treated with curettage after a core needle biopsy. Complete followups were available for 88% (90 of 102) and 93% (80 of 88) of patients in those groups, respectively. During that period, a curopsy was performed for all patients with benign bone lesions with imaging suggestive of classic primary ABCs and for whom the core needle biopsy simply showed blood with no solid component. Curettage after a core needle biopsy was reserved for histologically confirmed primary ABCs, lesions with impending fractures, large lesions, if the ABC was thought to be a secondary disorder, and patients for whom the curopsy failed. All patients were followed up until consolidation of the lesion (mean, 9.6 weeks, range, 3–25 weeks, 95% CI, 8.32–10.9 for curopsy; mean, 11.4 weeks, range, 8–32 weeks, 95% CI, 10.6–12.3 for curettage). The median followup for all patients was 14 months (range, 6–36 months).

Results Of the 102 patients who had curopsy and observation, 83 (81%) required no additional treatment and the lesion resolved. Of the 88 patients who underwent curettage (with or without adjuvant therapy) after core needle biopsy, the success rate was 90% (79 of 88). Local recurrences in both groups (curopsy or curettage) were treated

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Each author certifies that his or her institution approved the human protocol for this investigation that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.
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successfully with additional curettage in all but one case. Curopsy in comparison to curettage provided a mean shorter healing time (9.6 versus 11.4, p = 0.01) but there was a higher local recurrence and need for additional intervention rate (18.6% versus 10.2%, p = 0.04). There were no differences in the complications between the treatment groups.

Conclusions A curopsy is a novel biopsy technique that was successful in resolving ABCs in 81% of the patients in our study. Curopsy, as a biopsy technique, for ABCs needs consideration as it potentially minimizes the number of patients needing a second procedure (a core needle biopsy being the first) as is the current practice. Furthermore, it does not disadvantage the patient or surgeon should additional intervention be needed in the form of curettage with or without adjuvants.

Level of Evidence Level III, therapeutic study. See the Instructions for Authors for a complete description of levels of evidence.

Introduction

Jaffe and Lichtenstein [15] first described aneurysmal bone cysts (ABCs) as a separate clinicopathologic entity in 1942. In 2002, an ABC was defined by the WHO as "a benign cystic lesion of bone composed of blood filled spaces separated by connective tissue septa containing fibroblasts, osteoclast-type giant cells and reactive woven bone" [8]. An ABC may be primary or arise secondarily in other benign or malignant bone tumors [8]. Oliveira et al. [20] reported cytogenetic differences between primary and secondary ABCs, with a primary ABC being a mesenchymal neoplastic disease with spindle cell proliferation exhibiting USP6 or CDH11 rearrangements in 2/3 of the cases whereas a secondary ABC morphologically mimics a primary ABC without the hallmark USP6 or CDH11 rearrangements.

Traditionally, curettage and bone grafting have been regarded as the mainstays of treatment. In an attempt to decrease the rate of recurrence, some authors have promoted various adjuvants for treating ABCs such as use of liquid nitrogen (cryotherapy) [16, 18, 29], polymethylmethacrylate cementation [21, 22] or phenol in the bone cavity [3], use of a high-speed burr [7, 10], or bone marrow injections [6, 12] in the lesion. Percutaneous injection of alcohol or other agents (ie, sclerotherapy), has been used to treat ABCs that are difficult to approach surgically such as those in the pelvis, sacrum, or spine [9, 25]. The use of argon beam coagulation has been reported to reduce the rate of recurrence in ABCs [5, 27]. Intrinsic healing potential after minor intralesional procedures or even spontaneous resolution also was reported [1]. Radiation therapy has been used for lesions determined to be nonoperable [2, 4]. Arterial embolization has been used before surgery to decrease intraoperative blood loss and also as a stand-alone treatment for unresectable lesions [4, 26]. However, the use of adjuvants, although producing a lower recurrence rate, is not free from complications. Steffner et al. [27] enumerated the complications with adjuvant therapies such as cutaneous fistulas, abscesses, cellulitis, osteitis (with alcohol); induration and hypopigmentation (with sclerotherapy); hemolysis and coagulative necrosis (phenol), and local thermal necrosis with polymethylmethacrylate. In their study, the overall complication rate with Argon beam coagulation was higher than the rate for patients who had a high-speed burr used (19% versus 6%). We observed that some ABCs heal after biopsy alone. We developed a novel biopsy technique that we call a curopsy, which we define as a percutaneous limited curettage at the time of biopsy, obtaining the lining membrane from various quadrants of the cyst leading to consolidation (curopsy = biopsy with intention to cure). As a result of this, we changed our treatment regime. All patients with a likely primary ABC now have a curopsy to confirm the diagnosis and affect a cure. After curopsy, patients are followed up clinically and radiographically. Only if the lesion or symptoms progress do patients undergo additional treatment, mostly with curettage without adjuvants.

In the current study, we asked whether (1) a curopsy results in comparable likelihood of healing of the ABC compared with more aggressive approaches involving curettage, (2) the two approaches differ in terms of the likelihood of recurrence after treatment, and (3) the two approaches differ in terms of complications after surgery.

Patients and Methods

Between January 1, 1999 and June 30, 2012, 221 patients with a diagnosis of primary ABC were registered in our oncology database. Excluding patients seeking second opinions, patients presenting with a fracture, and those with no tissue diagnosis, 190 patients were included in the study. Six patients with giant cell reparative granulomas and a solid ABC also were not included in this study. Our study population consisted of patients with classic primary ABCs only. After obtaining our institutional ethics committee approval for the study, the medical records, radiographs, and histology reports for these patients were retrospectively reviewed. One hundred ninety patients were included in our study based on the criteria of a histologic primary ABC, treated surgically with a curopsy or biopsy followed by detailed curettage with or without adjuvants (bone grafting or prophylactic internal fixation). If the ABC was thought to be a secondary lesion, then a curopsy was

not performed and the histologic diagnosis was obtained with a core needle biopsy before any definitive surgical intervention. Cytogenetic testing was not used routinely and no frozen sections were done.

Surgical Techniques

Curopsy

All bone biopsies were performed with the patient receiving general anesthesia in the operating room or the radiology suite. However, a curopsy was performed only in the operating room with the patient under a general anesthetic. A curopsy was performed for all patients with benign bone lesions with imaging suggestive of a classic primary ABC and for whom the core needle biopsy simply showed blood with no solid component. In other words a small open biopsy was done to obtain diagnostic material and at the same time the curopsy was performed. At the time of biopsy an incision is made measuring approximately 5 to 10 mm in length. A core needle biopsy using a T-Lok^{TM} needle (Medical Device Technologies Inc, Gainesville, FL, USA) was done under image intensification. In addition to a core needle, we use a pituitary rongeur or a curette to obtain lining membrane from various quadrants of the lesion as part of the biopsy only in cases suggestive of an ABC on preoperative radiographs and perioperatively at the time of biopsy. We refer to this procedure as a curopsy to indicate a generous biopsy technique done to obtain a diagnosis in addition to having a therapeutic benefit (Fig. 1). The results of the biopsy are available through the tumor board. No adjuvants or injections were used. Skin incision was closed using one or two interrupted sutures. No tourniquets or embolization was used for any patient in the curopsy group.

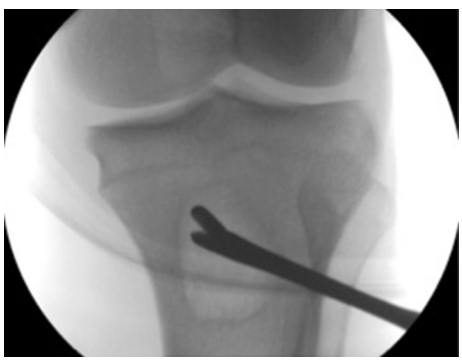

Fig. 1 An intraoperative fluoroscopic image is shown of a curopsy being performed in a primary ABC of the proximal tibia.

Curettage

Curettage following a core needle biopsy was reserved for patients with histologically confirmed primary ABCs, lesions with impending fractures, large lesions, and if the ABC was thought to be a secondary disorder. After a core needle biopsy and confirmation of the diagnosis, curettage was done in which a bigger skin incision was used for saucerization or deroofing the lesion over most of its length to scrape out the abnormal tissue under direct vision. A high-speed burr was used to obtain healthy bleeding cancellous bone. In patients who underwent curettage, the cavity preferably was left empty after curettage without filling with bone graft or cement (exceptions being locations like the femoral neck or talus to prevent collapse, where bone grafting was used; lesions in the peritrochanteric region of the femur were internally fixed prophylactically). Perioperative use of a tourniquet and/or fluoroscopic guidance and postoperative management were dependent on the extent and location of the lesion and the preference of the surgeon. Because of the perceived fracture risk after the procedure, some restriction (use of crutches, partial or nonweightbearing) or immobilization (plaster cast or sling) often was advised on a case-by-case basis. Preoperative embolization was used before curettage for three patients with a pelvic ABC.

Table 1. Skeletal distribution of all lesions

Site	Number
Tibia	50
Femur	28
Humerus	17
Fibula	22
Pelvis	17
Clavicle	8
Radius	7
Metatarsal	7
Ulna	6
Hand	5
Sacrum	5
Scapula	5
Calcaneum	4
Patella	4
Cuboid	1
Ribs	1
Spine	1
Sternum	1
Talus	1
Total	190

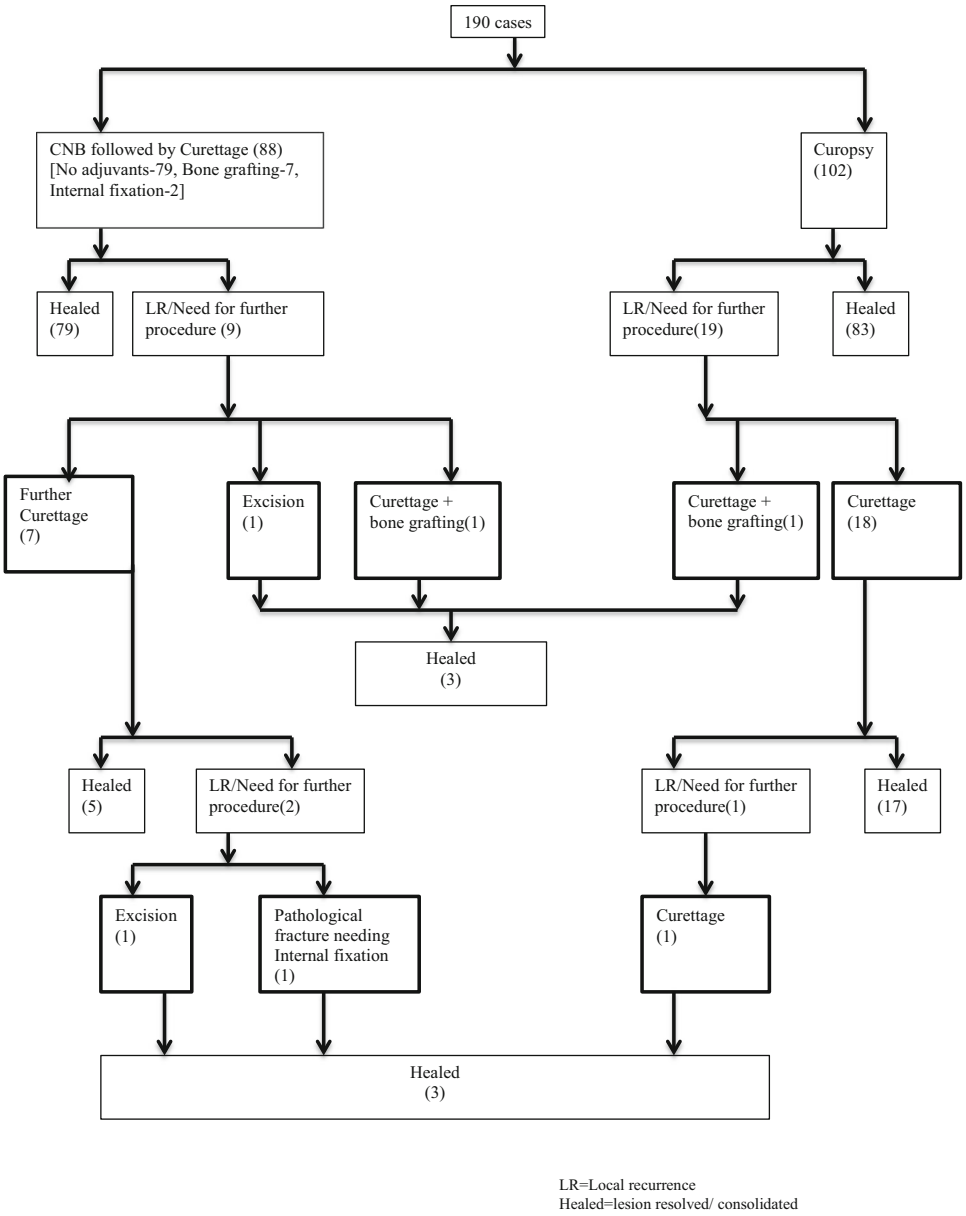

Fig. 2 A synopsis of treatment for the 190 patients with primary ABCs is shown. Healed = consolidation of lesion.

Followup

The radiologic healing was graded as described by Hashemi-Nejad et al. [11] and Neer et al. [19] as Grade I, the is cyst clearly visible; Grade II, the cyst is visible but multilocular and opaque; Grade III, there is sclerosis around or in a partially visible cyst; or Grade IV, there is complete obliteration of the cyst.

Postoperatively, both groups of patients were followed up at 6-week intervals, with radiographs of the involved site. If the patient had symptomatically improved and the radiographs showed early signs of consolidation (Grade II), they were followed up at 3-month intervals with serial radiographs until resolution of the lesion (Grades III/IV). If the patients' symptoms deteriorated or if the lesion size increased at any point, an additional surgical procedure was advocated. The only exception to this regimen was the presence of an extensive lesion with impending pathologic fracture in locations such as the proximal or distal femur, where curettage was performed without waiting for the cysts to consolidate.

The most common sites were the tibia (50) followed by the femur (28), fibula (22), and humerus (17) (Table 1).

Primary treatment was by curopsy in 102 patients and definitive curettage after core needle biopsy in 88 (79 curettages with no adjuvants, seven with bone grafting, and two curettages with internal fixation) (Fig. 2).

A local recurrence was diagnosed if there were increasing areas of radiolucency observed on plain radiographs or if

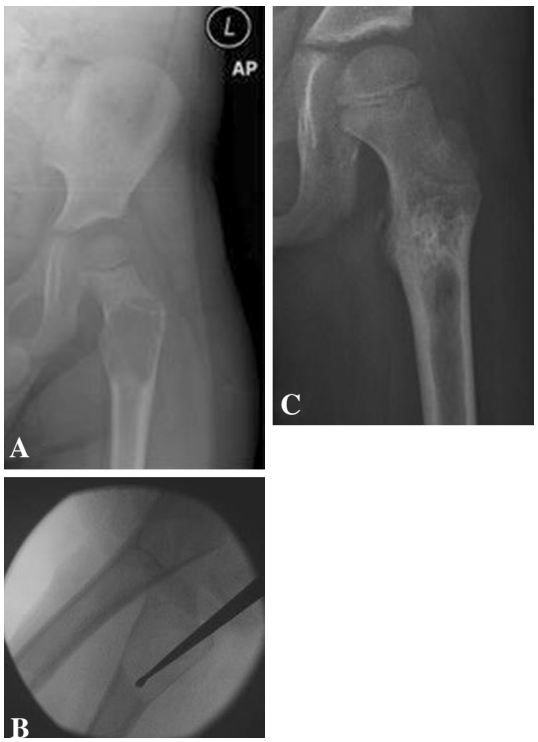

Fig. 3A–C (**A**) A preoperative AP view of the pelvis shows an ABC of the proximal femur in a 5-year old patient presenting with a limp of the left lower limb. (**B**) The perioperative fluoroscopic image obtained at curopsy is shown. (**C**) The patient's 6-month postoperative radiograph shows large volume reduction and consolidation of the lesion site.

patients were persistently symptomatic. This was confirmed by MRI. In all but one patient who underwent an excision of a proximal radius lesion following a local recurrence after curettage, the recurrences were treated with curettage and only occasionally supplemented with adjuvants (bone grafting) depending on the site and fracture risk.

Statistical Analysis

Treatment groups (curopsy versus curettage) were compared using a t-test and chi-square with $p < 0.05$ considered significant. Time to consolidation without additional surgery was examined using Kaplan-Meier analysis. Univariate and multivariate analyses were performed using log-rank test and Cox analysis. Failure was defined as the need for additional surgery (curettage for patients treated initially with curopsy, repeat curettage for patients initially treated with curettage) and time documented in months. This was performed using StatView® software (Version 5.0.1; SAS Institute Inc, Cary, NC, USA).

Results

Of the 102 lesions treated with curopsy, 83 (81.3%) showed signs of consolidation and did not require

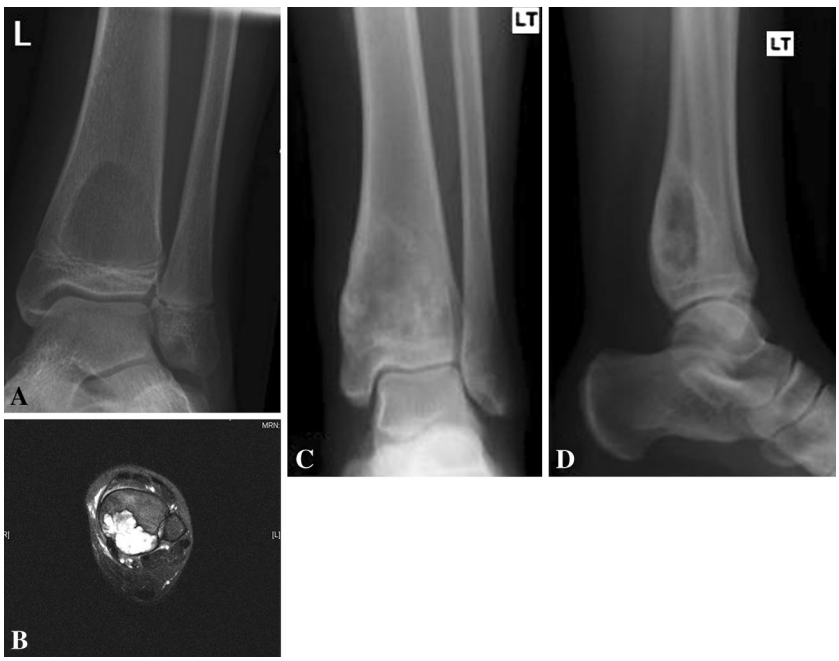

Fig. 4A–D (**A**) The AP radiographic view of lesion at presentation shows an ABC in the distal tibia. (**B**) The patient's MR image shows the fluid level. (**C**) AP and (**D**) lateral radiographs obtained 18 months after the curopsy show consolidation.

Table 2. Statistical data for patients

Variable	Curopsy	Curettage after core needle biopsy	p value
Age	Mean, 13.9 years; 95% CI, 12.1–15.8	Mean, 17.2 years; 95% CI,15.1–19.3	p = 0.01
Sex			
Male	n = 51	n = 39	p = 0.43
Female	n = 51	n = 49	
Site			
Long bones (femur, tibia, radius, ulna, fibula)	n = 72	n = 58	p = 0.73
Small bones (hands and feet, patella)	n = 11	n = 11	
Axial skeleton (rib, clavicle, scapula, spine, pelvis)	n = 19	n = 19	
Local recurrence rate (95% CI)	18.6%; (10.9–26.3)	10.2%; (3.7–16.7)	p = 0.04
Time to healing (95% CI)	Mean, 9.6 weeks; (8.32–10.9 weeks)	Mean, 11.4 weeks; (10.6–12.3 weeks)	p = 0.01

additional treatment (Fig. 3). Healing was seen on radiographs at a mean of 9.6 weeks (95% CI, 10.9–26.3) (Fig. 4). Nineteen patients (18.7%) in the curopsy group required an additional surgical procedure. Eighteen of these patients were treated with curettage and one had curettage and bone grafting. The median time for this was 3 months (range, 1.5–18 months).

Seventy-nine patients underwent definitive curettage after a core needle biopsy. This was partly because curopsy was not being done before 2006 as a routine procedure, or there were large lesions in regions such as the proximal or distal femur, or lesions in the os calcis or pelvis. In an additional seven of the lesions (six proximal femurs and one talus), cavities were filled with bone graft to provide structural support after curettage. In five of these six proximal femoral lesions, a fibular strut graft was used and in the other case, a milled femoral head allograft was used. There was one lesion in the talus that was filled with corticocancellous autograft from the iliac crest. Two subtrochanteric lesions were treated by aggressive curettage and prophylactic internal fixation.

Nine patients (10.2%) had a local recurrence develop after curettage. Seven were treated with additional curettage, one with curettage and bone grafting, and one with excision (proximal radius). Three patients needed a third surgical procedure. One underwent excision (metatarsal) and one patient each underwent additional curettage and curettage with internal fixation.

The overall rate of local recurrence for all patients requiring additional surgery was 14.7% (19 in the curopsy group and nine in the curettage group). The two groups showed statistically significant differences in mean age (Table 2), with patients in the curopsy group being younger (13.9 versus 17.2; p = 0.01), healing time (9.6 weeks for curopsy versus 11.4 weeks for curettage; p = 0.01), and local recurrence and additional intervention rates (18.6 versus 10.2 respectively; p = 0.04). Univariate and multivariate analyses showed a significant difference in local recurrence rates in female patients who underwent a curopsy (Hazard ratio [HR], 2.44, 95% CI, 1.07–5.56, p = 0.03). However, no significant statistical difference was found on further analysis with the tibia as the site (most common with 25 patients each in the curopsy and curettage groups). Local recurrence was not related to site or age. Kaplan-Meier survival curves showed 81% and 90% 5-year local recurrence-free survival for the curopsy and curettage groups respectively (Fig. 5). Simple treatment interventions for ABCs in the form of curopsy alone led to cure in 81.3% (82 of 102) of patients. Primary curettage following a core needle biopsy was successful in 90% (79 of 88).

Two patients in each group had a fracture as a complication after treatment. Two of these were in the humerus, one in the tibia, and one in the patella. In all cases, the lesion resolved as the fracture healed. The patient with a patella fracture needed internal fixation with tension band wiring. There were no significant wound complications in either group necessitating surgical intervention or hospital admission.

Discussion

Surgical treatment of ABCs traditionally has been curettage with or without the use of adjuvants with variable reported recurrence rates [1, 3, 5, 6, 10, 18, 22, 24, 27]. All patients with suspected ABCs undergo a biopsy to establish the diagnosis followed by surgical treatment as per the treating surgeon's preference of curettage with or without adjuvants. We describe a novel biopsy technique called a curopsy, to establish the diagnosis and affect a cure in

many such lesions. We asked whether (1) a curopsy resulted in a comparable likelihood of healing of the ABC compared with more aggressive approaches involving curettage following a core needle biopsy, (2) the two approaches differ in terms of the likelihood of recurrence after treatment, and (3) the two approaches differ in terms of complications after surgery.

This study had several limitations. First, the two groups were not comparable with respect to periods treated, locations of the cysts, and aggressiveness of the lesions (curettage was performed for the more aggressive and larger lesions). This selection bias may make the curopsy appear more effective than it would be if it were used unselectively. Cytogenetics were not performed routinely for all these patients. Another drawback of our study is that the curopsy was not used routinely before 2006 and therefore some patients underwent curettage within 2 weeks of having a curopsy. However, in this study, for these patients the curopsy was considered as failed. In addition, we could not establish any patients who received a curopsy and had a diagnosis other than primary ABC in this study group owing to its retrospective design. However, we reserve curopsies only for lesions clinically and radiologically typical of a primary ABC.

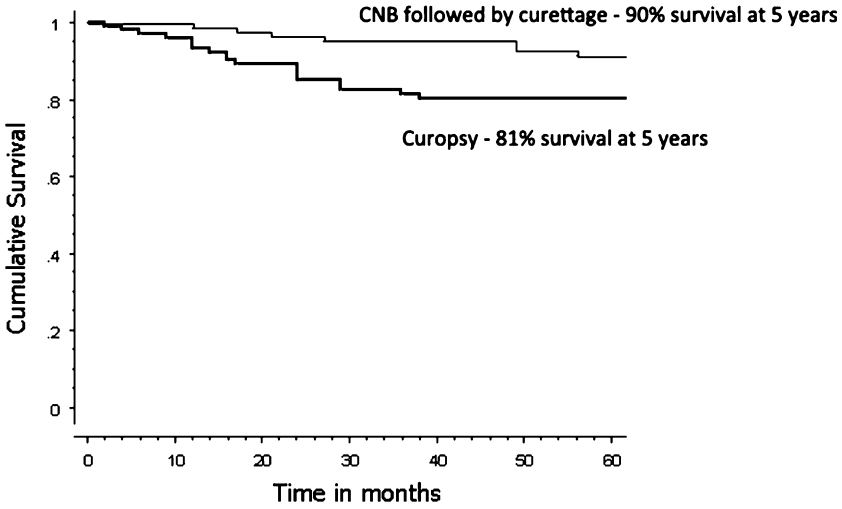

Fig. 5 The Kaplan-Meier survival plot is shown for curopsy and curettage. CNB = core needle biopsy.

Table 3. Comparative overview of studies

Study	Year	Treatment method	Number	Local recurrence rate
Biesecker et al. [1]	1970	Cryosurgery	7	14%
		No cryosurgery	44	59%
Capanna et al. [3]	1985	Phenol	5	20%
		No Phenol	38	21%
Marcove et al. [18]	1995	Cryosurgery	51	18%
Ozaki et al. [22]	1997	Cementation	35	37%
		No cementation	30	17%
Gibbs et al. [10]	1999	Burr	34	12%
Ramirez and Stanton [24]	2002	Burr	19	21%
		No burr	10	40%
Docquier and Delloye [6]	2005	Demineralized bone matrix and autogenous bone marrow	13	15%
Cummings et al. [5]	2010	Curettage	12	33%
	2010	Curettage and argon beam coagulation	17	0%
Steffner et al. [27]	2011	Curettage with burr	34	20%
		Curettage with burr and argon beam coagulation	40	7.5%
Current study	2014	Curopsy	102	18.6%
		Curettage alone	88	10.2%

We found curopsy led to healing in 81.3% of the lesions we treated with this technique. These patients avoided the morbidity associated with a second procedure, with the core needle biopsy being the first procedure and curettage with or with adjuvants the second procedure. Several authors have reported that the natural history of ABCs seems to suggest that these lesions are more of a reactive nature and have an intrinsic potential to heal by ossification [1, 18].

Biesecker et al. [1] supported the hypothesis that an ABC was a secondary reactive lesion of bone occurring owing to hemodynamic disturbances based on the results of manometric pressure studies showing increased intracystic pressure. Marcove et al. [18] suggested that arresting this hemodynamic disturbance should induce healing and prevent recurrence. Healing therefore may occur either spontaneously or after biopsy or fracture. However, this was rather uncommon and it has been suggested that most of these lesions require some surgical treatment [6]. Our understanding is that the destruction of internal cyst architecture interferes with the hemodynamic changes and induces healing and this is the rationale of treatment with curopsy or curettage without any adjuvants. We found that curettage alone led to healing in 90% of patients so treated. Ibrahim et al. [14] recently compared their results of percutaneous curettage with those of an open intralesional procedure and concluded it was a safe and minimally invasive alternative that could be performed as an outpatient procedure. However, they had small patient numbers (nine and eight respectively for both groups with two failures in percutaneous curettage and one in the open

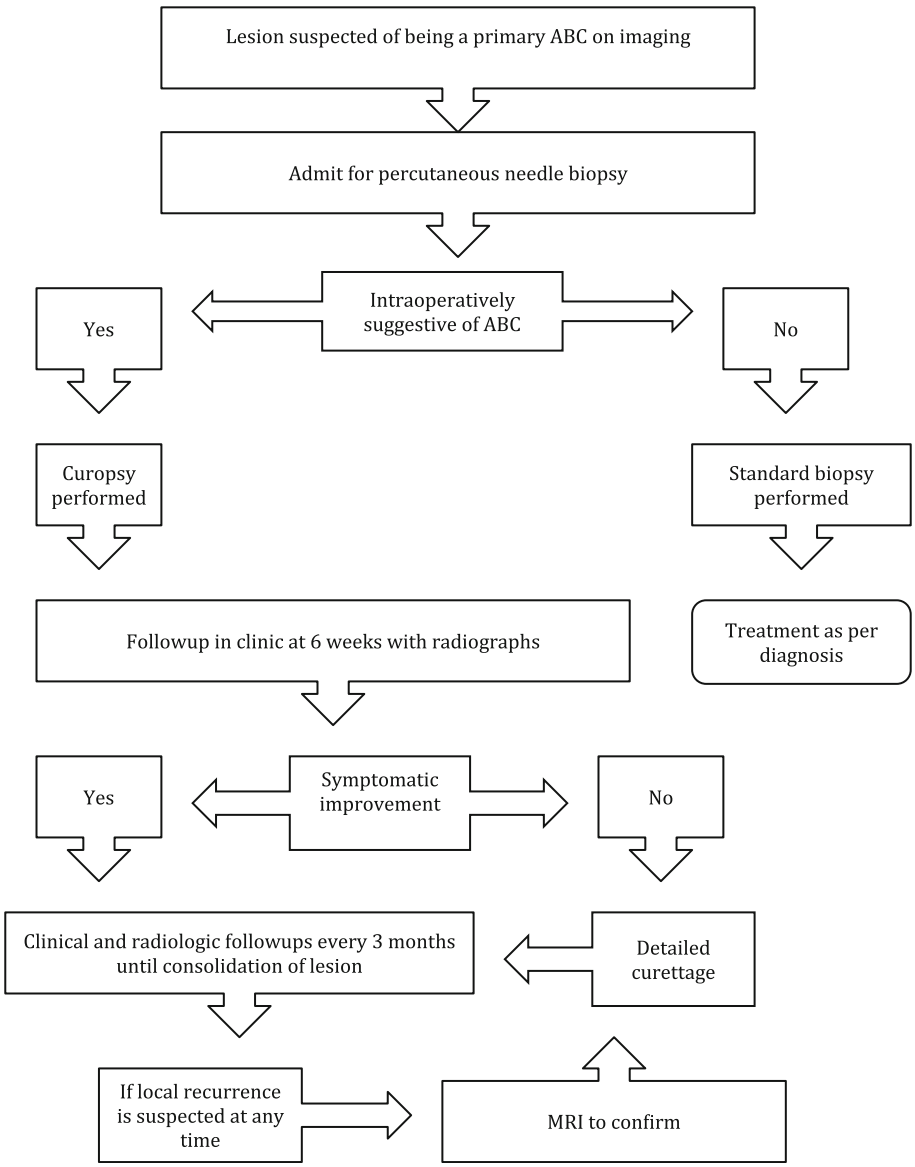

Fig. 6 The proposed management algorithm for treatment of ABCs is shown.

procedure group respectively) and all their patients had a biopsy before the percutaneous curettage. Curopsy is less invasive than the described percutaneous curettage and essentially is a modification of the core needle biopsy technique used. It adheres to the principles of biopsy for musculoskeletal lesions.

We observed that our local recurrence rate for curopsy was 19% and that for curettage was 10% ($p = 0.04$). Our study population was similar to populations in other series regarding age and sex distribution and location [1, 22, 24, 27] and therefore we believe our population is representative of patients with ABCs. There is a large variation in the rates of local recurrences ranging from 0% to 59% in the literature (Table 3). The more recently published series report lower recurrence rates with argon beam coagulation in conjunction with curettage [5, 27]. However, in our series, 81% of the lesions healed with curopsy which is a modified biopsy technique, and this is better than the results of curettage observed in some series [1, 3, 5, 24, 27]. This may be attributable to selection bias as curopsy was performed on smaller, less aggressive lesions in our series. We performed grafting in only seven of 190 patients (3.6%) at primary treatment. We recommend grafting only when structural support is needed which also is supported by other authors [13, 23, 31]. We believe most ABCs heal by gradual ossification after disruption of the internal cyst architecture unless structural stability is warranted, which could be provided by bone grafting.

Curopsy did not increase the risks or complication profile any more than what is already associated with a percutaneous biopsy. Core needle biopsies have been used for diagnosis of musculoskeletal tumors for more than 60 years [28]. Mankin et al. [17] reported that rates of altered treatment and altered outcome were considerably lower after needle biopsy. However, there was a higher rate of nonrepresentative biopsies in comparison to open or incisional techniques. Welker et al. [30] evaluated 175 needle biopsies and reported only two complications: one was a hematoma and the other was persistent drainage from a hemorrhagic sarcoma after biopsy. We had two fractures in the curopsy group and no major wound-related complications requiring hospitalization or surgical intervention in these patients.

With our approach using curopsy to obtain tissue diagnosis (and affecting cure) and curettage (without adjuvants) only for nonresponding lesions, our overall cure rate of 85.2% compares favorably with published rates [1, 6, 10, 18]. We recommend a curopsy only when the patient has a lesion that is suggestive of a primary ABC on preoperative radiographs and MR images and perioperatively at the time of biopsy in an orthopaedic oncology unit setting, supported by a formal multidisciplinary tumor board. However, if the ABC is considered to be a secondary lesion, we prefer to use a standard core needle biopsy. Curopsy is a simple procedure that offers diagnostic and therapeutic benefit for many patients with primary ABCs without any added morbidity. We believe curettage should be reserved only for lesions not showing signs of consolidation radiologically in 6 to 12 weeks (Fig. 6). With this approach additional treatment, if needed, is not compromised.

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