Biopsy of Soft Tissue Masses

Evidence-based Medicine for the Musculoskeletal Tumor Society

Bruce T. Rougraff MD, Albert Aboulafia MD,
J. Sybil Biermann MD, John Healey MD

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Abstract The literature contains a number of controversies regarding key questions: (1) When is a biopsy indicated? (2) How should the biopsy be placed? (3) How should the biopsy be performed and which has the greatest diagnostic accuracy? (4) Who should perform the biopsy? (5) What clinical parameters present the greatest diagnostic difficulty? Using PubMed and Google Scholar we performed English-language literature searches of clinical studies reporting biopsy of soft tissue masses. Thirty-two studies met the inclusion criteria but were only able to address three of the five questions the authors had hoped to evaluate. Available evidence suggests open biopsy has the highest diagnostic accuracy over core needle biopsy, which was higher than fine needle aspiration. There was no evidence to address who is best suited to perform the biopsy (general surgeon, orthopaedic surgeon, radiologist, pathologist) in terms of accuracy of diagnosis. Frozen section at

the time of biopsy may improve diagnostic accuracy. Diagnostic difficulty was associated with myxoid and round cell neoplasms, infections, and tumors located in the paraspinal region. The limited number of references addressing these issues demonstrated the need for more Level I research in the area of biopsy of soft tissue masses. **Level of Evidence:** Level III, therapeutic study. See Guidelines for Authors for a complete description of levels of evidence.

Introduction

The most definitive diagnostic procedure for most musculoskeletal tumors is a biopsy. However, not all musculoskeletal lesions require treatment or a biopsy. Certain benign and low-grade chondroid bone lesions can be observed over time to see if the lesion is increasing in size or developing new radiographic features. Likewise, many small soft tissue masses (such as cysts, small lipomas, inflammatory nodules, dermatofibroma, or other benign fibrous lesions) do not need surgical treatment. Large, deep lipomatous masses can be diagnosed with a carefully performed MRI. Most other lesions, particularly those greater than 4 cm in greatest dimension, will require histologic evaluation to confirm the diagnosis.

Biopsy of musculoskeletal lesions should be carefully planned and performed after radiographic staging studies are completed. This allows for correlation of radiographic and histologic findings. Radiographic studies performed after biopsy can have artifact from the surgery that confounds accurate interpretation. Several issues arise concerning the biopsy of musculoskeletal soft tissue masses. Because it is estimated as many as one-fourth of adults have small soft tissue masses at some time in their life, and

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This work was performed at Indiana Orthopaedic Hospital, Indianapolis, IN.

B. T. Rougraff (✉)
Indiana Orthopaedic Hospital, 8450 Northwest Boulevard,
Indianapolis, IN 46278, USA
e-mail: brougraff@aol.com

A. Aboulafia
Sinai Hospital Cancer Institute, Baltimore, MD, USA

J. S. Biermann
University of Michigan Medical Center, Ann Arbor, MI, USA

J. Healey
Memorial Sloan Kettering Cancer Center, New York, NY, USA

only one of 200,000 people will develop soft tissue sarcoma, an appropriate clinical screening mechanism is necessary to avoid overuse of biopsy and underdiagnosing sarcoma. Defining how the biopsy should be performed to maximize diagnostic accuracy and minimize morbidity is critical. Understanding who is best suited to perform the biopsy (ie, radiologist, primary care physician, general surgeon, general orthopaedic surgeon, orthopaedic oncologic surgeon) should be clarified if, in fact, there is a difference in outcome.

Therefore, the authors believe the following questions important to explore the literature and provide clinical guidelines: (1) When is a biopsy indicated? (2) How should the biopsy be placed? (3) How should the biopsy be performed (open incisional biopsy, core needle biopsy, fine needle aspiration biopsy) and which has the greatest diagnostic accuracy? (4) Who should perform the biopsy (radiologist, sarcoma pathologist, general pathologist, general surgeon, general orthopaedic surgeons, orthopaedic oncologic surgeon)? (5) What clinical parameters present the greatest diagnostic difficulty?

Materials and Methods

In 2006, the Musculoskeletal Tumor Society assembled a subcommittee for evidence-based medicine that consisted of the four authors (all orthopaedic tumor surgeons with extensive clinical experience who are active in the diagnosis and treatment of patients with soft tissue masses). They provided input as to key questions concerning biopsy of soft tissue masses, reviewed the literature, and met with consensus as to the conclusions, literature cited, clinical guidelines, and remaining unanswered questions.

To identify all original human research of effectiveness of biopsy of soft tissue masses, we performed a literature search of all English manuscripts from 1966 to 2007 using PubMed and Google Scholar electronic search using the words “biopsy musculoskeletal masses” and “soft tissue biopsies.” Boolean operators “not” were used to exclude the following terms: kidney, renal, prostate, skin, lung, liver, node, esophagus, abscess, breast, and seroma. This resulted in 2211 and 1980 references from the two searches, respectively. Clinical studies were censored (99%) based on abstract content if they were case reports (22.4%), review or opinion articles (22%), radiographic study of a technique or retrospective review of patients with known diagnostic entities (21%), biopsy of bone lesions (14.5%), not a biopsy paper (13.1%), biopsy of metastatic carcinomas of bone and soft tissue (5%), or a duplicate paper to a previously accepted reference (1%). This left 41 references (1%) whose manuscripts were reviewed completely by two

authors (BTR, AA). Thirty-two of 41 total papers were included in this review because they reported biopsy data that were limited to the biopsy of soft tissue masses (28 found with both Google Scholar and PubMed, three found with PubMed alone, and one with Google alone). Nine of 41 references were excluded because they included bone biopsies comingled with the soft tissue masses and/or did not give diagnostic accuracy results of biopsies. To ensure a comprehensive literature search, all four authors reviewed bibliographies of all included articles and all review articles concerning biopsy. No additional references were found with these methods. After the manuscript was finalized, it was sent electronically to all members of the Musculoskeletal Tumor Society to review on two separate occasions. Three articles were questioned by the membership as to their exclusion by this society review. All three articles had been identified by our literature search and were excluded because they included bone biopsy results (nine of 41 papers that included bone biopsy results). No additional references were otherwise identified by the society membership.

Two authors (BTR, AA) independently screened the 32 referenced soft tissue biopsy articles for level of evidence based on the criteria espoused by Clinical Orthopaedics and Related Research (Table 1). Level I evidence was designated in any study that used a high-quality randomized, prospective trial with 80% or greater followup with a statistically significant difference or no statistically significant difference but narrow confidence intervals. Level II was given to studies that were lesser-quality clinical trial that may include retrospective data or lower-quality prospective data with less than 80% followup. Level III was given to retrospective, case-control studies of nonconsecutive patients. Level IV was given to retrospective case series with a poor reference standard and no sensitivity analysis. No editorial reviews or case reports were included in this analysis. There was no disagreement between reviewers on this level of evidence analysis of the 32 referenced papers.

The papers included in the review were then studied to determine (1) who performed the biopsy; (2) the accuracy of distinguishing benign from malignant lesions; (3) the accuracy in predicting a definitive diagnosis; and (4) the accuracy of predicting grade of the tumor. Papers that did not include percentage of nondiagnostic results in their percentage of accuracy were so noted or had accuracy percentage calculated from their raw data (see Appendix 1).

The American Academy of Orthopaedic Surgeons Guideline recommendation classification was used. Practice guideline recommendation classification was “We recommend = A” for EBM Level I studies; “We suggest = B” based on EBM Level II or III; and “Option = C” based on EBM Level IV [4].

Table 1. Levels of evidence for primary research question

Level	Types of studies				
	Therapeutic studies investigating the results of treatment	Prognostic studies investigating the effect of a patient characteristic on the outcome of disease	Diagnostic studies investigating a diagnostic test	Economic and decision analyses: developing and economic or decision model	
I	High-quality randomized trial with statistically significant difference or no narrow confidence intervals Systematic review of Level I RCTs (and study results were homogenous)	High-quality prospective study (all patients were enrolled at the same point in their disease with 80% or greater followup of enrolled patients) Systematic review of Level I studies	Testing of previously developed diagnostic criteria on consecutive patients (with universally applied reference "gold" standard) Systematic review of Level I studies	Sensible costs and alternatives; values obtained from many studies; with multiway sensitivity analyses Systematic review of Level I studies	
II	Lesser-quality RCT (eg, less than 80% followup, no blinding, or improper randomization) Prospective comparative study Systematic review of Level II studies or Level I studies with inconsistent results	Retrospective study Untreated controls from an RCT Lesser-quality prospective study (eg, patients enrolled at different points in their disease or less than 80% followup) Systematic review of Level II studies Case-control study	Development of diagnostic criteria on consecutive patients (with universally applied reference "gold" standard) Systematic review of Level II studies	Sensible costs and alternatives; values obtained from limited studies; with multiway sensitivity analyses Systematic review of Level II studies	
III	Case-control study Retrospective comparative study Systematic review of Level III studies	Case-control study Case-control study Case series	Study of nonconsecutive patients; without consistently applied reference "gold" standard Systematic review of Level III studies Case-control study Poor reference standard	Analyses based on limited alternatives and costs and poor estimates Systematic review of Level III studies Analyses with no sensitivity analyses	
IV	Case series				

RCTs = randomized, controlled trials.

Results

(1) When is a biopsy indicated? No referenced evidence-based articles addressed when a biopsy of a soft tissue mass was indicated. In fact, large variability in the incidence of neoplastic and nonneoplastic lesions was noted in the referenced articles. This variability resulted in confounding results of diagnostic accuracy of needle biopsy, particularly when larger inflammatory, infectious, and myxoid lesions were sampled. In the absence of any evidence-based data, the authors offer their opinions on this question. A biopsy is indicated whenever a mass has biologic activity and further surgical or medical treatment will be based on that result. Because many musculoskeletal lesions are inactive processes, many lesions do not require a biopsy or treatment. (a) Soft tissue masses larger than 3 cm are more likely to require biopsy. Masses that are actively growing or symptomatic are lesions that may require biopsy. (b) A soft tissue “hematoma” that is not associated with trauma, has no history of ecchymosis, and is increasing in size or symptoms may require biopsy. Suspected hematomas that do not resolve over time may need a biopsy.

(2) How should the biopsy be placed? (a) None of the referenced evidence-based articles addressed technical aspects of biopsy placement. In the absence of evidence-based data, the authors offer their opinions on this question. The procedure of biopsy is a simple technical skill but a difficult cognitive skill. The biopsy must be carefully planned and placed so definitive resection of the tumor is not limited or compromised. The surgeon must respect the following principles whenever tissue is removed from the body, because any time tissue is removed, it should be considered a biopsy. Failure to send tissue to pathology or process it appropriately is a particularly distressing problem and may be the fault of the surgeon, the operating room staff, or the staff of the facility, particularly when biopsies are rarely performed. Complete hemostasis during the biopsy is critical to prevent hematoma dissection outside of the tumor bed, which could potentially transport tumor cells into wider or newer areas. The biopsy tract must be placed in a location that is resectable at the time of tumor excision (if the lesion is malignant). Excision of the biopsy tract, all contaminated tissues, and the tumor as one piece with adequate surgical margins is necessary at the time of sarcoma resection for optimum local control. This requires longitudinally placed extremity incisions and biopsies that do not expose critical neurovascular structures that could become contaminated with sarcoma. This requires the biopsy incision be placed in a position that can be safely excised en bloc with the resected specimen. (b) No referenced study addressed whether needle biopsy placement affected local control or survival of patients with

soft tissue sarcoma. Case reports of local recurrences in unresected needle biopsy tracts have been separately reported.

(3) How should the biopsy be performed? Five referenced studies addressed this question. One study had EBM Level I evidence [32], one Level III [2], and three Level IV [9, 10, 33]. The first objective of a biopsy is to obtain diagnostic material. If the biopsy is performed in conjunction with frozen section histology additional tissue may be obtained if the frozen section is initially nondiagnostic. This can be accomplished with fine needle aspiration (FNA), trocar (or cutting needle), open incisional biopsy, or open excisional biopsy (based on recommendation Grade A). (a) FNA had a lower diagnostic accuracy compared with core needle biopsy in five studies that addressed this comparison [32]. (b) Incisional biopsy was associated with a 94% diagnostic accuracy and was more accurate than core biopsy (83%) but at a much higher expense [27]; EBM Level II. (c) Excisional biopsy should be reserved for carefully selected clinical situations such as small subcutaneous tumors or lesions that have a diagnostic MRI appearance. No referenced EBM article addressed diagnostic accuracy of excisional biopsy.

(4) Who should perform the biopsy? Radiologists, pathologists, general surgeons, general orthopaedic surgeons, and sarcoma specialists were all represented in these studies [1–3, 5–33] (based on recommendation Grade B). Needle biopsies performed by all physicians had equal rates of diagnostic accuracy whether or not they were at a sarcoma center [12]; EBM Level III. Needle biopsy performed with computed tomography, ultrasound, or MRI assistance can improve quality of diagnostic material, but this is not supported by the EBM articles studied [1, 9, 12, 13, 21–23, 29, 31, 33]; EBM Level IV. The highest diagnostic accuracy results were reported by core needle biopsy performed by surgeons [2, 24, 26, 27]; EBM Level IV. However, this may be explained by a selection bias whereby the most difficult diagnostic cases in the worst anatomic locations were excluded as a result of clinical and radiographic clues by surgeons. Frozen section at the time of biopsy improves diagnostic accuracy 6% to 8% [9], but this is based on EBM Level IV. Therefore, a recommendation cannot be supported by the current literature about the use of frozen section to rationalize the increased cost. The complications reported in four studies ranged from 0% to 2% [5, 6, 15, 23]; EBM Level IV.

(5) What clinical parameters present the greatest diagnostic difficulty? Three articles addressed this question (based on recommendation Grade B). (a) Myxoid, infection, and round cell histology were associated with the lowest diagnostic accuracy rate with needle biopsies [10, 21]. (b) The paraspinal anatomic location had the lowest diagnostic accuracy rate [8].

Discussion

Our report is one of a subcommittee of the Musculoskeletal Tumor Society. We began our charge by agreeing on five important questions concerning biopsy of soft tissue masses: (1) When is a biopsy indicated? (2) How should the biopsy be placed? (3) How should the biopsy be performed and which has the greatest diagnostic accuracy? (4) Who should perform the biopsy? (5) What clinical parameters present the greatest diagnostic difficulty? The report was presented to and accepted by the MSTS after their meeting November 6–8, 2008.

Perhaps the most profound finding of this study was the literature on this subject is very sparse despite the fact that the biopsy is a critical step in the routine treatment of soft tissue tumors that dictates treatment options. We only identified 32 studies that provided evidence about biopsy of soft tissue tumors and only two of the 32 studies had Level I or Level II evidence. Of the five questions that the authors proposed, two were not addressed by the literature. This lack of evidence should encourage investigators to study these issues to allow us to answer these questions confidently.

In terms of comparing accuracy of open biopsy, core biopsy, and FNA, the five studies that addressed this suggested open biopsy was the most accurate modality, but the authors do not believe the level of evidence is strong enough to suggest one biopsy technique over another. Therefore, all three modalities are acceptable biopsy techniques for soft tissue masses.

Likewise, there is insufficient evidence to suggest which specialty is preferred to perform the biopsy. Although there is Level IV evidence that surgeons performing core biopsies have the highest accuracy, it is likely biased in that the simplest diagnostic cases are biopsied with core biopsy and the more challenging cases undergo open biopsy or computed tomography-directed needle biopsy.

Concerning diagnostic problems, myxoid and round cell neoplasms, infections, and paraspinal anatomic location have the lowest diagnostic accuracy with needle biopsy [9, 20].

After evaluating the current literature, future research should be explored. First, examining the role of frozen section at the time of core needle biopsy should be done. Frozen section adds to the complexity of performing the biopsy because it would be difficult in many clinical settings and add to the cost of the biopsy considerably. Another area of some controversy but also poorly covered in the literature is the role of excisional biopsy. At what size soft tissue tumor is it no longer appropriate to perform excisional biopsy? What is the morbidity and impact on limb salvage? Another powerful question to explore is to address whether there are diagnostic accuracy differences

between specialists performing the biopsy and whether it impacts local control. A study of the clinical and radiographic parameters that suggest biopsy over observation is needed. Does the addition of three-dimensional radiologic support during the biopsy increase the accuracy and justify the greater cost? A prospective, randomized study analyzing the diagnostic accuracy, the morbidity, and the cost of FNA versus open biopsy versus core needle biopsy for soft tissue masses is very important.

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Appendix 1. Annotated References

Accuracy and Comparison of Biopsy Techniques

1. Altuntas AO, Slavin J, Smith PJ, Schlicht SM, Powell GJ, Ngan S, Toner G, Choong PF. Accuracy of computed tomography guided core needle biopsy of musculoskeletal tumors. *ANZ J Surg*. 2005;75:187–191.

EBM Level IV: This is a retrospective study on a series of 127 patients with musculoskeletal tumor. Computed tomography-guided core needle biopsy in the present series has an overall accuracy of 80.3%. The effective accuracy as determined by a malignant versus benign lesion was 89%. There were 86 malignant tumors with a biopsy accuracy of 81.4% and there were 41 benign tumors with a biopsy accuracy of 78%. The positive predictive value (PPV) of a malignant tumor is 98.9% and the PPV of benign tumor 90.2%. There were no reported complications arising from the biopsy.

2. Ball AB, Fisher C, Pittam M, Watkins RM, Westbury G. Diagnosis of soft tissue tumors by Tru-Cut biopsy. *Br J Surg*. 1990;77:756–758.

EBM Level IV: Sarcoma surgeon performed core biopsy with 94% accuracy (includes 4% inadequate tissue) for malignancy, 85% accuracy for subtype, and 88% accuracy for grade. Tru-Cut biopsies were obtained from 52 consecutive patients referred with soft tissue tumors. Of the biopsies, 96% provided adequate material for diagnosis. The accuracy of Tru-Cut biopsy was 98% for the diagnosis of malignancy and 94% for the diagnosis of sarcoma. Tumor subtype was correctly specified in 85% of sarcomas and tumor grade in 88%.

3. Barth RJ Jr, Merino MJ, Solomon D, Yang YC, Baker AR. A prospective study of the value of core needle biopsy and fine needle aspiration in the diagnosis of soft tissue masses. *Surgery*. 1992;112:536–543.

EBM Level III: Core accuracy 96%, FNA 64%.

4. Carrino JA, Khurana B, Ready JE, Silverman SG, Winalski CS. Magnetic resonance imaging-guided

percutaneous biopsy of musculoskeletal lesions. *J Bone Joint Surg Am.* 2007;89:2179–2187.

EBM Level IV: In a retrospective case series, 45 consecutive biopsies were performed in an open midfield 0.5-T interventional MRI unit. Samples were obtained with FNA, core needle biopsy, or a combination of these techniques. The diagnostic yield was 91% (41 of 45 biopsies yielded sufficient material for a diagnosis) overall, 95% (19 of 20) for the bone lesions, 94% (17 of 18) for the extra-articular soft tissue lesions, and 71% (five of seven) for the intra-articular soft tissue lesions. With regard to the diagnostic accuracy, the sensitivity was 0.86, the specificity was 1.00, the PPV was 1.00, and the negative predictive value was 0.76 in the overall group. The respective values were 0.92, 1.00, 1.00, and 0.86 for the bone lesions; 0.77, 1.00, 1.00, and 0.57 for the extra-articular soft tissue lesions; and 1.00, 1.00, 1.00, and 1.00 for the intra-articular soft tissue lesions. There was one complication: exacerbation of neuropathic pain related to a biopsy of a peripheral nerve sheath tumor.

5. Costa MJ, Campman SC, Davis RL, Howell LP. Fine-needle aspiration cytology of sarcoma. Retrospective review of diagnostic utility and specificity. *Diagn Cytopathol.* 1996;15:23–32.

EBM Level IV: The pathologist obtained tissue with FNA with 20.9% diagnostic accuracy; suspicion of malignancy was 88% accurate.

6. Das K, Hameed M, Heller D, Mirani N, Doty N, Benevenia J, Patterson F, Aisner S. Liquid-based vs conventional smears in fine needle aspiration of bone and soft tissue tumors. *Acta Cytol.* 2003;47:197–201.

EBM Level III: Pathologists obtained tissue using FNA with 64% diagnostic accuracy.

7. Domanski HA, Akerman M, Carlen B. Core-needle biopsy performed by the cytopathologist: a complement to FNA of soft tissue and bone lesions. *Cancer.* 2005;105:229–239.

EBM Level IV: Combined core needle biopsy with FNA resulted in 77% accuracy and grade accuracy of 90%.

8. Dupuy DE, Rosenberg AE, Punyaratabadhu T, Tan MH, Mankin HJ. Accuracy of CT-guided needle biopsy of musculoskeletal neoplasms. *AJR Am J Roentgenol.* 1998;171:759–762.

EBM Level IV: A radiologist performed the biopsy with core needle biopsy and had diagnostic accuracy of 93% (includes nondiagnostic biopsies) and 80% FNA (includes nondiagnostic biopsies). Using frozen section increased diagnostic accuracy from 88% to 94%. Higher diagnostic error occurred with paravertebral lesions and round cell histology.

9. Hau A, Kim I, Kattapuram S, Hornicek FJ, Rosenberg AE, Gebhardt MC, Mankin HJ. Accuracy of CT-guided

biopsies in 359 patients with musculoskeletal lesions. *Skeletal Radiol.* 2002;31:349–353.

EBM Level IV: Computed tomography-guided core needle biopsies and fine needle aspirates were performed on 359 musculoskeletal lesions. The overall accuracy was determined to be 71%. The accuracy for 101 FNAs was 63% and for 258 computed tomography-guided core biopsies was 74%. It is of note that the biopsies of 81 pelvic lesions had higher rates of diagnostic accuracy (81%) than those of 278 nonpelvic sites (68%), and especially 94 lesions of the spine (61%). The lowest success rates occurred in 26 patients with infectious diseases (50%).

10. Hodge JC. Percutaneous biopsy of the musculoskeletal system: a review of 77 cases. *Can Assoc Radiol J.* 1999;50:121–125.

EBM Level IV: A total of 77 percutaneous biopsies were performed under computed tomographic or fluoroscopic guidance of 63 bone and 14 soft tissue biopsies. No followup information was available for eight patients, and one patient died before an accurate diagnosis could be made. There were 44 true-positive, 17 true-negative, eight false-negative, and no false-positive results. The correct diagnosis was obtained in 57 of 68 cases (83.8%). For bone biopsies, the accurate diagnosis was obtained in 47 of 55 cases (85.5%). For soft tissue biopsies, the correct diagnosis was obtained in 10 of the 13 cases (76.9%). Diagnostic accuracy was slightly better for osteolytic than for osteosclerotic lesions. Accuracy also varied with lesion site and needle type. Cytology and pathology specimens were almost equally useful in contributing to the correct diagnosis.

11. Hoeber I, Spillane AJ, Fisher C, Thomas JM. Accuracy of biopsy techniques for limb and limb girdle soft tissue tumors. *Ann Surg Oncol.* 2001;8:80–87.

EBM Level III: Core needle biopsy was 80% accuracy, defined malignancy from benign lesion 98.7%, and outside needle biopsies had similar diagnostic accuracy.

12. Issakov J, Flusser G, Kollender Y, Merimsky O, Lifschitz-Mercer B, Meller I. Computed tomography-guided core needle biopsy for bone and soft tissue tumors. *Isr Med Assoc J.* 2003;5:28–30.

EBM Level IV: There were 80 soft tissue and 135 bony lesions. All biopsies were performed by the same radiologist and the histologic examination by the same pathologist. Of the 80 soft tissue biopsies, 35 were malignant (25 soft tissue sarcomas, six lymphomas, four metastatic carcinomas); 40 were benign (myositis ossificans, neurofibroma, desmoid tumor, schwannoma, hematoma, and others), and five were inconclusive and followed by an open incisional biopsy. The core needle biopsy histologic diagnosis was compared with that of the definitive surgery and the diagnostic accuracy was 90%.

Only three samples initially diagnosed as benign turned out to be malignant. No significant complications occurred during the procedures.

13. Kissin MW, Fisher C, Carter RL, Horton LW, Westbury G. Value of Tru-Cut biopsy in the diagnosis of soft tissue tumors. *Br J Surg.* 1986;73:742–744.

EBM Level IV: Tru-Cut needle biopsies from 50 consecutive soft tissue tumors were assessed by three pathologists and compared with the definitive histologic diagnosis. A correct predictive diagnosis of sarcoma was made on 87% to 98% of adequate Tru-Cut specimens, the accuracy varying between pathologists. Three sources of diagnostic error were recognized: false-positive cores (8%), false-negative cores (8%), and cores inadequate for diagnosis (16%).

14. Maitra A, Ashfaq R, Saboorian MH, Lindberg G, Gokasian ST. The role of FNA biopsy in the primary diagnosis of mesenchymal lesions. A community hospital-based experience. *Cancer.* 200;90:178–185.

EBM Level IV: Pathologists using FNA were able to determine malignancy 88% of the time in a nonsarcoma center.

15. Mitsuyoshi G, Naito N, Kawai A, Kunisada T, Yoshida A, Yanai H, Dendo S, Yoshino T, Kanazawa S, Ozaki T. Accurate diagnosis of musculoskeletal lesions by core needle biopsy. *J Surg Oncol.* 2006;94:21–27.

EBM Level IV: The diagnoses were determined on 163 core needle biopsies (bone, 91; soft tissue, 72) performed on 157 consecutive patients. One hundred forty-three specimens (88%) were determined to be adequate for histologic examination. A pathologist with experience in musculoskeletal lesions was able to differentiate malignant tumors from benign lesions in 97% of the cases (bone, 100%; soft tissue, 94%) and arrive at a specific diagnosis in 88% (bone, 96%; soft tissue, 78%) when adequate cores were obtained. The overall accuracy was 77% (bone, 85%; soft tissue, 68%). There was no morbidity related to the procedure.

16. Madhavan VP, Smile SR, Chandra SS, Ratnakar C. Value of core needle biopsy in the diagnosis of soft tissue tumors. *Indian J Pathol Microbiol.* 2002;45:165–168.

EBM Level IV: This was a prospective study to determine the accuracy of core needle biopsy in the diagnosis and grading of soft tissue tumors and to study the morbidity of core needle biopsy. Forty-one cases with 85.3% of core biopsies yielded an adequate sample. Core needle biopsy had a sensitivity of 90%, specificity of 100%, PPV of 100%, and a negative predictive value of 88.23%. Overall accuracy for diagnosis of malignancy was 94.28%, 77.7% of tumors were correctly subtyped, and none of them were histologically graded.

17. Moore TM, Meyers MH, Patzakis MJ, Terry R, Harvey JP Jr. Closed biopsy of musculoskeletal lesions. *J Bone Joint Surg Am.* 1979;61:375–380.

EBM Level IV: Pathologists using core biopsy had 76% diagnostic accuracy.

18. Moulton JS, Blebea JS, Dunco DM, Braley SE, Bisset GS 3rd, Emery KH. MR imaging of soft-tissue masses: diagnostic efficacy and value of distinguishing between benign and malignant lesions. *AJR Am J Roentgenol.* 1995;164:1191–1199.

EBM Level IV: The imaging features of 225 soft tissue tumors (179 benign, 46 malignant) in 222 patients were analyzed. By quantitative analysis, no single imaging feature or combination of features could reliably be used to distinguish benign from malignant lesions. For the subjective analysis, a correct and specific benign diagnosis could be made on the basis of MRI findings in 100 (44%) of the 225 tumors. For the entire cohort, the sensitivity was 78%, the specificity was 89%, the PPV was 65%, and the negative predictive value was 94% for a malignant diagnosis. When the diagnostic benign tumors were excluded, the specificity and negative predictive value decreased to 76% and 86%, respectively, whereas the sensitivity and PPV remained the same.

19. Nagira K, Yamamoto T, Akisue T, Marui T, Hitora T, Nakatani T, Kurosaka M, Ohbayashi C. Reliability of FNA biopsy in the initial diagnosis of soft tissue lesions. *Diagn Cytopathol.* 2002;27:354–361.

EBM Level IV: A sarcoma surgeon performed FNA with 92% accuracy in predicting malignancy and 54% diagnostic accuracy.

20. Ogilvie CM, Torbert JT, Finstein JL, Fox EJ, Lackman RD. Clinical utility of percutaneous biopsies of musculoskeletal tumors. *Clin Orthop Relat Res.* 2006;450:95–100.

EBM Level IV: FNA by radiologists were predictive of malignancy 75% and increased to 81% if included core biopsy. Twenty-five percent required open biopsy by a sarcoma surgeon. Myxoid histology was more often associated with diagnostic error.

21. Parkkola RK, Mattila KT, Heikkilä JT, Ekfors TO, Komu ME, Vaara T, Aro HT. MR-guided core biopsies of soft tissue tumors on an open 0.23 T imager. *Acta Radiol.* 2001;42:302–305.

EBM Level IV: Twenty-nine consecutive patients with known or suspected benign or malignant soft tissue tumors underwent MRI. MR-guided core biopsy of the tumor was performed on an open 0.23-T magnet. The MR-guided core biopsy specimens were sufficient for histopathologic diagnosis in 27 of 29 cases.

22. Puri A, Shingade VU, Agarwal MG, Anchan C, Juvekar S, Desai S, Jambhekar NA. CT-guided percutaneous core needle biopsy in deep seated musculoskeletal lesions: a prospective study of 128 cases. *Skeletal Radiol.* 2006;35:138–143.

EBM Level IV: One hundred thirty-six consecutive computed tomography-guided biopsy sessions were

undertaken for musculoskeletal lesions in 128 patients. In 121 patients, a single session was sufficient to obtain representative material, whereas for six patients, two sessions and for one patient three sessions were necessary. One hundred eight biopsy sessions yielded a diagnosis, whereas 28 were inconclusive (diagnostic yield of 79.41%). Of 108 diagnostic biopsies, five were considered inaccurate (accuracy rate of 95.37%). The overall diagnostic yield and accuracy rate for soft tissue lesions were 70% and 92.85%. There were two complications with no permanent sequelae.

23. Ray-Coquard I, Ranchère-Vince D, Thiesse P, Ghesquière H, Biron P, Sunyach MP, Rivoire M, Lancry L, Méus P, Sebban C, Blay JY. Evaluation of core needle biopsy as a substitute to open biopsy in the diagnosis of soft-tissue masses. *Eur J Cancer*. 2003;39:2021–2025.

EBM Level IV: Its diagnostic usefulness was investigated retrospectively in 110 patients with soft tissue masses (s-t-M) undergoing core needle biopsy between September 1994 and September 2000. One hundred three of 110 core needle biopsies were suitable for analysis. Core needle biopsy specificity and PPV were 100%; sensitivity was 95%, 99%, and 92%; and negative predictive value 85%, 95%, and 88% for diagnosing malignancy, soft tissue tumor, and sarcoma, respectively. Core needle biopsy sensitivity and negative predictive value were 100% for malignancy, connective tumor and sarcoma in lymphomas, high-grade sarcomas, and desmoid tumors. In low-grade sarcomas, sensitivity was 94% and 85% and negative predictive value 84% and 77% for malignancy and sarcoma, respectively.

24. Rydholm A, Akerman M, Idvall I, Persson BM. Aspiration cytology of soft tissue tumors. A prospective study of its influence on choice of surgical procedure. *Int Orthop*. 1982;6:209–214.

EBM Level IV: The pathologist at a sarcoma center using FNA was 83% accurate in predicting malignancy.

25. Serpell JW, Pitcher ME. Pre-operative core biopsy of soft-tissue tumors facilitates their surgical management. *Aust N Z J Surg*. 1998;68:345–349.

EBM Level IV: All patients with primary soft tissue tumors managed by two surgeons with a special interest in soft tissue sarcomas since 1991 were reviewed. The overall accuracy of core biopsy was 84%. The sensitivity was 94% with 100% specificity.

26. Skrzynski MC, Biermann JS, Montag A, Simon MA. Diagnostic accuracy and charge-savings of outpatient core needle biopsy compared with open biopsy of musculoskeletal tumors. *J Bone Joint Surg Am*. 1996;78:644–649.

EBM Level II: A sarcoma surgeon using core biopsy had 84% diagnostic accuracy versus 94% open biopsy. Core biopsy had 78% grade accuracy. Core needle biopsy was less expensive than open biopsy.

27. Smith TJ, Safail H, Foster EA, Reinhold RB. Accuracy and cost-effectiveness of fine needle aspiration biopsy. *Am J Surg*. 1985;149:540–545.

EBM Level IV: Pathologists were able to predict malignancy 86% of the cases using FNA.

28. Soudack M, Nachtigal A, Vladovski E, Brook O, Gaitini D. Sonographically guided percutaneous needle biopsy of soft tissue masses with histopathologic correlation. *J Ultrasound Med*. 2006;25:1271–1277.

EBM Level IV: Retrospective review of the medical records of patients who underwent sonographically guided core biopsy of 183 soft tissue masses at our institution during a 50-month period. Biopsy results were diagnostically accurate in 174 (91%) cases. Thirteen biopsies were inconclusive. No complications occurred. The overall sensitivity, specificity, PPV, and accuracy in separating malignant from benign lesions were 97%, 99%, 99%, and 98%, respectively.

29. Torriani M, Etchebehere M, Amstalden E. Sonographically guided core needle biopsy of bone and soft tissue tumors. *J Ultrasound Med*. 2002;21:275–281.

EBM Level IV: A prospective study was performed in 74 patients referred for image-guided core needle biopsy of primary or recurrent musculoskeletal neoplasms and suspected solitary metastasis. An accurate diagnosis was obtained in 47 (97%) of 48 biopsies; sensitivity was 96%, and specificity was 100%. The method did not yield sufficient tissue to establish a diagnosis in one case. Considering all 65 biopsies, high-quality specimens were obtained in 96%. There were no complications.

30. Wakely PE, Kneisl JS. Soft tissue aspiration cytopathology. Diagnostic accuracy and limitations. *Cancer*. 2000;90:292–298.

EBM Level IV: Pathologists using FNA predicted accurately malignancy 97% and 83% grade.

31. Yang YJ, Damron TA. Comparison of needle core biopsy and fine-needle aspiration for diagnostic accuracy in musculoskeletal lesions. *Arch Pathol Lab Med*. 2004;128:759–764.

EBM Level I: Pathologist using both FNA and core biopsy in all patients found core needle biopsy was associated with a higher diagnostic accuracy of malignancy than FNA (93% versus 88%) and prediction of specific diagnosis (83% versus 64%).

32. Yeow KM, Tan CF, Chen JS, Hsueh C. Diagnostic sensitivity of ultrasound-guided needle biopsy in soft tissue masses about superficial bone lesions. *J Ultrasound Med*. 2000;19:849–855.

EBM Level IV: Authors evaluated the value of ultrasound-guided needle biopsy in 20 soft tissues masses. A diagnostic sensitivity of 95% and specificity of 100% in separating a benign or a malignant lesion was obtained. Fine needle aspiration cytology allowed the specific cell

type of malignancy to be diagnosed in 80% of cases, whereas core needle biopsy allowed it in 91%.

EBM = evidence-based medicine; FNA = fine needle aspiration.

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