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Revisiting CT-Guided Percutaneous Core Needle Biopsy of Musculoskeletal Lesions: Contributors to Biopsy Success

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OBJECTIVE. The purpose of this article is to investigate potential technical, imaging, and histopathologic contributors to the success of CT biopsy.

MATERIALS AND METHODS. Four hundred forty-four consecutive CT biopsies of musculoskeletal lesions performed from 2005 to 2008 were retrospectively classified as diagnostic or nondiagnostic and as accurate or inaccurate. A biopsy was considered as diagnostic if it provided a definitive pathologic diagnosis or was clinically useful; as accurate if it was concordant with the ultimate diagnosis with respect to identification of malignancy, grade, and histopathologic features; and as successful if it was both diagnostic and accurate. Biopsy success rate, diagnostic yield, and accuracy were assessed according to lesion location, use of sedation, biopsy equipment type, bone lesion matrix type, and lesion histologic type (i.e., bone or soft-tissue origin, malignant or benign neoplasm, and low- or intermediate-to-high-grade neoplasm).

RESULTS. Of 444 biopsies, 71% were diagnostic, 86% were accurate, and 70% were successful. Biopsy success and diagnostic yield were greater in bone lesions, malignant neoplasms, and intermediate-to-high-grade neoplasms compared with soft-tissue lesions ($p < 0.01$), benign neoplasms ($p < 0.0001$), and low-grade neoplasms ($p < 0.0001$). Success and diagnostic yield were not significantly associated with technical or imaging factors. Biopsy accuracy was not associated with any of the tested variables. Of the 128 nondiagnostic biopsy results, 53% were accurate with respect to subsequent surgical pathologic findings. Most of these biopsy results were of benign soft-tissue lesions.

CONCLUSION. CT biopsy of musculoskeletal lesions is accurate and effective. It may be limited in the evaluation of benign and low-grade soft-tissue neoplasms.

Percutaneous core needle biopsy is an important tool in the evaluation of musculoskeletal lesions. Its accuracy, safety, and cost-effectiveness have been well documented. However, open or excisional biopsy remains the reference standard.

For a biopsy to be successful, it must first be considered diagnostic. This requires imparting a specific diagnosis from which the treating clinician can make a decision of whether to dismiss, monitor, or treat a lesion. Ideally, the result would also be definitive, without the possibility of additional differential diagnoses. Also, the referring clinician must have sufficient confidence in the result. If a biopsy fails to meet one or more of these criteria, it is generally considered nondiagnostic. The reported diagnostic yield of percutaneous biopsy of musculoskeletal lesions in the literature is 69–88% [1–6].

Accuracy is a separate but equally important aspect of biopsy success. Inaccurate biopsies can result in delayed or inappropriate treatment. Most authors agree that an accurate biopsy should at least correctly detect the presence of malignancy and indicate tumor grade, if not also specific histopathologic features. Recent reported accuracy rates of percutaneous biopsy of musculoskeletal lesions range from 74% to 96% [1, 3–18].

Several determinants of biopsy success (whether referring to diagnostic yield or accuracy) have been suggested, with reports of decreased success in primary bone lesions [16, 17], bone lesions with no extraosseous component [1, 11], sclerotic bone lesions [6, 8], cystic bone lesions [8, 19], soft-tissue lesions [14, 15, 20], myxoid lesions [20], benign tumors or lesions [7, 11, 17, 21], infection [11, 16, 17], suspected primary musculoskeletal tumors [10], round cell lesions [9], paraspinal

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TABLE 1: Technical and Imaging Factors and Biopsy Accuracy, Diagnostic Yield, and Success

Factor	Total No. of Lesions	Diagnostic Yield			Biopsy Accuracy			Biopsy Success		
		No. of Diagnostic Biopsies	Diagnostic Yield (%)	*p*	No. of Accurate Biopsies	Accuracy (%)	*p*	No. of Successful Biopsies	Success Rate (%)	*p*
Anatomic location				0.36			0.60			0.40
Peripheral	341	239	70		295	87		237	70	
Central	103	77	75		87	84		76	74	
Use of sedation				0.87			0.05			0.97
No	380	271	71		332	87		268	71	
Yes	64	45	70		50	78		45	70	
Biopsy equipment				0.93			0.25			0.84
Soft tissue	398	283	71		345	88		280	70	
Bone	46	33	71		37	80		33	72	
Bone lesion matrix				0.47			1.00			0.47
Sclerotic	13	8	62		11	85		8	62	
Lytic or mixed	33	25	76		26	79		25	76	

lesions [4, 9, 11], and in biopsies with few number of specimens [6].

The purpose of this study was to better elucidate factors that may contribute to the success of CT-guided core needle biopsy.

Materials and Methods

This study included 493 CT-guided percutaneous core needle biopsies of soft-tissue or bone lesions, performed on 474 patients (252 male and 222 female), with a mean age of 50 years (range, 1–94 years). The procedures were performed consecutively from January 2005 to August 2008 at a single tertiary care institution.

After approval by the institutional review board, data were retrospectively acquired by one of the authors for each biopsy from the computerized hospital information system and radiology information system. The data included patient demographics, biopsy technical factors, imaging features, lesion histologic features, and clinical follow-up. CT biopsy results were compared with subsequent surgical pathologic results. For 190 lesions that did not undergo surgical biopsy or excision, CT biopsy results were compared with the final clinical diagnoses. Forty-nine equivocal biopsies with clinical follow-up of less than 6 months were excluded, leaving a total of 444 biopsies for statistical analysis. Clinical follow-up in the remaining cases without subsequent surgical biopsy or excision ranged from 6 to 40 months.

One of two musculoskeletal radiologists performed each needle biopsy after obtaining informed consent from the patient or a guardian. Local anesthesia was administered in all cases, and conscious sedation was used in 64 cases. For soft-tissue lesions or bone lesions with accessible soft-tissue components, three to eight core biopsy specimens were routinely obtained with an automated 14-gauge cutting needle inserted coaxially through an 11- or 12-gauge trocar (Quick-Core Biopsy Needle Set, Cook Medical). For bone lesions in which the cortex was intact, a bone-cutting biopsy device was used (KyphX, Kyphon; Jamshidi, CareFusion; or Bonopty, AprioMed). Specimens were sent in buffered formalin and saline solution for histologic analysis and possible flow cytometry or cytogenetic analysis and karyotyping. Pathologic specimens were examined by one of two experienced musculoskeletal pathologists.

On the basis of pathologic and clinical follow-up data, biopsies were classified as diagnostic or nondiagnostic and as accurate or inaccurate. A biopsy was considered diagnostic if a definitive pathologic diagnosis could be determined or if the result proved clinically useful and no subsequent confirmatory tissue sampling was required. A biopsy was classified as accurate if the result was consistent with subsequent surgical pathologic findings or the final clinical diagnosis in the detection of malignancy, tumor grade, and salient histologic features. Biopsies were considered successful if they were both diagnostic and accurate.

The overall biopsy success rate was calculated as the number of biopsies that were both diagnostic and accurate, divided by the total number of biopsies. Diagnostic yield and accuracy were calculated as the number of diagnostic or accurate biopsies, respectively, divided by the total number of biopsies.

Biopsy success rate, diagnostic yield, and accuracy were analyzed by subgroups using the chi-square and Fisher exact tests, when appropriate. Tested variables included lesion anatomic location (peripheral or central), use of sedation, biopsy equipment type (soft tissue or bone), bone

TABLE 2: Lesion Histopathologic Type and Biopsy Success

Lesion Histopathologic Type	Total No. of Lesions	No. of Successful Biopsies	Success Rate (%)	*p*
Origin				0.001
Bone	219	170	78	
Soft tissue	225	143	64	
Malignant vs benign				< 0.0001
Malignant neoplasm	284	226	80	
Benign neoplasm	97	46	47	
Grade				< 0.0001
Intermediate or high	260	209	80	
Low	121	63	52	

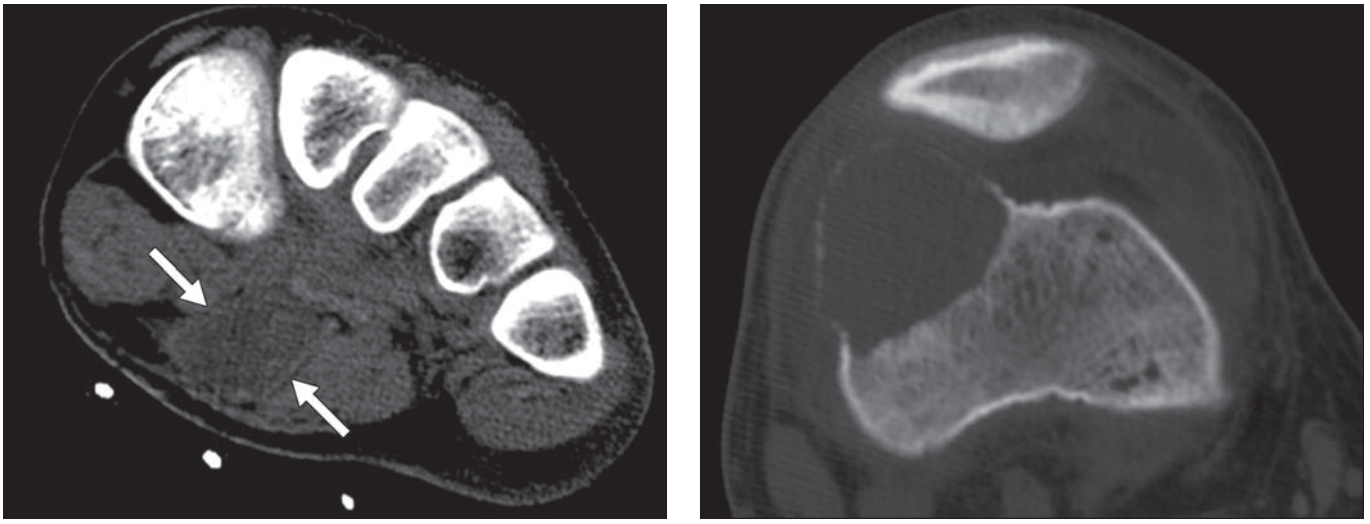

Fig. 1—Images show example of soft-tissue lesion with nonspecific imaging appearance and bone lesion with characteristic imaging appearance.
A, Hypoattenuating soft-tissue mass in plantar aspect of foot (*arrows*), without specific radiographic features in 13-year-old boy. CT biopsy results were suggestive of hemangioma, but open biopsy was required for confirmation.
B, Lytic lesion of distal femoral epiphysis extending to subchondral bone with thin zone of transition, characteristic of giant cell tumor in 19-year-old man. CT biopsy results confirmed imaging impression, and patient subsequently underwent intralesional curettage and cementing.

lesion matrix (sclerotic or lytic and mixed), and lesion histologic type (bone or soft-tissue origin, malignant or benign neoplasm, and low-grade or intermediate-to-high-grade neoplasm). A p value of 0.01 was considered statistically significant.

Results

Of 444 biopsies, 316 (71%) were diagnostic, 382 (86%) were accurate, and 313 (70%) were considered successful (both diagnostic and accurate).

There were no statistically significant differences in biopsy success rates when evaluated by lesion anatomic location, use of sedation, biopsy equipment type, or bone lesion matrix (Table 1). There were, however, significant associations between biopsy success and lesion histopathologic features (Table 2). Biopsies of lesions arising from bone were 78% successful, compared with 64% of soft-tissue lesions ($p = 0.001$) (Fig. 1). Malignant and intermediate-to-high-grade neoplasms were also associated with higher biopsy success rates than benign ($p < 0.0001$) and low-grade ($p < 0.0001$) neoplasms (Table 2 and Fig. 2).

These same groups had significant differences in diagnostic yield; 78% of bone lesion biopsies were diagnostic, compared with 64% of soft-tissue lesions ($p = 0.002$). Biopsies of malignant neoplasms were more often diagnostic (80%) than those of benign neoplasms (47%; $p < 0.0001$). Finally, 80% of intermediate-to-high-grade neoplasms had diagnostic biopsy results, compared with 52% of low-grade neoplasms ($p < 0.0001$).

No significant associations were found between accuracy and biopsy technical factors, lesion imaging features, or lesion histologic type (Table 1).

Of the 128 nondiagnostic biopsies, 68 (53%) were accurate with respect to subsequent surgical pathologic results. The majority of these were benign soft-tissue lesions (Table 3).

Sixty-two of 444 biopsies (14%) were inaccurate. These included 32 false-negative biopsies, one false-positive biopsy, seven that were inaccurate with respect to grade, and 22 that were inaccurate with respect to lesion

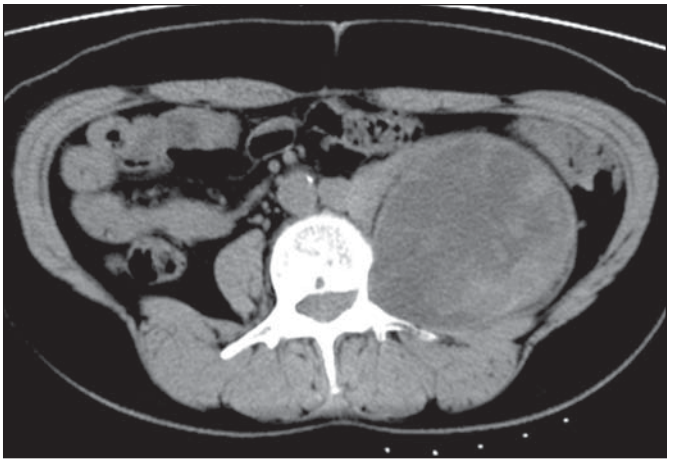

Fig. 2—51-year-old woman. Image shows example of nondiagnostic but accurate biopsy in benign low-grade lesion. Unenhanced CT scan of abdomen shows heterogeneous soft-tissue mass in left retroperitoneum. CT-guided biopsy pathologic diagnosis was consistent with schwannoma with degeneration; however, possibility of malignant peripheral nerve sheath tumor could not be excluded. Wide excision was performed and confirmed diagnosis of schwannoma with degeneration.

TABLE 3: Nondiagnostic But Accurate Biopsies

Lesion Histologic Type	No. of Lesions
Benign	52
Soft tissue	41
Neoplasm	26
Lipoma	8
Hemangioma	6
Myxoma	4
Other	8
Nonneoplastic[a]	15
Bone[b]	11
Malignant	16
Sarcoma	12
Lymphoma	3
Metastasis	1

[a]Includes abscess, synovitis, bursitis, myositis, Baker cyst, hematoma, and no diagnosis.
[b]Includes chondroma, chondroblastoma, chondromyxoid fibroma, desmoplastic fibroma, osteochondroma, aneurysmal bone cyst, simple bone cyst, and no diagnosis.

histopathologic features. Three of the inaccurate biopsies were considered diagnostic at the time of interpretation. One was an anaplastic ependymoma, which was initially reported as ependymoma on CT biopsy. The second was an intermediate-grade myxofibrosarcoma, previously called low-grade on CT biopsy. The third was a malignant giant cell tumor, originally reported as a (benign) giant cell tumor.

Discussion

Reported rates of biopsy diagnostic yield and accuracy in the literature range from 69% to 96% [1–18], with diagnostic yield inferior to accuracy in most studies [1, 3–5, 12]. Our study showed similar rates, with a diagnostic yield of 71% and accuracy of 86%. Our overall success rate, defined as both diagnostic and accurate, was 70%.

There are several potential causes for unsuccessful CT biopsy. These include, but are not limited to, failure to biopsy the lesion; failure to obtain sufficient material; the inability to render a definitive diagnosis because of nonspecific histologic features, necrosis, crush artifact, and so forth; and a lack of confidence in the biopsy result, requiring additional tissue sampling. Failure to biopsy the lesion or to obtain sufficient material can be the result of technical factors, such as difficulty accessing or penetrating a lesion. This is suggested by reports of lower biopsy success rates for lesions in or around the spine [4, 9, 11], bone lesions without soft-tissue components [1, 11], and sclerotic bone lesions [6, 8]. Our study found no significant difference in success rates for these subgroups; however, the sample sizes were small.

Wu et al. [6] reported increased biopsy success with greater number of specimens obtained and proposed three cores for bone lesions and four cores for soft-tissue lesions as the optimal numbers. Analysis of this nature could not be performed in our retrospective study, because the number of core samples obtained was not routinely reported, and pathologic reports of specimen size varied depending on the quality of the specimen (i.e., some were reported as core lengths, others as specimen button volume).

We hypothesized that the use of sedation would result in better patient cooperation and thus greater biopsy success; however, our data showed no positive associations between the use of sedation and biopsy success, diagnostic yield, or accuracy. In fact, biopsies performed with sedation showed an accuracy rate of 78%, compared with 87% accuracy of biopsies performed without sedation. This approaches statistical significance ($p = 0.05$) but is of doubtful clinical significance.

Our study did find lower success rates with lesions of soft-tissue origin, which may reflect the relative lack of characteristic radiologic features in soft-tissue lesions. Bone lesions, in contrast, often have specific imaging features that can be corroborated by pathology (Fig. 1). This finding is commensurate with other reports of lower success with soft-tissue lesions [14, 15, 20].

Our study also showed lower success rates in biopsies of benign and low-grade neoplasms. These lesions are inherently difficult to distinguish from their higher-grade counterparts by CT biopsy because the possibility of sampling error must always be considered (Fig. 2). For example, a CT biopsy result of "lipoma" could be considered nondiagnostic because an undersampled liposarcoma cannot be excluded. If surgical pathology confirms the diagnosis of lipoma, the CT biopsy would be considered accurate but nondiagnostic. This scenario was not rare in our study because 53% of nondiagnostic biopsies subsequently proved to be accurate. Of the nondiagnostic but accurate biopsies, the majority were benign soft-tissue lesions, including many low-grade neoplasms such as lipoma, hemangioma, or myxoma (Table 3). Practitioners should be aware of the limitations of CT biopsy in diagnosing these types of lesions.

Interventionalists should also take measures to increase confidence in biopsy results. Some strategies could include targeting the most aggressive-appearing portion of a lesion, avoiding necrotic areas, and sampling from multiple areas when a lesion is large.

This study was limited by its retrospective nature. There were also relatively small sample sizes of bone lesions without soft-tissue components, sclerotic bone lesions, and spine lesions, limiting evaluation of technical and imaging factors as determinants of success.

In conclusion, CT-guided core needle biopsy is generally an accurate and effective tool in the diagnosis of musculoskeletal lesions. There may be some inherent limitations in its evaluation of benign and low-grade soft-tissue neoplasms. Nonspecific imaging features and concern for sampling error likely contribute to lower diagnostic yield in CT biopsies of these lesions.

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