The diagnostic value of needle biopsy for musculoskeletal lesions

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Abstract The purpose of this study was to assess the diagnostic value of imaging-guided core needle biopsy for the diagnosis of musculoskeletal lesions. Between 2004 and 2007, 309 biopsies (ultrasound 151, computed tomography 89, and fluoroscopy 69) were included. There were 142 soft tissue and 167 bony lesions. Diagnostic yields and accuracies were assessed using the chi-square test or Fisher's exact test with Bonferroni's correction when necessary. Overall diagnostic yield was 90.6% for all 309 lesions (bone 91.6% vs. soft tissue 89.3%, $p=0.5125$). The diagnostic accuracy of the 185 core needle biopsies, which were confirmed by definitive surgical biopsies, was 84.3% (bone 88.9% vs. soft tissue 79.1%, $p=0.0669$). The yields of homogenous bone tumours (96.8%) were not significantly higher than those of bone tumours with a heterogenic architecture (86.4%, $p=0.0794$). The difference between accuracies for homogenous bone tumours (89.1%) and heterogenous bone tumours (85.0%) was not significant ($p=0.6930$). However, for soft tissue tumours, homogenous tumours had a significantly higher diagnostic yield than heterogenous tumours (97.5% vs. 81.4%, $p=0.0036$). Diagnostic accuracy for homogenous tumours was also significantly higher than that for heterogenous soft tissue tumours (94.4% vs. 60.6%, $p<0.0001$). The image-guided percutaneous needle biopsy of musculoskeletal lesions is a safe and effective procedure if it is performed selectively in soft tissue tumours with homogenous architectures.

Introduction

The majority of musculoskeletal tumours require a histological diagnosis before clinicians can decide on appropriate treatment, and surgical biopsy is the most accurate way of obtaining tumour tissue samples. However, surgical biopsy has been reported to cause complications in up to 17.3% of cases, and in 8.5% to hamper further treatment [1–3]. Percutaneous needle biopsy is widely accepted as a standard method for the diagnosis of many different types of tumours, yet orthopaedic oncologists still prefer surgical biopsies because the accuracy of needle biopsies has been reported to be significantly lower for musculoskeletal tumours [4]. Nevertheless, the role of needle biopsy has been recently promoted because it is less traumatic than surgical biopsy. Because it does not cause surgical wounds, treatments, such as, radiation and chemotherapy can be administered immediately after the confirmation of pathological diagnosis. Furthermore, it is less expansive and more convenient because it is usually performed under local anaesthesia in an outpatient clinic.

Recent studies have reported that the diagnostic accuracy of needle biopsy ranges from 70% to 98% for musculoskeletal tumours [1, 5–13]. These values are dependent on many different factors, but overall values have been improved by advances in imaging-based guidance techniques, which enhance the collection of viable tissue from tumour sites.

Furthermore, imaging studies can be useful in terms of predicting diagnostic yield and providing clinicians with guidelines for the optimal biopsy method in a given situation. Wu et al. analysed 151 core needle biopsies of musculoskeletal tumours in an attempt to identify factors that affect the diagnostic yield of needle biopsy. It was found that higher diagnostic yields were obtained for lytic

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and larger bone lesions [14]. However, to our knowledge, no prior study has evaluated the effects of histological factors on the diagnostic yield of image guided needle biopsy for musculoskeletal tumours. In this study, we retrospectively collected 322 cases of image-guided needle biopsies in musculoskeletal tumours and analysed the diagnostic yields and accuracies of needle biopsy with respect to different factors, including tumour histology. It was hoped that information obtained would aid decision-making regarding biopsy type, when a specific tumour type is indicated by imaging analysis.

Materials and methods

We reviewed retrospectively all 322 core needle biopsies (322 patients) performed in musculoskeletal lesions between January 2004 and December 2007 at the Samsung Medical Centre, Seoul.

Thirteen cases were excluded due to follow-up loss without a clear diagnosis. Accordingly, 309 biopsies were included in this study. One hundred eighty-five patients underwent a core needle biopsy and surgical biopsy or resection. However, the remaining 124 biopsies were deemed unsuitable for further histological evaluation. These were composed of some biopsies of benign tumours, metastatic diseases, lymphomas, and infections.

The 309 cases included 158 males and 151 females with an average age 47.5 years (range 3–84). The anatomical locations of tumours subjected to core needle biopsy are shown in Table 1. There were 167 bone tumours and 142 soft tissue tumours including tumour-like lesions (Tables 2, 3, 4).

Either the Gunbiopsy Needle (M.I.Tech) or the Bone Biopsy (BONOPTY) system was used according to tumour

size and depth. At least four biopsy samples were obtained at different tumour sites under imaging guidance by two radiologists specialised in the musculoskeletal system. The imaging study used ultrasound in 151 cases, CT in 89, and fluoroscopy in 69. All samples from core needle biopsies were fixed in 10% formaldehyde and examined by pathologists specialising in musculoskeletal tumours. A compressive bandage was applied to skin for 12–24 hours after biopsy. After the procedure, patients were observed for at least 30 minutes to ensure the absence of immediate complications, such as haemorrhage or neurovascular injury. Delayed complications were assessed by orthopedic surgeons two weeks after biopsy.

Diagnostic yields were calculated to assess whether core needle biopsy can provide diagnostic information and whether it is possible or not. To achieve this, we analysed the biopsies of all 309 patients, including the 124 that did not undergo a surgical biopsy. The pathology reports of all biopsies were reviewed and categorised as diagnostic and non-diagnostic specimens or insufficient specimens for pathological diagnosis by pathologists.

To determine diagnostic accuracy, we excluded the 124 cases not confirmed by surgical biopsy, and analysed the findings of the 185 patients who underwent both needle biopsy and surgery. The histological results of surgical specimens were used as the reference standard. Accuracy was defined as the sum of true positive and true negative results divided by the total number of biopsies performed.

Statistics

Statistical analyses were performed by using SAS software (version 9.13; SAS Institute Inc, Cary, NC). To compare proportions, we used the chi-square test or Fisher's exact

Table 1 Distribution of the lesions ($n=309$)

Bone	Number of lesions	Soft tissue	Number of lesions
Femur	41	Neck	3
Tibia	11	Shoulder	18
Fibula	2	Upper arm	2
Calcaneus	2	Forearm	8
Pelvic bone	13	Axilla	3
Vertebra	73	Back	13
Humerus	15	Pelvis	8
Clavicle	4	Thigh	34
Scapula	2	Knee	17
Sternum	1	Lower leg	9
Rib	3	Ankle	6
		Foot	17
		Elbow	1
		Retroperitoneal	3
Total	167	Total	142

Table 2 Final histopathology results for bone tumours ($n=117$)

Benign	Number of lesions	Malignant	Number of lesions
Giant cell tumour	17	Chondrosarcoma	9
Fibrous dysplasia	5	Osteosarcoma	14
Enchondroma	6	Malignant lymphoma	5
Simple bone cyst	2	Multiple myeloma	4
Osteoblastoma	2	Ewing's sarcoma	1
Intra-osseous haemangioma	2	Angiosarcoma	1
Osteoid osteoma	3	Cancer, metastatic	
Chondroblastoma	1	Squamous cell carcinoma, lung	2
Fibroma	1	Adenocarcinoma, lung	10
Langerhans cell histiocytosis	1	Ductal carcinoma, breast	3
Osteochondroma	1	Clear cell carcinoma, kidney	1
Others	2	Angiosarcoma	1
		Plasmacytoma, anaplastic	1
		Other sites	13
		Unknown origin	6
		Others	3
Total	43	Total	74

test and Bonferroni's correction when necessary. Statistical significance was accepted for p values of <0.05 .

Histologically tumour types were classified as heterogenous and homogenous. Heterogeneity was defined as a mixture of different types of cells, tumour grades, or marker expressions of different markers in the same tissue. Thus, comparatively large amounts of tissue were required for accurate histological diagnoses.

Results

Diagnostic yield

The overall diagnostic yield from 309 core needle biopsies was 90.6%, and no statistically significant difference in diagnostic yield ($p=0.5125$) was found between bone tissue (91.6%) and soft tissue lesions (89.3%). The diagnostic yields of benign bone tumours and malignant bone tumours (88.4% vs 91.9%, $p=0.5297$) and of benign and malignant soft tissue tumours were not significantly different (92.2% vs 90.6%, $p=0.7210$).

Diagnostic yields were found to depend on the histological architecture of the original tumours (Table 5). Benign and malignant soft tissue tumours with a heterogenic architecture, such as haemangiomas, schwannomas, angiosarcomas, liposarcomas, and synovial sarcomas, had significantly lower

diagnostic yield than relatively homogenous tumours (81.4% vs 97.5%, $p=0.0036$). But, no significant difference was found between bone tumours containing heterogenous tissues, such as giant cell tumours [15], chondroblastomas, haemangiomas, angiosarcomas, and others (86.4% vs 96.8%; $p=0.0794$).

The different imaging techniques used to guide core needle biopsies for all 309 lesions did not significantly affect diagnostic yield (ultrasound 90.1%, fluoroscopy 92.8%, CT 89.9%; $p=0.7867$).

Diagnostic accuracy

The diagnostic accuracy of the 185 cases examined by core needle biopsy and surgery was 84.3%. The diagnostic accuracy was greater for biopsied bone lesions than for soft tissue lesions (88.9% vs 79.1%), but this was not significant ($p=0.0669$). Furthermore, the diagnostic accuracy of benign and malignant bone tumours were not significantly different (85.3% vs 90.2%; $p=0.7233$). However, the diagnostic accuracy of core needle biopsy for benign and malignant soft tissue tumours were significantly different (87.3% vs 66.7%; $p=0.0345$).

The histological architecture of original tumors (Table 5) were found to be correlated with diagnostic accuracy of core needle biopsy. Diagnostic accuracy of the group of heterogenous soft tissue tumours, including haemangiomas, schwannomas, angiosarcomas, liposarcomas, and synovial

Table 3 Final histopathology results for soft tissue tumours ($n=122$)

Benign	Number of lesions	Malignant	Number of lesions
Lipoma	23	Synovial sarcoma	7
Haemangioma	7	Chondrosarcoma	1
Schwannoma	21	Rhabdomyosarcoma	3
Synovial osteochondromatosis	3	Liposarcoma	7
Granular cell tumour	2	Squamous cell carcinoma	1
Glomus tumour	2	Malignant fibrous histiocytoma	3
Myxoma	1	Angiosarcoma	1
Neurofibroma	6	Ewing's sarcoma	1
Epidermoid cyst	2	Osteosarcoma	3
Fibromatosis	10	Malignant lymphoma/leukemia	1
Fibroma	9	Cancer, metastatic	
Leiomyoma	2	Thymic	1
Masson's tumor	1	Adenocarcinoma, lung	2
Myochondroma	1	Malignant melanoma	1
Total	90	Total	32

Table 4 Final histopathology results for tumour-like lesions ($n=70$)

Tumour-like lesions	Bone lesions	Soft tissue lesions
Chronic synovitis (including pigmented villonodular synovitis)		7
Fibrocalcific nodule	2	4
Infection (including tuberculosis)	34	5
Mature bone (including fracture)	11	
Osteonecrosis	2	
Gout		1
Others	1	3
Total	50	20

sarcomas, differed significantly from that of the others (60.6% vs 94.4%, $p<0.0001$), but no significant difference was observed between heterogenous bone tumours, such as giant cell tumours, chondroblastomas, haemangiomas, angiosarcomas, and the others (85.0% vs 89.1%; $p=0.6930$).

The different imaging techniques were not found to be associated with significant differences in the diagnostic accuracy of core needle biopsy for all 185 lesions (ultrasound 81.4%, fluoroscopy 88.5%, CT 87.1%; $p=0.5204$).

Complications

No complications related to image-guided core needle biopsy, such as haemorrhage or neurovascular injury, were encountered.

Discussion

The diagnostic yield of image-guided core needle biopsy has been reported to be up to 97% for musculoskeletal tumours [5, 7–10, 12, 13, 16]. Needle samples of metastatic tumours reportedly have the highest probability of achieving a diagnostic result. We retrospectively analysed 309 cases of core needle biopsies in musculoskeletal tumours and obtained an overall diagnostic yield of 90.6%. Recent studies have reported that complications resulting from needle biopsies occur at rates ranging from 0 to 1.1% [2, 7, 8, 10, 17–20]. We did not encounter any complications related to core needle biopsy. Accordingly, we consider that our core needle biopsy is representative of those used at other institutes.

In this study, there were 29 non-diagnostic cases that did not include diagnostic materials. The majority of these showed only necrosis, fibrosis, or a blood component, and

Table 5 Diagnostic values for categorical variables

Variables	Diagnostic yield (%)	p value	Diagnostic accuracy (%)	p value
All lesions	90.6		84.3	
Diagnostic tools		0.7867		0.5204
USG	90.1		81.4	
CT	89.9		87.1	
Fluoroscopy	92.8		88.5	
Anatomical locations		0.5125		0.0669
Bone lesions	91.6		88.9	
Soft tissue lesions	89.3		79.1	
Malignancy, bone		0.5297		0.7233
Benign	88.4		85.3	
Malignant	91.9		90.2	
Malignancy, soft tissue		0.7210		0.0345
Benign	92.2		87.3	
Malignant	90.6		66.7	
Tissue heterogeneity, bone		0.0794		0.6930
Heterogenous	86.4		85.0	
Homogenous	96.8		89.1	
Tissue heterogeneity, soft tissue		0.0036		<0.0001
Heterogenous	81.4		60.6	
Homogenous	97.5		94.4	

USG ultrasonography, CT computed tomography

these cases usually contributed to the lower diagnostic yields of core needle biopsy for musculoskeletal tumours [7, 13, 19, 21–23]. A pathological diagnosis was made in 20 of these 29 cases by consecutive needle biopsies or by surgical biopsies.

To prevent lower diagnostic yields, McCarthy suggested that core needle biopsies should be performed after a full discussion between an orthopaedic surgeon, pathologist, and radiologist. This is in order to aid radiologists in determining a biopsy location in tumours and for the pathologist to confirm the histological diagnosis [21].

In our study, we obtained higher diagnostic accuracy for core needle biopsy in bone lesions than in soft tissue lesions, but, as in other studies, this difference was not significant [1, 5, 15]. Some studies have shown that core needle biopsies of bone lesions are more accurate than those of soft tissue lesions [18, 24]. However, in most of these studies, bone lesions included a large number of metastatic tumours, which usually yield higher accuracy [21, 25]. The reason for this appears to be that biopsies of metastatic tumours are more likely to contain diagnostic tumour cells because of their homogenous nature. However, for bone tumours, the diagnostic yields and the accuracies of homogenous and heterogenous tumours were found to be no different, which suggests that the homogeneities of bone tumours are not significantly related to an accurate diagnosis. Unfortunately, we could not identify any significant factors that affected the diagnostic accuracy of core needle biopsy for bone tumours.

On the other hand, the diagnostic yields and accuracy of soft tissue tumours were significantly affected by histological type [3, 21, 26]. We found that tumours with lower diagnostic accuracy were composed of heterogenic cells. These tumours included angiosarcomas, liposarcomas, synovial sarcomas, haemangiomas, and schwannomas.

Needle biopsy has been shown to have a low diagnostic accuracy for liposarcoma. Mitsuyoshi et al. reported that it was difficult to differentiate low-grade liposarcomas from lipomas by core needle biopsy [1]. Other studies have shown that it is difficult to obtain diagnostic samples from lower grade soft tissue tumours because these tumours are often heterogenous [3, 7, 18, 21, 26, 27]. Low-grade liposarcomas contain various types of cells, and often, different grades of tumour cells are observed in different parts of the same tumours. As such, the diagnostic accuracy of core needle biopsy is probably unacceptable for liposarcomas because needle biopsy gives little information about the entire tumour. MRI is now being routinely used to evaluate soft tissue masses in the extremities. Low-grade liposarcomas are easily diagnosed by MRI and show fat signals with high signal intensity in T1W and T2W images, and hypointensity in fat-suppression view. Core needle biopsies should not be performed on these tumours.

Synovial sarcoma is also composed of heterogenic cells that express biomarkers differently. The histological diagnosis of this tumour requires an examination of structural tissue rather than cells, especially in the biphasic type of synovial sarcoma, because the shape of cells are not characteristic. This probably explains the lower diagnostic accuracy observed for these tumours in our study. Unfortunately, needle biopsies of synovial sarcomas cannot be avoided, because their imaging findings are unpredictable. However, needle biopsy is often attempted because a tumour mass is located near a joint or neurovascular structure and it is not amenable to surgical biopsy due to the risk of contamination. We suggest that FISH analysis could improve the diagnostic accuracy of core needle biopsy for synovial sarcomas when cytological diagnosis is difficult and when synovial sarcoma is suspected after needle biopsy of a soft tissue tumour.

Schwannoma and haemangioma were found to have lower diagnostic accuracy. The heterogenous nature of these tumours also hampers histological diagnoses. Wu et al. reported that haemangioma has a low diagnostic yield, because it is difficult to determine the tissue architecture of a whole tumour by needle biopsy [14].

The diagnostic outcome of needle biopsy for musculoskeletal tumours varies and is largely dependent on tumour type. When tissue architecture is needed to make a histological diagnosis, needle biopsy struggles to achieve diagnostic accuracy, and thus, it cannot be performed indiscriminately. MRI may help exclude heterogenous soft tissue tumours unsuitable for needle biopsy. Furthermore, a musculoskeletal team approach, including an orthopaedic surgeon, a radiologist and a pathologist, should be used to determine the manner in which a core needle biopsy is performed. This will decrease the cost and time required to diagnose musculoskeletal tumours by avoiding unnecessary core needle biopsies.

References

1. Mitsuyoshi G, Naito N, Kawai A et al (2006) Accurate diagnosis of musculoskeletal lesions by core needle biopsy. *J Surg Oncol* 94:21–27
2. Mankin HJ, Mankin CJ, Simon MA (1996) The hazards of the biopsy, revisited. Members of the Musculoskeletal Tumor Society. *J Bone Jt Surg Am* 78:656–663
3. Kilpatrick SE, Cappellari JO, Bos GD, Gold SH, Ward WG (2001) Is fine-needle aspiration biopsy a practical alternative to open biopsy for the primary diagnosis of sarcoma? Experience with 140 patients. *Am J Clin Pathol* 115:59–68
4. Skrzynski MC, Biermann JS, Montag A, Simon MA (1996) Diagnostic accuracy and charge-savings of outpatient core needle biopsy compared with open biopsy of musculoskeletal tumors. *J Bone Jt Surg [Am]* 78-A:644–649
5. Altuntas AO, Slavin J, Smith PJ et al (2005) Accuracy of computed tomography guided core needle biopsy of musculoskeletal tumors. *ANZ J Surg* 75:187–191

6. Preteseille O, Barral FG, Court L et al (2003) Value of percutaneous core needle biopsy in the investigation of a suspected bone tumor. *J Radiol* 84:693–697
7. Issakov J, Flusser G, Kollender Y, Merimsky O, Lifschitz-Mercer B, Meller I (2003) Computed tomography-guided core needle biopsy for bone and soft tissue tumors. *Isr Med Assoc J* 5:28–30
8. Torriani M, Etchebehere M, Amstalden E (2002) Sonographically guided core needle biopsy of bone and soft tissue tumors. *J Ultrasound Med* 21:275–281
9. Yeow KM, Tan CF, Chen JS, Hsueh C (2000) Diagnostic sensitivity of ultrasound-guided needle biopsy in soft tissue masses about superficial bone lesions. *J Ultrasound Med* 19:849–855
10. Welker JA, Henshaw RM, Jelinek J, Shmookler BM, Malawer MM (2000) The percutaneous needle biopsy is safe and recommended in the diagnosis of musculoskeletal masses. *Cancer* 89:2677–2686
11. Yao L, Nelson SD, Seeger LL, Eckardt JJ, Eilber FR (1999) Primary musculoskeletal neoplasms: effectiveness of core-needle biopsy. *Radiology* 212:682–686
12. Dupuy DE, Rosenberg AE, Punyaratabandhu T, Tan MH, Mankin HJ (1998) Accuracy of CT-guided needle biopsy of musculoskeletal neoplasms. *AJR Am J Roentgenol* 171:759–762
13. Logan PM, Connell DG, O'Connell JX, Munk PL, Janzen DL (1996) Image-guided percutaneous biopsy of musculoskeletal tumors: an algorithm for selection of specific biopsy techniques. *AJR Am J Roentgenol* 166:137–141
14. Wu JS, Goldsmith JD, Horwich PJ, Shetty SK, Hochman MG (2008) Bone and soft-tissue lesions: what factors affect diagnostic yield of image-guided core-needle biopsy? *Radiology* 248:962–970
15. Werner M (2006) Giant cell tumour of bone: morphological, biological and histogenetical aspects. *Int Orthop* 30(6):484–489
16. Stoker DJ, Cobb JP, Pringle JA (1991) Needle biopsy of musculoskeletal lesions. A review of 208 procedures. *J Bone Jt Surg Br* 73:498–500
17. Contreras O, Burdiles A (2006) Diagnosis of bone lesions using image guided percutaneous biopsy. *Rev Med Chil* 134:1283–1287
18. Kawai A, Taguchi K, Sugihara S, Kunisada T, Inoue H (1996) The value of needle biopsy in the diagnosis of musculoskeletal tumors. *Int J Clin Oncol* 1:35–38
19. Jelinek JS, Murphey MD, Welker JA et al (2002) Diagnosis of primary bone tumors with image-guided percutaneous biopsy: experience with 110 tumors. *Radiology* 223:731–737
20. Konermann W, Wuisman P, Ellermann A, Gruber G (2000) Ultrasonographically guided needle biopsy of benign and malignant soft tissue and bone tumors. *J Ultrasound Med* 19:465–471
21. McCarthy EF (2007) CT-guided needle biopsies of bone and soft tissue tumors: a pathologist's perspective. *Skeletal Radiol* 36:181–182
22. Saifuddin A, Mitchell R, Burnett SJ, Sandison A, Pringle JA (2000) Ultrasound-guided needle biopsy of primary bone tumours. *J Bone Jt Surg Br* 82:50–54
23. Ayala AG, Zornosa J (1983) Primary bone tumors: percutaneous needle biopsy. Radiologic-pathologic study of 222 biopsies. *Radiology* 149:675–679
24. Hodge JC (1999) Percutaneous biopsy of the musculoskeletal system: a review of 77 cases. *Can Assoc Radiol J* 50:121–125
25. Fraser-Hill MA, Renfrew DL (1992) Percutaneous needle biopsy of musculoskeletal lesions. 1. Effective accuracy and diagnostic utility. *AJR Am J Roentgenol* 158:809–812
26. Association of Directors of Anatomic and Surgical Pathology (1999) Recommendations for reporting soft tissue sarcomas. *Am J Clin Pathol* 111:594–598
27. Layfield LJ, Glasgow BJ, Anders KH, Mirra JM (1987) Fine needle aspiration cytology of primary bone lesions. *Acta Cytol* 31:177–184