European Journal of Surgical Oncology 45 (2019) 1293–1298

Contents lists available at ScienceDirect

European Journal of Surgical Oncology

journal homepage: www.ejso.com

Comparison of the diagnostic performances of core needle biopsy in myxoid versus non-myxoid tumors

Himanshu Rohela [a], Cheol Lee [b], Hye Jin Yoo [c], Han-Soo Kim [a, e], Yongsung Kim [a], Hwan Seong Cho [d], Ilkyu Han [a, e, *]

[a] Department of Orthopaedic Surgery, Seoul National University Hospital, Seoul, South Korea
[b] Department of Pathology, Seoul National University College of Medicine, Seoul, South Korea
[c] Department of Radiology, Seoul National University Hospital, Seoul, South Korea
[d] Department of Orthopaedic Surgery, Seoul National University Bundang Hospital, Seongnam, South Korea
[e] Department of Orthopaedic Surgery, Seoul National University College of Medicine, Seoul, South Korea

ARTICLE INFO

Article history:
Received 27 December 2018
Received in revised form
7 April 2019
Accepted 1 May 2019
Available online 2 May 2019

Keywords:
Myxoid tumor
Core needle biopsy
Diagnostic accuracy
Soft tissue sarcoma
Histologic subtype

ABSTRACT

Background: Despite the overall diagnostic utility of core needle biopsy (CNB) comparable to incisional biopsy, increased diagnostic errors have been suggested of CNB for myxoid soft tissue tumors. This study compared the diagnostic performance of CNB between myxoid and non-myxoid soft tissue tumors.
Methods: 369 patients who underwent ultrasound-guided CNB prior to resection for soft tissue tumors were classified into two groups according to resection pathology; myxoid group (n = 75) and non-myxoid group (n = 294). One-hundred and ninety-three patients were male and the median age of the patients was 40 years. Two-hundred and sixty-three tumors were malignant.
Results: CNB correctly diagnosed malignancy in 84% (58 of 69) for the myxoid group and 95% (184 of 194) for the non-myxoid group. For diagnosing histologic grade of soft tissue sarcoma, CNB correctly identified high grade in 78% (18 of 23) for the myxoid group and 74% (94 of 128) for the non-myxoid group. Correct diagnosis rate of histological type was significantly lower in the myxoid group (63% [47 of 75] in the myxoid group and 83% [242 of 294] in the non-myxoid group, p = 0.013).
Conclusion: Our study suggests that CNB is useful for myxoid soft tissue tumors of the extremity, with regard to diagnosing malignancy and histologic grade. However, CNB was less useful for identifying histologic subtype in myxoid tumors than in non-myxoid tumors.

Introduction

Percutaneous core needle biopsy (CNB) is being used increasingly as an alternative to open biopsy for the diagnosis of soft tissue tumors of the extremity. CNB is advantageous over open biopsy with regard to the patient morbidity, cost and time [1,2]. In general, CNB can achieve diagnostic accuracy comparable to those of incisional biopsy [3,4]. However, increased diagnostic errors have been reported in association with small number of cores obtained, heterogeneity of the tumor and myxoid soft tissue tumors [5].

Myxoid soft tissue tumors encompass a heterogeneous group of lesions characterized by a marked abundance of extracellular myxoid matrix [6]. Myxoid soft tissue tumors demonstrate significant variability in their biological behavior including tumors which are entirely harmless, tumors with a tendency to recur locally but not metastasize, and soft tissue sarcomas (STSs). Histologically, there is broad morphological overlap between many different myxoid tumors which can present diagnostic difficulties for the pathologist [7,8]. Likewise, CNB for myxoid tumors such as myxoid liposarcoma and fibro-myxoid sarcoma has been reported to be less useful than CNB for non-myxoid tumors [9,10]. This may result in an inability to distinguish between benign tumors and STSs, and to separate lesions with low metastatic risk from those lesions which have more aggressive behavior. However, to our knowledge, no study has been published regarding the diagnostic utility of CNB with regard to diagnosing malignancy, histologic grade and histologic subtype in myxoid soft tissue tumors of the extremity. Moreover, the diagnostic usefulness of CNB in myxoid and non-

* Corresponding author. Department of Orthopaedic Surgery, Seoul National University Hospital, 101 Daehak-ro Jongno-gu, Seoul, 03080, South Korea.
E-mail addresses: drrohela@gmail.com (H. Rohela), fejhh@hanmail.net (C. Lee), dalnara3@gmail.com (H.J. Yoo), hankim@snu.ac.kr (H.-S. Kim), noweapon9@gmail.com (Y. Kim), mdchs111@snu.ac.kr (H.S. Cho), hik19@snu.ac.kr (I. Han).

https://doi.org/10.1016/j.ejso.2019.05.001
0748-7983/

myxoid soft tissue tumors has never been compared. With this regard, this study was performed to compare the usefulness of CNB between myxoid and non-myxoid soft tissue tumors in diagnosing malignancy, histologic grade and histologic subtype.

Materials and methods

Patient selection

From our institutional database, 3651 patients who underwent surgery for soft tissue tumors of the extremity or trunk wall between 2000 and 2018 were reviewed. Of these patients, 450 patients were identified to have undergone CNB prior to surgery. For the purpose of analyses, patients who presented with recurred tumors (n = 42) and patients with well differentiated liposarcoma (n = 24) were excluded [1,11,12]. In addition, patients with non-diagnostic CNBs, in which samples were taken outside of the tumor, were excluded from analyses (n = 15), which left 369 patients for analyses. Myxoid tumors were defined as tumors characterized by a varying degree of myxoid histology, resulting from an abundance of myxoid extracellular matrix [7]. Of the 369 patients, 75 patients (20%) were identified to have myxoid tumors with myxoid/round cell liposarcoma (n = 32) and myxofibrosarcoma (n = 25) being the most common diagnoses (Table 1). Patients were classified into myxoid group (n = 75) and non-myxoid group (n = 294) for analyses. The institutional review board of our institute approved this study.

Procedural details

CNB was performed as an outpatient procedure in the radiology department using ultrasound guidance. An 18-gauge coaxial STERICUT biopsy needle (TSK Laboratory, Tochigi, Japan) was used with a Philips EPIQ 5G or 7G ultrasound scanner and an average of four (range, 2 to 6) biopsy cores were obtained to secure adequate tissue specimen (Fig. 1). Hemostasis was secured by firm pressure once adequate tissue was obtained. No complications related to CNB, such as hemorrhage or neurovascular injury, were documented. Of the 369 patients, 20 patients (5%) underwent re-biopsy with CNB. Re-biopsy rates were 8% (n = 6) in the myxoid group and 5% (n = 14) in the non-myxoid group (p = 0.003). Nine patients (2.4%) eventually underwent open biopsy with rate of 2.7% (n = 2) in the myxoid group and 2.3% (n = 7) in the non-myxoid group (p = 0.291). All samples were fixed in 10% formaldehyde and analyzed.

Table 1
Histological subtypes of myxoid and non-myxoid tumors.

Histological subtype	Number
Myxoid tumors	
Myxoid/round cell liposarcoma	32
Myxofibrosarcoma	26
Fibro-myxoid sarcoma	6
Extra-skeletal myxoid chondrosarcoma	6
Myxoma	4
Myxoid neurofibroma	1
Non-myxoid tumors	
Undifferentiated pleomorphic sarcoma	57
Synovial sarcoma	33
Fibromatosis	32
Schwannoma	25
Leiomyosarcoma	14
Malignant peripheral nerve sheath tumor	10
Dedifferentiated liposarcoma	9
Pleomorphic liposarcoma	9
Extraskeletal Ewings sarcoma	7
Solitary fibrous tumor	7
Fibrosarcoma	5
Epitheloid haemangioendothelioma	5
Nodular fasciitis	5
Tenosynovial giant cell tumor	4
Rhabdoid tumor	3
Rhabdomyosarcoma	3
Myofibroblastic tumor	3
Granulomatous Inflammation	2
Haemangioendothelioma	2
Neurofibroma	2
Inflammation	2
Pleomorphic sarcoma	2
Round cell tumor	2
Myonecrosis	1
Necrotizing panniculitis	1
Neurofibromatosis	1
Ganglion cyst	1

Analyses of CNB

CNB was analyzed by experienced pathologists who specialize in musculoskeletal pathology. Immunohistochemistry, cytogenetic or molecular genetic analyses were utilized for subtyping of STS unless the tissue by CNB allowed straightforward morphological diagnosis on H&E staining. CNB results were analyzed with the MRI findings interpreted by the radiologists with expertise in musculoskeletal tumors. Mismatch between the CNB results and MRI findings was discussed routinely in the multi-disciplinary conference.

Statistical analyses

Statistical analyses were conducted with the Statistical Package for the Social Sciences (SPSS) for Windows (version 21; IBM Co., Endicott, NY, USA). Sensitivities, specificities, positive predictive values (PPVs), and negative predictive values (NPVs) were determined with 95% confidence interval (CI). Diagnostic accuracy was defined as the sum of true positive and true negative results divided by the total number of biopsies performed. The significance of differences between frequencies was calculated using chi-square or Fisher's exact test and differences in means were evaluated using the independent *t*-test. A p value of <0.05 was considered significant.

Results

Patient and tumor characteristics

Medical records including histology and imaging reports were reviewed for the potential patient and tumor characteristics that might be associated with correct diagnosis by CNB. For patient characteristics, gender and age were investigated (Table 2). One hundred ninety-three (52.3%) were male and 176 patients (47.7%) were female. The most common locations of tumors were thigh (n = 144, 39%) and pelvis (n = 52, 14.1%). Three hundred and forty-five tumors (93.5%) were deep-seated and 24 (6.5%) were superficial. As for histologic grading, there were 33 grade 1 (59%), 7 grade 2 (12.5%), and 16 grade 3 (28.5%) STSs in myxoid group according to the Federation Nationale des Centres de Lutte Contre le Cancer (FNCLCC) classification system [1]. For the purpose of analyses, grade 2 or 3 STSs were grouped as high-grade STSs. Mean size of the primary tumor, defined as the largest diameter on the pathology report or preoperative MRI, was 8.1 cm (range 1.2–20.8). There was no significant difference between the myxoid and non-myxoid group with regard to patient and tumor characteristics except for the higher proportion of low-grade tumors in the myxoid group. (Table 2). As for the imaging modality, all patients underwent MRI prior to CNB.

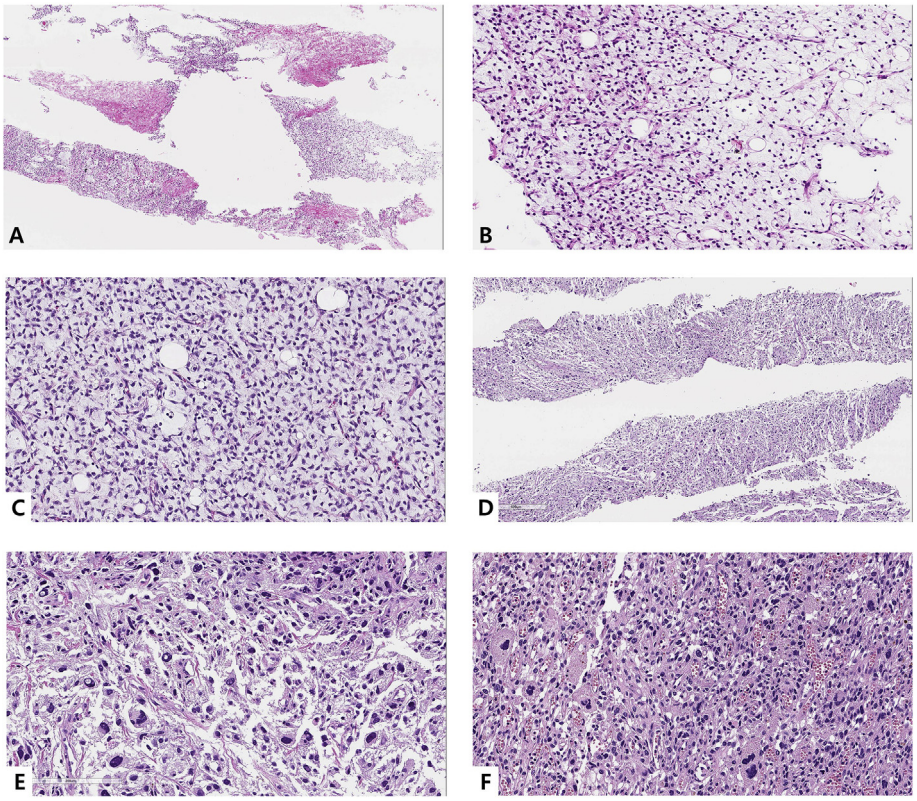

Fig. 1. Representative H&E sections of myxoid tumor (a–c) and non-myxoid tumor (d–f). Myxoid liposarcoma ((a) core needle biopsy, magnification ×40 (b) core needle biopsy, magnification ×200 (c) resection, magnification ×200) and undifferentiated pleomorphic sarcoma ((d) core needle biopsy, magnification ×40, (e) core needle biopsy, magnification ×200, (f) resection, magnification ×200)).

Table 2
Comparison between the myxoid group and non-myxoid group.

Characteristic	Non-myxoid (n = 294)	Myxoid (n = 75)	P value
Age, years [mean (±SD)]	46.1 (±19.3)	53.5 (±15.1)	0.845
Gender			0.345
Male	150 (51%)	43 (57%)	
Female	144 (49%)	32 (43%)	
Tumor size, cm [mean (±SD)]	7.7 (±4.9)	9.6 (±5.5)	0.746
Tumor grade			< 0.001
Grade 1	29 (19%)	33 (59%)	
Grade 2	38 (24%)	7 (13%)	
Grade 3	90 (57%)	16 (28%)	
Tumor depth			0.124
Deep	275 (94%)	70 (93%)	
Superficial	19 (6%)	5 (4%)	
Tumor location			0.365
Thigh	104 (36%)	40 (53%)	
Pelvis	46 (16%)	6 (8%)	
Leg	30 (10%)	7 (9%)	
Shoulder	14 (5%)	4 (5%)	
Arm	18 (6%)	8 (11%)	
Truncal	19 (7%)	5 (7%)	
Others	63 (21%)	5 (7%)	

Data are expressed as *n* (%) unless otherwise specified SD, standard deviation.

Diagnosing malignancy

In all, CNB correctly diagnosed 91.5% (97 of 106) of benign tumors and 92.0% (242 of 263) STSs (Table 3). In the non-myxoid group, CNB correctly identified 94% (94 of 100) of benign tumors and 95% (184 of 194) of STS. In contrast, in the myxoid group, CNB correctly identified only 50% (3 of 6) of benign tumors and 84% (58 of 69) of STSs. The sensitivity, specificity, PPV, NPV and diagnostic accuracy of CNB for diagnosing malignancy were 94.8% (95%CI 89–99), 94.0% (95%CI 90–98), 96.8% (95%CI 94–98), 90.3% (95%CI 85-95) and 94.5% in the non-myxoid group, and 84.0% (95%CI 82-88), 50.0% (95%CI 44–56), 95.0% (95%CI 91-99), 21.4% (95%CI 19–23) and 81.3% in the myxoid group, respectively. Fibromatosis (n = 32) and schwannomas (n = 25) were the most common benign soft tissue tumors diagnosed and myxoid/round cell liposarcoma (n = 32), myxofibrosarcoma (n = 26) and fibro-myxoid sarcoma

Table 3
Diagnostic ability of core needle biopsy in differentiating malignant and benign soft tissue tumors.

	All (n = 369)	Non-myxoid (n = 294)	Myxoid (n = 75)
CNB-Resection			
Malignant-Malignant	242	184	58
Malignant-Benign	9	6	3
Benign-Malignant	21	10	11
Benign-Benign	97	94	3
Diagnostic parameters			
Sensitivity	92.0% (CI = 89–95)	94.8% (CI = 89–99)	84.0% (CI = 82-88)
Specificity	91.5% (CI = 89–93)	94.0% (CI = 90–98)	50.0% (CI = 44–56)
Positive predictive value	96.4% (CI = 95–97)	96.8% (CI = 94–98)	95.0% (CI = 91-99)
Negative predictive value	82.2% (CI = 78-86)	90.3% (CI = 85-95)	21.4% (CI = 19–23)
Diagnostic accuracy	91.8%	94.5%	81.3%

(n = 6) were the most common malignant tumor diagnosed by CNB. Among the 21 STSs misdiagnosed as benign tumors, myxoid liposarcoma (n = 6), and synovial sarcoma (n = 3) were the most common tumor subtypes. Among the 9 benign tumors misdiagnosed as malignant, fibromatosis (n = 5) and neurofibroma (n = 2) were the most common subtypes.

Diagnosing grade in soft tissue sarcoma

For all 240 STSs diagnosed, a grade was reported for both the CNB and the resected specimen. For the purpose of analyses, patients who received neoadjuvant chemotherapy (n = 21) or radiation (n = 6) were excluded. In the non-myxoid group, CNB correctly identified 100% (29 of 29) of low-grade STS but only 74% (94 of 128) of high-grade STS (Table 4). In contrast, in the myxoid group, CNB correctly identified 97% (32 of 33) of low-grade STS and 78% (18 of 23) of high-grade STS. The sensitivity, specificity, PPV, NPV and diagnostic accuracy of CNB for diagnosing histologic grade were 73.4% (95%CI 66–80), 100%, 100%, 46.0% (95%CI 37–55) and 79.0% in the non-myxoid group, and 78.2% (95%CI 59–97), 96.9% (95%CI 92–100), 94.7% (95%CI 89–99), 86.4% (95%CI 56–87) and 89.3% in the myxoid group, respectively. Analyses of 39 STSs which were under-graded showed an underestimation of necrosis in 22 (56%), mitosis in 21 (54%) and differentiation in 6 (15%) among the 3 items of FNCLCC grading system.

Identifying histologic subtype

In all, histologic subtype was reported by CNB in 97% of the patients (359 of 369). There was no difference between the myxoid group and non-myxoid group in reporting the histologic subtype [96% (72 of 75) in the myxoid group and 98% (287 of 294) in the non-myxoid group (p = 0.975)]. However, the rate of correct identification was significantly lower in the myxoid group than that of the non-myxoid group [63% (47 of 75) and 82.3% (242 of 294) respectively, (p = 0.013)].

Discussion

Because of its minimal invasiveness, percutaneous CNB is being increasingly performed for diagnosing extremity soft tissue tumors [13]. The major goals of CNB are to diagnose malignancy, and in STS, to identify the grade and histologic subtype. Myxoid nature of soft tissue tumor has been suggested as an adverse factor for correct diagnosis using CNB [9,10], with one study reporting only 11% of CNB being useful for myxoid tumors, compared with 80% for non-myxoid tumors [9]. However, to our knowledge, no study exists regarding the diagnostic ability of CNB for malignancy, grade and histology in myxoid soft tissue tumors. We hypothesized that myxoid characteristic reduces the diagnostic ability of CNB in soft tissue tumors of the extremity. We sought to address this question by comparing the diagnostic ability of CNB between the myxoid soft tissue tumor and non-myxoid soft tissue tumor with regard to malignancy, grade, and histology.

In diagnosing malignancy, the myxoid group showed similar sensitivity and PPV but lower specificity and NPV when compared with the non-myxoid group. The low specificity (50.0%) and NPV (21.4%) of the myxoid tumors warrant caution, although the small number of benign tumors might have contributed these findings. Diagnostic inaccuracy has a substantial impact on patient and treatment offered. Of the 75 myxoid tumors, there were 14 misdiagnoses (19%), 11 STSs misdiagnosed as benign and 3 benign tumors misdiagnosed as STS (Table 5). Of the 11 STSs misdiagnosed, 9 were low grade STSs with myxoid liposarcoma and myxofibrosarcoma being the most common histologic subtypes. Of the 11 patients, 8 were considered highly suspicious for STS and were

Table 4
Diagnostic ability of core needle biopsy in differentiating low grade and high grade in soft tissue sarcoma.

	All (n = 213)	Non-myxoid (n = 157)	Myxoid (n = 56)
CNB-Resection			
High-High	112	94	18
High-Low	1	0	1
Low-High	39	34	5
Low-Low	61	29	32
Diagnostic parameters			
Sensitivity	74.2% (CI = 67–87)	73.4% (CI = 66–80)	78.2% (CI = 59–97)
Specificity	98.3% (CI = 97–99)	100%	96.9% (CI = 92–100)
Positive predictive value	99.1% (CI = 98–100)	100%	94.7% (CI = 89–99)
Negative predictive value	61.0% (CI = 52–70)	46.0% (CI = 37–55)	86.4% (CI = 56-87)
Diagnostic accuracy	81.2%	79%	89.3%

Table 5
Myxoid soft tissue sarcomas misdiagnosed as benign by core needle biopsy.

Case	Age	Sex	MRI Diagnosis	CNB Diagnosis	Resection Diagnosis	Resection Grade	Adjuvant Treatment	Surgical Margin	Pathologic margin	Local Recurrence
1	50	Female	Liposarcoma	Benign spindle cell tumor	Myxoid liposarcoma	Low	No	Marginal	Negative	Yes
2	63	Female	Liposarcoma	Intramuscular myxoma	Myxoid liposarcoma	Low	Radiation	Marginal	Negative	No
3	38	Male	Liposarcoma	Intramuscular myxoma	Myxoid liposarcoma	Low	Radiation	Marginal	Negative	Yes
4	56	Female	Liposarcoma	Benign spindle cell tumor	Myxofibrosarcoma	Low	No	Wide	Negative	No
5	57	Female	Liposarcoma	Necrotic tissue	Myxofibrosarcoma	Low	No	Wide	Negative	No
6	59	Female	Soft tissue sarcoma	Benign spindle cell tumor	Fibro-myxoid sarcoma	Low	No	Wide	Negative	No
7	55	Male	Soft tissue sarcoma	Intramuscular myxoma	Extra-skeletal myxoid chondrosarcoma	Low	No	Wide	Negative	No
8	78	Male	Soft tissue sarcoma	Necrotic tissue	Fibro-myxoid sarcoma	High	No	Wide	Negative	No
9	28	Female	Synovial sarcoma	Haemorrhagic tissue	Myxofibrosarcoma	High	Radiation	Wide	Negative	Yes
10	62	Female	Soft tissue sarcoma	Haemorrhagic tissue	Myxofibrosarcoma	Low	No	Wide	Negative	No
11	75	Female	Fibromatosis	Necrotic tissue	Fibro-myxoid sarcoma	Low	No	Wide	Negative	No

CNB, core needle biopsy.

treated with wide excision. Therefore, only 3 misdiagnoses resulted in errors in definitive surgery, 2 of whom resulted in local recurrence. All 3 benign tumors misdiagnosed as STS underwent wide excision which potentially adds to the morbidity of surgery and loss of function. Careful interpretation of clinical and radiological findings is warranted to reduce the adverse consequences due to incorrect CNB.

In defining grade, the myxoid STS showed good sensitivity, specificity, PPV, and NPV. On the contrary, the low sensitivity (73.4%) and NPV (46.0%) in the non-myxoid STS warrants caution, as histologic grade is one of the key parameters in deciding the administration of adjuvant treatment or the surgical margin in STS [14]. Our finding of low NPV in non-myxoid group suggest that when CNB shows low grade in a non-myxoid STS, the possibility of false negative should be considered. The heterogeneity of non-myxoid STS, in which the mixed areas of high grade and low grade co-exist, may have contributed to this finding [15]. Imaging characteristics could be helpful in defining grade, such as the morphological heterogeneity on MRI [16]. Of note, synovial sarcoma was the most frequent subtype misdiagnosed high grade as low grade (34%, 11 of 33). Out of 157 non-myxoid STS where grade was reported, there were 34 misdiagnoses. Of the 34 under-graded non-myxoid STSs, 33 were resected with wide margin and 1 with marginal margin. Twenty-two patients received adjuvant radiation and 10 received adjuvant chemotherapy. Forty-seven percent of these patients developed LR compared with 27% (33 of 1230) of the correctly graded patients. Of the 5 under-graded myxoid STSs, all were resected with a wide margin with 4 patients receiving adjuvant radiation and 1 receiving adjuvant chemotherapy. One patient (20%) developed LR in these patients. These findings highlight the importance of grade assessment by CNB, especially for non-myxoid STS. Utilization of molecular signature such as CINSARC, a possible more robust prognosticator for the clinical outcome than FNCLCC grading system, would be helpful in CNB [17].

Identifying histologic subtype of an STS is becoming important as current treatment strategies for STS are increasingly adapted to a specific histological subtype [18,19]. Moreover, identification of histologic subtype is important for planning surgical margin, as local growth patterns of STS may differ according to the histologic subtype [20,21]. Infiltrative histologic growth pattern which necessitates wider surgical margin, has been well-documented in undifferentiated pleomorphic sarcoma and myxofibrosarcoma, which can be identified on MRI findings such as the tail-sign [22–25]. In this study, CNB identified histologic subtypes in only 63% of myxoid tumors compared with in 82% of non-myxoid tumors ($p = 0.013$). Improvement of CNB in identifying histologic subtypes in myxoid tumors seems necessary although the benefit of subtype-based chemotherapy for locally advanced STS has not yet been proven [18,26,27].

Imaging studies could be helpful in interpreting CNB results. Some studies have also shown that malignant tumors have increased vascularity at the periphery [28], which reflects the more aggressive peripheral growth pattern of high-grade tumors. Peritumoral fluid signal intensity is significantly more common in high-grade than in low-grade STS [16]. A myxoid tumor that demonstrates a tail sign and a fibrous signal on MRI is more likely to be myxofibrosarcoma than a myxoma or a neurogenic tumor. Thus, MRI could also help to distinguish benign from malignant myxoid tumors. The use of PET/CT to target metabolically active lesions may be helpful in estimating the grade of an STS [29]. The use of real-time ultrasound-MRI fusion or ultrasound- PET/CT fusion may help targeting the relevant areas of tumor, thus improving CNB performance for diagnosing malignancy and histological subtype [30,31].

Out of 20 patients who underwent repeat CNB in this study, 11 (55%) had a diagnostic yield. The diagnostic yield of a re-CNB was not different between myxoid tumors and non-myxoid tumors. Myxofibrosarcoma was the most common non-diagnostic tumor subtypes in myxoid tumors, whereas undifferentiated pleomorphic sarcoma and synovial sarcoma were the most common non-diagnostic tumor subtypes in non-myxoid tumors. Taken together, these findings suggest that re-CNB of myxoid tumors can be useful.

A few things should be considered while interpreting the results of this study. First, procedures of CNB and pathology specimen processing may not have been standardized as this study was performed over a relatively long period of time. However, the protocols for these procedures have remained largely unchanged over the study period at our institute. The overall diagnostic accuracies of 92%, 81% and 73% in assessing malignancy, histologic grade and histologic subtype, respectively, were similar to those of previous studies [3,32,33]. Second, this study included only the

patients who had the tumors resected, the results of this study may not represent the entire spectrum of CNB as the proportion of benign tumors was small. Moreover, most benign myxoid tumors are excised based on clinical and radiological findings without a preoperative biopsy. However, the percentage of higher grade tumors and histological types were similar to previous studies [1,3,32,33]. Third, as the patients were selected from our surgical database, non-tumorous conditions were excluded. Thus, the results of this study may not allow extrapolation to the entire patients undergoing CNB. Fourth, the grouping of myxoid tumors was based on postoperative resection pathology, which limits the usefulness of the grouping in the clinical setting. Fifth, the reasons for misdiagnoses with CNB could be multi-factorial, such as the number of samples, the experience of the pathologists or the radiologists, the degree of morphological heterogeneity of the tumor and size of the tumor. Indeed, tumor size was associated with the estimation of grade in non-myxoid STS, with larger tumors showing a better estimation of grade.

In conclusion, our study suggests that CNB is useful for myxoid soft tissue tumors of the extremity, with regard to diagnosing malignancy and histologic grade. However, CNB was less useful for identifying histologic subtype in myxoid tumors than in non-myxoid tumors. Careful consideration of clinical and radiological findings is warranted to reduce the adverse consequences due to incorrect CNB in myxoid soft tissue tumors.

Disclosures and funding sources

The authors declare that they have nothing to disclose.

Ethical review committee statement

The institutional review board of our institute approved this study.

This study was performed at

Department of Orthopaedic Surgery, Seoul National University Hospital, Seoul, Korea.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ejso.2019.05.001.

References

[1] Strauss DC, Qureshi YA, Hayes AJ, Thway K, Fisher C, Thomas JM. The role of core needle biopsy in the diagnosis of suspected soft tissue tumours,. J Surg Oncol 2010;102:523–9.
[2] Yang YJ, Damron TA. Comparison of needle core biopsy and fine-needle aspiration for diagnostic accuracy in musculoskeletal lesions. Arch Pathol Lab Med 2004;128:759–64.
[3] Heslin MJ, Lewis JJ, Woodruff JM, Brennan MF. Core needle biopsy for diagnosis of extremity soft tissue sarcoma. Ann Surg Oncol 1997;4:425–31.
[4] Welker JA, Henshaw RM, Jelinek J, Shmookler BM, Malawer MM. The percutaneous needle biopsy is safe and recommended in the diagnosis of musculoskeletal masses. Cancer 2000;89:2677–86.
[5] Rougraff BT, Aboulafia A, Biermann JS, Healey J. Biopsy of soft tissue masses: evidence-based medicine for the musculoskeletal tumor society. Clin Orthop Relat Res 2009;467:2783–91.
[6] Graadt van Roggen JF, Hogendoorn PC, Fletcher CD. Myxoid tumours of soft tissue. Histopathology 1999;35:291–312.
[7] Mackenzie DH. The myxoid tumors of somatic soft tissues. Am J Surg Pathol 1981;5:443–58.
[8] Ball AB, Fisher C, Pittam M, Watkins RM, Westbury G. Diagnosis of soft tissue tumours by Tru-Cut biopsy. Br J Surg 1990;77:756–8.
[9] 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.
[10] 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;78:644–9.
[11] Mitsuyoshi G, Naito N, Kawai A, Kunisada T, Yoshida A, Yanai H, et al. Accurate diagnosis of musculoskeletal lesions by core needle biopsy. J Surg Oncol 2006;94:21–7.
[12] Woon DT, Serpell JW. Preoperative core biopsy of soft tissue tumours facilitates their surgical management: a 10-year update. ANZ J Surg 2008;78:977–81.
[13] Mankin HJ, Mankin CJ, Simon MA. The hazards of the biopsy, revisited. Members of the Musculoskeletal Tumor Society. J Bone Joint Surg Am 1996;78:656–63.
[14] Bajpai J, Susan D. Adjuvant chemotherapy in soft tissue sarcomas Conflicts, consensus, and controversies. South Asian Journal of Cancer 2016;5:15–9.
[15] Peterson KK, Renfrew DL, Feddersen RM, Buckwalter JA, el-Khoury GY. Magnetic resonance imaging of myxoid containing tumors. Skeletal Radiol 1991;20:245–50.
[16] Zhao F, Ahlawat S, Farahani SJ, Weber KL, Montgomery EA, Carrino JA, et al. Can MR imaging be used to predict tumor grade in soft-tissue sarcoma? Radiology 2014;272:192–201.
[17] Chibon F, Lagarde P, Salas S, Perot G, Brouste V, Tirode F, et al. Validated prediction of clinical outcome in sarcomas and multiple types of cancer on the basis of a gene expression signature related to genome complexity. Nat Med 2010;16:781–7.
[18] D'Adamo D. Is adjuvant chemotherapy useful for soft-tissue sarcomas? Lancet Oncol 2012;13:968–70.
[19] Saponara M, Stacchiotti S, Casali PG, Gronchi A. (Neo)adjuvant treatment in localised soft tissue sarcoma: The unsolved affair. Eur J Cancer 2017;70:1–11.
[20] Cable MG, Randall RL. Extremity soft tissue sarcoma: Tailoring resection to histologic subtype. Surg Oncol Clin N Am 2016;25:677–95.
[21] Park JW, Kim HS, Lee C, Yoo HJ, Yun JY, Han I. Preoperative factors associated with infiltrative histologic growth patterns in extremity soft tissue Sarcoma. Sarcoma 2017;2017:5419394.
[22] Kaya M, Wada T, Nagoya S, Sasaki M, Matsumura T, Yamaguchi T, et al. MRI and histological evaluation of the infiltrative growth pattern of myxofibrosarcoma. Skeletal Radiol 2008:1085–90.
[23] Lefkowitz RA, Landa J, Hwang S, Zabor EC, Moskowitz CS, Agaram NP, et al. Myxofibrosarcoma: prevalence and diagnostic value of the "tail sign" on magnetic resonance imaging. Skeletal Radiol 2013;42:809–18.
[24] Waters B, Panicek DM, Lefkowitz RA, Antonescu CR, Healey JH, Athanasian EA, et al. Low-grade myxofibrosarcoma: CT and MRI patterns in recurrent disease. AJR Am J Roentgenol 2007;188:W193–8.
[25] Yoo HJ, Hong SH, Kang Y, Choi JY, Moon KC, Kim HS, et al. MR imaging of myxofibrosarcoma and undifferentiated sarcoma with emphasis on tail sign; diagnostic and prognostic value. Eur Radiol 2014;24:1749–57.
[26] Gronchi A, Ferrari S, Quagliuolo V, Broto JM, Pousa AL, Grignani G, et al. Histotype-tailored neoadjuvant chemotherapy versus standard chemotherapy in patients with high-risk soft-tissue sarcomas (ISG-STS 1001): an international, open-label, randomised, controlled, phase 3, multicentre trial. Lancet Oncol 2017;18:812–22.
[27] Casali PG, Abecassis N, Aro HT, Bauer S, Biagini R, Bielack S, et al. Soft tissue and visceral sarcomas: ESMO-EURACAN clinical practice guidelines for diagnosis, treatment and follow-up. Ann Oncol 2018;29. iv268-iv9.
[28] Ma LD, Frassica FJ, McCarthy EF, Bluemke DA, Zerhouni EA. Benign and malignant musculoskeletal masses: MR imaging differentiation with rim-to-center differential enhancement ratios. Radiology 1997;202:739–44.
[29] Klaeser B, Wiskirchen J, Wartenberg J, Weitzel T, Schmid RA, Mueller MD, et al. PET/CT-guided biopsies of metabolically active bone lesions: applications and clinical impact. Eur J Nucl Med Mol Imaging 2010;37:2027–36.
[30] Martins PH, Costa FM, Lopes F, Canella C. Advanced MR imaging and ultrasound fusion in musculoskeletal procedures. Magn Reson Imaging Clin N Am 2018;26:571–9.
[31] Paparo F, Piccazzo R, Cevasco L, Piccardo A, Pinna F, Belli F, et al. Advantages of percutaneous abdominal biopsy under PET-CT/ultrasound fusion imaging guidance: a pictorial essay. Abdom Imaging 2014;39:1102–13.
[32] Hoeber I, Spillane AJ, Fisher C, Thomas JM. Accuracy of biopsy techniques for limb and limb girdle soft tissue tumors. Ann Surg Oncol 2001;8:80–7.
[33] Kasraeian S, Allison DC, Ahlmann ER, Fedenko AN, Menendez LR. A comparison of fine-needle aspiration, core biopsy, and surgical biopsy in the diagnosis of extremity soft tissue masses. Clin Orthop Relat Res 2010;468:2992–3002.