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Ultrasound guided core needle biopsy of soft tissue tumors; a fool proof technique?

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Abstract:

Aim: To assess technical and lesion related factors affecting the quality of ultrasound guided core needle biopsy (CNB) of musculoskeletal soft tissue tumors. **Materials and methods:** Data of 223 CNBs were evaluated in a retrospective study. Diagnostic yield was calculated for all lesions on the basis of lesion location (extremity/torso), examiner, biopsy needle gauge/length and number of acquired samples. Diagnostic accuracy was calculated for surgical lesions (n= 113) based on final specimen histology. Chi-square test based Phi-coefficient calculations were performed to search for associations between each factor and diagnostic yield. **Results:** Overall diagnostic yield was 94.6%. There was no significant difference in diagnostic yield between specialist biopsies (96.8%) and resident biopsies (93.1%), between lesions located in the extremities (94.9%) and lesions in the torso (93.8%) and on the basis of needle gauge or number of acquired cores. Diagnostic accuracy was 100% for surgical lesions. The only factor influencing the quality of CNB was lesion composition (repeat biopsies in myxoid and/or inhomogeneous lesions). **Conclusion:** The most important aspects to achieve constant high quality results with ultrasound guided CNBs in the work-up of musculoskeletal soft tissue tumors are expertise concerning identification and targeting of viable tumor components and strict adherence to a quality controlled biopsy procedure. Once this is achieved, technical factors have almost no effect on the quality of CNB.

Keywords: ultrasound, biopsy, soft tissue neoplasms

Rezumat

Obiective: Evaluarea factorilor tehnici şi a celor legaţi de leziune care influenţează calitatea biopsiei ghidate ecografic în tumorile musculoscheletale. **Material şi metodă:** Datele a 223 biopsii ghidate ecografic au fost evaluate retrospective. Randamentul diagnostic a fost calculat pentru toate leziunile pe baza localizării acestora (extremităţi/trunchi), a examinatorului, a calibrului şi lungimii acului de puncţie şi a numărului de fragmente recoltate. Acurateţea diagnostică a fost calculată pentru leziunile chirurgicale (n=113) pe baza histologiei finale. Testul Chi-pătrat şi coeficientul Phi au fost calculate pentru căutarea asocierilor dintre factorii menţionaţi şi randamentul diagnostic. **Rezultate:** Randamentul diagnostic global a fost de 94,6%. Nu s-au găsit diferenţe semnificative ale randamentului diagnostic între biopsiile efectate de către specialişti (96,8%) şi rezidenţi (93,1%), între leziunile localizate la nivelul extremităţilor (94,9%) şi cele de la nivelul trunchiului (93,8%) şi nici legate de dimensiunile acului şi numărul de specimene recoltate. Acurateţea diagnostică a fost de 100% pentru leziunile chirurgicale. Singurul factor ce a influenţat calitatea biopsiilor ghidate ecografic a fost structura leziunilor (biopsii repetate în tumorile mixoide şi/sau inomogene). **Concluzii:** Cele mai importante aspecte pentru a obţine în mod constant rezultate bune la biopsiile ghidate ecografic a tumorilor musculoscheletale sunt legate de corecta identificare şi ţintirea componentelor tumorale viabile şi stricta aderenţă la calitatea procedurii bioptice. Odată ce acestea sunt atinse factorii tehnici au o influenţă nesemnificativă asupra calităţii biopsiei ghidate ecografic.

Cuvinte cheie: ecografie, biopsie, tumori musculoscheletale

Introduction

Imaging guided biopsy has achieved high clinical relevance in the work up of soft tissue tumors [1-3]. If a patient presents with a soft tissue mass and malignancy cannot be ruled out definitely by imaging, tissue sampling for histopathological diagnosis is generally recommended. The same is true for masses showing clear signs of malignancy, where histological characterization of the mass is considered mandatory before institution of treatment.

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For many years open surgical biopsy has been the first choice for obtaining adequate tissue samples. While at some institutions this is still considered the golden standard, percutaneous core needle biopsy (CNB) guided with ultrasound, computed tomography or even magnetic resonance imaging is widely used for sampling of tumor tissue. Compared with open biopsy these techniques have multiple advantages: they combine safety, lack of serious complications, high levels of accuracy and low cost [4-7]. Quite interestingly there are no published and generally accepted rules/recommendations/standards on the use of musculoskeletal tumor biopsies: when and how they should be done, which technique for guidance should be used, who should perform the biopsy, which material should preferentially be used, etc [8]. Some reports in the literature however address biopsy related factors influencing the quality of the procedure: in a study on 151 CNBs of bone and soft tissue tumors Wu et al found, that diagnostic yield is higher in lytic than in sclerotic bone lesions, in larger lesions and for longer specimens [9]. However, neither needle thickness nor image guidance modality (computed tomography versus ultrasound) influenced the diagnostic yield in their patient population. In a quest to arrive at an evidence based recommendation for biopsies Rougraff et al report, that available evidence suggests open biopsy still has the highest diagnostic accuracy over CNB [8]. Yang et al consider the need for an experienced musculoskeletal tumor team with frequent communication to correlate clinical, radiographic, and histological information, a key factor for appropriate use of biopsies in the work-up of musculoskeletal tumors [10].

From a practical point of view most of that seems comprehensible, but the methodology of the available studies is overtly different, which may be one reason, why the reported diagnostic yield and accuracy for guided CNB vary largely and range from 70% to well above 90% [4-6,11]. Several publications however agree, that one crucial factor affecting the quality of biopsy results is the type and distribution of viable and relevant tumor tissue within a mass [9-11].

Therefore we hypothesize, that targeting the correct tumor area – i.e. an area with high probability of viable and thus representative tumor tissue – is the single most important factor affecting the quality of a biopsy. We further believe that a well trained examiner, who carefully targets the tumor region with potentially viable tissue, can achieve a high level of diagnostic accuracy in biopsies.

Materials and Methods

Subjects:

Institutional review board approval for the current investigation was granted by means of a general waiver for investigations with retrospective analysis of data (Ethikkommission Innsbruck 274/19.02.2009). All data were handled according to the Austrian and European regulations concerning the protection of patient rights and sensible patient related data.

Between July 2007 and December 2010, 223 ultrasound guided CNBs of a musculoskeletal soft tissue tumor were performed in 209 patients (age 3–94 years, mean 55). Our institution is a major referral center for patients with musculoskeletal neoplasms and is staffed by an interdisciplinary sarcoma team.

Study data concerning biopsy procedures derived from a quality assurance database at the ultrasound department, with documentation of all interventional procedures. Standardized documented items include name of the examiner (ultrasound and histopathology), lesion location, a sonographic differential diagnosis, the type of material used, the number of acquired specimens, procedure related complications and the respective histopathology report. Additional data concerning pre-biopsy imaging, patient demographics and follow-up (surgical excision, definite histopathology report and clinical follow-up) derived from the in house electronic patient record.

Standardized biopsy procedure

Biopsies were either performed by one of two specialists for musculoskeletal ultrasound intervention with more than 5 years experience, or by residents in their second or third year of residency enrolled in specialized training in diagnostic and interventional ultrasound. All residents were trained by the two ultrasound specialists.

All ultrasound guided biopsies were performed on a Philips IU22 (Philips Ultrasound, Bothell, WA) according to a strictly enforced protocol, which includes:

- Review of pre-biopsy imaging studies.
- Initial gray scale ultrasound exam with assessment of lesion location, size, internal structure and the transitional zone towards surrounding inconspicuous tissue (fig 1). The choice of transducer was based on lesion size and depth (12-5 MHz or 9-5 MHz linear array broadband transducer).
- Color Doppler ultrasound for definition of tumor vascularity and regions with high probability of viable tumor tissue (fig 2).
- Planning of the optimal needle pass: for subcutaneous lesions this is generally straight forward; for deep lying lesions the referring orthopedic surgeon is consulted to plan the most adequate access route in anticipation of possible limb-sparing surgery or intra-compartmental resection. In resident biopsies the optimal access route was always planned in discussion with the ultrasound specialist on duty.

- Local anesthesia of skin and needle path with lidocaine: the needle is advanced under ultrasound control close to the tumor border to guarantee for sufficient anesthesia but without puncture of the tumor and without "blowing" anesthetic inside the lesion (fig 3).
- Choice of adequate biopsy material (diameter and length of true cut needle) according to size and depth of lesion (14G/9 cm, 14G/13 cm, 16G/16 cm or 16G/18 cm throwing needles). Again, for resident biopsies this choice was made together with the specialist on duty.
- Introduction of an introducer needle (Trueguide®, Bard Biopsy Systems, AZ, USA) through a single skin incision under constant ultrasound guidance. Subsequent sampling of at least 3-5 adequate tissue cores from representative tumor regions (avoidance of samples from cystic/necrotic areas) in coaxial technique with either a disposable (Monopty®, Bard Biopsy Systems, AZ, USA; maximum core length of 11 mm) or reusable (Magnum®, Bard Biopsy Systems, AZ, USA; maximum core length of 22 mm) spring loaded core biopsy system. Representative regions – regions with distinct soft tissue components and/or detectable tumor vasculature – were identified in the pre-biopsy exam (fig 4).
- Control scan after the procedure to document any postprocedural hematoma.
- While planning of resident biopsies was done together with the specialist on duty, residents performed the biopsy with the specialist on immediate call but without direct, continuous observation.

Histopathological diagnosis

Biopsy specimens were put in 4% formalin and standard histopathological work-up was performed. Specimens were classified as *diagnostic* or *non-diagnostic* by the reporting pathologist: "*Diagnostic"* included all cases in which sufficient material for a diagnosis of either a be-

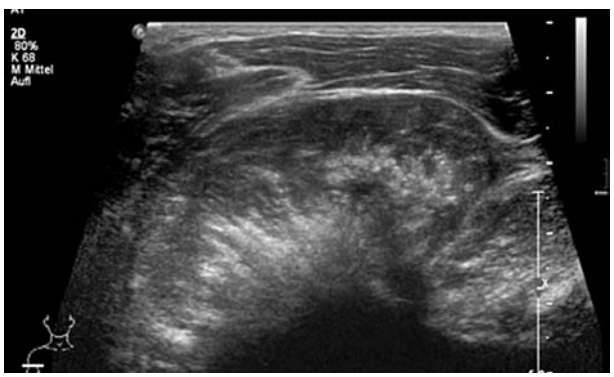

Fig 1. Gray-scale ultrasound of a 20-year old male patient with a histologically verified osteosarcoma of the proximal humeral shaft. Note the "sunburst-phenomenon" which is typical for osteosarcoma.

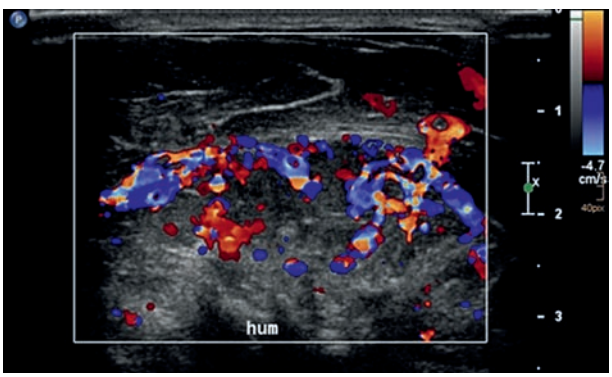

Fig 2. Color-Doppler ultrasound shows a highly vascularized lesion with inhomogeneous distribution of tumor vessels.

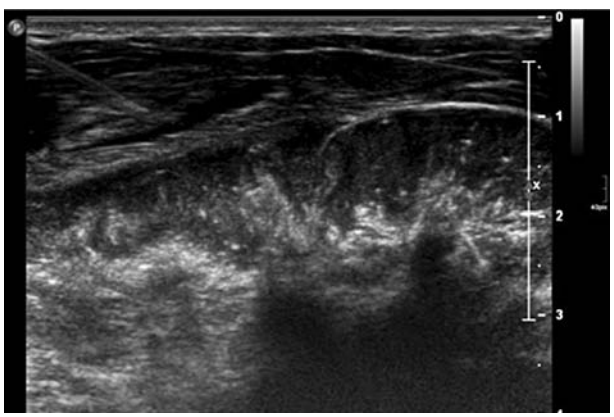

Fig 3. US-guided local anesthesia of the tumor-capsule.

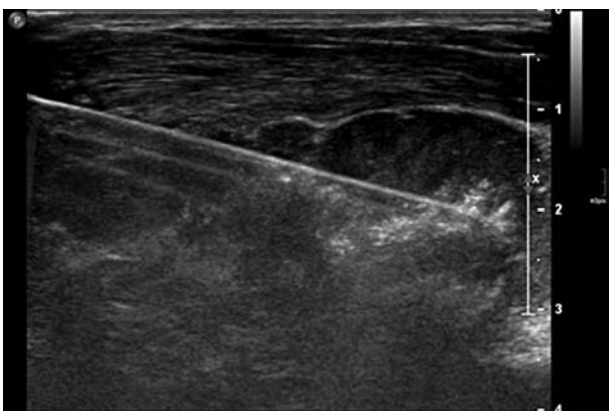

Fig 4. US-guided biopsy using a 14G/13cm coaxial core-needle system.

nign or malignant lesion was obtained. "*Non-diagnostic"* cases were all others, where the aforementioned differentiation was not possible based on the biopsy samples.

Statistical analysis

The diagnostic performance was assessed by determining *diagnostic yield* and *diagnostic accuracy*. *Diagnostic yield* was calculated as follows: number of diagnostic biopsies/all biopsies x 100%. The numerator denotes the cases with a definite judgment of either benign or malignant status, the denominator the number of all specimens submitted for histopathological diagnosis. In surgical cases (n = 117) *diagnostic accuracy* was determined by comparison of biopsy results with definite histopathology of resection specimens. Included in accuracy calculation were all diagnostic cases (biopsy histology and surgical specimen histology allowed for a definite attribution to either a benign or malignant lesion; n = 113). The non-diagnostic cases (n = 4) had to be excluded, as a definite attribution to either a benign or malignant lesion (either for the biopsy or surgical specimen) was impossible.

Contingency testing concerning statistical independence of cross tabulated categorical data – diagnostic yield versus tumor location (extremity or torso), examiner (specialist, resident), chosen material (needle type and diameter) and number/size of acquired specimens – was performed with a Chi-square test based Phi-coefficient calculation (alpha = 0.01). Diagnostic accuracy (sensitivity, specificity, PPV, NPV) was calculated for biopsy results versus final histopathology in patients undergoing surgery.

Results

Patients

A total of 223 ultrasound guided CNBs were performed in 209 patients (118 males, 91 females). The mean patient age was 55 years (range, 3 - 94 years). 11 patients underwent multiple biopsies; two patients were biopsied twice because of lesion recurrence after initial biopsy and treatment: one of these patients had recurrence of a desmoid tumor, one patient a second event of tophaceous gout. One patient with osteosarcoma and an initial diagnostic biopsy underwent a second biopsy two years later due to potential recurrence, but the histology was of an inflammatory pseudotumor.

One patient underwent repeat biopsy due to the clinicians' suspicion, that the initial histology of a haemangioma was false; haemangioma was confirmed in the second biopsy.

Seven patients underwent a second biopsy due to an inconclusive first biopsy. Two of these patients had a second inconclusive biopsy: histopathology of both initial and follow-up biopsies did not show any malignant cells. The pathologist found one potential hematoma and one potential lipoid lesion, but based on biopsy material a definite diagnosis could not be established. In both patients the interdisciplinary board decided against open biopsy or surgery, because of a low clinical evidence for malignancy. Patient follow-up was inconspicuous, without any evidence of tumor growth or malignant disease. In four patients with an inconclusive first biopsy, second biopsy revealed one lipoma, one myxoid schwannoma, one myxoid liposarcoma – which were confirmed by surgical resection and specimen histology – and one hematoma with resolution on clinical follow-up. One patient underwent a total of four biopsies of the same lesion during the course of several months. Data of all four biopsies were reviewed for study purposes: according to documented sonograms the lesion located in the gluteal area consisted mainly of cystic components with only sparse solid tissue. All biopsies were correctly targeted to the solid component, but nevertheless the histology was inconclusive. After two inconclusive biopsies the effectiveness of another biopsy was considered doubtful by the radiologist in charge, but the surgical oncologist advised to have a further guided biopsy performed before going to open biopsy or surgery. Finally the fourth biopsy revealed a potentially malignant myxoid lesion and the patient went to surgery. Final diagnosis – confirmed by specimen histology – was retiform haemangioendothelioma.

Biopsy related factors

159 lesions = 71% were located in the extremities, 64 lesions = 29% in the torso. 93 biopsies = 42% were performed by specialists, 130 biopsies = 58% by residents. 120 biopsies = 54.5% were performed with a disposable core biopsy system with a 14 G diameter needle and a needle length of 9 cm (compared to the 14 G 13 cm needle the disposable needle has the same thickness but yields a shorter core). 90 biopsies = 40% were performed with a reusable device with a 14 G diameter needle and 13 cm needle length. 12 biopsies = 5% were performed with a reusable device with a 16 G diameter needle and 16 cm needle length, and 1 biopsy = 0.5% with a 16 G diameter needle and 18 cm needle length.

Diagnostic Yield

The overall diagnostic yield was 94.6% (211 of 223). There was no significant difference in the diagnostic yield between specialist biopsies (96.8% [90 of 93]) and resident biopsies (93.1% [121 of 130]) (table I), between lesions located in the extremities (94.9% [151 of 159])

Table I. Diagnostic yield: examiner

	No. of diagnostic cases	Total No. of cases	Diagnostic Yield	χ^2 (at critical χ^2 = 5.41)	Φ -coefficient
All lesions	211	223	94.6%		
Examiner				1.45	0.08
Specialist	90	93	96.8%		
Resident	121	130	93.1%		

Table II. Diagnostic yield: lesion location

	No. of diagnostic cases	Total No. of cases	Diagnostic Yield	χ^2 (at critical χ^2 = 5.41)	Φ -coefficient
All lesions	211	223	94.6%		
Lesion location				0.13	0.02
Extremity	151	159	94.9%		
Torso	60	64	93.8%		

Table III Diagnostic yield: technical factors

	No. of diagnostic cases	Total No. of cases	Diagnostic Yield	χ^2 (at critical χ^2 = 5.41)	Φ -coefficient
All lesions	211	223	94.6%		
Needle Gauge					
9/14 vs. 13/14	114 vs. 85	120 vs. 90	95.1% vs. 94.4%	1.69	0.08
9/14 vs. 16/16	114 vs. 11	120 vs. 12	95.1% vs. 92.3%	0.24	0.04
9/14 vs. 18/16	114 vs. 1	120 vs. 1	95.1% vs. 100%	0.05	0.02
13/14 vs. 16/16	85 vs. 11	90 vs. 12	94.4% vs. 92,3%	0.14	0.03
13/14 vs. 18/16	85 vs. 1	90 vs. 1	94.4% vs. 100%	0.05	0.02
Number of cores taken					
3-5 vs. 5-10	114 vs. 89	121 vs. 94	94.3% vs. 94.7%	0.02	0.01
3-5 vs. >10	114 vs. 8	121 vs. 8	94.3% vs. 100%	0.48	0.06
5-10 vs. >10	89 vs. 8	94 vs. 8	94./% vs. 100%	0.44	0.06

and lesions in the torso (93.8% [60 of 64]) (table II), and on the basis of needle gauge or number of acquired cores. Diagnostic yield was 95.1% for biopsies with a 14G/9 cm needle (114 of 120), 94.4% for biopsies performed with a 14G/13 cm needle (85 of 90), 92.3% for biopsies performed with a 16G/16 cm needle (11 of 12) and 100% for biopsies performed with a 16G/18 cm needle (1 of 1). For biopsies with sampling of 3 to 5 cores diagnostic yield was 94.3% (11 of 121), with sampling of 5 to 10 cores 94.7% (89 of 94) and 100% with sampling of more than 10 cores (8 of 8) (table III). These differences have no statistical significance.

Diagnostic accuracy

According to the definition given above in the surgical group (n=113) 100% of CNBs were diagnostically accurate (57 benign biopsies with benign specimen histology and 56 malignant biopsies with malignant specimen histology), there were no false positive or false negative biopsies – however 4 biopsies had to be excluded from the evaluation, as a definite attribution to a benign or malignant variant could not be reached for biopsy histology. Sensitivity, specificity, PPV and NPV for CNB were 100%.

Discussion

Tissue sampling is an important step in the management of musculoskeletal soft tissue masses. At most sarcoma centers guided biopsy techniques are at present state of the art for tissue sampling with open surgical

biopsy reserved for special cases – i.e. further work-up after a previous inconclusive guided biopsy. The diagnostic value of a biopsy has been largely debated in the scientific community but a close look at our data and the available literature highlights the basic rationale behind such practice. MRI is the golden standard for pre-biopsy imaging in musculoskeletal soft tissue tumors. Even with state of the art technique however, MRI cannot reliably predict malignancy in a substantial percentage of cases. According to Daniel et al [14] the sensitivity of MRI in prediction of a malignant tumor is 95% at a specificity of 84%. Thus a substantial number of patients still receive an indeterminate MRI report and are therefore referred for biopsy. Biopsy – open or guided – is the only means to rule out malignancy with high specificity, given that it yields representative tissue samples.

The latter has been the scope of many scientific evaluations. If we generalize their results, we find that a variety of factors might potentially influence the quality of guided CNBs. Some of these are lesion related – tumor type, size, location – some are technical in nature – needle size and diameter, experience of the examiner, number and size of acquired tissue samples. The available literature partly supports the existence of such factors, but results are often contradictory due to differences in the methodology of the evaluations.

Based on our experience during years of work in a dedicated sarcoma team, we hypothesized that most of the reported influential factors do not exist – at least not for a dedicated quality controlled interventional ultrasound facility.

Technical factors, for example, did not show any influence at all on diagnostic yield or accuracy in our series of biopsies. The maximum specimen length, which may be acquired with the disposable 14G/9 cm biopsy system used in 54.5% of our CNBs is 11 mm. The 14G/13 cm reusable biopsy gun used in 40% of our CNBs results in a maximum specimen length of 22 mm at the same specimen thickness. Among these two devices there was no significant difference in diagnostic yield. There was no significant difference between the 14 Gauge and the 16 Gauge needles either. Generally speaking needle length and diameter did not show any influence on diagnostic yield in our series and the same was true in the study performed by Wu et al [9]. In everyday practice the choice of needle Gauge and length is thus only influenced by the location and size of the tumor: quite simply speaking we chose a longer needle (typically these are of smaller diameter i.e. 16G) for deep lying lesions, a needle with a maximum throw of 11 mm for smaller lesions, while a throw of 15 or 22 mm may be chosen for lesions larger than 3 cm in size. This decision is achieved with planning of the needle trajectory on pre-biopsy sonograms: after definition of the target area inside the tumor the distance from the skin to the target area is measured from a point on the skin surface, which lies inside the same anatomical compartment with the tumor (the latter is of utmost importance to allow for intra-compartmental resection in case of a malignant sarcoma)! The point for positioning of the coaxial needle close to the margin of the tumor target area is marked on screen and the distance from here to the posterior tumor border in the trajectory of the future needle pass is measured accordingly. The throw of the biopsy needle is then chosen according to the distance from the coaxial needle tip to the posterior tumor border, which by no means must be crossed.

In coaxial biopsy technique we may acquire more samples through a single incision/puncture without increasing the risk of complications such as bleeding or the risk of needle tract seeding. Therefore, some people opt for the sampling of multiple cores, believing that more samples should improve the diagnostic yield. Neither our results nor the data reported by Wu et al [9] as well as Fishman et al [15] support this. Based on published evidence and our own data acquiring 3 to 5 cores is sufficient, to achieve a high diagnostic yield. Sampling of more than 5 cores did not result in any significant improvement of diagnostic yield in our series, nor so in the studies cited above.

We do not know of any publications comparing the quality of biopsies done by specialists in interventional ultrasound with procedures performed by residents: while there is some agreement in the literature, that biopsies should be performed at dedicated centers with a specialized sarcoma team [9,12], no difference in diagnostic accuracy is reported for biopsies performed by interventional radiologists, clinical oncologists or other specialists. We might expect that specialists perform better than residents, but this is not supported by our data. With a small but not significant difference in the diagnostic yield for specialist (96.8%) and resident biopsies (93.1%), our results indicate, that a well trained and supervised radiology resident may reach an equal level of diagnostic yield compared with an interventional specialist. We do not know of any comparable results in the literature or experience of similar institutions, therefore this result has to be interpreted with caution. Most probably two key factors may explain this favorable result. First, both interventional specialists and residents follow the same proven standardized procedure when performing a biopsy. As mentioned above, this includes the type of pre-biopsy work-up, decision concerning how to place the biopsy, as well as how the procedure is technically executed. Second, all the residents were trained and in-

structed by the same specialists. During training, adherence to the biopsy protocol is strictly enforced. While we did not compare our results with a group of residents with different training, we still believe it permissible to draw the following conclusion: sufficient training and adherence to a well elaborated biopsy protocol are the single technical factors, which matter concerning the quality of real-time guided ultrasound CNBs.

Diagnostic yield in our series is not entirely comparable with the diagnostic yield reported in some other investigations. Some reports in the literature interpret diagnostic yield based on tumor histology i.e. the classification of tumor subtype. In contrast our approach in this evaluation was merely to look at the possibility of CNB to confirm or rule out malignancy (classification of tumor subtype was performed in all biopsies but not included for study purpose). Thus, diagnostic yield in our evaluation is based on the prediction of malignancy only! This conforms to the primary goal of the biopsy: the identification of malignant lesions and the triage of surgical candidates.

Various reports in the literature have addressed the problem of tumor subtype on the quality of CNB [3,4,8,10,16]. Ogilvie et al in a series of 120 percutaneous biopsies found low diagnostic usefulness for biopsies of myxoid lesions [3]. Sung et al found a low diagnostic yield and accuracy in heterogeneous tumors, such as angiosarcomas, liposarcomas, synovial sarcomas and haemangiomas [16]. Mitsuyoshi et al reported difficulties differentiating low-grade liposarcoma from benign lipoma [4]. The same is evident in our data. Among our inconclusive biopsies we found 1 myxoid Schwannoma, 1 myxoid liposarcoma, 2 hematomas, 2 lipomatous lesions and 1 haemangioendothelioma. The inherent problem with these tumor subtypes is their inhomogeneity with existence of myxoid and necrotic tissue areas. This results in an important question: is there any sense in performing biopsies in tumors with overtly myxoid features on pre-biopsy imaging studies, or should these lesions primarily go to open biopsy? Based on current evidence there is no definite answer to this question and open surgical biopsy may be an option but is less than perfect. If however such a lesion is biopsied at all, the importance of targeting tumor areas with potentially viable and thus representative tissue cannot be overstressed. At our institution we aim at the definition of viable tumor areas suited for biopsy by a standardized pre-biopsy ultrasound study, including Color-Doppler and spectral wave analysis. Newer technical developments, such as contrast enhanced ultrasound may further improve the process of biopsy targeting in overtly inhomogeneous lesions, as was recently reported by Loizides et al [17] and Sparchez et al [18].

There are limitations to our study: first it is retrospective in nature, but so are most of the studies on this topic. Second it is a single centre experience of a department dedicated to musculoskeletal intervention with some special features, which may definitely influence the results of CNB: both interventional specialists work at the facility for more than 5 years. Interventions are exclusively performed by one of them or by residents trained and instructed by one of them. They both adhere to the same procedural standards, institutionalized in close collaboration and they share the same dedication to constant quality control. So aside from the technical skill of the individual performing the biopsy, every other aspect of ultrasound guided CNB is highly standardized. While this may influence the results of the current investigation, it also stresses the importance of a dedicated team.

Conclusion

In this single center experience the most important aspects to achieve constant high quality results with ultrasound guided CNBs in the work-up of musculoskeletal soft tissue tumors are expertise concerning the interpretation of the tumor and strict adherence to a quality controlled biopsy procedure. Even then certain histological tumor subtypes pose a problem. First results of clinical trials with the application of microbubble contrast agents are promising in so far, that pre-biopsy identification of viable tumor tissue is improved. This may result in an even better diagnostic yield of up to 100% [17]. Once viable tumor tissue is identified, technical factors such as needle gauge/size, throw of the biopsy needle and number of specimens have only a limited effect on the quality of the procedure. In this regard we may not call ultrasound guided CNB fool-proof but exceptionally safe and reliable. As it closes the gap of uncertainty, which remains even with state of the art MR-imaging, ultrasound guided CNB must be generally recommended as a first line procedure for the work-up of unclear musculoskeletal soft tissue tumors.

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