Acta Orthop. Belg., 2018, **84**, 30-37

ORIGINAL STUDY

Comparison of fine needle aspiration and core needle biopsy in the diagnosis of bone tumours

Pedro Filipe CARDOSO, João ESTEVES, Vânia OLIVEIRA, Ricardo RODRIGUES-PINTO

From the Centro Hospitalar do Porto, Hospital de Santo António, Portugal

Much literature exists regarding the diagnostic yield and accuracy of core needle biopsy (CNB) and fine needle aspiration (FNA) but none compares both in the same tumour. Ninety-four patients were prospectively studied using a FNA and CNB. With FNA 70 diagnoses were possible (74,5%). Accurate diagnosis rate was 97,1%. In 92 patients (97,9%) a diagnosis was obtained with CNB and 91 (98,9%) were accurate.. The diagnostic yield was 74,5% for FNA and 97,9% for CNB (p < 0.0001). The diagnostic accuracy was 97,1% for FNA and 98,9% for CNB (p = 0.5787). Regarding determining malignancy FNA and CNB had 98,3% and 98,5% sensibility, 100% and 100% specificity, 100% and 100% positive predictive value and 95,2% and 96,2% negative predictive value, respectively. In conclusion FNA is as accurate as CNB on all accounts. Despite the reliability of FNA, the number of inconclusive cases makes it an inferior technique when compared with CNB.

Keywords : Bone neoplasms ; Diagnosis ; Biospy ; fine-needle ; core needle.

INTRODUCTION

With the exception of the "usually leave me alone lesions", biopsy is mandatory to diagnose bone tumours and related lesions. In this procedure the goal is to obtain the maximum representative sample causing a minimum morbidity and tumour spread.

Open biopsy is no longer the gold standard for the diagnosis of these lesions *(15)* and percutaneous biopsies – core needle biopsy (CNB) and fine needle aspiration (FNA) – have emerged as the primarily diagnostic modalities *(5,7,10,15)*.

Accuracy of FNA has been described to be at least 85% and to be even higher in discriminating between benign and malignant lesions (4). Söderlud and colleagues (14) have shown that FNA accuracy could reach 99% when radiographic findings aid the cytological interpretation (concordance). In fact, radiographic analysis of bone lesions gives valuable information about the tumour matrix and the reaction of surrounding host tissues. These elements are absent in soft tissue lesions.

Traditionally, CBN is favoured over FNA because its accuracy is higher (4,11) but mainly because insufficient FNA samples are a significant problem, ranging from 4% to 33% *(4)*.

This study is a prospective evaluation of 94 bone lesions in which FNA was performed followed by CNB in order to compare the accuracy, the scarcity of samples and the possibility to initiate the treatment with each method. To our knowledge no previous study has evaluated these 2 techniques in the same bone lesion.

■ Pedro Filipe Cardoso.
■ João Esteves.
■ Vânia Oliveira.
■ Ricardo Rodrigues-Pinto.
Centro Hospitalar do Porto - Hospital de Santo António
Correspondence: Pedro Filipe Cardoso,Centro Hospitalar do Porto, Hospital de Santo António.
E-mail : pffcardoso@gmail.com

No benefits or funds were received in support of this study.
The authors report no conflict of interests.

PATIENTS AND METHODS

Between January 2011 and January 2014 all patients with undiagnosed bone lesions were invited to participate in the study. Indications for biopsy were the presence of a bone lesion whose diagnosis was not obtainable by anamnesis, physical examination, laboratory and imaging studies; another group of patients were those with a history of malignancy elsewhere and in which a secondary bone lesion could not be excluded by the aforementioned methods – in this group of patients the objective was to exclude malignancy.

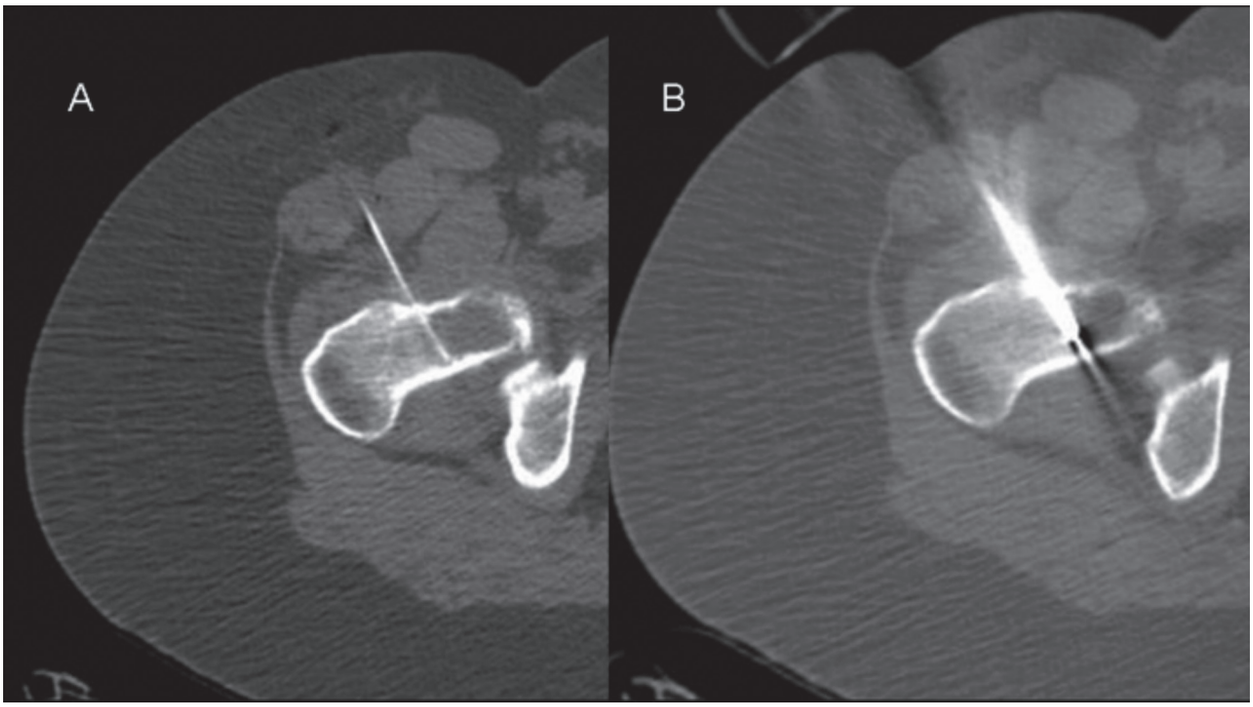
The average age of the patients was 53,5 years (12-86). There were 61 males and 33 females. All biopsies were performed under image guidance (64 with the use of CT-scan and 30 with radioscopy). Thirty lesions were localized to the lower limb, 15 to the upper limb, 23 to the spine, 22 to the pelvis and 4 to the trunk.

Patients were initially submitted to image-guided FNA. The most suitable route was chosen in order to avoid noble structures such as neurovascular bundles and organs. After the selection of the area, the whole path from the skin to the periosteum, was anesthetized with 3-5 ml of 2% Lidocaine. A 22-gauge needle was introduced and a cytoaspiration was performed (Fig. 1). Samples were kept in CytoRich®Red Preservative Fluid allowing further cytobiological studies. Immediately after the aspiration, within the same cutaneous region, an 8-gauge needle biopsy (ZamarCatchsystem®) was introduced 3-4 times in order to get a macroscopically sufficient sample which was immediately placed in a sterile flask containing formaldehyde.

In the majority of these cases a diagnosis of bone tumour was necessary to start treatment but in a few the exclusion of malignancy was also mandatory. All procedures were performed by the same orthopaedic surgeon and all samples were analysed by the same pathologist.

Results of both biopsy techniques were compared with final diagnoses which were established by surgical specimen (41 patients) or ulterior clinical and imaging evaluation (53 patients) since in some benign tumours, metastases and haematopoietic lesions no surgery is needed. With the exception

Fig. 1. – Percutaneous biopsy of a metastasis (breast). A – FNA; B- CNB



of metastases, the minimum follow up to confirm these diagnoses was 2,5 years. Exclusion of malignancy or infection, when clinically suspected, was included in the group of diagnosis.

The diagnostic yield (ratio between the number of diagnosis obtained and the number of all procedures) and accuracy (ratio between the confirmed diagnosis and the number of established diagnosis) were determined for both procedures and compared using the t test for proportion, set to a 95% confidence interval. The proportion of patients in which FNA and CNB were able to exclude malignancy, establish diagnosis and initiate treatment were calculated for both techniques and compared using the Chi-Square test. Specificity, sensibility, positive predictive value (PPV) and negative predictive value (NPV) of both techniques were analysed using MedCalc version® 15.11.4. The MedCalc software was used for statistical analysis and a p value < 0.05 was considered to represent a significant difference between both techniques.

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation and with the Helsinki Declaration of 1975, as revised in 2000.

RESULTS

There were no complications associated with the procedures and all patients were discharged on the same day, with the prescription of a simple analgesic.

Final diagnoses were: 29 metastases, 28 primitive malignant tumours, 13 benign tumours, 12 haematological diseases and 5 infections. In 7 cases pathology could be excluded. Results for all patients are summarised in table 1.

With FNA 70 diagnoses were possible (74,5%). Two of them were wrong - a spinal discitis was initially taken as a giant cell tumour and a low-grade chondrosarcoma of the scapula was assumed as an enchondroma (Table 1 – cases 9 and 32). Accurate diagnoses were then 97,1%. With this technique, 15 results (16%) were completely inconclusive but in 9 cases, although a diagnosis was not obtained, the pathologist could differentiate a benign lesion (n = 5) from a malignant one (n = 4) and this differentiation was correct in all cases. Excluding the inconclusive cases, and regarding determining malignancy, FNA had 98,3% sensibility, 100% specificity, 100% positive predictive value and 95,2% negative predictive value (Table 2).

In 92 patients (97,9%) a diagnosis was obtained with CNB. Of these, 91 (98,9%) were accurate. Only 1 benign lesion was misdiagnosed - a low-grade chondrosarcoma of the proximal femur was assumed as an osteochondroma (Table 1 – case 19). Regarding determining malignancy CNB had 98,5% sensibility, 100% specificity, 100% positive predictive value and 96,2% negative predictive value (Table 2).

The diagnostic yield was significantly lower ($p < .0001$) with FNA than with CNB. There was no statistical difference ($p=0.4046$) between the diagnostic accuracy when using both techniques nor there were differences in the sensitivity, sensibility, PPV and NPV (Table 2). Comparing the possibility of exclude malignancy FNA and CNB were statistically similar (Table 3). However, FNA was inferior to CNB establishing an accurate diagnosis and initiating a treatment (Table 3).

DISCUSSION

All cytological and histological results should always be interpreted integrating clinical and imaging information. Percutaneous biopsy also depends on the operator technique and on the experience of the pathologist *(15)* and this is especially important in FNA.

The percutaneous biopsy's first challenge is obtaining an appropriate sample, which means sufficient in quantity and representative of the lesion. This point is measured by yield, and values can vary between 69 and 97% for FNA *(5,7)* and up to 97% for CNB *(5,7)*.

There are two main reasons that help explaining the wide variation of rates in FNA: the type of lesion selected and the accomplishment of preliminary evaluation. Lesions with lower diagnostic yield by percutaneous biopsy are cysts, lesions with and surrounding cortex and lesions with a dense calcified matrix (5,10). In this study, from the

Table 1 – Demographic and pathologic information for 94 patientes with the FNA, CNB and final diagnosis. FNA – Fne Nedle Apiration. CNB – Core Needle Biopsy. B – benign. M – malignant. Y – match. N – nonmatch. ND – non diagnostic

Patient	Age	Gender	Location	FNA diagnosis	CNB diagnosis	FINAL diagnosis	MALIGNANCY		DIAGNOSIS		TREATMENT MANAGEMENT	
							FNA	CNB	FNA	CNB	FNA	CNB
1	46	Male	Tibia	Osteosarcoma	Osteosarcoma	Osteosarco	M	M	Y	Y	Y	Y
2	43	Male	Rib	Benign lesion	Enchondroma	Enchondroma	B	B	N	Y	Y	Y
3	17	Male	Iliac	Malignant lesion	Ewing Sarcoma	Ewing Sarcoma	M	M	N	Y	N	Y
4	14	Male	Iliac	Malignant lesion	Ewing Sarcoma	Ewing Sarcoma	M	M	N	Y	N	Y
5	46	Male	Sacrum	Metastasis	Metastasis	Metastasis	M	M	Y	Y	Y	Y
6	74	Female	Spine	Myeloma	Myeloma	Myeloma	M	M	Y	Y	Y	Y
7	16	Male	Sacrum	Benign lesion	Osteoid osteoma	Osteoid osteoma	B	B	N	Y	Y	Y
8	74	Female	Spine	Inconclusive	Infection	Infection	ND	B	ND	Y	N	Y
9	66	Male	Spine	Giant Cell Tumor	infection	Infection	B	B	N	Y	N	Y
10	30	Male	Isquiopubic ramus	Giant Cell Tumor	Giant Cell Tumor	Giant Cell Tumor	B	B	Y	Y	Y	Y
11	67	Female	Metacarpal	Chondrosarcoma	Chondrosarcoma	Chondrosarcoma	M	M	Y	Y	Y	Y
12	57	Male	Femur	Benign lesion	Chondromyxoid fibroma	Chondromyxoid fibroma	B	B	N	Y	Y	Y
13	28	Male	Femur	Chondrosarcoma	Chondrosarcoma	Chondrosarcoma	M	M	Y	Y	Y	Y
14	77	Female	Sternum	Myeloma	Myeloma	Myeloma	M	M	Y	Y	Y	Y
15	62	Male	Spine	Infection	Infection	Infection	B	B	Y	Y	Y	Y
16	66	Male	Spine	Exclusion tumour	Exclusion tumour	Exclusion tumour	B	B	Y	Y	Y	Y
17	86	Female	Tibia	Inconclusive	Chondrosarcoma	Chondrosarcoma	ND	M	ND	Y	N	Y
18	16	Male	Iliac	Inconclusive	Osteochondroma	Osteochondroma	ND	B	ND	Y	N	Y
19	19	Male	Femur	Inconclusive	Osteochondroma	Chondrosarcoma	ND	B	ND	N	N	N
20	17	Female	Femur	Chondrosarcoma	Chondrosarcoma	Chondrosarcoma	M	M	Y	Y	Y	Y
21	50	Female	Ulna	Inconclusive	Haemangioma	Haemangioma	ND	B	ND	Y	N	Y
22	66	Female	Spine	Myeloma	Myeloma	Myeloma	M	M	Y	Y	Y	Y
23	41	Male	Femur	Chondrosarcoma	Chondrosarcoma	Chondrosarcoma	M	M	Y	Y	Y	Y
24	79	Male	Spine	Inconclusive	Myeloma	Myeloma	ND	M	ND	Y	N	Y
25	78	Female	Sacrum	Chordoma	Chordoma	Chordoma	M	M	Y	Y	Y	Y

26	28	Male	Femur	Ewing Sarcoma	Ewing Sarcoma	Ewing Sarcoma	M	M	Y	Y	Y	Y
27	29	Male	Humerus	Metastasis	Metastasis	Metastasis	M	M	Y	Y	Y	Y
28	70	Male	Iliac	Metastasis	Metastasis	Metastasis	M	M	Y	Y	Y	Y
29	53	Male	Femur	Metastasis	Metastasis	Metastasis	M	M	Y	Y	Y	Y
30	61	Male	Sacrum	Chordoma	Chordoma	ChordomaM	M	M	Y	Y	Y	Y
31	67	Male	Iliac	Myeloma	Myeloma	Myelom	M	M	Y	Y	Y	Y
32	21	Female	Scapula	Enchondroma	Chondrosarcoma	Chondrosarcoma	B	M	N	Y	N	Y
33	28	Male	Acetabulum	Giant Cell Tumor	Giant Cell Tumor	Giant Cell Tumor	B	B	Y	Y	Y	Y
34	63	Male	Spine	Infection	Infection	Infection	B	B	Y	Y	Y	Y
35	62	Male	Spine	Metastasis	Metastasis	Metastasis	M	M	Y	Y	Y	Y
36	55	Male	Femur	Metastasis	Metastasis	Metastasis	M	M	Y	Y	Y	Y
37	77	Male	Humerus	Metastasis	Metastasis	Metastasis	M	M	Y	Y	Y	Y
38	37	Female	Spine	Metastasis	Metastasis	Metastasis	M	M	Y	Y	Y	Y
39	22	Male	Femur	Osteosarcoma	Osteosarcoma	Osteosarcoma	M	M	Y	Y	Y	Y
40	72	Male	Sacrum	Chordoma	Chordoma	Chordoma	M	M	Y	Y	Y	Y
41	49	Male	Femur	Benign lesion	Aneurysmal bone Cyst	Aneurysmal bone Cyst	B	B	N	Y	Y	Y
42	59	Male	Humerus	Metastasis	Metastasis	Metastasis	M	M	Y	Y	Y	Y
43	34	Male	Tibia	Brown tumour	Brown tumour	Brown tumour	B	B	Y	Y	Y	Y
44	12	Male	Tibia	Exclusion tumour	Exclusion tumour	Exclusion tumour	B	B	Y	Y	Y	Y
45	19	Female	Femur	Osteosarcoma	Osteosarcoma	Osteosarcoma	M	M	Y	Y	Y	Y
46	76	Male	Spine	Exclusion tumour	Exclusion tumour	Exclusion tumour	B	B	Y	Y	Y	Y
47	70	Male	Spine	Angiosarcoma	Angiosarcoma	Angiosarcoma	M	M	Y	Y	Y	Y
48	70	Male	Spine	Exclusion tumour	Exclusion tumour	Exclusion tumour	B	B	Y	Y	Y	Y
49	14	Female	Tibia	Benign lesion	Non ossifying fi-broma	Non ossifying fibroma	B	B	N	Y	Y	Y
50	54	Male	Tibia	Metastasis	Metastasis	Metastasis	M	M	Y	Y	Y	Y
51	67	Male	Femur	Metastasis	Metastasis	Metastasis	M	M	Y	Y	Y	Y
52	24	Male	Humerus	Inconclusive	Osteosarcoma	Osteosarcoma	ND	M	ND	Y	N	Y
53	85	Female	Femur	Chondrosarcoma	Chondrosarcoma	Chondrosarcoma	M	M	Y	Y	Y	Y
54	55	Male	Pubis	Metastasis	Metastasis	Metastasis	M	M	Y	Y	Y	Y
55	39	Female	iliac	Metastasis	Metastasis	Metastasis	M	M	Y	Y	Y	Y
56	21	Female	Femur	Giant Cell Tumor	Giant Cell Tumor	Giant Cell Tumo	B	B	Y	Y	Y	Y
57	39	Female	Iliac	Metastasis	Metastasis	Metastasis	M	M	Y	Y	Y	Y
58	17	Female	Femur	Osteosarcoma	Osteosarcoma	Osteosarcoma	M	M	Y	Y	Y	Y
59	78	Male	Humerus	Myeloma	Myeloma	Myeloma	M	M	Y	Y	Y	Y

60	76	Male	Spine	Inconclusive	Infection	Infection	ND	B	ND	Y	N	Y
61	73	Female	Femur	Inconclusive	Lymphoma	Lymphoma	ND	M	ND	Y	N	Y
62	77	Female	Humerus	Metastasis	Metastasis	Metastasis	M	M	Y	Y	Y	Y
63	61	Male	Femur	Metastasis	Metastasis	Metastasis	M	M	Y	Y	Y	Y
64	60	Male	Acetabulum	Metastasis	Metastasis	Metastasis	M	M	Y	Y	Y	Y
65	69	Male	Spine	Myeloma	Myeloma	Myeloma	M	M	Y	Y	Y	Y
66	68	Female	Femur	Chondrosarcoma	Chondrosarcoma		M	M	Y	Y	Y	Y
67	74	Female	Humerus	Metastasis	Metastasis	Metastasis	M	M	Y	Y	Y	Y
68	70	Female	Iliac	Metastasis	Metastasis	Metastasis	M	M	Y	Y	Y	Y
69	70	Female	Iliac	Exclusion tumour	Exclusion tumour	Exclusion tumour	B	B	Y	Y	Y	Y
70	85	Male	Iliac	Metastasis	Metastasis	Metastasis	M	M	Y	Y	Y	Y
71	64	Male	Iliac	Myeloma	Myeloma	Myeloma	M	M	Y	Y	Y	Y
72	59	Female	Iliac	Metastasis	Metastasis	Metastasis	M	M	Y	Y	Y	Y
73	78	Female	Tibia	Metastasis	Metastasis	Metastasis	M	M	Y	Y	Y	Y
74	76	Female	Humerus	Metastasis	Metastasis	Metastasis	M	M	Y	Y	Y	Y
75	60	Male	Metacarpal	Metastasis	Metastasis	Metastasis	M	M	Y	Y	Y	Y
76	53	Male	Sacrum	Inconclusive	Enchondroma	Enchondroma	ND	B	ND	Y	N	Y
77	53	Male	Sacrum	Lymphoma	Lymphoma	Lymphoma	M	M	Y	Y	Y	Y
78	59	Female	Rib	Metastasis	Metastasis	Metastasis	M	M	Y	Y	Y	Y
79	83	Male	Iliac	Myeloma	Myeloma	Myeloma	M	M	Y	Y	Y	Y
80	53	Female	Spine	Inconclusive	Metastasis	Metastasis	ND	M	ND	Y	N	Y
81	38	Male	Tibia	Giant Cell Tumor	Giant Cell Tumor	Giant Cell Tumor	B	B	Y	Y	Y	Y
82	56	Male	Femur	Exclusion tumour	Exclusion tumour	Exclusion tumour	B	B	Y	Y	Y	Y
83	56	Male	Femur	Exclusion tumour	Exclusion tumour	Exclusion tumour	B	B	Y	Y	Y	Y
84	81	Male	Sternum	Myeloma	Myeloma	Myeloma	M	M	Y	Y	Y	Y
85	22	Male	Scapula	Ewing sarcoma	Ewing sarcoma	Ewing sarcoma	M	M	Y	Y	Y	Y
86	80	Female	Femur	Inconclusive	chondrosarcoma	Chondrosarcoma	ND	M	ND	N	N	Y
87	76	Male	Humerus	Metastasis	Metastasis	Metastasis	M	M	Y	Y	Y	Y
88	24	Male	Humerus	Chondrosarcoma	Chondrosarcoma	Chondrosarcoma	M	M	Y	Y	Y	Y
89	67	Female	Iliac	Inconclusive	Inconclusive	Osteosarcoma	ND	ND	ND	N	N	N
90	67	Female	Iliac	Malignant lesion	Osteosarcoma	Osteosarcoma	M	M	N	Y	N	Y
91	78	Male	Iliac	Metastasis	Metastasis	Metastasis	M	M	Y	Y	Y	Y
92	20	Male	Femur	Inconclusive	Inconclusive	Ewing sarcoma	ND	ND	ND	N	N	N
93	20	Male	Femur	Malignant lesion	Ewing Sarcoma	Ewing Sarcoma	M	M	N	Y	N	Y
94	66	Male	Iliac	Inconclusive	Metastasis	Metastasis	ND	M	ND	Y	N	Y

Table II – Accuracy of Fine Needle Aspiration (FNA) and Core Needle Biopsy (CNB) regarding determining malignancy in comparison to the final diagnosis. P values indicate de differences of both biopsy techniques.

	Fine Needle Aspiration	Core Needle Biopsy	p value
Diagnostic yield	70/94 (74.5%)	92/94 (97.9%)	<0.0001
Diagnostic accuracy	68/70 (97.1%)	91/92 (98.9%)	0.4046
Specificity	100.0%	100.0%	1.0
Sensibility	98.31%	98.51%	0.9288
Positive predictive value	100.0%	100.0%	1.0
Negative predictive value	95.24%	96.15%	0.8792

24 non-diagnostic FNA it was possible to find at least 18 lesions with these characteristics. The preliminary evaluation comes from the observation of the sample by the pathologist during the procedure, allowing its repetition if necessary, with substantially improved results when compared to studies where this evaluation is not performed *(5,10)*. In this study, the quantity and quality of the sample was decided by the executant alone without the presence of the pathologist. It is possible that this is one of the reasons for the poor diagnostic yield (74,5%) of FNA.

All the cases of non-diagnostic results were due to technical issues with samples such as tissue scarcity, acellularity or an artifactually distorted specimen.

Table III – Comparison of FNA and CNB excluding malignancy, establishing diagnosis and initiating treatment.

	Fine Needle Aspiration	Core Needle Biopsy	p value
Excluding malignancy	78/79 (98.7%)	91/92 (98.9%)	0.9047
Establishing diagnosis	68/79 (86.1%)	91/92 (98.9%)	0.0011
Initiating treatment	73/94 (77.7%)	91/94 (96.8%)	0.0001

The accuracy of a diagnostic technique is the most important parameter in its assessment, and obtaining an exact result is its main objective. In different studies, the diagnostic accuracy of FNA varies between 67% and 99%, where the lowest values are obtained in smaller samples *(4,6,11)*. If it were only considered studies with high samples (n > 300) this value would be greater than 95% *(1,7,10,12,13)*. Here, the accuracy of FNA was equivalent to that of CNB on all accounts and close the highest published rates *(3,6,11,12)*, showing the reliability of this technique in diagnosing benign tumours, sarcomas, metastases, infections, haematologic disease lesions and in excluding pathology.

In many cases of musculoskeletal tumours, the specific diagnosis has a minor role in the initiation of treatment. The histological grade, staging and anatomical location are the most important factors for therapeutic decisions and it may even be said that the existing protocols are less based on the histological subtype. Some authors go further, referring to the minor importance of histological subtype and highlighting the relevance of the distinction between sarcoma and metastasis, since the treatment of most sarcomas in adults is primarily based on its size, location and proximity to vital structures *(2)*. Kilpatrick and colleagues *(9)* considered FNA sufficient to initiate treatment in 87% of bone tumours. In a study conducted in 2010, concerning soft tissue masses of extremities, definitive treatment could be initiated based solely

on FNA in 81.3% of benign, in 78% of malignant and in 43% of indeterminate tumours *(13)*. Assuming the same criteria, the technique in the present study would therefore allow for the initiation of treatment in all 68 patients with a diagnosis proven correct and in the other 5 in which malignancy had been excluded. This would represent 73 of the 94 (77,7%). In other words, although statistically inferior to CNB due to the inconclusive results, if these are results were excluded, FNA would be a reliable technique and would enable the treatment.

Finally, caution should be taken in malignancies since the initial treatment is different according to each diagnosis. The utility of cytogenetics in the routine work-up of sarcomas collected by FNA has been reinforced *(8)*. Nevertheless this was not done in this study.

In conclusion, FNA is reliable and enables the initiation of treatment every time it establishes a diagnosis or excludes malignancy. The number of inconclusive cases, the real problem with this technique, can potentially be decreased by a better selection of the lesions to be analysed by this technique and by the preliminary evaluation by a pathologist. Until then, CNB remains the preferable method for bone tumours diagnosis.

REFERENCES

1. Bommer, K.K., I. Ramzy, and D. Mody, Fine-needle aspiration biopsy in the diagnosis and management of bone lesions: a study of 450 cases. *Cancer*, 1997. 81: 148-56.
2. Domanski, H.A., Fine-needle aspiration cytology of soft tissue lesions: diagnostic challenges. *Diagn Cytopathol*, 2007. 35: 768-73.
3. Domanski, H.A., et al., Core-needle biopsy performed by the cytopathologist: a technique to complement fine-needle aspiration of soft tissue and bone lesions. *Cancer*, 2005. 105: 229-39.
4. Hirachand, S., et al., Fine needle aspiration (FNA) of soft tissue tumours (STT). *Kathmandu Univ Med J (KUMJ)*, 2007. 5: 374-7.
5. Jorda, M., et al., Fine-needle aspiration cytology of bone: accuracy and pitfalls of cytodiagnosis. *Cancer*, 2000. 90: 47-54.
6. Kasraeian, S., et al., 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.
7. Khalbuss, W.E., L.A. Teot, and S.E. Monaco, Diagnostic accuracy and limitations of fine-needle aspiration cytology of bone and soft tissue lesions: a review of 1114 cases with cytological-histological correlation. *Cancer Cytopathol*, 2010. 118: 24-32.
8. Kilpatrick, S.E., et al., The usefulness of cytogenetic analysis in fine needle aspirates for the histologic subtyping of sarcomas. *Mod Pathol*, 2006. 19: 815-9.
9. Kilpatrick, S.E., et al., 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*, 2001. 115: 59-68.
10. Kreicbergs, A., et al., Cytological diagnosis of bone tumours. J Bone Joint Surg Br, 1996. 78: 258-63.
11. Maitra, A., et al., The role of fine-needle aspiration biopsy in the primary diagnosis of mesenchymal lesions: a community hospital-based experience. *Cancer*, 2000. 90: 178-85.
12. Nagira, K., et al., Reliability of fine-needle aspiration biopsy in the initial diagnosis of soft-tissue lesions. *Diagn Cytopathol*, 2002. 27: 354-61.
13. Ng, V.Y., et al., Fine needle aspiration for clinical triage of extremity soft tissue masses. *Clin Orthop Relat Res*, 2010. 468: 1120-8.
14. Soderlund, V., Combined radiology and cytology in the diagnosis of bone lesions--a review of 399 cases. *Acta Orthop Scand Suppl*, 2004. 75: 51-6.
15. Yang, Y.J. and T.A. Damron, Comparison of needle core biopsy and fine-needle aspiration for diagnostic accuracy in musculoskeletal lesions. *Arch Pathol Lab Med*, 2004. 128: 759-64.