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ORIGINAL ARTICLE

Observational Study

Role of macroscopic on-site evaluation of endoscopic ultrasound-guided fine-needle aspiration/biopsy: Results of a multicentric prospective study

Hussein H Okasha, Hiwa A Hussein, Khaled M Ragab, Omar Abdallah, Fedoua Rouibaa, Borahma Mohamed, Fahd Ghalim, Mahmoud Farouk, Mohamed Lasheen, Mohamed A Elbasiony, Ahmed E Alzamzamy, Ahmed El Deeb, Hassan Atalla, Mahmoud El-Ansary, Sahar Mohamed, Moaz Elshair, Wafaa Khannoussi, Mohamed Z Abu-Amer, Amine Elmekkaoui, Mohammed S Naguib, Adil Ait Errami, Ahmed El-Meligui, Ahmed H El-Habashi, Mahmoud G Ameen, Dalia Abdelfatah, Mona Kaddah, Hanane Delsa

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Abstract

BACKGROUND

The concept of macroscopic on-site evaluation (MOSE) was introduced in 2015 when the endoscopist observed better diagnostic yield when the macroscopically visible core on MOSE was superior to 4 mm. Recent studies suggest that MOSE by the endoscopist may be an excellent alternative to rapid on-site evaluation, and some classifications have been published. Few studies have assessed the adequacy of histologic cores in MOSE during endoscopic ultrasound-guided fine-needle aspiration/biopsy (EUS-FNA/FNB).

AIM

To evaluate the performance of MOSE during EUS-FNA/FNB.

METHODS

This multicentric prospective study was conducted in 16 centers in 3 countries (Egypt, Iraq, and Morocco) and included 1108 patients with pancreatic, biliary, or gastrointestinal pathology who were referred for EUS examination. We prospectively analyzed the MOSE in 1008 patients with available histopathological reports according to 2 classifications to determine the adequacy of the histological core samples. Data management and analysis were performed using a Statistical Package for Social Sciences (SPSS) version 27.

RESULTS

A total of 1074 solid lesions were biopsied in 1008 patients with available cytopathological reports. Mean age was 59 years, and 509 patients (50.5%) were male. The mean lesion size was 38 mm. The most frequently utilized needles were FNB-Franseen (74.5%) and 22 G (93.4%), with a median of 2 passes. According to 2 classifications, 618 non-bloody cores (61.3%) and 964 good samples (95.6%) were adequate for histological evaluation. The overall diagnostic yield of cytopathology was 95.5%. The cytological examination confirmed the diagnosis of malignancy in 861 patients (85.4%), while 45 samples (4.5%) were inconclusive. Post-procedural adverse events occurred in 33 patients (3.3%). Statistical analysis showed a difference between needle types ($P = 0.035$) with a high sensitivity of FNB (97%). The analysis of the relationship between the MOSE-score and the final diagnosis showed a significant difference between the different scores of the MOSE ($P < 0.001$).

CONCLUSION

MOSE is a simple method that allows endoscopists to increase needle passes to improve sample quality. There is significantly higher FNB sensitivity and cytopathology diagnostic yield with good MOSE cores.

Key Words: Macroscopic on-site evaluation; Fine-needle aspiration; Fine-needle biopsy; Endoscopic ultrasound; Specimen

adequacy

Core Tip: This work is a multicentric international prospective study of 1108 patients to evaluate macroscopic on-site evaluation (MOSE) performance in endoscopic ultrasound-guided fine-needle aspiration/biopsy for diagnostic accuracy. MOSE is a simple procedure that allows the endoscopist to increase the number of needle passes to improve sample quality. The current study confirmed the relationship between good cores by MOSE scoring and a high diagnostic yield in cytopathology and showed a higher sensitivity of fine-needle biopsy (97%).

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INTRODUCTION

Endoscopic ultrasound-guided fine needle aspiration/biopsy (EUS-FNA/FNB) are highly accurate for pathological diagnosis. To increase their diagnostic yield, macroscopic on-site evaluation (MOSE), performed by an endoscopist, was described in 2015 as an alternative to rapid on-site evaluation (ROSE)[1-3]. The MOSE of the biopsy involves a direct assessment of the adequacy of the sample through visual inspection of the core tissue obtained during the puncture. The endoscopist observed a better diagnostic yield when the macroscopically visible core (MVC) on MOSE was greater than 4 mm[3,4]. Various classifications have been published based on the appearance of a MVC in histological specimens[5,6].

Only a few studies have evaluated the adequacy of histology cores in MOSE during EUS-FNA/FNB. However, without robust data, MOSE has not been broadly adopted as a standard technique[4]. Although evidence supports the utility of MOSE, diagnostic yield varies with needle type and number of passes. This prospective multicentre study aimed to evaluate the performance of MOSE using multiple EUS-FNA/FNB needles (19 G, 20 G, and 22 G) and the feasibility of using 2 classifications to determine histological core adequacy.

MATERIALS AND METHODS

Study design

This study was conducted at 16 centers in 3 countries (Egypt, Iraq, and Morocco). Ethical approval for the study was obtained from the Research Ethics Committee of the University of Cairo (protocol number: MD-319-2022). All patients provided written informed consent.

Patients

This prospective multicentric study included 1108 patients with pancreatic, biliary, or gastrointestinal pathology who were referred for EUS examination and underwent EUSFNA/FNB. Patient demographics, EUS findings, lesion characteristics, FNA and FNB methods, MOSE classification, and histological results were collected and analyzed. Patients with unknown cytopathology data were excluded from the present study.

Procedure technique

All procedures were performed under anesthesia (deep sedation) using the linear array echoendoscope by an experienced operator in each center. The needle types used for EUS-FNB were Franseen (Acquire, Boston Scientific Corporation, Natick, MA, United States), Microtech (Nanjing, China), Procore (Cook Medical, Winston-Salem, NC, United States), and Medtronic (Medtronic, Minneapolis, MN, United States). In contrast, for EUS-FNA, the needles used were Expect (Boston Scientific Corporation, Natick, MA, United States) and Echotip (Cook Medical, Winston-Salem, NC, United States). The needle sizes used in the procedures were 22 G, 20 G, and 19 G. If insufficient material was obtained, many passes were made. After each pass, the sample was immediately analyzed by the endosonographer to classify the MOSE. The adequacy of the histological core samples was determined using two classifications. For each patient, the highest MOSE score was considered.

MOSE-1 classification: After each puncture, the material was carefully examined for visible cores. A whitish tissue with apparent bulk was defined as a visible core. Macroscopic evaluation of the core samples was categorized as follows[7]:

Score 1: Definitely visible tissue core with scanty blood clots. Score 2: Visible tissue core with moderate blood clots. Score 3: Scanty tissue core with mainly blood clots. Score 1 was considered to be the most optimal sample on MOSE.

MOSE-2 classification: Furthermore, in the current study, the sample was classified based on the size of the yellowish-white core, as shown in Table 1, using the MOSE classification proposed by Gaia *et al*[5] in 2022.

Table 1 Macroscopic on-site evaluation - 2 classification[5]

Score	Aspects of the core	Classification of the biopsy
0	No material	Negative
1	Haematic or necrotic material	Acceptable
2	≥ 1 core tissue with ≤ 2 mm yellowish-white	Positive
3	≥ 1 core tissue with > 2 mm yellowish-white	Positive

Histological analysis
After inspection of the core by the operator, all specimens were fixed in 10% formalin solution or 95% absolute alcohol for cytological analysis. An experienced gastrointestinal and pancreaticobiliary pathologist evaluated the specimens.

Measured outcomes
In the current study, the primary outcome was diagnostic accuracy using MOSE. Sensitivity, specificity, and diagnostic accuracy were calculated to determine the efficacy of EUS-FNA/FNB in diagnosing tumors. The number of passes, needle type and size, and procedural adverse events were assessed. Sample histopathology was categorized as benign, malignant, or inconclusive. Inconclusive samples were defined as hypocellular or acellular smears, which are insufficient to diagnose a malignant or benign disease. MOSE efficacy was determined by calculating the accuracy of MOSE classifications 1 and 2 in obtaining the conclusive sample.

Statistical analysis
Data management and analysis were performed using Statistical Package for Social Sciences (SPSS) version 27. Numerical data were summarized using means and standard deviations. Categorical data were summarized as numbers and percentages. Estimates of the frequency were performed using the numbers and percentages. Numerical data were explored for normality using the Kolmogrov-Smirnov and Shapiro-Wilk tests. The χ^2 or Fisher's tests were used to compare the independent groups for categorical data, as appropriate. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy of the MOSE technique were calculated using a 2 × 2 table against the gold standard method (pathology). All tests were two-tailed; a probability (P value) ≤ 0.05 was considered significant.

RESULTS

Patients
Over 1108 patients were screened for eligibility, 1008 patients were finally included, and 100 patients with unavailable cytopathology results were excluded from the study. This multicenter study was conducted in three countries, including 1008 patients: Six hundred thirty-three from Egypt (62.8%), 200 from Iraq (19.8%), and 175 from Morocco (17.4%). The mean age was 59 ± 12 years, with 509 (50.5%) males. The baseline characteristics of enrolled patients are reported in Table 2. A total of 1074 solid lesions underwent biopsy, comprising 664 pancreatic (62%) and 410 extrapancreatic (38%) lesions. The mean lesion size was 38 ± 17 mm.

FNB was the predominant procedure, performed in 907 patients (90%), whereas only 101 patients (10%) underwent FNA. The most common needles used were "Acquire" from Boston Scientific in 751 patients (74.5%) for EUS-FNB and "Expect" from Boston Scientific in 68 patients (6.7%) for EUS-FNA. Needle sizes used during the procedures were 22 G (93.4%), 20 G (3.8%), and 19 G (2.9%), with a median number of needle passes of 2 (1-4 passes).

Outcomes and diagnostic accuracy
According to MOSE classification 1 (Figure 1), the endosonographer classified 618 non-bloody cores (61.3%), and according to MOSE classification 2 (Figure 2), 964 good specimens of scores 2 and 3 (95.6%) were adequate for histological evaluation. The detailed description of MOSE 1 and MOSE 2 classifications is illustrated in Table 3. A statistically significant correlation existed between MOSE classifications and needle type, number of needle passes, and tissue sampling techniques (Table 4). The 22 G needle demonstrated statistical superiority in generating good cores when classified according to MOSE-1. There was a statistically significant difference of 97.3% for both techniques (capillary and suction) compared to 93.4% for suction alone in the MOSE-2 classification. Out of the 1008 samples examined by

Table 2 Baseline characteristics of patients who underwent macroscopic on-site evaluation after endoscopic ultrasound-guided fine-needle aspiration or biopsy

Characteristics	
Age (years), mean ± SD	59 ± 12
Sex, *n* (%)	
Female	499 (49.5)
Male	509 (50.5)
Lesion location, *n* (%)	
Pancreas	664 (62)
Stomach	101 (9.4)
Lymph nodes	96 (8.9)
Liver	46 (4.2)
Mediastinum	38 (3.5)
Other	129 (12)
Total	1074 (100)
The mean size of the target lesion on EUS (mm), mean ± SD	38 ± 17
Approach, *n* (%)	
Transduodenal	585 (58)
Transgastric	350 (34.7)
Transesophageal	62 (6.2)
Transrectal	11 (1.1)
Type of the needle (FNA or FNB), *n* (%)	
FNA	101 (10)
FNA-Expect-Boston	68 (6.7)
FNA-EchoTip-Cook	33 (3.3)
FNB	907 (90)
FNB-Acquire-Boston	751 (74.5)
FNB-Medtronic	20 (2)
FNB-ProCore-Cook	40 (4)
FNB-Trident-Microtech	96 (9.5)
Specimen acquisition method, *n* (%)	
Suction method	381 (37.8)
Capillary method	290 (28.8)
Both	337 (33.4)
Number of needle passes (FNB), *n* (%)	
1	154 (15.3)
2	680 (67.5)
3	149 (14.8)
4	25 (2.5)
Final diagnosis (conclusive or inconclusive), *n* (%)	
Conclusive	963 (95.5)
Benign	102 (10.1)
Malignant	861 (85.4)

Inconclusive	45 (4.5)
Postprocedural adverse events, *n* (%)	
No	975 (96.7)
Yes	33 (3.3)
Abdominal pain	17 (1.7)
Small blood collection	10 (1)
Transient fever	6 (0.6)

EUS: Endoscopic ultrasound; FNA: Fine-needle aspiration; FNB: Fine-needle biopsy.

Table 3 Macroscopic on-site evaluation-1 and macroscopic on-site evaluation-2 classifications

Classification	
MOSE-1 classification, *n* (%)	
Score 1: Definite visible tissue core with scanty blood clots	618 (61.3)
Score 2: Visible tissue core with moderate blood clots	325 (32.2)
Score 3: Scanty tissue core with mainly blood clots	65 (6.5)
MOSE-2 classification, *n* (%)	
Score 0: Punctio sicca/no material	0 (0)
Score 1: Only necrotic or haematic material	44 (4.4)
Score 2: ≥ 1 core tissue, ≤ 2 mm yellowish-white	194 (19.2)
Score 3: ≥ 1 core tissue, > 2 mm yellowish-white	770 (76.4)

MOSE: Macroscopic on-site evaluation.

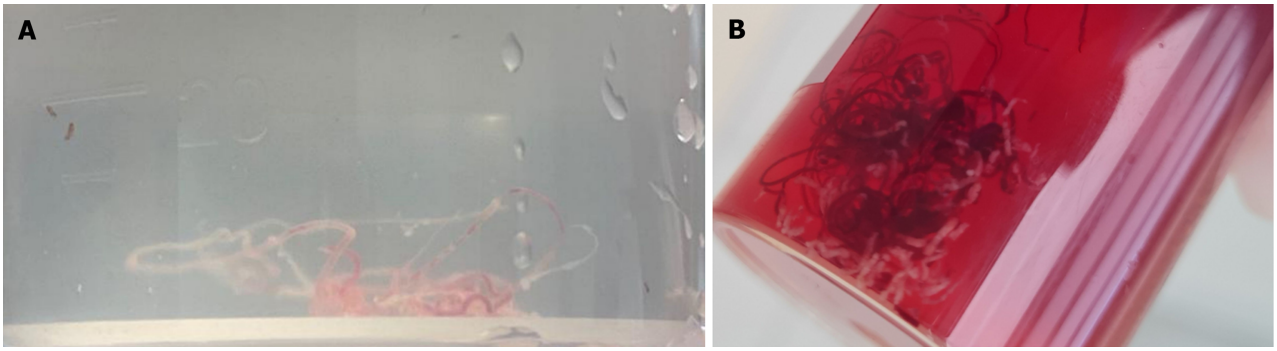

Figure 1 Macroscopic on-site evaluation-1 classification. A: Score 1 definite visible tissue core with scanty blood clots; B: Score 2 visible tissue core with moderate blood clots.

experienced cytopathologists, 45 (4.5%) were inconclusive; however, the overall diagnostic yield of cytopathology was 95.5%. The cytological examination confirmed the diagnosis of malignancy in 861 patients (85.4%) and benign lesions in 102 cases (10.1%).

Specimen adequacy

Comparing the two groups with inconclusive and conclusive diagnoses, a statistically significant difference between needle types was observed ($P = 0.035$), with the greatest disparity seen between FNB-Trident-Microtech (100% conclusive results) and FNA-EchoTip-Cook (87.9%). However, the 2 groups were comparable in needle size and specimen acquisition methods (Table 5). When comparing score 1 with scores 2 and 3 in the MOSE-1 classification, score 1 showed a sensitivity of 95%, specificity of 31%, a PPV of 97%, NPV of 22%, and an overall accuracy of 92% in obtaining conclusive samples, whether benign or malignant. According to the MOSE-2 classification, score 3 has a statistically significant difference in diagnostic accuracy (97.5%) with a P value of 0.002 and in malignancy detection (89.6%) with a P value <

Table 4 Relation between macroscopic on-site evaluation classifications and the type of needles and tissue acquisition techniques

	MOSE-1 classification				MOSE-2 classification		
	1, *n* (%)[1]	2, *n* (%)[1]	3, *n* (%)[1]	*P* value	Scores 0 and 1, *n* (%)[1]	Scores 2 and 3, *n* (%)[1]	*P* value
Type of the needle							
FNA-EchoTip	13 (39.4)	15 (45.5)	5 (15.2)	< 0.001	1 (3)	32 (97)	0.009
FNA-Expect	37 (54.4)	28 (41.2)	3 (4.4)		7 (10.3)	61 (89.7)	
FNB-Acquire	465 (61.9)	241 (32.1)	45 (6)		33 (4.4)	718 (95.6)	
FNB-Medtronic	4 (20)	10 (50)	6 (30)		3 (15)	17 (85)	
FNB-Pro Core	12 (30)	22 (55)	6 (15)		0 (0)	40 (100)	
FNB-Trident-Microtech	87 (90.6)	9 (9.4)	0 (0)		0 (0)	96 (100)	
Type of the needle (FNA or FNB)							
FNA	50 (49.5)	43 (42.6)	8 (7.9)	0.036	8 (7.9)	93 (92.1)	0.073
FNB	568 (62.6)	282 (31.1)	57 (6.3)		36 (4)	871 (96)	
Size of the needle							
19 G	13 (44.8)	11 (37.9)	5 (17.2)	0.034	4 (13.8)	25 (86.2)	0.249
20 G	11 (28.9)	20 (52.6)	7 (18.4)		1 (2.6)	37 (97.4)	
22 G	594 (63.1)	294 (31.2)	53 (5.6)		39 (4.1)	902 (95.9)	
Specimen acquisition method							
Both	248 (73.6)	69 (20.5)	20 (5.9)	< 0.001	9 (2.7)	328 (97.3)	0.026[2]
Capillary method	150 (51.7)	116 (40)	24 (8.3)		10 (3.4)	280 (96.6)	
Suction method	220 (57.7)	140 (36.7)	21 (5.5)		25 (6.6)	356 (93.4)	
Number of needle passes							
1	89 (57.8)	60 (39)	5 (3.2)	< 0.001	4 (2.6)	150 (97.4)	< 0.001
2	451 (66.3)	197 (29)	32 (4.7)		15 (2.2)	665 (97.8)	
3	67 (44.9)	56 (37.6)	26 (17.5)		16 (10.7)	133 (89.3)	
4	11 (44)	12 (48)	2 (8)		9 (36)	16 (64)	

[1]Percentages were calculated within the row.
[2]Both *vs* suction (*P* value = 0.021).
P value < 0.05 is considered significant. MOSE: Macroscopic on-site evaluation; FNA: fine-needle aspiration; FNB: Fine-needle biopsy.

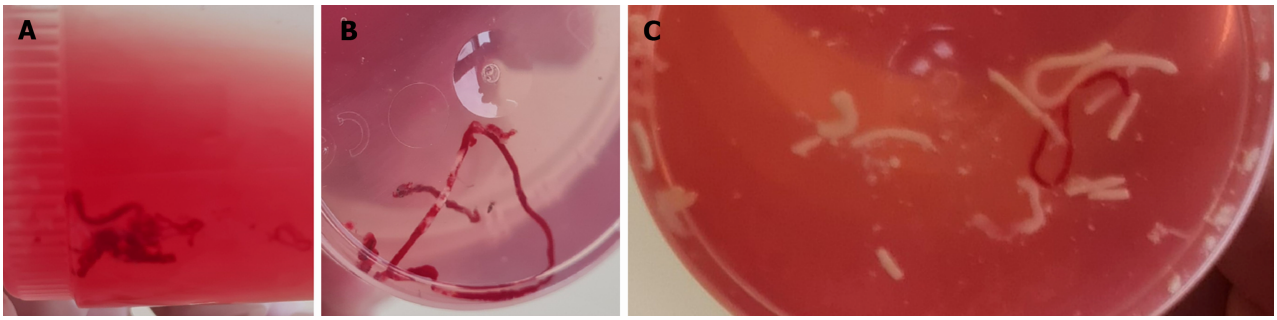

Figure 2 Macroscopic on-site evaluation-2 classification. A: Score 1 haematic or necrotic material; B: Score 2 ≥ 1 core tissue with ≤ 2 mm yellowish-white; C: Score 3 ≥ 1 core tissue with > 2 mm yellowish-white.

Table 5 Relation between the final diagnosis and the type and size of the needle

	Final diagnosis		
	Inconclusive, *n* (%)[1]	Conclusive, *n* (%)[1]	*P* value
Type of needle			
FNA-EchoTip-Cook	4 (12.1)	29 (87.9)	0.035[a]
FNA-Expect-Boston	1 (1.5)	67 (98.5)	
FNB-Franseen Acquire-Boston	39 (5.2)	712 (94.8)	
FNB-Medtronic	0 (0)	20 (100)	
FNB-ProCore-Cook	1 (2.5)	39 (97.5)	
FNB-Trident-Microtech	0 (0)	96 (100)	
Type of needle (FNA or FNB)			
FNA	5 (5)	96 (95)	0.803
FNB	40 (4.4)	867 (95.6)	
Size of the needle			
19 G	3 (10.3)	26 (89.7)	0.176
20 G	3 (7.9)	35 (92.1)	
22 G	39 (4.1)	902 (95.9)	
Specimen acquisition method			
Both	10 (3)	327 (97)	0.079
Capillary method	11 (3.8)	279 (96.2)	
Suction method	24 (6.3)	357 (93.7)	
MOSE-1 classification			
Good cores (score 1)	16 (2.6)	602 (97.4)	< 0.001[a]
Bloody cores (scores 2 and 3)	29 (7.4)	361 (92.6)	
MOSE-2 classification			
Score 2	14 (7.2)	180 (92.8)	0.002[a]
Score 3	20 (2.6)	750 (97.4)	

[a]*P* value < 0.05 is considered significant.
[1]Percentages were calculated within the row.
MOSE: Macroscopic on-site evaluation; FNA: fine-needle aspiration; FNB: Fine-needle biopsy.

0.001 (Table 6). Further analysis revealed that the MOSE-2 classification with FNA had a sensitivity of 92.7%, a specificity of 20%, a PPV of 96%, an NPV of 12.5%, and an overall accuracy of 89% in providing conclusive, whether benign or malignant, samples. With FNB, the MOSE-2 classification has demonstrated a sensitivity of 97%, specificity of 25%, PPV of 97%, NPV of 28%, and overall accuracy of 94% in obtaining conclusive samples.

Safety

Post-procedural adverse events occurred in only 33 patients (3.3%) and included tolerable abdominal pain in 17 patients (1.7%), self-limiting small blood collection in 10 patients (1%), and transient fever in 6 patients (0.6%). No significant complications or mortality occurred.

DISCUSSION

Since its description in 2015, MOSE has demonstrated simplicity and ease of use, effectively enhancing the diagnostic yield of biopsies performed under EUS. The recent study was conducted by Sundaram *et al*[8], published in 2023, and involved 155 patients with solid pancreatic lesions. It compared the efficacy of EUS-FNB in terms of adequacy as assessed by MOSE and smear cytology with adequacy as confirmed by ROSE obtained with the same needle. This study confirmed that MOSE and ROSE effectively assess sampling adequacy, with no discernible difference in overall diagnostic accuracy

Table 6 Comparison between scores 2 and 3 in the macroscopic on-site evaluation-2 classification

	MOSE-2 classification		*P* value
	Score 2, *n* (%)[1]	Score 3, *n* (%)[1]	
Diagnosis conclusive or inconclusive			
Inconclusive	14 (7.2)	20 (2.6)	0.002[a]
Conclusive	180 (92.8)	750 (97.4)	
Final diagnosis			
Inconclusive	14 (7.2)	20 (2.6)	< 0.001[a]
Benign	35 (18)	60 (7.8)	
Malignant	145 (74.7)	690 (89.6)	
Number of needle passes FNB1			
1	32 (16.5)	118 (15.3)	< 0.001[a]
2	103 (53.1)	562 (73)	
3	56 (28.9)	77 (10)	
4	3 (1.5)	13 (1.7)	

[a]*P* value < 0.05 is considered significant.
[1]Percentages were calculated within the column.
MOSE: Macroscopic on-site evaluation; FNBI: First Nations Biomonitoring Initiative.

for solid pancreatic lesions[8]. In addition, in a meta-analysis encompassing 2147 patients, EUS-FNB plus ROSE did not exhibit superiority over EUS-FNB with newer end-cutting needles[9]. Therefore, considering the additional costs and logistics involved, the utility of ROSE should be deliberated[8,9]. Moreover, the Mohan *et al*'s meta-analysis of 1508 lesions confirmed the efficacy of MOSE with a high pathologic diagnosis[4].

The multicentric prospective study of Mangiavillano, including 504 samples, confirmed a strong correlation between MOSE after the first pass and histologic adequacy, with a high rate of concordance (90%)[10]. Regardless of the first pass MOSE result, this study showed that a second pass is necessary to increase diagnostic accuracy[10]. Visible cores superior to or equal to 4 mm on MOSE may indicate sample adequacy for pathological interpretation, as reported in the first studies on MOSE[3]. However, recent studies have confirmed that the accuracy of EUS-FNB improves as the length of the visible core increases[10]. Visible cores of at least 10 mm are strongly associated with the probability of a correct diagnosis [9,10]. These findings may indicate that the 10 mm white-yellow core adequacy cut-off may be proposed[10,11].

The current study demonstrated that a score of 3 according to the MOSE 2 classification (≥ 1 core tissue > 2 mm yellowish-white) exhibited a statistically significant increase in diagnostic accuracy (97.5%), correlating with an improvement in EUS-FNB accuracy with tissue length. Regarding needle type, previous studies on solid lesions confirmed that EUS-FNB is superior to EUS-FNA in diagnosing solid lesions because it allows more cell blocks to be assessed with a similar number of passes. Sensitivity was identical between EUS-FNA with ROSE, EUS-FNB with ROSE, and EUS-FNB alone[12,13]. The current findings are consistent, showing a significantly higher rate of conclusive diagnoses with the FNB-Trident Microtech (100%) compared to the FNA-EchoTip Cook (87.9%).

Moreover, Mohan *et al*'s meta-analysis demonstrated excellent pooled sensitivity, specificity, and PPV for EUS-guided MOSE (91.5%, 98.9%, and 98.8%, respectively)[4]. Similarly, the study of 155 solid pancreatic lesions using FNB with MOSE reported 96.12% sensitivity and 100% specificity[8]. In a study of 79 patients undergoing EUS-FNB to diagnose abdominal mass using the MOSE-1 classification, Oh *et al*[7] found diagnostic accuracy, sensitivity, and specificity to be 94.5%, 94.3%, and 100%, respectively. Furthermore, Gaia *et al*'s prospective study of 76 consecutive patients undergoing EUS-FNB for pancreatic and extrapancreatic solid lesions reported better accuracy for score 3 of the MOSE-2 classification (78.3%)[5].

A recent prospective randomized study including 96 patients with solid gastro-intestinal, pancreatic, biliary lesions, and enlarged lymph nodes studied the diagnostic performance of MOSE compared with conventional technique of EUS-FNB using Franseen biopsy needles[14]. They concluded that EUS-FNB with MOSE is a simple reliable technique that can achieve a high and comparable diagnostic accuracy with lesser number of passes. Obtaining longer length and greater number of MVC increase the sensitivity to diagnose malignancy with MOSE[14].

In the current study, MOSE-2 classification by FNA was 92.7% sensitive and 20% specific, whereas FNB was 97% sensitive and 25% specific. Regarding MOSE-1 classification, score 1 compared to score 2 and score 3 had 95% sensitivity, 31% specificity, and 92% overall accuracy. Following the development of ROSE and MOSE, further alternatives have now been described. The introduction of stereomicroscope MOSE (S-MOSE) bridge technology aims to identify the optimal cut-off length for visible white cores that indicate pathology. S-MOSE provides stereomicroscopic magnification to differentiate between core tissue and blood clots, allowing endoscopists to perform assessments comfortably in the endoscopy room. Compared to ROSE, this innovative approach can reduce overall procedure time[15-17]. Additionally, sample

isolation processing by stereomicroscopy (SIPS) was employed to acquire stereomicroscopically visible white cores (SVWCs). This method enhances sample quality for diagnosis by isolating the tissue core from red components like red blood cells and fibrin during magnified stereomicroscopic examination. Using an SVWC cut-off of ≥ 3.5 mm or ≥ 4 mm with a 22-gauge Franseen FNB needle, SIPS has a high sensitivity of 98.8% for malignancy in upper gastrointestinal subepithelial lesions[16]. Nevertheless, it is a complicated and time-consuming process and seems to be unnecessary for pancreatic cancer[18,19].

More recently, Nakatani *et al*[20] introduced stereomicroscope on-site evaluation, which resembles S-MOSE but excludes the SIPS procedures. Stereomicroscope on-site evaluation solely confirms whether the SVWC cut-off (≥ 4 mm) is attained, making it simpler than S-MOSE. Recently Iwashita *et al*'s review analysed the advances in EUS-FNA/FNB techniques and equipment and highlighted the importance of sample handling, including MOSE, for diagnostic accuracy [21]. This emphasizes the need for a comprehensive understanding of the characteristics of each technique to optimize diagnostic efficiency and procedure safety[21].

CONCLUSION

MOSE is a feasible and safe method that allows the endoscopist to increase the number of needle passes to improve the sample quality on each EUS-FNA/FNB. Good MOSE cores are significantly associated with a high sensitivity of the FNB and a better diagnostic yield in cytopathology. In the current multicenter study, we affirmed the utility of MOSE using two classifications, noting a notably higher rate of conclusive diagnoses with the FNB-Trident Microtech compared to the FNA-EchoTip Cook. FNB exhibited higher sensitivity (97%) in the MOSE-2 classification, while score 1 yielded the best sensitivity (95%) in the MOSE-1 classification, particularly with 22 G needles. Ultimately, each endoscopist should strive to achieve a MOSE-1 score of 1 and a MOSE-2 score of 3 during observation of the cores.

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FOOTNOTES

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REFERENCES

1 **So H**, Seo DW, Hwang JS, Ko SW, Oh D, Song TJ, Park DH, Lee SK, Kim MH. Macroscopic on-site evaluation after EUS-guided fine needle biopsy may replace rapid on-site evaluation. *Endosc Ultrasound* 2021; **10**: 111-115 [PMID: 33885006 DOI: 10.4103/EUS-D-20-00113]
2 **Delsa H**, Bellahammou K, Okasha HH, Ghalim F. Cheesy material on macroscopic on-site evaluation after endoscopic ultrasound-guided fine-needle biopsy: Don't miss the tuberculosis. *World J Clin Cases* 2023; **11**: 2181-2188 [PMID: 37122512 DOI: 10.12998/wjcc.v11.i10.2181]
3 **Iwashita T**, Yasuda I, Mukai T, Doi S, Nakashima M, Uemura S, Mabuchi M, Shimizu M, Hatano Y, Hara A, Moriwaki H. Macroscopic on-site quality evaluation of biopsy specimens to improve the diagnostic accuracy during EUS-guided FNA using a 19-gauge needle for solid lesions: a single-center prospective pilot study (MOSE study). *Gastrointest Endosc* 2015; **81**: 177-185 [PMID: 25440688 DOI: 10.1016/j.gie.2014.08.040]
4 **Mohan BP**, Madhu D, Reddy N, Chara BS, Khan SR, Garg G, Kassab LL, Muthusamy AK, Singh A, Chandan S, Facciorusso A, Mangiavillano B, Repici A, Adler DG. Diagnostic accuracy of EUS-guided fine-needle biopsy sampling by macroscopic on-site evaluation: a systematic review and meta-analysis. *Gastrointest Endosc* 2022; **96**: 909-917.e11 [PMID: 35932815 DOI: 10.1016/j.gie.2022.07.026]
5 **Gaia S**, Rizza S, Bruno M, Ribaldone DG, Maletta F, Sacco M, Pacchioni D, Rizzi F, Saracco GM, Fagoonee S, De Angelis CG. Impact of Macroscopic On-Site Evaluation (MOSE) on Accuracy of Endoscopic Ultrasound-Guided Fine-Needle Biopsy (EUS-FNB) of Pancreatic and Extrapancreatic Solid Lesions: A Prospective Study. *Diagnostics (Basel)* 2022; **12** [PMID: 35204519 DOI: 10.3390/diagnostics12020428]
6 **Kim DH**, Kim GH, Cho CM, Park CH, Na SY, Kim TH, Cho YK, Kim JH, Seo DW; Korean EUS Study Group. Feasibility of a 20-gauge ProCore needle in EUS-guided subepithelial tumor sampling: a prospective multicenter study. *BMC Gastroenterol* 2018; **18**: 151 [PMID: 30340469 DOI: 10.1186/s12876-018-0880-1]
7 **Oh D**, Seo DW, Hong SM, Song TJ, Park DH, Lee SS, Lee SK, Kim MH. The impact of macroscopic on-site evaluation using filter paper in EUS-guided fine-needle biopsy. *Endosc Ultrasound* 2019; **8**: 342-347 [PMID: 31268010 DOI: 10.4103/eus.eus_34_19]
8 **Sundaram S**, Chhanchure U, Patil P, Seth V, Mahajan A, Bal M, Kaushal RK, Ramadwar M, Prabhudesai N, Bhandare M, Shrikhande SV, Mehta S. Rapid on-site evaluation (ROSE) versus macroscopic on-site evaluation (MOSE) for endoscopic ultrasound-guided sampling of solid pancreatic lesions: a paired comparative analysis using newer-generation fine needle biopsy needles. *Ann Gastroenterol* 2023; **36**: 340-346 [PMID: 37144017 DOI: 10.20524/aog.2023.0790]
9 **Facciorusso A**, Gkolfakis P, Tziatzios G, Ramai D, Papanikolaou IS, Triantafyllou K, Lisotti A, Fusaroli P, Mangiavillano B, Chandan S, Mohan BP, Crinò SF. Comparison between EUS-guided fine-needle biopsy with or without rapid on-site evaluation for tissue sampling of solid pancreatic lesions: A systematic review and meta-analysis. *Endosc Ultrasound* 2022; **11**: 458-465 [PMID: 36537383 DOI: 10.4103/EUS-D-22-00026]
10 **Mangiavillano B**, Facciorusso A, Di Matteo FM, Barbera C, Larghi A, Rizzatti G, Carrara S, Lisotti A, Fusaroli P, De Luca L, Di Leo M, Conti Bellocchi MC, Spadaccini M, Dabizzi E, Auriemma F, Stigliano S, Ramai D, Calabrese F, Manfrin E, Paduano D, Hassan C, Repici A, Crinó SF. Establishing the optimal number of passes during EUS-FNB for diagnosis of pancreatic solid lesions: Prospective multicenter study. *Endosc Int Open* 2024; **12**: E467-E473 [PMID: 38585018 DOI: 10.1055/a-2236-7654]
11 **Kaneko J**, Ishiwatari H, Sasaki K, Satoh T, Sato J, Matsubayashi H, Yabuuchi Y, Kishida Y, Yoshida M, Ito S, Kawata N, Imai K, Kakushima N, Takizawa K, Hotta K, Ono H. Macroscopic on-site evaluation of biopsy specimens for accurate pathological diagnosis during EUS-guided fine needle biopsy using 22-G Franseen needle. *Endosc Ultrasound* 2020; **9**: 385-391 [PMID: 32913149 DOI: 10.4103/eus.eus_49_20]
12 **Moura DTH**, McCarty TR, Jirapinyo P, Ribeiro IB, Farias GFA, Madruga-Neto AC, Ryou M, Thompson CC. Endoscopic ultrasound fine needle aspiration vs fine needle biopsy in solid lesions: A multi-center analysis. *World J Clin Cases* 2021; **9**: 10507-10517 [PMID: 35004982 DOI: 10.12998/wjcc.v9.i34.10507]
13 **Khan MA**, Grimm IS, Ali B, Nollan R, Tombazzi C, Ismail MK, Baron TH. A meta-analysis of endoscopic ultrasound-fine-needle aspiration compared to endoscopic ultrasound-fine-needle biopsy: diagnostic yield and the value of onsite cytopathological assessment. *Endosc Int Open* 2017; **5**: E363-E375 [PMID: 28497108 DOI: 10.1055/s-0043-101693]
14 **Sonthalia N**, Kumbar V, Tewari A, Roy A, Ghoshal UC, Goenka MK. Endoscopic ultrasound-guided fine needle biopsy using macroscopic on-site evaluation technique reduces the number passes yet maintains a high diagnostic accuracy: A randomized study. *J Gastroenterol Hepatol* 2024 [PMID: 39288986 DOI: 10.1111/jgh.16744]
15 **Okuwaki K**, Masutani H, Kida M, Yamauchi H, Iwai T, Miyata E, Hasegawa R, Kaneko T, Imaizumi H, Watanabe M, Kurosu T, Tadehara M, Adachi K, Tamaki A, Koizumi W. Diagnostic efficacy of white core cutoff lengths obtained by EUS-guided fine-needle biopsy using a novel 22G franseen biopsy needle and sample isolation processing by stereomicroscopy for subepithelial lesions. *Endosc Ultrasound* 2020; **9**: 187-192 [PMID: 32584314 DOI: 10.4103/eus.eus_18_20]
16 **Masutani H**, Okuwaki K, Kida M, Yoshida T, Imaizumi H, Yamauchi H, Iwai T, Kaneko T, Hasegawa R, Miyata E, Koizumi W. On-site stereomicroscope quality evaluations to estimate white core cutoff lengths using EUS-FNA biopsy sampling with 22-gauge needles. *Gastrointest Endosc* 2019; **90**: 947-956 [PMID: 31493384 DOI: 10.1016/j.gie.2019.08.033]
17 **Cho YK**. What method can we choose if rapid on-site evaluation is not available for the endoscopic ultrasound-guided tissue acquisition of upper gastrointestinal subepithelial lesions? *Clin Endosc* 2024; **57**: 53-55 [PMID: 38302249 DOI: 10.5946/ce.2023.299]
18 **Okuwaki K**, Imaizumi H, Kida M, Masutani H, Iwai T, Watanabe M, Adachi K, Tadehara M, Hasegawa R, Nakatani S, Kurosu T, Tamaki A, Koizumi W. Usefulness of the automated multiband imaging system for EUS-FNA biopsy specimen evaluation in patients with upper gastrointestinal subepithelial lesions. *Endosc Ultrasound* 2022; **11**: 283-290 [PMID: 35313420 DOI: 10.4103/EUS-D-21-00143]
19 **Watanabe M**, Okuwaki K, Kida M, Imaizumi H, Matsumoto T, Iwai T, Hasegawa R, Masutani H, Kurosu T, Minato N, Tamaki A, Ishizaki J, Kusano C. Multicenter prospective study of the efficacy of stereomicroscopic on-site evaluation in endoscopic ultrasound-guided tissue acquisition in patients with pancreatic cancer. *Pancreatology* 2022; **22**: 311-316 [PMID: 34969602 DOI: 10.1016/j.pan.2021.12.011]
20 **Nakatani S**, Okuwaki K, Watanabe M, Imaizumi H, Iwai T, Matsumoto T, Hasegawa R, Masutani H, Kurosu T, Tamaki A, Ishizaki J, Ishizaki

A, Kida M, Kusano C. Stereomicroscopic on-site evaluation in endoscopic ultrasound-guided tissue acquisition of upper gastrointestinal subepithelial lesions. *Clin Endosc* 2024; **57**: 89-95 [PMID: 37070203 DOI: 10.5946/ce.2022.288]

21 **Iwashita T**, Uemura S, Ryuichi T, Senju A, Iwata S, Ohashi Y, Shimizu M. Advances and efficacy in specimen handling for endoscopic ultrasound-guided fine needle aspiration and biopsy: A comprehensive review. *DEN Open* 2024; **4**: e350 [PMID: 38495467 DOI: 10.1002/deo2.350]

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