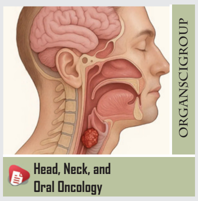
Peertechz

Head, Neck, and Oral Oncology

OPEN ACCESS

DOI: https://dx.doi.org/10.17352/hnoo



Research Article

Evaluation of a Training Course for Simulating Head and Neck Ultrasound-guided Core Needle Biopsy

Farrokh Heidari[1], Benyamin Mousavi-as[1], Parnian Khamushian[2], Hosna Razeghian[3], Niloufar Saeedi[1], Mahdieh Mohebbi[1], Kayvan Aghazadeh[1], Ebrahim Karimi[1] and Niloufar Shabani[4]*

[1]Assistant Professor of Otorhinolaryngology, Head and Neck Surgery, Otorhinolaryngology, Research Center, Tehran University of Medical Sciences, Tehran, Iran

[2]MD, Board-Certified in Internal Medicine, Fellowship-Trained in Pulmonary and Intensive Care Medicine, Internal medicine research center, Tehran University of Medical sciences, Tehran, Iran

[3]MD, Ankara University School of Medicine, Ankara, Turkey

[4]MD, Faculty of Medicine, Shahid Beheshti University of Medical Sciences, Tehran, Iran

Received: 30 July, 2025
Accepted: 25 August, 2025
Published: 26 August, 2025

***Corresponding author:** Dr. Niloufar Shabani, MD, Faculty of Medicine, Shahid Beheshti University of Medical Sciences, Arabi Ave, Daneshjoo Blvd, Velenjak, Tehran, Iran, E-mail: Niloufarshabani1377@gmail.com

Keywords: Core Needle Biopsy (CNB); Ultrasound-guided biopsy; Head and neck lesions; Clinical skills training; Phantom

Abstract

Background: Ultrasound-guided Core Needle Biopsy (US-CNB) is widely used for diagnosing head and neck lesions due to its high accuracy and minimal invasiveness. However, clinicians often face challenges in acquiring the necessary technical skills because of limited exposure during training. Simulation-based learning has emerged as a targeted educational strategy to bridge this gap, allowing trainees to practice in a safe and controlled setting. Previous studies have shown that structured simulation programs can improve procedural confidence and accuracy in various specialties. Yet, evidence regarding their impact on head and neck US-CNB training remains limited.

Methods: This study evaluated the effectiveness of a structured hands-on training workshop focused on head and neck US-CNB. Twenty-three clinicians attended a two-hour theoretical session followed by a two-hour practical training using an agar-agar phantom model. Knowledge was assessed via pre- and post-training multiple-choice questions. Confidence and skill improvement were surveyed, and linear regression analysis factors affecting outcomes.

Results: Post-training scores improved significantly (mean increase: 9.83 to 16.87, $p < 0.001$). Older participants scored marginally higher (0.134 points/year, $p = 0.022$), but experience did not influence gains ($p = 0.243$). Most rated the workshop highly, particularly hands-on training, reporting greater confidence and technical skill.

Conclusion: Our findings support the growing body of literature that simulation-based training enhances diagnostic biopsy skills. Despite the small cohort and model limitations, the workshop effectively improved knowledge and confidence across different experience levels. Expanding such programs, possibly incorporating advanced technologies such as Virtual Reality (VR) or Augmented Reality (AR), may further strengthen future head and neck US-CNB training.

Abbreviations

CNB: Core Needle Biopsy; US: Ultrasound; FNA: Fine Needle Aspiration; MCQ: Multiple Choice Question; US-CNB: Ultrasound-guided Core Needle Biopsy

Introduction

An accurate diagnosis is necessary to treat head and neck lesions effectively. Due to the long list of differential diagnoses of head and neck pathologies, tissue sampling can play an important role in addition to history taking, physical

Citation: Heidari F, Mousavi-as B, Khamushian P, Razeghian H, Saeedi N, Mohebbi M, et al. Evaluation of a Training Course for Simulating Head and Neck Ultrasound-guided Core Needle Biopsy. Head Neck Oral Oncol. 2025;1(1):001-006. Available from:: https://dx.doi.org/10.17352/hnoo.000001

examination, and imaging to reach a reliable diagnosis. Standard sampling techniques include open surgical biopsy, Fine Needle Aspiration (FNA), and Core Needle Biopsy (CNB). The ideal method should provide adequate and best-quality material for diagnosis and be easy to perform with the lowest complication rate [1].

Since open surgical biopsy is an invasive method that requires general anesthesia and may increase the chance of tumor spread and recurrence, less invasive methods, such as FNA and CNB, are recommended as alternatives [2,3]. Both procedures can be performed under local anesthesia with a low complication rate. Previous studies have shown that the nondiagnostic rate of CNB is lower than that of FNA. Also, CNB has higher diagnostic accuracy than FNA, making it comparable to open surgical biopsy [2,4,5]. In 2011, a systematic review and meta-analysis reported that CNB detected malignancy in the head and neck lesions with an overall accuracy of 96% [6]. It provided a correct specific diagnosis in 87% of cases and was associated with no major complications. Similar studies have confirmed that CNB can provide a high-quality histopathological yield with high diagnostic utility for head and neck lesions [7-9]. Using Utrasound (US) guidance for CNB enables precise needle placement, reducing the risk of damaging surrounding tissue or missing the lesion [10,11].

Since US-guided CNB has become an essential diagnostic tool to evaluate head and neck lesions, we held a Head and Neck CNB Workshop for graduate clinicians to improve their skills. The goal of this study was to determine how effectively our head and neck CNB Workshop enhanced the knowledge and hands-on skills of graduate clinicians.

Material and methods

The participants attended the head and neck CNB Workshop during the 18th International Congress of the Iranian Society of Otorhinolaryngology and Head and Neck Surgery. The CNB workshop took place at the Espinas Palace Hotel in Tehran, Iran, on Thursday, October 26, 2023. A total of 23 participants attended the workshop (Figure 1). Our training program consisted of 2 hours of theoretical followed by 2 hours of hands-on training. Before the theoretical program, participants took a baseline test consisting of 7 Multiple-Choice Questions (MCQs) designed based on expert consensus.

The first question assessed their experience, and the remaining six assessed their basic understanding of US-guided CNB. Knowledge improvement was tested using the same six MCQs immediately after the end of the hands-on training program. Additional MCQs were applied to evaluate participants' perceptions of the program's effectiveness in teaching US-guided CNB skills.

In the theoretical session, participants learned about one free-hand technique, different types of biopsy needles, suitable gauges of needles, and the importance of preprocedural US to pass the needle correctly through the skin and to decrease the chance of bleeding. The theoretical session also discussed the necessary ultrasound imaging information relevant to core needle biopsy.

In the hands-on session, participants were instructed to perform a US-guided core-needle biopsy on training phantoms. Simulation-based training using a phantom can improve clinicians' competency, which increases patient safety and reduces healthcare cost [10]. To enhance the efficacy of the workshop, participants were divided into small groups, and modified Peyton's 4-step training approach was used. Peyton's 4-step training method consists of the following steps: Step 1: "Demonstrate": The trainer demonstrates the skill at a normal pace without any further explanation; Step 2: "Talk the trainee through": the trainer demonstrates the skill while explaining details of each sub-step; Step 3: "Trainee talks trainer through": the trainee describes the sub-steps to the trainer while the trainer performs the skill for the third time, based on trainees description; Step 4: "Trainee does": the trainee performs the skill by themselves. This training approach is suitable for a student-teacher ratio of 1:1 but since there were 23 participants in this workshop divided into small groups, modified Peyton's 4-step training approach was applied which consists of the following parts: (A): the trainer performs steps 1 and 2 for all the trainees (B): trainee number 1 and the trainer carry out step 3 together and the other trainees observe (C): trainee number 1 performs the skill based on the instructions of trainee number 2 while other trainees observe (D): peer trainees and trainer give feedback to trainee number 1 (E) part C and D are repeated in turns until the last trainee (F) the last trainee performs step 4 and receives feedback from other trainees and trainer [13].

Training Phantom and US devices

Participants practiced the US-guided core-needle biopsy on an in-house-designed training phantom of methylene blue and

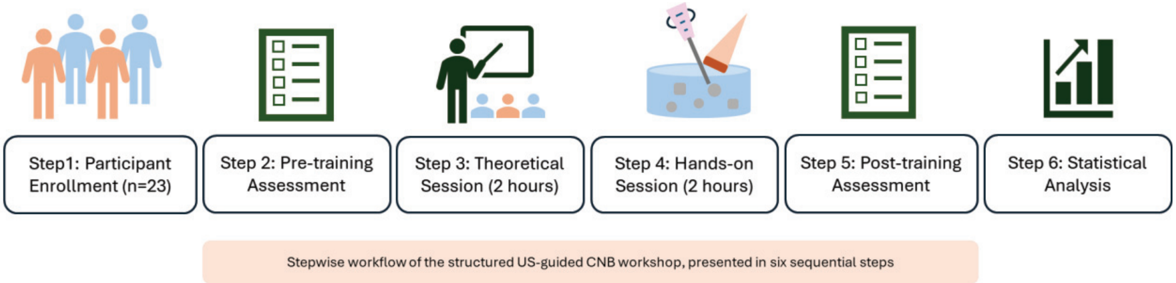


Figure 1: Schematic representation of the seven-step CNB workshop process: (1) Participant enrollment, (2) Pre-training assessment, (3) theoretical session, (4) hands-on session, (5) post-training assessment, (6) statistical analysis. CNB: Core Needle Biopsy; US: Ultrasound.

Citation: Heidari F, Mousavi-as B, Khamushian P, Razeghian H, Saeedi N, Mohebbi M, et al. Evaluation of a Training Course for Simulating Head and Neck Ultrasound-guided Core Needle Biopsy. Head Neck Oral Oncol. 2025;1(1):001-006. Available from:: https://dx.doi.org/10.17352/hnoo.000001

agar–agar gel, with several chicken and potato pieces floating inside, mimicking the targeted tissue for biopsy (Figure 2). The presence of chicken or potato material inside the biopsy needle confirmed a correct biopsy.

The ultrasonography was performed using the Alpinon E-Cube i7 Vet device with an L8-17H linear probe (Alpinon Medical Systems, Seoul, South Korea). We defined the same settings for every participant.

Baseline test

We designed seven Multiple-choice Questions (MCQs) to evaluate participants' previous experience and knowledge of CNB. The first question assessed participants' experience and categorized them into two groups: Group A, participants with experience performing US-guided CNB at least once, and Group B, participants without expertise. The remaining six questions evaluated their proficiency in general ultrasound knowledge, types of CNB needles and their functions, needle sizes required for CNB, the capability of assessing the sufficiency of the sample volume obtained using CNB, the "one free hand" technique in performing CNB, and the recommendations and necessary actions for patients after CNB (Table 1).

Participants utilized a 3-point Likert scale for these questions with the following response options: 1 = Not at all, 2 = To some extent, 3 = Completely.

The null hypothesis for each of the six scientific background MCQs was that the chosen answers were equal before and after the program. This null hypothesis was tested using the Wilcoxon Signed Rank Test. For the total MCQ score of participants, the null hypothesis that the total score was equal before and after the program was tested using the paired sample test. We also calculated participants' total MCQ scores for groups A and B separately, and we used an independent samples t-test to evaluate the null hypothesis that the mean MCQ score was equal in the two groups.

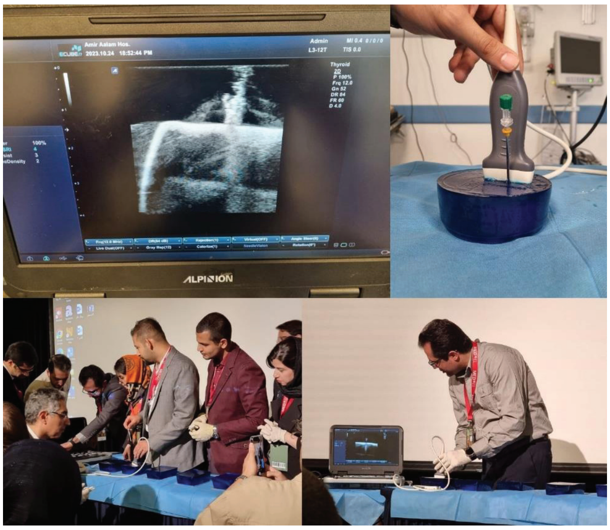


Figure 2: Participants practiced the ultrasound-guided core-needle biopsy on the training phantom of methylene blue and agar–agar gel, with several chicken and potato pieces floating inside.

Table 1: Participants' pre-training and post-training evaluation questions expressed by mean Likert scores.

MCQ Questions	Pre-training mean Score	Post-training mean score	*p* -value
Are you familiar with the general sonography knowledge required before performing a core needle biopsy (CNB)?	1.87	2.7	< 001
Do you know the types of CNB needles and how they work?	1.78	2.96	< 001
Do you know the needle size required for performing CNB?	1.83	2.91	< 001
Can you assess the sufficiency of the sample volume obtained with CNB?	1.39	2.74	< 001
Are you familiar with the "one free hand" technique when performing CNB?	1.48	2.87	< 001
Do you know the recommendations and necessary actions for the patient after performing CNB?	1.48	2.78	< 001
Total MCQ score	9.83	16.87	< 001

Liker scores: 1 not at all, 2 to some extent, 3 completely

The impact of variables such as gender, age, and pre-training MCQ score on the post-training score was tested using linear regressions. We performed statistical analysis using the IBM SPSS Statistics version 27.01.0 and used a significance level of 0.05 in this study.

Participants' program evaluation

At the end of the program, the participants were asked to evaluate the program using a standardized 3-point Likert scale questionnaire (1 = not at all, 2 = to some extent, 3 = completely) on 3 questions. Also, a comment box was available for participants at the end of the questionnaire.

Results

MCQ

The MCQ score for each question increased significantly following the training program ($p < 0.001$), as shown in Table 1. The total MCQ score of participants ranged from 6 to 18. After the course, the mean total MCQ score increased from 9.83 to 16.87 ($p < 0.001$) (Table 2). An independent samples t-test revealed no significant difference in score increase between the two groups (A and B), with a p - value of 0.243. (Table 3). When comparing participants with and without prior US-CNB experience, both groups demonstrated significant improvement after training. The mean score increase did not differ significantly between Group A (experienced) and Group B (inexperienced) ($p = 0.243$), indicating comparable learning effects across different baseline experience levels.

We investigated the effect of each factor on the post-training total MCQ score using linear regression. The only significant finding was a positive correlation of age with post-training scores (0.134 score per year (95% CI 0.022–0.246, $p = 0.022$)), indicating that older participants tended to achieve higher post-training scores. However, gender and pre-training scores did not show a significant correlation ($p = 0.457$ and $p = 0.232$, respectively). Overall, while age demonstrated a

Citation: Heidari F, Mousavi-as B, Khamushian P, Razeghian H, Saeedi N, Mohebbi M, et al. Evaluation of a Training Course for Simulating Head and Neck Ultrasound-guided Core Needle Biopsy. Head Neck Oral Oncol. 2025;1(1):001-006. Available from:: https://dx.doi.org/10.17352/hnoo.000001

significant relationship with post-training performance, the remaining predictors did not exhibit statistical significance, suggesting that other factors may contribute to variations in post-training scores.

Participants' program evaluation

All participants completed program evaluation tests, and the results were positive with a mean score of 8.13 (95% Cl: 7.62-8.64). The first and most crucial question, "How do you rate the success of this workshop in terms of learning?" had a mean score of 2.73 (91%). The second question, "Did you earn the CNB skill and the confidence to perform it?" had a mean score of 2.6 (86%), and the third question, "Did you gain a basic understanding of CNB?" had the highest mean score of 2.87 (95%). These results illustrate that most participants found the workshop highly effective (Figure 3). 16/23 participants completed the comment box. All the comments reflected the positive results of the workshop.

Discussion

CNB is a safe, minimally invasive, and highly efficient technique for obtaining a histopathological diagnosis of head and neck masses. Proficiency in performing accurate CNB benefits both clinicians and patients by improving diagnostic yield and reducing procedural complications [14,15]. This study evaluated the efficacy of a structured head and neck CNB Workshop in enhancing participants' theoretical knowledge and hands-on skills using an agar-agar phantom. The results demonstrated that the training program significantly enhanced participants' knowledge and skills. Older participants tended to achieve higher post-training scores, likely attributable to their accumulated clinical experience. However, the improvement of scores did not significantly differ between participants with prior CNB experience and participants without prior CNB experience, supporting the broad applicability of this training model across varying levels of prior experience. Additionally, most attendees rated the workshop highly, particularly the hands-on component, and expressed their willingness to recommend this program and similar learning opportunities to other clinicians.

Our findings aligned with previous studies assessing simulation-based training for ultrasound-guided biopsies. Schmidt, et al. assessed the effectiveness of a breast ultrasound training program including CNB using a gelatin phantom for undergraduate medical students. Results showed this supplementary program increased students' knowledge and enhanced their hands-on skills [16]. Cheng, et al. evaluated the efficacy of a training program using a gelatin phantom to practice head and neck US-guided procedures, including CNB, FNA, percutaneous ethanol injection, and radiofrequency ablation. This study confirmed that the program effectively informed the participants about the necessary steps and skills for the procedures [17]. These studies, like ours, highlight the value of combining theoretical instruction with practical simulation in skill acquisition.

Alternative training models for US-guided head and neck biopsies have been explored, including cadavers, mannequin simulators, and tofu-based phantoms [18-20]. However, our agar-agar phantom offers distinct advantages: it is cost-effective, easy to produce, portable, and durable under needle pressure compared to fragile alternatives like tofu. Additionally, its customizable design allows for the simulation of diverse lesion textures by embedding multiple targets, improving its versatility for training purposes [21-23].

Despite these advantages, it is important to acknowledge the limitations of our study. First, while the agar-agar model provides an accessible and practical training option, its downside is the lack of an accurate human anatomical representation and visible needle tracks after each needle pass [21]. Second, the small sample size (n = 23) may restrict the generalizability of our findings, warranting further validation in larger cohort studies.

Looking ahead, emerging technologies such as Virtual Reality (VR) and Augmented Reality (AR) may offer opportunities to further enhance the realism and immersion of simulation-based CNB training [24,25]. VR platforms can create interactive three-dimensional anatomical environments in which trainees practice needle positioning, hand–eye coordination, and probe manipulation in a highly controlled and repeatable manner. Unlike phantom models or cadavers, VR-based systems can simulate anatomies with varying degrees of deformation, providing broader exposure to clinically relevant scenarios [24]. For instance, Kyle Kleiman, et al. demonstrated that a VR breast biopsy simulator reduced both procedure time and the number of needle insertions required for successful biopsy [26]. Similarly, VR-based platforms have been developed for training in US-guided FNA of thyroid nodules, showing their adaptability across different biopsy procedures [27].

Table 2: Paired samples t - test results comparing the total pre- and post-test scores of participants

	Mean	N	Std. Deviation	Std. Error Mean	t	df	p
Total score pre-test	9.83	23	3.284	.685	-9.194	22	<.001
Total score post-test	16.87	23	1.792	.374			

Table 3: Independent Samples t - test results comparing groups A and B.

Group	N	Mean	Std. Deviation	Std. Error Mean	t	p
A	11	6.09	3.859	1.163	-1.203	.243
B	12	7.92	3.423	.988		

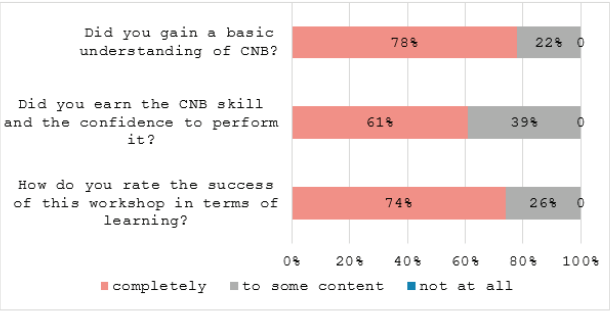


Figure 3: Participants' feedback on the effectiveness of the workshop, based on responses to a 3-point Likert scale.

Citation: Heidari F, Mousavi-as B, Khamushian P, Razeghian H, Saeedi N, Mohebbi M, et al. Evaluation of a Training Course for Simulating Head and Neck Ultrasound-guided Core Needle Biopsy. Head Neck Oral Oncol. 2025;1(1):001-006. Available from:: https://dx.doi.org/10.17352/hnoo.000001

AR technologies, on the other hand, can overlay real-time guidance, anatomical landmarks, or error-correction prompts directly onto physical phantom models, thereby combining the tactile realism of hands-on training with enhanced digital visualization [28,29]. When integrated with haptic feedback, AR-based systems have been reported to create highly immersive and efficient training environments, as evidenced in US-guided percutaneous liver biopsy training [30]. Incorporating VR or AR into US-CNB training could therefore address some limitations of traditional phantoms, such as the lack of anatomical fidelity or restricted feedback on needle trajectory. While cost and accessibility remain barriers, gradual integration of these tools into structured workshops may provide a scalable pathway toward more immersive and effective training for clinicians across different experience levels [31,32].

Conclusion

In conclusion, our head and neck CNB workshop significantly improved participants' knowledge and hands-on skills, regardless of prior experience. We recommend that training on a model should be considered for all trainees in head and neck US-guided CNB before application to patients. The agar-agar phantom proved to be a practical, low-cost training tool, though supplementary methods may be needed to address its anatomical limitations.

Ethical considerations

This study was approved by the Institutional Research Board (IRB) of Tehran University of Medical Sciences. Informed consent was obtained from all participants.

Author contributions

Farrokh Heidari: Design, Conduct, Writing – review and editing, final approval of the version to be published.

Benyamin Mousavi-asl: Design, Writing – review and editing, final approval of the version to be published.

Parnian Khamushian: Design, Writing – review and editing, final approval of the version to be published.

Hosna Razeghian: Analysis, Writing, review and editing, final approval of the version to be published.

Niloufar Saeedi: Design, Writing – review and editing, final approval of the version to be published.

Mahdieh Mohebbi: Design, Writing – review and editing, final approval of the version to be published.

Kayvan Aghazadeh: Design, Writing – review and editing, final approval of the version to be published.

Ebrahim Karimi: Design, Writing – review and editing, final approval of the version to be published.

Niloufar Shabani: Analysis, Writing – original draft, and Writing – review and editing, final approval of the version to be published.

Ethical approval

This study was approved by the Institutional Research Board (IRB) of Tehran University of Medical Sciences. Informed consent was obtained from all participants.

Data availability statement

The datasets analyzed during the current study are available from the corresponding author upon reasonable request.

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(5):523-529. Available from: https://onlinelibrary.wiley.com/doi/10.1002/jso.21600
2. Kiefer J, Mutschler M, Kurz P, Stark GB, Bannasch H, Simunovic F. Accuracy of core needle biopsy for histologic diagnosis of soft tissue sarcoma. Sci Rep. 2022;12(1):1886. Available from: https://www.nature.com/articles/s41598-022-05752-4
3. Pynnonen MA, Gillespie MB, Roman B, Rosenfeld RM, Tunkel DE, Bontempo L, et al. Clinical Practice Guideline: Evaluation of the Neck Mass in Adults. Otolaryngol Head Neck Surg. 2017;157(2_suppl):S1-S30. Available from: https://aao-hnsfjournals.onlinelibrary.wiley.com/doi/10.1177/0194599817722550
4. Saha S, Woodhouse NR, Gok G, Ramesar K, Moody A, Howlett DC. Ultrasound-guided Core Biopsy, Fine Needle Aspiration Cytology, and Surgical Excision Biopsy in the diagnosis of metastatic squamous cell carcinoma in the head and neck: an eleven-year experience. Eur J Radiol. 2011;80(3):792-795. Available from: https://www.ejradiology.com/article/S0720-048X(10)00531-0/abstract
5. VanderLaan PA. Fine-needle aspiration and core needle biopsy: An update on 2 common minimally invasive tissue sampling modalities. Cancer Cytopathol. 2016;124(12):862-870. Available from: https://doi.org/10.1002/cncy.21742
6. Novoa E, Gürtler N, Arnoux A, Kraft M. Role of ultrasound-guided core-needle biopsy in the assessment of head and neck lesions: a meta-analysis and systematic review of the literature. Head Neck. 2012;34(10):1497-1503. Available from: https://onlinelibrary.wiley.com/doi/10.1002/hed.21821
7. Ferreira VHC, Sassi LM, Zanicotti RTS, Ramos GHA, Jung JE, Schussel JL. Core needle biopsy in the diagnosis of head and neck lesions: a retrospective study of 3 years. Eur Arch Otorhinolaryngol. 2016;273(12):4469-4472. Available from: https://link.springer.com/article/10.1007/s00405-016-4139-6
8. Bowyer DJ, Smillie I, Ganly I. Diagnostic utility of freehand core-needle biopsy in head and neck masses. J Laryngol Otol. 2013;127(2):175-180. Available from: https://doi.org/10.1017/s0022215112002915
9. Nyquist GG, Tom WD, Mui S. Automatic core needle biopsy: a diagnostic option for head and neck masses. Arch Otolaryngol Head Neck Surg. 2008;134(2):184-189. Available from: https://jamanetwork.com/journals/jamaotolaryngology/fullarticle/408165#google_vignette
10. Apesteguía L, Pina LJ. Ultrasound-guided core-needle biopsy of breast lesions. Insights Imaging. 2011;2(4):493-500. Available from: https://insightsimaging.springeropen.com/articles/10.1007/s13244-011-0090-7
11. Kim SY, Chung HW, Oh TS, Lee JS. Practical Guidelines for Ultrasound-Guided Core Needle Biopsy of Soft-Tissue Lesions: Transformation from Beginner to Specialist. Korean J Radiol. 2017;18(2):361-369. Available from: https://doi.org/10.3348/kjr.2017.18.2.361
12. Al-Elq AH. Simulation-based medical teaching and learning. J Family Community Med. 2010;17(1):35-40. Available from: https://journals.lww.com/jfcm/fulltext/2010/17010/simulation_based_medical_teaching_and_learning.7.aspx

Citation: Heidari F, Mousavi-as B, Khamushian P, Razeghian H, Saeedi N, Mohebbi M, et al. Evaluation of a Training Course for Simulating Head and Neck Ultrasound-guided Core Needle Biopsy. Head Neck Oral Oncol. 2025;1(1):001-006. Available from:: https://dx.doi.org/10.17352/hnoo.000001

13. Nikendei C, Huber J, Stiepak J, Huhn D, Lauter J, Herzog W, et al. Modification of Peyton's four-step approach for small group teaching - a descriptive study. BMC Med Educ. 2014;14:68. Available from: https://bmcmededuc.biomedcentral.com/articles/10.1186/1472-6920-14-68

14. Pfeiffer J, Kayser L, Ridder GJ. Minimal-invasive core needle biopsy of head and neck malignancies: clinical evaluation for radiation oncology. Radiother Oncol. 2009;90(2):202-207. Available from: https://www.thegreenjournal.com/article/S0167-8140(08)00562-8/abstract

15. Franzén B, Auer G, Lewensohn R. Minimally invasive biopsy-based diagnostics in support of precision cancer medicine. Mol Oncol. 2024;18(11):2612-2628. Available from: https://doi.org/10.1002/1878-0261.13640

16. Schmidt G, Gerlinger C, Endrikat J, Gabriel L, Müller C, Baus S, et al. Teaching breast ultrasound skills, including core-needle biopsies on a phantom, enhances undergraduate students' knowledge and learning satisfaction. Arch Gynecol Obstet. 2021;304(1):197-202. Available from: https://doi.org/10.1007/s00404-021-06016-8

17. Cheng PC, Lo WC, Chang CM, Wen MH, Liao LJ. A Training Course for Simulating Head and Neck Ultrasound-Guided Procedures Using a Gelatin Phantom Model. Ann Otol Rhinol Laryngol. 2024;133(9):792-799. Available from: https://doi.org/10.1177/00034894241262113

18. McCrary HC, Faucett EA, Hurbon AN, Milinic T, Cervantes JA, Kent SL, et al. A Fresh Cadaver Model for the Instruction of Ultrasound-Guided Fine-Needle Aspiration of Thyroid Nodules. Otolaryngol Head Neck Surg. 2017;157(1):30-35. Available from: https://doi.org/10.1177/0194599817699596

19. Davis JR, Hale AL, Ewing JA, Lokey JS. Instituting Ultrasound-Guided FNA for Thyroid Nodules into a General Surgery Residency Program: What We Learned. J Surg Educ. 2018;75(3):594-600. Available from: https://doi.org/10.1016/j.jsurg.2017.09.031

20. Zhang YF, Li H, Wang XM. Technical Report: A Cost-Effective, Easily Available Tofu Model for Training Residents in Ultrasound-Guided Fine Needle Thyroid Nodule Targeting Punctures. Korean J Radiol. 2019;20(1):166-170. Available from: https://doi.org/10.3348/kjr.2017.0772

21. Farjad Sultan S, Shorten G, Iohom G. Simulators for training in ultrasound-guided procedures. Med Ultrason. 2013;15(2):125-131. Available from: https://www.medultrason.ro/simulators-for-training-in-ultrasound-guided-procedures/

22. Earle M, Portu G De, Devos E. Agar ultrasound phantoms for low-cost training without refrigeration. African Journal of Emergency Medicine. 2016;6(1):18-23. Available from: https://doi.org/10.1016/j.afjem.2015.09.003

23. Zhao X, Ersoy E, Ng DL. Comparison of low-cost phantoms for ultrasound-guided fine-needle aspiration biopsy training. J Am Soc Cytopathol. 2023;12(4):275-283. Available from: https://doi.org/10.1016/j.jasc.2023.03.005

24. Ni D, Chan WY, Qin J, Yim-Pan Chui, Ingrid Qu, Ho SS, et al. A virtual reality simulator for ultrasound-guided biopsy training. IEEE Comput Graph Appl. 2011;31(2):36-48. Available from: https://doi.org/10.1109/mcg.2009.151

25. Lin HC, Hwang GJ, Chou KR, Tsai CK. Fostering complex professional skills with interactive simulation technology: A virtual reality-based flipped learning approach. British Journal of Educational Technology. 2023;54(2):622-641. Available from: https://doi.org/10.1111/bjet.13268

26. Kleiman K, Zalasin S, Yalniz C, Zamora K, Li Y, Woodard S. Preliminary investigation: Feasibility study of a virtual reality breast biopsy simulation. Curr Probl Diagn Radiol. 2025;54(3):361-368. Available from: https://doi.org/10.1067/j.cpradiol.2024.10.034

27. Souza IA, Sanches C Jr, Zuffo MK. A virtual reality simulator for training in needle biopsy of thyroid gland nodules. Stud Health Technol Inform. 2009;142:352-357. Available from: https://pubmed.ncbi.nlm.nih.gov/19377183/

28. Magee D, Zhu Y, Ratnalingam R, Gardner P, Kessel D. An augmented reality simulator for ultrasound-guided needle placement training. Med Biol Eng Comput. 2007;45(10):957-967. Available from: https://doi.org/10.1007/s11517-007-0231-9

29. Bettati P, Chalian M, Huang J, Dormer JD, Shahedi M, Fei B. Augmented reality-assisted biopsy of soft tissue lesions. Proc SPIE Int Soc Opt Eng. 2020;11315:222-231. Available from: https://doi.org/10.1117/12.2549381

30. Mangalote IAC, Aboumarzouk O, Al-Ansari AA, Dakua SP. A comprehensive study to learn the impact of augmented reality and haptic interaction in ultrasound-guided percutaneous liver biopsy training and education. Artif Intell Rev. 2024;57(7):1-36. Available from: https://doi.org/10.1007/s10462-024-10791-6

31. Baniasadi T, Ayyoubzadeh SM, Mohammadzadeh N. Challenges and practical considerations in applying virtual reality in medical education and treatment. Oman Med J. 2020;35(3):1-10. Available from: https://doi.org/10.5001/omj.2020.43

32. Sohlin AM, Kjærgaard J, Hoffman IM, Chang TP, Poulsen A, Lee JY, et al. Immersive virtual reality training: Addressing challenges and unlocking potentials. Med Educ. 2025 Jun 15. Available from: https://doi.org/10.1111/medu.15748

Citation: Heidari F, Mousavi-as B, Khamushian P, Razeghian H, Saeedi N, Mohebbi M, et al. Evaluation of a Training Course for Simulating Head and Neck Ultrasound-guided Core Needle Biopsy. Head Neck Oral Oncol. 2025;1(1):001-006. Available from:: https://dx.doi.org/10.17352/hnoo.000001