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ORIGINAL RESEARCH

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Head and neck ultrasound training improves the diagnostic performance of otolaryngology residents

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Abstract

Objective: Surgeon-performed head and neck ultrasound (US) is increasingly used among otolaryngologists in office-based and surgical settings. However, it is unknown how formal US training affects otolaryngology residents' diagnostic workup of patients with cervical pathology. This study examined how a formal US course for residents affected their outpatient clinic US performance and diagnostic accuracy.

Methods: We conducted a randomized cross-over trial, where 13 otolaryngology residents participated in a 6-h formal US course. Participants were randomized to perform head and neck US on four patient cases before and after completing the course. Eight patients with and without neck pathology were invited to participate as test cases. The ultrasound examinations were video recorded and anonymized before two consultants rated the US performance using the Objective Structured Assessment of Ultrasound Skills (OSAUS) scale. Otolaryngology residents wrote an ultrasound report with a diagnosis based on their US examination, which was used to calculate the specificity and sensitivity.

Results: We found a statistically significant difference in the OSAUS score before compared to after the hands-on training ($p = .035$). The diagnostic accuracy also increased from 62% before the course to 75% after the course ($p = .02$). Specificity increased from 54% prior to the course to 62% following the course, and sensitivity increased from 64% prior to the course to 79% following the course. The intraclass correlation coefficient with "absolute agreement" was 0.63.

Conclusion: This study demonstrates that short, formal ultrasound training can improve otolaryngology residents' ultrasound skills and diagnostic accuracy in an outpatient clinic setting.

Lay summary: This study looks at the change of otolaryngology residents' diagnostic workup of patients after they take a formal ultrasound course and shows that they get better at using ultrasound and make more accurate diagnoses if they take a formal course.

Level of Evidence: Level 2.

KEYWORDS
competency-based assessment, diagnostic accuracy, head and neck ultrasonography, otolaryngology, surgeon-performed ultrasonography

1 | INTRODUCTION

Traditionally, head and neck ultrasound (US) has been performed in the radiology department,[1,2] but it is now expanding to office-based and surgical settings.[3,4] Surgeon-performed US can be used as an extension of the clinical examination to ensure faster diagnostic workup, guide biopsies, and perform minimally invasive treatments.[5–8] However, US is an operator-dependent imaging modality, and competency in head and neck US should be ensured among the clinicians conducting US for independent practice.[1] The American Institute of Ultrasound in Medicine and the European Federation of Societies for Ultrasound In Medicine and Biology recommend that physicians complete formal US courses as an essential part of training.[9,10] Still, only a few countries have incorporated formal ultrasound training into their otolaryngology residency programs.[11] A study from the United States found strong interest in surgeon-performed ultrasound among 78% of the otolaryngology residents, while only 24% had attended a formal ultrasound course.[12] Hands-on courses are also associated with considerable monetary cost and faculty time, and transferring skills learned in a simulated setting to clinical practice can be difficult.[13] This study, therefore, investigated whether a formal hands-on course in head and neck US can improve otolaryngology residents' ultrasound performance and diagnostic workup of patients with suspected neck pathology.

2 | MATERIALS AND METHODS

We conducted an experimental study measuring the ultrasound performance of otolaryngology residents before and after a formal head and neck ultrasound course. The participants conducted ultrasound examinations on patients and healthy volunteers that were video-recorded and assessed with the OSAUS scores (see Table 1) by two raters blinded to their identities afterwards. This project was granted ethical exemption in the form of an exemption letter from the regional ethical committee of the Capital Region of Denmark (Project-ID H-3-2013-081) and registered at ClinicalTrials.gov under the identifier NCT02304133. The otolaryngology residents and patients all gave informed consent to participate in this study.

2.1 | Setting, participants, and test setup

In Denmark, head and neck US has been an integrated part of the otolaryngology residency for a few decades. The residents receive bedside US teaching during their training and are expected to perform supervised US scans in the outpatient clinic. Further, they need to complete a mandatory 2-day formal US course, including hands-on training, during their second to third year of training. The hands-on head and neck US course in our study was held at Copenhagen University Hospital Rigshospitalet prior to the official residency-integrated US course. All residents who enrolled for the voluntary course were invited to participate in the study. Otolaryngology specialists were excluded.

We created a before-and-after setup in which we tested participants' US performance before and after the course. During this setup, the participants scanned eight different US cases: four before the course and four after the course. The participants were randomly assigned to one of two groups: group 1 scanned the first four US cases (cases A, B, C, and D) before the course, and group 2 scanned the latter four US cases (cases E, F, G, and H) before the course. After the course, group 1 scanned their remaining cases E, F, G, and H, and group 2 scanned their remaining cases A, B, C, and D (see Figure 1). The patients who were used for the ultrasound examinations in this study were the same as those previously used in a study exploring the validity evidence for using the OSAUS scale to assess head and neck ultrasound competence.[14]

Patient cases were spread at eight different stations with eight individual US machines (seven GE LOGIQ e machines and one GE Venue 40 machine, all with a linear Probe 4–12 MHz; GE Healthcare, Chicago, Illinois, USA). The participants were allowed to use a maximum of 4 min to complete a focused US scan, and afterward, they could use a maximum of 4 min to write down the US report, including a tentative diagnosis. Residents were given a blank paper to write down and document their diagnostic findings and diagnose.

2.2 | Intervention

A 6-h basic course in head and neck ultrasound was conducted following the ultrasound training recommendations from Hofer.[15] In our 6-h US course, approximately half of the time was allocated to didactic sessions and half for hands-on training on volunteer participants. The course themes covered knobology, systematic ultrasound examination, thyroid, salivary glands, lymph nodes, and various pathological conditions. See Appendix S1 for course program. The US course faculty consisted of a team of ultrasound experienced radiologists and head and neck surgeons.

TABLE 1 The objective structured assessment of ultrasound skills (OSAUS).

	1	2	3	4	5
1. Applied knowledge of ultrasound equipment	Unable to operate equipment		Operates the equipment with some experience		Familiar with operating the equipment
2. Image optimization	Fails to optimize images		Competent image optimization, but not done consistently		Consistent optimization of images
3. Systematic examination	Unsystematic approach		Displays some systematic approach		Consistently displays systematic approach
4. Interpretation of images	Unable to interpret any findings		Does not consistently interpret findings correctly		Consistently interprets findings correctly
5. Documentation of examination	Unable to interpret any findings		Does not consistently interpret findings correctly		Consistently documents relevant images

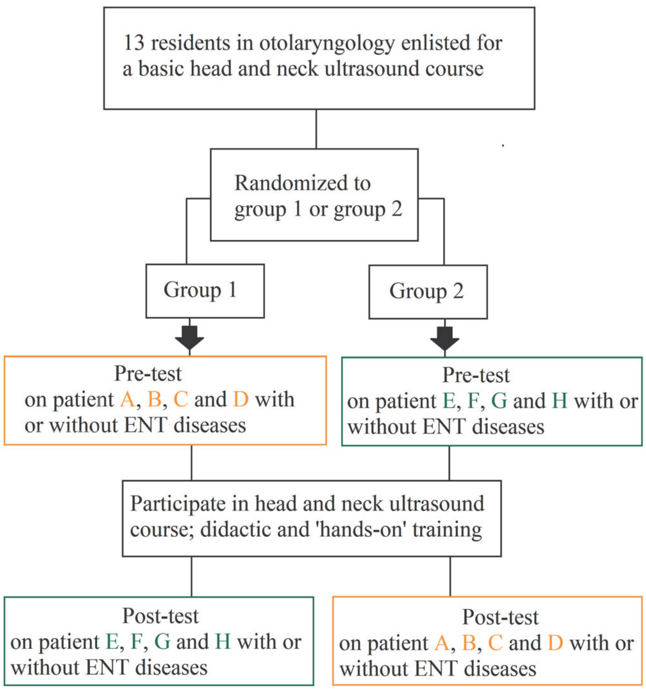

FIGURE 1 Flowchart of study design. ENT, ear, nose, and throat.

2.3 | Patient cases and video processing before performance rating

Healthy volunteers and patients with relevant neck pathology were invited to participate in the study as ultrasound cases. Six patients with sonographically verifiable pathology and two with normal necks were recruited from the Department of Otorhinolaryngology, Head & Neck Surgery, and Audiology, Rigshospitalet (see Table 2 for a description of cases and pathology). A short text at each station described the symptoms and objective findings of the case and directed the otolaryngology residents to perform a focused ultrasound examination to establish a diagnosis. The residents were only presented with written text descriptions of patient symptoms and objective findings as seen in "Description" Table 2, with no additional data such as lab values or imaging results provided.

The participants were video recorded while doing their US exams using a stationary tripod, filming the neck area of the patient. Simultaneously with the recording of the participant and patient, the US screen was recorded from the US machine. The video recordings of the ultrasound examinations were merged with the ultrasound screen recordings to form one clip (see Figure 2). Therefore, the assessors could review the ultrasound image and how the physician handled the equipment at the same time. The clip was anonymized because the video recording only displayed the neck area of the patient and the hands of the participant. Furthermore, the sound of the video recording was removed. The clip ended with the US description and tentative diagnosis proposed by the participant. Each video was randomized to an anonymous ID and stored in an arbitrary order for the raters to watch. All videos were blinded for identity and available for performance rating on an encrypted online database on Vimeo.

2.4 | Outcome and performance ratings

All the video clips with recorded ultrasound examinations were assessed individually by two US experienced consultants in otolaryngology surgery who also teach national and international US courses. Prior to the data acquisition, the two consultants participated in a 60-min rater training session with an introduction to the use of the OSAUS rating scale. Afterward, they OSAUS scored three video clips demonstrating different performances of head and neck ultrasound (not used in the main study) and discussed their ratings until a consensus was reached.

The raters accessed the US cases through an encrypted online database. REDCap electronic data capture tools hosted at Rigshospitalet were used to collect and manage study data.[16,17] The validated OSAUS scale was used for performance rating, consisting of the following items: (1) Applied knowledge of ultrasound equipment; (2) image optimization; (3) systematic examination; (4) interpretation of images; (5) documentation of examination.[14]

The written US findings were assessed by a third consultant in otolaryngology surgery (JM), who evaluated the participants written documentation of their ultrasound findings blinded to their ultrasound performance. Their diagnosis was classified as either "correct" or

TABLE 2 Patient cases presented to the participants and percentage of correct diagnoses before and after intervention.

Case	Presentation	Task	US findings	Accepted HNUS diagnosis	Histopathological diagnosis	Percentage of correct diagnoses before course	Percentage of correct diagnoses after course
A[a]	The patient describes a sensation of tightness from the left side of the neck.	Examine the thyroid gland with US.	A nodule in the left thyroid gland.	Solitary thyroid nodule	Colloid thyroid adenoma	50%	100%
B	The patient complains about a swelling from the right cheek.	Examine the parotid gland with US.	A tumor in the right parotid gland.	Parotid tumor	Pleomorphic adenoma	83%	86%
C	The patient complains about pain from the right submandibular gland area.	Examine the right submandibular gland with US.	No pathology, normal US anatomy.	No pathology	–	67%	57%
D[a]	The patient complains about a swelling under the chin.	Examine the floor of the mouth with US.	A process in the sublingual space.	Cystic process or hypoechoic lipoma	Lipoma	50%	71%
E[a]	The patient complains about a feeling of a lump in the throat.	Examine the thyroid gland with US.	No pathology, normal US anatomy.	No pathology	–	43%	67%
F[a]	You palpate an indolent lump on the left side of the neck.	Examine the left side of the neck with US.	A branchial cyst in the lateral neck.	Cystic lesion	Epidermal inclusion cyst	50%	67%
G	You palpate a soft mass under the tongue during the physical examination.	Examine the floor of the mouth with US.	Ranula of the floor of the mouth.	Ranula or lymphatic malformation	Lymphatic malformation	57%	83%
H[a]	You palpate a lump on the right side of the neck.	Examine the right side of the neck with US.	Lymphoma.	Lymph node metastases or malignant lymphoma	Metastatic lymph node from squamous cell carcinoma	100%	67%

Abbreviations: HN, head and neck; US, ultrasound.
[a]Cases used for video assessment.

"incorrect" and used to calculate a diagnostic accuracy score in percentage for each participant before and after training.

3 | STATISTICS

A mean OSAUS score for each US case was calculated based on both raters' assessments. A total mean OSAUS score for the participant was then based on the mean OSAUS score for each case. The pre-group OSAUS score was calculated from both pre-groups' mean scores. Then, the mean scores from both post-groups were used to calculate the post group's total OSAUS score. The total OSAUS score from the groups before and after intervention was compared using a paired sample *t*-test. The final OSAUS score was calculated as percentage out of 100% (equal to an OSAUS score of 5) for easier interpretation. To assess the yield of the intervention, Cohen's *d* was used for effect size, considering values above 0.2 to be small, values above 0.5 to be medium, and values above 0.8 to be large.[18]

Comparisons of the diagnostic accuracy, specificity, and sensitivity were explored as binary data (correct or incorrect) by comparing the number of correct diagnoses before and after the course with McNemar's Chi-squared test. Intraclass correlation coefficient (ICC) with "absolute agreement" was used to analyze interrater reliability. Values <0.5 were considered to have poor reliability, values between

FIGURE 2 Image of an anonymized video clip as presented to the rater demonstrating an ultrasound examination by a study participant.

TABLE 3 Demographics of the participants.

	Overall N = 13	Group 1 N = 6	Group 2 N = 7
Sex, male (%)	7 (54%)	4 (67%)	3 (43%)
Mean age (range)	31.8 (26–40)	32.3 (27–40)	31.3 (26–37)
Mean neck US-scans performed (range)	57 (0–200)	52 (0–175)	62 (6–200)
Mean other US-scans performed (range)	2 (0–10)	0	4 (0–10)
Mean years' experience as physician (range)	4.5 (0–11)	5 (0.5–11)	4.2 (1–9)
Formal US training, yes (%)	6 (46%)	2 (33%)	4 (57%)

Abbreviation: US, ultrasound.

0.5 and 0.75 as moderate reliability, and values above 0.75 as good reliability.[19]

The results were considered statistically significant when $p < .05$. The statistical analysis was performed with RStudio, version 2022.07.1, Build 554.

4 | RESULTS

We enrolled 13 otolaryngology residents in the study, with seven (54%) being male. The mean age was 31.8 (interquartile range, IQR = 8), and they had performed a mean of 57 neck US exams prior to the study (ranging from 0 to 200). Six of the 13 participants had participated in some form of introductory formal US training before this course. The demographics and levels of the residents are shown in Table 3. Thirteen participants scanned eight patient cases, resulting in a total of 104 US cases. Table 2 shows the eight patient cases. See Table 4 for the mean OSAUS score stratified by cases and groups.

Due to technical problems, only five of the eight cases were video recorded and available for evaluating OSAUS scores. The written US findings were available for all eight cases, which were used for evaluating the diagnostic accuracy.

The mean OSAUS score was significantly higher after the course, at 46.9 (Standard Deviation (SD) = 9.3) before the course compared to 53.8 (SD = 9.5) after the course ($p = .035$; see Figure 3). After the training, the percentage of correct diagnoses was significantly better, with 62% correct diagnoses before the course and 75% correct diagnoses after the course ($p = .02$). The specificity of the participants increased from 54% before the course to 62% after the course, and their sensitivity increased from 64% before the course to 79% after the course. The intraclass correlation coefficient (ICC) with "absolute agreement" for the two raters was 0.63, equivalent to moderate reliability, and the Cohen's *d* effect size for the study participants was 0.73.

5 | DISCUSSION

This study found that otolaryngology residents can successfully transfer the skills from a formal 6-h neck ultrasound course to improve the diagnostic performance of patients with neck pathology. Both their ultrasound performance (measured with the OSAUS scale) and their diagnostic accuracy significantly improved after completing the course.

TABLE 4 The mean OSAUS-score stratified by case and group (transparent boxes correspond to group 1 and shadowed boxes correspond to group 2).

Case	A	D	E	F	H
Mean OSAUS-score before intervention	42.4 (SD 11.2)	49.4 (SD 9.6)	49.8 (SD 13.6)	43.6 (SD 12.4)	50.2 (SD 11.8)
Mean OSAUS-score after intervention	58.2 (SD 7.6)	56.6 (SD 12.6)	54 (SD 14.4)	47 (SD 8.4)	47.6 (SD 14.2)

Abbreviation: OSAUS, objective structured assessment of ultrasound skills.

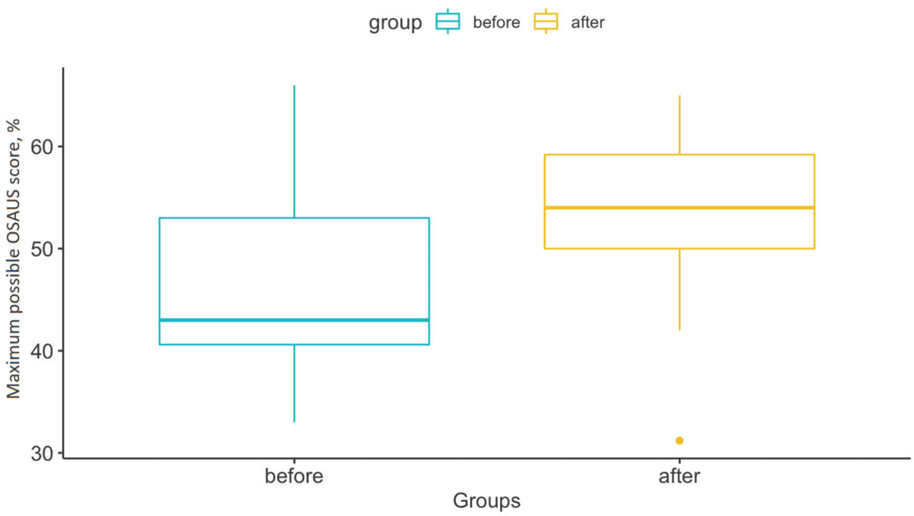

FIGURE 3 Boxplot of the mean OSAUS-score before and after the intervention. Boxes enclose the middle half of the sample, with the upper end representing the upper quartile and the lower end representing the lower quartile. Whiskers going vertically from the two ends of the box represent the sample maximum and sample minimum. The bold horizontal line across the box represents the sample median. OSAUS, objective structured assessment of ultrasound skills.

A strength of our study is the randomized trial design with real patients, which allows us to compare the ultrasound performance in real clinical practice before and after the course. Our randomization was done to prevent an ultrasound case from influencing the US performance rating. If all the participants scanned the same US cases before and after the course, there would be a risk of the participants remembering the same cases, resulting in a measurement of memory rather than the effect of the course. With our randomization, we prevent this, and the participants see new cases after the course.

It is more effective to test the transfer of skill with a transfer test than with a theoretical MCQ or a simple retention test. We assessed the ultrasound competence on real patients using a validated objective assessment tool to ensure reliable assessment.[20] Furthermore, a big strength of our study is that we used both patients with and without pathologies, which allowed us to evaluate both the sensitivity and specificity of the participants ultrasound examinations. We therefore believe these results can be generalized to a clinical setting at the hospital.

Our study also has some limitations to consider. According to motor skill learning theory, the participants might have artificially increased performance scores in a post-test immediately after training due to using short-term memory. A retention test is instead recommended to ensure the skills have been learned and stored in long-term memory. However, we conducted instead a transfer test—in which participants must adapt the US skill they have practiced on normal anatomy to scan real pathology—and should thereby assess the actual learning of the participants.[21] Furthermore, we found an interrater reliability rating with a moderate level of reliability. Both raters had higher total OSAUS scores after the course, and moderate reliability should therefore not have an essential impact on our results. Another limitation is that, due to technical limitations, we video recorded five of the eight ultrasound cases in the study. Although we could only perform an OSAUS assessment in five cases, it is still sufficient for reliable skills assessment.[20] While participants' hands and use of the US probe were video recorded, the presence of rings, fingernail painting, or other characteristic skin markings may prevent full ability to "blind" raters to the study participants.

To our knowledge, this is the first experimental study performing an objective US skills assessment of otolaryngology residents before and after formal US training. Prior studies have primarily performed knowledge testing with multiple-choice questionnaires or surveys on medical students.[22–25] In contrast, we performed a transfer test of performance on real patients, corresponding to the highest assessment level on Miller's pyramid.[26] Our findings are comparable to those of a study in rural Kenya that found that an ultrasound boot camp for otolaryngologists improved their US performance.[27] In contrast to our study, the participants' performance was assessed by unblinded raters on normal cases without pathology. Another study found that the combination of surgeon-performed ultrasound with preoperative studies showed remarkable accuracy in predicting cure rates, also offering strong support for the integration of surgeon-performed ultrasound into otolaryngology resident training.[28] Our findings indicate that otolaryngology residents can use US to improve the diagnostic workup of patients in the outpatient clinic after completing a short hands-on course. Surgeon-performed ultrasound can therefore be used in a one-stop cancer clinic, where referrals to radiologist-performed diagnostic US and US-guided biopsies may be avoided. The residents in our study had prior neck US experience (mean neck US scans = 57), yet their performance improved following the course. While their US performance significantly improved after the hands-on training, they did not reach a sufficient assessment score for independent practice, and further clinical training was therefore needed. Future research should investigate the learning curve for surgeon-performed neck US after completing a formal course and how to integrate training in US-guided interventions.

6 | CONCLUSION

In conclusion, this study shows that a formal hands-on neck ultrasound course can improve the ultrasound performance and diagnostic accuracy of otolaryngology residents. Our study suggests that it is important to include formal ultrasound training as a part of a competency-based training curriculum.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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