Manuscript Details

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Abstract

Objective: To describe the conception and evaluation of a novel educational intervention to teach Direct Ophthalmoscopy with retinal simulators using a peer-assessed Group Objective Structured Clinical Examination (OSCE) format. Design: Prospective, single-centre educational trial at Oxford University Medical School, Oxford, UK. Participants: 160 consecutive undergraduate fifth-year medical students participated in the study. Methods: Students identified prior experience, teaching, examination and feedback relevant to direct ophthalmoscopy. Students self-evaluated perceived confidence across 6 domains of direct ophthalmoscopy examination prior to, and following, the educational intervention using a Likert-type psychometric scale. Wilcoxon matched pair testing was used to determine statistical significance for each domain. Results: The Group OSCE intervention increased confidence in direct ophthalmoscopy overall from 2.5% to 63.8% ($p<0.001$). Confidence improved in all 6 domains, most significantly in controls of ophthalmoscope ($p<0.001$) and sequence of examination ($p<0.001$) but also in the identification and interpretation of retinal signs ($p<0.001$). Students rated the tutorial as very effective or effective across all 6 domains, and 96.29% rated the tutorial as effective overall. Conclusions: Retinal simulation, integrated with a peer-assessed Group OSCE format, is effective in increasing confidence in all aspects of direct ophthalmoscopy. It may be insufficient alone for training in the identification and interpretation of posterior segment clinical signs. Diminishing ophthalmology clerkships worldwide require ophthalmologists to identify innovative teaching methods, utilising modern technology and pedagogy to deliver high-quality, yet high-throughput training in direct ophthalmoscopy. This novel teaching strategy may be considered by ophthalmologists responsible for direct ophthalmoscopy training in a teaching hospital context.

Keywords	Direct ophthalmoscopy; direct ophthalmoscope; group OSCE; peer-assessment; simulation; undergraduate ophthalmology
Manuscript category	Medical Education

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16th August 2016

Dear Editor,

We wish to re-submit this original research study for consideration of publication in your *Journal*. We have responded to the reviewers comments, addressing each in full, point-by-point.

The undergraduate ophthalmology clerkship is gradually being supplanted from the medical curriculum, worldwide. With technological advances in clinical simulation, and the emergence of modern pedagogy, novel methodologies in teaching must be identified by ophthalmologists to enhance student learning during a short period of exposure to clinical ophthalmology.

Over the course of four years, we at Oxford University have conceived, delivered and evaluated a novel tutorial that we hope may be of relevance to a global audience. Large student numbers in this study permit a detailed analysis of the efficacy of the tutorial across all domains of direct ophthalmoscopy.

We believe this study has identified an effective, yet high-throughput teaching methodology for undergraduates learning direct ophthalmoscopy. We have provided extensive supplementary material to enable your readership worldwide to accurately reproduce the details of the tutorial, and be of practical value in medical student teaching within our discipline.

There are no financial conflicts of interest in the subject matter of the submitted manuscript.

We thank you for your consideration.

With best wishes,

Mr Imran Yusuf

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Response to reviewers comments

1 The first sentence in the introduction is not necessary for the journal's audience.

This has been removed

2 In the introduction, the 1st sentence in the 3rd paragraph needs a colon as opposed to a period at the end.

This has been amended

3 I would include a sentence in the first paragraph of the "Format of DO tutorial" section that introduces the 2 groups for reader orientation (for those who don't immediately turn to the supplement). For example: "Students worked in 2 groups: Group 1 did an OSCE and group 2 used the retinal simulator."

This has been added

4 Supplement 3 is referred to prior to supplement 2?

This has been re-ordered so that Supplement 2 is referred to prior to Supplement 3.

5 I am curious as to why the tutor-led presentation regarding retinal pathology is done last as opposed to prior to group 1 and 2 work. Wouldn't this help orient the learner? Perhaps this rationale could be explained in the manuscript.

We have added: "This was conducted at the end of the tutorial rather than at the beginning as many of the students had undertaken their ophthalmology clerkship previously. It was considered that the students would have a working knowledge of key ophthalmic pathologies to permit participation in this learning event."

Fig 1a and 1b are not necessary.

These, and their Figure legends have been removed.

Integrating Retinal Simulation with a Peer-Assessed Group OSCE Format to Teach Direct Ophthalmoscopy

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Short title: Direct Ophthalmoscopy using Retinal Simulators

Keywords: Direct ophthalmoscopy; direct ophthalmoscope; group OSCE; peer-assessment; simulation; undergraduate ophthalmology

Abstract

Objective: To describe the conception and evaluation of a novel educational intervention to teach Direct Ophthalmoscopy with retinal simulators using a peer-assessed Group Objective Structured Clinical Examination (OSCE) format.

Design: Prospective, single-centre educational trial at Oxford University Medical School, Oxford, UK.

Participants: 160 consecutive undergraduate fifth-year medical students participated in the study.

Methods: Students identified prior experience, teaching, examination and feedback relevant to direct ophthalmoscopy. Students self-evaluated perceived confidence across 6 domains of direct ophthalmoscopy examination prior to, and following, the educational intervention using a Likert-type psychometric scale. Wilcoxon matched pair testing was used to determine statistical significance for each domain.

Results: The Group OSCE intervention increased confidence in direct ophthalmoscopy overall from 2.5% to 63.8% ($p<0.001$). Confidence improved in all 6 domains, most significantly in controls of ophthalmoscope ($p<0.001$) and sequence of examination ($p<0.001$) but also in the identification and interpretation of retinal signs ($p<0.001$). Students rated the tutorial as very effective or effective across all 6 domains, and 96.29% rated the tutorial as effective overall.

Conclusions: Retinal simulation, integrated with a peer-assessed Group OSCE format, is effective in increasing confidence in all aspects of direct ophthalmoscopy. It may be insufficient alone for training in the identification and interpretation of posterior segment clinical signs. Diminishing ophthalmology clerkships worldwide require ophthalmologists to identify innovative teaching methods, utilising modern technology and pedagogy to deliver high-quality, yet high-throughput training in direct ophthalmoscopy. This novel teaching strategy may be considered by ophthalmologists responsible for direct ophthalmoscopy training in a teaching hospital context.

Introduction

~~Direct Ophthalmoscopy is an examination technique that utilises a direct ophthalmoscope to examine the retina and optic nerve of a patient's eye.~~ Competent examination by direct ophthalmoscopy may be undertaken by specialists or general internists to elicit clinical signs contributing to the diagnosis of a sight- or life- threatening disease, and consequently improve patient outcome. It is important that medical students learn to perform direct ophthalmoscopy competently.

Direct ophthalmoscopy training at undergraduate level has become increasingly challenging. Firstly, ownership of ophthalmoscopes has fallen following withdrawal of bursaries traditionally used to fund them[1]. Secondly, the duration of undergraduate clerkships in ophthalmology are falling worldwide[2, 3]; some medical schools do not offer any formal clinical placement in ophthalmology[3]. Thirdly, there is some difference of opinion from international bodies and researchers on the level of competency in direct ophthalmoscopy that an undergraduate should satisfy[2, 4]. These factors in combination have undermined clinical training; as a consequence, many undergraduates have little or no confidence in direct ophthalmoscopy[5].

Concurrent advances in simulation technology and educational pedagogy offer significant potential for augmenting clinical skills training across medical and surgical specialties~~:~~. (1) Simulation: improved technology has yielded high-fidelity recreation of clinical pathology outside the clinical context for training (2) Formative assessment: increasing trend in medical education towards formative rather than traditional summative assessment, elevating student learning over performance grading (3) Peer-assessment: utilising students as examiners, involving mandatory engagement with assessment criteria with improved understanding of the definitions of "competence" in a given skill (4) Emerging examination-oriented formats: such as Group Objective Structured Clinical Examination (OSCE) which engages students around a simulated examination environment.

Ophthalmologists, in response to such challenges, must lead the development of innovative teaching methods that combine advances in proven educational methodologies to deliver high-quality practical skills training in direct ophthalmoscopy. We designed an innovative peer-assessed Group OSCE tutorial to teach direct ophthalmoscopy to medical students using retinal simulators, delivered as part of an educational trial at Oxford Medical School.

Methods

Conception and Funding of Direct Ophthalmoscopy Tutorial

The direct ophthalmoscopy tutorial was conceived and developed in consultation with a tutor (Dr Kathleen Quinlan) at the Oxford Learning Institute (17 St. Ebbes Street, Oxford, UK), as part of a portfolio submitted for a Postgraduate Diploma in Education (PG Dip Ed.) by IHY. A formal application for funding for 20 direct ophthalmoscopes (Welch Allyn, Buckinghamshire, UK) and 4 retinal simulators (Adam,Rouilly, Kent, UK)- specific requirements for the tutorial outline - was made to the Nuffield Oxford Hospitals Fund (NOHF), whose trustees approved the contribution (Reference: Fund 7300, Grant 84009) in 2010.

Student participants

Approval for the compulsory integration of the direct ophthalmoscopy tutorial as part of the year 5 tutorial series in ophthalmology was granted by the Head of Clinical Studies at Oxford Medical School for the 2012-13 academic year. Institutional Review Board ethical approval was not considered necessary locally for this study. The study was in adherence with the tenets of the Declaration of Helsinki. 160 consecutive fifth-year medical students (one year group) who had successfully completed pre-clinical studies were included. No students were excluded. 78 were female and 82 were male (range: 21-37; mean 23 years).

Format of Direct Ophthalmoscopy tutorial

A full outline of the structure of the tutorial is detailed in **Supplement 1**. Briefly, 160 students undertook the tutorial in groups of approximately 28. A pre-tutorial feedback form was completed, stating prior experience, training, assessment and feedback in DO ~~**(Supplement 3)**~~**.** Self-rated confidence in all aspects of direct ophthalmoscopy was established. A 25-minute introduction was delivered outlining indications for and value of direct ophthalmoscopy, a description of the ophthalmoscope and controls, and a practical demonstration of a competent examination by direct ophthalmoscopy. Students worked in 2 groups: Group 1 did an OSCE and group 2 used the retinal simulator.

The tutorial then entered into a peer-assessed Group OSCE format. Students in Group 1 participated in groups of 3: one acted as examiner, one as a candidate, and the third as a patient subject. ~~(Figure 1, top left).~~ The emphasis of assessment related to patient approach and direct ophthalmoscopy technique. Laminated instruction sheets were prepared for candidates describing an OSCE-style scenario. Simultaneously, the examiner read laminated assessment criteria, and officiated a 5-minute time period for the OSCE station. The examiner graded the student on a scale of 1-5 according to the assessment criteria, and provided verbal feedback (3 minutes). The students then rotated three times, such that each acted as the examiner and the candidate (30 minutes). Examples of candidate instruction sheets and assessment criteria are provided in **Supplement 2**.

Group 2 simultaneously worked in groups of 2-3 using the retinal simulators with emphasis directed towards identification and interpretation of clinical signs. ~~(Figure 1, top right).~~ 4 groups worked around 4 retinal simulators (Adam,Rouilly, Kent, UK) **(Figure 1, middle left & right)**, each with three discrete pathological retinal slides matching to three unique clinical scenarios and marking criteria for each station **(Supplement 2)**. Twelve key simulated retinal pathologies were selected in total: central retinal vein occlusion **(Figure 1, bottom left)**, central retinal artery occlusion, glaucoma, papilledema **(Figure 1, bottom right)**, optic atrophy, treated proliferative diabetic retinopathy with pan-retinal photocoagulation scars, exudative age-related macular degeneration, hypertensive retinopathy, retinal detachment, cytomegalovirus retinitis, retinitis pigmentosa and choroidal melanoma. The assessment criteria integrated three viva-style questions posed to the candidate, with responses graded by the examiner. Each student acted as examiner and candidate, and timings mirrored those in Group 1.

After 30 minutes, the students alternated, such that Group 1 performed the Group OSCE with retinal simulators, and Group 2 with other students. Each student was given two grades for their formative benefit. Three tutors (IHY, TMHF, ZS) supervised, answered questions and ensured compliance with the teaching format, but *never* assessed any student.

A 20-minute presentation illustrating retinal and optic nerve pathologies that were encountered with the retinal simulators was undertaken with the entire group. This was conducted at the end of the tutorial rather than at the beginning as many of the students had undertaken their ophthalmology clerkship previously. It was considered that the students would have a working knowledge of key ophthalmic pathologies to permit participation in this learning event. Identification of clinical signs, image interpretation and further management were the focus of the

presentation. In the final 5 minutes, students had opportunities for questions and discussion. Feedback forms were then completed (Supplement 3).

Student Evaluation

Prior experience, training and assessment in direct ophthalmoscopy were established through questionnaires completed by each student. Comprehensive pre- and post-tutorial self-evaluation of perceived competence across 6 domains of direct ophthalmoscopy was evaluated using a 5-point Likert-type psychometric scale **(Supplement 3)**. Efficacy of the tutorial in teaching each component of direct ophthalmoscopy and the students' perceptions of GOSCE format in relation to other traditional teaching formats were evaluated.

Statistical analysis

Wilcoxon matched pairs testing was used to analyse differences between pre-tutorial and post-tutorial self-evaluation of confidence across all 6 domains of direct ophthalmoscopy examination. The value for normality was set at p=0.05. Data, where applicable, were reported as mean±standard deviation.

Results

Experience, Teaching, Assessment and Feedback in Direct Ophthalmoscopy

Experience of direct ophthalmoscopy in a clinical setting was limited; only 43.7% (70/160) of students had performed DO more than twice in this context. Direct ophthalmoscopy experience on peers or volunteers was much higher with 92.5% (148/160) of students performing direct ophthalmoscopy more than once in this setting.

Most students (96.7%, 155/160) had received some training in direct ophthalmoscopy. However, only 6.85% had received formal practical session with a clinician, and only 20.84% (33/160) had received formal practical training. 75.90% (121/160) of students had received only passive instruction in direct ophthalmoscopy through observation.

Assessment in direct ophthalmoscopy was rare: the majority of students had received no formal assessment (83.34%, 133/160). None had undertaken a formative or summative OSCE examination in direct ophthalmoscopy, with only 16.6% assessed by a clinician in any context. Some participants had received feedback in a clinical skills laboratory (28.06%, 45/160), and 22.80% (36/160) had received feedback from a clinician in a clinical setting. However, 49.12% (79/160) had received no feedback in direct ophthalmoscopy **(Supplement 4).**

Student confidence prior to educational intervention

Prior to the tutorial, most students reported having little (56.6%, 91/160) to no confidence (12.0%, 19/160) in direct ophthalmoscopy overall; only 2.52% (4/160) reported confidence, but none "very confident". Many students reported being very confident or confident in the initial introduction and consenting of the procedure (55.0%), but were poorly confident in identifying controls on the ophthalmoscope (15.1%), sequence of examination (8.6%), identifying normal retinal anatomy (2.2%), identifying (0%) and interpreting clinical signs (1.1%) **(Table 1).**

Efficacy of educational intervention on self-evaluated confidence in Direct Ophthalmoscopy

Following the educational intervention, 63.81% of students (compared to 2.52% prior to the tutorial) reported being confident to very confident with direct ophthalmoscopy overall (p <0.001). The tutorial increased confidence in all 6 domains of direct ophthalmoscopy examination (p <0.001), in particular with introduction and consent (98.45%), controls of the ophthalmoscope (89.20%) and sequence of examination (88.27%). Students were more confident with identifying normal retinal anatomy (51.9%), identifying clinical signs (33.1%) and interpretation (33.1%) (p <0.001 for each domain) **(Table 2).**

Student perceptions of efficacy of educational intervention

Students were asked directly about the efficacy of the tutorial in teaching each component of direct ophthalmoscopy: 96.3% felt it was very effective or effective for teaching direct ophthalmoscopy overall. Applications of direct ophthalmoscopy to general and emergency medicine (82.0%), functions of the ophthalmoscope (84.5%), approach to patient pre-examination (98.8%), practical conduct of direct ophthalmoscopy examination (98.8%), and interpretation of key posterior segment signs (83.2%) were all evaluated as very effective or effective by the student cohort **(Table 3).**

Discussion

Simulation is recognized as an effective means of establishing technical skills in a protected environment, particularly for inexperienced students. Improvised model eyes have been utilised for some time to build confidence before clinical encounters with patients[6]. Internet-based assessments[7], and peer fundus photographs distributed to encourage identification of normal anatomy with use of the direct ophthalmoscopy [8] both illustrate the need for self-directed learning outside of ophthalmic clinics. Whilst such strategies are helpful, simulated pathology, online assessment, and task-directed learning cannot in isolation provide all essential facets of high-quality training in direct ophthalmoscopy: thorough instruction, opportunities to practice the sequence of examination, simulation of retinal pathology, interpretation of pathology – with objective and structured formative feedback individualised to the candidate in each domain to augment all components of proficient direct ophthalmoscopy.

Peer-assessment in adult learners is a powerful method that guarantees the mandatory understanding of the definition of "competence" by the student examiner. Peer-assessment is unquestionably active: two candidates learn simultaneously and inter-dependently. Simulated examination formats set a powerful context for peer-assessment. They demonstrate four main advantages: (1) Students are familiar with their structure (ie, OSCE) and implicitly understand their practical conduct (2) An examination context arouses focus and concentration in adult learners who are eager to perform well (3) Simulation of direct ophthalmoscopy examination ascribes prominence to the topic in strategic learners: it is recognized that students focus their learning increasingly around likely examination content rather than syllabi (4) Development of insight: students are exposed to a range of peer-abilities and gain insight into their level of competence (a student will compare their feedback against peers).

Although formative assessment was traditionally applied to a single examiner and candidate, an emerging paradigm in medical education is the recognition of the potential of simulated OSCE experiences for formative peer-feedback in a group context. A group OSCE allows a cluster of students to collectively identify the difficulties experienced, and engage all participants around their own learning - the essential characteristics of a deep approach to learning[9]. Group OSCEs and Team OSCEs have been demonstrated effective in integrating peer feedback of a clinical skill with a deeper understanding of the assessment criteria used to grade performance[10-12]. Although no formal comparative study has been undertaken, team OSCEs may be better suited to the reinforcement of established clinical skills where the additional facet of competition may judge the ability of a student to perform under pressure and scrutiny. Group OSCEs may be better suited to the development of clinical skills in poorly confident students by engendering an atmosphere of parity, on which competence can be collectively established: this is the likely scenario with direct ophthalmoscopy.

Peer-feedback is considered beneficial in providing insight into performance, particularly in settings where student: tutor ratios are low[13]. This is likely to be the case in ophthalmic clinics in teaching hospitals with responsibility for training large cohorts of medical students. Student examiners were found to be equally capable to faculty examiners in a formative OSCE context both in scoring a candidate and providing feedback[14]. Group work when tailored sensitively to the student group size and characteristics has been shown to permit students to engage more deeply with the subject matter[15]. Two studies explored iteratively putting candidates through three OSCE stations, as the candidate, the observer and the examiner finding particular strengths in the transparency of the goals of the learner and the emphasis on immediate feedback[16].

Despite the findings of improved confidence in all domains of direct ophthalmoscopy examination in this study, it is likely that identification and interpretation of retinal signs requires further training. Predictably, students identified retinal signs more accurately when examining fundus photographs than using retinal simulators or human volunteers, as this eliminates the barrier of a technical skill (direct ophthalmoscopy) to visualise them[17]. This tutorial engages students with all three modalities – human volunteers, retinal simulators and fundus photographs - each of which emphasises particular aspects of direct ophthalmoscopy examination: approach to patient, identification of clinical signs, and interpretation of clinical signs – all recommended in the objectives of undergraduates in direct ophthalmoscopy examination[4].

We acknowledge the potential for bias in student responses who may respond favourably to tutors who provide highly-organised teaching of this nature. Data was collected anonymously and could not be traced to the student participant. Subjective measures of confidence may be considered a lower-fidelity outcome measure of an educational intervention when compared to objective measures of competence. However, self-rated confidence has been demonstrated predictive of competence after a specific training intervention in which insight is acquired[18, 19]. No correlation between pre-training confidence and competence was identified[18], although pre-tutorial evaluation of confidence was useful for baseline comparison in this study.

Confidence may also be a valuable outcome measure in predicting the likelihood that a clinical skill will be utilised in a clinical context[20]; consistent performance of direct ophthalmoscopy is likely to augment competence through continued practice. It has been demonstrated, that in the absence of practice, longitudinal ophthalmology skills erode significantly over a 3-year period[21]. Whilst the outcome measures in this study are not objective, we believe them to be valid in the context of the above evidence with adult learners.

Conclusions

Direct Ophthalmoscopy, performed competently, may elicit signs of sight- or life-threatening pathology. This novel study demonstrates the efficacy of an experimental educational approach that combines retinal simulation with modern pedagogical methods of formative peer-assessment within a Group OSCE format to teach direct ophthalmoscopy to undergraduate medical students. The advantage of this technique is that it offers both high-quality and high-throughput training by engaging medical students with the examination criteria (as peer-assessors), permitting intensive technical feedback on direct ophthalmoscopy with small numbers of tutors acting only as facilitators.

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Contributions of authors:

Design of the study (I.H.Y, E.R, T.F., Z.S, C.K.P.)

Conduct of the study (I.H.Y, E.R, T.F., Z.S, C.K.P.)

Collection and management of the data (I.H.Y, E.R, T.F., Z.S, C.K.P.)

Analysis and interpretation of the data (I.H.Y, E.R, T.F., Z.S, C.K.P.)

Preparation and review of the manuscript (I.H.Y, E.R, T.F., Z.S, C.K.P.)

Approval of the manuscript (I.H.Y, E.R, T.F., Z.S, C.K.P.)

References

1. McNaught AI, Pearson RV. Ownership of direct ophthalmoscopes by medical students. *Medical education*. 1992;**26**:48-50.

2. Mottow-Lippa L. Ophthalmology in the medical school curriculum: reestablishing our value and effecting change. *Ophthalmology*. 2009;**116**:1235-6.

3. Baylis O, Murray PI, Dayan M. Undergraduate ophthalmology education - A survey of UK medical schools. *Medical teacher*. 2011;**33**:468-71.

4. Benbassat J, Polak BC, Javitt JC. Objectives of teaching direct ophthalmoscopy to medical students. *Acta ophthalmologica*. 2012;**90**:503-7.

5. Gupta RR, Lam WC. Medical students' self-confidence in performing direct ophthalmoscopy in clinical training. *Canadian Journal of Ophthalmology*. 2006;**41**:169-74.

6. Chung KD, Watzke RC. A simple device for teaching direct ophthalmoscopy to primary care practitioners. *American journal of ophthalmology*. 2004;**138**:501-2.

7. Asman P, Linden C. Internet-based assessment of medical students' ophthalmoscopy skills. *Acta ophthalmologica*. 2010;**88**:854-7.

8. Milani BY, Majdi M, Green W, Mehralian A, Moarefi M, Oh FS, et al. The use of peer optic nerve photographs for teaching direct ophthalmoscopy. *Ophthalmology*. 2013;**120**:761-5.

9. Rushton A. Formative assessment: a key to deep learning? *Med Teach*. 2005;**27**:509-13.

10. Biran LA. Self-assessment and learning through GOSCE (group objective structured clinical examination). *Med Educ*. 1991;**25**:475-9.

11. Hill DA, Guinea AI, McCarthy WH. Formative assessment: a student perspective. *Med Educ*. 1994;**28**:394-9.

12. Singleton A, Smith F, Harris T, Ross-Harper R, Hilton S. An evaluation of the Team Objective Structured Clinical Examination (TOSCE). *Med Educ*. 1999;**33**:34-41.

13. Brazeau C, Boyd L, Crosson J. Changing an existing OSCE to a teaching tool: the making of a teaching OSCE. *Acad Med*. 2002;**77**:932.

14. Moineau G, Power B, Pion AM, Wood TJ, Humphrey-Murto S. Comparison of student examiner to faculty examiner scoring and feedback in an OSCE. *Med Educ*.**45**:183-91.

15. Griffiths S. Enhancing student learning through tutoring in higher education. *University of Ulster, Coleraine*. 1996.

16. Cushing A, Abbott S, Lothian D, Hall A, Westwood OM. Peer feedback as an aid to learning--what do we want? Feedback. When do we want it? Now! *Med Teach*.**33**:e105-12.

17. Kelly LP, Garza PS, Bruce BB, Graubart EB, Newman NJ, Biousse V. Teaching ophthalmoscopy to medical students (the TOTeMS study). *American journal of ophthalmology*. 2013;**156**:1056-61.e10.

18. Clanton J, Gardner A, Cheung M, Mellert L, Evancho-Chapman M, George RL. The relationship between confidence and competence in the development of surgical skills. *Journal of surgical education*. 2014;**71**:405-12.

19. Leopold SS, Morgan HD, Kadel NJ, Gardner GC, Schaad DC, Wolf FM. Impact of educational intervention on confidence and competence in the performance of a simple surgical task. *The Journal of bone and joint surgery American volume*. 2005;**87**:1031-7.

20. Stewart J, O'Halloran C, Barton JR, Singleton SJ, Harrigan P, Spencer J. Clarifying the concepts of confidence and competence to produce appropriate self-evaluation measurement scales. *Medical education*. 2000;**34**:903-9.

21. Lippa LM, Boker J, Duke A, Amin A. A novel 3-year longitudinal pilot study of medical students' acquisition and retention of screening eye examination skills. *Ophthalmology*. 2006;**113**:133-9.

Figures

Figure 1. Direct Ophthalmoscopy Group OSCE tutorial using retinal simulators

~~**(Top, left)** Students in Group 1 undertake Direct Ophthalmoscopy on fellow students; 1 student is the examination candidate (right), 1 student as examiner (left; referring to assessment criteria), and 1 as patient (centre). **(Top, right)** Students in Group 2 undertake Direct Ophthalmoscopy using the retinal simulator; 1 student acts as examiner (left; referring to assessment criteria); and 1 student is the candidate (right).~~ **(~~Centre~~Top, left)** Retinal simulator (Adam,Rouilly, Kent, UK): front view. The mannequin simulates the dimensions and contours of the face, with a central 4mm pupillary aperture through which direct ophthalmoscopy is undertaken. **(~~Centre~~Top, right)** Retinal simulator: reverse view. Slides are mounted into slide holders in either right or left eye by the examiner according to instructions, and then examined from the front with the direct ophthalmoscopy by the candidate. **(Bottom, left)** Simulated pathology: Central Retinal Vein Occlusion, **(Bottom, right)** Simulated pathology: Papilledema (All slide images reproduced with permission from Adam, Rouilly, Kent, UK).

Table 1. Pre-Tutorial self-evaluation of confidence in direct ophthalmoscopy

Table 2. Post-Tutorial self-evaluation of confidence in direct ophthalmoscopy

Table 3. Post-Tutorial student perceptions of efficacy of direct ophthalmoscopy tutorial

Supplement 1. Teaching plan for Direct Ophthalmoscopy Tutorial

Supplement 2. Example of Candidate Instructions and Assessment Criteria

Supplement 3. Student Feedback Form

Supplement 4. Student Responses to Direct Ophthalmoscopy Tutorial

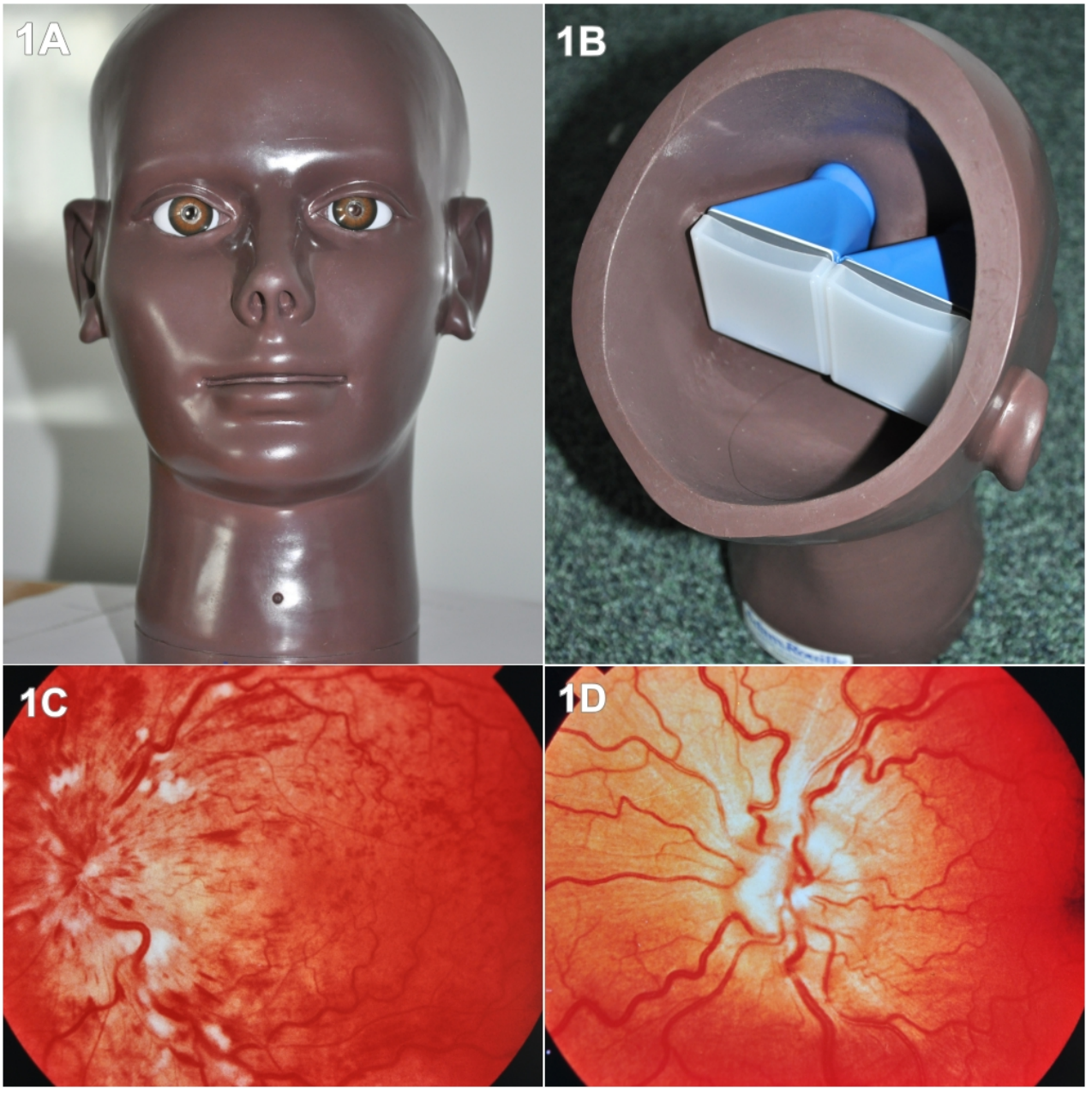

1A
1B
1C
1D

Table 1. Pre-Tutorial self-evaluation of confidence in direct ophthalmoscopy

Pre-tutorial: Student confidence	**Very confident**	**Confident**	**Some confidence**	**Very little confidence**	**No confidence**
Introduction/consent	13.97%	38.00%	34.08%	8.38%	5.59%
Controls on direct ophthalmoscope	2.63%	12.50%	46.71%	28.29%	9.87%
Sequence of examination in direct ophthalmoscopy	1.23%	7.41%	36.42%	40.74%	14.20%
Identifying the normal retinal anatomy	0%	2.16%	39.57%	35.97%	22.30%
Identifying clinical signs	0%	0%	15.75%	56.85%	27.40%
Interpreting clinical signs	0%	1.12%	16.85%	70.79%	11.24%
Direct ophthalmoscopy overall	**0%**	**2.52%**	**28.93%**	**56.60%**	**11.95%**

Table 2. Post-Tutorial self-evaluation of confidence in direct ophthalmoscopy

Post-tutorial: Participant confidence	**Very confident**	**Confident**	**Some confidence**	**Very little confidence**	**No confidence**	**Pre vs post-tutorial**
Introduction/consent	47.53%	50.92%	1.23%	0%	0%	$p < 0.001$*
Controls on direct ophthalmoscope	32.95%	56.25%	10.23%	0%	0%	$p < 0.001$*
Sequence of examination in direct ophthalmoscopy	31.48%	56.79%	12.35%	0%	0%	$p < 0.001$*
Identifying normal retinal anatomy	8.02%	43.83%	43.21%	4.94%	0%	$p < 0.001$*
Identifying clinical signs	4.82%	28.31%	59.64%	7.23%	0%	$p < 0.001$*
Interpreting clinical signs	4.82%	28.31%	59.64%	7.23%	0%	$p < 0.001$*
Direct ophthalmoscopy overall	**7.98%**	**55.83%**	**34.97%**	**1.23%**	**0%**	$p < 0.001$*

Table 3. Post-tutorial student perceptions of efficacy of tutorial

Post-tutorial: How effective was the tutorial at teaching different components of the direct ophthalmoscopy procedure?	**Very effective**	**Effective**	**Quite effective**	**Not very effective**	**Ineffective**
Applications of direct ophthalmoscopy to general medicine	21.74%	60.25%	17.39%	0.62%	0%
Functions of the direct ophthalmoscope	40.37%	44.10%	14.91%	0.62%	0%
Approach to patient pre-examination	55.90%	42.86%	1.24%	0%	0%
Practical conduct of direct ophthalmoscopy	58.33%	40.47%	1.79%	0%	0%
Interpretation of key posterior segment signs	31.05%	52.17%	14.90%	1.86%	0%
Direct ophthalmoscopy overall	**33.33%**	**62.96%**	**3.09%**	**0.62%**	**0%**

Supplement 1. Teaching plan for Direct Ophthalmoscopy Tutorial

Group size: 28 students **Session duration:** 120 minutes

Equipment:

4 tables

4 model heads with 12 retinal inserts (12 individualised candidate instructions and assessment criteria)

14 direct ophthalmoscopes

Stopwatches for time keeping

Facilities for projection

5 minutes	Introduction: Format and learning objectives, pre-tutorial written survey completed by all students
20 minutes	Introduction to direct ophthalmoscopy (DO) Indications for DO in ophthalmology and general medicine The direct ophthalmoscope: controls and functions Pupil dilation: pharmacologic agents and safety Practical conduct of direct ophthalmoscopy: demonstration on volunteer
5 minutes	Group splits into two: ~14 students in Group 1 and ~14 in Group 2 Students working in clusters of 3 students for Group 1, and 2-3 students in group 2 (tutor can substitute if needed to match groups)
30 minutes	**<u>Group 1</u>** Practice of direct ophthalmoscopy on student peer volunteer 1 student is the patient (seated) 1 student is the candidate 1 student is the examiner Examiner provides student with clinical scenario to read, with specific instructions on the examination to be undertaken (2 minutes) Examiner is provided with a laminated sheet with assessment criteria to read and learn (2 minutes) Examined student carries out procedure of direct ophthalmoscopy (5

	minutes, timed) Examiner grades student, gives a mark (1-5) and verbal feedback to student (3 minutes) Students rotate round; so that each acts as patient, candidate and examiner (3 x 10 minutes) **<u>Group 2</u>** Each group of 3 students is allocated 3 OSCE stations with a clinical scenario appropriate to the simulated retinal pathology. Student examiner provides student candidate with clinical scenario to read, with specific instructions on the examination to be undertaken (2 minutes) Examiner is provided with a laminated sheet with assessment criteria to read and learn (2 minutes). Candidate performs clinical examination on retinal simulator, and is asked questions by the examiner specified on their assessment sheet: reponses are graded (5 minutes). Examiner grades student, gives a mark (1-5) and verbal feedback to student (3 minutes) Students rotate round x3; so that each acts as candidate and examiner (3 x 10 minutes)
5 minutes	Summarising and addressing pitfalls: Common pitfalls in examination technique are addressed to entire student group, to improve performance from second OSCE session.
30 minutes	**Students in Group 1 (student examination) swap with those in Group 2 (retinal simulator examination)**
20 minutes	Clinical presentation led by tutor: Interpretation of direct ophthalmoscopy signs demonstrated by retinal simulation Slides showing abnormalities in retina/ optic disc, interpretation and management
5 minutes	Summary of key learning points Questions/ Discussion Completion and return of feedback forms
Total Duration = 120 minutes	

Supplement 2. Example of Candidate Instructions and Assessment Criteria

GROUP 1

Candidate instructions:

Your colleague mentions that they have been suffering from headaches, worse in the mornings for three weeks. They have suffered from troubling nausea and three episodes of vomiting over the same period.

You are worried that this symptom complex may represent raised intracranial pressure. You are keen to exclude papilledema.

Please examine the patient's right eye using a direct ophthalmoscope. You must explain to your colleague in full what you are doing and why, and obtain verbal consent for the examination.

You have five minutes to examine the fundus. Please identify the optic disc margin, the colour of the optic disc, the cup: disc ratio, the presence or absence of new vessels on the optic disc. Attempt to identify the presence or absence of spontaneous venous pulsations at the optic disc.

Please communicate your findings to the examiner.

There will be two minutes at the end for feedback.

GROUP 1

Examiner marking sheet:

Examination of medical student volunteer

Mark	Assessment criteria
5	• Introduces themselves to the patient in a professional manner, demonstrates ability to develop good rapport with the patient • Introduces the task clearly, using appropriate language, stating purpose of ophthalmoscopy and gives clear instructions regarding fixation and breathing and warns about the proximity/contact, checking consent verbally • Clearly familiar with ophthalmoscope, easily finds the on/off switch, selects appropriate light source and lenses confidently • Easily elicits red reflex from approx 30cm distance bilaterally • Places a hand on forehead/shoulder of the patient and attains necessary close proximity to patient by following the red reflex • Uses right eye to examine patient's right eye and left eye to examine left eye • Inspects optic disc, macula major vascular arcades and all four quadrants using clear instructions and/or by rotating ophthalmoscope • Correctly describes the optic disc margin, colour, cup:disc ratio, presence/absence of new vessels, presence/absence of spontaneous venous pulsations.
4	• Introduces themselves to the patient in a professional manner, demonstrates ability to develop good rapport with the patient • Introduces the task clearly, using appropriate language, stating purpose of ophthalmoscopy and gives instructions regarding fixation and warns about the proximity/contact, checking consent verbally • Able to operate ophthalmoscope on/off switch easily, selects appropriate light source and lenses • Elicits red reflex from approx 30cm distance bilaterally • Attains necessary close proximity to patient by following the red reflex • Uses right eye to examine patient's right eye and vice versa • Inspects optic disc, macula, major vascular arcades and all four quadrants of retina using clear instructions and/or by rotating the ophthalmoscope • Correctly describes the margin of the optic disc
3	• Introduces themselves to the patient • Gives some instruction to patient regarding fixation and purpose of the examination • Able to turn ophthalmoscope on but takes time/difficulty with selecting appropriate light source and lenses • Elicits red reflex from approx 30cm distance bilaterally • Attains necessary close proximity to patient by following the red reflex • Uses right eye to examine patient's right eye and vice versa • Inspects macula, optic disc, major vascular arcades but with no clear system • Is able to identify the optic disc, but not comment on any of it's features
2	• Demonstrates ability to introduce themselves to the patient • Unclear explanation of ophthalmoscopy, no instructions given to patient on fixation • Able to turn ophthalmoscope on but not able to select appropriate light source/lenses • Uses right eye to examine patient's right eye and vice versa • Inspects the posterior pole but with no clear system; does not get close enough to examine eye effectively • Unable to identify optic disc
1	• Demonstrates ability to introduce themselves to the patient • Unable to provide instructions/explanation to patient

	• Takes long time/unable to switch on ophthalmoscope • Attempts to examine the back of the eye, without clear system or necessary proximity • Unable to identify optic disc

GROUP 2

One example from 12 OSCE stations/scenarios generated for 12 distinct retinal pathologies demonstrated by the retinal simulator.

Candidate instructions:

Scenario 2

You are an intern working in the emergency department when this 60-year-old male presents complaining of headaches and vomiting for 2 days. He noticed episodes of blurred vision in both eyes this morning, particularly when he coughs or strains. He has a 60-pack-year history and is under investigation for haemoptysis.

Please examine the patient's left eye using a direct ophthalmoscope and comment on any abnormalities you find. There will be several questions related to this case asked by the examiner at the end.

Assume the examination has been explained to the patient and he has given consent.

You have five minutes to examine the fundus. Please comment on any abnormalities you find. There will be several questions related to this case asked by the examiner at the end of the station.

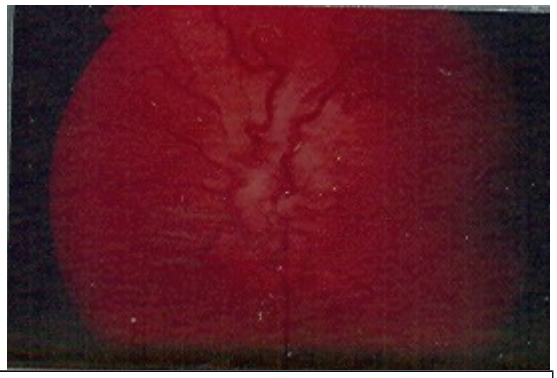
There will be two minutes at the end for feedback.

GROUP 2

Examiner marking sheet:

Scenario 2

Please place SLIDE 9 into LEFT EYE whilst candidate reads instructions



Mark	Assessment criteria
5	• Clearly familiar with ophthalmoscope, easily finds the on/off switch, selects appropriate light source and lenses confidently • Easily elicits red reflex from approx 30cm distance • Attains necessary close proximity to patient by following the red reflex • Uses left eye to examine patient's left eye • Inspects optic disc and major vascular arcades by rotating ophthalmoscope • Correctly identifies and clearly summarises pathology found: blurred swollen disc margin and tortuous blood vessels • Correctly answers following questions: 1. You find that the right eye fundus looks very similar to left eye. What is the key clinical sign? What does this signify? A: Papilledema signifying raised intracranial pressure 2. Please list 3 possible differential diagnoses A: space occupying lesion (tumour, haematoma, abscess); venous sinus thrombosis; malignant (accelerated) hypertension; benign intracranial hypertension 3. What investigations would you like to perform? A: Neuroimaging (MRI/MRV/CT head), lumbar puncture
4	• Able to operate ophthalmoscope on/off switch easily, selects appropriate light source and lenses • Elicits red reflex from approx. 30cm distance • Attains necessary close proximity to patient by following the red reflex • Uses left eye to examine patient's left eye • Inspects optic disc using ophthalmoscope • Correctly identifies blurred swollen optic disc margin • Correctly answers the 3 questions above
3	• Able to turn ophthalmoscope on but takes time/difficulty with selecting appropriate light source and lenses • Elicits red reflex from approx. 30cm distance • Attains necessary close proximity to patient by following the red reflex • Uses left eye to examine patient's left eye • Inspects optic disc using ophthalmoscope • Identifies some pathology, stating blurred/swollen disc margin • Correctly answers 2/3 questions above
2	• Able to turn ophthalmoscope on but not able to select appropriate light source/lenses • Uses left eye to examine patient's left eye • Attempts to examine the optic disc with difficulty; does not get close enough to examine eye effectively • Identifies optic disc swelling/blurred margin • Correctly answers 1st question
1	• Takes long time/unable to switch on ophthalmoscope • Attempts to examine the back of the eye, without clear system or necessary proximity • Unable to identify any pathology • Unable to answer questions

Supplement 3. Student Feedback Form

Group OSCE to learn direct ophthalmoscopy: Student Feedback

Pre-tutorial

Your skills in direct ophthalmoscopy

How many times have you performed direct ophthalmoscopy before? *Please tick appropriate boxes.*

	0 times	1-2 times	3-4 times	5-6 times	>6 times
On a patient					
On a volunteer					

What training have you previously had? *Please tick all responses that apply.*

- ☐ None at all
- ☐ Seen a lecture/ presentation on it
- ☐ Seen clinician demonstrate in a lab/classroom setting
- ☐ Seen clinician using ophthalmoscope in clinical setting
- ☐ Formal practical training in lab/classroom setting
- ☐ Formal practical training by clinician in clinical setting

What assessment have you previously had? *Please tick all responses that apply.*

- ☐ None at all
- ☐ Assessed in a clinical skills lab/classroom setting by non-clinician
- ☐ Assessed in a clinical skills lab/classroom setting by clinician
- ☐ Assessed in a clinical setting by clinician
- ☐ Assessed through summative OSCE assessment (assessment for grading)
- ☐ Assessed through formative OSCE assessment (assessment for learning)

What feedback have you previously had on your performance of direct ophthalmoscopy?

Please tick all responses that apply.

- ☐ None at all
- ☐ Feedback in clinical skills lab/classroom setting by non-clinician
- ☐ Feedback in a clinical skills lab/classroom setting by clinician
- ☐ Feedback in a clinical setting by clinician
- ☐ Feedback after summative OSCE assessment (assessment for grading)
- ☐ Feedback after formative OSCE assessment (assessment for learning)

How confident are you in the following components of direct ophthalmoscopy (pre-tutorial)?

	Very confident	Confident	Some confidence	Very little confidence	No confidence
Introduction/consent					
Controls on direct ophthalmoscope					
Sequence of examination in direct ophthalmoscopy					
Identifying the normal retinal anatomy					
Identifying clinical signs					
Interpreting clinical signs					
Direct ophthalmoscopy overall					

Post-tutorial

How effective was this tutorial in teaching you about the following components of direct ophthalmoscopy?

	Very effective	Effective	Quite effective	Not very effective	Ineffective
The applications of direct ophthalmoscopy to general medicine, emergency medicine.					
The functions of the direct ophthalmoscope (uses of filters, corrective lenses)					
Approach to the patient before direct ophthalmoscopy (explanation, consent)					
Practical conduct of direct ophthalmoscopy (sequence of examination)					
Interpretation of key posterior segment signs (papilloedema, diabetic retinopathy)					

Direct Ophthalmoscopy Overall					

How confident are you in the following components of direct ophthalmoscopy (post-tutorial)?

	Very confident	Confident	Some confidence	Very little confidence	No confidence
Introduction/consent					
Controls on direct ophthalmoscope					
Sequence of examination in direct ophthalmoscopy					
Identifying the normal retinal anatomy					
Identifying clinical signs					
Interpreting clinical signs					
Direct ophthalmoscopy overall					

<u>Group OSCE teaching (small group teaching with peer feedback)</u>

This section is to get your feedback about the format of today's tutorial.

Do you feel the following teaching formats would be more effective or less effective at teaching you direct ophthalmoscopy compared with today's tutorial?

Teaching format	This would be ***more effective*** than today's tutorial	This would be ***equally as effective*** as today's tutorial	This would be ***less effective*** than today's tutorial
Lecture			
Clinical Videos			
Workbased-placed assessment (DOPS or equivalent)			
Practising with a peer			
Individual skills lab practice			
Formative OSCE			
Finals OSCE			

Supplement 4 – Student Responses to Direct Ophthalmoscopy Tutorial

Tabulated data from responses not presented with main manuscript

How many times have you performed direct ophthalmoscopy before?	0	1-2 times	3-4 times	5-6 times	>6 times
On patient	24.38%	31.88%	14.38%	12.50%	16.88%
On volunteer	7.50%	63.75%	21.25%	4.38%	3.13%

What training have you previously had?	
None at all	3.27%
Seen a lecture/ presentation on it	19.35%
Seen clinician demonstrate in a lab/classroom setting	27.68%
Seen clinician using ophthalmoscope in clinical setting	28.87%
Formal practical training in lab/classroom setting	13.99%
Formal practical training by clinician in clinical setting	6.85%

What assessment have you previously had?	
None at all	83.43%
Assessed in a clinical skills lab/classroom setting by non-clinician	1.70%
Assessed in a clinical skills lab/classroom setting by clinician	8.00%
Assessed in a clinical setting by clinician	6.86%
Assessed through summative OSCE assessment (assessment for grading)	0%
Assessed through formative OSCE assessment (assessment for learning)	0%

What feedback have you previously had on your performance of	

direct ophthalmoscopy?	
None at all	49.12%
Feedback in clinical skills lab/classroom setting by non-clinician	7.01%
Feedback in a clinical skills lab/classroom setting by clinician	21.05%
Feedback in a clinical setting by clinician	22.80%
Feedback after summative OSCE assessment (assessment for grading)	0%
Feedback after formative OSCE assessment (assessment for learning)	0%

Do you feel the following teaching formats would be more effective or less effective at teaching you direct ophthalmoscopy compared with today's tutorial?	More effective	Equally effective	Less effective
Lecture	1.23%	11.73%	87.04%
Clinical videos	1.26%	23.27%	75.47%
Workbased-placed assessments	5%	35.63%	59.37%
Practising with peer	3.66%	48.17%	48.17%
Individual skills lab practice	9.20%	39.88%	50.92%
Formative OSCE	11.52%	36.97%	51.52%
Finals OSCE	4.91%	19.63%	74.85%