Level of experience of ophthalmologists and ophthalmic health professionals impacts identification of foveal hypoplasia

Riddhi Shenoy[1], Gail DE Maconachie[1,2], Swati Parida[3], Zhanhan Tu[1], Abdullah Aamir[1], Chung S Chean[3], Michael Taylor[3], George Garratt[1], Sohaib Rufai,1 Basu Dawar[3], Steven Isherwood[3], Ryan Ramoutar[3], Alex Stubbing-Moore[3,4], Esha Prakash[1], Jennifer Kwan[3], Ian DeSilva[3], Helen J Kuht[1], Irene Gottlob[1,5], Mervyn G Thomas[1,3]*

1. The University of Leicester Ulverscroft Eye Unit, Robert Kilpatrick Clinical Sciences Building, School of Psychology and Vision Sciences, Leicester LE2 7LX, UK
2. Division of Ophthalmology and Orthoptics, Health Science School, University of Sheffield, Sheffield, UK
3. Department of Ophthalmology, University Hospitals of Leicester, Leicester Royal Infirmary, Leicester, LE1 5WW, UK.
4. Department of Ophthalmology, Nottingham University Hospitals, Nottingham, NG7 2UH, UK
5. Cooper Neurological Institute and Cooper Medical School of Rowan University, Camden, NJ, USA.

Introduction: Diagnosis and prognosis of arrested foveal development or foveal hypoplasia (FH) can be ascertained using the Leicester grading system for FH using optical coherence tomography (OCT)(Figure 1) [1,2]. To date, the FH grading system has only been validated amongst experts. We compare inter-grader and intra-grade agreement of healthcare professionals against expert consensus across all grades of FH.

Grader	Grading experience (years)	Professional role
1	10	Ophthalmologist
2	10	Orthoptist
3	6	Ophthalmologist
4	3	Orthoptist
5	2	Ophthalmologist
6	1	Ophthalmologist
7	<1	Post graduate doctor
8	<1	Ophthalmologist

Table 1: Clinician grader profile showing years of experience in interpreting OCT images, professional qualification for each grader.

Methods: Hand-held and table-mounted OCT images (n=341) obtained retrospectively were graded independently at a single centre by experts (n=3) with over six years of experience, and "novice" medical and allied health professionals (n=5) with between less than one to three years of experience (Table 1). The images showed no FH (n=133), grade 1 FH (n=106), grade 2 FH (n=43), grade 3 FH (n=42), grade 4 FH (n=11), and atypical FH (n=6). Sensitivity, specificity and Cohen's kappa scores were calculated for each grader, and expert vs novice performance was compared.

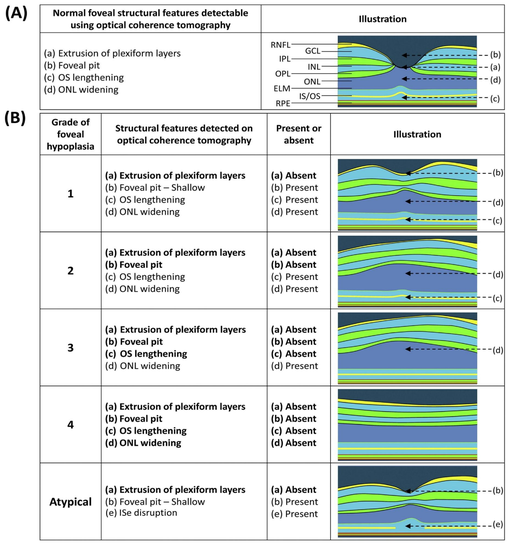


Figure 1: Illustration showing the unique features of a normal fovea detectable on optical coherence tomography. B, Illustration of typical and atypical grades of FH. All grades of FH had incursion of inner retinal layers. Atypical FH also had incursion of the inner retinal layers. Grade 1 FH is associated with a shallow foveal pit, outer nuclear layer (ONL) widening, and outer segment (OS) lengthening relative to the parafoveal ONL and OS length, respectively. Grade 2 FH, all features of grade 1 are present except the presence of a foveal pit. Grade 3 FH consists of all features of grade 2 FH except the widening of the cone outer segment. Grade 4 FH represents all the features seen in grade 3 except there is no widening of the ONL at the fovea. Atypical FH shows a shallower pit with disruption of the inner segment ellipsoid (ISe), possibly a sign of photoreceptor degeneration. ELM =external limiting membrane; GCL =ganglion cell layer; INL =inner nuclear layer; IPL =inner plexiform layer; OPL =outer plexiform layer; RNFL= retinal nerve fibre layer; RPE=retinal pigment epithelium. (Adapted from Thomas MG, et al. Structural Grading of FH Using Spectral-Domain Optical Coherence Tomography. Ophthalmology. 2011 -08;118(8):1653)[1]

Results: All graders showed high sensitivity (median 97% (IQR:94-99)) and specificity (median 94% (IQR:90-95)) for identifying the presence or absence of FH. No significant difference was seen for specificity between expert and novice graders, but experts had significantly greater diagnostic sensitivity (median difference = 5.3%, H = 5.00, p = 0.025) (Figure 2). Expert graders had the highest agreement with ground truth and inter-grader agreement. Novice graders with one year or less experience in grading had the lowest agreement with ground truth (kappa 0.7-0.9) and showed high variability in inter-grader agreement (pairwise kappa 0.7-0.54) particularly for atypical FH. Review of misclassified images with atypical FH suggest lack of awareness that changes at the inner segment ellipsoid may exist despite observation of features of normal foveal structure, such as the presence of a foveal pit (Figure 3). Our results also suggested difficulty identifying the fovea in handheld OCT images in children where the macula is decentred due to lack of fixation while acquiring the images.

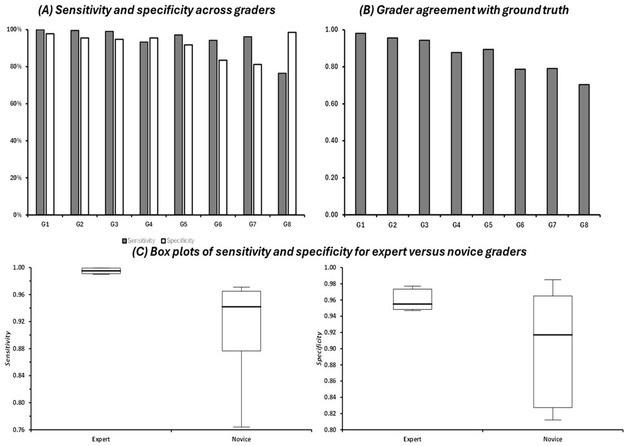


Figure 2: (A) Distribution of sensitivity and specificity of identifying FH by grader. (B) Inter-grader agreement assessed by Cohen's kappa scores, comparing each grader's classification to the ground truth. (C) Box plots of sensitivity and specificity for expert versus novice graders.

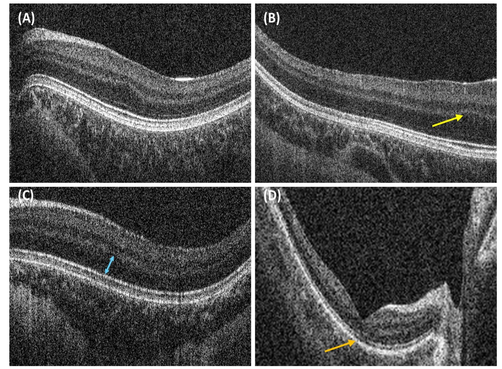


Figure 3: Examples of misclassified cases of FH. A) grade 2 expert consensus with subtle OS lengthening and absence of foveal pit. B) grade 2 expert consensus, fovea not centred on handheld OCT image, see fovea (yellow arrow). C) grade 3 expert consensus, subtle ONL widening (blue arrow), absent OS lengthening. D) atypical expert consensus, note disruption of inner segment ellipsoid (ISe) (orange arrow)

Conclusions: Health professionals of a variety of backgrounds and levels of experience can accurately identify FH using handheld and table-mounted OCT images. Considering the diagnostic and prognostic value of accurate grading of FH, grading in clinical practice by less experienced ophthalmologists can be improved by including handheld OCT and FH grading in the Royal College of Ophthalmologists training curriculum. Creating education resources for ophthalmologists and ophthalmic health professionals can upskill all professional groups to ultimately improve patient outcomes.

References:

1. Thomas MG, Kumar A, Mohammad S, Proudlock FA, Engle EC, Andrews C, et al. Structural Grading of Foveal Hypoplasia Using Spectral-Domain Optical Coherence Tomography. Ophthalmology. 2011 -08;118(8):1653.
2. Kuht HJ, Maconachie GDE, Han J, Kessel L, Van Genderen MM, Mclean RJ, et al. Genotypic and Phenotypic Spectrum of Foveal Hypoplasia. Ophthalmology. 2022 -06;129(6):708.

Financial disclosures: No conflicting relationship exists for any authors. AA is currently an employee of F. Hoffmann-La Roche Ltd**Funding:** This study was supported by Medical Research Council (MRC), London, UK (grant number: MR/J004189/1, MRC/N004566/1 and MC_PC_17171), Ulverscroft Foundation and Fight for Sight (grant ref: 24NN181). RS (ACF-2023-11-004)and SRR are supported by National Institute for Health and Care Research (NIHR). MGT acknowledges prior support from NIHR during study period (CL-2017-11-003).

Correspondence: sr670@leicester.ac.uk or mt350@leicester.ac.uk