IMJ Official Journal of the Irish Medical Organisation

Ir Med J; January 2025; Vol 118; No. 1; P3
January 27th, 2025

Utilising Digital Ocular Imaging for Paediatric Retinal Haemorrhages

A. Al Zaabi[1], A. Naji[2], B. Tang[3], W. Alruzaiqi[1], S. Farrell[3], L. Kyne[1].

1. General Paediatrics Department, Temple Street Children's Hospital, Children's Health Ireland, Rotunda, Dublin 1, Ireland.
2. School of Medicine, Royal College of Surgeons in Ireland, Dublin 2, Ireland.
3. Paediatric Ophthalmology Department, Temple Street Children's Hospital, Children's Health Ireland, Rotunda, Dublin 1, Ireland.

Abstract

Aim

To evaluate the role of paediatric ocular imaging in paediatric ophthalmology through a case series, defining the retinal features observed in various paediatric pathological and trauma-related (abusive or non-abusive) conditions in patients aged four weeks to 16 years in a tertiary paediatric hospital in Dublin, Ireland.

Methods

A retrospective record-based study was conducted at Children's Health Ireland (CHI) at Temple Street, analysing ocular images of patients aged four weeks to 16 years, spanning five years, from 2018 to 2022. Following pupillary dilation, retinal examinations were performed using the 'RetCam 3', a handheld device for supine examinations in younger children, or the 'Topcon KR 800' for older patients. Images were reviewed with haemorrhages categorised by number, size, and location. Demographic and clinical details were tabulated, with counts and percentages calculated for categorical variables. Odds ratios and 95% confidence intervals (CI) were derived using the Mantel-Haenszel method, with statistical significance set at p-value <0.05.

Results

Of the 25 cases that met the age category of four weeks to 16 years, RHs were most common in infants (16 cases). Retinopathy of prematurity (ROP) was identified in nine cases (age range: 2 mo – 19 mo, mean age 7 mo), presumed trauma in five cases (age range: 2 mo – 10 mo, mean age 6 mo), metabolic/genetic conditions in four cases (age range: 8 mo – 8 years), infections in two cases, tumours in two cases, and three cases with no confirmed diagnosis. Most RHs were few, intraretinal, located in the posterior pole and periphery of the eye. RH incidence was significantly higher in ROP and trauma cases (p = 0.027), with an odds ratio of 1.4 (95% CI: 0.08 - 25.14). ROP cases showed small, localised haemorrhages, while cases of presumed trauma had multilayer and large (> 5 disc diameter (DD)) haemorrhages (p = 0.058) that extend to the ora serrata (p = 0.018).

Discussion

The study highlights paediatric ocular imaging's role in documenting RH patterns, aiding differential diagnosis across paediatric conditions. Paediatric ocular imaging's detailed capabilities provide clinical insights, reducing the need for multiple exams while promoting standardised documentation. Integrating ocular imaging technology supports establishing national guidelines and training programs that improve accessibility across diverse healthcare settings. Future research should validate these findings through multi-modal approaches and standardised practices, exploring paediatric ocular imaging utility in routine paediatric care. Additionally, advancements in artificial intelligence (AI) can further improve retinal examination efficiency, ultimately enhancing paediatric ophthalmology and child welfare in Ireland.

Introduction

Ocular imaging is pivotal in paediatric ophthalmology, offering high-standard images that enhance diagnostic accuracy, improve clinical workflow, and facilitate better patient outcomes. It is a valuable tool for characterising retinal pathologies in children and was initially used for neonatal retinal haemorrhage (RH) in healthy newborns.[1] Paediatric ocular imaging's immediate visualisation and real-time recording of fundus findings provide detailed imaging and documentation of RH, facilitating thorough examinations, supporting second opinions, reducing the need for multiple exams, and improving accuracy through standardised documentation (Appendix 1).[2]

RHs occur in various clinical scenarios, particularly in birth-related incidents such as spontaneous vaginal delivery, with higher incidence following instrumental or prolonged second-stage delivery compared to caesarean deliveries. These haemorrhages are typically bilateral, intra-retinal, located at the posterior pole, and usually resolve within the first few weeks of life, with some persisting up to 58 days.[2] Systematic reviews by Watts et al. found that birth-related RHs occurred in 25% of spontaneous vaginal delivery, increasing to 42.6% after vacuum-assisted and 52% after double instrumental deliveries.[3] RH can also occur from hyperacute elevations of intracranial pressure, as seen in crush injuries or ruptured aneurysms. These RHs are often peripapillary, intraretinal and associated with papilloedema.[4] Retinoschisis and retinal folds, once thought specific for abusive head trauma, have also been documented in non-abusive severe trauma. Accidental trauma from falls or motor vehicle accidents can result in unilateral, mild posterior pole RH.[5,6] Severe crush injuries show extensive multi-layered haemorrhages extending from the posterior pole to the periphery, with retinoschisis and retinal folds.[7] Adam et al.[8] outlined conditions such as leukaemia, sickle cell retinopathy, ECMO treatment, ROP, intracranial pathology, severe hypertension, homocystinuria, osteogenesis imperfecta, central retinal vein occlusion, seizures, cardio-

pulmonary resuscitation, and intracranial injury in abusive head trauma (AHT) cases, each showing distinct patterns.

A systematic review by Bhardwaj et al.[9] highlighted the significant role of intraocular findings in diagnosing child abuse, specifically AHT, with 75% sensitivity and 94% specificity. Bechtel et al. reported that in AHT, RHs are typically numerous, extend to the periphery, are multi-layered, and bilateral with moderate to severe intraocular haemorrhages.[10] Traumatic retinoschisis, almost exclusive to AHT, is likely caused by repetitive acceleration-deceleration forces inducing vitreous traction on the macula, often associated with subdural haemorrhage, neurologic symptoms, and poor or fatal outcomes, indicating abuse as the most likely cause.[11]

Maguire et al.'s [12] review of six studies identified symptom combinations strongly indicative of AHT, including apnoea, RH, seizures, rib, skull, or long-bone fractures, and head/neck bruising. The presence of rib fractures or RH, coupled with any other symptom, increases the odds ratio for AHT to over 100, with a positive predictive value exceeding 85%.[12] According to Macher et al., ophthalmic imaging plays a crucial role when assessing for AHT, and if combined with clinical examination, it can enhance diagnostic precision, aid in documentation, and facilitate communication in medicolegal contexts.[13]

Aim

To evaluate the role of paediatric ocular imaging in paediatric ophthalmology through a case series, defining the retinal features observed in various paediatric pathological and trauma-related (abusive or non-abusive) conditions in patients aged four weeks to 16 years in a tertiary paediatric hospital in Dublin, addressing a gap in Irish literature.

Methods

This retrospective record-based study was conducted at Children's Health Ireland (CHI) at Temple Street, a tertiary paediatric hospital in Dublin, serving approximately 145,000 children annually and offering regional and national referral services.[14] The hospital's comprehensive multidisciplinary team, including neurosurgical and Ophthalmology services, makes it an ideal setting for our study. According to CHI at Temple Street Children's Hospital, a child protection protocol is initiated if a child's welfare is at risk. Children under two years suspected of physical abuse require a skeletal survey, and those under one year necessitate the addition of an ophthalmology exam, a CT head scan, and an MRI of the brain & spine. A follow-up study is required 14 days following the initial skeletal survey. A follow-up MRI may be considered after three months if neurological issues persist.[15] In cases requiring retinal examinations, the paediatric ophthalmology team conducts indirect examinations, and if RHs are detected, further detailed examination and imaging are performed. The pupils were dilated with age-appropriate cycloplegic agents: Phenylephrine 2.5% and Cyclopentolate 1% for children over one year old, and Cyclopentolate 0.5% for younger children. The study employed the RetCam

3, ideal for supine examinations in young children, and the Topcon KR 800 for older children. Based on ethical committee guidance, access to and comprehensive review of specific patient records related to child protection cases were restricted to ensure the integrity of active child protection cases. Following ethical committee approval (Approval number: REC-158-22), our study focused on analysing ocular images, final medical reports, and investigations.

The study involved the Paediatric Ophthalmology team reviewing RetCam database images from 2018 to 2022, to identify all RHs. Related patients' records were then retrieved and examined to extract relevant details. We focused on patients aged four weeks to 16 years, including both outpatients and inpatients, regardless of gestational age at birth or pre-existing conditions. To mitigate confounding factors from birth-related RH, we excluded children under four weeks old.[16] We also excluded patients without an ophthalmology examination or ocular images. Ophthalmologic findings were recorded per the standardised Royal College of Ophthalmologists, UK guidelines[2] (RCOphth) (Appendix 1). Paediatric ophthalmologist B.T. on the research team, reviewed all fundal images, classifying the morphology and type of RHs. RHs were categorised by number: few (<5), many (between 5-9), and numerous (>10), by size: small (< 1 disc diameter (DD)), medium (1-5 DD) and large (>5 DD) and by the presence of extension or retinoschisis.[17] Demographic and clinical details were retrieved from medical reports and tabulated in an encrypted folder. A summary table included columns for variables of clinical presentation and condition and rows detailing demographic and ophthalmological findings. Count and percentages were calculated for the categorical variables. A p-value of <0.05 was considered significant and used to evaluate significant differences, and the odds ratio and 95% confidence interval (CI) were calculated using the Mantel-Haenszel method.

Results

Of the 528 ocular images identified in the database, 28 cases demonstrated evidence of RHs. Upon applying the inclusion and exclusion criteria, three cases were excluded, resulting in a final analysis of 25 cases. This included nine ex-preterm infants with ROP (age range: 2 mo – 19 mo, mean age 7 mo), five presumed trauma cases (age range: 2 mo – 10 mo, mean age 6 mo), four metabolic/genetic conditions (age range: 8 mo – 8yrs), two infections, two tumours, and three classified as other conditions (Figure 1). The cohort included 56% males and 44% females. The odds ratio for gender distribution was 0.84 (95% CI: 0.26 - 2.71). The median age demographics, as per the CDC classification of age group,[18] ranged predominantly in infants under one year, accounting for 16 cases (64%). Other age groups included five middle-aged children (20%), two toddlers (8%), and two teenagers (8%) (Table 1 and Table 2).

The incidence of RH was significantly higher in cases of ROP and presumed trauma in infants compared to other aetiologies (p = 0.027), with an odds ratio of 1.4 (95% CI: 0.08 - 25.14). Most cases had few haemorrhages (<5), with a significant proportion being intraretinal, 55.6%

in ROP and 40% in presumed trauma, this demonstrated an odd ratio of 2.14 (95% CI: 0.44-10.40) and located in the posterior pole & periphery with an odd ratio of 1.48 (95% CI: 0.21-10.57). In cases of presumed trauma, haemorrhages were multilayer and large (>5DD) compared to other aetiologies (p = 0.058), with an odds ratio of 0.9 (95% CI: 0.19 - 4.21). Notably, only cases of presumed trauma had an extension to the ora serrata (p = 0.018).

Presumed Trauma

Ocular imaging in cases of presumed trauma showed consistent findings of bilateral eye involvement with large, multilayered haemorrhages in the posterior pole and periphery, extending to the ora serrata with or without retinoschisis (Figure 2: H-I). All presumed trauma cases underwent skeletal surveys and neuroimaging (CT or MRI) that reported the presence of subdural haemorrhages, some exhibiting more extensive injury and one involving the spine (Table 1). Blood tests (CBC, LFT, coagulation and bone profile) were normal in four cases, while one had abnormal LFT and coagulation results (Table 1).

ROP

In ex-preterm infants with ROP, retinal exams revealed similar patterns of haemorrhages, either unilateral or bilateral, with few small haemorrhages in the subretinal or intraretinal areas, often located at the demarcation zone between vascular and avascular retina (Figure 2). One 6-month-old infant with severe prematurity had neuroimaging demonstrating multifocal intracranial haemorrhage, thrombi in the transverse sinuses and increased ventricular size. Blood tests performed in some cases noted no abnormalities (Table 1).

Genetic/metabolic

Cases with genetic and metabolic conditions presented with abnormal visual behaviour. Paediatric ocular images revealed unilateral RHs, small to medium sized, in the subretinal or intraretinal areas, located in the posterior pole, periphery, or both, with no extension to the ora serrata or retinoschisis. No further radiological workup was performed (Table 1).

IMJ
Official Journal of the Irish Medical Organisation

Ir Med J; January 2025; Vol 118; No. 1; P3
January 27th, 2025

Clinical Presentation	Presentation	Ophthalmology exam of Retinal Haemorrhage	Investigations
Presumed Trauma			
Case 1 – 5m of age	Pre-hospital arrest, with history of seizures. Requiring ICU admission. No further history available	Bilateral, large, multilayered, in post pole & periphery. Extending to Ora serrata with retinoschisis	**MRI:** Subdural collection & hematoma, subarachnoid haemorrhage, enlarged ventricular size. **SS & CT:** Normal
Case 2 – 2m of age	Fall from siblings' arm (<10yrs) – inconsistency in history	Unilateral, small, intraretinal haemorrhage, in posterior pole. Not extending to Ora serrata	**MRI:** Subdural haematomas. **SS:** Normal
Case 3 – 3m of age	Fall from car seat. Developed seizures and required ICU admission	Bilateral, many, multi layered, Large, in post. pole & periphery Extending to Ora serrata with retinoschisis.	**MRI:** Severe Ischemic brain injury. Subdural Hematoma with septation. Extensive epidural hematoma. Widespread diffusion restriction of brain cortex & deep brain structures. Spinal epidural hematomas. **SS:** Healing L. clavicular Fracture.
Case 4 – 9m of age	History of fall – details not available. Developed seizures and required ICU admission	Bilateral, many, large, intraretinal haemorrhages, in the post. Pole and periphery	**MRI + CT:** Large R. Subdural hematoma + midline shift. **SS:** Normal
Case 5 – 10m of age	Pre-hospital arrest – no further history available Patient deceased	Bilateral, many, large, multilayered, in post. Pole & periphery. Extending to Ora serrata with retinoschisis	**CT:** Bil. Subdural hematomas, midline shift, R. parietal subarachnoid haemorrhage. Post. Fossa subdural haemorrhage. **SS:** Normal
ROP			
Total of 9 cases 2m – 1yr 7m of age	Ex-preterm	Unilateral/bilateral, few, small, located in subretinal or intraretinal. In posterior or peripheral poles. No extension to Ora serrata or any retinoschisis.	1 case had neuroimaging: Multifocal intracranial haemorrhage, transverse sinuses thrombus, ventricular enlargement
Metabolic/ Genetic			
2 cases: COAT's disease (3yr, 5yrs) 1 case: Rod-Cone Dystrophy (8yrs) 1 case: Oculo-cutaneous albinism (8m)	Decreased visual acuity, night vision impairment Abnormal red reflex, Squint,	Unilateral or bilaterally, Few or many, small or medium in size, located in subretinal or intraretinal area, Distributed in posterior pole or periphery or both. No extension to Ora serrata or retinoschisis	No neuroimaging carried out
Tumours			
1 case – 6 yr. old Retinoblastoma	Acute blurring and change in vision	Unilateral involvement, few, small, in subretinal, and periphery, with no extension to Ora serrata.	MRI: Small L. retinal lesion, in inferomedial quadrant of left globe
1 case – 8yr old Craniopharyngioma	Headaches, diplopia, vomiting	Bilateral, small, few, in intraretinal and posterior pole, with no extension to Ora serrata.	Neuroimaging: Large cystic lesion arising from Sella turcica + mild hydrocephalus.
Infections			
1 case – 5m of age Congenital CMV	Delayed development with leukocoria	Many, multilayered, in post. Pole and periphery, medium in size with no extension to Ora serrata.	No neuroimaging carried out
1 case – 15 yrs. COVID	Abnormal visual behaviour	Few, small, intraretinal, in posterior pole, dot blot haemorrhage, with no extension to Ora serrata.	Neuroimaging noted evidence of old thrombus in the L. Internal Jugular vein

IMJ
Official Journal of the Irish Medical Organisation

Ir Med J; January 2025; Vol 118; No. 1; P3
January 27th, 2025

Table 2: Retinal Haemorrhage Characteristics and Distribution: Comparison Across Various

Variable	Ex-preterm ROP (N = 9)	Head injury (N = 5)	Infection (N = 2)	Metabolic/ Genetic condition (N = 4)	Tumours (N = 2)	Other (N = 3)	P Value	Mantel-Haenszel Odds Ratio, 95% CI
Gender							0.413	0.84 (0.26 - 2.71)
Female	2 (22.2%)	2 (40.0%)	2 (100.0%)	2 (50.0%)	1 (50.0%)	2 (66.7%)		
Male	7 (77.8%)	3 (60.0%)	0 (0.0%)	2 (50.0%)	1 (50.0%)	1 (33.3%)		
Age group							0.027	1.4 (0.08 - 25.14)
Infant (<1yr)	8 (88.9%)	5 (100.0%)	1 (50.0%)	1 (25.0%)	0 (0.0%)	1 (33.3%)		
Middle childhood (5.1-11yrs)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (50.0%)	2 (100.0%)	1 (33.3%)		
Teenager (11.1 - 16yrs)	0 (0.0%)	0 (0.0%)	1 (50.0%)	0 (0.0%)	0 (0.0%)	1 (33.3%)		
Toddler (1-3yrs)	1 (11.1%)	0 (0.0%)	0 (0.0%)	1 (25.0%)	0 (0.0%)	0 (0.0%)		
Involvement							0.669	0.996 (0.2-5.07)
Bilateral	2 (22.2%)	4 (80.0%)	0 (0.0%)	1 (25.0%)	1 (50.0%)	1 (33.3%)		
Unilateral - Left	4 (44.4%)	1 (20.0%)	1 (50.0%)	2 (50.0%)	1 (50.0%)	1 (33.3%)		
Unilateral - Right	3 (33.3%)	0 (0.0%)	1 (50.0%)	1 (25.0%)	0 (0.0%)	1 (33.3%)		
Number of haemorrhages							0.206	3.5 (0.51-24.05)
Few (<5)	8 (88.9%)	2 (40.0%)	1 (50.0%)	2 (50.0%)	2 (100.0%)	3 (100.0%)		
Many (5-10)	1 (11.1%)	3 (60.0%)	1 (50.0%)	2 (50.0%)	0 (0.0%)	0 (0.0%)		
Location							0.262	2.14 (0.44-10.40)
Intraretinal	5 (55.6%)	2 (40.0%)	1 (50.0%)	2 (50.0%)	1 (50.0%)	1 (33.3%)		
Multilayered	0 (0.0%)	3 (60.0%)	1 (50.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)		
Preretinal	2 (22.2%)	0 (0.0%)	0 (0.0%)	1 (25.0%)	0 (0.0%)	0 (0.0%)		
Subretinal	2 (22.2%)	0 (0.0%)	0 (0.0%)	1 (25.0%)	1 (50.0%)	2 (66.7%)		
Distribution							0.074	1.48 (0.21-10.57)
Periphery	4 (44.4%)	0 (0.0%)	0 (0.0%)	1 (25.0%)	1 (50.0%)	0 (0.0%)		
Post-pole + Periphery	5 (55.6%)	4 (80.0%)	1 (50.0%)	2 (50.0%)	0 (0.0%)	0 (0.0%)		
Posterior Pole	0 (0.0%)	1 (20.0%)	1 (50.0%)	1 (25.0%)	1 (50.0%)	3 (100.0%)		
Size							0.058	0.9 (0.19-4.21)
Large (>5dd)	3 (33.3%)	4 (80.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (33.3%)		
Medium (1-5dd)	0 (0.0%)	0 (0.0%)	1 (50.0%)	2 (50.0%)	0 (0.0%)	0 (0.0%)		
Small (<1dd)	6 (66.7%)	1 (20.0%)	1 (50.0%)	2 (50.0%)	2 (100.0%)	2 (66.7%)		
Extend to the Ora serrata							0.018	NaN (Not Calculable)
No	9 (100.0%)	2 (40.0%)	2 (100.0%)	4 (100.0%)	2 (100.0%)	3 (100.0%)		
Yes	0 (0.0%)	3 (60.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)		
Dot/blot haemorrhages							0.497	0.5 (0.04-6.68)
No	6 (66.7%)	4 (80.0%)	1 (50.0%)	4 (100.0%)	2 (100.0%)	3 (100.0%)		
Yes	3 (33.3%)	1 (20.0%)	1 (50.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)		
Retinal Detachment / Retinoschisis							0.247	0.83 (0.08-8.50)
No	4 (44.4%)	2 (40.0%)	1 (50.0%)	3 (75.0%)	2 (100.0%)	2 (66.7%)		
Unknown	4 (44.4%)	0 (0.0%)	1 (50.0%)	1 (25.0%)	0 (0.0%)	1 (33.3%)		
Yes	1 (11.1%)	3 (60.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)		

Official Journal of the Irish Medical Organisation

Ir Med J; January 2025; Vol 118; No. 1; P3
January 27th, 2025

Clinical Conditions

Figure 1 - Flow chart of cases, retinal examination and Neuroimaging

IMJ
Official Journal of the Irish Medical Organisation

Ir Med J; January 2025; Vol 118; No. 1; P3
January 27th, 2025

28 Cases of Retinal Haemorrhage

3 Cases Excluded due to age

25 Cases of Retinal Haemorrhage

9 Ex-preterm ROP	4 Metabolic / Genetic	2 Infection	2 Tumours	5 Presumed Trauma	3 Other
Examination: Unilateral/Bil., few, small, in subretinal/ intraretinal, posterior/ peripheral poles. Not extending to Ora serrata & no retinoschisis. **Imaging:** Multifocal intracranial haemorrhage with thrombus in transverse sinuses, increased ventricular size, multifocal	**Examination:** Unilateral/ Bil., few/many, small/ medium in size, located subretinal/ intraretinal, in post. Pole /& periphery. No extension to ora serrata, no retinoschisis **Imaging:** Not done	**Examination:** Many/ few, medium/ small, multilayered/ intraretinal, in post. pole and periphery, with no extension to ora serrata. COVID: Dot blot haemorrhage. **Imaging:** **COVID:** old thrombus in L. Internal Jugular vein	**Examination:** Unilateral /Bil., few, small, in subretinal, intraretinal / periphery, no extension to Ora serrata. **Imaging:** Consistent with underlying tumour **Retinoblastoma:** Small L. retinal lesion in L. globe **Craniopharyngioma:** Large cystic lesion arising from Sella turcica, mild hydrocephalus.	**Examination:** Bil. many, large, multilayered, in post pole & periphery. Extending to Ora serrata with retinoschisis **Imaging:** Subdural collection & hematoma, subarachnoid haemorrhage, enlarged ventricular size.	No confirmed diagnosis **Examination:** Large, pigmented R. Fundus Lesion, Peripapillary Choroidal Neurovascular membranes Papilledema **Imaging:** Normal

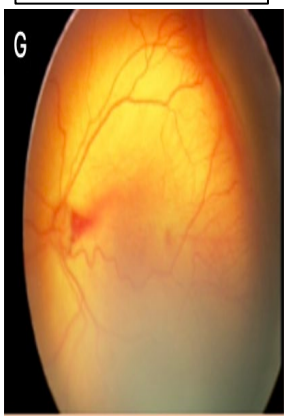


Image G: ROP

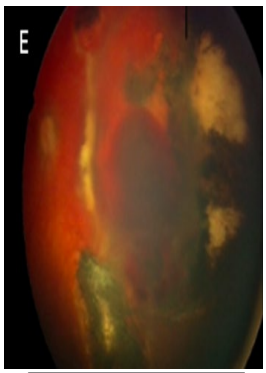


Image E: Chorioretinal scarring in CMV

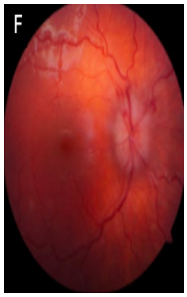


Image F: Craniopharyngioma – Optic disc swelling

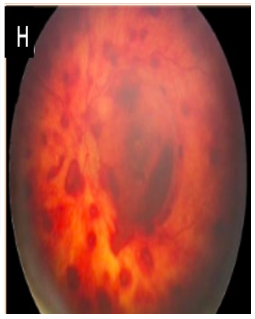


Image H,I: Multi-layered Haemorrhages – presumed trauma

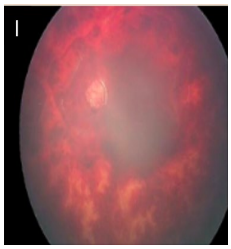
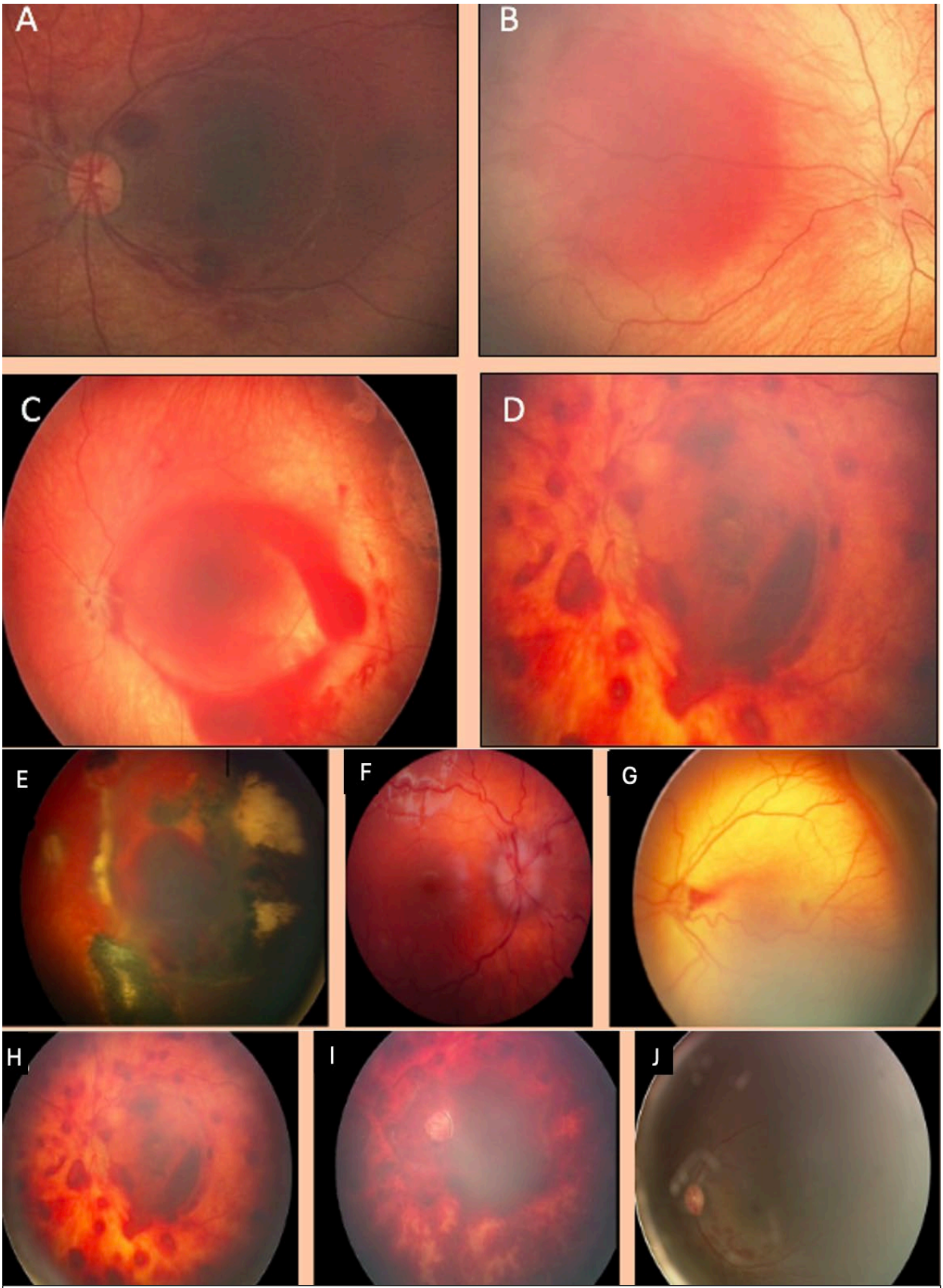


Figure 2: Ocular Images of the study population



A) Intraretinal Haemorrhages; B) Subretinal Haemorrhages; C) Preretinal Haemorrhages; D) Multi-layered Haemorrhages; E) Chorioretinal scarring in CMV; F) Optic disc swelling in Craniopharyngioma; G) ROP; H-I) Haemorrhages in Presumed Trauma

Discussion

In this study, we analysed 25 cases of RH from a paediatric ocular image database at CHI Temple Street Children's Hospital. The cases that were selected based on predefined criteria demonstrated ocular imaging's role in identifying distinct RH patterns associated with various conditions. The demographic analysis noted the majority being infants (16 cases), with a slight predominance of males (56%). Cases of presumed trauma exhibited bilateral retinal involvement with extensive multilayered haemorrhages extending to the ora serrata. In contrast, ROP cases had localised haemorrhages, unilateral or bilateral, small, located in the subretinal or intraretinal area and often at the demarcation zone. Although the clinical presentation of the genetic and metabolic conditions differed, RH findings were similar to those in ROP cases. All presumed trauma cases underwent neuroimaging and a skeletal survey. The above distinct patterns highlight paediatric ocular imaging's role in better understanding the features of RH and its pivotal role in documenting RH findings essential for diagnostic assessment, particularly in cases of AHT.[19] Maguire et al. highlighted that while certain RHs are typical of AHT, the absence of a pattern necessitates alternative diagnoses.[20] Our report identifies other conditions presenting with RH, crucial for comprehensive patient examination.

Saleh et al. state that RetCam was instrumental in diagnosing abusive head injuries (AHI) in 92.8% of patients, providing high-resolution images that detect subtle retinal changes, even in uncooperative young patients.[21] Despite producing two-dimensional images necessitating detailed descriptions, ocular imaging simplifies examinations, encourages professional collaboration, implements standardised protocols and optimises clinical practice.[19,22] Maguire et al. emphasised the importance of standardised terminology, examination protocols, and diligent recording to ensure clarity and consistency in documentation, minimising clinical uncertainty and enhancing patient care.[20] Ocular imaging proves valuable for rapid diagnostic decisions, specifically in critically unwell patients or child maltreatment cases.[21,23] Saleh et al. demonstrated that integrating RetCam imaging enhances diagnostic precision and enables effective telemedicine screening, particularly in ROP and AHT, with strong collaboration between ophthalmoscopic examination and telemedical interpretation.[21] Wu et al. demonstrated digital photography sensitivity reaching 100% and specificity between 95% and 97.5% for case identification.[24] Its digital data transmission capability supports remote assessments, suggesting a future role in telemedicine for AHT screening.[21]

Advances in artificial intelligence (AI) may further improve retinal examination efficiency.[25] This highlights ocular imaging's transformational potential in elevating the standard of care across facilities in Ireland. Integrating AI advancements can enhance peer review processes, facilitate efficient consultations and broaden the scope of educational opportunities.

The study's limitations stem from its retrospective design and small sample size, possibly influenced by the COVID-19 pandemic. Not all retinal exam documentation adhered to the consistent format of RCOphth standards, and the ethical exclusions of certain case information may have introduced bias. Additionally, ocular images were reviewed by a single ophthalmologist, introducing the potential for observer bias. Future research could adopt a multi-modal approach, combining ocular imaging with optical coherence tomography (OCT). Improved documentation, standardised examinations, and collaboration among healthcare professionals (HCP) could enrich reporting and diagnostic accuracy. The findings impact clinical practice, policy development, and future studies in paediatric ophthalmology. Based on our findings, we recommend that clinicians prioritise the use of paediatric ocular imaging to identify RH, particularly in critical settings such as emergency departments and child protection units. Access to ocular imaging technology is crucial, and the development of national guidelines and comprehensive training programmes to standardise practice across regions is essential. Training programs should focus on equipping healthcare professionals with the necessary skills to effectively use imaging technologies and interpret the results to provide optimal patient care. Utilising ocular images in telemedicine can expedite the interpretation of retinal images, especially in suspected AHT cases. Future research is encouraged to validate the diagnostic accuracy of ocular imaging and explore its cost-effectiveness compared to traditional methods through longitudinal and multi-centre studies in Ireland.

This research contributed to the existing literature by analysing high-resolution ocular imaging in pediatric patients and real-time visualisation of retinal haemorrhages, highlighting its role in diagnosing and identifying RH patterns and associated conditions. It underscores the importance of integrating relevant information using standardised protocols for accurate differential diagnosis. The potential of telemedicine with ocular imaging can enhance clinical practice and research, especially in regional facilities.

In paediatric ophthalmology, retinal haemorrhages often present distinct patterns based on their aetiology. It is crucial to assert that retinal haemorrhages must not be viewed as definitive indicators for diagnosis in the absence of a comprehensive clinical context. Advances in retinal imaging technologies have enhanced the documentation of haemorrhages, yielding high-resolution records that facilitate understanding of their diverse aetiologies. These advancements augment diagnostic accuracy and enable specialised remote consultations that are essential for the progression of telemedicine frameworks, offering opportunities for clinician education and transforming multidisciplinary collaboration. Advances in AI possess immense potential to further refine both the accuracy and efficiency of retinal evaluations, with future studies focusing on multi-center prospective research across Ireland to validate these advancements.

IMJ
Official Journal of the Irish Medical Organisation

Ir Med J; January 2025; Vol 118; No. 1; P3
January 27th, 2025

Appendix 1: RCOphth[2] Proforma for recording ophthalmology exam findings

OPHTHALMOLOGY PATIENT RECORD
- FOR SUSPECTED PAEDIATRIC HEAD TRAUMA

The ROYAL COLLEGE of OPHTHALMOLOGISTS

HISTORY _____

PATIENTS DETAILS

If possible to assess

Visual Acuity	Right eye	Left eye

OCULAR MOTILITY

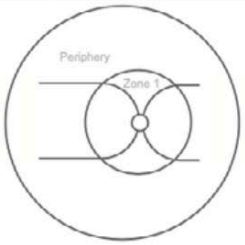
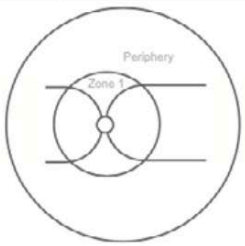
☐ ☐ ☐ Right eye ☐ ☐ ☐ ☐ ☐ ☐ Left eye ☐ ☐ ☐

SUBCONJUNCTIVAL HAEMORRHAGES			
Right eye		Left eye	
Yes	No	Yes	No
ANTERIOR SEGMENT			
Right eye		Left eye	

Pupil size and Pupillary reflexes

PERIOCULAR BRUISING: (mark areas of bruising)

Circle single or multiple appropriate responses if present or enter free text

FUNDUS Circle if present	**RIGHT** EYE				**LEFT** EYE			
Retinal Haemorrhages	YES		NO		YES		NO	
NUMBER of Retinal haemorrhages	Few (1-10)	Many (11-20)	Too numerous to count		Few (1-10)	Many (11-20)	Too numerous to count	
LOCATION of retinal haemorrhages	Pre retinal	Intraretinal	Subretinal	Multilayered	Pre retinal	Intraretinal	Subretinal	Multilayered
DISTRIBUTION of retinal haemorrhages	Posterior Pole Few/many/ too numerous to count (Zone 1 – ROP classification)		Periphery Few/many/too numerous to count (outside Zone 1)		Posterior Pole Few/many/ too numerous to count (Zone 1 – ROP classification)		Periphery Few/many/too numerous to count (outside Zone 1)	
SIZE of retinal haemorrhages	Small (< 1dd)	Medium 1-2dd	Large >2dd		Small (< 1dd)	Medium 1-2dd	Large >2dd	
MORPHOLOGY of haemorrhages White centered etc								
Macula Retinoschisis	Yes / No				Yes / No			
Perimacular folds	Yes / No				Yes / No			
Optic disc (findings) oedema	Yes / No				Yes / No			

Summary	Pupils dilated with Phenylephrine 2.5% ☐ Tropicamide 1% ☐ 0.5% ☐
Management plan	**Fundus examined with** Indirect ophthalmoscope (and 20d / 28d / 30d / 2.2d) Photography ☐ Wide angle ☐ → *Contact* ☐ → *Non contact* ☐ Other ☐ OCT ☐
Name and signature	Date and time of examination

Declarations of Conflicts of Interest:
None declared.

Corresponding author:
Abrar Al Zaabi
General Paediatrics Department,
Temple Street Children's Hospital,
Children's Health Ireland,
Rotunda,
Dublin 1,
Ireland.
E-Mail: abrar_alsharif@hotmail.com.

References:

1. Chen F, Cheng D, Pan J, Huang C, Cai X, Tian Z, et al. The efficacy and safety of Retcam in detecting neonatal retinal hemorrhages. BMC Ophthalmology. 2018 Aug 20;18(1). doi:10.1186/s12886-018-0887-y.
2. Royal College of Ophthalmologists. Abusive Head Trauma and the Eye [Internet]. 2nd ed. London: Royal College of Ophthalmologists; 2024 [cited April 23, 2024]. Available from: https://www.rcophth.ac.uk/wp-content/uploads/2021/08/Abusive-Head-Trauma-and-the-Eye-2024_v2.pdf.
3. Watts P, Maguire S, Kwok T, Talabani B, Mann M, Wiener J, et al. Newborn retinal hemorrhages: A systematic review. Journal of American Association for Pediatric Ophthalmology and Strabismus {JAAPOS} [Internet]. 2013 Feb 1;17(1):70–8. Available from: https://www.jaapos.org/article/S1091-8531(12)00416-8/fulltext.
4. Binenbaum G, Rogers DL, Forbes BJ, Levin AV, Clark SA, Christian CW, et al. Patterns of Retinal Hemorrhage Associated With Increased Intracranial Pressure in Children. Pediatrics. 2013 Aug 1;132(2):e430–4. doi:10.1542/peds.2013-0262.
5. Vinchon M, de Foort-Dhellemmes S, Desurmont M, Delestret I. Confessed abuse versus witnessed accidents in infants: comparison of clinical, radiological, and ophthalmological data in corroborated cases. Child's Nervous System. 2009 Nov 28;26(5):637–45. doi:10.1007/s00381-009-1048-7.
6. Trenchs V, Ana Isabel Curcoy, Morales M, Serra A, Navarro R, Pou J. Retinal haemorrhages in- head trauma resulting from falls: differential diagnosis with non-accidental trauma in patients younger than 2 years of age. Childs Nervous System. 2008 Feb 13;24(7):815–20. doi:10.1007/s00381-008-0583-y.
7. Watts P, Obi E. Retinal folds and retinoschisis in accidental and non-accidental head injury. Eye. 2008 Jul 18;22(12):1514–6. doi:10.1038/eye.2008.224.

8. Adams GGW, Agrawal S, Rajnish Sekhri, Peters MJ, Pierce CM. Appearance and location of retinal haemorrhages in critically ill children. British Journal of Ophthalmology. 2013 May 4;97(9):1138–42. doi:10.1136/bjophthalmol-2012-302429.
9. Bhardwaj G, Chowdhury V, Jacobs MB, Moran KT, Martin FJ, Coroneo MT. A Systematic Review of the Diagnostic Accuracy of Ocular Signs in Pediatric Abusive Head Trauma. Ophthalmology. 2010 May;117(5):983-992.e17. doi:10.1016/j.ophtha.2009.09.040.
10. Bechtel K. Characteristics That Distinguish Accidental From Abusive Injury in Hospitalized Young Children With Head Trauma. PEDIATRICS. 2004 Jul 1;114(1):165–8. doi:10.1542/peds.114.1.165.
11. Shouldice M, Fadiah Al-Khattabi, Thau A, McIntyre S, Wendy K.Y. Ng, Levin AV. Traumatic macular retinoschisis in infants and children. Journal of American Association for Pediatric Ophthalmology and Strabismus. 2018 Dec 1;22(6):433-437.e2. doi:10.1016/j.jaapos.2018.08.007.
12. Maguire SA, Kemp AM, Lumb RC, Farewell DM. Estimating the Probability of Abusive Head Trauma: A Pooled Analysis. Pediatrics. 2011 Sep 1;128(3):e550–64. doi:10.1542/peds.2010-2949.
13. Macher J, Porter RS, Levin AV. Ophthalmic imaging in abusive head trauma. Child Abuse Negl. 2023 May;139:106106. doi: 10.1016/j.chiabu.2023.106106.
14. Temple Street- Children's Health Foundation [Internet]. [cited March 18, 2024]. Available from: https://www.childrenshealth.ie/site/temple-street
15. Investigation of Children With Suspected Physical Abuse [Internet]. CHI Clinical Guidelines. Dublin: Children's Health Ireland; 2023 [cited March 19, 2024]. Available from: https://app.clinibee.com/articles/7debfbc5-ebdd-4a8b-b69d-df7e1b631386
16. Emerson MV, Pieramici DJ, Stoessel KM, Berreen JP, Gariano RF. Incidence and rate of disappearance of retinal hemorrhage in newborns. Ophthalmology. 2001 Jan;108(1):36–9. doi:10.1016/S0161-6420(00)00474-7.
17. Hattenbach LO. Management of Macular Hemorrhage. 1st ed. New York: Springer; 2018.
18. Age Classification [Internet]. Centers for Disease Control and Prevention. 2019 [cited April 25, 2024]. Available from: https://www.cdc.gov/ncbddd/childdevelopment/positiveparenting/infants.html
19. Nakagawa TA, Skrinska R. Improved Documentation of Retinal Hemorrhages Using a Wide-Field Digital Ophthalmic Camera in Patients Who Experienced Abusive Head Trauma. Archives of Pediatrics & Adolescent Medicine. 2001 Oct 1;155(10):1149. doi:10.1001/archpedi.155.10.1149.
20. Maguire SA, Lumb RC, Kemp AM, Moynihan S, Bunting HJ, Watts PO, et al. A Systematic Review of the Differential Diagnosis of Retinal Haemorrhages in Children with Clinical Features associated with Child Abuse. Child Abuse Review. 2012 Nov 13;22(1):29–43. doi.org/10.1002/car.2224.

21. Saleh M, Schoenlaub S, Desprez P, Bourcier T, Gaucher D, Astruc D, et al. Use of digital camera imaging of eye fundus for telemedicine in children suspected of abusive head injury. British Journal of Ophthalmology. 2008 Nov 19;93(4):424–8. doi:10.1136/bjo.2008.147561.
22. Sturm V, Landau K, Menke MN. Optical Coherence Tomography Findings in Shaken Baby Syndrome. American Journal of Ophthalmology. 2008 Sep 1;146(3):363–8. doi:10.1016/j.ajo.2008.04.023.
23. Morad Y, Kim YM, Mian M, Huyer D, Capra L, Levin AV. Nonophthalmologist accuracy in diagnosing retinal hemorrhages in the shaken baby syndrome. The Journal of Pediatrics. 2003 Apr;142(4):431–4. doi:10.1067/mpd.2003.161.
24. Wu C, Petersen RA, VanderVeen DK. RetCam Imaging for Retinopathy of Prematurity Screening. Journal of American Association for Pediatric Ophthalmology and Strabismus {JAAPOS} [Internet]. 2006;10(2):107–11 [cited May 11, 2024]. Available from: https://www.sciencedirect.com/science/article/abs/pii/S1091853105003204.
25. Parmar UPS, Surico PL, Singh RB, Romano F, Salati C, Spadea L, et al. Artificial Intelligence (AI) for Early Diagnosis of Retinal Diseases. Medicina [Internet]. 2024 Mar 23;60(4):527–7 [cited Apr 1, 2024]. Available from: https://www.mdpi.com/1648-9144/60/4/527.

Abbreviations:

1. Bil.: Bilateral
2. CBC: Complete Blood Count
3. CMV: Cytomegalovirus
4. CT: Computed Tomography
5. ICU: Intensive care unit
6. L: Left
7. LFT: Liver function test
8. MRI: Magnetic Resonance Imaging
9. Post.: Posterior
10. R: Right
11. RCOPhth: The Royal College of Ophthalmologists
12. SS: Skeletal Survey