Recognition of Intracranial Hypertension in Children using Handheld Optical Coherence Tomography: The RIO Study

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Introduction: Intracranial hypertension (IH) can damage the brain and vision in affected children, thus early detection is vital. Gold standard measurement of intracranial pressure (ICP) (Figure 1) is highly invasive and carries risk. Optical coherence tomography (OCT) can detect papilloedema due to IH[1], but table-mounted systems are not designed for young children (Figure 2). Fundoscopy delivers poor sensitivity (17-32%) in this scenario.[2-4] Handheld OCT may recognise papilloedema in a child-friendly manner (Figure 3). This world-first study assesses the diagnostic accuracy of handheld OCT for IH in at risk children.



Figure 1: Invasive ICP measurement
ICP bolt system (RAUMEDIC AG). Image taken with parental consent.

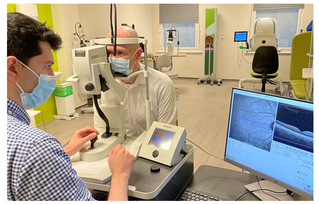


Figure 2: Adult OCT
Table-mounted OCT system (Spectralis, Heidelberg Engineering) – useful in adults but not designed for infants/young children.



Figure 3: Handheld OCT in infants with craniosynostosis
Craniosynostosis is characterised by premature fusion of the skull bones. Left: Envisu C2300 (Leica Microsystems); right: Spectralis Flex (Heidelberg Engineering). Images taken with parental consent.

Methods:

Multi-centre (GOSH and Oxford), prospective, diagnostic accuracy study

Inclusion criteria:

- Children <18 years at risk of IH
- Handheld OCT performed during invasive ICP measurement

Main outcome measures:

- OCT appearance (Figure 3)
- ICP: normal / raised (median ICP >20mmHg ± prolonged spikes)
- Handheld OCT feasibility

Statistical analysis

- Sensitivity and specificity analysis
- Fisher's exact test (OCT/ICP groups)

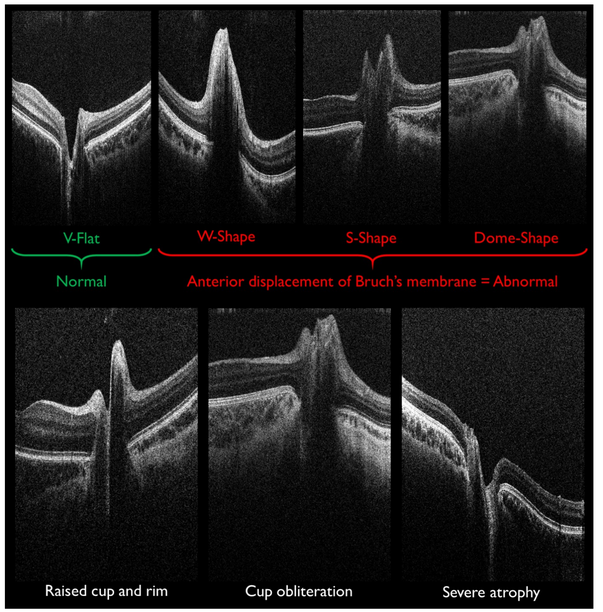


Figure 4: Qualitative OCT signs for assessing ICP
The top row displays possible configurations of Bruch's membrane, graded as per Sibony et al.[1] The normal configuration of Bruch's membrane is 'V-flat', while any anterior displacement of Bruch's membrane is abnormal and suggestive of IH. The bottom row displays further OCT signs proposed in this study. The cup and rim is deemed raised if the cup is above the level of the disc edges and the rim is bilaterally upward-sloping. The cup is deemed obliterated if the criteria for raised cup and rim are met, plus the normal 'U' shaped profile of the cup is disturbed. Severe atrophy is deemed present if the retinal nerve fibre layer appears extremely thin or is no longer visible.

Results: Handheld OCT was successful in 41 of 42 (98%) eligible children. Diagnoses included craniosynostosis (n=26), hydrocephalus (n=9), idiopathic intracranial hypertension (n=2) and other (n=4). Median age was 6.5 years (range: 0.5-17; IQR 4-13). Figure 5 summarises the diagnostic accuracy results. When including all OCT signs, sensitivity was 90% and specificity 75%. When excluding the raised cup and rim sign, sensitivity was 62% and specificity 100%. There was a highly significant difference between OCT and ICP groups (Fisher's exact test, p<0.001).

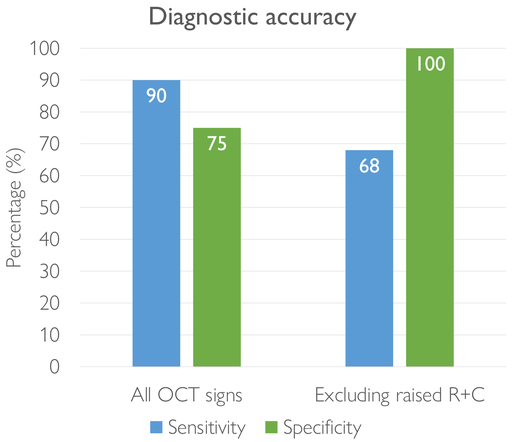


Figure 5: Diagnostic accuracy of handheld OCT for IH
All OCT signs: anterior displacement of Bruch's membrane, raised cup and rim, cup obliteration and severe atrophy. R+C = rim and cup.

Conclusions: Handheld OCT can recognise IH in children. We found excellent feasibility of handheld OCT in children at risk of IH. Ongoing work includes quantitative and longitudinal OCT analysis in these children.

References:
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The RIO Study Information Video

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