

Evaluation Of Retinal Nerve Fiber Layer Changes After Csf Diversion In Obstructive Hydrocephalus: A Prospective Interventional Study

Musannah Ashfaq¹, Shamir Rezwan Sabree², Mehede Hasan Osru³, Nabila Ishrat⁴, Musaddik Ahnaf⁵

¹Assistant Professor, Department of Neurosurgery, Ibn Sina Medical College Hospital, Dhaka, Bangladesh

²Assistant Registrar (Neurosurgery), Department of Neurosurgery, Dhaka Medical College Hospital, Dhaka, Bangladesh

³Resident, Neurosurgery, National Institute of Neurosciences and Hospital, Dhaka, Bangladesh

⁴Orthodontist, Department of Dentistry, Sodesh Hospital Pvt. Ltd, Mymensingh, Bangladesh

⁵Indoor Medical Officer, Medicine, Mymensingh Medical College Hospital, Dhaka, Bangladesh

*Corresponding Author: Dr. Musannah Ashfaq, Assistant Professor, Department of Neurosurgery, Ibn Sina Medical College Hospital, Dhaka, Bangladesh, Email ID: musannah45@gmail.com, Orchid ID: 0009-0007-4123-3977

KEYWORDS

Retinal nerve fiber, CSF, diversion, obstructive, hydrocephalus

ABSTRACT:

Background: Hydrocephalus is a neurological condition caused by excessive accumulation of cerebrospinal fluid (CSF) within the ventricles, leading to raised intracranial pressure (ICP) and papilledema. Persistent papilledema, if untreated, can result in irreversible optic atrophy. The primary aim of CSF diversion procedures such as ventriculoperitoneal (VP) shunt or endoscopic third ventriculostomy (ETV) is to lower ICP and relieve optic disc swelling. Optical Coherence Tomography (OCT) provides a non-invasive, objective method for measuring retinal nerve fiber layer (RNFL) thickness, serving as a surrogate marker for papilledema and ICP changes. **Methods:** This prospective interventional study was conducted in the Department of Neurosurgery, Dhaka Medical College and Hospital, from January 2019 to June 2020. Fourteen patients with obstructive hydrocephalus and bilateral papilledema were included following clinical and radiological confirmation. RNFL thickness was measured using OCT preoperatively and on the 10 th postoperative day after CSF diversion through VP shunt or ETV. Statistical analysis was performed using paired t-tests to determine significance. **Results:** The mean preoperative RNFL thickness in the right eye was $155.07 \pm 50.23 \mu\text{m}$ and postoperatively $120.50 \pm 36.38 \mu\text{m}$ ($p < 0.001$). For the left eye, the mean preoperative and postoperative RNFL thicknesses were $178.00 \pm 51.33 \mu\text{m}$ and $116.43 \pm 26.60 \mu\text{m}$ respectively ($p < 0.001$). Both VP shunt and ETV resulted in significant postoperative reductions in RNFL thickness, indicating effective ICP control. **Conclusion:** OCT-based RNFL measurement is a reliable and non-invasive tool for quantifying papilledema and monitoring treatment outcomes following CSF diversion in obstructive hydrocephalus. The significant postoperative reduction in RNFL thickness underscores its clinical utility as an objective marker for ICP normalization and visual prognosis.

INTRODUCTION

Hydrocephalus is a neurological disorder characterized by abnormal accumulation of cerebrospinal fluid (CSF) within the cerebral ventricles, leading to ventricular enlargement and raised intracranial pressure (ICP).[1] Its pathophysiology involves impaired CSF absorption, excessive production, or obstruction. Papilledema, optic disc swelling due to elevated ICP, is a key clinical feature, and if persistent, can cause irreversible optic nerve damage and visual impairment.

Surgical CSF diversion, including ventriculoperitoneal (VP) shunting or endoscopic third ventriculostomy (ETV), is the mainstay of management for obstructive hydrocephalus, aiming to reduce

ICP and alleviate symptoms. Papilledema resolution is a more reliable indicator of treatment success than radiological ventricular size reduction. [2,3,4] Traditional ophthalmoscopic assessment is subjective and prone to interobserver variability, highlighting the need for noninvasive, quantitative monitoring. [5]

Optical Coherence Tomography (OCT) provides high-resolution imaging of the retina and optic nerve head, allowing quantitative measurement of retinal nerve fiber layer (RNFL) thickness, which correlates with papilledema severity. [4,6] RNFL swelling reflects axoplasmic stasis from raised ICP, and reduction in RNFL thickness post-CSF diversion mirrors ICP normalization, serving as a surrogate marker for treatment response. [2,7,8] Spectral-Domain OCT (SD-OCT) offers improved resolution, speed, and reproducibility compared to Time-Domain OCT, reducing observer bias. [5]

CSF diversion carries risks, including obstruction and infection, particularly in infants. [9,10] and mixed obstructive-absorptive hydrocephalus may occur in pediatric patients.[11] Despite international validation, OCT-based monitoring remains underutilized in low- and middle-income countries, including Bangladesh.

This study aimed to evaluate quantitative changes in papilledema by measuring pre- and postoperative RNFL thickness via OCT in patients with obstructive hydrocephalus undergoing CSF diversion. It also sought to correlate clinical papilledema grading with RNFL thickness, validating OCT as a reliable surrogate for ICP monitoring and supporting evidence-based postoperative management.

MATERIALS AND METHODS:

This was a prospective interventional study conducted in the Department of Neurosurgery, Dhaka Medical College and Hospital (DMCH), from January 2019 to June 2020. The study aimed to quantitatively evaluate changes in papilledema following cerebrospinal fluid (CSF) diversion in patients with obstructive hydrocephalus, using Optical Coherence Tomography (OCT) to measure retinal nerve fiber layer (RNFL) thickness before and after surgery.

The study population consisted of patients admitted to the Department of Neurosurgery, DMCH, diagnosed with obstructive hydrocephalus and presenting with papilledema due to raised intracranial pressure (ICP). The diagnosis of hydrocephalus was confirmed through computed tomography (CT) or magnetic resonance imaging (MRI) findings. A total of 14 patients who fulfilled all inclusion criteria and provided informed consent were enrolled in the study. A non-probability purposive sampling technique was employed to recruit participants.

Data were collected using a structured sheet covering patient demographics, clinical findings, imaging results, and OCT measurements. Each patient underwent clinical and fundoscopic evaluation, with papilledema graded by the modified Frisen scale. Preoperative RNFL thickness was measured using OCT, followed by a CSF diversion procedure (VP shunt or ETV). On the 10th postoperative day, OCT and fundoscopic reassessments were performed to evaluate papilledema resolution. The primary variable was the change in RNFL thickness before and after CSF diversion, with secondary variables including demographics and papilledema grade. Mean pre- and postoperative RNFL values were compared, and statistical analysis assessed the significance of changes following surgery.

RESULTS:

Age of the patients was divided into 5 categories. The highest 5 (35.72%) patients were between 21-30 years. The second highest 4 (28.57%) patients were between 31-40 years followed by 3 (21.43%) patients from 6-10 years and 1 (7.14%) patient came from other two age groups. The mean age of the patients was 25.50 ($\pm$ 11.647) years (Table I). The majority 9 (64.29%) of the patients were male with 5 (35.71%) were female. Male to female ratio is 1.8:1.

Table I: Distribution of Patients According to Age. (N=14)

Age (years)	Frequency (%)
6-10	3 (21.43)
11-20	1 (7.14)
21-30	5 (35.72)
31-40	4 (28.57)
41-50	1 (7.14)
Total	14 (100)
Mean $\pm$ SD	25.50 $\pm$ 11.647

The most common etiology of obstructive hydrocephalus was Cerebello Pontine Angle tumor in 5 (35.7%) patients, followed by Posterior fossa tumor in 3 (21.4%) patients, aqueductal stenosis in 3 (21.4%) patients. Two (14.3%) patients had pineal tumor. There was 1 (7.1%) patient of choroid plexus papilloma also (Fig 1).

Figure 1: Distribution of Causes for Obstructive Hydrocephalus. (N = 14)

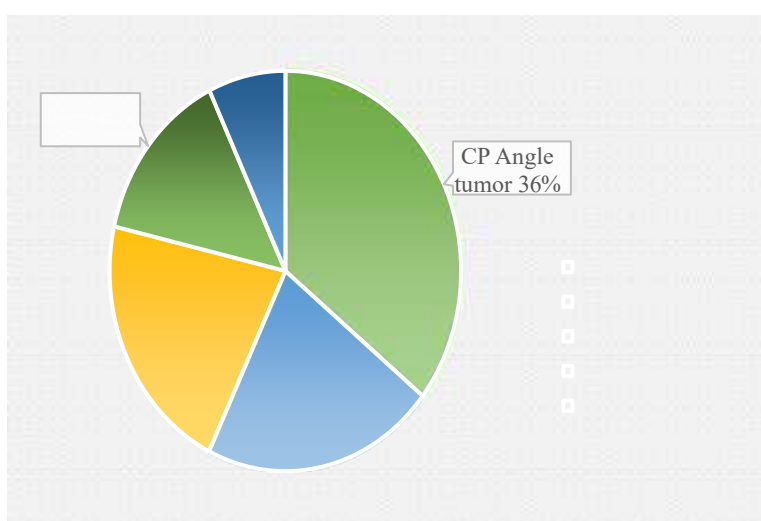
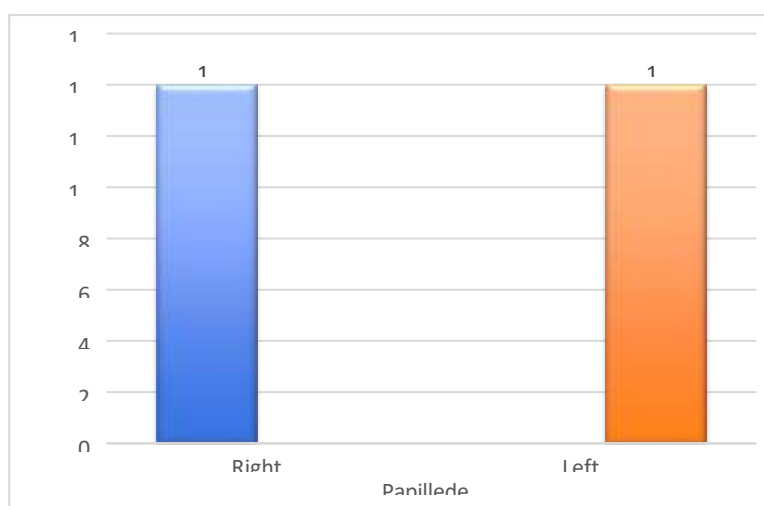


Figure 2: Distribution of Pre-operative Visual Symptoms. (N=14)



All 14 (100%) patients had bilateral papilledema; whereas 1 (7.14%) patient had diplopia also (Fig 2). The main clinical presentations of the patients were headache and vomiting in 13 (92.86%) patients and hearing loss in 5 (35.71%) patients. Only 3 (21.43%) patients had gait disturbances (Table II). Regarding

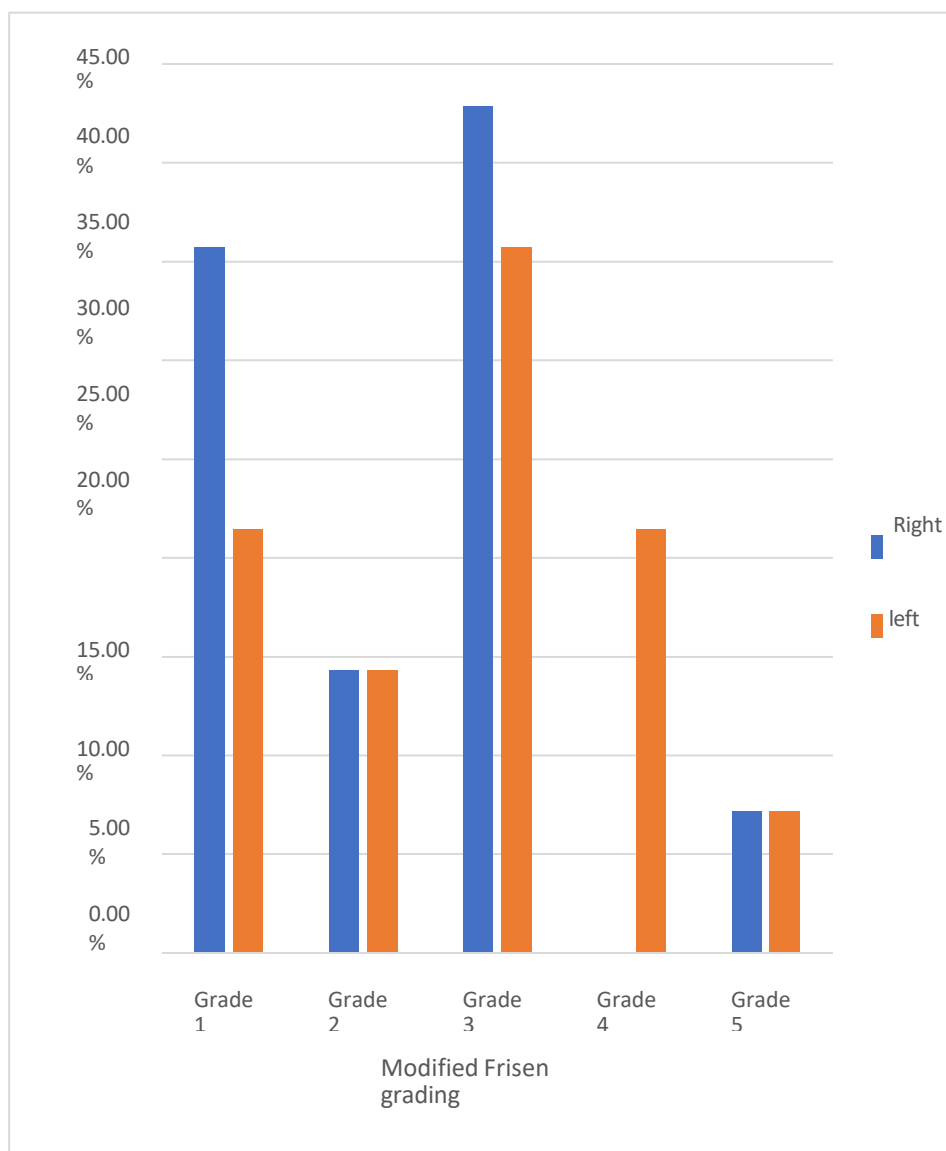
ventricular dilatation majority 13 (92.86%) patients had Tri ventriculomegaly. One (7.14%) patient had BI ventriculomegaly.

Table II: Distribution of Patients According to Other Associated Pre-operative Complaints. (N=14).

Other associated complaints	Frequency (%)
Headache	13 (92.86)
Vomiting	13 (92.86)
Gait disturbances	3 (21.43)
Hearing loss	5 (35.71)

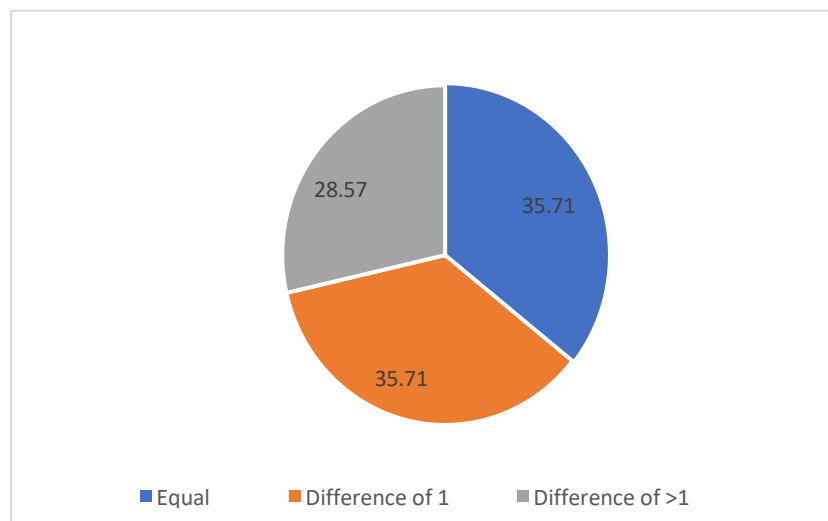
Fundoscopy examination of right eye showed that 6 (42.85%) patients had grade 3 papilledema in right eye. 5 (35.71%) patients had grade 1, 2 (14.28%) patients had grade 2 and 1 (7.14%) patient had grade 5 papilledema in right eye. Fundoscopy examination of left eye showed that 5 (35.71%) patients had grade 3 papilledema in left eye. 3 (21.43%) patients had grade 1, 3 (21.43%) patients had grade 4, 2 (14.28%) patients had grade 2 and 1 (7.14%) patient had grade 5 papilledema in left eye (Fig 3).

Figure 3: Bar Diagram Showing Grading and Distribution of Papilledema in Both Eyes in Pre-operative Period.



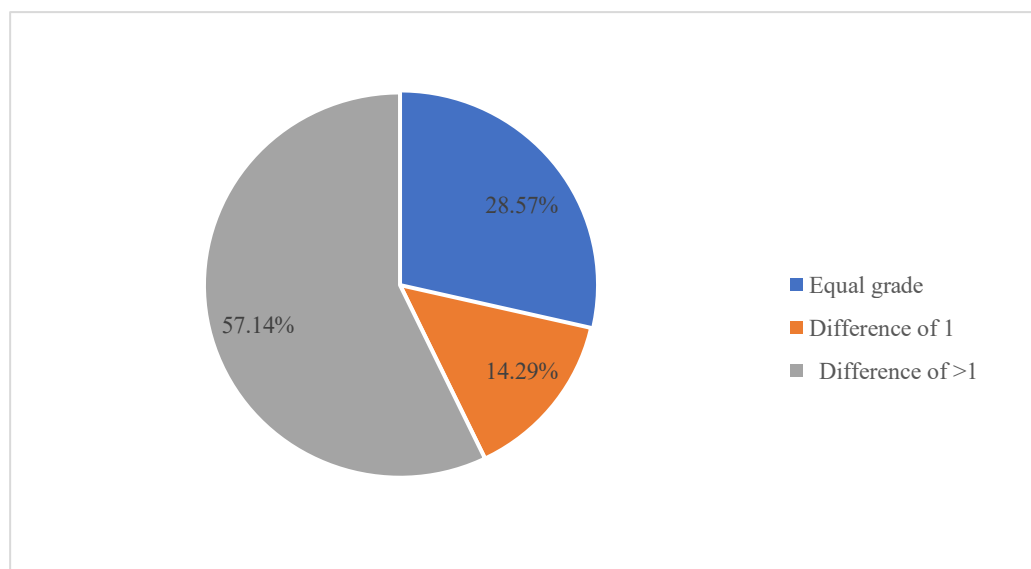
For right eye, most of the patients are in grade 1 papilledema post-operatively. In pre-operative condition most of them were in grade 3 and grade 1. After CSF diversion 3 (28.57%) patients had similar pre-operative grade. 5 (35.71%) patients had one grade change. Other 5 (35.71%) patients had more than one grade change.

Figure 4: Papilledema Grading Change Following CSF Diversion (Right Eye)



In left eye 8 (57.14%) patients showed difference of more than 1 grade of papilledema following CSF diversion. 4 (28.57%) patients had similar pre-operative grade and 2 (14.29%) patients had difference of 1 grade.

Figure 5: Change of Papilledema Grading Following CSF Diversion (Left Eye)



Paired t-test was done to measure the level of significance and p-value <0.001. The mean of the pre-operative RNFL thickness for right eye was 155.07 ± 50.231 range (99 – 300) micrometers. While the mean of the post-operative RNFL thickness for right eye was 120.50 ± 36.384 range (63 – 197) micrometers. The mean of the change in RNFL measured 34.571 ± 27.781 micrometers which is found to be statistically significant at 5% level of significance (p-value <0.001). The mean of the pre-operative RNFL thickness for left eye was 178 ± 51.327 range (112 – 300) micrometers. The mean of the post-

operative RNFL thickness for left eye was 116.43 ± 26.599 range (68 – 176) micrometers (Table III). The mean of the change in RNFL measured 61.571 ± 39.397 micrometers which is found to be statistically significant at 5% level of significance, p-value <0.001 (Table III).

Table III: Pre- and Post-operative Retinal Nerve Fiber Layer (RNFL) Thickness (Left Eye). (N=14)

Parameter	Right Eye		Left Eye	
RNFL Thickness	Pre-operative	Post-operative (after 10 days)	Pre-operative	Post-operative (after 10 days)
p-value	< .001		< .001	
Range (min–max), μm	99–300	63–197	112–300	68–176
M $\pm$ SD, μm	155.07 ± 50.23	120.50 ± 36.38	178.00 ± 51.33	116.43 ± 26.60

Note: RNFL = Retinal Nerve Fiber Layer; M = Mean; SD = Standard Deviation. Paired t-test was done to measure the level of significance.

Table IV shows the change of RNFL after ventriculo peritoneal shunt and endoscopic third ventriculostomy in both eyes. Following ETV p-value is 0.011 in right and 0.028 in left eye; both of which are statistically significant. Following VP Shunt p-value is 0.013 and 0.002 in right and left eye respectively which is also statistically significant.

Table IV: Change of RNFL After VP shunt and ETV

	Procedure	No of patients	Percentage	Pre-op RNFL Mean $\pm$ SD (Range)	Post-op RNFL Mean $\pm$ SD (Range)	p-value
(Right eye)	Ventriculoperitoneal shunt	10	71.43	156.2 ± 57.27 (99-300)	126.8 ± 36.82 (96-197)	0.013
	ETV	4	28.57	152.25 ± 32.86 (97-176)	104.75 ± 34.722 (63-148)	0.011
(Left eye)	Ventriculoperitoneal shunt	10	71.43	185.3 ± 54.71 (120-300)	123.6 ± 26.12 (97-176)	0.002
	ETV	4	28.57	159.75 ± 42.586 (112-212)	98.50 ± 20.469 (68-112)	0.028

DISCUSSION:

This study evaluated RNFL thickness as a noninvasive modality for assessing pre- and postoperative changes in papilledema in patients with obstructive hydrocephalus undergoing CSF diversion at DMCH from January 2019 to June 2020. Patients with communicating hydrocephalus or those unlikely to cooperate with OCT (e.g., <3 years, poor GCS, cognitive decline) were excluded, consistent with [12] and normative RNFL databases.

Fourteen patients (both eyes affected) were enrolled, with a mean age of 25.50 ± 11.674 years (range 6–45); 64.29% were male. All patients experienced blurred vision, and one had diplopia. The classic triad of raised ICP—headache, vomiting, and visual disturbance was present in 92.86% of patients, with hearing loss (35.71%) and gait disturbances (21.43%) observed in cases with cerebello-pontine angle

(CP Angle) and posterior fossa tumors. Etiology included CP angle tumors (35.7%), posterior fossa tumors (21.43%), aqueductal stenosis (21.43%), pineal tumors (14.3%), and choroid plexus papilloma (7.14%). [13,14]

Preoperatively, all 28 eyes had papilledema; Frisen grade 3 was most common (39.28%). Postoperatively, most eyes improved to grade 1 (78.57%), with an average Frisen grade reduction of 1.25 ± 1.076 . Comparable studies reported similar trends. [15,16]

Mean preoperative RNFL thickness was $155.07 \pm 50.231 \mu\text{m}$ (right eye) and $178 \pm 51.327 \mu\text{m}$ (left eye), decreasing to $120.50 \pm 36.384 \mu\text{m}$ and $116.43 \pm 26.599 \mu\text{m}$, respectively (mean changes $34.571 \pm 27.781 \mu\text{m}$ and $61.571 \pm 39.397 \mu\text{m}$; $p < 0.001$). Procedure-specific analysis showed significant RNFL reduction after VP shunt (right $p = 0.013$, left $p = 0.002$) and ETV (right $p = 0.034$, left $p = 0.044$), consistent with.[2]

Limitations include small sample size, short follow-up, preoperative timing variability, unmeasured intraocular pressures, refractive errors, and inter-machine OCT variation. Despite these, OCT-based RNFL measurement provides a reliable, noninvasive tool for documentation, follow-up, and patient counseling in managing papilledema associated with obstructive hydrocephalus. [4,5,6,7,8]

CONCLUSION:

This study confirms that Optical Coherence Tomography (OCT) measurement of retinal nerve fiber layer (RNFL) thickness is a reliable, non-invasive tool for assessing papilledema changes following cerebrospinal fluid (CSF) diversion in obstructive hydrocephalus. A significant postoperative reduction in RNFL thickness and papilledema grading demonstrates effective relief of raised intracranial pressure. The consistency of findings across both eyes and various etiologies highlights OCT's clinical value for monitoring treatment outcomes and guiding patient counselling. Despite limitations such as small sample size and short follow-up, OCT-based RNFL assessment proves to be an objective and practical approach for evaluating visual recovery and documenting postoperative improvement in papilledema.

REFERENCES:

1. ReKate HL. A consensus on the classification of hydrocephalus: its utility in the assessment of abnormalities of cerebrospinal fluid dynamics. *Child's nervous system*. 2011 Oct;27(10):1535-41.
2. Koktekir E, Koktekir BE, Karabagli H, Gedik S, Akdemir G. Resolution of papilledema after endoscopic third ventriculostomy versus cerebrospinal fluid shunting in hydrocephalus: a comparative study. *Journal of Neurosurgery*. 2014 Jun 1;120(6):1465-70.
3. Buxton N, Turner B, Ramli N, Vloeberghs M. Changes in third ventricular size with neuroendoscopic third ventriculostomy: a blinded study. *Journal of Neurology, Neurosurgery & Psychiatry*. 2002 Mar 1;72(3):385-7.
4. Schuman JS, Pedut-Kloizman T, Hertzmark E, Hee MR, Wilkins JR, Coker JG, Puliafito CA, Fujimoto JG, Swanson EA. Reproducibility of nerve fiber layer thickness measurements using optical coherence tomography. *Ophthalmology*. 1996 Nov 1;103(11):1889-98.
5. Xu W, Gerety P, Aleman T, Swanson J, Taylor J. Noninvasive methods of detecting increased intracranial pressure. *Child's nervous system*. 2016 Aug;32(8):1371-86.
6. Huang D, Swanson EA, Lin CP, Schuman JS, Stinson WG, Chang W, Hee MR, Flotte T, Gregory K, Puliafito CA, Fujimoto JG. Optical coherence tomography. *science*. 1991 Nov 22;254(5035):1178-81.
7. Karam EZ, Hedges TR. Optical coherence tomography of the retinal nerve fibre layer in mild papilloedema and pseudopapilloedema. *British Journal of Ophthalmology*. 2005 Mar 1;89(3):294-8.
8. Skau M, Milea D, Sander B, Wegener M, Jensen R. OCT for optic disc evaluation in idiopathic intracranial hypertension. *Graefes Archive for Clinical and Experimental Ophthalmology*. 2011 May;249(5):723-30.
9. Drake JM, Kestle JR, Tuli S. CSF shunts 50 years on—past, present and future. *Child's Nervous System*. 2000 Nov;16(10):800-4.

10. Del Bigio MR, Di Curzio DL. Nonsurgical therapy for hydrocephalus: a comprehensive and critical review. *Fluids and Barriers of the CNS*. 2015 Dec;13(1):3.
11. Beni-Adani L, Biani N, Ben-Sirah L, Constantini S. The occurrence of obstructive vs absorptive hydrocephalus in newborns and infants: relevance to treatment choices. *Child's Nervous System*. 2006 Dec;22(12):1543-63.
12. Swanson JW, Aleman TS, Xu W, Ying GS, Pan W, Liu GT, Lang SS, Heuer GG, Storm PB, Bartlett SP, Katowitz WR. Evaluation of optical coherence tomography to detect elevated intracranial pressure in children. *JAMA ophthalmology*. 2017 Apr 1;135(4):320-8.
13. Gangemi JJ, Kern JA, Kron IL, Ross SD, Shockey KS, Tribble CG. Retrograde venous perfusion of an NMDA receptor antagonist provides spinal cord protection during aortic cross-clamping. *InSURGICAL FORUM-CHICAGO-* 1999 (pp. 183-183).
14. Chahlav A, El-Babaa SK, Luciano MG. Adult-onset hydrocephalus. *Neurosurgery Clinics of North America*. 2001 Oct 1;12(4):753-60.
15. Scott CJ, Kardon RH, Lee AG, Frisén L, Wall M. Diagnosis and grading of papilledema in patients with raised intracranial pressure using optical coherence tomography vs clinical expert assessment using a clinical staging scale. *Archives of ophthalmology*. 2010 Jun 1;128(6):705-11.
16. Rizzo JL, Lam KV, Wall M, Wilson MD, Keltner JL. Perimetry, retinal nerve fiber layer thickness and papilledema grade after cerebrospinal fluid shunting in patients with idiopathic intracranial hypertension. *Journal of Neuro-Ophthalmology*. 2015 Mar 1;35(1):22-5.