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Perimetry, Retinal Nerve Fiber Layer Thickness and Papilledema Grade after Cerebrospinal Fluid Shunting in Patients with Idiopathic Intracranial Hypertension

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Abstract

Objective—To investigate the effect of cerebrospinal fluid (CSF) shunting on quantitative perimetry and papilledema in patients with uncontrolled idiopathic intracranial hypertension (IIH).

Methods—We retrospectively reviewed all cases of IIH with CSF shunting at our institution between 2004 and 2011. Perimetry was performed before and after surgery in 15 patients, and the mean deviation (MD) was compared before and after surgery to assess for the effect of the intervention.

Results—Fourteen of the IIH patients were female and one was male. The average age was 34 years. CSF shunting resulted in significant improvement in the perimetry results with an increase in the MD of 5.63 ± 1.19 dB ($p < 0.0001$). Additionally, average retinal nerve fiber layer (RNFL) thickness measurement by optical coherence tomography (OCT) decreased by 87.27 ± 16.65 μ m ($p < 0.0001$), and Frisen papilledema grade decreased by 2.19 ± 0.71 ($p < 0.0001$).

Conclusion—Our results suggest that CSF shunting results in improvement in perimetry, RNFL swelling, and papilledema grade in patients with IIH.

Greater than 90% of patients with idiopathic intracranial hypertension (IIH) experience visual field loss on static or kinetic perimetry, and it may become permanent (1). Because the disease can progress rapidly and result in irreversible visual loss, it is imperative to monitor and treat promptly and effectively. Patterns of perimetric field loss often resemble

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glaucoma, including generalized depression of the visual field (2, 3). Fortunately, treatment of patients with IIH improves visual function in at least half of patients (1).

Weight loss and oral medications, including acetazolamide, topiramate, and furosemide, are initial therapies for IIH if the disease is mild (1). When visual compromise is severe or if medical management is insufficient, surgical options include optic nerve sheath fenestration (ONSF) and cerebrospinal fluid cerebrospinal fluid (CSF) shunting (CSF diversion). Uncontrolled studies of ONSF and CSF shunting suggest that these procedures are effective in restoring visual function and improving symptoms of IIH, although neither is always effective and both can result in treatment failures (4, 5, 6) or adverse outcomes (7).

In some centers, CSF shunting procedures have become mainstays in the surgical treatment of IIH. Most commonly used are the ventriculoperitoneal (VP) and lumboperitoneal (LP) shunts. Uncontrolled retrospective studies suggest that these procedures can result in improvement of the visual field (with kinetic perimetry) (8) and lessen symptoms of headache in some cases (9).

There are no case series of automated perimetry outcomes following CSF shunting in IIH patients. Our goal was to measure these outcomes in this patient population using the perimetric mean deviation (MD). Additionally, we studied Frisen papilledema grade and measurement of the average thickness of retinal nerve fiber layer (RNFL) by optical coherence tomography (OCT) to assess for changes in papilledema related to CSF shunting (10).

Methods

A retrospective chart review was performed at the University of California Davis Eye Center to include all patients with the diagnoses of IIH and CSF shunting between 2004 and 2011. Upon review, we were able to identify 34 patients whose records included a diagnosis of IIH as well as CSF shunting. Of these 34 patients, 15 fulfilled the Modified Dandy Criteria for IIH, had documented papilledema, had a shunt placed to treat IIH and were included in the study. These patients underwent surgery if they experienced persistent headache and/or progressive vision loss despite maximal medical therapy and weight loss recommendations. The timing of the surgery was variable depending on the severity of signs and symptoms.

All patients were required to have undergone Humphrey Automated Perimetry, either full threshold or SITA 24-2 or 30-2, at baseline prior to the shunt placement, and the same visual field testing method was repeated after surgery.

Mixed effects regression models were fit to compare pre- and post-surgical MD, average RNFL thickness measurement, and Frisen grade, controlling for differences due to age and sex, using the SAS® software version 9.3 (SAS Institute, Cary, North Carolina) procedures GLIMMIX (Frisen grade) and MIXED (MD, average RNFL thickness measurement). Standard linear or logistic regression models cannot be used for data with multiple measurements per subject because it violates the assumption of independence that standard regression models require. Mixed effects models control for intra-subject variability

(differences between the eyes within a subject) and hence allow for repeated measurements on a subject (11).

Results

Fifteen patients met entrance criteria. Fourteen of the patients were female and one was male. The ages ranged from 16 to 66 years, and the average age was 34 ± 12.7 years. Two of the patients underwent LP shunting, and 13 had VP shunting. Of the 15 patients, four underwent revisions of pre-existing shunts. Perimetry was performed between 0 and 7 months prior to the surgical intervention and between 2 and 17 months after surgery. Cirrus or Stratus OCT was obtained in 14 of the 15 patients preoperatively and in all 15 patients postoperatively. The same OCT device was used consistently in each patient. Fundus photography was obtained preoperatively in all 15 patients and in 13 of the patients postoperatively. A masked observer (MW) performed Frisen grading (12).

An example of patient testing results is shown in the Figure 1 which demonstrates the pre-operative and post-operative fundus photos, perimetry results, and OCT measurement of the average RNFL thickness.

Table 1 shows the average values of MD, average RNFL thickness measurement, and Frisen papilledema grade before and after shunting.

Mean Deviation

Average preoperative MD was -11.03 ± 9.53 dB, and average postoperative MD was -5.40 ± 7.16 dB, yielding a difference of 5.63 ± 1.19 dB (p -value <0.0001). All 15 patients (100%) had improved MD postoperatively in both eyes.

Retinal Nerve Fiber Layer

The preoperative average RNFL thickness measured 184.32 ± 93.63 μ m. Postoperatively the average RNFL thickness measured 97.05 ± 23.59 μ m. The average RNFL thickness measurement was significantly smaller in postoperative measurements compared to preoperative (p -value <0.0001). The average RNFL decreased by 87.27 ± 16.65 μ m after surgery. Of the 14 patients with RNFL thickness data, 11 patients (78.57%) improved in both eyes, two patients (14.29%) improved in one eye but worsened in the other, and one patient (7.14%) worsened in both eyes.

Frisen Papilledema Grade

The average preoperative Frisen grade was 2.46 ± 1.50 . The average postoperative Frisen grade was 0.27 ± 0.44 . The average Frisen grade was significantly smaller postoperative measurements compared to preoperative (p -value <0.0001). Frisen grade decreased by an average of 2.19 ± 0.71 after surgery. Of the 13 patients with Frisen grading both preoperatively and postoperatively, nine patients (69.23%) improved in both eyes, one patient (7.69%) improved in only one eye while remaining the same in the other, two patients (15.38%) remained the same in both eyes, and one patient (7.69%) remained the same in one eye but worsened in the other.

Discussion

While IIH patients with minimal or no visual loss can be managed conservatively with weight loss, if visual failure progresses medical or surgical treatments are utilized (1, 4). There are two main surgical options that may be offered to patients. Optic nerve sheath fenestration (ONSF) has been shown to improve or stabilize visual function in approximately 90% of cases of IIH in retrospective uncontrolled case series (13, 14, 15). About 10% of these cases continue to worsen in spite of ONSF (5, 16, 17).

CSF shunting procedures also may be utilized for treatment of IIH. Both VP and LP shunting have resulted in improvement or stabilization of visual function in about 90% of cases in retrospective uncontrolled case series (5, 6). However, despite treatment success with shunting, shunt failures occur frequently in greater than 50% of LP shunts (5, 7) and approximately 30-40% of VP shunts (5, 6). Shunt failure can have significant consequences, such as acute rises in intracranial pressure that may result in severe and rapid visual loss and worsening papilledema (8). Additionally, the longer-term outcomes of CSF shunting are unclear with regard to visual function.

Few previous studies of CSF shunting for IIH patients have reported visual field data. In one report of the efficacy of LP shunting, patients underwent static or kinetic perimetry, with improvement in static perimetry defined as at least 1 dB of improvement in MD (6). Another study evaluating the role of LP shunting used kinetic perimetry exclusively (8). A study of VP shunting for IIH included assessment with visual field function but did not report the type of perimetry or criteria defining improvement (5). A recent report of visual acuity and shunt survival in patients with LP shunting included results of automated perimetry and MD was a secondary outcome measure (18).

We are unaware of any prior studies analyzing the quantitative effect of CSF shunting on perimetry results. Our study analyzed pre-operative and post-operative outcomes and demonstrated that patients treated medically and with CSF diversion procedures had improved MD.

Our OCT data showed that the average RNFL thickness is also reduced by surgical intervention resulting in a reduction of the average RNFL thickness. As reported by Rebolleda and Munoz-Negrete (19) changes in RNFL in cases of mild papilledema are associated with visual field sensitivity losses and that sensitivity increased with resolution of papilledema. However, they also noted that the decreasing RNFL volume may also be due to loss of axons with resulting optic atrophy.

Additionally, our Frisen grading data demonstrates that CSF shunting results in an improvement in disc appearance in both eyes in the majority of patients. Frisen grading was also utilized in the Neuro-Ophthalmology Research Disease Investigator Consortium (NORDIC) Idiopathic Intracranial Hypertension Treatment Trial to evaluate 6 months of acetazolamide and diet for mild visual loss in IIH. Significant improvements in Frisen grade in both the study eye and the fellow eye were noted in fundus photographs and site investigator ratings (20). While Frisen grading is subjective and dependent on experience, a study by Scott and colleagues reported good correlation between Frisen grading of optic

nerve photographs and OCT analysis of optic nerves. In their study Frisen grading was also bound to be more reliable than OCT at higher grades of papilledema (21).

Limitations of this study include the time gaps between preoperative evaluation, surgery, and postoperative testing. Although only the data most proximate to surgical intervention was included, it is possible that there were other causes of change in visual function.

Additionally, both 24-2 and 30-2 visual field protocols were utilized so that comparison of the MD between patients cannot be compared exactly. While some patients had multiple visual fields prior to surgery, others had this performed only once, and this may have resulted in preoperative visual field measurements that overestimated the severity of the condition (22). It is possible that patients presenting with severe acute visual field loss may have been excluded from the study due to a lack of pre-operative data. Patients with profound visual loss may not have had visual function measurable with perimetry or they may have gone quickly to surgery without perimetry. Therefore, our patient population may be skewed toward those with less severe visual loss.

The results of our retrospective uncontrolled study suggest that CSF shunting may be an effective treatment for IIH. Long-term prospective studies are required to further explore the effects of CSF shunting with regard to visual function. Comparison of CSF shunting with ONSF, as well as outcomes after shunt failures, also require further investigation.

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Figure 1.

Patient 3. Fundus photographs, automated visual fields and optical coherence tomography measurement of the average retinal nerve fiber layer thickness are shown OD, right eye; OS, left eye.

Table 1

Average pre-operative and post-operative mean deviation, average retinal nerve fiber layer thickness, and Frisen grade of papilledema. (P-values are from mixed model results. Odds ratio for Frisen grade represents the probability of having lower values after shunting).

	Average Before Shunt	Average After Shunt	Change
MD (dB)	-11.03 ± 9.53	-5.40 ± 7.16	+5.63 ± 1.19 (p<0.0001)
Average peripapillary RNFL thickness (µm)	184.32 ± 93.63	97.05 ± 23.59	-87.27 ± 16.65 (p<0.0001)
Frisen grade	2.46 ± 1.50	0.27 ± 0.44	-2.19 ± 0.71 Odds ratio: 35.7 (p<0.0001)