Binocular disturbance after glaucoma drainage device implantation

Ta Chen Chang, Kara M Cavuoto
Bascom Palmer Eye Institute, University of Miami Miller School of Medicine, Miami, FL 33136, United States

Abstract

Binocular vision disturbance is a well-described complication of glaucoma drainage device (GDD) implantation. The pathophysiology is not well-understood, but may involve bulk effects from the implant and surrounding bleb, as well as modulation of muscle function due to surgical trauma and post-operative inflammation, resulting in a combined resection/posterior fixation effect. Retrospective studies have found the risks of motility disorder and diplopia vary widely, estimated to be 56%–86% and 57%–75%, respectively. More recently, cross-sectional studies and prospective trials estimate post-GDD incidence to be approximately 1%–44%, with the incidence in newer generation of implants designed to limit bleb size likely lower at 1%–5%. Suggested methods of management strategies include prismatic spectacles, monocular occlusion, extreme monovision, and strabismus surgery.

Keywords

Glaucoma; Drainage; Implant; Device; Diplopia; Motility; Binocular; Disturbance; Strabismus

INTRODUCTION

New onset, persistent binocular disturbance is a well-described complication of glaucoma drainage device (GDD) implantation[1]. Studies estimate the risk of post-GDD binocular disturbance to be between 2%–18%[2–10]. Broad categories such as “strabismus,” “diplopia,” “motility disorder,” and “motility disturbance” are used to capture all cases of post-operative binocular disturbances without articulating their natures. The incidences of post-GDD binocular disturbance are often reported as complications in prospective trials or retrospective case series designed to assess the implants’ efficacy in controlling intraocular pressure. Additionally, most of these studies lack rigorous pre-operative motility and binocular function evaluation, and the reports of post-operative binocular disturbances are often descriptive with no quantitative measurements. Assuming that the motility evaluations in these studies were triggered by the patients’ complaint of diplopia, it may be reasonable to assume that the true incidence of diplopia (especially if intermittent) and asymptomatic
motility disturbances to be underestimated. Furthermore, intentional or unintentional post-operative anisometropia may result in decompensation of long-standing phoria and diplopia, which should not be attributed to the glaucoma drainage device implantation.

PATHOPHYSIOLOGY

The pathophysiology of binocular disturbance after GDD implantation is not well-understood, and the proposed mechanisms would include bulk effect, paresis, posterior fixation effect, and mechanical restriction. Earlier case reports suggest the implant or a large filtering bleb around the implant exerts a bulk effect on the globe, causing duction limitations in the direction of the implant\cite{11-16}. Approximately 36% of patients in a retrospective series of double-plated Molteno implants had paretic strabismus in the muscle or muscles concordant to the quadrants of the implant. This suggests that muscle manipulation may result in injuries and paresis, and secondarily motility disturbance\cite{17}. In other reports, a heterotropic, post-GDD eye deviates toward the implant 46%–100% of the time\cite{1,17-21}, implying a restrictive mechanism. During strabismus surgery to correct post-GDD strabismus, Roizen et al\cite{22} noted uniformly restricted forced duction tests and presence of thick, fibrous capsule surrounding the implant and adjacent muscles, regardless of pattern of motility disorder. It is plausible that after the GDD implantation, the postsurgical inflammatory changes, development of the bleb and presence of muscle injury result in altered muscle length-tension relationship as well as a posterior fixation effect. Glaucomatous visual field loss may increase the risk of binocular disturbance due to brittle fusional ability from damaged peri-foveal visual fields and reduced binocular stimulation. This may suggest that patients with long-standing strabismus (presence of suppression) and/or greater visual field loss may be at higher risk of post-operative binocular disturbance. However, the tube versus trabeculectomy (TVT) study found that the mean deviation on automated visual field and prevalence of pre-operative motility disturbance did not differ between those who had new-onset diplopia after GDD compared to those who did not, possibly due to insufficient power\cite{20}.

INCIDENCE OF POST-GDD BINOCULAR DISTURBANCES IN ADULTS

Binocular disturbance includes motility disorder, heterotropia and binocular diplopia, which describe a spectrum of dysfunctions ranging from limited ductional deficits to disrupted binocular cooperation. These entities can exist alone or, more frequently, in combination. General ophthalmic surgical approaches, especially when involving a peri- or retrobulbar infiltrate of local anesthetic agents, may result in binocular disturbances even when the extraocular muscles are not manipulated, although the risk is likely small. This provides a context of background incidence in which the incidence attributed to GDD can be elucidated. In a retrospective review of 20453 cataract cases performed under retrobulbar block with ropiva-caine diluted with hyaluronidase, persistent diplopia was noted in 19 (0.093%) patients\cite{23}. A similar survey of 2024 patients who had undergone cataract surgery with peri- or retrobulbar block yields an overall incidence of 0.25\%\cite{24}. Neither study includes a pre-operative assessment of motility and binocular function, but the reported incidences are adequate estimates of diplopia after procedures involving peri- or retrobulbar block anesthesia.

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Retrospective studies on post-GDD binocular disturbance are often case series of consecutive glaucoma patients receiving implants or cross-sectional studies of diplopic patients referred to strabismus clinic who have previously received GDD implantation. In both scenarios, the patients originate from the glaucoma service and had undergone strabismus evaluation only after the onset of binocular disturbance, making baseline motility and binocular function tests rarely available. Frank et al.\textsuperscript{18} reviewed 7 patients who had undergone Krupin valve implantation, and found four patients (57%) with intermittent or constant diplopia, with the other three patients being functionally monocular. Six of the seven patients (86%) had significant deviation in primary position post-operatively\textsuperscript{18}.

Smith et al.\textsuperscript{21} described 37 eyes of 36 patients that had received Baerveldt glaucoma implant, with 5 of the 36 patient having documented motility disturbance and none with diplopia. Post-operatively, 23 of 30 eyes (77%) with adequate motility follow-up demonstrated motility restriction, and 11 of 17 (65%) binocular patients experienced diplopia\textsuperscript{21}. It is not clear whether any or all of the 5 patients with pre-existing binocular disturbance were included in the follow-up. Wilson-Holt et al reported 16 eyes of 16 patients who had inferior surgical implantation of double-plate Molteno tubes and found 9 of the 16 patients (56%) developed a significant hypertropia, which averaged 8.9 prism diopters (range 2–15 prism diopters). The time of onset of diplopia and hypertropia after tube surgery ranged from 1 to 4 mo. All patients showed restriction on depression of the globe\textsuperscript{25}.

Taken together, one can infer from these three studies that the risk of motility disorder after GDD implantation in a glaucoma cohort ranges between 56%–86% and risk of diplopia between 57%–75%. Some patients develop heterotropia but not diplopia from being functionally monocular. It should be noted that some of these case series involve older generations of glaucoma drainage devices without modifications to modulate bleb size, thus the risks of motility disturbance and diplopia may be lower today with the newer generation devices.

Looking specifically at a group of patients carrying the diagnosis of “diplopia” or who had procedural codes for strabismus surgery, Abdelaziz et al.\textsuperscript{1} used financial claims information to identify patients who had undergone GDD surgery between 1991 and 2005 at a large tertiary referral center\textsuperscript{1}. After review of medical records to exclude diplopia or strabismus surgeries unrelated to the GDD, 1.4% of these patients had persistent, new-onset diplopia attributed to GDD implantation at one year. Despite the meticulous search methodology, the retrospective design and use of financial claims information is likely to underestimate the true incidence of new-onset, persistent diplopia after GDD implantation, especially if the diplopia diagnosis was not submitted for financial claims, or if the patients were lost to follow up.

Few prospective studies evaluated the effect of GDD implantation on motility. In a prospective, consecutive observational series, Dobler-Dixon et al.\textsuperscript{17} performed pre- and post-GDD (double-plated Molteno implant) sensory-motor testing on 24 patients undergoing GDD implantation. The majority had between 1 to 3 prior ocular surgeries. Eight patients (33%) had pre-existing motility disturbance, and 15 patients (63%) were binocular (defined as Snellen visual acuity of 20/70 or better in both eyes). New-onset, persistent motility disorder was noted in 11 of 24 patients (46%) after GDD implantation, 91% of which
occurred in binocular patients. Seven of the 16 patients (44%) with normal pre-operative motility developed new-onset, persistent diplopia after GDD implantation, which were confirmed with red glass test. The authors further delineated the mechanism of strabismus to be paretic in 4 of the 11 patients, with high concordance of the paretic muscle being in the same quadrant as the implant, suggesting paresis associated with hardware implantation and intraoperative manipulation of the extraocular muscles during GDD implantation. However, the determination of paretic versus restrictive mechanisms and relative saccade velocities were not reported. The high likelihood of post-GDD motility disturbance in this series compared to the other studies may be attributed to meticulous post-GDD motility evaluations, which makes under-reporting less likely. The implant’s double-plated design also requires access to multiple quadrants and larger peritomies, and the surgical technique requires elevation of at least one muscle in order to pass the distal plate underneath to the other quadrant.

The TVT Study included a formal motility evaluation on all patients at pre-operative baseline and at the 1-year follow-up visit\[20\]. A total of 101 patients were randomized to the tube group, 71% of whom were binocular (defined as Snellen visual acuity of better than 20/200 in both eyes). Pre-operatively, 26% of GDD patients were heterotropic (most commonly exodeviation at near), while only 2% had diplopia. Post-operatively, new-onset persistent diplopia developed in 5% of patients. However, saccade velocity and sensory confirmation of diplopia were not part of the pre- or post-operative evaluation, and the definition of binocularity was broad. The baseline pre-operative prevalence of heterotropia (26%) was much higher than that estimated by a random sampling of Medicare beneficiaries (< 1%) in a comparable age group\[26\]. This implies that glaucoma diagnosis and history of prior ocular surgeries (cataract extraction, glaucoma filtering procedures) may confer a higher risk of strabismus at baseline compared to the general population. Overall, the study’s prospective design, large number of subjects and pre- and post-operative motility assessment makes it one of the more convincing reports on binocular disturbance after GDD implantation.

**MANAGEMENT STRATEGIES**

Anecdotally, many instances of motility disturbance will resolve without intervention within six months. However, if unresolved, the complex nature of post-operative binocular disturbance may require employment of a number of different strategies. Treatment is complicated by the variability of alignment during the healing process, incomitant nature of the deviations, torsion, and abnormal saccadic velocities.

Prismatic spectacle correction can be used as either a temporizing or a permanent solution, successfully alleviating symptoms in 65% of treated patients\[11\]. Prism correction can be used to facilitate fusion by aligning the images or by moving the second image further so that it can be suppressed. Its utility as a temporizing measure preceding strabismus surgery to test fusion or as a permanent measure to alleviate diplopia makes it extremely helpful in these complicated cases. The options include press-on Fresnel prisms for variable deviations or ground-in prisms for smaller, stable deviations.
Strabismus surgery may be indicated if the deviation is fairly comitant in a patient with adequate motor fusion; however, the patient must understand the goal of surgery is alleviation of diplopia in primary and reading positions and may not correct misalignment in other directions of gaze. The patient should be aware of the increased risk of compromised intraocular pressure control when operating next to filtering blebs and drainage devices. A multidisciplinary approach involving both strabismus and glaucoma services may increase the likelihood of success and minimize complications.

Alternatively, other surgical strategies include implanting a second implant in the opposite quadrant of the same eye (without or without removal of offending implant) or, when indicated, implanting a GDD in fellow eye under the yoke muscles. This strategy capitalizes on the observation that the implant may result in a combined resection/posterior-fixation effect, and thus decrease heterotropia. Aggressive lysis of adhesion with amniotic membrane grafts around the implant and affected muscles to reduce scarring have some anecdotal success.

Additionally, others have suggested extreme monovision in the form of glasses, contact lenses or intraocular lens implants as means to alleviate persistent diplopia by blurring the unwanted image and allowing suppression[27]. Lastly, while far from ideal, partial or complete occlusion of the involved eye with a patch, tape or foil may be the only option should resolution of the diplopia with alternate methods prove unsuccessful.

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Core tip:

The reported incidence of binocular disturbance after glaucoma drainage device (GDD) implantation is variable due to inconsistent study designs, disturbance definition and lack of pre-operative baseline evaluations. The incidence of motility disorder is likely higher than persistent diplopia, as some glaucoma patients requiring GDD are functionally monocular. The mechanism or disturbance is not well-understood, but the bulk of implant/bleb, changes in muscle length, tension and strength may result in a combined resection/posterior-fixation effect. Post-GDD diplopia may resolve spontaneously in some instances, while the intractable cases are usually managed with prismatic spectacles.