



Cigna Medical Coverage Policy

**Subject Emerging Surgical Procedures
for Glaucoma**

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Coverage Policy

Aqueous Shunts/Aqueous Drainage Devices

Cigna covers one or more U.S. Food and Drug Administration (FDA) cleared/approved aqueous shunts/aqueous drainage devices (e.g., Ahmed™ glaucoma valve, Baerveldt® glaucoma implant, EXPRESS™ mini glaucoma shunt, Krupin eye valve, Molteno® implant) (CPT®/HCPCS Codes 66180, 66183, C1783, L8612) as medically necessary for refractory glaucoma when there is failure, intolerance or contraindication to conventional medical (i.e., topical or oral medication) and surgical (i.e., laser therapy, trabeculectomy) treatment.

Cigna covers insertion of a single FDA-approved microstent (i.e., Glaukos iStent Trabecular Micro-Bypass Stent inserted in conjunction with cataract surgery for the reduction of intraocular pressure in an individual with mild to moderate open-angle glaucoma currently treated with ocular hypotensive medication.

Cigna does not cover an aqueous shunt/aqueous drainage device for ANY other indication because it is considered experimental, investigational or unproven.

Procedures

Cigna does not cover ANY of the following procedures for ANY indication because each is considered experimental, investigational or unproven:

- ab interno trabeculectomy (trabectome) (66999)
- canaloplasty (66174, 66175)
- transcliliary fistulization (transcliliary filtration, Singh filtration) (0123T)
- viscocanalostomy (including phacoviscocanalostomy) (66999)

General Background

Glaucoma is a chronic disorder involving increased pressure in the eye due to fluid build up. There are several forms of glaucoma with open angle glaucoma (OAG) being the most common. The increased pressure associated with OAG can lead to optic neuropathies characterized by visual field loss and structural damage to the optic nerve fiber. If left untreated, glaucoma can result in partial or complete visual impairment. Currently, intraocular pressure (IOP) is the only treatable risk factor for glaucoma, and lowering IOP has proven beneficial in reducing the progression of loss of vision.

In most cases, topical or oral medication is the first treatment of choice. For patients who are unwilling or unable to use medications or are unresponsive to medications, laser therapy or trabeculectomy, may be an option. Although laser therapy reduces IOP initially, its effects diminish over the course of a few years, and repetition of the procedure may not be beneficial. Trabeculectomy (CPT[®] 66170 and 66172), an invasive procedure, is the current standard surgical technique for reduction of IOP, but it can result in extremely low IOP, causing ocular damage. Over time, the surgery may fail due to scar formation at the drainage site. Aqueous shunts have been developed as alternative surgical treatment for patients with inadequately controlled glaucoma. Microstents have also been evaluated in the treatment of mild to moderate glaucoma in patients who are receiving treatment with ocular hypotensive medication.

Additional surgical procedures including ab interno trabeculectomy (trabectome), canaloplasty, transcliliary fistulization and viscocanalostomy (including phacoviscocanalostomy) have been proposed for the treatment of glaucoma. There is insufficient evidence in the published medical literature to demonstrate the safety and efficacy of these procedures.

Aqueous Shunts/Aqueous Drainage Devices

Aqueous shunts, also known as aqueous drainage devices, glaucoma drainage devices, setons, tube implants and tube shunts, are drainage devices used to control intraocular pressure (IOP) in the management of glaucoma. First generation shunts in widespread use (e.g., Ahmed [New World Medical, Inc., Rancho Cucamonga CA], Baerveldt [Advanced Medical Optics, Inc. Santa Ana, CA, Krupin [Eagle Vision, Inc., Memphis TN', Molteno [Molteno Ophthalmic Ltd, Dunedin, New Zealand]) follow the same principles. They include an explant plate that, when encapsulated, creates a potential space into which aqueous humor can drain via a connecting tube. The explant plates are constructed of polypropylene or silicone rubber to which fibroblast cannot tightly adhere. Typically the tube of a shunt is placed into the anterior chamber of the eye and drains into one or more plates. Shunts differ based on the type of materials used (e.g., silicone, gold, stainless steel); presence or absence of a valve or flow restrictor in the tube; explant surface area; and shape, size, thickness and number of plates. Aqueous shunts are associated with intraoperative and postoperative complications similar to trabeculectomy plus an additional risk related to implantation of a foreign body and erosion of the tube. Diplopia has also been reported. However the risk of postoperative infection appears less with shunts compared to trabeculectomy. When a single quadrant device is in place and not providing adequate IOP control (i.e., clinical failure), an option is to add a second device in another quadrant (California Technology Assessment, 2011; American Academy of Ophthalmology, 2010; Minckler, et al., 2008; Schwartz, et al., 2006).

The ExPRESS[™] Mini Glaucoma Shunt (Optomol, Israel) is a stainless steel non-valved device designed to have more reproducible results with less dependency on surgical skills than other aqueous shunts. The device is placed under a partial thickness scleral flap and transports aqueous fluid from the anterior chamber to the sub-conjunctival space, forming a bleb similar to trabeculectomy. Unlike a standard trabeculectomy, the procedure is noninvasive and does not require a traditional sclerectomy or iridectomy.

The iStent Trabecular Micro-bypass Stent is a heparin-coated titanium L-shaped implant that was developed as a treatment option for patients with mild or moderate open-angle glaucoma. It is intended to improve aqueous outflow and decrease IOP by creating an opening in the trabecular meshwork and allow aqueous humor to drain into Schlemm's canal and exit the eye. The iStent is a one-piece, heparin-coated, titanium L-shaped implant that can be inserted by either an internal or external approach. Unlike the devices described above, the iStent is an ab interno device (entirely within the eye with no communication to the outside. It is used in patients with mild-to-moderate chronic open-angle glaucoma who are also candidates for cataract surgery. A single iStent device

was implanted in each eye in randomized controlled trials evaluating the device. Additional studies are in progress evaluating the use of more than one iStent in each eye.

U.S. Food and Drug Administration (FDA)

Examples of first generation aqueous drainage devices that received FDA 510(k) clearance between 1988 and 1995 include the following:

- Ahmed™ Glaucoma Valve (New World Medical, Inc., Rancho Cucamonga, CA): management of intractable glaucoma, particularly in cases where previous filtering procedures have failed or are known to have unsatisfactory results
- Baerveldt® Pars Plana Glaucoma Implant (Pharmacia Iovision, Inc., Peapack, NJ): medically uncontrollable glaucoma with poor surgical prognosis
- Krupin eye valve with disk (Hood Laboratories, Pembroke, MA)
- Molteno Valve (Staar Surgical Co., Monrovia, CA)

Modified versions of the Ahmed and Molteno devices received subsequent 510(k) clearance in 2006. The most recent version of the Molteno Valve, the Molteno 3, is intended to reduce intraocular pressure in neovascular glaucoma or glaucoma where medical and conventional surgical treatments have not been successful in controlling the progression of disease. The Ahmed™ Glaucoma Valve (AGV™) Model M4 is intended for use in patients with intractable glaucoma to reduce intraocular pressure where medical and conventional surgical treatments have failed.

The ExPRESS™ Mini Glaucoma Shunt (Optonol, Ltd, Israel), originally received 510(k) clearance in 2002. It was considered to be substantially equivalent to several predicate devices, including the Ahmed and Baerveldt devices, described above. A revised version, the Blunt Tip ExPRESS mini glaucoma shunt, was cleared in 2003, and is indicated for use in reduction of intraocular pressure in patients with glaucoma where medical and conventional surgical treatments have failed.

The Glaukos iStent Trabecular Micro-Bypass Stent (Glaukos Corp., Laguna Hills, CA) received FDA premarket approval (PMA) in June 2012 for use in conjunction with cataract surgery for the reduction of intraocular pressure (IOP) in adult patients with mild to moderate open-angle glaucoma currently treated with ocular hypotensive medication.. As a condition of approval, Glaukos is required to submit follow-up of the Investigational Device Exemption (IDE) study cohort extending to five years, a prospective, randomized multicenter parallel study with new enrollment (n=360) to assess long-term safety, and a prospective multicenter registry to include 500 patients.

Several additional devices are under development/investigation but have not yet received FDA approval, including the EyePass™ Glaucoma Implant (GMP Companies, Inc., Ft. Lauderdale, FL) and the SOLX® Gold Shunt (SOLX, Inc., Waltham, MA), and the CyPass® Micro-Stent (Transcend Medical, Menlo Park, CA).

Literature Review: Aqueous Drainage Devices

First generation devices: Although the evidence evaluating the Ahmed, Baerveldt, Krupin, and Molteno devices is limited, these early devices have been in use for many years and have become established treatment options for selected patients with glaucoma.

Randomized controlled trials and case series with up to seven-year outcomes have reported that Ahmed device was as good as other established treatment options in lowering intraocular pressure (Wishart, et al., 2010; Wilson, et al., 2003). Randomized controlled trials with 3-5 year follow-ups compared outcomes of patients treated with the Baerveldt device to patients who underwent trabeculectomy with mitomycin C.. The authors reported that the Tube shunt group had an overall higher success rate and a lower reoperation rate. One study reported a larger number of surgical complications in the Baerveldt group but most were transient and self-limiting. Early postoperative complications were higher following trabeculectomy (Gedde, et al., 2012a; Gedde, et al., 2012b; Gedde, et al., 2009) Studies evaluating the Krupin valve consist of retrospective reviews with small patient population published prior to 2000. Studies evaluating the Molteno device are primarily in the form of case reports, case series (n=21–145) or retrospective reviews (n=30–162) with up to ten years follow-up. The studies reported improvement or no worsening of visual field loss, IOP, or use of hypotensive medication (Molteno, et al., 2011; Woodcock, et al., 2008; Broadway, et al., 2001).

ExPRESS™ Mini Glaucoma Shunt: de Jong (2009) conducted the first randomized controlled trial to compare the safety and efficacy of Ex-PRESS (n=40) (group A) to trabeculectomy (n=40) (group B). Patients, age greater than 18 years, had primary open-angle glaucoma, pseudoexfoliative or pigmentary glaucoma not controlled with maximal-tolerated medical therapy. Complete success was defined as a final IOP > 4 mmHg and ≤ 18 mmHg without antiglaucoma medications. Overall success was a final IOP > 4 mmHg and ≤ 18 mmHg with or without medications and failure was considered as an IOP > 18 mmHg or requirement for further glaucoma surgery. At the one-year follow-up, significantly more patients in group A achieved complete success (p=0.020), or achieved overall success. Both groups had a significant reduction in medication requirements following surgery, but the difference between the groups was not significant. There were no significant differences between the groups in visual acuity, complications or postoperative interventions.

Five-year outcomes of the original randomized controlled trial were published by de Jong et al. in 2011. Compared to trabeculectomy, there was significantly better control of IOP without medications from one year (p=0.001) to three years (p=0.02) following implantation of the Ex-PRESS device. At year one, 12.8% of Ex-PRESS patients required IOP medication compared to 35.9% of the trabeculectomy patients, although the difference was less significant at five years (41% versus 53.9%, respectively). Postoperatively, Ex-PRESS patients showed stable IOP from year one to year five (p=0.67) compared to a significant decrease in IOP at years three, four and five following trabeculectomy (p<0.0001). Up to the end of year three, IOP was significantly better controlled with the Ex-PRESS device (p=0.04), but at years four and five the differences were not significant. The responder rate was higher, time to failure was longer and surgical interventions for complications were less in the Ex-PRESS group.

Glaukos iStent Trabecular Micro-Bypass Stent: Samuelson et al. (2011) conducted a multicenter randomized controlled trial to assess the safety and efficacy of cataract surgery with iStent compared to cataract surgery alone. Patients with open-angle glaucoma who planned to undergo phacoemulsification for cataracts were randomized to cataract surgery with implantation of an iStent (n=117 eyes) or to cataract surgery alone (n=123 eyes). Implantation was unsuccessful in one eye. Follow-up occurred for up to 12 months. The primary outcome measure was IOP ≤ 21 mmHg without ocular hypotensive medication and the secondary measure was ≥ 20% reduction in IOP from baseline without medication. Additional efficacy measures included medication use and visual acuity. Compared to the control group, significantly more patients in the treatment group achieved primary and secondary outcomes (p<0.001, p=0.003, respectively). At the 12-month follow-up 70% of the treatment group vs. 50% of the control group had achieved both the primary and secondary outcomes. There was a significant delay in the introduction of medication in the treatment group vs. the control group (p<0.001) and significantly more patients in the control group required medication at 12 months (p=0.001). The overall adverse events were similar in both groups. Both groups improved in vision with no significant differences between the groups.

Craven et al. (2012) reported the two year results from this study. At 24 months, the number of patients with an IOP of ≤ 21mm/Hg without ocular hypotensive medications was significantly higher in the iStent group compared to the control group (p=0.036). The proportion of patients with an IOP reduction of ≥ 20% from baseline without medications demonstrated a trend in favor of the stent group, although the difference between groups was not statistically significant (p=0.09). At 24 months, the mean number of medications used was not significantly different between the two groups. At 24 months, the corrected distance visual acuity was worse than 20/40 in seven eyes in the study group and nine eyes in the control group. There was no significant difference in postoperative complications between the two groups.

Fernandez-Barrientos et al. (2010) conducted a randomized controlled trial to evaluate the changes in aqueous humor dynamics and the efficacy and safety of the iStent in combination with cataract surgery (n=17) (group 1) compared to cataract only surgery (n=16) (group 2). Study patients were eligible for cataract surgery, had a visual acuity worse than 20/40, had a medicated IOP > 17 mmHg and < 31 mmHg and an IOP > 21 mmHg and < 35 mmHg after appropriate washout of hypotensive medications. Group 1 received two iStents and 32% required a second and 6% required a third attempt to successfully implant the stent. At the 12-month follow-up trabecular outflow increased significantly in both groups and was significantly greater in the iStent group (p=0.02). The decrease in IOP and medication use was also significantly better in the iStent group (p=0.04, p=0.007). Limitations of the study include the small patient population and short-term follow-up.

Fea (2010) conducted a randomized controlled trial to compare phacoemulsification alone (control group) (n=24) to phacoemulsification with iStent (n=12). Patients had previously been diagnosed with primary open-angle

glaucoma with an IOP above 18 mmHg at three separate visits, were on one or more ocular hypotensive medications, and had a preoperative corrected distance visual acuity no better than 20/80. Given the investigational nature of the iStent patients were randomized more heavily to the control group. Follow-ups occurred intermittently for up to 15 months. At 15 months, the IOP and medication usage were significantly lower in the iStent group compared to the control group ($p=0.031$, $p=0.007$, respectively). Following a one month washout period of ocular hypotensive agents 16 months after surgery, the IOP was significantly lower in the iStent group ($p=0.042$). Limitations of the study include the small patient population, short-term follow-up and unequal number of patients in each group.

A 2013 ECRI Evidence Report, Trabecular Micro-bypass Stent (iStent) for Treating Open-angle Glaucoma provided the following conclusions, based on analysis of one multicenter randomized controlled trial, two single center randomized controlled trials, and three case series:

- The results of three randomized controlled trials indicate that iStent implantation and cataract surgery decreased IOP and ocular hypotensive medication use compared with cataract surgery alone. According to three RCTs, the average number of ocular hypotensive medications used by patients receiving iStent and cataract surgery was significantly fewer than the average number used by patients undergoing cataract surgery alone. Lack of data prevented assessment on visual field loss, and no comparative data were available to assess vision-related quality of life and patients satisfaction
- No studies addressed how iStent implantation and cataract surgery compare with cataract surgery and any other treatment
- There were no significant differences in adverse events between patients treated with iStent implantation and cataract surgery and patients treated with cataract surgery alone. No studies addressed how adverse events for iStent implantation and cataract surgery compare with adverse events for cataract surgery and any other surgical treatments for patients with mild to moderate open angle glaucoma.

Comparison of Aqueous Shunts

Budenz et al. (2011) conducted a multicenter, randomized controlled trial to determine the efficacy and complications of the Ahmed glaucoma valve (AGV) model FP7 ($n=143$) compared to the Baerveldt glaucoma implant (BGI) model 101-350 ($n=133$) for the treatment of refractory glaucoma. Patients with uncontrolled glaucoma who had previously been treated with incisional surgery or who had other glaucoma diagnoses known to be poor candidates for trabeculectomy were included in the study. The primary outcome was failure (i.e., IOP > 21 mmHg or not reduced by 20% from baseline, IOP ≤ 5 mmHg, reoperation for glaucoma or removal of implant, or loss of light perception vision). Secondary outcomes included mean IOP, visual acuity, use of supplemental medical therapy, and complications. Eyes with successfully controlled IOPs (i.e., ≤ 21 mmHg and > 5 mmHg and reduced by at least 20% from baseline) were considered complete successes if medications were not used at either the 6- or 12-month visits and were considered qualified successes otherwise. A significant decrease in IOP was seen in both groups at the one-year follow-up ($p<0.001$, each). The AGV group had a significantly lower mean IOP at one day and one week following implantation compared to BGI ($p<0.001$, each) but the BGI group had a significantly lower IOP at one month ($p=0.024$), three months ($p=0.043$) and one year ($p=0.007$). Both groups achieved significantly lower medication requirement ($p<0.001$, each) but the difference between the groups was not significant ($p=0.071$). There was no significant difference in failure rates or overall successes between the groups, but the BGI group had more complete successes ($p=0.031$). More AVG patients required reoperation ($p=0.016$). More BGI patients experienced early postoperative complications compared to AGV patients ($p=0.016$) and serious postoperative complications associated with reoperation, vision loss of ≥ 2 Snellen lines, or both ($p=0.014$). In summary, the authors noted that greater IOP reduction occurred with the BGI but fewer early and serious complications were observed with the AGV and stated that "this study does not demonstrate clear superiority of one implant over the other." Limitations of the study include the short-term follow-up, number of patients lost to follow-up ($n=16$) and potential bias in reoperation for glaucoma because the surgeon was not masked to the treatment assignment.

In a multicenter, randomized controlled trial, Christakis et al. (2011) reported the one-year treatment outcomes of patients treated with the Ahmed-FP7 valve ($n=124$) compared to the Baerveldt-350 implant ($n=114$). Failure was defined as an IOP > 18 mmHg, < 5 mmHg or reduction from baseline of $< 20\%$ on two consecutive visits at or after three months, or additional glaucoma surgery required including device explant, vision-threatening complications, or loss of light perception. Complete success differed from qualified success in that the "IOP had to be in range at all visits from three months onward, no glaucoma medications were used, no additional

surgical interventions, were required, and vision loss did not exceed doubling of the algorithm of the minimum angle of resolution, which corresponds to approximately two Snellen lines". Secondary outcomes compared the groups on the basis of IOP, medication use, visual acuity, complications related to the surgery, and interventions required. At the one-year follow-up, compared to the Ahmed group, the Baerveldt group had a significantly lower mean IOP ($p=0.001$) and required less medication ($p=0.001$). There was no significant difference between the groups in visual acuity ($p=0.66$). Failure occurred in 51 Ahmed patients and 30 Baerveldt patients ($p=0.02$). Nine Ahmed patients were considered complete successes compared to 18 Baerveldt patients ($p=0.43$). The cumulative probability of failure was higher in the Ahmed group ($p=0.02$). There was no significant difference in postoperative complications ($p=0.19$), but the Baerveldt group required more interventions ($p=0.19$). Author-noted limitations include the fact that the patients had advanced glaucoma refractory to conventional medicinal, laser, and surgical therapy, and were at a high risk of surgical failure which limited the generalizability of the study, and the use of the Snellen acuity to monitor vision loss instead of more sensitive predictors of glaucoma progression. The study is also limited by the short-term follow-up.

In a Cochrane systematic review, Minckler et al. (2006) compared various aqueous shunts for IOP control and safety. Fifteen randomized and quasi-randomized trials ($n=1153$) met inclusion criteria. Meta-analysis of two trials that compared Ahmed implant to trabeculectomy found trabeculectomy resulted in lower mean IOPs with a difference of 3.81 mmHg at 11 to 13 months following implantation. One study compared ridged to standard double-plate Molteno implants and found no clinically significant differences in outcome. Two trials investigated variation in surgical techniques with the Ahmed. One study investigated the double- versus single-plate Molteno and one trial compared the size of the Baerveldt shunts. Other studies investigated the adjunctive use of mitomycin (MMC) or systemic steroids. The authors concluded that "relatively few randomized trials have been published on aqueous shunts and methodology and data quality among them is poor. To date there is no evidence of superiority of one shunt over another."

Technology Assessments

American Academy of Ophthalmology (AAO): The American Academy of Ophthalmology (AAO) (Minckler, et al., 2008) conducted a technology assessment on aqueous shunts for the treatment of Glaucoma. Following a systematic review of the literature, AAO made the following conclusions:

- Aqueous shunts are comparable to trabeculectomy for IOP control and duration of benefit.
- Larger explant surface area is related to better IOP control.
- Although primary indication for aqueous shunts is when prior medical or surgical therapy has failed, they may be used as primary surgical therapy for selected conditions such as trauma, chemical burns or pemphigoid.
- There is sufficient level I evidence that demonstrates no benefit in using antifibrotic agents as adjuncts to aqueous shunt procedures.
- There is sufficient level I evidence that demonstrates no benefit of systemic corticosteroids as adjuncts to aqueous shunt procedures.
- There are insufficient published data to draw any definitive conclusions about the relative likelihood of early postoperative hypotony with implantation of valved or nonvalved devices.

The assessment concluded that, based on level I evidence, aqueous shunts offer a valuable alternative to standard filtering surgery or to cyclodestructive therapy for many refractory glaucomas. The failure rate is approximately the same rate for trabeculectomy with adjunctive antifibrotic agents and in favorable cases shunts may continue to function to control IOP for more than two decades."

California Technology Assessment Forum (CTAF): A 2011 CTAF technology assessment evaluated the evidence for aqueous shunts for the treatment of glaucoma. Studies evaluating the Ahmed, Molteno, Baerveldt, Krupin and Ex-Press devices were included in the assessment. The author concluded that the use of aqueous shunts for the treatment of glaucoma not adequately controlled by medication and/or laser therapy met the CTAF technology assessment criterion for safety, effectiveness and improvement in health outcomes.

Procedures

In an effort to forego the complications of trabeculectomy, the established surgical treatment for glaucoma, new surgical techniques are being investigated. These proposed procedures include ab interno trabeculectomy using the Trabectome™ system, canaloplasty, transcliliary fistulization and viscocanalostomy including

phacoviscocanalostomy. However, there is insufficient evidence to support the safety and efficacy of these evolving surgical interventions for the treatment of glaucoma.

Ab Interno Trabeculectomy (Trabectome)

Ab interno trabeculectomy, or trabectome, is a new, minimally invasive surgical procedure aimed at selectively removing the trabecular meshwork and the inner wall of Schlemm's canal using an internal approach and the Trabectome system (Neomedix Corp., Tustin, CA). The Trabectome system consists of a disposable hand piece tip that will fit through a 1.6 millimeter corneal incision. The hand piece is connected to a console with irrigation and aspiration capabilities and to an electrocautery generator. Using the microcautery tip, the arc of the trabecular meshwork and inner wall of Schlemm's canal are removed in order to open the drainage system in the eye. The targeted tissue is vaporized using bursts of high-frequency electrocautery. The procedure takes about 20 minutes and is performed in an outpatient setting. The proposed advantages of trabectome are that the procedure opens a large pathway for aqueous drainage from the anterior chamber to the collector channels with minimal damage to adjacent structures; the temporal clear cornea approach spares the conjunctiva; absence of a filtering bleb; and it allows for further glaucoma surgery if needed. Proposed disadvantages are the lack of circumferential flow in Schlemm's canal limiting outflow; possibility of cleft closure; the limitation of IOP reduction by episcleral venous pressure and Schlemm's canal resistance; and reported postoperative intraocular pressure (IOP) remained, at best, in the mid-teen range making it undesirable in patients with low-target IOP goals. It is proposed to be well suited for use in conjunction with cataract surgery (Francis, et al., 2011; ECRI, 2010; Pantcheva and Kahook, 2010; Filippopoulos and Rhee, 2008).

U.S. Food and Drug Administration (FDA): The Trabectome High Frequency Generator/LP is FDA 510(k) approved "for use with compatible electrosurgical instruments in low power microsurgical applications for the removal, destruction and coagulation of tissue" (FDA, 2006). The FDA approval does not specifically say that the Trabectome is indicated for the treatment of glaucoma.

Literature Review: There is insufficient evidence to support the safety and efficacy of trabectome. Studies are primarily in the form of case reports, case series and retrospective reviews with short-term follow-ups (six months to two years). Patient selection criteria have not been established. Current concepts regarding the IOP goal at which a patient would avoid optic nerve damage would not be achieved by trabectome in patients with advanced glaucoma. Trabectome may assume a role in the treatment of early or moderately advanced glaucoma where a percentage reduction in IOP cannot be achieved with medication alone. Long-term data comparing trabectome to trabeculectomy or established aqueous shunts are needed to clarify the role of this procedure for the treatment of OAG (Jea, et al., 2012; Ting, et al., 2012; Filippopoulos and Rhee, 2008; Mosaed, et al., 2009; Minckler, et al., 2008).

Francis et al. (2008) reported the outcomes of a prospective case series in 304 patients who underwent trabeculectomy with Trabectome combined with cataract extraction. Patients had OAG and visually significant cataracts. Preoperatively the mean IOP was 20.0 mmHg \pm 6.3 compared to 14.8 \pm 3.5 mmHg at six months and 15.5 \pm 2.9 mmHg at one year. Glaucoma medication usage dropped from 2.65 \pm 1.13 to 1.76 \pm 1.25 at six months and 1.44 \pm 1.29 at one year. Success defined as a 20% or greater drop in IOP or a decrease in glaucoma medications without the need for additional medications or surgical procedures was 78% at six months and 64% at 12 months. Nine patients required a second procedure. The only significant intraoperative complication was blood reflux which occurred in 239 patients. Limitations of the study include the small patient population, short-term follow-up and lack of a comparison or control group. The authors noted that because trabectome was performed in conjunction with cataract extractions, it is not possible to determine to what extent the procedure contributed to the lowering IOP and medication usage.

Canaloplasty

Canaloplasty is a nonpenetrating procedure, similar to viscocanalostomy, aimed at lowering the IOP by permanently stretching the trabecular meshwork and restoring the natural drainage of fluid out of the eye. Conceptually, canaloplasty is an extension of viscocanalostomy with the addition of catheter-aided dilation, the placement of a permanent suture under tension in Schlemm's canal, and the creation of an intrascleral reservoir. The surgery is technically challenging and is contraindicated in eyes with angle recession, neovascular glaucoma, chronic angle closure, and narrow-angle glaucoma and in patients with previous ocular surgery that would prevent 360° catheterization of the Schlemm's canal (Francis, et al., 2011; Razeghinejad and Spaeth, 2011; Koerber, 2007; Goldberg, 2006).

Literature Review: There is insufficient evidence in the published peer-reviewed scientific literature to support the safety and efficacy of canaloplasty for the treatment of glaucoma. Studies are primarily in the form of case series with heterogeneous patient populations and short-term follow-ups. Comparisons of canaloplasty to established treatment modalities are lacking. Many questions remain regarding the proper degree of tension of the suture, long-term effect of the suture in the canal, and resultant microscopic changes in the outflow system morphology (Shingleton, et al., 2008).

Lewis et al. (2011) conducted a multicenter, prospective case series (n=157 eyes) to analyze the safety and efficacy of canaloplasty. Patients had a diagnosis of primary open-angle glaucoma, pigmentary dispersion glaucoma, pseudoexfoliative glaucoma or mixed mechanism. Many patients were on maximally tolerated medical therapy and 73 patients had previously undergone surgical intervention. One group of patients had canaloplasty alone with or without successful suture placement (n=123) (group 1) and one group had canaloplasty with successful suture placement combined with phacoemulsification (n=36) (group 2). At the three year follow-up (n=134), all eyes had a mean IOP of 15.2 ± 3.5 mmHg with a mean glaucoma medication use of 0.8 ± 0.9 compared to 23.8 ± 5.0 mmHg and 1.8 ± 0.9 at baseline, respectively. Eyes that underwent cataract surgery with canaloplasty had a mean IOP of 13.6 ± 3.6 mmHg on 0.3 ± 0.5 medications compared to a baseline IOP of 23.5 ± 5.2 mmHg on 1.5 ± 1.0 medications. IOP and medication usage were significantly decreased from baseline in all eyes ($p < 0.001$) at all follow-up visits. Thirteen eyes lost two or more lines of visual acuity. At 36 months, 36.0% of patients in group 1 achieved complete success and 77.5% achieved qualified success compared to 70.4% of patient in group 2 who achieved a qualified success. Overall, surgical and postsurgical complication rates were low. A total of 12.7% of patients had cataract progression of which 3.8% had preexisting cataracts. Limitations of the study include the lack of a control group, number of patients lost to follow-up (n=23) and the short-term follow-up.

In a prospective, multicenter case series, Bull et al. (2011) evaluated the safety and efficacy of canaloplasty (n=109 eyes) in patients with open-angle glaucoma. Group 1 underwent canaloplasty alone and group 2 underwent canaloplasty plus cataract surgery. Diagnosis included primary open-angle glaucoma, pigmentary dispersion glaucoma or pseudoexfoliative glaucoma. A complete success was defined as reaching the specified IOP without glaucoma medication and a qualified success was defined as including the use of one or two medications. Follow-ups occurred for up to three-years (n=96). Group 1 had a mean baseline IOP of 23.0 ± 4.3 mmHg and a mean glaucoma medication usage of 1.9 ± 0.7 compared to a mean IOP of 15.1 ± 3.1 mmHg on 0.9 ± 0.9 medications at the three-year follow-up. Group 2 had a mean baseline IOP of 24.3 ± 6.0 mmHg on 1.5 ± 1.2 medications compared to a mean IOP of 13.8 ± 3.2 mmHg on 0.5 ± 0.7 medications at 3 years. Compared to baseline, there was a significant decrease in IOP and medication usage in all eyes at each follow-up visit ($p < 0.0001$, each). Group one showed no significant change from baseline visual acuity results ($p = 0.70$). A total of 36.5% of group 1 eyes achieved complete success at an IOP ≤ 18 mmHg and 82.4% achieved a qualified success. In group 2, 61.5% achieved complete success and 100% achieved a qualified success. Fifty-one patients required postoperative interventions and 39 had ocular-related surgical and post-surgical complications. Limitations of the study include the lack of a comparative group, small patient population, patients lost to follow-up (n=13) and short-term follow-up.

In a randomized controlled trial (n=90), Grieshaber et al. (2010) compared the safety and efficacy of two polypropylene sutures for tensioning of the inner wall of Schlemm's canal during canaloplasty in patients with primary open-angle glaucoma. A 6-0 prolene suture was used in group 1 and a 10-0 suture was used in group 2. The mean preoperative IOP was 42.7 ± 12.5 mmHg in group 1 compared to a mean postoperative pressure without medication of 19.2 ± 6.4 mmHg at the fifteen-month follow-up. The mean preoperative IOP was 45.0 ± 12.1 mmHg in group 2 compared to a mean postoperative pressure without medication of 6.4 ± 4.9 mmHg at fifteen months. IOP < 18 mmHg without medication was significantly less with the 10-0 prolene suture ($p = 0.01$). Limitations of the study include the small patient population and short-term follow-up.

Grieshaber et al. (2010) selected 60 eyes from consecutive patients to evaluate the efficacy and safety of canaloplasty in patients with primary open-angle glaucoma. Mean follow-up was 30.6 ± 8.4 months. The mean preoperative IOP was 45.0 ± 2.1 mmHg compared to a mean postoperative IOP (without medications) at six months of 15.4 ± 5.4 mmHg (n=57), at 12 months 15.4 ± 5.2 mmHg (n=54), at 24 months 16.3 ± 4.2 mmHg (n=51), and at 36 months 13.3 ± 1.7 mmHg (n=49). For IOP ≤ 21 mmHg, complete success rate (without medications) was 77.5% (38/49), and qualified success rate (with or without medications) was 81.6% (40/49) at 36 months. The complete success rate of an IOP of 21, 18 or 16 mmHg or less after 36 months was 81%, 67.8% and 47.2%, respectively. During the three-year follow-up, best corrected visual acuity did not deteriorate

in 57 eyes (95%). Complications included two detachments of Descemet's membrane, and one passage of the microcatheter into the anterior chamber and one in the suprachoroidal layer. Limitations of the study include the small patient population, short-term follow-up, lack of comparison to an established treatment option, and patients (n=11) lost to follow-up.

Lewis et al. (2009) reported on an ongoing 14-center, open-label study (n=127) conducted to demonstrate the safety and efficacy of canaloplasty. Diagnoses included primary OAG, pigmentary dispersion glaucoma, exfoliation glaucoma or primary OAG mixed with another type of glaucoma. Efficacy analysis of canaloplasty was based on three subgroups. Group 1 (n=127) included all patients, group 2 (n=97) included patients with successful suture implantation during canaloplasty alone, and group 3 (n=32) included patients with successful suture implantation during canaloplasty plus cataract surgery. At 24 months, all patients had a mean IOP of 16.0 mmHg \pm 4.2 and a mean glaucoma medication use of 0.5 \pm 0.8. Patients treated with canaloplasty alone had a mean IOP of 16.3 \pm 3.7 mmHg and 0.6 \pm 0.8 mean medications and eyes with combined surgery had a mean IOP of 13.4 \pm 4.0 mmHg and 0.2 \pm 0.4 mean medications. All results were statistically significant compared to the baseline values (P<0.001). The most frequent post-operative intervention was cataract surgery (8.6%) and laser goniotomy (4.7%). Three patients had increased IOP at the 24-month follow-up and three patients lost 3 or more lines of best corrected visual acuity. The two most frequent post-operative complications were microhyphema and early elevated IOP in the first three months (7.9% each). Other complications included: hyphema (6.3%), blebs (3.8%), and late elevated IOP (2.4%). In addition to the small heterogeneous patient population and short-term follow-ups, limitations of the study include lack of randomization, and comparison to an established surgical intervention. The authors noted that long-term results and comparative studies are needed to validate the results of this study.

In a prospective case series involving nine centers, Shingleton et al. (2008) evaluated the safety and efficacy of canaloplasty combined with clear corneal phacoemulsification and posterior chamber intraocular lens (IOL) implantation for the treatment of OAG. Adult patients (n=54 eyes) with qualifying treated preoperative IOP of at least 21 mmHg or higher and open angles were eligible. At the three-, six-, and 12-month follow-ups, 85%, 89%, and 74% of eyes were examined, respectively. In all eyes, the mean postoperative IOP was 13.6 \pm 3.8 mmHg at 1 month, 14.2 \pm 3.6 mmHg at 3 months, 13.0 \pm 2.9 mmHg at 6 months, and 13.7 \pm 4.4 mmHg at 12 months (p<0.0001). Medication use dropped to a mean of 0.2 \pm 0.4 per patient at 12 months (p< 0.0001). Overall, a mean improvement in best corrected visual acuity was observed after 12 months. Surgical complications included hyphema (n=3, 5.6%), Descemet tear (n=1, 1.9%), and iris prolapse (n=1, 1.9%). Transient IOP elevation of more than 30 mmHg was observed in four eyes (7.3%) one day postoperatively. Author-noted limitations of the study included lack of randomization and a control group. It was also acknowledged that the learning curve inherent to this and many new surgical procedures also played a key role in outcomes, as sites with larger numbers of enrolled patients had greater success with the procedure.

Transciliary Fistulization

Transciliary fistulization, transciliary filtration or Singh filtration uses the Fugo Blade™ (MediSURG Ltd., Norristown, PA), also called the Plasma Blade, for tissue ablation and noncauterizing hemostatic mechanisms to create a nonbleeding micropore which drains aqueous from behind the iris and into subconjunctival lymphatics. The proposed advantages of this procedure are the posterior route of aqueous filtration, lack of use of antifibrotic agents, low relative cost and shorter surgery time relative to trabeculectomy. The disadvantages are that it is an external filtration procedure with bleb formation with a risk of overfiltration and hypotony (Francis, et al., 2011, Singh and Singh, 2002).

U.S. Food and Drug Administration (FDA): The Fugo Blade for glaucoma (MediSURG Ltd., Norristown, PA) is 510(k) approved by the FDA for "sclerostomy for the treatment of primary open-angle glaucoma when maximum tolerated medical therapy and trabeculectomy have failed" (FDA, 2004).

Literature Review: There is insufficient evidence in the peer-reviewed literature to support the safety and efficacy of transciliary fistulization using the Fugo blade. The limited number of studies are primarily in the form of case series and retrospective reviews with small patient populations (n=16–147) and six to 12 months follow-up. Studies lacked specific inclusion and exclusion criteria and paucity of data (Francis, et al., 2011).

Viscocalostomy and Phacoviscocalostomy

Viscocalostomy involves creating a scleral reservoir and an injection of a viscoelastic biocompatible polymer to open the ostia of the canal. This opening allows passage of fluid from the anterior chamber into the canal

which lowers the IOP. Unlike trabeculectomy, viscocanalostomy avoids full-thickness penetration into the anterior chamber of the eye (Goldberg, 2006; Koerber, 2007; National Institute for Health and Clinical Excellence [NICE], 2008).

Viscocanalostomy is also proposed for use in conjunction with phacoemulsification (i.e., the removal of lens nucleus within the lens capsule by breaking up the lens into tiny pieces for extraction) during cataract surgery. The combination of cataract surgery and viscocanalostomy is called phacoviscocanalostomy and is proposed for use in the place of phacotrabeulectomy. The combined surgery is used for patients who require surgical intervention for the treatment of cataract and glaucoma. Compared to cataract surgery alone, phacoviscocanalostomy is proposed to provide better long-term control of IOP, protection from postoperative IOP spikes and prevention of late-failure trabeculectomy (Kobayashi and Kobayashi, 2007; Shoji, et al., 2007; Park, et al., 2006; Wishart, et al., 2006). The evidence in the published peer-reviewed literature does not support viscocanalostomy or phacoviscocanalostomy for the treatment of glaucoma.

Literature Review-Viscocanalostomy: Randomized controlled trials have reported that viscocanalostomy is not clinically comparable to trabeculectomy, the standard surgical procedure for the treatment of glaucoma, in reducing and maintaining lower IOP values. Overall, significantly better reductions in IOP were seen following trabeculectomy and in some cases, with less repeat treatments needed.

Chai and Loon (2010) conducted a meta-analysis of ten randomized controlled trials (n=458 eyes/397 patients) to compare the outcomes of viscocanalostomy to trabeculectomy mainly for the treatment of primary (n=371) or secondary (n=75) open-angle glaucoma. The authors compared the postoperative mean intraocular pressure (IOP), mean number of antiglaucomatous medications, as well as adverse events. Follow-ups ranged from six months to four years. At six, 12, and 24 months, a significantly lower mean IOP was reported following trabeculectomy (p<0.00001, p<0.00001, p<0.0001, respectively). Trabeculectomy patients required a significantly less number of postoperative antiglaucomatous medications compared to viscocanalostomy (P<0.00001). Six studies reported that viscocanalostomy had a significantly higher relative risk of perforation of Descemet membrane (p=0.007). The relative risk of hypotony, hyphema, shallow anterior chamber, and cataract formation were significantly less in the viscocanalostomy group (p=0.0005, p=0.008, p=0.0002, p=0.002, respectively). Author-noted limitations of the study include: the studies may not be completely comparable due to various surgical techniques and surgeon experience; two studies lacked data on IOP; and the follow-ups were short-term.

Hondur et al. (2008) performed a meta-analysis of randomized controlled trials and case series that evaluated nonpenetrating glaucoma surgery (NPGS), including deep sclerectomy (n=22) and viscocanalostomy (n=14) for the treatment of OAG. Success was defined as IOP of ≤ 21 millimeters of mercury (mmHg) without the use of antiglaucoma medicine. Because they affect the results of NPGS, data related to postoperative goniopuncture and needling with antimetabolite application were noted. In general, the mean follow-up of the viscocanalostomy studies was 25.6 months. The percentage of cases achieving ≤ 21 mmHg was 51.1% following primary viscocanalostomy (n=9) and 36.8% after viscocanalostomy with antimetabolite or implant (n=3). With lower set IOP targets, the rates of success ranged from 10%–67% following viscocanalostomy. Several factors were identified that may account for the wide variation in the success rates of NPGS including the variations in surgical techniques (i.e., use of implants and antimetabolite application) and post-operative manipulation (e.g., goniopuncture, subconjunctival 5-FU injection), variations in success criteria and targeted IOPs, and differences in follow-up lengths. There was an absence of data regarding the severity of glaucoma in the pre-operative patient populations and a lack of data regarding visual acuity following viscocanalostomy. The authors noted that data regarding the success of NPGS beyond three years was limited. According to the authors, the analysis implied that NPGS can achieve IOP reduction. However, these procedures “may not be suitable surgical options for patients in whom vigorous IOP reduction is required.” Long-term studies with data related to glaucoma severity and proper target IOPs are needed.

Earlier published reports from randomized controlled trials also compared the results of viscocanalostomy to trabeculectomy for the treatment of glaucoma (Gilmour, et al., 2007; Cheng, et al., 2004; O’Brart, et al., 2004; Yalvac, et al., 2004; Yarangümeli, et al., 2004; Carassa, et al., 2003; Kobayashi, et al., 2003; O’Brart, et al., 2002; Lüke, et al., 2002; Jonescu-Cuypers, et al., 2001). Overall, trabeculectomy provided a statistically significant decrease in IOP and an increase in IOP control compared to viscocanalostomy. Reported complications were varied and conflicting. Some studies reported no significant differences in complications

while others reported a lower incidence of post-operative cataract formation and hypotony following viscocanalostomy.

Literature Review-Phacoviscocanalostomy: The evidence in the published peer-reviewed literature does not support the safety and efficacy of phacoviscocanalostomy for the treatment of glaucoma. Published studies include a limited number of case series and retrospective reviews with small patient populations and short-term follow-ups (Awalda and Hassan, 2011; Kobayashi and Kobayashi, 2007; Wishart, et al., 2006). The effects on postoperative medication usage, as well as the long-term effects of phacoviscocanalostomy are unknown. Studies comparing phacoviscocanalostomy to established treatment modalities are lacking.

Technology Assessments

Agency for Healthcare Research and Quality (AHRQ): AHRQ (2012) conducted a comparative effectiveness review on treatments for glaucoma. The report included 23 systematic reviews (12 on medical treatment and 9 on surgical treatment), 73 randomized or quasi-randomized controlled trials and 13 observational studies. A search for studies including medical therapy (topical and systemic), laser therapy, trabeculectomy, aqueous drainage devices (I.e., Baerveldt, Ahmed, Krupin, Molteno), deep sclerectomy, viscocanalostomy, iScience microcatheter (canaoplasty), Trabectome, ExPRESS shunt, Glaukos iStent, and SOLX Gold Shunt was conducted. One randomized controlled trial each on ExPRESS (n=80), iStent (n=36), and viscocanalostomy (n=40) met inclusion criteria. No studies on iScience microcatheter (canaoplasty), trabectome, or the SOLX Gold Shunt were included. The study populations were age \geq 40 years, with open-angle or suspect open-angle glaucoma. Due to the “appreciable variability in interventions, follow-up intervals, and assessments of outcomes” meta-analysis of primary studies could not be performed. AHRQ concluded: 1) trabeculectomy lowers IOP more than nonpenetrating surgeries; 2) trabeculectomy results in more complications than nonpenetrating surgeries; and 3) the data available on the role of aqueous drainage devices in open-angle glaucoma are inadequate to draw conclusions.

Professional Societies/Organizations

American Academy of Ophthalmology (AAO): The AAO published an ophthalmic technology assessment on novel glaucoma procedures (Francis, et al., 2011). The assessment included Fugo blade transcliliary filtration, iStent, Ex-PRESS glaucoma shunt, SOLX Gold Shunt, canaloplasty, and trabectome. AAO concluded that these devices and techniques “are still in the initial stage (\leq 5years) of clinical experience and lacking widespread use.” Clinical trials were limited to “nonrandomized, retrospective or prospective, interventional, clinical case series, generally classified as providing only level III evidence in support of the procedures”. Randomized clinical trials are needed to compare these procedures to trabeculectomy and phacoemulsification. AAO concluded “it is possible to state that these novel procedures show potential for the treatment of glaucoma and that they warrant continued support and future studies. It is not possible to conclude if they are superior, equal to, or inferior to surgery such as trabeculectomy or to one another”.

The AAO (2010) practice guidelines on the management of primary OAG stated that medical therapy is the most common intervention for the management of glaucoma and when indicated surgical interventions include laser therapy and trabeculectomy. AAO included aqueous shunts that divert aqueous humor to an end plate as another treatment option and listed the Baerveldt glaucoma implant, Molteno implant, Ahmed glaucoma valve and the Krupin implant as examples of these devices. AAO further explained that “aqueous shunts have traditionally been used to manage medically uncontrolled glaucoma when trabeculectomy has failed to control IOP or is deemed unlikely to succeed. This includes eyes with neovascular glaucoma, uveitic glaucoma, extensive conjunctival scarring from previous ocular surgery or cicatrizing diseases of the conjunctiva, and congenital glaucoma in which angle surgery has failed”. These devices are now being proposed for a broader scope of surgical management for this population. Viscocanalostomy is a nonpenetrating surgery used by some physicians as an alternative to trabeculectomy, but AAO stated that the precise role of nonpenetrating surgeries (i.e., viscocanalostomy and nonpenetrating deep sclerectomy) is yet to be determined. They also noted that the role of canaloplasty is currently under evaluation.

Use Outside the U.S.

The following devices have been awarded the CE mark permitting commercial distribution in Europe and are listed in Health Canada’s Medical Devices Active Listing (may not be all inclusive):

- Ahmed Glaucoma Valve (New World Medical, Inc., Rancho Cucamonga, CA)
- Baerveldt Glaucoma Implant (Abbot Medical Inc., Santa Ana, CA)

- CyPass Micro-Stent (Transcend Medical, Inc., Menlo Park, CA)
- Double Plate Glaucoma Implant (Molteno Ophthalmic, Ltd, Dunedin, New Zealand)
- Glaukos iStent Trabecular Micro-bypass Stent (Models GTS-100R and GTS-100-L0 and inserter (GTS-100i)
- Ex-Press Glaucoma Filtration Device (Alcon Laboratories, Sinking Spring PA)
- SOLX Gold Shunt (SOLX, Inc., Waltham MA)

National Institute for Health and Care Excellence (NICE) (United Kingdom): NICE guidance on the diagnosis and management of chronic open-angle (OAG) and ocular hypertension (2009) concluded from the evidence (low to moderate quality) that trabeculectomy is more effective than non-penetrating surgery (e.g., viscocanalostomy) in reducing IOP from baseline at six- and 12-month follow-ups, but the effect size may be too small to be clinically significant. Trabeculectomy is also more effective in reducing the number of eyes with unacceptable IOP at six- and 12-month follow-ups. Regarding complications, trabeculectomy is more likely to cause cataract formation and persistent hypotony compared to non-penetrating surgery, but there were no significant differences in postoperative wound leaks. Regarding canaloplasty, NICE (2008) stated that the procedure should be used only in the “context of research or formal prospective data collection” for the treatment of primary OAG. They noted that the current evidence on the safety and efficacy of canaloplasty is inadequate in quality and quantity.

NICE guidance published in 2012 states that current evidence, primarily from case series, on the safety and efficacy of trabeculotomy ab interno for open angle glaucoma is adequate to support the use of this procedure but encouraged the collection of long-term efficacy data.

A 2008 NICE guidance document states that the current evidence on the safety and efficacy of canaloplasty for primary open-angle glaucoma was inadequate in quality and quantity and the procedure should only be used in the context of research.

Summary

Although there are a limited number of published, well-designed clinical trials evaluating the safety and efficacy of aqueous shunts/aqueous drainage devices implantation of these devices-(i.e., Ahmed™ Glaucoma Valve, Baerveldt® glaucoma implants, ExPRESS™ Mini Glaucoma Shunt, Krupin eye valve, Molteno® implant) has become a well-established surgical intervention for patients with refractory glaucoma who are unresponsive to medical and standard surgical intervention or in whom medical and surgical treatment is not tolerated or is contraindicated. Implantation of a microstent (i.e., iStent Trabecular Micro Bypass Stent) may be a reasonable treatment option when performed in conjunction with cataract surgery in an individual with mild to moderate glaucoma being treated with ocular hypotensive medication.

Evidence in the published peer-reviewed scientific literature does not support the safety and efficacy of ab interno trabeculectomy (trabectome), canaloplasty, transcliliary fistulization, viscocanalostomy and/or phacoviscocanalostomy for the treatment of glaucoma. The published studies are primarily in the form of case reports, case series and retrospective reviews with small, heterogeneous patient populations and short-term follow-ups. For some of these procedures, patient selection criteria have not been established. Based on the available evidence, it is not possible to determine how these procedures compare to established medical and surgical treatment of glaucoma.

Coding/Billing Information

- Note:** 1) This list of codes may not be all-inclusive.
 2) Deleted codes and codes which are not effective at the time the service is rendered may not be eligible for reimbursement

Aqueous Shunts/Aqueous Drainage Devices

Covered when medically necessary:

CPT®*	Description
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Codes	
66180	Aqueous shunt to extraocular reservoir (eg, Molteno, Schocket, Denver-Krupin)
66183	Insertion of anterior segment aqueous drainage device, without extraocular reservoir; external approach (Code effective 01/01/2014)
0191T	Insertion of anterior segment aqueous drainage device, without extraocular reservoir; internal approach, into the trabecular meshwork.
0192T	Insertion of anterior segment aqueous drainage device, without extraocular reservoir; external approach (Code deleted 01/31/2013)

HCPCS Codes	Description
C1783	Ocular implant, aqueous drainage assist device
L8612	Aqueous shunt

Experimental/Investigational/Unproven/Not Covered for any indications:

CPT* Codes	Description
66174	Transluminal dilation of aqueous outflow canal; without retention of device or stent
66175	Transluminal dilation of aqueous outflow canal; with retention of device or stent
0123T	Fistulization of sclera for glaucoma, through ciliary body
0253T	Insertion of anterior segment aqueous drainage device, without extraocular reservoir; internal approach, into the suprachoroidal space (researching this code to determine applicability)

Experimental/Investigational/Unproven/Not Covered when used to report ab interno trabeculectomy (Trabectome) or viscocanalostomy (including phacoviscocanalostomy):

CPT* Codes	Description
66999	Unlisted procedure, anterior segment of eye

*Current Procedural Terminology (CPT®) © 2013 American Medical Association: Chicago, IL.

References

1. Abbott Medical Optics. Glaucoma drainage devices. 2013. Accessed Feb 10, 2014. Available at URL address: <http://www.amo-inc.com/products/cataract/glaucoma-implants>
2. Agency for Healthcare Research and Quality (AHRQ). Effective Health Care Program. Treatment for glaucoma: comparative effectiveness. Comparative effectiveness review number 60. Apr 2012. Accessed Feb 10, 2014. Available at URL address: <http://effectivehealthcare.ahrq.gov/search-for-guides-reviews-and-reports/?pageaction=displayproduct&productid=1023>
3. American Academy of Ophthalmology (AAO). Preferred practice pattern®. Primary open-angle glaucoma. 2013. Accessed Feb 10, 2014. Available at URL address: <http://one.aao.org/summary-benchmark-detail/primary-openangle-glaucoma-suspect-summary-benchma>
4. Awadalla MA, Hassan KM. Phacoviscocanalostomy in pseudoexfoliation glaucoma versus primary open-angle glaucoma. *Can J Ophthalmol*. 2011 Feb;46(1):77-82.
5. Barton K, Gedde SJ, Budenz DL, Feuer WJ, Schiffman J; Ahmed Baerveldt Comparison Study Group. The Ahmed Baerveldt Comparison Study methodology, baseline patient characteristics, and intraoperative complications. *Ophthalmology*. 2011 Mar;118(3):435-42. Epub 2010 Oct 8.

6. Broadway DC, Iester M, Schulzer M, Douglas GR. Survival analysis for success of Molteno tube implants. *Br J Ophthalmol*. 2001 Jun;85(6):689-95.
7. Budenz DL, Barton K, Feuer WJ, Schiffman J, Costa VP, Godfrey DG, Buys YM; Ahmed Baerveldt Comparison Study Group. Treatment outcomes in the Ahmed Baerveldt Comparison Study after 1 year of follow-up. *Ophthalmology*. 2011 Mar;118(3):443-52.
8. Bull H, von Wolff K, Körber N, Tetz M. Three-year canaloplasty outcomes for the treatment of open-angle glaucoma: European study results. *Graefes Arch Clin Exp Ophthalmol*. 2011 Oct;249(10):1537-45.
9. Burr J, Azuara-Blanco A, Avenell A, Tuulonen A. Medical versus surgical interventions for open angle glaucoma. *Cochrane Database of Systematic Reviews* 2012, Issue 9. Art. No.: CD004399. DOI: 10.1002/14651858.CD004399.pub3.
10. California Technology Assessment Forum® (CTAF). Aqueous shunts for the treatment of glaucoma. Jun 29, 2011. Accessed Feb 10, 2014. Available at URL address: <http://www.ctaf.org/assessments/aqueous-shunts-treatment-glaucoma>
11. Carassa RG, Bettin P, Fiori M, Brancato R. Visco canalostomy versus trabeculectomy in white adults affected by open-angle glaucoma: a 2-year randomized, controlled trial. *Ophthalmology*. 2003;110(5):882-7.
12. Chai C, Loon SC. Meta-analysis of visco canalostomy versus trabeculectomy in uncontrolled glaucoma. *Glaucoma*. 2010 Oct-Nov;19(8):519-27.
13. Cheng JW, Ma XY, Wei RL. Efficacy of non-penetrating trabecular surgery for open angle glaucoma: a meta-analysis. *Chin Med J (Engl)*. 2004 Jul;117(7):1006-10.
14. Christakis PG, Kalenak JW, Zurakowski D, Tsai JC, Kammer JA, Harasymowycz PJ, Ahmed II. The Ahmed Versus Baerveldt study: one-year treatment outcomes. *Ophthalmology*. 2011 Nov;118(11):2180-9.
15. Craven ER, Katz LJ, Wells JM, Giamporcaro JE; iStent Study Group. Cataract surgery with trabecular micro-bypass stent implantation in patients with mild-to-moderate open-angle glaucoma and cataract: two-year follow-up. *J Cataract Refract Surg*. 2012 Aug;38(8):1339-45. doi: 10.1016/j.jcrs.2012.03.025.
16. Dahan E, Carmichael TR. Implantation of a miniature glaucoma device under a scleral flap. *J Glaucoma*. 2005 Apr;14(2):98-102.
17. Dahan E, Ben Simon GJ, Lafuma A. Comparison of trabeculectomy and Ex-PRESS implantation in fellow eyes of the same patient: a prospective, randomised study. *Eye (Lond)*. 2012 May;26(5):703-10. doi: 10.1038/eye.2012.13.
18. de Jong L, Lafuma A, Aguadé AS, Berdeaux G. Five-year extension of a clinical trial comparing the EX-PRESS glaucoma filtration device and trabeculectomy in primary open-angle glaucoma. *Clin Ophthalmol*. 2011;5:527-33.
19. de Jong LA. The Ex-PRESS glaucoma shunt versus trabeculectomy in open-angle glaucoma: a prospective randomized study. *Adv Ther*. 2009 Mar;26(3):336-45.
20. de Jong L, Lafuma A, Aguadé AS, Berdeaux G. Five-year extension of a clinical trial comparing the EX-PRESS glaucoma filtration device and trabeculectomy in primary open-angle glaucoma. *Clin Ophthalmol*. 2011;5:527-33. doi: 10.2147/OPHTH.S18565. Epub 2011 Apr 29.
21. EagleVision®. Glaucoma drainage devices. 2013. Accessed Feb 10, 2014. Available at URL address: <http://www.eaglevis.com/glaucoma.htm>

22. EagleVision. Glaucoma valves. 2004. Accessed Feb 1, 2013. Available at URL address: <http://dryeye.org/pdf/920121.pdf>
23. ECRI Institute. Evidence Report: Trabecular micro-bypass stent (iStent) for treating open-angle glaucoma.. Plymouth Meeting (PA): ECRI Institute Health Technology Assessment Information Service; 2013 Mar. Available at URL address: <http://www.ecri.org>
24. ECRI Institute. Hotline Response [database online]. Plymouth Meeting (PA): ECRI Institute; 2013 Mar. Implants for lowering intraocular pressure in patients with glaucoma. Available at URL address: <http://www.ecri.org>
25. ECRI Institute. Hotline Response [database online]. Plymouth Meeting (PA): ECRI Institute; 2013 Dec. Transciliary fistulization for treating glaucoma. Available at URL address: <http://www.ecri.org>
26. ECRI Institute. Hotline Response [database online]. Plymouth Meeting (PA): ECRI Institute; 2013 Dec. Viscocanalostomy and canaloplasty for treating glaucoma. Available at URL address: <http://www.ecri.org>
27. Estermann S, Yuttitham K, Chen JA, Lee OT, Stamper RL. Comparative In Vitro Flow Study of 3 Different Ex-PRESS Miniature Glaucoma Device Models. *J Glaucoma*. 2012 Jan 20. [Epub ahead of print]
28. Every SG, Molteno AC, Bevin TH, Herbison P. Long-term results of Molteno implant insertion in cases of neovascular glaucoma. *Arch Ophthalmol*. 2006 Mar;124(3):355-60.
29. Fea AM. Phacoemulsification versus phacoemulsification with micro-bypass stent implantation in primary open-angle glaucoma: randomized double-masked clinical trial. *J Cataract Refract Surg*. 2010 Mar;36(3):407-12.
30. Fernández-Barrientos Y, García-Feijoó J, Martínez-de-la-Casa JM, Pablo LE, Fernández-Pérez C, García Sánchez J. Fluorophotometric study of the effect of the glaukos trabecular microbypass stent on aqueous humor dynamics. *Invest Ophthalmol Vis Sci*. 2010 Jul;51(7):3327-32.
31. Filippopoulos T, Rhee DJ. Novel surgical procedures in glaucoma: advances in penetrating glaucoma surgery. *Curr Opin Ophthalmol*. 2008 Mar;19(2):149-54.
32. Francis BA, Minckler D, Dustin L, Kawji S, Yeh J, Sit A, Mosaed S, Johnstone M; Trabectome Study Group. Combined cataract extraction and trabeculotomy by the internal approach for coexisting cataract and open-angle glaucoma: initial results. *J Cataract Refract Surg*. 2008 Jul;34(7):1096-103.
33. Francis BA, Singh K, Lin SC, Hodapp E, Jampel HD, Samples JR, Smith SD. Novel glaucoma procedures: a report by the American Academy of Ophthalmology. *Ophthalmology*. 2011 Jul;118(7):1466-80.
34. Gedde SJ, Herndon LW, Brandt JD, Budenz DL, Feuer WJ, Schiffman JC; Tube Versus Trabeculectomy Study Group. Postoperative complications in the Tube Versus Trabeculectomy (TVT) study during five years of follow-up. *Am J Ophthalmol*. 2012a May;153(5):804-814.e1. doi: 10.1016/j.ajo.2011.10.024.
35. Gedde SJ, Panarelli JF, Banitt MR, Lee RK. Evidenced-based comparison of aqueous shunts. *Curr Opin Ophthalmol*. 2013 Jan 2. [Epub ahead of print].
36. Gedde SJ, Schiffman JC, Feuer WJ, Herndon LW, Brandt JD, Budenz DL; Tube versus Trabeculectomy Study Group. Treatment outcomes in the Tube Versus Trabeculectomy (TVT) study after five years of follow-up. *Am J Ophthalmol*. 2012b May;153(5):789-803.e2. doi: 10.1016/j.ajo.2011.10.026.

37. Gedde SJ, Schiffman JC, Feuer WJ, Herndon LW, Brandt JD, Budenz DL; Tube Versus Trabeculectomy Study Group. Three-year follow-up of the tube versus trabeculectomy study. *Am J Ophthalmol*. 2009 Nov;148(5):670-84.
38. Gilmour DF, Manners TD, Devonport H, Varga Z, Solebo AL, Miles J. Visco canalostomy versus trabeculectomy for primary open angle glaucoma: 4-year prospective randomized clinical trial. *Eye*. 2009 Sep;23(9):1802-7.
39. Goldberg, Leslie Canaloplasty: A Promising New Extension to Non-Penetrating Surgery. *Ophthalmology Management*. 10(3), March 2006.
40. Good TJ, Kahook MY. Assessment of bleb morphologic features and postoperative outcomes after Ex-PRESS drainage device implantation versus trabeculectomy. *Am J Ophthalmol*. 2011 Mar;151(3):507-13.e1.
41. Grieshaber MC, Fraenkl S, Schoetzau A, Flammer J, Orgül S. Circumferential visco canalostomy and suture canal distension (canaloplasty) for whites with open-angle glaucoma. *J Glaucoma*. 2011 Jun-Jul;20(5):298-302.
42. Grieshaber MC, Pienaar A, Olivier J, Stegmann R. Canaloplasty for primary open-angle glaucoma: long-term outcome. *Br J Ophthalmol*. 2010 Nov;94(11):1478-82.
43. Grieshaber MC, Pienaar A, Olivier J, Stegmann R. Clinical evaluation of the aqueous outflow system in primary open-angle glaucoma for canaloplasty. *Invest Ophthalmol Vis Sci*. 2010 Mar;51(3):1498-504.
44. Hammel N, Lusky M, Kaiserman I, Robinson A, Bahar I. Changes in Anterior Segment Parameters After Insertion of Ex-PRESS Miniature Glaucoma Implant. *J Glaucoma*. 2012 Mar 7. [Epub ahead of print]
45. Hoffman RS, Crandall AS, Crandall DA, Fine IH, Packer M, Sims AC. Minimally Invasive External Mini-Glaucoma Shunt Implantation Without Conjunctival Dissection. *J Glaucoma*. 2012 Aug 23. [Epub ahead of print]
46. Hondur A, Onol M, Hasanreisoglu B. Nonpenetrating glaucoma surgery: meta-analysis of recent results. *J Glaucoma*. 2008 Mar;17(2):139-46.
47. Jea SY, Mosaed S, Vold SD, Rhee DJ. Effect of a failed trabectome on subsequent trabeculectomy. *J Glaucoma*. 2012 Feb;21(2):71-5.
48. Jonescu-Cuyper C, Jacobi P, Konen W, Krieglstein G. Primary visco canalostomy versus trabeculectomy in white patients with open-angle glaucoma: a randomized clinical trial. *Ophthalmology*. 2001;108(2):254-8.
49. Junk AK, Katz LJ. Ch 17. Tube shunts for refractory glaucoma. In: *Duane's Ophthalmology*. Philadelphia. Lippincott Williams & Wilkins. 2011.
50. Kanner EM, Netland PA, Sarkisian SR Jr, Du H. Ex-PRESS miniature glaucoma device implanted under a scleral flap alone or combined with phacoemulsification cataract surgery. *J Glaucoma*. 2009 Aug;18(6):488-91.
51. Kobayashi H, Kobayashi K. Randomized comparison of the intraocular pressure-lowering effect of phacovisco canalostomy and phacotrabeculectomy. *Ophthalmology*. 2007 May;114(5):909-14.
52. Kobayashi H, Kobayashi K, Okinami S. A comparison of the intraocular pressure-lowering effect and safety of visco canalostomy and trabeculectomy with mitomycin C in bilateral open-angle glaucoma. *Graefes Arch Clin Exp Ophthalmol*. 2003;241(5):359-66.
53. Koerber, N. Canaloplasty-a new approach to nonpenetrating glaucoma surgery. *Techniques in Ophthalmology*. 5(3):102-106, September 2007.

54. Lewis RA, von Wolff K, Tetz M, Koerber N, Kearney JR, Shingleton BJ, Samuelson TW. Canaloplasty: circumferential viscodilation and tensioning of Schlemm canal using a flexible microcatheter for the treatment of open-angle glaucoma in adults: two-year interim clinical study results. *J Cataract Refract Surg.* 2009 May;35(5):814-24.
55. Lewis RA, von Wolff K, Tetz M, Korber N, Kearney JR, Shingleton B, Samuelson TW. Canaloplasty: circumferential viscodilation and tensioning of Schlemm's canal using a flexible microcatheter for the treatment of open-angle glaucoma in adults: interim clinical study analysis. *J Cataract Refract Surg.* 2007 Jul;33(7):1217-26.
56. Lewis RA, von Wolff K, Tetz M, Koerber N, Kearney JR, Shingleton BJ, Samuelson TW. Canaloplasty: Three-year results of circumferential viscodilation and tensioning of Schlemm canal using a microcatheter to treat open-angle glaucoma. *J Cataract Refract Surg.* 2011 Apr;37(4):682-90.
57. Lüke C, Dietlein TS, Jacobi PC, Konen W, Krieglstein GK. A prospective randomized trial of viscocanalostomy versus trabeculectomy in open-angle glaucoma: a 1-year follow-up study. *J Glaucoma.* 2002;11(4):294-9.
58. Maris PJ Jr, Ishida K, Netland PA. Comparison of trabeculectomy with Ex-PRESS miniature glaucoma device implanted under scleral flap. *J Glaucoma.* 2007 Jan;16(1):14-9.
59. Marzette L, Herndon LW. A comparison of the Ex-PRESS™ mini glaucoma shunt with standard trabeculectomy in the surgical treatment of glaucoma. *Ophthalmic Surg Lasers Imaging.* 2011 Nov-Dec;42(6):453-9. doi: 10.3928/15428877-20111017-03.
60. Melamed S, Ben Simon GJ, Goldenfeld M, Simon G. Efficacy and safety of gold micro shunt implantation to the supraciliary space in patients with glaucoma: a pilot study. *Arch Ophthalmol.* 2009 Mar;127(3):264-9.
61. Minckler D, Baerveldt G, Ramirez MA, Mosaed S, Wilson R, Shaarawy T, Zack B, Dustin L, Francis B. Clinical results with the Trabectome, a novel surgical device for treatment of open-angle glaucoma. *Trans Am Ophthalmol Soc.* 2006;104:40-50.
62. Minckler DS, Francis BA, Hodapp EA, Jampel HD, Lin SC, Samples JR, Smith SD, Singh K. Aqueous shunts in glaucoma: a report by the American Academy of Ophthalmology. *Ophthalmology.* 2008 Jun;115(6):1089-98.
63. Minckler D, Mosaed S, Dustin L, Ms BF; Trabectome Study Group. Trabectome (trabeculectomy-internal approach): additional experience and extended follow-up. *Trans Am Ophthalmol Soc.* 2008;106:149-59; discussion 159-60.
64. Minckler D, Vedula SS, Li T, Mathew M, Ayyala R, Francis B. Aqueous shunts for glaucoma. *Cochrane Database of Systematic Reviews* 2006, Issue 2. Art. No.: CD004918. DOI: 10.1002/14651858.CD004918.pub2.
65. Molteno AC, Bevin TH, Herbison P, Husni MA. Long-term results of primary trabeculectomies and Molteno implants for primary open-angle glaucoma. *Arch Ophthalmol.* 2011 Nov;129(11):1444-50.
66. Molteno® Ophthalmic Limited. Molteno3®. 2012. Accessed Feb 1, 2013. Available at URL address: <http://www.molteno.com/glaucoma-drainage-devices>
67. Molteno AC, Whittaker KW, Bevin TH, Herbison P. Otago Glaucoma Surgery Outcome Study: long term results of cataract extraction combined with Molteno implant insertion or trabeculectomy in primary glaucoma. *Br J Ophthalmol.* 2004 Jan;88(1):32-5.
68. Mosaed S, Dustin L, Minckler DS. Comparative outcomes between newer and older surgeries for glaucoma. *Trans Am Ophthalmol Soc.* 2009 Dec;107:127-33.

69. National Institute for Health and Clinical Excellence (NICE). Canaloplasty for primary open-angle glaucoma. Interventional procedure guidance 260. May 2008. Accessed Feb 10, 2014. Available at URL address: <http://guidance.nice.org.uk/IPG260>
70. National Institute for Health and Clinical Excellence (NICE). Glaucoma: diagnosis and management of chronic open angle glaucoma and ocular hypertension. Apr 2009. Accessed Feb 10, 2014. Available at URL address: <http://guidance.nice.org.uk/CG85>
71. National Institute for Health and Clinical Excellence (NICE). Trabecular stent bypass micro-surgery for open angle glaucoma (IPG396). May 25, 2011. Accessed Feb 10, 2014. Available at URL address: <http://guidance.nice.org.uk/IPG396>
72. NeoMedix. Trabectome® 2013. Accessed Feb 10, 2014. Available at URL address: <http://www.neomedix.net/Technology/LearningFromNature/>
73. New World Medical Inc. Ahmed™ glaucoma valve. 2011. Accessed Feb 10, 2014. Available at URL address: http://www.ahmedvalve.com/index.php?option=com_content&view=article&id=23&Itemid=24
74. Nichamin LD. Glaukos iStent Trabecular Micro-Bypass. *Middle East Afr J Ophthalmol*. 2009 Jul;16(3):138-40.
75. O'Brart DP, Rowlands E, Islam N, Noury AM. A randomized, prospective study comparing trabeculectomy augmented with antimetabolites with a viscocanalostomy technique for the management of open angle glaucoma uncontrolled by medical therapy. *Br J Ophthalmol*. 2002;86(7):748-54.
76. O'Brart DP, Shiew M, Edmunds B. A randomized, prospective study comparing trabeculectomy with viscocanalostomy with adjunctive antimetabolite usage for the management of open angle glaucoma uncontrolled by medical therapy. *Br J Ophthalmol*. 2004;88:1012-7.
77. Optonol Ltd. Ex-PRESS™ Mini Glaucoma Shunt. 2012. Accessed Feb 10, 2014. Available at URL address: <http://www.opthalmologyweb.com/5588-Glaucoma-Shunt-Valve/51952-Ex-PRESS-Mini-Glaucoma-Shunt/>
78. Pantcheva MB, Kahook MY. Ab interno trabeculectomy. *Middle East Afr J Ophthalmol*. 2010 Oct;17(4):287-9.
79. Park M, Hayashi K, Takahashi H, Tanito M, Chihara E. Phaco-viscocanalostomy versus phaco-trabeculectomy: a middle-term study. *J Glaucoma*. 2006 Oct;15(5):456-61.
80. Razeghinejad MR, Spaeth GL. A history of the surgical management of glaucoma. *Optom Vis Sci*. 2011 Jan;88(1):E39-47.
81. Rhee DR. Which therapy to use in glaucoma? In: Yanoff and Duker, editors. *Yanoff Ophthalmology*, 4th ed. Saunders, an imprint of Elsevier, 2013.
82. Salim S. Current variations of glaucoma filtration surgery. *Curr Opin Ophthalmol*. 2012 Jan 13. [Epub ahead of print].
83. Shaarawy T, Nguyen C, Schnyder C, Mermoud A. Five year results of viscocanalostomy. *Br J Ophthalmol*. 2003;87(4):441-5.
84. Samuelson TW, Katz LJ, Wells JM, Duh YJ, Giamporcaro JE; US iStent Study Group. Randomized evaluation of the trabecular micro-bypass stent with phacoemulsification in patients with glaucoma and cataract. *Ophthalmology*. 2011 Mar;118(3):459-67.
85. Sarkisian SR. The ex-press mini glaucoma shunt: technique and experience. *Middle East Afr J Ophthalmol*. 2009 Jul;16(3):134-7.

86. Schwartz KS, Lee RK, Gedde SJ. Glaucoma drainage implants: a critical comparison of types. *Curr Opin Ophthalmol*. 2006 Apr;17(2):181-9.
87. Seider MI, Rofagha S, Lin SC, Stamper RL. Resident-performed Ex-PRESS shunt implantation versus trabeculectomy. *J Glaucoma*. 2012 Sep;21(7):469-74. doi: 10.1097/IJG.0b013e3182182bfb.
88. Shingleton B, Tetz M, Korber N. Circumferential viscodilation and tensioning of Schlemm canal (canaloplasty) with temporal clear corneal phacoemulsification cataract surgery for open-angle glaucoma and visually significant cataract: one-year results. *J Cataract Refract Surg*. 2008 Mar;34(3):433-40.
89. Shoji T, Tanito M, Takahashi H, Park M, Hayashi K, Sakurai Y, Nishikawa S, Chihara E. Phacoviscocanalostomy versus cataract surgery only in patients with coexisting normal-tension glaucoma: midterm outcomes. *J Cataract Refract Surg*. 2007 Jul;33(7):1209-16.
90. Singh D, Singh K. Transciliary filtration using the fugo blade™. *An Ophthalmol*. 2002;34(3):183-187.
91. Stangos AN, Whatham AR, Sunaric-Megevand G. Primary viscocanalostomy for juvenile open-angle glaucoma. *Am J Ophthalmol*. 2005 Sep;140(3):490-6.
92. Sugiyama T, Shibata M, Kojima S, Ueki M, Ikeda T. The first report on intermediate-term outcome of Ex-PRESS glaucoma filtration device implanted under scleral flap in Japanese patients. *Clin Ophthalmol*. 2011;5:1063-6.
93. Ting JL, Damji KF, Stiles MC; Trabectome Study Group. Ab interno trabeculectomy: outcomes in exfoliation versus primary open-angle glaucoma. *J Cataract Refract Surg*. 2012 Feb;38(2):315-23.
94. Tran DH, Souza C, Ang MJ, Loman J, Law SK, Coleman AL, Caprioli J. Comparison of long-term surgical success of Ahmed Valve implant versus trabeculectomy in open-angle glaucoma. *Br J Ophthalmol*. 2009 Nov;93(11):1504-9.
95. U.S. Food and Drug Administration (FDA). Premarket approval (PMA). Glaukos iStent® Trabecular Micro-Bypass Stent. P080030. Jun 25, 2012. Accessed Feb 10, 2014. Available at URL address: <http://www.fda.gov/MedicalDevices/ProductsandMedicalProcedures/DeviceApprovalsandClearances/Recently-ApprovedDevices/ucm312053.htm>
96. U.S. Food and Drug Administration (FDA). 510(k) premarket notification. EX-PRESS. K12852. Mar 26, 2002. Accessed Feb 10, 2014. Available at URL address: http://www.accessdata.fda.gov/cdrh_docs/pdf/K012852.pdf
97. U.S. Food and Drug Administration (FDA). 510(k) premarket notification. Fugo Blade. K041019. Oct 8, 2004. Accessed Feb 10, 2014. Available at URL address: http://www.accessdata.fda.gov/cdrh_docs/pdf4/K041019.pdf
98. U.S. Food and Drug Administration (FDA). 510(k) premarket notification. Product code KYF. Accessed Feb 10, 2014. Available at URL address: <http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfPMN/pmn.cfm>
99. U.S. Food and Drug Administration (FDA). 510(k) premarket notification. Guidance for industry and for FDA reviewers/staff: aqueous shunts - 510(k) submissions. Nov 16, 1998. Accessed Feb 10, 2014. Available at URL address: <http://www.fda.gov/MedicalDevices/DeviceRegulationandGuidance/GuidanceDocuments/ucm073805.htm>
100. U.S. Food and Drug Administration (FDA). 510(k) premarket notification. Trabectome™ high frequency generator/LP. Apr 12, 2006. Accessed Feb 10, 2014. Available at URL address: http://www.accessdata.fda.gov/cdrh_docs/pdf6/K061258.pdf

101. Vold SD. Ab interno trabeculotomy with the trabectome system: what does the data tell us? *Int Ophthalmol Clin*. 2011 Summer;51(3):65-81. doi: 10.1097/IIO.0b013e31821e5da3.
102. Walland MJ, Carassa RG, Goldberg I, Grehn F, Heuer DK, Khaw PT, Thomas R, Parikh R. Failure of medical therapy despite normal intraocular pressure. *Clin Experiment Ophthalmol*. 2006 Dec;34(9):827-36.
103. Wishart PK, Wishart MS, Choudhary A, Grierson I. Long-term results of viscocanalostomy in pseudoexfoliative and primary open angle glaucoma. *Clin Experiment Ophthalmol*. 2008 Mar;36(2):148-55.
104. Wilson MR, Mendis U, Paliwal A, Haynatzka V. Long-term follow-up of primary glaucoma surgery with Ahmed glaucoma valve implant versus trabeculectomy. *Am J Ophthalmol*. 2003 Sep;136(3):464-70.
105. Wishart PK, Choudhary A, Wong D. Ahmed glaucoma valves in refractory glaucoma: a 7-year audit. *Br J Ophthalmol*. 2010 Sep;94(9):1174-9.
106. Wishart MS, Dages E. Seven-year follow-up of combined cataract extraction and viscocanalostomy. *J Cataract Refract Surg*. 2006 Dec;32(12):2043-9.
107. Wishart PK, Wishart MS, Porooshani H. Viscocanalostomy and deep sclerectomy for the surgical treatment of glaucoma: a long term follow-up. *Acta Ophthalmol Scand*. 2003;81(4):343-8.
108. Woodcock MG, Richards JC, Murray AD. The last 11 years of Molteno implantation at the University of Cape Town. Refining our indications and surgical technique. *Eye (Lond)*. 2008 Jan;22(1):18-25.
109. Yalvac IS, Eksioglu U, Satana B, Duman S. Long-term results of Ahmed glaucoma valve and Molteno implant in neovascular glaucoma. *Eye (Lond)*. 2007 Jan;21(1):65-70.
110. Yalvac IS, Sahin M, Eksioglu U, Midillioglu IK, Aslan BS, Duman S. Primary viscocanalostomy versus trabeculectomy for primary open-angle glaucoma: Three-year prospective randomized clinical trial. *J Cataract Refract Surg*. 2004;30:2050-7.
111. Yarangumeli A, Gureser S, Koz OG, Elhan AH, Kural G. Viscocanalostomy versus trabeculectomy in patients with bilateral high-tension glaucoma. *Int Ophthalmol*. 2004 Jul;25(4):207-13. Epub 2005 Sep 29.

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