## Title

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# Tube Versus Trabeculectomy IRIS Registry Study: 1-Year Secondary Treatment Outcomes

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## Abstract

**PURPOSE:** To describe 1-year secondary outcomes in the Tube Versus Trabeculectomy IRIS® (Intelligent Registry In Sight) Registry Study ($TVT_{IRIS}$), and to compare to the TVT randomized controlled trial ($TVT_{RCT}$).

**DESIGN:** $TVT_{IRIS}$ was a retrospective cohort study.

**METHODS:** The 2013–2017 IRIS Registry was used to identify eyes that received a tube shunt (tube) or trabeculectomy after a previous trabeculectomy and/or cataract surgery and had 1 year of follow-up. The $TVT_{RCT}$ compared a Baerveldt 350-$mm^2$ glaucoma implant to trabeculectomy in similar eyes.

**RESULTS:** In the $TVT_{IRIS}$ cohort, the tube (n = 236, 56.3%) and trabeculectomy (n = 183, 43.7%) groups had similar and significant reductions in intraocular pressure (IOP) from baseline to 1 year. In the tube group, IOP (mean ± SD) decreased from 26.6 ± 6.5 mm Hg at baseline to 14.3 ± 4.8 mm Hg at 1 year. In the trabeculectomy group, IOP decreased from 25.3 ± 6.4 mm Hg at baseline to 13.5 ± 5.2 mm Hg at 1 year. The trabeculectomy groups from both studies had similar 1-year IOP reduction ($P$ =.18), although the $TVT_{RCT}$ cohort used fewer medications at all time points ($P$ <.01). There were more pronounced differences in the mean IOP and medications between the tube groups in the 2 studies, presumably due to the inclusion of valved tubes in $TVT_{IRIS}$. More reoperations occurred in $TVT_{IRIS}$.

**CONCLUSIONS:** The $TVT_{IRIS}$ tube and trabeculectomy groups had comparable 1-year IOP reduction, although trabeculectomy eyes used fewer glaucoma medications. The trabeculectomy

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group in $TVT_{IRIS}$ and $TVT_{RCT}$ had similar IOP and medication reduction at 1 year. Randomized controlled trials and electronic health record data both provide invaluable insight into surgical outcomes.

The role of real-world evidence has become increasingly important in recent years. There is significant interest in using real-world evidence to supplement findings from randomized controlled trials (RCTs), with the hope of increasing the generalizability of research findings to a more diverse set of patients, and potentially reducing labor and cost.[1, 2] As part of the 21st Century Cures Act, the Food and Drug Administration is also developing guidance for evaluating real-world evidence to assess the safety and effectiveness of drugs and medical devices.[1] However, there are challenges to using electronic health record (EHR) data to replicate patient cohorts of RCTs and to generate real-world evidence, especially in identifying available and consistent inclusion and exclusion criteria.[3, 4] Prior to conducting prospective randomized studies, the feasibility of the study may be assessed using EHR data. Few other published studies, outside of our group, have explored how EHR data compares to published RCTs in ophthalmology.[5–8]

The Tube Versus Trabeculectomy RCT ($TVT_{RCT)}$ contributed to a paradigm shift in surgical practice patterns, with increased use of glaucoma drainage devices (tubes) and decreased use of trabeculectomies.[9–11] The $TVT_{RCT}$ study was a multicenter prospective study that compared the safety and efficacy of the Baerveldt 350-$mm^2$ glaucoma implant (BGI) to trabeculectomy with mitomycin C (MMC) in eyes with prior filtering surgery and/or cataract surgery.[10] At 1 year, eyes that underwent trabeculectomy had a higher rate of failure compared to those with BGIs, and this finding persisted throughout 5 years of follow-up.[10, 12] The 1-year outcomes indicated similar IOP reduction after both surgical procedures but less need for supplemental medical therapy after trabeculectomy.[10] Eyes that underwent BGI were also less likely to undergo reoperation for glaucoma at 1 year.[10]

The initial results of the $TVT_{RCT}$ study were published in 2007.[10] Since then, advancements in glaucoma care have included new glaucoma medications, safer settings for cyclophotocoagulation, and the development of microinvasive glaucoma surgery (MIGS).[13] These alternative therapies, many of which are performed in earlier stages of glaucoma, may have also contributed to the shifting practice patterns for “traditional” glaucoma surgery (eg, tubes and trabeculectomies). To understand the applicability of the original TVT study results to our current practice patterns, and to compare patient outcomes from EHR data to those of a published RCT, the Intelligent Research in Sight (IRIS) Registry was used to identify an analogous real-world cohort of eyes to compare to the $TVT_{RCT}$ study.

The TVT IRIS Registry study ($TVT_{IRIS}$) was a retrospective clinical cohort study using EHR data to study 1-year post-surgical outcomes in a cohort of eyes that underwent valved and non-valved tube shunt surgery (tubes) compared to trabeculectomies, as opposed to BGI vs trabeculectomy in the original $TVT_{RCT}$ study. The $TVT_{IRIS}$ cohort included surgeries that were performed from 2013 to 2016, more than a decade after the $TVT_{RCT}$ study enrolled patients (ie, 1999–2004). Previously, we described the design, cohort selection, and feasibility of a retrospective EHR-based study that aimed to replicate the cohort of an existing RCT.[6] We reported that the failure rate of tube and trabeculectomy eyes were

similar in $TVT_{IRIS}$ (12.3% for tube eyes and 16.4% for trabeculectomy eyes, $P$ =.231).[14] However, the rate of tube failure (ie, valved and non-valved tubes) was higher in $TVT_{IRIS}$ compared to that in the $TVT_{RCT}$ study, which consisted of only non-valved tubes.[14] The rate of trabeculectomy failure was similar in both studies.[14]

This paper describes the 1-year post-surgical secondary outcomes of $TVT_{IRIS}$. We describe the intraocular pressure (IOP), glaucoma medications, reoperations for glaucoma, and visual acuity (VA) in the $TVT_{IRIS}$ cohort, and provide comparisons to $TVT_{RCT}$. The study objective was to determine how patient outcomes from the IRIS Registry data compare to data from prospective RCTs, which are currently our gold standard for assessing interventions. By doing so, we hope to improve our understanding of how best to use real-world evidence to complement RCT findings.

## METHODS

### STUDY DESIGN:

This study is a retrospective cohort study using the IRIS Registry. Because the IRIS Registry data were de-identified, no informed consent was required. The University of Miami Institutional Review Board approved this study as exempt. This research conformed to all country, federal, or state laws, and adhered to the tenets of the Declaration of Helsinki and the Health Insurance Portability and Accountability Act. The $TVT_{RCT}$ was registered at http://www.clinicaltrials.gov (NCT00306852).

The design and methods of the $TVT_{RCT}$ and $TVT_{IRIS}$ studies were previously described in detail and are summarized here.[6, 15] In brief, the $TVT_{RCT}$ study randomized patients to a 350-$mm^2$ BGI or trabeculectomy with MMC in eyes with prior trabeculectomy and/or cataract surgery.[15] In the $TVT_{IRIS,}$ study, we used 2013 to 2017 data from the IRIS Registry to identify eyes that had a “qualifying” surgery (prior trabeculectomy and/or cataract surgery) followed by a “baseline” surgery (tube or trabeculectomy) using Current Procedural Terminology (CPT) codes. Any eye with prior MIGS was excluded from the IRIS cohort. These 236 (56.3%) tube eyes and 183 (43.7%) trabeculectomy eyes were based, as closely as possible, on the eligibility criteria of the $TVT_{RCT}$ study.[15]

The salient differences between the $TVT_{RCT}$ and $TVT_{IRIS}$ studies were due to unavailable data in the IRIS Registry. The IRIS Registry lacked data on the type of tube implanted; thus, all tubes were included in the IRIS Registry cohort tube group. There were no data in the IRIS Registry to determine whether a trabeculectomy included use of MMC or the MMC dose. Unlike the $TVT_{RCT,}$ in which all trabeculectomy eyes received MMC (0.4 mg/ml for 4 minutes), all trabeculectomies regardless of MMC use were included in the IRIS Registry cohort trabeculectomy group. Since adjunctive use of MMC was standard of care from 2013 to 2017, it is likely that all trabeculectomy eyes received MMC. In addition, there were limited or no IRIS Registry data to determine the following exclusion criteria that was applied in the $TVT_{RCT}$: conjunctival scarring that would preclude a superior trabeculectomy, anticipated need for additional ocular surgery, pregnancy or breastfeeding, unwillingness to discontinue contact lens use after surgery, presence of silicone oil, unwillingness or inability

to give consent, unwillingness to accept randomization, or inability to return for scheduled protocol visits.

## PATIENT POPULATION, DATA, AND ELIGIBILITY CRITERIA:

A 1-year follow-up analysis cohort of 419 eyes was created using 2013 to 2017 data from the IRIS Registry. We excluded eyes with < 1 year of data in the IRIS Registry before the qualifying surgery, with < 90 days between the qualifying and baseline surgeries, that did not meet eligibility criteria for the $TVT_{RCT,}$ that had "baseline" surgery in 2017 as many of these lacked 1-year follow-up data, or had other missing data.[6] In the IRIS Registry, only the week and year of service were previously available. From each eye's follow-up data in the IRIS Registry, we designated the 1-week (1–2 weeks), 1-month (3–8 weeks), 3-month (9–19 weeks), 6-month (20–38 weeks), and 1-year (39–64 weeks) follow-up visit windows using data from the visit closest to the actual follow-up time.[6]

## VARIABLES AND OUTCOMES:

The outcomes analyzed in this paper include IOP, number of glaucoma medications, reoperations for glaucoma (defined as laser cyclophotocoagulation [CPC] or additional glaucoma surgery requiring a return to the operating room), and VA. All IOP and VA measurements for each week were averaged as follows.

Baseline IOP was the mean IOP during the week preceding and closest to the baseline surgery. If there were no IOP measurements prior to the baseline surgery, the mean IOP during the week of the baseline surgery (ie, week 0) was used. Only 85 patients (20.3%) had a week 0 baseline IOP measurement. There was no significant difference in the composite failure outcome between the eyes of these 85 patients who had a week 0 baseline IOP measurement compared to the 334 (79.7%) eyes that had a baseline IOP measurement prior to week 0 ($P = 0.1906$).[14] The baseline VA was defined similarly, and all eyes in the intent-to-treat analyses had baseline data before week 0. If the IRIS Registry data for a designated follow-up visit had more than 1 IOP measurement and/or more than 1 VA measurement during the week of that visit, then the mean was calculated and used as the IOP and/or VA measurement for that follow-up visit.

For preoperative baseline glaucoma medication, we used data only from before week 0. If an eye had no glaucoma medication data prior to the week of surgery, that eye was considered to have zero baseline glaucoma medications. The medication laterality was not available at the time of data extraction. Therefore, we assumed that all glaucoma medications used in the preoperative and postoperative periods were used in both eyes.

When analyzing reoperations for glaucoma, the maximum IOP was determined during the follow-up visit window in which the reoperation or other failure event occurred. Eyes that underwent additional glaucoma surgery were censored from analysis after the time of reoperation, except as noted in the intent-to-treat analyses for 1-year outcomes.

### STATISTICAL ANALYSIS:

For continuous variables, the treatment group means were compared using independent-samples *t* tests when sample sizes were > 30; otherwise, medians were compared using the Mann–Whitney–Wilcoxon test, and variances were compared using the folded *F* test. Changes in continuous variables during follow-up were assessed using paired *t* tests. For categorical variables, the treatment groups were compared, and changes during follow-up were assessed using $\chi^2$ or exact $\chi^2$ tests.

Comparisons between $TVT_{IRIS}$ and $TVT_{RCT}$ results were done with 1-sample *t* tests for continuous variables and with $\chi^2$, Fisher exact, or exact $\chi^2$ tests for specified proportions for categorical variables. The reoperation rate for glaucoma was estimated using the Kaplan–Meier survival analysis log rank test. These statistical analyses were performed using SAS version 9.4 software (SAS Inc). Inter-study comparisons of reoperation rates were performed with 1-sample *z* tests using Microsoft Excel version 1902 (Microsoft Corp). A *P* value of <.050 was considered statistically significant.

## RESULTS

The $TVT_{IRIS}$ study used EHR data from 2013 through 2017, and identified 236 tube eyes and 183 trabeculectomy eyes that met the eligibility criteria. In the tube group, 137 patients (58.1%) had prior cataract surgery and 99 patients (42.0%) had a prior trabeculectomy or combined procedure (ie, cataract surgery and trabeculectomy), whereas in the trabeculectomy group, 151 (82.5%) had prior cataract surgery and 32 (17.5%) had a prior trabeculectomy or combined procedure (Table 1). In the trabeculectomy group, there were insufficient data to determine whether patients received an anti-fibrotic agent at the time of baseline surgery. Additional baseline characteristics are shown in Table 1.[6]

### IOP REDUCTION:

The baseline and follow-up IOPs for $TVT_{IRIS}$ tube and trabeculectomy groups are reported in Table 2 and in the Figure. Eyes that underwent additional glaucoma surgery were censored from analysis after the time of reoperation, except as noted in the intent-to-treat analyses. Both surgical procedures produced a significant reduction in IOP (*P* <.0001 at all follow-up visits). In the tube group, IOP (mean ± SD) decreased from 26.6 ± 6.5 mm Hg at baseline to 14.3 ± 4.8 mm Hg at the 1-year follow-up visit, and in the trabeculectomy group, IOP decreased from 25.3 ± 6.4 mm Hg at baseline to 13.5 ± 5.2 mm Hg at the 1-year follow-up visit.

The trabeculectomy group had significantly lower mean IOP than the tube group at month 1 (3.7 mm Hg lower) and month 3 (2.6 mm Hg lower) (Table 2). By month 6, the IOP difference was not significantly lower (1.1 mm Hg, *P* =.09), and this remained to 1 year (0.7 mm Hg, *P* =.19). At month 6, the trabeculectomy group had significantly greater variability in IOP (SD = 6.3 mm Hg) than the tube group (SD = 5.4 mm Hg; *P* =.035). The 6-month visit was the only follow-up visit in which the IOP variability difference was statistically significant. An additional intent-to-treat analysis was also performed, which included eyes that had undergone reoperation for glaucoma. At 1 year, IOP was 14.4 ± 5.0 mm Hg in the

tube group and 13.9 ± 5.2 mm Hg in the trabeculectomy group, which was not significantly different ($P$ =.3428).

**$TVT_{IRIS}$ VS $TVT_{RCT}$—**Table 3 compares the IOP and medication results between $TVT_{IRIS}$ and $TVT_{RCT}$ studies. The trabeculectomy groups in the 2 studies had similar baseline mean IOPs ($TVT_{IRIS}$ 25.3 mm Hg vs $TVT_{RCT}$ 25.6 mm Hg, $P$ =.5887). Although the 1-year mean IOP was higher in the $TVT_{IRIS}$ trabeculectomy group (13.5 mm Hg) compared to that in the $TVT_{RCT}$ trabeculectomy group (12.7 mm Hg), this was not a statistically significant difference ($P$ = 0.059). In addition, the IOP reduction from baseline to 1 year was similar between the 2 studies ($P$ =.1807).

There were, unsurprisingly, more differences in mean IOP between the tube groups in the 2 studies, likely due to the inherent difference in the compositions of the groups with the inclusion of valved tube shunts and other non-valved implants in $TVT_{IRIS}$. The tube group in $TVT_{IRIS}$ had significantly higher baseline mean IOP compared to the tube group in $TVT_{RCT,}$ respectively (26.6 mm Hg vs 25.1 mm Hg, $P$ =.0006). At 1 week, the mean IOP in the $TVT_{IRIS}$ tube group (14.3 mm Hg) was significantly lower than that in the $TVT_{RCT}$ (19.0 mm Hg; $P$ <.0001). The mean IOPs were similar at months 1 and 3. At month 6, the mean IOP in the $TVT_{IRIS}$ tube group was significantly higher than the $TVT_{RCT}$ tube group, and this persisted at 1 year (14.3 mm Hg in $TVT_{IRIS}$ vs 12.4 mm Hg in $TVT_{RCT,}$ $P$ <.0001). The IOP reduction from baseline to 1 year was > 12 mm Hg in both tube groups, and this was not a statistically significant difference ($P$ =.67).

## GLAUCOMA MEDICATIONS:

Table 2 shows the number of glaucoma medications in the tube and trabeculectomy groups in the $TVT_{IRIS}$ cohort at baseline and follow-up. When censoring for reoperation, there was a significantly greater need for supplemental medical therapy in the tube group compared with the trabeculectomy group at all follow-up visits ($P$ <.01) except week 1 ($P$ =.9760). The number of glaucoma medications (mean ± SD) in the tube group decreased from 3.6 ± 1.3 at baseline to 1.7 ± 1.4 at the 1-year follow-up visit, and the number of glaucoma medications in the trabeculectomy group decreased from 3.4 ± 1.2 at baseline to 1.2 ± 1.4 at the 1-year follow-up visit ($P$ <.0001) (Table 2). The mean number of medications was 1.8 ± 1.4 in the tube group and 1.2 ± 1.4 in the trabeculectomy group at 1 year in an intent-to-treat analysis, which included eyes that underwent additional glaucoma surgery ($P$ = 0.0003).

Twelve eyes in each group failed because of inadequate IOP control. At the time of failure, the IOP was 21.6 ± 5.2 in the tube group and 20.7 ± 4.6 in the trabeculectomy group, which was marginally different ($P$ =.0610), and the number of medications (mean ± SD) was 1.4 ± 1.2 in the tube group and 1.5 ± 1.3 in the trabeculectomy group, which was not significantly different ($P$ =.9523). These analyses had low power because of the small sample sizes.

**$TVT_{IRIS}$ VS $TVT_{RCT}$—**The trabeculectomy group in $TVT_{IRIS}$ was on significantly more glaucoma medications at all time points compared to the $TVT_{RCT}$ trabeculectomy group (Table 3). At baseline, the mean number of medications used by the $TVT_{IRIS}$ group was 3.4 compared to 3.0 for the $TVT_{RCT}$ trabeculectomy group ($P$ <.0001). At 1 year, the mean number of medications decreased to 1.2 for the $TVT_{IRIS}$ trabeculectomy group compared to

0.5 for the $TVT_{RCT}$ trabeculectomy group ($P$ <.0001). The $TVT_{RCT}$ trabeculectomy group had marginally higher reduction of medications from baseline to 1 year than the $TVT_{IRIS}$ group (2.5 vs 2.3 medications, $P$ =.0558).

The differences in the mean number of glaucoma medications used by the tube groups in the 2 studies varied by time point. The tube group in $TVT_{IRIS}$ was on significantly more mean glaucoma medications at baseline compared to the $TVT_{RCT}$ tube group, respectively (3.6 vs 3.2; $P$ <.0001). At 1 week and 1 month, the tube group in $TVT_{IRIS}$ was on significantly fewer medications compared to the $TVT_{RCT}$ tube group. By month 3, the $TVT_{IRIS}$ tube group was on more medications than the $TVT_{RCT}$ tube group, and this persisted through 1 year. At 1 year, the $TVT_{IRIS}$ tube group was on 1.7 medications compared to 1.3 medications for the $TVT_{RCT}$ tube group ($P$ <.0001). The difference in medication reduction from baseline to 1 year was similar between the tube groups in both studies at 1.9 medications ($P$ =.8959).

## REOPERATION FOR GLAUCOMA:

Table 4 shows the number and types of reoperations that occurred in the $TVT_{IRIS}$ cohort. A total of 29 eyes failed (13 tube and 16 trabeculectomy) because of a reoperation for glaucoma, and 2 tube eyes failed because of inadequate IOP control but later underwent reoperation for glaucoma, for a total of 31 eyes. There was no significant difference between treatment groups for the percentage of eyes that underwent reoperation for glaucoma (6.4% of tube eyes vs 8.7% of trabeculectomy eyes, $P$ =.3545). The types of reoperations for glaucoma did not differ significantly by treatment group.[14] For the tube group, the most common reoperation was a transscleral CPC followed by a second tube shunt. For the trabeculectomy group, the most common reoperation was a tube shunt followed by CPC. The time to reoperation (mean ± SD) was 6.66 ± 3.49 months for the tube group and 5.68 ± 3.56 months for the trabeculectomy group ($P$ =.44).

To evaluate whether there was selection bias for reoperation between the tube and trabeculectomy groups, the IOP levels were compared between treatment groups among eyes that underwent reoperation for glaucoma. The maximum IOP (mean ± SD) in the visit window in which the reoperation for glaucoma occurred was lower in the tube group (20.5 ± 8.5) than in the trabeculectomy group (27.9 ± 14.4, $P$ =.0478), suggesting the potential for earlier reoperation in the tube group than in the trabeculectomy group.

**$TVT_{IRIS}$ VS $TVT_{RCT}$—**The reoperation rates for the 2 studies were significantly different for eyes that received tubes ($TVT_{IRIS}$ 6.4%, $TVT_{RCT}$ 1.0%; $P$ =.0023) and marginally different for eyes that received trabeculectomies ($TVT_{IRIS}$ 8.7%, $TVT_{RCT}$ 5.0%; $P$ =.0729).[10] In the tube group, 9 patients (3.8%) in $TVT_{IRIS}$ underwent CPC compared to 1 patient (0.9%) in $TVT_{RCT}$. In the trabeculectomy group, 10 patients (5.5%) had a tube shunt placed in $TVT_{IRIS}$ compared to 5 (4.8%) in $TVT_{RCT}$.[10]

The maximum IOP prior to reoperation for eyes that underwent reoperation for glaucoma were similar between the studies. The $TVT_{IRIS}$ trabeculectomy group had a maximum mean IOP of 27.9 mm Hg compared to the $TVT_{RCT}$ trabeculectomy group of 25.1 mm Hg ($P$

=.4416). The maximum mean IOP was 20.5 mm Hg in the $TVT_{IRIS}$ tube eyes and 24 mm Hg for the $TVT_{RCT}$ tube eyes ($P$=.1291).

## VISUAL ACUITY:

Intent-to-treat analyses were performed for the 301 eyes (169 tube group, 132 trabeculectomy group) that had VA data at baseline and 1 year, and are discussed here. There were significant decreases in VA from baseline to 1 year in both treatment groups. At baseline, the VA in the trabeculectomy group was significantly better than the tube group ($P$ =.0135). In the trabeculectomy group, logMAR VA (mean ± SD) decreased from 0.31 ± 0.42 at baseline to 0.38 ± 0.51 at 1 year ($P$=.0279). In the tube group, logMAR VA decreased from 0.44 ± 0.49 at baseline to 0.54 ± 0.59 at 1 year ($P$=.0039). The difference in VA from baseline to 1 year was approximately 1 line of logMAR vision for both treatment groups, which was not significantly different ($P$=.5450).

The proportion of patients with loss of ≥2 Snellen lines of VA was greater in the tube group compared to the trabeculectomy group. At 1 year, 44 (26.0%) patients in the tube group and 21 (15.9%) patients in the trabeculectomy group lost ≥2 lines of VA from baseline ($P$ =.0341). Two (0.8%) patients in the tube group had loss of light perception vision, compared to 1 (0.5%) patient in the trabeculectomy group. The reasons for VA loss were unknown because of insufficient data in the IRIS Registry.

**$TVT_{IRIS}$ VS $TVT_{RCT}$—**For trabeculectomy eyes, the 1-year VA was different between the 2 studies, but the changes in VA from baseline to 1 year were similar. The $TVT_{IRIS}$ mean baseline VA of 0.31 ± 0.42 logMAR was marginally better than the $TVT_{RCT}$ mean baseline VA of 0.37 ± 0.38 ($P$=.0559). However, the $TVT_{IRIS}$ mean 1-year VA of 0.38 ± 0.51 was significantly better than the $TVT_{RCT}$ mean 1-year VA of 0.49 ± 0.56 ($P$=.0166). The $TVT_{IRIS}$ eyes had a mean 1-year decrease in VA of 0.07 logMAR, whereas the $TVT_{RCT}$ eyes had a marginally larger mean 1-year reduction in VA of 0.12 logMAR ($P$=.1116).[10]

For tube eyes, the baseline and 1-year VA were not significant differently between the studies, but the $TVT_{RCT}$ group had a greater reduction in VA from baseline to 1 year. Specifically, the $TVT_{IRIS}$ baseline VA (mean ± SD) of 0.47 ± 0.5 logMAR was similar to the $TVT_{RCT}$ mean baseline VA of 0.42 ± 0.54 ($P$=.1639), and the $TVT_{IRIS}$ mean 1-year VA of 0.54 ± 0.59 was marginally better than the $TVT_{RCT}$ mean 1-year VA of 0.61 ± 0.75 ($P$=.1204). The $TVT_{IRIS}$ tube eyes had a mean 1-year decrease in VA of 0.10 logMAR, whereas the $TVT_{RCT}$ tube eyes had a greater mean 1-year decrease in VA of 0.19 ($P$ =.0060). This finding of greater VA reduction in $TVT_{RCT}$ compared to $TVT_{IRIS}$ eyes was seen in both the tube and trabeculectomy groups.

In $TVT_{IRIS,}$ a lower percentage of eyes in both groups had VA loss of ≥2 Snellen lines compared to the $TVT_{RCT}$. Specifically, 21 (15.9%) trabeculectomy eyes in $TVT_{IRIS}$ had a decrease in vision of ≥2 lines compared to 30 trabeculectomy eyes (33%) in $TVT_{RCT}$ ($P$ <.0001). For tube eyes, the $TVT_{IRIS}$ group had 44 eyes (26%) with ≥2 lines of vision loss compared to 31 eyes (32%) in $TVT_{RCT}$ ($P$=.0965).

## DISCUSSION

The $TVT_{IRIS}$ study compared eyes with medically uncontrolled glaucoma that had undergone previous cataract surgery or trabeculectomy, and had subsequent tube shunt surgery or trabeculectomy. The main difference between the $TVT_{IRIS}$ study and the original $TVT_{RCT}$ was the composition of the tube group, with the inclusion of valved and non-valved tubes in $TVT_{IRIS}$ and only non-valved BGI 350-$mm^2$ in $TVT_{RCT}$. The type of tube shunt implanted was not captured in the IRIS Registry data. Both trabeculectomy and tube shunt surgery had similar IOP reduction at 1 year in the $TVT_{IRIS}$ study, although the tube group was on more supplemental medications at 1 year. Among patients who completed a 1-year follow-up visit, trabeculectomy surgery produced a 46.3% reduction in IOP, and tube shunt surgery resulted in a 46.2% decrease in IOP. The IOP findings are consistent with the composite treatment outcomes of the $TVT_{IRIS}$ study, which found a similar risk of failure between the trabeculectomy group (16.4%) and the tube group (12.3%) ($P$=.231).[14]

The $TVT_{IRIS}$ study also yielded some findings similar to those of the original $TVT_{RCT}$ study. In $TVT_{IRIS,}$ there was no significant difference in mean IOP between the treatment groups after month 3, and the tube group required more medications than the trabeculectomy group at all time points after week 1. The $TVT_{RCT}$ also showed that there was no significant difference in mean IOP between treatment groups after month 3 and that the tube group required more medications than the trabeculectomy group from week 1 to 1 year. The trabeculectomy groups in both studies had similar mean IOP at baseline, 1 year, and change from baseline to 1 year. Although the $TVT_{IRIS}$ trabeculectomy group was on more medications at all time points compared to the trabeculectomy group in the $TVT_{RCT,}$ the mean reduction of medications from baseline to 1 year was similar between the studies. This finding is consistent with our previous report that trabeculectomy eyes in both studies had similar risk of failure at 1 year ($TVT_{IRIS}$ 16.4%, $TVT_{RCT}$ 13.0%; $P$=.172).[14] The comparable finding in clinical efficacy between the trabeculectomy groups in the 2 studies is a very promising finding, and demonstrates that data from the IRIS Registry can be used to reliably assess real-world outcomes of surgical interventions. As of January 2023, the IRIS Registry captured data on 78.6 million patients seen by ophthalmic practices in the United States (F. Lum, personal communication, 2023) and is a powerful data source to assess the effectiveness of interventions in routine settings, as opposed to idealized settings in RCTs.[16] One of the important benefits of real-world evidence is to increase the generalizability of study outcomes to a more diverse patient population, especially as the literature demonstrates that there exist health disparities in glaucoma prevalence and outcomes.[17–21]

Although the trabeculectomy groups in the 2 studies had similar IOP reduction at 1 year, the $TVT_{IRIS}$ trabeculectomy group was on significantly more medications at all time points. This finding could reflect data limitations, as medications in the IRIS Registry did not have eye laterality specified, so medications were assumed to apply to the study eye. In the post-operative period, if patients were using eye drops in the non-operative eye, then the medication numbers would be falsely elevated. The higher medication numbers in $TVT_{IRIS}$ could also reflect the more diverse patient population that exists in a real-world setting with more variable disease severity, medication adherence, and follow-up adherence.

Clinical trials often take measures to control variability, with strict eligibility criteria, detailed intraoperative and postoperative protocols for clinicians, and retention procedures to increase follow-up adherence. We tried to follow the $TVT_{RCT}$ eligibility criteria when creating our IRIS Registry cohort, but there were limitations in the IRIS Registry data, such as reliance on *International Classification of Diseases*, Ninth or Tenth Revision (*ICD-9* or *ICD-10)* codes alone for identifying diagnoses and clinical findings given the lack of clinical notes. Examples include being unable to apply the following exclusion criteria: conjunctival scarring that would preclude a superior trabeculectomy, anticipated need for additional ocular surgery, pregnancy or breastfeeding, and unwillingness to discontinue contact lens use after surgery. In the future, access to clinical notes and additional clinical examination fields may be able to help reduce this limitation.

Furthermore, there can be differences in outcomes because of the variability of real-world clinical practice compared to more protocolized trials. In the $TVT_{RCT,}$ patients randomized to the tube group had a 350-$mm^2$ BGI implanted in the superotemporal quadrant, with the tube positioned in the anterior chamber using a 23-gauge needle and with no anti-fibrotics. For those patients randomized to trabeculectomy, the trabeculectomy surgery was performed superiorly with MMC-soaked sponges (0.4 mg/mL) applied to the superior sclera for 4 minutes and 10–0 nylon sutures used to close the scleral flap. The TVT study left all other aspects of the intraoperative and postoperative management to the discretion of the surgeon, including the type of tube occlusion, limbus or fornix-based scleral flap, the dimension of the scleral flap, intraoperative and postoperative medications, and the timing of post-operative procedures such as suturelysis. Despite the flexibility in management provided in the TVT study, there can be even more variability in practice patterns among glaucoma surgeons in real-world practice. Some intraoperative and postoperative variations that may result in a difference in patient outcomes include use and duration of anti-fibrotics such as MMC, use and duration of intraoperative and postoperative steroids, and timing of laser suturelysis.[22–25]

The inclusion of both valved (ie, Ahmed Glaucoma Valve) and non-valved (ie, Baerveldt, Molteno) tubes in the $TVT_{IRIS}$ tube group and only non-valved BGI 350 in the TVT tube group is presumably the main reason for differences in results between the studies. Valved tube shunts produce an immediate reduction in IOP after surgery, whereas non-valved tube shunts require temporary restriction of aqueous flow until fibrous encapsulation of the plate occurs, usually 1 to 2 months after surgery. As such, it is consistent that the $TVT_{IRIS}$ tube group had lower IOP than the $TVT_{RCT}$ tube group at 1 week, and similar IOP at months 1 and 3. At month 6, the $TVT_{RCT}$ tube group had significantly lower mean IOP than the $TVT_{IRIS}$ tube group on similar number of medications. At year 1, the $TVT_{RCT}$ tube group continued to have significantly lower mean IOP and required fewer medications than the $TVT_{IRIS}$ tube group. As such, the results from the $TVT_{IRIS}$ study are more comparable to the pooled data from the Ahmed Baerveldt Comparison (ABC) Study and the Ahmed Versus Baerveldt (AVB) Study, which found that Ahmed tubes were associated with significantly higher IOP (15.9 mm Hg vs 13.6 mm Hg, respectively) and required more medications (1.8 vs 1.4, respectively) at 1 year compared to BGIs.[26] The $TVT_{IRIS}$ tube group had a mean IOP of 14.3 mm Hg on 1.7 medications at 1 year, which is close to the average of the Ahmed

and Baerveldt results in the pooled ABC and AVB study. As such, we presumed that Ahmed tubes made up a good proportion of our $TVT_{IRIS}$ tube group.

The reoperation rates for glaucoma were similar between the 2 groups in $TVT_{IRIS}$ but higher than $TVT_{RCT}$. At 1 year, 6.4% of the tube group and 7.4% of the trabeculectomy group in $TVT_{IRIS}$ had undergone subsequent glaucoma surgery. Eyes that failed trabeculectomy were most likely to undergo tube shunt surgery, followed by CPC. Eyes that failed a tube shunt were most likely to undergo CPC, followed by a second tube shunt. Compared to $TVT_{RCT,}$ $TVT_{IRIS}$ had significantly more eyes that required reoperation after tube shunt surgery and marginally more eyes after trabeculectomy. In $TVT_{RCT,}$ only 1 patient (1%) in the tube group required reoperation at 1 year, and CPC was performed. The $TVT_{RCT}$ trabeculectomy group had 5 patients (5%) who underwent BGI implantation. The number of CPCs performed as reoperation increased in $TVT_{IRIS}$ compared to $TVT_{RCT,}$ possibly due to advancements that have improved the safety profile of CPC since 2004 (when enrollment ended for $TVT_{RCT)}$. CPC was traditionally reserved for refractory glaucoma with limited visual potential, given the high rates of complication.[27] The “slow coagulation” technique was described in 2009 as a way to reduce damage to collateral tissue by decreasing the laser power, increasing the laser duration, and titrating by iris color.[28] The new “micropulse” laser setting for CPC was approved by the FDA in 2015. These new “safer” techniques have increased the use of CPC in non-refractory glaucoma and for repeated treatments.[29, 30]

In both $TVT_{RCT}$ and $TVT_{IRIS,}$ there was the potential for selection bias in the decision to reoperate for glaucoma. In $TVT_{RCT,}$ there was no difference in the mean IOP at the time of reoperation for glaucoma; the IOP was 24 mm Hg in the 1 patient in the tube group and 25.1 ± 3.4 mm Hg in the 5 patients in the trabeculectomy group ($P$ =.78). However, we found a marginally significant difference ($P$ =.0478) in the mean IOP before reoperation between the tube (20.5 mm Hg) and the trabeculectomy (27.9 mm Hg) groups in $TVT_{IRIS}$. The finding in the $TVT_{IRIS}$ study may explain why more patients in the $TVT_{IRIS}$ tube group underwent reoperation compared to those in the $TVT_{RCT}$. Because we were not able to perform detailed chart review of clinical and operative notes for these patients, we have a limited understanding of why these patients underwent reoperation. One possibility is that the tube shunt patients requiring reoperation had more advanced glaucoma than the trabeculectomy patients requiring reoperation.[9] A surgeon’s IOP threshold for glaucoma surgery is often lower in advanced glaucoma, where there is more imminent risk of visual field progression and vision loss.[31] Another possibility is miscoding when using CPT codes. We tried to restrict our CPT codes to only glaucoma surgeries performed to control IOP, and to exclude those for a complication after tube shunt or trabeculectomy surgery. Furthermore, surgery and visit dates were provided only by week and year. As such, it was not possible to determine the order of events that occurred in the same week, which can occur if a patient is seen in clinic and urgent surgery is performed the same day or a few days later.

Visual acuity decreased by a similar amount in both treatment groups during the first year in $TVT_{IRIS}$ as well as in $TVT_{RCT}$. However, the baseline VA was significantly better in the trabeculectomy group compared to the tube group in $TVT_{IRIS}$. The tube group also had more eyes that lost ≥2 lines of VA compared to the trabeculectomy group. Two eyes in the tube group also had loss of light perception vision, but only 1 eye in the trabeculectomy group.

These findings suggest that the tube eyes may have had more advanced glaucoma and/or more comorbidities than the trabeculectomy eyes in $TVT_{IRIS}$. One reason could be that valved tube shunts are often used in cases of very elevated IOP with multiple comorbidities, given the lower risk of complications such as hypotony.[26]

There are several limitations to the $TVT_{IRIS}$ study that have been reported in previous papers.[6, 14] The $TVT_{IRIS}$ study was a retrospective, non-randomized study using deidentified EHR data. As such, there were several differences in the baseline variables between the 2 surgical groups, including race, diabetes mellitus, prior laser trabeculoplasty, prior cataract extraction, number of patients on oral carbonic anhydrase inhibitors, and glaucoma severity.[6] Because only 419 eyes met all selection criteria, our numbers were not large enough to adjust for unbalanced covariates using methods such as propensity score matching. In addition, as with any study using EHR data, there are limitations in the availability of data elements. In the IRIS Registry, we used *ICD-9* or *ICD-10* codes for diagnoses and CPT codes to define procedures and surgeries. We did not have unstructured data elements available, such as clinical and operative notes, so we did not know what type of tube shunt was implanted or whether MMC was given at the time of trabeculectomy. We presumed that MMC was given for trabeculectomies, as it would be standard of care from 2013 to 2017. Because the IRIS Registry was de-identified, dates were provided by week and year only at the time of our data extraction. As such, we could not distinguish events that happened in the same week, and used the average per week for measurements. In addition, as we discussed above, medication laterality was not available at the time of data extraction. Therefore, if patients were using eye drops in the non-operative eye in the post-operative period, then the medication numbers would be falsely elevated in $TVT_{IRIS}$. Finally, clinical measurements such as IOP and VA may not be measured in a standardized manner as in RCTs or captured at set follow-up timepoints in the EHR. All of the limitations described above stem from the fact that EHR data are captured as part of routine health care and not specifically for research. The benefit of using EHR data is capturing a more diverse patient population with more disease severity who likely would not be represented in an RCT.

In conclusion, the $TVT_{IRIS}$ study demonstrated comparable IOP reduction at 1 year between the tube and trabeculectomy groups, although patients with eyes that underwent trabeculectomy were on fewer supplemental medications. The trabeculectomy groups in both studies had similar IOP and medication reduction from baseline to 1 year. The $TVT_{IRIS}$ tube group had higher mean IOP on more medications at 1 year compared to the $TVT_{RCT}$ tube group, likely due to the inclusion of valved and non-valved tubes. Interestingly, the $TVT_{IRIS}$ tube group's 1-year results were comparable to the averaged Ahmed and Baerveldt groups in the pooled ABC and AVB studies. Both $TVT_{IRIS}$ and $TVT_{RCT}$ studies showed a decrease in VA after glaucoma surgery. Furthermore, more reoperations occurred in $TVT_{IRIS}$ in both the tube and trabeculectomy groups, potentially due to more advanced disease or improvements in the safety profile of surgical and laser glaucoma procedures. The comparable clinical efficacy between the $TVT_{RCT}$ and $TVT_{IRIS}$ trabeculectomy groups suggests that the IRIS Registry can be used to accurately assess real-world outcomes of surgical interventions. Both RCTs and real-world studies using EHR data provide valuable information for informing surgical outcomes, and should be used together to improve patient care in the future.

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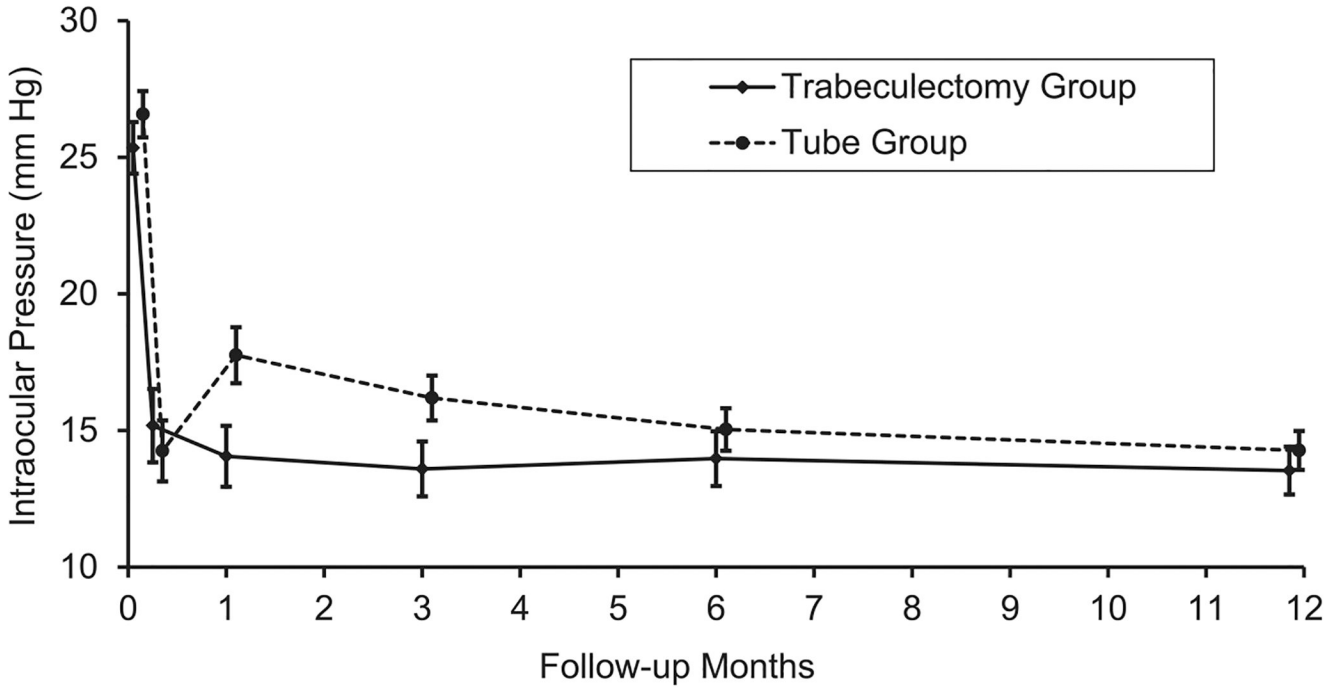


**FIGURE.**

Distribution of the intraocular pressure (IOP) at baseline and during follow-up in the IRIS Registry Tube Versus Trabeculectomy (TVT) Study. Data are presented as mean ± 2 standard errors of the mean.

**TABLE 1.**

Baseline Characteristics of the Tube Versus Trabeculectomy IRIS Registry Study Patients.

| Characteristic | Tube Group (N = 236) | Trabeculectomy Group (N = 183) | *P* Value |
|---|---|---|---|
| Age at time of baseline surgery, y, mean (SD) | 70.0 (9.8) | 71.8 (8.8) | .056 |
| Sex, male, n (%) | 113 (47.9) | 84 (45.9) | .687 |
| Race/Ethnicity, n (%) | | | .003 |
| White | 106 (44.9) | 113 (61.8) | |
| Black | 84 (35.6) | 38 (20.8) | |
| Hispanic/Latino | 26 (11.0) | 14 (7.7) | |
| Asian | 6 (2.5) | 3 (1.6) | |
| Other/Mixed | 14 (5.9) | 15 (8.2) | |
| Presence of diabetes mellitus, n (%) | 97 (41.1) | 57 (31.2) | .036 |
| Presence of hypertension, n (%) | 172 (72.9) | 119 (65.0) | .083 |
| Intraocular pressure, mm Hg, mean (SD) | 26.6 (6.5) | 25.3 (6.4) | .054 |
| Total glaucoma medications, mean (SD) | 3.6 (1.3) | 3.4 (1.2) | .170 |
| Glaucoma Diagnosis, n (%) | | | .654 |
| Primary open-angle glaucoma | 204 (86.4) | 159 (86.9) | |
| Chronic angle closure glaucoma | 12 (5.1) | 8 (4.4) | |
| Pseudoexfoliation glaucoma | 10 (4.2) | 12 (6.6) | |
| Pigmentary glaucoma | 4 (1.7) | 2 (1.1) | |
| Other glaucoma | 6 (2.5) | 2 (1.1) | |
| Lens Status, n (%) | | | .041 |
| Phakic | 64 (27.1) | 34 (18.6) | |
| Pseudophakic | 172 (72.9) | 149 (81.4) | |
| Previous intraocular surgeries, mean (SD) | 1.9 (1.1) | 1.5 (0.7) | <.001 |
| Interval from most recent intraocular surgery to baseline surgery, mo, mean (SD) | 11.5 (10.2) | 13.4 (8.4) | .033 |
| Visual acuity, logMAR, mean (SD) | 0.67 (0.58) | 0.47 (0.48) | <.001 |
| Stratum, n (%) | | | <.001 |
| Previous cataract extraction | 137 (58.1) | 151 (82.5) | |
| Previous trabeculectomy or combined procedure | 99 (42.0) | 32 (17.5) | |
| Glaucoma Stage, n (%) | | | .035 |

| Characteristic | Tube Group (N = 236) | Trabeculectomy Group (N = 183) | P Value |
|---|---|---|---|
| Mild | 12 (5.1) | 20 (10.9) | |
| Moderate | 43 (18.2) | 36 (19.7) | |
| Severe | 128 (54.2) | 81 (44.3) | |
| Unspecified | 53 (22.5) | 46 (25.1) | |

IRIS = Intelligent Research in Sight; logMAR = logarithm of the minimum angle of resolution; tube = tube shunt.

Table 1 above is adapted from Tables 3 and 4 of Vanner et al,[6] copyright 2021, with permission from Elsevier.

**TABLE 2.**

Intraocular Pressure and Glaucoma Medical Therapy at Baseline and Follow-up in the Tube Versus Trabeculectomy IRIS Registry Study.

| Variable | Tube Group | | Trabeculectomy Group | | Tube Minus Trabeculectomy Group, Mean Difference (95% CI)[a] | *P* Value[b] |
|---|---|---|---|---|---|---|
| | n | Mean (SD) | n | Mean (SD) | | |
| Baseline | | | | | | |
| IOP (mm Hg) | 236 | 26.6 (6.5) | 183 | 25.3 (6.4) | 1.23 (−0.02, 2.48) | 0.0540 |
| Glaucoma medications (n) | 236 | 3.6 (1.3) | 183 | 3.4 (1.2) | 0.17 (−0.07, 0.41) | 0.0006 |
| 1 Week[c] | | | | | | |
| IOP (mm Hg) | 212 | 14.3 (8.1) | 163 | 15.2 (8.6) | −0.93 (−2.63, 0.78) | 0.2864 |
| Glaucoma medications (n) | 212 | 0.4 (1) | 163 | 0.4 (1) | 0 (−0.2, 0.21) | 0.976 |
| 1 Month[c] | | | | | | |
| IOP (mm Hg) | 221 | 17.8 (7.6) | 173 | 14.1 (7.3) | 3.7 (2.21, 5.2) | < 0.0001 |
| Glaucoma medications (n) | 221 | 0.9 (1.2) | 173 | 0.5 (1) | 0.38 (0.16, 0.6) | 0.0009 |
| 3 Months[c] | | | | | | |
| IOP (mm Hg) | 205 | 16.2 (5.9) | 156 | 13.6 (6.3) | 2.6 (1.33, 3.86) | < 0.0001 |
| Glaucoma medications (n) | 206 | 1.4 (1.4) | 158 | 1 (1.4) | 0.4 (0.11, 0.69) | 0.0073 |
| 6 Months[c] | | | | | | |
| IOP (mm Hg) | 195 | 15 (5.4) | 161 | 14 (6.3) | 1.07 (−0.18, 2.31) | 0.0935 |
| Glaucoma medications (n) | 197 | 1.4 (1.4) | 164 | 0.9 (1.2) | 0.49 (0.22, 0.75) | 0.0003 |
| 1 Year[c] | | | | | | |
| IOP (mm Hg) | 183 | 14.3 (4.8) | 140 | 13.5 (5.2) | 0.74 (−0.36, 1.84) | 0.1862 |
| Glaucoma medications (n) | 183 | 1.7 (1.4) | 140 | 1.2 (1.4) | 0.52 (0.21, 0.83) | 0.0012 |

IOP = intraocular pressure; IRIS = Intelligent Research in Sight; tube = tube shunt; trab = trabeculectomy.

[a] In the treatment group comparisons, a positive mean difference indicates that the tube group had a larger mean than the trabeculectomy group, whereas a negative mean difference indicates that the tube group had a smaller mean than the trabeculectomy group.

[b] Independent-samples *t* test.

[c] Eyes prior to glaucoma reoperation.

**TABLE 3.**

Comparisons of Intraocular Pressure and Glaucoma Medical Therapy Between the Tube Versus Trabeculectomy IRIS Registry Study and the TVT Randomized Controlled Trial.

| Variable | Treatment Group | TVT IRIS Registry Mean (SD) | TVT RCT Mean (SD) | TVT IRIS Registry Minus TVT RCT Mean Difference | *P* Value[a] |
|---|---|---|---|---|---|
| Baseline[b] | | | | | |
| IOP (mm Hg) | Tube | 26.6 (6.5) | 25.1 (5.3) | 1.5 | 0.0006 |
| | Trab | 25.3 (6.4) | 25.6 (5.3) | −0.3 | 0.5887 |
| Glaucoma Medications | Tube | 3.6 (1.3) | 3.2 (1.1) | 0.4 | < 0.0001 |
| | Trab | 3.4 (1.2) | 3.0 (1.2) | 0.4 | < 0.0001 |
| 1 Week[c] | | | | | |
| IOP (mm Hg) | Tube | 14.3 (8.1) | 19.0 (9.8) | −4.7 | < 0.0001 |
| | Trab | 15.2 (8.6) | 14.0 (8.5) | 1.2 | 0.0815 |
| Glaucoma Medications | Tube | 0.4 (1) | 1.2 (1.4) | −0.8 | < 0.0001 |
| | Trab | 0.4 (1) | 0.2 (0.7) | 0.2 | 0.0027 |
| 1 Month[c] | | | | | |
| IOP (mm Hg) | Tube | 17.8 (7.6) | 18.5 (9.8) | −0.7 | 0.1477 |
| | Trab | 14.1 (7.3) | 12.6 (7.3) | 1.5 | 0.0098 |
| Glaucoma Medications | Tube | 0.9 (1.2) | 1.3 (1.3) | −0.4 | < 0.0001 |
| | Trab | 0.5 (1) | 0.1 (0.6) | 0.4 | < 0.0001 |
| 3 Months[c] | | | | | |
| IOP (mm Hg) | Tube | 16.2 (5.9) | 16.2 (6.4) | 0 | 0.9815 |
| | Trab | 13.6 (6.3) | 13.7 (6.6) | −0.1 | 0.8341 |
| Glaucoma Medications | Tube | 1.4 (1.4) | 1.1 (1.1) | 0.3 | 0.0123 |
| | Trab | 1 (1.4) | 0.5 (1.0) | 0.5 | < 0.0001 |
| 6 Months[c] | | | | | |
| IOP (mm Hg) | Tube | 15 (5.4) | 13.5 (4.2) | 1.5 | 0.0001 |
| | Trab | 14 (6.3) | 12.8 (5.9) | 1.2 | 0.0207 |
| Glaucoma Medications | Tube | 1.4 (1.4) | 1.2 (1.2) | 0.2 | 0.0789 |
| | Trab | 0.9 (1.2) | 0.6 (1.1) | 0.3 | 0.0036 |
| 1 Year[c] | | | | | |

| Variable | Treatment Group | TVT IRIS Registry Mean (SD) | TVT RCT Mean (SD) | TVT IRIS Registry Minus TVT RCT Mean Difference | *P* Value[a] |
|---|---|---|---|---|---|
| IOP (mm Hg) | Tube | 14.3 (4.8) | 12.4 (3.9) | 1.9 | < 0.0001 |
| | Trab | 13.5 (5.2) | 12.7 (5.8) | 0.8 | 0.059 |
| Glaucoma Medications | Tube | 1.7 (1.4) | 1.3 (1.3) | 0.4 | < 0.0001 |
| | Trab | 1.2 (1.4) | 0.5 (0.9) | 0.7 | < 0.0001 |
| IOP Reduction From Baseline (mm Hg)[d] | Tube | 12.9 (7.8) | 12.7[e] | 0.2 | 0.67 |
| | Trab | 12 (8.1) | 12.9[e] | −0.9 | 0.1807 |
| Glaucoma Medication Reduction From Baseline[d] | Tube | 1.9 (1.6) | 1.9[e] | 0 | 0.8959 |
| | Trab | 2.3 (1.5) | 2.5[e] | −0.2 | 0.0558 |

IOP = intraocular pressure; IRIS = Intelligent Research in Sight; tube = tube shunt; trab = trabeculectomy; TVT = Tube Versus Trabeculectomy.

[a] One-sample *t* test.

[b] Baseline mean values.

[c] Eyes prior to glaucoma reoperation.

[d] In the comparisons of baseline to follow-up, all numbers are baseline minus follow-up, and all *P* values were <.0001 in paired *t* tests.

[e] SDs were not reported in the Tube Versus Trabeculectomy 1-year outcomes paper.[10]

**TABLE 4.**

Numbers of Reoperation Procedures for Glaucoma in the Tube Versus Trabeculectomy IRIS Registry Study.

| Procedure | CPT Code | Tube Group (n = 15) | Trabeculectomy Group (n = 16) |
|---|---|---|---|
| Trabeculectomy in absence of previous surgery | 66170 | 1 | 1 |
| Trabeculectomy with scarring from previous ocular surgery or trauma | 66172 | 0 | 1 |
| Tube shunt without graft | 66179 | 0 | 2 |
| Tube shunt with graft | 66180 | 5 | 8 |
| Trans-scleral cyclophotocoagulation | 66710 | 9 | 4 |

CPT = Current Procedural Terminology; IRIS = Intelligent Research in Sight; tube = tube shunt.