Comparison of Circumferential and Traditional Trabeculotomy in Pediatric Glaucoma

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ABSTRACT

INTRODUCTION: The aim of this study is to compare intraocular pressure (IOP) control of pediatric glaucoma patients undergoing traditional trabeculotomy (< 360 degrees or partial) with those receiving circumferential trabeculotomy (360 degrees or complete).

METHODS: Charts of pediatric glaucoma patients receiving trabeculotomy were retrospectively reviewed. Patients were divided into two groups: traditional trabeculotomy group (N=77 eyes; age at surgery 1.52±2.68 years) and circumferential trabeculotomy group (N=14 eyes; age at surgery 0.61±0.42 years). Statistical comparisons of IOP at baseline, 1-month, 3-months, 6-months, and 1-year of follow-up were performed within and between each group.

RESULTS: Mean baseline IOP was similar between traditional and circumferential groups at 28.75±8.80mmHg and 30.35±6.04mmHg, respectively (t-test, $p = 0.43$). Mean 1-year IOP was 17.05±5.92mmHg in the traditional group and 11.0±2.31mmHg in the circumferential group. At 1-year, surgical success rate was 58.44% in the traditional group and 85.71% in the circumferential group; 32 eyes in the former and 2 eyes in the later required another glaucoma procedure within 1 year for IOP

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eyes in the former and 2 eyes in the later required another glaucoma procedure within 1 year for IOP control. For both groups, there was significant decrease in IOP when comparing baseline values with all post-operative measurements (paired t-test, all $p < 0.01$). The circumferential group had significantly lower IOP compared to the traditional group at 1-year (t-test, $p < 0.01$).

CONCLUSIONS: Both circumferential and traditional trabeculotomy significantly reduce IOP in children at 1-month, 3-months, 6-months, and 1-year of follow-up. Circumferential trabeculotomy shows better 1-year post-operative IOP control with higher rate of surgical success.

INTRODUCTION

The mainstay of treatment of pediatric glaucoma is surgical. Standard initial treatment of choice, either goniotomy or trabeculotomy, opens approximately one third of the drainage angle with 78 – 93% success [1]. Children often require multiple glaucoma procedures and trips to the operating room to obtain intraocular pressure (IOP) control. In 1960, Smith described a technique using a nylon suture to partially open the trabecular meshwork[2]. Ultimately, the suture was used to traverse 360 degrees of Schlemm's canal. Although reported success rates of suture trabeculotomy are 87-93%, published experience is limited and this surgery was found to have complications such as creation of a false passage, misdirected suture, hyphema, inability to pass the suture 360 degrees, iris tear and prolonged hypotony [3-6]. An illuminated microcather is now available and enables visualization of travel through Schlemm's canal thereby allowing circumferential trabeculotomy to be performed safely and provide excellent IOP lowering in patients with minimal complications [7]. The primary advantage of circumferential trabeculotomy with microcatheter over suture approaches is that it avoids potentially devastating inadvertent misdirection into the suprachoroidal space by permitting continuous visual verification of the location of the microcatheter within the canal. The microcatheter is more rigid than prolene suture and allows viscoelastic to be injected distally into the canal, potentially facilitating circumferential passage.

While prior studies have compared the efficacy of goniotomy with circumferential trabeculotomy[3], there is no study investigating the surgical success between circumferential (360 degrees or complete) trabeculotomy and traditional (<360 degree, typically 120 degrees, or partial) trabeculotomy directly. The purpose of this study is to compare IOP control and surgical success of traditional (<360 degree) with circumferential (360 degrees) trabeculotomy in patients with pediatric glaucoma. In particular, we separated primary congenital glaucoma (PCG) for further investigation.

METHODS

The Indiana University Institutional Review Board approved this study. The Health Insurance Portability and Accountability Act was maintained during this study. Patients receiving first-time trabeculotomy at Riley Children's Hospital in Indianapolis, IN were identified and charts were retrospectively reviewed. Inclusion criteria: All patients that received trabeculotomy under the age of 18 with at least 6 months of follow up were included. Exclusion criteria (N=40 eyes): Patients who were older than 18 at time of surgery (N=1), had prior glaucoma procedure (N=18), had insufficient follow-up (N=10), had trabeculotomy combined with another procedure (N=5), had incomplete charts (N=4), or were not fixing/following at initial visit (one patient with late presentation and poor visual potential, N=2) were excluded. All trabeculotomies were performed by pediatric ophthalmologists in our tertiary care center who decided based on preferred practice patterns at the time of surgery whether a patient would receive either traditional or circumferential trabeculotomy.

Age at time of surgery, number of previous eye surgeries, number of eye medications prior to trabeculotomy, baseline IOP, and post-operative IOP at 1-month, 3-months, 6-months, and 1-year of follow-up were recorded. Surgical complications and glaucoma diagnosis (**Table 1**) were also noted.

follow-up were recorded. Surgical complications and glaucoma diagnosis (**Table 1**) were also noted. Surgical failure was defined as the need for another glaucoma procedure after initial trabeculotomy. Patients were separated into traditional (N=77 eyes of 56 patients) and circumferential groups (N = 14 eyes of 10 patients); 3 eyes of the traditional group were attempted circumferential trabeculotomies. Statistical comparisons of IOP at baseline, 1-month, 3-months, 6-months, and 1-year of follow-up were conducted within and between each group.

RESULTS

All Pediatric Glaucoma Diagnoses

Average age at time of surgery was 1.52±2.68 years for the traditional group and 0.61±0.42 years for the circumferential group (independent t-test, p<0.01, 95% CI of difference between means -0.53-2.34 years). Mean baseline IOP was similar between traditional and circumferential groups at 28.75±8.80 mmHg and 30.36±6.05 mmHg, respectively (independent t-test, p=0.41, 95% CI of difference between means -3.27-6.49 mmHg). **Table 2** shows baseline characteristics of each group.

When including all glaucoma diagnoses, there was significant decrease in baseline IOP compared to all IOP measurements 1 year after surgery in both groups (paired t-test, all p<0.01). Mean 1-month IOP was 19.63±5.47 mmHg (Range: 7-34 mmHg, N=60 eyes, 95% CI of difference between baseline and post-operative means 6.57-11.68 mmHg) in the traditional group and 12.17±5.20 mmHg (Range: 5-24 mmHg, N=12 eyes, 95% CI of difference between baseline and post-operative means 13.58-22.80 mmHg) in the circumferential group. At three months, mean IOP was 19.63±7.84 mmHg (Range: 6-39 mmHg, N=40 eyes, 95% CI of difference between baseline and post-operative means 5.84-12.40 mmHg) and 13.15±6.71 mmHg (Range: 6-30 mmHg, N=13 eyes, 95% CI of difference between baseline and post-operative means 12.15-22.27 mmHg) in the traditional and circumferential groups, respectively. One year after traditional trabeculotomy, IOP was 17.05±5.92 (Range: 6-34 mmHg, N=37 eyes, 95% CI of difference between baseline and post-operative means 8.53-14.87 mmHg) compared to 11.00±2.31 mmHg (Range: 7-14 mmHg, N=7 eyes, 95% CI of difference between baseline and post-operative means 14.35-24.37 mmHg) in the circumferential group. Except for the 6-month follow-up, there was significantly lower IOP for 1-, 3-, and 12-months follow up in the circumferential group compared to the traditional group (independent t-test, all p<0.01 [95% CI of difference between means at 1-month: 4.07-10.88 mmHg, 3-months: 1.62-11.34, 12-months: 1.43-10.67 mmHg]). See **Figure 1**. There was no significant difference in the average number of glaucoma drops for either group compared to baseline or between each group after surgery.

In the circumferential group, two eyes (2/14=14.29%) required a second glaucoma surgery for IOP control within the first 12 months (Average time to failure: 0.42±0.19 years, Range: 0.28-0.56 years). In contrast, 32 eyes failed traditional trabeculotomy (32/77=41.56%) at 12 months with an average time to failure of 0.18±0.16 years (Range: 0.02-0.79 years). The respective success rates at 1 year are 85.71% for the circumferential group and 58.44% for the traditional group. After failure of initial trabeculotomy, another glaucoma procedure was required for IOP control (**Table 3**). Complication rate in the traditional group was 3.90% and included hyphema lasting longer than 1 week (N = 2 eyes, both managed medically) and intraoperative iris prolapse (N = 1 eye). Three eyes in the circumferential group had hyphema lasting more than 1 week yielding a complication rate of 21.43% (3/14); all were treated with medical management.

Three eyes in the traditional group had attempted circumferential trabeculotomy. All of these eyes had PCG with an average age of surgery of 1.36±1.97 years (Range: 0.03-3.62 years). Baseline and post-operative IOP was similar to other traditional eyes. If these eyes are excluded, results are minimally affected and the circumferential group still has significantly lower IOP at post-operative months 1-, 3-, and 12. Two of these eyes required a second surgery within the first year bringing the success rate of traditional trabeculotomy to 59.46%. Average time to failure for these eyes is 0.21±0.13 years (Range: 0.12-0.30 years).

Primary Congenital Glaucoma Only

When eyes with secondary glaucoma diagnoses were excluded, there were 58 eyes of 41 patients in the traditional group and 11 eyes of 6 patients in the circumferential group with primary congenital glaucoma. Baseline IOP were similar between PCG patients receiving traditional and circumferential trabeculotomy (**Table 4**). Results are plotted in **Figure 2**. Compared to baseline IOP, there was a significant decrease in post-operative IOP within each group (paired t-test, all p < 0.01 [Traditional Group 95% CI of difference between baseline and post-operative means: 1-month 7.22-13.56 mmHg, 3-months 6.49-14.84 mmHg, 6-months 7.76-16.26 mmHg, 12-months 10.35-18.22 mmHg; Circumferential Group 95% CI of difference between baseline and post-operative means: 1-month 16.14-25.56 mmHg, 3-months 16.85-25.85 mmHg, 6-months 14.10-28.50 mmHg, 12-months 15.37-25-73 mmHg]) as well as significant decrease in all post-operative IOPs between each group (independent t-test, all p < 0.05 [95% CI of difference between means at 1-month: 4.72-11.28 mmHg, 3-months: 3.53-12.91 mmHg, 6-months: 0.07-13.60 mmHg, 12-months: 0.23-7.39 mmHg]). There was a significant difference in glaucoma

0.07-13.60 mmHg, 12-months: 0.23-7.39 mmHg]). There was a significant difference in glaucoma medications compared to baseline at 1-, 3-, and 12- months after surgery in the circumferential group (paired t-test, all $p < 0.05$ [95% CI of difference between baseline and post-operative means at 1-month 0.42-1.54, 3-months 0.42-1.54, 12-month 0.39-1.69 medications]). At one month, the circumferential group (Average number of glaucoma medication: 0.20±0.42 medications) required less medication than the traditional group (Average number of glaucoma medication: 0.68± 0.71 medications) (independent t-test, $p = 0.01$, 95% CI of difference between means 0.01-0.96 medications). See **Figure 3.** Twenty-six PCG eyes failed traditional trabeculotomy yielding a success rate of 55.17% (Average time to failure of 0.16±0.11 years, Range: 0.02–0.52 years). See **Table 3** for procedures performed after failure of initial trabeculotomy. In the traditional group, one PCG eye had a complication of intraoperative iris prolapse. No PCG eyes in the circumferential group required a second glaucoma procedure at one year of follow-up, yielding a 100% success rate; persistent hyphema managed medically was seen in 2 PCG eyes. There were no sight-threatening complications seen in either PCG group.

DISCUSSION

To our knowledge, no other paper investigates the surgical success of circumferential trabeculotomy (360 degrees) with traditional trabeculotomy (< 360 degrees). Our results demonstrate that circumferential trabeculotomy has significantly better IOP control and fewer surgical failures. This is consistent with data comparing goniotomy and 360-degree circumferential trabeculotomy. Prior studies have cited a success rate ranging from 81–92% with circumferential trabeculotomy for primary congenital, glaucoma showing that it is equal to or better than goniotomy at gaining IOP control[1,3,4,7,8]. This is particularly notable when one considers the fact that goniotomy is mainly performed in eyes with less severe glaucoma and clear corneas. Additionally, the success rate is higher when the entire angle is successfully cannulated compared to cases where the suture/microcatheter is unable to completely pass the full length of Schlemm's canal. Similar with our study, Girkin found that post-operative IOP was reduced at all times when compared to baseline[7]. Most prior studies have reported transient hyphema as the only complication, however, one study of circumferential trabeculotomy in aphakic glaucoma reported several complications including: hypotony with choroidals, a cyst at the cut down site, scar in Descemet's membrane, and hyphema with vitreous hemorrhage requiring vitrectomy [9]. In our study, patients undergoing circumferential trabeculotomy were more likely to have postoperative hyphemas requiring medical management compared to those patients undergoing traditional trabeculotomy (21.43% versus 3.9%). Fortunately, none of these was vision threatening and none required surgical intervention. It should also be noted that, like traditional trabeculotomy, circumferential trabeculotomy generally has a lower success rate for secondary forms of glaucoma as compared to cases of PCG[9,10]. In our study, patients who failed circumferential trabeculotomy all had secondary glaucoma and no patients with PCG failed after circumferential trabeculotomy.

Patients with pediatric glaucoma often require multiple angle surgeries to control IOP. In our study, traditional trabeculotomy patients who failed initial surgery typically required another angle surgery (See **Table 3**). This highlights the benefit of a procedure that surgically opens the entire angle in one procedure through one surgical site (temporal or superior cut down). As a result, patients have fewer trips to the operating room and less post-operative visual recovery time [1]. In addition to undergoing fewer surgical procedures, PCG patients who received circumferential trabeculotomy required fewer glaucoma medications after surgery when compared to baseline at 1-, 3-, and 12-months of follow-up. It would be reasonable to assume that requiring fewer surgical procedures and postoperative glaucoma medications would result in both a decreased healthcare expense and a decreased opportunity for iatrogenic complications.

While the results of this study are very encouraging, it is somewhat limited by the small number of patients in the circumferential group and the short length of follow-up currently available. The multiple comparisons made increase the chance of Type I statistical error. Notably, our success rate for PCG eyes is higher than others reported in the literature. Possible reasons for this may be that only eyes with no prior procedures and with complete passage of the microcatheter were included. A greater number of subjects and a longer period of follow-up are desired to verify the significant differences observed between groups. Another potentially confounding factor are the small number of eyes where circumferential trabeculotomy was attempted, unable to be completed, and then converted to a traditional surgical approach with metal trabeculotomes or a cutdown was made and only a partial microcatheter trabeculotomy was performed. These eyes may have anomalous anatomy that precludes passage of the illuminated microcatheter and this may predispose to general surgical failure. Of the three eyes that were attempted circumferential trabeculotomies, 2 failed within the first year requiring a second angle surgery. When these eyes are excluded, the circumferential group still obtains significantly lower post-operative IOP at one year. Also, the age at time of surgery between the traditional and circumferential groups for all types of glaucoma is statistically different in our study. We postulate that this reflects the fact that secondary glaucomas typically present at an older age than primary congenital glaucomas. Data collection continues for the circumferential group as more patients receive this procedure at our institution and longer follow up time becomes available.

CONCLUSION

Both circumferential and traditional trabeculotomy significantly reduce IOP from baseline in children with pediatric glaucoma at 1-, 3-, 6- and 12-months post-operative follow-up. When compared to traditional trabeculotomy at one year, circumferential trabeculotomy has significantly better IOP control and a higher success rate (86.6% all eyes) with a lower rate of reoperation; this is particularly true when comparing PCG eyes (100% success rate).

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FIGURE LEGEND

Figure 1: Comparison of baseline IOP and post-operative IOP, all glaucoma diagnoses included

** indicates p < 0.01 when compared with baseline IOP within groups*

^ indicates p < 0.01 when compared between groups

Figure 2: Comparison of baseline IOP and post-operative IOP, primary congenital glaucoma eyes only

** indicates p < 0.01 when compared with baseline IOP within groups*

^ indicates p < 0.01 when compared between groups

Figure 3: Comparison of baseline and post-operative glaucoma medications