Cyclodiode Laser as the First Surgical Approach in Childhood Glaucoma Under the Age of 8 Years

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Precis: Cyclodiode as a primary treatment for childhood glaucoma patients younger than 8 years has a 12-month success rate of 55.24%. It can delay the need for penetrating glaucoma surgery.

Purpose: The purpose of this study was to evaluate the treatment outcome of cyclodiode laser in childhood glaucoma for patients under the age of 8 years.

Design: This was a retrospective, consecutive, noncomparative case series.

Participants: All childhood glaucoma patients who underwent cyclodiode from March 2005 to January 2017 as a primary surgical treatment under the age of 8 years.

Methods: A retrospective review of the medical records of consecutive patients who underwent cyclodiode by a single surgeon.

Main Outcome Measures: Success for single-diode intervention was defined as intraocular pressure (IOP) >6 mm Hg postoperatively ≤21 mm Hg with antiglaucoma medications and ≥20% IOP reduction, no further glaucoma surgery including cyclodiode, no loss of perception of light, and no major complications. Success for multiple-diode interventions was defined similar to the single diode, except that repeated cyclodiode is not considered a failure.

Results: In all, 59 eyes of 43 patients were studied. The most common diagnosis was aphakic glaucoma. The mean age at cyclodiode treatment was 2.7 years (SD = 2.2). Fifty-six percent of the patients were under 3 years. Success rates at 12 months after the procedure were 46.67% and 55.24% for single-diode and multiple-diode interventions, respectively. An IOP of > 20 mm Hg 6 weeks after a cyclodiode session is a significant risk factor for failure with an hazard ratio of 2.41 (95% confidence interval: 1.00-5.81; P = 0.05). Among the operated eyes, the surgeon could avoid further glaucoma surgery in 67.8% of the eyes during the first year after single or multiple cyclodiode sessions. None of the eyes experienced phthisis bulbi, hypotony, and severe uveitis.

Conclusions: Cyclodiode laser in childhood glaucoma patients under the age of 8 years can be considered a safe alternative for glaucoma patients who can have a high risk of surgical complications.

Performing cyclodiode laser can delay the need for penetrating glaucoma surgery. The IOP at 6 weeks may be a good predictor for the treatment outcome.

Key Words: childhood glaucoma, pediatric glaucoma, cyclodiode, cyclophotocoagulation, cyclodestructive procedures, primary treatment (J Glaucoma 2021;30:352–356)

Treatment of childhood glaucoma and especially secondary types is challenging. A common example is the glaucoma following cataract surgery that requires more medications, results in poorer visual acuity (VA) compared with primary congenital glaucoma, and in half of the patients require 2 or 3 surgical interventions.

There are several treatment options to manage refractory childhood glaucoma. However, in young patients, it is even more important to consider the sequence of surgeries that might be required during their longer life expectancy and the risk of complications that might require multiple examinations under anesthesia. Angle surgery is an option in early-onset glaucoma associated with the Sturge-Weber syndrome and glaucoma secondary to childhood uveitis. Although trabeculectomy and glaucoma drainage devices (GDDs) are treatment options for some secondary glaucomas, a drawback of any type of penetrating glaucoma surgery in young children is the risk of devastating complications such as choroidal effusion and suprachoroidal hemorrhage especially in cases with a high risk of hypotony such as aphakia. In addition, penetrating surgery in small children usually requires multiple examinations under anesthesia during the postoperative period, which put children at risk of having complications related to anesthesia. For this reason, some clinicians prefer not to intervene at all in cases with a poor prognosis or eye anomalies that significantly increase the risk of surgical complications.

A nonpenetrating procedure such as the transscleral diode laser cyclophotocoagulation (cyclodiode) is a good surgical option that can avoid the risks of penetrating glaucoma surgeries or help as a temporizing measure before a penetrating glaucoma surgery is decided. Although publications in adults have shown that cyclodiode is a safe and effective way to manage refractory glaucoma cases even as a primary surgery, few reports document its role in children, even fewer document its role in children, and even fewer use cyclodiode as a primary procedure. However, the age of the children included in the pediatric publications vary widely. Patients under the age of 8 years have more similar diagnostic and treatment challenges compared with older children and adults. Young children require more frequent examinations under anesthesia, have their intraocular pressure (IOP) assessed in the clinic with less reliable tonometers, and cooperate less during examinations. They also...
tend to have aggressive wound healing\(^{23}\) that results in a higher failure rate in any surgical procedure compared with adults,\(^{24}\) which might also affect the response to laser. We aim to report on the efficacy and safety of cyclodiode laser as a first surgical approach for patients with childhood glaucoma under the age of 8 years in whom a lower IOP was required, but a penetrating glaucoma surgery was not considered a more appropriate option.

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**METHODS**

**Participants**

Consecutive childhood glaucoma cases undergoing cyclodiode laser under the age of 8 years between March 2005 and January 2017 at Moorfields Eye Hospital NHS Foundation Trust (MEH) and Great Ormond Street Hospital for Children NHS Foundation Trust (GOSH) under the care of one of the authors (J.B.). The hospitals’ research and development or audit office approved this study (7BA24 for GOSH and CA17/GL/18 for MEH). The study adhered to the Declaration of Helsinki.

The reasons for delaying or not proceeding with a penetrating glaucoma surgery were the high risk of complications with penetrating glaucoma procedure and poor visual prognosis.

**Intervention, Postoperative Treatment, and Follow-up**

The contact G-probe (IRIS Medical Instruments Inc., Mountain View, CA) was used. An illuminated probe was used in all cases to identify the ciliary body position. The superotemporal region was avoided to preserve healthy conjunctiva if a future GDD was required. We treated 270 degrees with 30 shots with a power ranging from 1000 to 1500 mJ with a duration of 1500 ms. Subconjunctival injection of 1 mL betamethasone (4 mg/mL) was given immediately after the procedure. Maxitrol eye drops were prescribed 4 times daily, and antiglaucoma drops were continued until the subsequent visit. Patients were seen for a follow-up visit between 4 and 6 weeks after the procedure.

On clinical examination, IOP measurement was made using the Goldmann applanation tonometer or the iCare tonometer for young patients who were not able to cooperate.

Baseline IOP was defined as Goldmann applanation tonometer listing IOP or IOP with Perkins tonometer during examination under anesthesia on the day of the procedure. The last visit IOP was defined as the average of the last 2 visits. Reduction in VA was defined as visual deterioration > 0.3 LogMAR or progression from perception of light to no perception of light.

**Outcomes**

Treatment success for a single cyclodiode session was evaluated after 6 weeks of the surgery. Success for single-diode intervention was defined as IOP (≥6 wk postoperative) ≤21 mm Hg with antiglaucoma medications and ≥20% IOP reduction; there were no further glaucoma surgery including cyclodiode, no loss of perception of light, and no major complications. The IOP at 6 weeks was investigated as a risk factor for failure, and patients were divided into 2 groups depending on the IOP 6 weeks after the procedure: IOP ≤20 mm Hg (low IOP group) and IOP > 20 mm Hg (high IOP group).

**Statistical Analysis**

We collected data in Microsoft Excel 2010. We used IBM SPSS Statistics for Windows (version 21.0; IBM Corp., Armonk, NY) for statistical analysis. The demographic data, diagnoses, and the number of treatments were analyzed descriptively. Kaplan-Meier survival curves were created for the evaluation of surgical success for single and multiple cyclodiode laser sessions. Log-rank test was used to analyze the effect on success of binary variables such as high or low IOP at 6 weeks and aphakic glaucoma. The Cox proportional hazards regression analysis was used to identify risk factors for failure. According to univariable analysis, variables that had a P-value < 0.2 and factors that are known to affect the outcome were included in the multivariable analysis.

**RESULTS**

Sixty-one eyes of 45 patients underwent cyclodiode laser during the study period (Fig. 1). One-year follow-up data was available on 59 eyes of 43 patients. Median follow-up time after surgery was 4.9 years (interquartile range = 0.9 to 12.3 y).

**Baseline Characteristics**

Baseline data and glaucoma diagnoses are summarized in Table 1. Fifty-six percent of the patients were younger than 3 years. The most common type of glaucoma was aphakic followed by anterior segment dysgenesis. Four eyes of 2 patients with primary congenital glaucoma were included due to late presentation, advanced disease, poor visual prognosis, and more limited prognosis with angle surgery.\(^{25,26}\)

![Chart review patients who underwent cyclodiode at Great Ormond Street hospital (GOSH) and Moorfields eye hospital (MEH).](image)

**FIGURE 1.** Patients’ flow chart.
Laser Parameters

Mean (SD) cyclodiode power and duration were 1254.80 (306.45) mW and 1545.45 (222.36) ms, respectively. Thirty-three eyes (58.3%) had 1 treatment, 14 eyes (28.3%) had 2 treatments, and 11 eyes (18.3%) had 3 or more treatments. Mean (SD) number of cyclodiode treatments were 1.6 (0.9).

Success Rate

Kaplan-Meier survival curves (Figs. 2A, B) show success rates of single and multiple cyclodiode interventions at 12 months of 46.67% and 55.24%, respectively. The mean probabilities of success at 24 months were 26.41% and 30.43% for single-diode and multiple-diode analysis, respectively. A subgroup analysis (Fig. 2C) comparing the success rates for high and low IOP at 6 weeks shows a significant difference between groups (log-rank test, \( P = 0.007 \)). Figure 2D shows no difference in the success rates for a phakic compared with other types of glaucoma. For the single-diode analysis, a second diode was the first reason for failure (Table 2) whereas for the multiple cyclodiode analysis, further glaucoma surgery was the first reason for failure. None of the eyes failed from complications or reduction in VA.

High IOP at 6 weeks after treatment was the only statistically significant factor that affected success with a

| TABLE 1. Baseline Characteristic of Patients Who Underwent Cyclodiode Laser as a Primary Treatment |
|-----------------------------|-----------------------------|
| Characteristics             | Eyes | Values |
| Age at first cyclodiode (y) | 60   | 2.66 ± 2.16 |
| Mean ± SD                   | 60   | 2.66 ± 2.16 |
| Range                       | 0.06-7.54                        |
| Participants [n (%)]        | 60   | 41 (68.3) |
| Female                      | 51   | 27.54 ± 6.57 |
| Listing IOP (mm Hg)         | 56   | 25.02 ± 4.91 |
| Mean ± SD                   | 18-49 |
| IOP on the day of surgery (mm Hg) | 56 |
| Mean ± SD                   | 25.02 ± 4.91 |
| Range                       | 16-35 |
| No. glaucoma medication     | 58   | 3, 1 |
| Median (IQR)                | 60   | 33 (55) |
| Diagnosis [n (%)]           | 17   | 17 (28.3) |
| Aphakic glaucoma            | 4    | 4 (6.7) |
| Anterior segment dysgenesis | 4    | 4 (6.7) |
| Primary congenital glaucoma | 2    | 2 (3.3) |
| Coat disease                | 2    | 2 (3.3) |
| Others (SWS, PFV, JXG, Rubella) | 4 |
| IOP indicates intraocular pressure; IQR, interquartile range; JXG, juvenile xanthogranuloma; PFV, persistent fetal vasculature; SWS, Sturge-Weber syndrome. |

FIGURE 2. Kaplan-Meier curves showing cumulative survival probability of success after a single session of cyclodiode laser (A), after multiple cyclodiode laser sessions (B), after multiple cyclodiode lasers according to high (IOP > 20 mm Hg) or low (IOP < 20 mm Hg) at 6 weeks after surgery (C), and after multiple cyclodiode laser according to the diagnosis of aphakic glaucoma (D). IOP indicates intraocular pressure.
TABLE 2. Reason of Failure According to Single and Multiple Cyclodiode Intervention Criteria

| Reason for Failure at Last Visit | No. Patients [n (%)] |
|----------------------------------|----------------------|
| Single cyclodiode analysis (n = 50) |                       |
| Further cyclodiode               | 22 (44)              |
| Further penetrating glaucoma surgery | 16 (32)          |
| IOP                              |                      |
| IOP ≥ 21 mm Hg                   | 7 (14)               |
| IOP < 20% reduction              | 5 (10)               |
| Multiple cyclodiode analysis (n = 44) |                   |
| Further penetrating glaucoma surgery | 22 (50)         |
| IOP                              |                      |
| IOP ≥ 21 mm Hg                   | 16 (36)              |
| IOP < 20% reduction              | 6 (14)               |

IOP indicates intraocular pressure.

TABLE 3. Effect of Primary Cyclodiode for Childhood Glaucoma Treatment in Summary

| Clinical Points | No. Patients [n (%)] |
|-----------------|----------------------|
| Patients who avoided further penetrating glaucoma surgery in the first year with single cyclodiode | 21 (35.6) |
| Patients who avoided further penetrating glaucoma surgery in the first year with multiple cyclodiode sessions | 19 (32.2) |
| Temporary effect (intraocular pressure decrease for 6-12 mo) | 11 (18.6) |
| No effect (fail before 6 mo) | 8 (13.6) |

hazard ratio of 2.41 (95% confidence interval: 1.00-5.81; \( P = 0.05 \)). The number of treatment sessions had a trend toward more treatment failure without being statistically significant. Age at surgery, aphakic glaucoma, higher pre-operative IOP, and laser parameters did not demonstrate a significant change in the risk for treatment failure.

Time to further glaucoma surgery was ≥ 12 months in 67.8% of eyes (Table 3). Of the 16 eyes that underwent further penetrating glaucoma surgery after a single diode, 81.3% had “temporary” IOP decrease for 6 to 12 months. Eighty-three percent of the eyes achieved a lower last visit IOP compared with baseline IOP.

Complications

There were no devastating complications related to cyclodiode. None of the study eyes experienced hypotony, phthisis bulbi, or severe uveitis. VA before and after the cyclodiode was recorded in 38 eyes. A decrease in VA was observed in 3 eyes (7.8%) of 3 patients. One of these patients had a painful eye diagnosed with anterior segment dysgenesis with an initial doubtful VA of perception of light that ended with no light perception. This patient was not considered failure and the patient remained free of pain. The remaining 2 patients had a stable VA after cyclodiode but later lost light perception after Baerveldt GDD implantation.

DISCUSSION

Cyclodiode is a safe and effective primary management of childhood glaucoma patients in whom penetrating glaucoma surgery is intended to be delayed or avoided due to poor visual prognosis or high risk of complications. According to multiple cyclodiode intervention criteria, 55.24% of eyes had a successful treatment 1 year after the procedure. It was successful in delaying further glaucoma surgery in 67.8% of cases. Moreover, if focused on the percentage of patients who avoided penetrating glaucoma surgery during the first year after the procedure, 35.6% and 32.2% could achieve that with single and multiple cyclodiode, respectively. The absence of devastating complications related to the procedure supports our finding that cyclodiode appears to be a safe procedure in managing childhood glaucoma. Three patients experienced deterioration of VA during the complete follow-up; none of these cases had a vision-threatening complication resulting from cyclodiode.

The results of a single cyclodiode session have been previously published by different authors such as Bock et al.\(^{20}\) who reported a success of 20% at 1 year and Autrata et al.\(^{27}\) who reported 68% using similar success criteria. The present study identified a success of 46.67% after a single diode at 1 year. The variability of the results could be secondary to the difference on when clinicians decided that a patient required further cyclodiode or penetrating glaucoma surgery.

The results of multiple cyclodiode sessions have also been reported by Bock et al.\(^{20}\) with a success of 50% at a mean follow-up of 18.5 months and by Autrata et al.\(^{27}\) with a success of 63% at 2 years of follow-up. The present study identified a success of 30.43% after multiple-diode interventions at 2 years of follow-up. Bock and Autrata publications repeated cyclodiode for a mean of 2.2 and 2.1 sessions, respectively, whereas in the present study cyclodiode was repeated for a mean of 1.6 sessions. The lower success rate of the present study is likely due to the use of cyclodiode as primary surgery because the most common cause of failure in our study was the implantation of GDD, which was not possible in the other publication because the patients had already undergone GDD or other types of glaucoma surgery.

The results of the present study might be better compared with a previous publication by Kirwan et al.\(^{19}\) from Moorfields Eye Hospital (two thirds of the patients in the present study were treated at the same hospital). Although there are many similarities in the clinical management between the Kirwan and colleagues’ publication and the present study, the present study reports the use of cyclodiode only as first surgical approach and in patients under the age of 8 years. Kirwan and colleagues reported that 24% and 59% of patients had controlled IOP after 1 year with single and multiple cyclodiode, respectively. In this study, 46.67% and 55.24% of the participants had controlled IOP after 1 year with single and multiple cyclodiode, respectively. In addition, 67.8% of the eyes in the present study avoided further penetrating glaucoma surgery for > 1 year (Table 3), which is comparable to the 59% of participants in Kirwan and colleagues’ report that had IOP controlled for > 1 year. No response to cyclodiode laser was identified in 13% of the patients in the Kirwan and colleagues’ study and the present study. It is interesting to note that Kirwan and colleagues identified a shorter duration of the IOP-lowering effect in children younger than 5 years and in the present study patients with “no effect” (Table 3) tended to be younger. The “no effect” group had a mean (SD) age of 1.5 (1.62) years compared with the remaining patients with a mean of 2.9 (2.25) years (mean difference = 1.43; 95% confidence interval: 0.21-2.65; \( P = 0.024 \)). The reduced effect in younger children could be explained by a more unpredictable laser response or by the more severe characteristics of the disease earlier in life.

There are multiple limitations in our study that arise from the retrospective nature of the study. Because of the
rarity of these types of glaucoma, randomization to different treatment pathways was impossible. To increase the homogeneity of the study population, we only included patients treated under the care of a single surgeon with a narrower age range (under 8 y old). In addition, among the 43 included patients, 16 underwent cyclotherapy in both eyes and were included in the final analysis. Although both eyes of the same patient are usually correlated, there was no difference in the survival analysis including one randomly selected eye or both eyes.

In conclusion, this is the first study in young children under the age of 8 years that reports the results of cyclotherapy as a primary surgical treatment. Cyclotherapy could be used as a primary procedure for childhood glaucoma patients in whom a penetrating glaucoma surgery is intended to be delayed or avoided due to high risk of complications, very young age, or unknown visual prognosis.

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