Original Article

Success of Trabeculotomy Procedure in Primary Pediatric Glaucoma by Measuring the Change in Axial Length After Procedure

Sarfraz Hussain Syed

ABSTRACT

Objective: To study the success of Trabeculotomy procedure in Primary Pediatric glaucoma by measuring the change in axial length after procedure. **Study Design:** This was prospective, non-comparative, interventional study. **Study Period:** One year from July, 2011 to June, 2012. **Material and Methods:** This was carried out in the department of Pediatric Ophthalmology at College of Ophthalmology and Allied Vision Sciences (COAVS), King Edward Medical University (KEMU), Mayo Hospital, Lahore, Pakistan. Thirty (30) eyes of patients, from birth to 8 years of age with Primary pediatric glaucoma (PPG) were included in the study. The patients were selected after a suspicion of pediatric glaucoma from history and clinical examination. The patients were admitted from pediatric eye OPD of Mayo Hospital Lahore. Examination under general anesthesia was performed and axial length measurements were recorded. Those diagnosed as primary pediatric glaucoma underwent trabeculotomy. Post-operative serial examinations within 1st, 3rd and 6th month were performed with recording of axial length measurements. **Results:** Thirty eyes of 16 patients of primary pediatric glaucoma were included in this study. 9 patients (56%) were males and 7 patients (44%) were females. 2 (12.5%) patients had unilateral disease and 14 (87.5%) patients had bilateral disease. The age of patients ranged from 2 months to 96 months with a mean of 26.77 months. 16 eyes (53%) were involved in patients below 12 months of age, 5 eyes (17%) were involved in patients of 13 to 36 months. 9 eyes (30%) were involved in the patients of 37 months and above age. All patients have longer axial length than normal age matched children with higher growth rate. All underwent trabeculotomy. There was an increase in axial length in all eyes after trabeculotomy but the change in axial length was much slower than preoperative growth rate in age matched children. The change in axial length was stabilized and normalized in these cases after 6 months of surgery. **Conclusion:** The success of trabeculotomy procedure can be assessed by axial length measurements before and after the procedure. Ttrabeculotomy has proven to be a safe and effective procedure for control of primary pediatric glaucoma **Key words:** Primary pediatric glaucoma, axial length, axial

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INTRODUCTION

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The pediatric glaucoma is rare heterogeneous and potentially blinding group of disorders with a raised intraocular pressure in common.[1]

The clinical manifestations are due to the raised intraocular pressure (IOP). The control of IOP is the most important factor which is achieved surgically, with medical treatment playing a supportive role. After control of glaucoma,

correction of refractive error, treatment of amblyopia and restoration of useful vision throughout life is very important. All this is only possible by developing special relationships with parents of child. The pediatric glaucoma is further classified into two major groups, the Primary pediatric glaucoma (PPG) with no obvious ocular or systemic disease and secondary glaucoma caused by an ocular disease, injury, drugs or a systemic disease. The primary pediatric glaucoma is further sub classified into primary congenital glaucoma (PCG) that constitute congenital (presents at birth), infantile (presents before one year of age), delayed onset (presents before 3 years of age); and juvenile open angle glaucoma (JOAG) (presents after 3 years to early adulthood)[2,3] . The Primary congenital glaucoma is the commonest among the pediatric glaucoma and its incidence varies in different communities. It ranges from 1:10,000-20,000 live births in western countries and increases in eastern countries because of higher consanguineous marriages[4]. PCG has been mostly sporadic but in 10% cases there is a definite family history demonstrating an autosomal recessive inheritance. Four gene loci have been detected as GLC3A, GLC3B, GLC3C and GLC3D. It is CYP1B1 gene on locus GLC3A that is responsible for normal synthesis of enzyme cytochrome P4501B1[5,6,7]. The mutation of this gene leads to defective synthesis of that enzyme causing maldevelopment and malfunction of ocular tissues.

The males are affected more than females. The primary pediatric glaucoma is typically bilateral (70-80%) and usually manifests in the first year of life (25% at birth and 60% in first year). The Juvenile open angle glaucoma (JOAG) manifests after 3 years. These are caused by the developmental arrest of the anterior chamber angle structures (trabeculodysgenesis) resulting into the increased resistance to the aqueous outflow leading to rise of intraocular pressure with subsequent changes in the affected eye. The classic triad of epiphora, photophobia and blepharospasm / buphthalmos with corneal clouding is alarming symptom of primary pediatric glaucoma. The glaucoma is diagnosed on examination with detection of corneal signs like clouding, Haab's striae and/enlargement, deep Anterior chamber, gonioscopical findings of trabecular maldevelopment, Lens may be subluxated or dislocated, myopic refractive error, optic disc cupping and[8], raised IOP checked by tonometery[9] longer axial Length, B-Scan showing flat retina and cupping of disc in hazy cornea. Ultrasound biomicroscopy (UBM) can be utilized to assess the anterior segment, angle and lens abnormalities. High resolution Optical Coherence Tomography (OCT) of anterior segment is also helpful[10].

A-Scan can be performed for repeated measurements of axial length. Abnormally high readings are suggestive of enlargement of the eyeball. It can also be performed during follow-up periods because a stable axial length of eyeball is suggestive of good control of glaucoma.[11,12] The A-Scan is easy to perform, is not affected by corneal scarring or edema, less biased by examiner as is the case with other tests like applanation tonometry, C/D ratio, retinoscopy, and corneal diameter. Ultrasound/ optical pachymetry can be performed for central corneal thickness to avoid under- or overestimation of IOP.[13]

The treatment of pediatric glaucoma is essentially surgical. Medical therapy is only instituted when surgery carries a risk to the vision; eye or life because of general anesthesia.[14]It is only prescribed for short term to lower the IOP, when it is raised after surgery, or to clear the cornea before surgery for internal drainage as they have serious adverse effects and cannot be used on long term[15]. The drugs used in pediatric glaucoma are, Timolol 0.25% eye gel or 0.1% eye drops for newborn or Betaxolol eye drops in asthmatic children[16]and Pilocarpine 1% eye drops or gel. Carbonic anhydrase inhibitors (CIAs) can be used as topical eye drops like Dorzolamide and Brinzolamide, and or oral as Acetazolamide.[17] One of these is selected as first line drug.

Prostaglandins analogues as Latanoprost, Travoprost, Bimatoprost, Unoprostone,and Tafluprost may be used in JOAG but they are less effective and may cause lengthening and thickening of lashes and permanent color change in iris.[18] Sympathomimetic such as topical alpha-2 agonists Brimonidine and apraclonidine has not been used in infants because it crosses the blood-

brain barrier and leads to severe bradycardia, hypotension, somnolence and apnea[19].

Surgery on pediatric eye is difficult and sometimes complex because of different and changed anatomy in glaucomatous eyes[20]. So it should be performed at a referral center to ensure both skillful surgery and safe anaesthesia[14]The surgical procedures in primary pediatric glaucoma are goniotomy[21], trabeculotomy,[22,23] trabeculotomy combined with trabeculectomy,[24] trabeculectomy or augmented with use of antifibrotic agents like mitomycin-C (MMC)[25] or 5-fluorouracil (5FU), Tube drainage surgery [26,27] and cyclodestruction with trans-scleral semiconductor diode laser,[28] Nd:YAG laser, endocyclophotocoagulation[29] and cyclocryotherapy[30] . Prognosis regarding visual outcome is not favorable in PCG[33].

MATERIALS & METHODS

This prospective, non-comparative, interventional study was carried out in the department of Pediatric Ophthalmology at (COAVS), KEMU, Mayo Hospital, Lahore, Pakistan. After permission from institutional ethical committee, the patients were admitted from Pediatric Eye OPD of Mayo Hospital Lahore. The duration of the study was for one year from July, 2011 to June, 2012.

The study was conducted in an attempt to assess the success of trabeculotomy procedure for controlling primary pediatric glaucoma by Axial Length measurements before and after the procedure. 30 eyes were included in this study. Patients with Primary pediatric glaucoma (PPG) under the age of 8 years were included in study. Patients with secondary glaucoma were excluded from study. The diagnosis of primary pediatric glaucoma was based on history and clinical examination initially in clinic, with or without sedation. In case of suspected glaucoma the patient was admitted to the ward for examination under general anesthesia (EUA) and to proceed for trabeculotomy after confirmation of diagnosis. In the ward the detailed preoperative assessment was carried out and recorded by a senior pediatric ophthalmic surgeon including the detailed ocular and systemic history of the patients and parents. The detailed systemic examination of all the patients was performed and all relevant investigations for general anesthesia were performed. A formal informed consent was duly signed by parents.

The detailed ocular examination in operating room under general anesthesia included Slit lamp examination of anterior segment, fundus examination for vitreo-Retinal lesions and Cup/Disc Ratio, retinoscopy, intraocular pressure (IOP) with Perkin's applanation tonometer, Corneal diameter vertical and horizontal with Vernier caliper, Axial Length (AL) with Quantel medical AXIS-II biometer, B-Scan if corneal opacification precludes fundus examination. After the diagnosis of primary pediatric glaucoma was established, the patients with moderate to severely high IOP were advised on anti-glaucoma medical therapy for a few days before surgery. The trabeculotomy was performed by senior pediatric ophthalmologists by standard procedure. After all the aseptic measures the eye speculum was placed to open the lids. Bridal suture was passed to hold the superior rectus muscle. The operation was performed under the microscope. The eye was irrigated with Ringer's solution. The trabeculotomy was performed in superotemporal quadrant. Fornix based conjunctival flap was raised, a partial thickness scleral flap was fashioned as in trabeculectomy, a radial incision was made near the temporal incision of scleral flap. The incision was gradually deepened until the outer wall of Schlemm's canal was opened. The seepage of aqueous was used to identify the Schlemm's canal. The right sided Harm's trabeculotome was threaded into the Schlemm's canal and was swept into the anterior chamber and same was repeated on the other side. This ruptured the medial wall of the Schlemm's canal and trabecular meshwork to establish direct communication between the anterior chamber and Schlemm's canal for internal drainage of aqueous humor. The deep scleral incision was closed with 10/0 nylon to make it water tight. The scleral flap was closed again with 10/0 nylon sutures. The conjunctival flap was sutured with 10/0 nylon in the purse string manner. Subconjunctival injection of 5-10mg of gentamycin and 1-2mg of dexamethasone was given. A sterile pad was applied with sticking plaster. The detailed

operation notes were recorded containing name of the surgeon, type of Anesthesia, date of operation, name of anesthetist, per-operative complication if any and postoperative drugs were prescribe including syrup Ibuprofen 3 times a day for 3 days and then as required. Syrup Cephalex 3 times a day for 5 days. A combination of Tobramycin and Dexamethasone eye drops 2 hourly and Moxifloxacin 0.5% eye drops 2 hourly were given after removal of dressing on first postoperative day. The patient was examined on the 1st post-operative day for any complication and discharged from ward on 2nd post-operative day.

All data including preoperative, operative and post-operative recordings was collected in the proforma designed. Follow up period was extended to six months with visits within 1st month, 3rd month and at 6th month. On every visit, a detailed ocular examination was conducted as preoperatively. When second eye affected, the patient was advised on antiglaucoma drugs and surgery was planned after 2 weeks when EUA of both eyes was again performed. Also the amblyopia therapy was initiated.

RESULTS

In this study the success of trabeculotomy in primary pediatric glaucoma (PPG) was assessed by the change in axial length after the procedure. Total 30 eyes of 16 patients were selected for the study, 14 patients 28 eyes (87.5%) had bilateral disease and 2 (12.5%) patients had unilateral disease.

Out of 16 patients, 9 (56%) were males (8 bilateral, 1 unilateral) and 7 (44%) females (6 bilateral, 1 unilateral) with male to female ratio of 1.3:1, as shown in graph 1.

Three patients with bilateral disease (20%) gave a family history of glaucoma. In 24 eyes (80%) there was no family history. As shown in graph 2.

The age of children ranged between 2 months to 96 months mean = 49 months. As the number of eyes was small, these were divided into 9 groups for convenience and data processing. The age was recorded in months. The number of eyes in each group was also recorded. Each of the first four groups had a range of 3 months because of maximum number of eyes in these groups and each of the remaining 5 groups had a range of 12 months. 16 eyes (53%) presented in first year of life, 5 eyes (17%) in 2nd and 3rd year making a total of 21 eyes (70%) presented in first 3 years of age and remaining 9 eyes (30%) in other 5 years. This is shown in table 1. The age distribution has been shown in graph 3.

The comparison of axial length measurements of normal eyes with those having PPG before and within 1 month, 3rd month and 6th month after trabeculotomy in each age group has been shown in table 1 and graph 4. This shows much higher measurements in eyes with PPG than that of normal eyes. Table also explains that there is an increase in axial length after surgery but the change has been slower and has been normalized in 6 months.

Table 1: The comparison of axial length measurements of normal eyes with those having PPG before and within 1 month, 3rd month and 6th month after trabeculotomy.

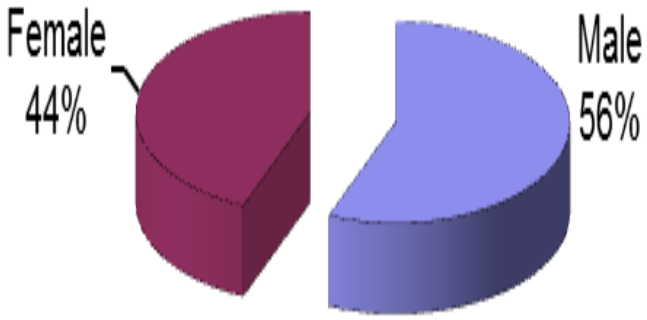
Age range(months)	Age(months)	Normal axial length (mm)	Pre-op axial length (mm)	Post-operative axial length (mm)		
				1M	3M	6M
1-3	3	17.50	20.79	21.12	21.83	22.42
4-6	6	18.21	22.28	22.53	23.38	23.97
5-9	9	19.05	24.54	24.81	25.18	25.38
10-12	12	19.42	23.29	23.31	23.62	24.25
13-24	24	20.61	21.44	21.48	21.62	21.89
25-36	36	20.79	22.56	22.60	22.70	22.90
37-48	48	21.27	24.27	24.30	24.37	24.46
49-60	60	21.68	25.33	25.37	25.49	25.69
61-96	96	22.09	23.82	23.84	23.87	23.93

Comparison of change in axial length / growth rate (mm/month) of normal eyes with those having PPG before and after trabeculotomy within 1 month, 3rd month and 6th month in age matched children has been presented in table 2. It has been much higher in the eyes with PPG than that of normal eyes. It has been found that the post-operative growth rate / change in axial length has decreased remarkably and has followed the pattern of normal growth rate. It has been shown in graph 5, 6, 7.

Table 2: Comparison of change in axial length / growth rate (mm/month) of normal eyes with those having PPG before and after trabeculotomy within 1 month, 3rd month and 6th month.

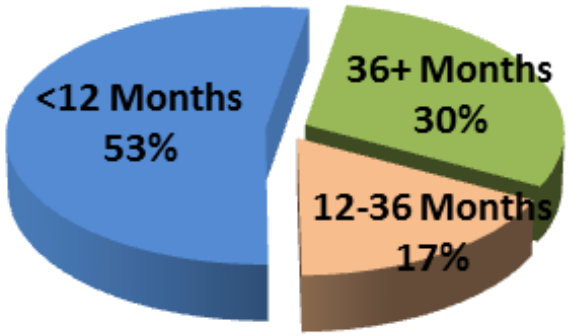
Age range (months)	Age (months)	No. of eyes	Pre-op Growth rate (change in axial length) (mm/month)	Post-op Growth rate (change in axial length) (mm/month)			Normal growth rate (mm/month)
				1M	3M	6M	
1 - 3	3	6	1.340	0.330	0.346	0.271	0.240
4 - 6	6	6	1.590	0.252	0.366	0.282	0.237
7 - 9	9	2	2.110	0.275	0.213	0.141	0.280
10 - 12	12	2	1.420	0.020	0.108	0.159	0.123
13 - 24	24	3	0.168	0.043	0.062	0.076	0.104
25 - 36	36	2	0.162	0.045	0.047	0.057	0.015
37 - 48	48	1	0.290	0.030	0.033	0.032	0.040
49 - 60	60	6	0.340	0.045	0.053	0.061	0.034
85 - 96	96	2	0.180	0.020	0.018	0.019	0.010

Graph 1: Gender distribution



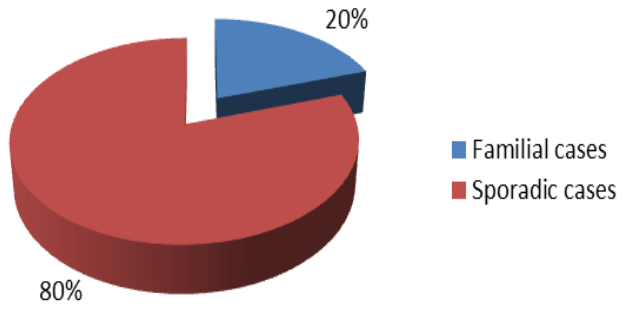
This graph shows the gender distribution with male 56% & female 44% with a ratio of 1.3:1

Graph 2: Age distribution

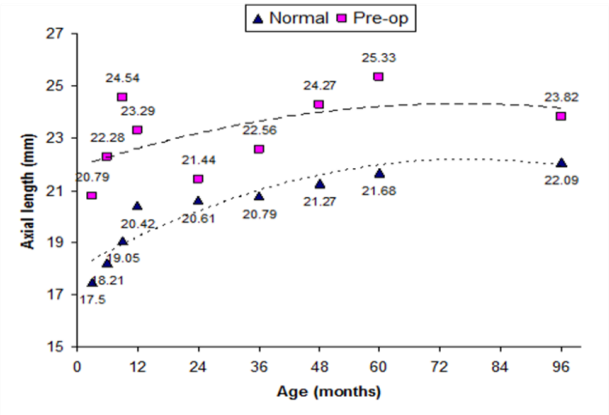


This graph shows the age distribution with 53 percent under 12 months, 17 percent between 12 to 36 months and 30 percent above 36 months of age.

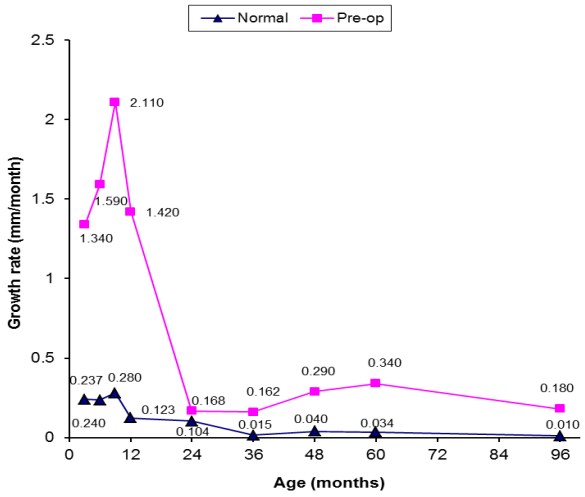
Graph 3



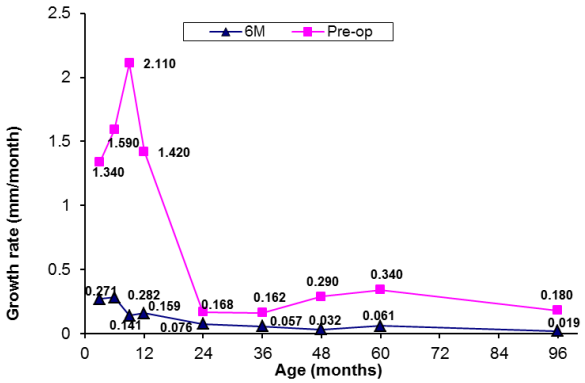
Graph 4: The comparison of preoperative axial length in eyes with PPG showing higher measurements to that in normal eyes of age matched children.



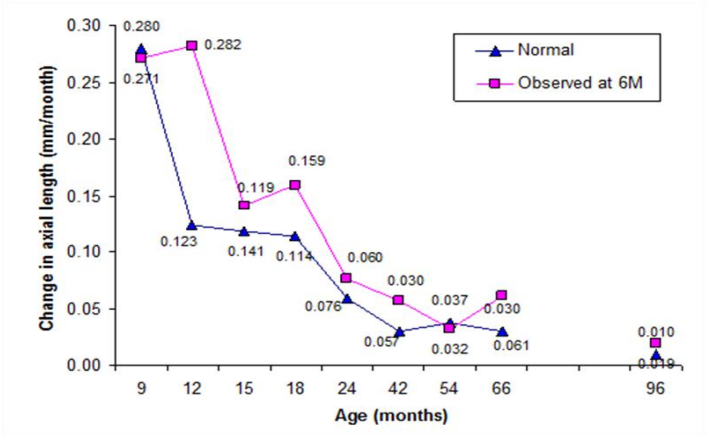
Graph 5: The comparison of pre-operative change in axial length / axial growth rate (mm/month) in eyes with PPG showing much higher values than that of the normal eyes



Graph 6: The comparison showing the pre-operative change in axial length / axial growth rate (mm/month) in eyes with PPG is higher to that of six months after trabeculotomy.



Graph 7: The comparison of six months post-operative change in axial length / axial growth rate (mm/month) in eyes with PPG showing the same pattern as of normal eyes in the same age group. This shows that the change in the axial length after control of glaucoma has been normalized to that of normal eyes in age matched children.



There was no significant complication during surgical procedure except mild hyphaema in 20(66.66%) eyes that resolved later. One eye (3.33%) had hypotony without associated complications and recovered later. Two eyes (6.66%) who had failed trabeculotomy, responded well to Trabeculectomy with MMC. These eyes were excluded from our study because of urgency of second surgery. In our study the success rate of trabeculotomy, assessed by change in axial length after 6 months of surgery, was 93.4%.

DISCUSSION

The primary pediatric glaucoma is a rare heterogenous group of potentially blinding ocular diseases with raised intraocular pressure in common.[1]It was recognized since long in the history with the names of hydrophthalmia, and buphthalmos[8]. The findings in my study are comparable with the different studies with the references quoted.

PPG presents since birth to 35 years of age but mostly before 7-8 years of age. It is bilateral in (70 to 80%). Up to 80% diagnosed in the 1st year of life[4]. These findings agree with that of my study.

Our finding of family history of 6 (20%) eyes (graph 3) agrees with that published in the literature of between 10% and 40%[4]. Most of the cases (80%) were sporadic without a family history which also is comparable with the other studies ranging from 40% to 100%. This high incidence may be due to parental consanguinity [5,6].

The axial length (AXL) is measured by an A-scan mode of the ophthalmic ultrasound system. A-scan has a transducer frequency of 10-12MHz. A single ultrasound wave used to measure axial length, corneal thickness, anterior chamber depth (ACD), and lens thickness. It produces one-dimensional time-amplitude evaluation in the form of vertical spikes along a baseline. The height of spike is proportional to strength of echo and the distance to right shows the distance from transducer to the reflecting surface. This distance can be precisely measured in fractions of millimeters.

The main use of A-scan is for measurement of axial length in biometry to calculate the power of IOL but here we are using axial length for assessment of control and progression of glaucoma. The axial length has the advantages over the other parameters used to assess the control and progression of glaucoma such as IOP, retinoscopy for myopia, ophthalmoscopy for assessment of C/D ratio, measurement of corneal diameter. The AXL measurement has the advantage that it is not biased by the examiner and the ultrasound system has been devised and programmed to minimize the error in measurements. The series of measurements are recorded and a mean and average of readings is displayed. It is further processed and a standard deviation (SD) of all recordings is displayed. SD of >0.10mm is taken as defective and the measurements are reassessed. This process makes these measurements more reliable and accurate than other parameters. Furthermore AXL is unaffected by corneal thickness, corneal scarring, media opacities, small palpebral fissure, small corneal diameter, the type of anaesthesia and anaesthetic drugs. The disadvantages of AXL measurement are that in the hands of an ophthalmologist with limited experience, the risk of false high or low readings may be possible. In my study reliable equipment was used by an experienced ophthalmologist to make the AXL measurements more accurate.

Before starting the discussion of results of change in axial length in our study, it is important to discuss the change in axial length/axial growth rate (mm per month) in normal age matched children.

The axial length changes with age, from birth to 13 years, after which it is minimal. At birth it ranges from 15.3 to 17.6 mm with an average of 16.6 mm. At the age of 1 year average axial length recorded was 20.19mm, 2-3 years 21.31mm, 4-5 year 21.68, 6-7 years 21.97, 8-9 years 22.33, 10-11 years 22.50, 12-13 years 22.97, 13-14 years 23.15[31,32]. As the age was limited to 96 months and more No. of cases of PPG were falling in the first year of age, so this was divided into four groups, each comprising of 3 months of age and remaining cases were classified into 5 groups, each comprising of 12 months. The maximum number of cases of primary pediatric glaucoma (53%) was diagnosed in first year of life with an incidence of 16 per year. This represents the primary congenital/infantile glaucoma group (PCG). 13% (5) cases of PPG were diagnosed between 2nd and 3rd year of age with an incidence of 2.5 per year. This may represent delayed onset or delayed diagnosed cases of PCG. Both of these groups comprise of 70% of cases of PPG. 9 cases (30%) were diagnosed between 4-8 years of age with an incidence of 1.8 per year. This is shown in graph 2. This may represent the Juvenile open angle glaucoma (JOAG) or delayed onset group of PPG. In other studies the incidence was higher in the 1st year up to 80% [4,8]. This difference of

incidence may be because of delay in bringing the child to our center and so delay in the diagnosis and treatment.

Serial axial length measurements can be useful in infants when the distensible eye is still vulnerable to the effect of glaucoma[11]. There may be a slight decrease in axial length following successful control of glaucoma. Although there is an increase in AXL in normal children up to the age of approximately13 years but an abnormal reading according to age on initial assessment and a disproportionate and progressive increase is suggestive of glaucoma in the presence of other findings[12]. It can also be used to assess the progression or control of glaucoma after surgical treatment.

The preoperative mean axial length was measured and recorded in all 30 eyes of PPG and mean of each of 9 groups was recorded in the data. It was compared with the mean axial length of age matched normal eyes[31,32]. It was found that measurement of axial length of all (100%) eyes with PPG was much higher than that of normal age matched children. This proves the importance of measurement of axial length as a diagnostic tool for PPG.

The preoperative mean change in axial length/ axial growth rate (mm per month) in the eyes with PPG calculated and compared with that of normal eyes of age matched children[31,32] and this was found to be much higher than normal in all eyes (100%)(table 2, graph 5). This proves that uncontrolled glaucoma results into faster axial growth of eyes and strengthens our previous statement.

Trabeculotomy ab externo has been a popular surgical technique in primary congenital glaucoma especially when cornea is hazy and precludes visualization of angle. It has been safe in the hands of a pediatric ophthalmic surgeon who is aware of the limbal anatomy and can recognize the Schlemm's canal with the advent of microscope and a special probe called Harm's trabeculotome. It has given promising results in different studies.

After trabeculotomy the serial axial length measurements of all eyes with PPG were recorded within 1 month, 3 months and 6 months as shown in table 1. It was found that the mean change in axial length or axial growth rate (mm per month) has been decreased when compared with the preoperative axial growth rate in the same age group (table 2, graph 6-7). This indicates that serial axial length measurement can be used postoperatively during follow up period to assess the effectiveness of treatment and control or progression of glaucoma.

The postoperative change in axial length/ axial growth rate of eyes with PPG was also compared with that of normal eyes of age matched children and it was found that mean axial growth rate/ change in axial length of eyes with PPG became closer to that of normal eyes and followed the same pattern in 6 months after surgery graph 7.

Serial axial length measurements have shown that these were initially higher than the normal age matched children but later after trabeculotomy these were stabilized and did not show any trend of increase in the children with controlled glaucoma. The axial length growth pattern paralleled with normal growth curve. This is quite in comparison with the study by Simon K Law, David Bui, Joseph Caprioli who assessed the utility of IOP and axial length measurements for good control of congenital glaucoma[15, 16].

The shortcomings of the study are smaller sample size and the shorter follow up period. The larger sample size and the longer follow up period are recommended to assess the role of axial length measurement in control and progression of primary congenital glaucoma.

CONCLUSION

The success of trabeculotomy in treatment of primary pediatric glaucoma can be assessed by using the axial length as a tool, in conjunction with other parameters like intraocular pressure, optic disc evaluation and corneal diameter.

REFERENCES

1. Papadopoulos M, Khaw PT. Chilhood Glaucoma. In: Taylor D, Hoyt CS (eds) Pediatcric Ophthalmology and Strabismus. Elsevier Saunders: Philedelphia, 2005: pp 458-457.
2. Beck A, ChangTCP, Freedman S. Definition, classification, differential diagnosis. In: Weinreb RN, Grajewski AL, Papadopoulos M,

Grigg J, Freedman S, eds. Childhood Glaucoma. Amsterdam: Kugler Publications; 2013:3-15.
3. Yanovitch TL, Freedman SF. Pediatric glaucoma. Focal Points: Clinical Modules for Ophthalmologists. San Francisco: American Academy of Ophthalmology; 2012, module 3.
4. Aponte EP, Diehl N, Mohney BG. Incidence and clinical characteristics of childhood glaucoma: a population-based study. Arch Ophthalmol. 2010 Apr; 128(4): 478-82.
5. Azmanov DN, Dimitrova S, Florez L, Cherninkova S, Draganov D, Morar B, et al. LTBP2 and CYP1B1 mutations and associated ocular phenotypes in the Roma/Gypsy founder population. Eur J Hum Genet. 2011;19:326–33.
6. Abu-Amero KK, Morales J, Aljasim LA, Edward DP. CYP1B1 mutations are a major contributor to juvenile-onset open angle glaucoma in Saudi Arabia. Ophthalmic Genet. 2013
7. Chen X, Chen Y, Wang L, Jiang D, Wang W, Xia M, Yu L, Sun X. CYP1B1 genotype influences the phenotype in primary congenital glaucoma and surgical treatment. Br J Ophthalmol. 2014;98:246–51. [PubMed]
8. Mandal A, Chakrabarti D. Update on congenital glaucoma. Indian Journal of Ophthalmology. 2011;59 (1,supplement): S148–S157.
9. Lambert SR, Melia M, Buffenn AN, Chiang MF, et al. Rebound tonometry in children: A report by the American Academy of Ophthalmology. Ophthalmology 2013 Apr;120(4):e21-7. doi: 10.1016/j.ophtha.2012.09.058. Epub 2013 Feb 8.
10. Guedes V, Schuman JS, Hertzmark E, et al. Optical coherence tomography measurement of macular and nerve fiber layer thickness in normal and glaucomatous human eyes. Ophthalmology 2003;110:177-189.
11. Simon K Law, David Bui, Joseph Caprioli. Serial axial length measurements in congenital glaucoma. American Journal of Ophthalmology. 2001 Dec;132(6): 926-928.
12. Kiefer G, Schwenn O, Grehn F. Correlation of postoperative axial length growth and intraocular pressure in congenital glaucoma - a retrospective study in trabeculotomy and goniotomy. Graefes Arch Clin Exp Ophthalmol. 2001 Dec;239(12):893-9.
13. Muir KW, Jin J, Freedman SF. Central corneal thickness and its relationship to intraocular pressure in children. Ophthalmology. 2004 Dec;111(12):2220-3.
14. Ahmed D. Updates in pediatric ophthalmic anesthesia. Anaesth Pain & Intensive Care 2014;18(1):72-79
15. Coppens G, Stalmans I, Zeyen T, Casteels I. The safety and efficacy of glaucoma medication in the pediatric population.1 Pediatr Ophthalmol Strabismus. 2009;46(1):12-18.
16. Maeda-Chubachi T, Chi-Burris K, Simons BD, Freedman SF, KhawPT, Wirostko B, Yan E. Comparison of Latanoprost and Timolol in Pediatric Glaucoma: A Phase 3,12-Week, Randomized, Double Masked Multicenter Study. Ophthalmology. 2011 Jun 14.
17. Kourosh Sabri, Alex V Levin. The Additive Effect of Topical Dorzolamide and Systemic Acetazolamide in Pediatric Glaucoma. Journal of AAPOS.2006 Oct;10 (5):464-68.
18. Orzalesi N, Rossetti L, Bottoli A, Fogagnolo P. Comparison of the effects of latanoprost, travoprost, and bimatoprost on circadian intraocular pressure in patients with glaucoma or ocular hypertension. Ophthalmology. 2006 Feb;113(2):239-46.
19. Bowman RJ, Cope J, Nischal KK. Ocular and systemic side effects of Brimonidine 0.2% eye drops (Alphagan) in children. Eye.2004;18:24-26.
20. Papadopoulos M, Cable N, Rahi J, Khaw PT, The BIG Eye Study Investigators. The British Infantile/Childhood Glaucoma(BIG) Eye Study. Invest Ophthalmol Vis Sci. 2007 Sep;48(9): 4100-6.
21. Kulkarni, Sedhana V. Damji, Karim F. Fournier, Annick V. Pan, Irene. et al. Endoscopic Goniotomy: Early Clinical Experience in Congenital Glaucoma. Journal of Glaucoma: 2010 April / May; 19 (4): 264-69.
22. Sarkisian SR Jr. An illuminated microcatheter for 360-degree trabeculotomy in congenital

glaucoma: a retrospective case series. f AAPOS. 2010;14(5):412-416.
23. Girkin CA, Rhodes L, McGwin G, Marchase N, Cogen MS. Goniotomy versus circumferential trabeculotomy with an illuminated microcatheter in congenital glaucoma. J AAPOS 2012;16(5):424-7.
24. Laudo Silva Costa, Roberta Martins Da Silva Costa. Combined Trabeculotomy – Trabeculectomy as a First Surgical Procedure for Primary Congenital Glaucoma. Annals of Ophthalmology 2006;38(1):25-27.
25. Sidoti PA, Belmonte SJ, Liebmann JM, et al. Trabeculectomy with mitomycin C in the treatment of pediatric glaucomas. Ophthalmology 2000;107:422-429.
26. Amir Pirouzian. Joseph L Demer. Clinical findings following Ahmad Glaucoma ValveTM implantation in Pediatric glaucoma. Clin Ophthalmol. 2008 March; 2 (1): 123-27.
27. K A van Overdam, J T H N de Faber, H G Lemij. et al. Baerveldt glaucoma implant in paediatric patients. Br J of Ophthalmol 2006; 90:326-332.
28. Autrata R, Rehurek J. Long-term Result of transscleral cyclophotocoagulation in refractory pediatric glaucoma patients. Ophthalmologica 2003;217:393-400.
29. Neely DE, Plager DA. Endocyclophotocoagulation for management of difficult pediatric glaucomas. f AAPOS. 2001;5(4):221-229.
30. Wagle NS, Freedman SF, Buckley EG, Davis JS, Biglan AW. Long-term outcome of cyclocryotherapy for refractory pediatric glaucoma. Ophthalmology 1998;105:1921-6; discussion 1926-7.
31. Fledelius HC, Christensen AC. Reappraisal of the humen ocular growth curve in fetal life, infancy and early childhood. Br J Ophthalmol 1996;80:918-21.
32. Blomdahl S. Ultrasonic measurements of the eye in the Neuborn infant. Acta Ophthalmol (Copenhagen) 1979;57:1048-56.
33. Khitri M, Mills M, Ying G, Davidson S, et al Visual acuity outcomes in pediatric glaucomas. J AAPOS 2012 Aug;16(4):376-81.

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