Original Article

Iris and knot configuration after Single Pass Four Throw (SFT) pupilloplasty as imaged by the spectral-domain optical coherence tomography

Dhivya Ashok Kumar, Amar Agarwal, Radhika Chandrasekar, Nagaraj Jaganathasamy

Purpose: To analyze the morphological changes in the iris-knot complex configuration using spectral-domain optical coherence tomography (SD-OCT) following the single pass four throw (SFT) pupilloplasty. **Methods:** In this retrospective case series, eyes with SFT pupilloplasty were examined by SD-OCT (Optovue). Iris morphology compared to the normal iris, presence of specific patterns (single hump, double humps, peaks and valleys, tethering), prolene suture, knot complex (length and orientation), and intraocular lens (IOL) vault were evaluated. **Results:** Overall, 41 knots of 26 patients with a mean time duration of 3.1 ± 2 months from surgery were analyzed. Iris configurations seen were single hump (n = 28, 63.8%), double humps (n = 7, 17%), loop (n = 2, 4.8%), flat (n = 3, 7.3%), and mulberry (n = 1, 2.4%). The mean length and the height of the knot complex was 784.1 ± 433.7 µm and 317.7 ± 110.4 µm, respectively. Knot positions were at 3 clock hours in 9 eyes (21.9%), 9 in 8 eyes (19.5%), and others in 24 eyes (58.5%). Cut end of the prolene suture was detectable in 26 eyes (63.4%) as hyper-reflective line, and the mean cut length was 465.8 ± 321.1 µm. The suture was predominantly vertically oriented (80.6%) to the iris with a mean distance of 3.6 ± 0.3 mm (2.6–4 mm) away from corneal endothelium. The mean distance from the knot complex and the IOL was 289.2 ± 146 µm and the mean anterior chamber depth was 4.1 ± 0.1 mm. **Conclusion:** A significant change in iris configuration was noted after SFT pupilloplasty, and vertically oriented retained prolene suture was predominant with good endothelial vault.

Access this article online

Website: www.ijo.in

DOI: 10.4103/ijo.IJO_885_18

Quick Response Code:

Key words: Optical coherence tomography, pupilloplasty, single pass four throw pupilloplasty

Iris is a part of the uveal tissue that is responsible for the control of pupil size and is also responsible for the distinctive color of eyes. It occasionally undergoes surgical interventions such as iridoplasty or iris structural repair after a trauma or surgery. The normal ultrastructure of iris is altered after surgical procedures and intervening sutures. There are several iris repair techniques reported in the literature which are performed for iris coloboma, iris trauma, iridodialysis, and iatrogenic iris tear.[1-11] However, there are no reports concerning the assessment of post surgical configuration changes in such eyes. Moreover, the intraocular polypropylene or prolene suture, which is commonly used in iris repair, has also not been widely studied after pupilloplasty. This has paved the way for the current study in which we have utilized the high-resolution, spectral-domain optical coherence tomography (SD-OCT) for the evaluation of iris and prolene knot configuration after single pass four throw (SFT) pupilloplasty.[12]

Methods

In this retrospective observational case series, the patients who have undergone single pass throw pupilloplasty for pupil configuration were included. After obtaining approval from the Institutional Review Board (IRB) (ECR/921/Inst/TN/2017) and informed consent from the patients, cases were included and the tenets of Declaration of Helsinki were followed. The SD-OCT (IVuecam, SIN81331, Optovue Incorporated, Fremont, CA, USA) was performed in all eyes that have minimum 1 month postoperative period following SFT pupilloplasty from September 2017 to March 2018. Patients not willing for OCT and those with comorbidities, such as uveitis, were excluded from the study as the pre-existing iris deformities could affect analysis. Out of 30 patients who underwent pupilloplasty during the study period, 4 patients were excluded for comorbid illnesses affecting the iris.

In the SFT procedure, two stab incisions were made on either side of the limbal area along the defect of the iris.[12] A 10-0 polypropylene single arm suture was passed from the proximal iris defect after grasping the iris leaflet with an end opening forceps. A 26-G needle was then passed through the opposite stab incision and the distal end of the iris defect was grasped with end opening forceps and the 26-G needle was passed through it. The suture end was anchored on to the barrel of the needle and was withdrawn along with the suture needle end. A Sinskey hook was then introduced inside the anterior chamber and a suture loop was formed in the anterior chamber by hooking the Sinskey hook along the suture, and the hook was pulled through the opposite paracentesis. The

Dr Agarwal's Eye Hospital and Eye Research Centre, Chennai, Tamil Nadu, India

Correspondence to: Dr. Amar Agarwal, Dr. Agarwal's Eye Hospital and Eye Research Centre, 19, Cathedral Road, Chennai - 600 086, Tamil Nadu, India. E-mail: dragarwal@vsnl.com

Manuscript received: 28.05.18; Revision accepted: 17.10.18

Cite this article as: Kumar DA, Agarwal A, Chandrasekar R, Jaganathasamy N. Iris and knot configuration after Single Pass Four Throw (SFT) pupilloplasty as imaged by the spectral-domain optical coherence tomography. Indian J Ophthalmol 2019;67:209-12.

loops were subsequently pulled onto the conjunctiva. The suture end was then passed four times into the loop and the two ends were pulled to approximate the knot, which slide on the iris in the anterior chamber. The suture ends were cut within the anterior chamber by microscissors approximately 1 mm from the knot.

The SD-OCT used in the analysis acquired 26,000 A-scans per second with a frame rate of 256 to 1024 frames per second. The depth resolution in tissue was 5 μ and transverse resolution was 15 μ. It utilized 840 nm wavelength with a pupil exposure power of 750 μW. In the OCT image in anterior segment module, the corneal angle mode, line scan was used in both longitudinal (on the knot along the iris defect) and cross-sectional (vertical line scan across the knot) axes. The elevation of the knot complex (knot with embedded iris) in the iris was measured in micrometers (μm). In the Ivuecam monitor, using the caliper, line tool was used to measure by a single examiner (D.A.K) for all OCT images in gray scale format. Line (I) was drawn along the iris plane, and the elevation (E) was measured as the highest point of elevation of the knot complex perpendicular to the line I [Fig. 1]. Height of elevation was indirectly taken as the height of the knot complex, and the length of the knot complex was measured as the entire length of the elevation of the iris from the surrounding normal iris [Fig. 2]. Specific configurations such as single hump (one elevation of knot complex), double humps (two elevations separated by small flattening iris in between), tethering (thinned and stretched iris), and Mulberry (irregular corrugated surface) were examined and documented. The iris–intraocular lens (IOL) vault near the pupillary margin of the knot complex was also measured in μm. The central anterior chamber depth (ACD) was documented in millimeters (mm) from the OCT. The incised prolene suture end was detected as a hyper-reflective line arising from the knot complex region and the length was measured in μm. It was documented as either vertically oriented (when the suture end was noted to be straight into the anterior chamber perpendicular to the iris surface) or flat (when the end was staying partly or wholly on the iris surface). Loosening of the knot was defined as nonapposed iris ends on OCT with bridging suture. Any peripheral iris holes in the knot region of the iris and synechiae formation were also noted on the OCT across the iris–knot complex axes. As one expects change in the pupil shape following pupilloplasty, the pupil shape was classified as round, pear, or saucer depending upon the shape according to slit lamp examination. Distance between the cut end of the suture and the peripheral corneal endothelium was also measured in mm in the OCT in eyes with visible suture ends in the anterior chamber.

Statistical analysis

Data were entered in a Microsoft Excel Sheet (Microsoft Corp, Redmond, Washington, US) and analyzed using SPSS version 16.1 (SPSS Inc., Chicago, Illinois, USA). Continuous variables were expressed as means (±standard deviations), and categorical variables were expressed as individual counts. After testing for normality distribution of data, the statistical tests were allotted. Nonparametric tests were used for intergroup comparison. Pearson's correlation test was used for calculating correlation coefficient. Differences were considered statistically significant when the *P* value was less than 0.05.

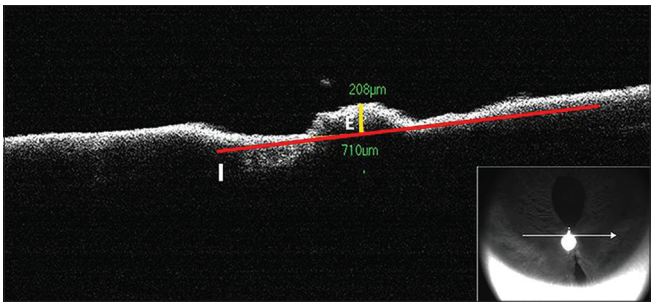

Figure 1: Spectral domain optical coherence tomography analysis of iris and knot complex in cross section. I: Line along the iris plane. E: Highest Elevation of the iris- knot complex perpendicular to iris plane

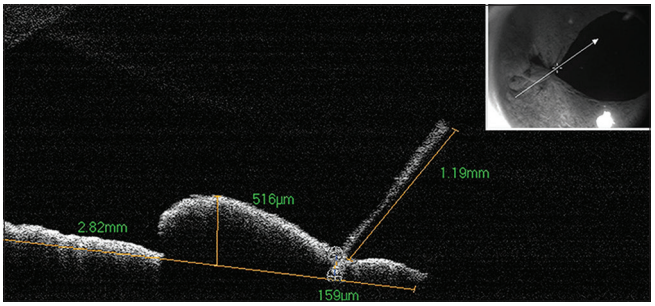

Figure 2: Spectral domain optical coherence image showing the measurement of the iris-knot complex including the knot, the cut end of suture and the iris elevation

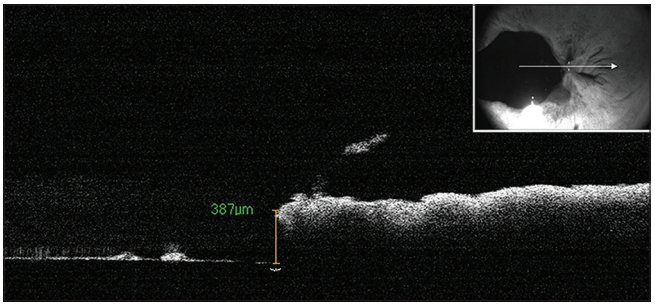

Figure 3: Spectral domain optical coherence image showing the measurement of the iris-knot complex and intraocular lens vault near the pupillary plane

Results

Overall, 41 knots in 26 patients were analyzed by SD-OCT. The mean age was 54.1 ± 16 years (24–78 years) [Table 1]. The mean duration from the date of surgery to the evaluation was 3.1 ± 2 months (1–8 months). Out of 26 patients, the indications for pupilloplasty were congenital pupillary defect (n = 4), posttraumatic pupil abnormality (n = 5), postoperative irregular or updrawn pupil (n = 15), and primary angle closure with failed peripheral iridotomy (n = 2). Posterior chamber IOL was noted in all the eyes. Pear (n = 10, 24.4%), round (n = 11, 26.8%), and saucer (n = 20, 48.7%) shaped pupil were the three pupil configurations observed. Out of 41 eyes, 5 (12.2%) had eccentric pupil after SFT.

Iris configuration

Prominent elevation as iris hump was seen in a majority of cases (n = 28, 63.8%). Other specific configurations noted were

Table 1: OCT characteristics of the knot complex

Variable (*N*=41)	Mean	± SD	Minimum	Maximum
Knot complex Length (μm)	784.1	433.7	177	2420
Knot complex Height (μm)	317.8	110.4	162	633
IOL- knot complex Vault (μm)	289.2	146	72	672
ACD (mm)	4.1	0.12	3.8	4.3

IOL: Intra ocular lens, ACD: Anterior chamber depth, μm: micrometers, mm: millimeters

double bumps (*n* = 7, 17%), loops (*n* = 2, 4.8%), flat (*n* = 3, 7.3%), and mulberry (*n* = 1, 2.4%). Iris tissue gap was noted in 3 eyes (7.3%) and tethering of iris was seen in 8 eyes (19.5%). Peripheral anterior synechiae was seen in 2 eyes (4.8%). Tethering of iris was noted with corresponding thinning of iris. The anterior border layer and stroma was tethered and torn, whereas the posterior pigment epithelium was retained in 8 eyes (19.5%). Iris holes were seen in 2 eyes (4.8%) and ectropion uvea in 1 eye (2.4%).

Knot configuration

The knot was seen as entangled mesh of prolene in the iris surface. The mean length and the height of the knot was 784.1 ± 433.7 μm and 317.7 ± 110.4 μm, respectively. Knot was positioned at 3 clock hours in 9 eyes (21.9%) and at 9 clock hours in 8 eyes (19.5%). Knots in other clock hours positions were 12 clock hours (*n* = 6, 14.6%), 6 clock hours (*n* = 5, 12.2%), 11 clock hours (*n* = 4, 9.7%), 2 clock hours (*n* = 3, 7.3%), 10 clock hours (4.8%), 8 clock hours (*n* = 2, 4.8%), 2 clock hours (*n* = 3, 2.4%), and 5 clock hours (*n* = 1, 2.4%), respectively. There was no significant difference in the length and height of knot with respect to the duration of months either less than or more than 3 months. There was no correlation of the knot length ($r = -0.18$, $P = 0.260$) and height ($r = -0.17$, $P = 0.285$) with the total duration from surgery. Similarly, the age of the patient was not correlated to the knot length ($r = -0.92$, $P = 0.569$) or height ($r = 0.08$, $P = 0.606$).

Prolene suture

Prolene suture was detectable in 26 eyes (63.4%) as hyper-reflective line in the anterior chamber [Fig. 2]. The end on view of the suture was seen as a hyper-reflective dot in the anterior chamber. A single suture end was seen in 22 eyes (84.6%) and both suture ends were seen in 4 eyes (15.3%). The suture ends were noted to have straight (*n* = 21, 80.6%), curved (*n* = 2, 7.7%), flat (*n* = 1, 3.8%), and triangle (*n* = 2, 7.7%) configurations on OCT. The average length of the cut end of the prolene suture protruding in the anterior chamber was 465.8 ± 321.1 μm. The mean vault distance between the prolene suture end and the corneal endothelium was 3.6 ± 0.3 mm (2.6–4 mm). Loosening of knot was seen in 1 (2.4%) eye. The mean specular count in eyes with poor vault (with suture cut length more than 500 μm) was 1309 ± 499 cells/mm^2 and good vault (cut length more than 500 μm) was 990.7 ± 158.7 cells/mm^2. No significant difference ($P = 0.190$) in specular count was noted with relation to the suture cut vault.

IOL and knot complex vault

The mean distance from the knot complex in the pupillary margin and the IOL [Fig. 3] was 289.2 ± 146 μm (72–672 μm) and the mean central anterior chamber depth was 4.1 ± 0.1 mm, as seen by the OCT. There is a significant correlation between the IOL vault and the duration from surgery ($P = 0.013$, $r = -0.39$). However, no correlation was observed between the IOL vault and the age of patient ($r = 0.17$, $P = 0.289$).

Discussion

Iris represents the anterior most part of uveal tissue; the middle vascularized layer of the eye and optically acts as diaphragm. The ultrastructure of iris comprises the anterior border layer, the intervening stroma, and the posterior two-layered pigment epithelium. Numerous iris suturing techniques and pupil reconstruction procedures have been practiced in ophthalmology for more than four decades.[1-11] The indications varied widely including congenital iris deformities, traumatic iris tear or dialysis, and pupil abnormalities due to surgery. Other than regular pupilloplasty procedures, few other indications have been introduced in recent years.[12-14] Synder *et al.* had sutured iris for the management of iris transillumination defects secondary to iris pigment epithelium loss, which included iris oversewing over the defect through partial iris stromal bites with 10-0 polypropylene.[13] Although 10-0 polypropylene has been used in majority of pupilloplasty case, iridodialysis repair has been performed by 8-0 polypropylene as well.[14] Prolene suture has known to have slow degradation and has late luxation in cases with IOL fixation.[15-18] Cameron *et al.* reported fissure formation in prolene material in chronic inflamed eye.[19] However, there are no reports on the analysis of nature of prolene sutures and iris morphology after pupilloplasty by imaging via OCT. This study is one of its kind documenting the configuration of prolene sutures in operated eyes.

The ends of the prolene suture cut in the anterior chamber usually are expected to be above the knot surface and there are no literature reports showing the measurement of the length of cut ends. The knot analysis showed a mean length of the cut end to be 465.8 ± 321.1 μm in our study. The positioning of prolene suture end in the chamber was noted to be vertical in a majority of eyes (80.6%). Such vertical orientation to the iris plane of prolene suture in anterior chamber can hinder graft unrolling during endothelial keratoplasty and may cause mechanical endothelial damage in such procedures. Significant iris defect and pupil deformities has to be ideally corrected before embarking on endothelial keratoplasty procedures.[20] Therefore, positioning prolene in anterior chamber becomes vital in surgical outcome after endothelial keratoplasty. Schoenberg *et al.* showed modified Seipser knot in which a posteriorly directed knot was placed to minimize the threat to the transplanted endothelium.[11] In our series, we noted a mean distance of 3.6 mm from the suture end and corneal endothelium. There was no corneal decompensation noted in any of the operated eyes. Narang *et al.* reported the outcome of SFT procedure along with pre Descemet's endothelial keratoplasty.[3] Though there was no incidence of primary graft failure or graft rejection reported in any of the eyes, long-term outcomes are awaited in such eyes.

There are techniques where the polypropylene sutures lie on the iris surface or intervening the stroma in the anterior chamber.[2,3,11] However, certain techniques place the knot under the scleral flap externally, especially when associated

with coloboma or dialysis.[21] In relevance to the patients, these procedures with internal suture ends may present the late complication of fiber segregation, inflammation, or pigment adhesion in the long term. Apart from causing endothelial rub in eyes with more peripheral located sutures and those with shallow anterior chamber, the suture ends can get loosened in the long term. Loosening of prolene sutures has been reported in trans-scleral IOL fixation and iris suturing.[16-19] Similarly, prolene suture loosening can happen in pupilloplasty due to degradation. In our series, we noted only one eye developing early knot loosening; however, long-term follow-up and serial analysis over a time period is required.

Conclusion

This pilot series demonstrates the morphological changes in the iris and knot orientation in eyes following pupilloplasty, which may be crucial for eyes with shallow anterior chamber, low endothelial cell count, and those which require endothelial keratoplasty in the future.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Siepser SB. The closed chamber slipping suture technique for iris repair. Ann Ophthalmol 1994;26:71-2.
2. Osher RH, Snyder ME, Cionni RJ. Modification of the Siepser slip-knot technique. J Cataract Refract Surg 2005;31:1098-100.
3. Narang P, Agarwal A, Kumar DA. Single-pass 4-throw pupilloplasty for pre-descemet endothelial keratoplasty. Cornea 2017;36:1580-3.
4. Behndig, A. Small incision single-suture-loop pupilloplasty for postoperative atonic pupil. J Cataract Refract Surg 1998;24:1429-31.
5. Zarranz-Ventura J, O'Connell E, Haynes RJ. Bow-string technique for iris pupilloplasty and posterior iris-claw artisan intraocular lens implant in traumatic aphakia with associated iris defects. Retina 2014;34:2306-10
6. Ogawa, G.S.H. The iris cerclage suture for permanent mydriasis: A running suture technique. (erratum 1999; 30:412). Ophthalmic Surg Lasers 1998;29:1001-9
7. Lee EJ, Ahn JY, Wee WR, Lee JH, Kim MK. *In situ* intraocular suture techniques for pupilloplasty and suspension of a subluxated intraocular lens. Ophthalmic Surg Lasers Imaging 2010;41:266-71.
8. Blackmon DM, Lambert SR. Congenital iris coloboma repair using a modified McCannel suture technique. Am J Ophthalmol 2003;135:730-2.
9. Pallin SL. Closed chamber iridoplasty. Ophthalmic Surg 1981;12:213-4.
10. Tsao SW, Holz HA. Iris mattress suture: A technique for sectoral iris defect repair. Br J Ophthalmol 2015;99:305-7.
11. Schoenberg ED, Price FW Jr. Modification of Siepser sliding suture technique for iris repair and endothelial keratoplasty. J Cataract Refract Surg 2014;40:705-8.
12. Narang P, Agarwal A. Single-pass four-throw technique for pupilloplasty. Eur J Ophthalmol 2017;27:506-8.
13. Snyder ME, Perez MA. Iris stromal imbrication oversewing for pigment epithelial defects. Br J Ophthalmol 2015;99:5-6.
14. Dağlioğlu MC, Coşkun M, Ilhan N, Ayintap E, Tuzcu EA, Ilhan O, *et al*. Repair of iridodialysis using 8-0 polypropylene. Semin Ophthalmol 2014;29:159-62.
15. Mowbray SL, Chang S-H, Casella JF. Estimation of the useful lifetime of polypropylene fiber in the anterior chamber. Am Intra-Ocular Implant Soc J 1983;9:143-7.
16. Clayman HM. Intracameral failure of polypropylene. J Cataract Refract Surg 1989;15:598-600.
17. Drews RC. Polypropylene in the human eye. J Am Intraocul Implant Soc 1983;9:137-42.
18. Altman AJ, Gorn RA, Craft J, Albert DM. The breakdown of polypropylene in the human eye: Is it clinically significant? Ann Ophthalmol 1986;18:182-5.
19. Cameron JD, Havener VR, Doughman DJ, Lindstrom RL. Ultrastructural changes of polypropylene loops in a chronically inflamed eye. J Am Intraocul Implant Soc 1985;11:283-6.
20. Yamada N, Hayashi T, Yuda K, Shimizu T, Oyakawa I, Takahashi H, *et al*. Outcomes of descemet membrane endothelial keratoplasty for vitrectomized eyes with sutured posterior chamber intraocular lens. J Ophthalmol 2018;2018. doi: 10.1155/2018/3127126.
21. Bardak Y, Ozerturk Y, Durmus M, Mensiz E, Aytuluner E. Closed chamber iridodialysis repair using a needle with a distal hole. J Cataract Refract Surg 2000;26:173-6.