튜부결찰 방법에 따른 실리콘관 내경의 변화

Changing the Inner Diameter of the Silicone Tube after Undergoing Different Ligation Suture Methods

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Purpose: This study aims to investigate and compare the changes of the inner diameter of the silicone tube of Ahmed valve after various ligation methods using anterior segment spectral-domain optical coherence tomography (AS-OCT).

Methods: In this study we prepared 25 different tubes for the in vitro examination. 5 tubes were allocated for each group. Tubes in group A were not ligated. In group B and group C, tubes were ligated externally with 7-0 Vicryl and 8-0 Vicryl, respectively. In Group D, 7-0 Prolene sutures were inserted inside the tubes as a stent and then the tubes were ligated externally with 7-0 Vicryl. In Group E, 7-0 Prolene sutures were inserted inside the tubes and then the tubes were ligated externally with 8-0 Vicryl. All ligations were made with maximal force as much as possible. For measuring inner diameter of each tube the OCT imaging was performed using Cirrus-OCT software version 4.5.

Results: Mean inner diameter of Ahmed valve was 246.4 μ m without any ligation. Mean inner diameter was 15.0 μ m and 62.0 μ m when ligation was applied with 7-0 Vicryl and 8-0 Vicryl respectively. Mean inner diameters were 147.6 μ m and 163.2 μ m when ligations were conducted by 7-0 Vicryl and 8-0 Vicryl respectively after inserting the 7-0 Prolene suture inside each tube. Inner diameter of silicone tube after the ligation using 8-0 Vicryl was wider than inner diameter after the ligation using 7-0 Vicryl (Mann-Whitney *U* test, $p = 0.008$). But there were no differences of inner diameter for the respect of different external ligation methods when ligation was applied after inserting suture stent inside tube ($p = 0.22$) and after removal of the inner suture ($p = 0.31$).

Conclusions: If a surgeon wants total ligation of silicone tube of Ahmed valve, external ligation with 7-0 Vicryl can be recommended. But, if the surgeon wants partial ligation the material doesn't matter.

Key words: Ahmed valve, ligation, Inner diameter

Introduction

Intraocular pressure (IOP) regulation is the primary target in glaucoma management. Glaucoma drainage devices are

used in refractory glaucoma to control IOP and it can be separated into valved and non-valved aqueous drainage device.¹⁻³ One of common early postoperative complication is post-operative hypotony and it can lead choroidal effusion and suprachoroidal hemorrhage.^{4,5} To reduce early post-operative hypotony non-valved drainage device require ligation around the drainage tube which connected to anterior chamber to the plate located in subconjunctival space. Once fibrous encapsulation around plate has occurred, the ligation suture is no longer needed, and surgical removal of suture, laser suture lysis, or relief releasable suture was performed

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according to surgeon's preferences.⁶⁻⁸

Even though early pressure control is more reliable in valved devices that are designed to control in-flow to avoid early postoperative hypotony, but it still occurs occasionally.^{9,10} The Ahmed Glaucoma implant adapted a valve mechanism which programmed to open when IOP increased over specific IOP level to act as a flow restrictor to decrease postoperative hypotony. But it also showed relatively high rate of early postoperative hypotony, and so some surgeons used total or partial ligation of tube to prevent hypotony.^{11,12} But in real clinical situation we can easily encountered relatively low intraocular pressure after total ligation and relatively high IOP after partial ligation. Therefore, we need to observe how much changes were happened in the diameter

of the actual tube after underwent ligation method.

This study aims to investigate and compare the changes of the inner diameter of the silicone tube of Ahmed valve after various ligation methods using anterior segment spectral-domain optical coherence tomography (AS-OCT).

Materials and Methods

This was *in vivo* examination study and it was conducted at the laboratory of ophthalmology at the Bundang Jesaeng General Hospital. This study was approved by the Bundang Jesaeng General hospital Institutional Review Board as a *in vivo* examination study which does not related to any patients information. Unused stocked Ahmed glaucoma

Figure 1. Schematic diagram of various ligation methods. (A) No ligation on tube. (B) Tubes were ligated externally with 7-0 vicryl. (C) Tubes were ligated externally with 8-0 vicryl. (D) 7-0 prolene suture was inserted inside each tubes and then tubes were ligated externally with 7-0 vicryl. (E) 7-0 prolene suture was inserted inside each tubes and then tubes were ligated externally with 8-0 vicryl.

Figure 2. Photomicrographs (upper image) and cross sectional image captured by HD-OCT (lower image). (A) No ligation on tube. (B) Tubes were ligated externally with 7-0 vicryl. (C) Tubes were ligated externally with 8-0 vicryl. (D) 7-0 prolene suture was inserted inside each tubes and then tubes were ligated externally with 7-0 vicryl. (E) 7-0 prolene suture was inserted inside each tubes and then tubes were ligated externally with 8-0 vicryl.

Figure 3. Photomicrographs (upper image) and cross sectional image captured by HD-OCT (lower image). (A) 7-0 prolene suture was inserted inside each tubes and then tubes were ligated externally with 7-0 vicryl and after then 7-0 prolene suture was removed. (B) 7-0 prolene suture was inserted inside each tubes and then tubes were ligated externally with 8-0 vicryl and after then 7-0 prolene suture was removed.

valves which past the expiration date were provided by manufacturer, and we used silicone tube of these valves for examination.

We prepared 25 different tubes. We divided 25 tubes into 5 groups and 5 tubes were allocated for each group. Tubes in group A were not ligated. In Group B, tubes were ligated externally with 7-0 Vicryl and 8-0 Vicryl was used for ligation in Group C. In Group D, 7-0 Prolene suture was inserted inside each tube and then the tube was ligated externally with 7-0 Vicryl. In Group E, 7-0 Prolene suture was inserted inside each tube and then the tube was ligated externally

with 8-0 Vicryl (Fig. 1, 2). All ligations were conducted using maximal force as much as possible only to the extent each suture material does not break.

For measuring inner diameter of each tube the OCT imaging was performed using Cirrus-OCT software version 4.5. This software allows for the acquisition of a high-definition anterior segment image using the five-line raster scan protocol, which produces five high-resolution (4096 A-scans) horizontal scan lines. Each 1-line raster scan comprises a 3-mm line with an axial resolution of 5 to 6 μm and a transverse resolution of 15 to 20 μm . Due to knot of suture

interfere the initial penetration of light and back-reflecting and backscattering light waves, OCT imaging was repeated after rotating tube until examiner can clearly identify inner diameter of each tubes. As shown in Fig. 4. Vertical and maximal inner diameters of each tube were measured by intrinsic roller function. Every measurement processes for each tubes were repeated three times and average values were used for statistical analysis.

Figure 4. Measured mean values of inner diameter of tubes of Ahmed valve after each ligation methods. (A) No ligation on tube. (B) Tubes were ligated externally with 7-0 vicryl. (C) Tubes were ligated externally with 8-0 vicryl. (D) 7-0 prolene suture was inserted inside each tubes and then tubes were ligated externally with 7-0 vicryl. (D') 7-0 prolene suture was inserted inside each tubes and then tubes were ligated externally with 7-0 vicryl and after then 7-0 prolene suture was removed. (E) 7-0 prolene suture was inserted inside each tubes and then tubes were ligated externally with 8-0 vicryl. (E') 7-0 prolene suture was inserted inside each tubes and then tubes were ligated externally with 8-0 vicryl and after then 7-0 prolene suture was removed.

Comparisons between inner diameters of each ligation method groups were carried out using the Mann-Whitney *U* test. Descriptive results are shown as means with standard deviation and *p*-values < 0.05 were considered significant. Data were analyzed using the SPSS ver. 20.0 (SPSS Inc., Chicago, IL, USA).

Results

For silicone tube of Ahmed valve, the average diameter as measured by OCT was 246.4 μm without any ligation methods. Mean inner diameter was decreased to 15.0 μm and 62.0 μm when external ligation was applied with 7-0 Vicryl and 8-0 Vicryl respectively. Mean inner diameters were 147.6 μm and 163.2 μm when external ligations were conducted by 7-0 Vicryl and 8-0 Vicryl respectively after inserting the 7-0 Prolene suture to inside the each tube. Mean inner diameters were decreased to 80.8 μm and 90.6 μm for ligation with 7-0 Vicryl and 8-0 Vicryl respectively after inserted 7-0 Prolene was removed (Table 1).

All ligation methods were showed statistically significant decrease of inner diameter when compared with inner diameter of original tube without ligation (Mann-Whitney *U* test, *p* < 0.05). Inner diameter of silicone tube after underwent ligation using 8-0 Vicryl was wider than inner diameter after underwent ligation using 7-0 Vicryl (*p* = 0.008). But there were no differences of inner diameter for the respect of different external ligation methods when ligation was applied after inserting suture probe inside Fig. 4. It showed no statistically significant differences with ex-

Table 1. Mean values, standard deviation, minimum and maximum values of measured inner diameter of tube in each group

Group	Ligation methods	Minimum (μm)	Maximum (μm)	Mean (μm)	Standard deviation
A	No ligation	243	248	246.4	2.07
B	Ligation /c 7-0 Vicryl	0	35	15.00	12.67
C	Ligation /c 8-0 Vicryl	54	72	62.00	8.75
D	Ligation /c 7-0 Vicryl with internal 7-0 Prolene stent	121	173	147.6	18.56
D'	Ligation /c 7-0 Vicryl after removal of 7-0 Prolene	64	89	80.80	11.05
E	Ligation /c 8-0 Vicryl with internal 7-0 Prolene stent	134	198	163.20	24.73
E'	Ligation /c 7-0 Vicryl after removal of 7-0 Prolene	72	102	90.60	12.22

istence of inner suture stent ($p = 0.22$) and after removal of inner suture ($p = 0.31$).

Discussion

Glaucoma drainage devices are composed with a flexible silicone tube and relatively hard plate connected with one end of silicone tube. The other end of tube is inserted in the anterior chamber through a scleral tunnel to drainage aqueous humor to plate. And so this tube transferred pressure of anterior chamber to membranous of valve of Ahmed glaucoma drainage (AGV) device. This membranous valve was opened at predetermined specific IOP level to act as a flow restrictor to prevent over-filtration. But, the dysfunction of valve itself, the valve dysfunction due to damage from the priming process, and other valve dysfunction from unknown causes might make the valve to be unable to function. And it makes postoperative hypotony and related complications after AGV implant surgery.¹³⁻¹⁶ Coleman et al¹³ reported that hypotony was observed among 22% of the AGV implanted patients and Taglia et al¹⁷ reported that 31% of patients received AGV implantation showed hypotony related complication.

If the surgeon is not convinced the function of the AGV, one of the surgical methods to reduce outflow until the reservoir plate becomes encapsulated is tube ligation. As ligation methods, some surgeons used total ligation and another surgeon prefers partial ligation with internal and/or external ligation. And various sizes of absorbable suture materials were used for external ligation and universally 7-0 and 8-0 Vicryl suture is used. In a previous study those various ligation methods and all the way seems to have a good effect on preventing hypotony. But it is not well known how much the interior diameter of tube is going to be narrow after external ligation and how the reproducibility of inner diameter is after the ligation. In our study ligation methods with 8-0 Vicryl showed a relatively low reproducibility. And in contrast with 7-0 Vicryl, ligation method with external 8-0 Vicryl ligation without internal 7-0 Prolene was difficult to expect a complete occlusion. In our study, we conducted each ligation with the full power and if the suture was cut

during ligation we performed a re-ligation with new suture material. But in case of using 8-0 Vicryl, there was more chance to break the suture material than 7-0 Vicryl, and so it was difficult to apply a sufficient force. It can be a cause of low reproducibility of ligation. On the other hand, in case of ligation method with internal 7-0 Prolene (in other words the partial ligation methods), type of ligation material showed having no effect on reproducibility and internal diameter of tube after ligation.

In conclusion, inner diameter of silicone tube after underwent ligation using 8-0 Vicryl was wider than inner diameter after underwent ligation using 7-0 Vicryl. (Mann-Whitney U test, $p = 0.008$). But there were no differences of inner diameter for the respect of different external ligation methods when ligation was applied after inserting suture probe inside tube. ($p = 0.22$) and after removal of inner suture. ($p = 0.31$). And so, if surgeon wants total ligation of silicone tube of Ahmed valve, external ligation with 7-0 Vicryl was recommended. But, if we want to make a partial ligation we can use any ligation material.

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