Yu *et al. BMC Ophthalmology* (2024) 24:435
https://doi.org/10.1186/s12886-024-03694-1

BMC Ophthalmology

RESEARCH Open Access

Use of double short tandem scleral tunnels for repairing eroded ahmed glaucoma valve tubes

Jun Yu[1], Xiangjun Dai[1], Xiaohua Chen[1], Xiaoming Gao[2*] and Weihua Pan[3*]

Abstract

Purpose To evaluate the effectiveness and safety of a method for repairing an eroded Ahmed glaucoma valve (AGV) tube using two short scleral tunnels made in tandem with a 22G needle instead of covering the eroded tube with another scleral graft.

Methods From May 12, 2015, to July 27, 2019, we retrospectively reviewed eight patients at Ningbo Aier Eye Hospital who developed AGV tube erosion secondary to necrosis of their overlying conjunctiva and scleral grafts. This defect was repaired in all the patients using the double short tandem scleral tunnel technique, which involved the creation of double short tandem scleral tunnels made by a 22G needle. Two parallel-to-limbus scleral incisions were made 3 mm and 6 mm from the limbus first, then a curved 22G needle was inserted between the two scleral cuts to make one scleral tunnel, the other scleral tunnel was completed during the first surgery, inserted the tube into the two tunnels. The mean length of time between the AGV placement and the first erosion was 12.25 ± 6.36 months (3–24 months). The mean age of the patients was 65.50 ± 11.70 years (49–78 years).

Results The surgical outcome was assessed in terms of the tectonic integrity of the conjunctiva over the follow-up period (12 months). There was no AGV tube erosion, scleral thinning, or ocular infection after a mean of 41.25 ± 26.54 months of follow-up in all eight patients.

Conclusion AGV tube erosion following shunt surgery can be successfully managed using the improved double short tandem scleral tunnel technique.

Keywords Ahmed glaucoma valve, Double short tandem scleral tunnels, Tube erosion

*Correspondence:
Xiaoming Gao
gaoxiaoming@aierchina.com
Weihua Pan
pan_weihua@163.com
[1]Dept of Ophthalmology, Zhejiang Yiwu Aier Eye Hospital, Jinhua 322000, China
[2]Dept of Ophthalmology, Zhejiang Ningbo Aier Eye Hospital, Ningbo 315100, China
[3]Dept of Ophthalmology, Zhejiang Hangzhou Aier Eye Hospital, Hagzhou 311200, China

Background

Numerous studies have shown that, compared with trabeculectomy, glaucoma drainage devices (GDDs) have greater success rates in intraocular pressure (IOP) control for up to 5 years [1]. However, GDD tube erosion is an uncommon but serious complication that patients may face. It is estimated that 2–9% of patients with GDDs develop tube exposure [2]. Such exposure puts the eye at risk of endophthalmitis [3, 4]. There is no evidence in the literature that the complication incidence rate of Ahmed glaucoma valves (AGVs; New World Medical, Inc., Rancho Cucamonga, California, USA) is different from that of other valves. Once tube erosion has occurred, the eroded tube should be promptly covered rather than merely observed to prevent endophthalmitis. Managing tube erosion includes preserving the human sclera [5] through a double amniotic membrane patch graft [6] or a long scleral tunnel [7]. When selecting a patch graft for this purpose, many factors must be considered, including the availability and economy of the graft's material, immune reactions produced by the graft tissue, and even sclera melting.

To avoid the aforementioned issues, we used an improved technique that combines the advantages of other GDDs and surgical procedures [7–9] and has not yet been reported as a method for repairing an eroded tube. Here, we describe the results of our study, in which eight patients experienced AGV tube erosion.

Materials and methods

This study adhered to the tenets of the Declaration of Helsinki. In particular, each participant signed an informed consent form. The study was approved by the Ethics Committee of Ningbo Aier Eye Hospital, Zhejiang, P. R. China. It included eight eyes of eight patients with refractory glaucoma who were treated at our hospital between May 12, 2015, and July 27, 2019. A single surgeon managed these complications in this study. Medical records were reviewed with regard to demographics, preoperative diagnoses, comorbid conditions, intraoperative details, postoperative complications, management strategies, and outcomes.

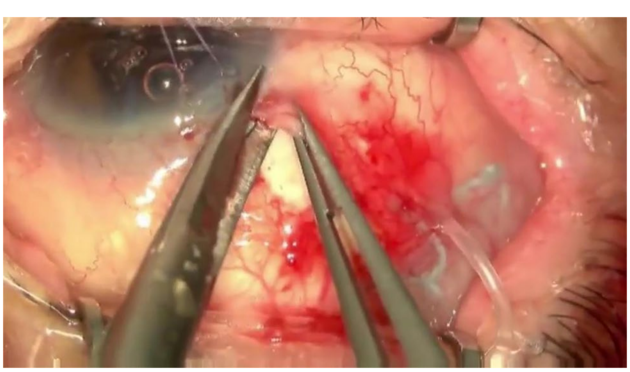

Fig. 1 Expose the scleral surface

The inclusion criteria were as follows: (i) previous failed attempts at AGV coverage; (ii) a severely scarred conjunctiva; and (iii) a limited conjunctival supply and/or monocular status. The exclusion criteria were as follows: (i) active conjunctivitis; (ii) nonfunctioning AGV and/or refusal of further treatment; and (iii) poor compliance with postoperative follow-up and inability to arrive in time for review. No patients were excluded from the study.

Patient records related to medical and surgical ocular history and the clinical course of glaucoma were obtained, and details concerning the original AGV insertion, AGV history, and previous erosions were drawn from patient care records. The surgery was defined as successful if adequate coverage of the eroded AGV was achieved. The repair of an eroded AGV tube was defined as a failure if, even though a repair had been attempted, the primary potential perioperative complications still included AGV erosion recurrence, wound dehiscence, bleb leakage, or endophthalmitis [10–12]. The follow-up period was defined as more than 1 years after the operation, and mark the first day after surgery as the beginning of the follow-up period .

Surgical techniques

AGV tube erosion occurred in all eight patients before surgery. After the application of topical and subconjunctival anesthesia with tetracaine and 2% lidocaine, the conjunctival flap based on the fornix was cut along the limbus from 10:00 to 12:30 in the right eye or from 12:00 to 14:30 in the left eye (Fig. 1). The width of the conjunctival flap was approximately 3 mm, and blunt separation of the bulbar conjunctiva and sclera was performed at the proximal end of the drainage disc to maintain the integrity of the bulbar conjunctiva. A small amount of viscoelastic agent (IVIZ; Bausch & Lomb, China) was injected into the anterior chamber for operation convenience, after which the drainage tube was removed from the anterior chamber, the entrance of the drainage tube was 3 mm from the limbus, and the end of the drainage disk was 8 mm from the limbus. Two parallel-to-limbus scleral incisions approximately 2 mm wide were made 3 mm (Fig. 2) and 6 mm (Fig. 3) from the limbus .

After the two scleral incisions were made, a curved 22G needle (Fig. 4) was inserted between the distal scleral cut and the proximal cut (Fig. 5), which was docked with the original scleral tunnel. During the first AGV implantation surgery, the AGV tube was trimmed to the proper length so that it could be inserted directly between the distal cut and the proximal cut. The tube was then inserted into the origin scleral tunnel again and entered the anterior chamber (Fig. 6). After that, the Tenon capsule and

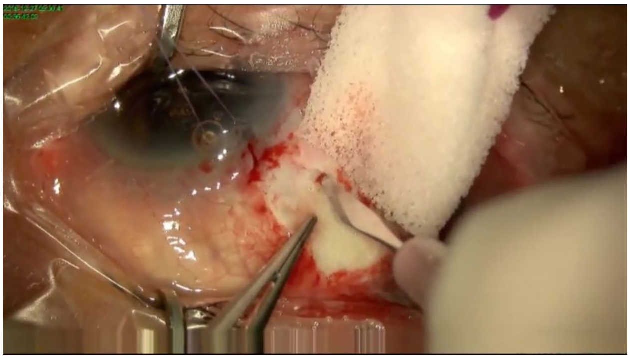

Fig. 2 Make a scleral incision 3 mm from the limbus

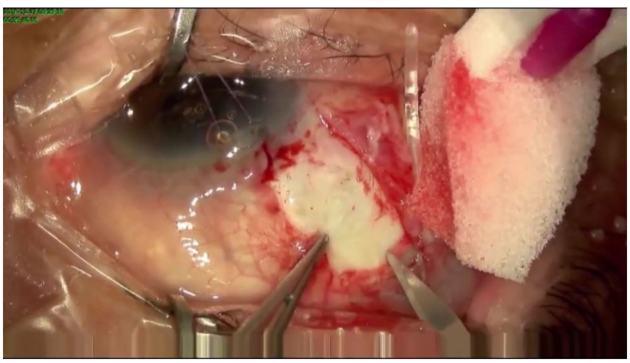

Fig. 3 Make a scleral incision 6 mm from the limbus

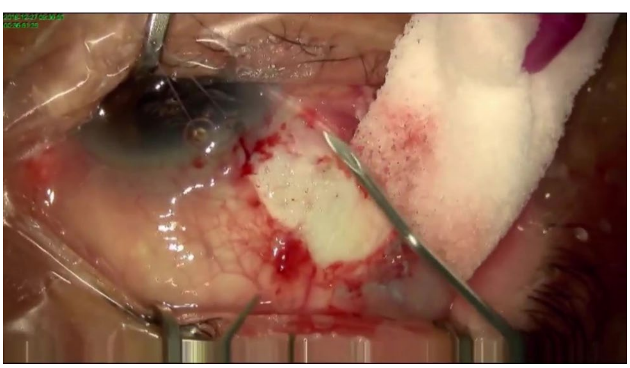

Fig. 4 Prepare a curved 22G needle

Fig. 5 The curved needle is inserted between the distal scleral cut and proximal cut

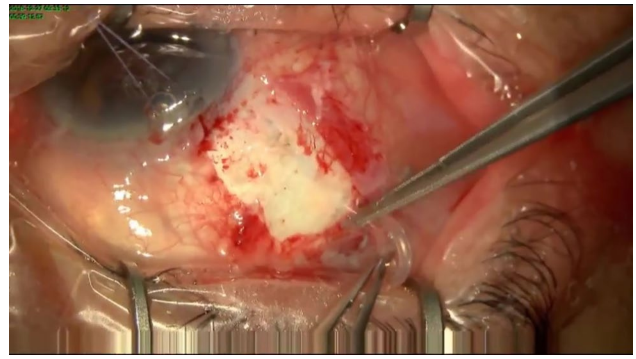

Fig. 6 The tube is inserted in to the origin scleral tunnel and then enter the anterior chamber

conjunctival incision were repositioned to the limbus using 8−0 absorbable sutures. A balanced salt solution was then injected into the anterior chamber to replace the viscoelastic fluid. (Video)

We noted that in one patient (case 6), reimplantation was not possible in the same sitting due to severe conjunctival scarring and thinning of the sclera in the anterior conjunctiva resulting from multiple previous surgeries. No antimetabolic drugs were administered during the operation.

Postoperative management

On the first day following surgery, the anterior chamber and the tube in it were inspected under a slit-lamp microscope. During the first week after the surgery, tobramycin, dexamethasone ophthalmic suspension, and 0.5% levofloxacin eye drops were administered six times a day, along with 0.1% bromfenac sodium eye drops two times a day and 0.3% sodium hyaluronate eye drops four times a day. During the second week, the number of medications administered was gradually reduced, depending on the condition of the eye operated on, until the inflammation in the eye completely subsided.

Results

Data from eight eyes of eight patients (3 [37.5%] females; mean age: 65.50±11.70 years [49–78 years]) were included in the analysis. All the patients successfully underwent surgery via the improved double short tandem scleral tunnel technique to repair the tube incision. The baseline data are summarized in Table 1.

No patient had anterior chamber hemorrhage during anterior chamber puncture. Anterior chambers were formed, and the tubes were well positioned, without any displacement in any of the patients after surgery. The AGV was originally covered by the conjunctiva. There were no instances of perioperative leakage, infection, or wound dehiscence; there was no tube contact with the iris posteriorly or with the cornea anteriorly; and no anterior tube protruded near the limbus or over the scleral

Table 1 Clinical characteristics of the patients

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8
Age	78	73	72	49	68	49	76	59
Race	Chinese	Chinese	Chinese	Chinese	Chinese	Chinese	Chinese	Chinese
Gender (M/F)	M	M	F	M	F	M	M	F
Eye (R/L)	L	L	L	R	R	R	R	L
Systemic disease	Nil	Hyper- tension	Nil	Nil	Nil	Nil	Nil	Diabetes mellitus
Glaucoma subtype	PACG	MG	POAG	POAG	SG	POAG	SG	NVG
Other ocular disease	Retino-schisis Patholo-gical myopia Intra-ocular lens	Uveitis Cataract	Intra-ocular lens	Patholo-gical myopia Intraocu-lar lens Postope-rative chronic dacryo- cystitis	Uveitis Intrao-cular lens	Patholo-gical myopia Intra-ocular lens Postope-rative chronic dacryo- cys-titis	Choroid detach-ment Uveitis Intra-ocular lens	Prolifera-tive diabetic retino-pathy Cataract
No. of pre-shunt procedures	3	1	2	3	2	4	2	0
Pre-shunt procedures	Trabecu-lectomy Phaco + IOL Laser photo-coagula-tion	Trabecu-lectomy	Trabe-cu-lec-tomy Phaco + IOL	Trabecu-lectomy Phaco + IOL DCR	Trabe-cu-lec-tomy Phaco + IOL	Trabe-culec-tomy Phaco + IOL DCR	Trabe-cu-lec-tomy Phaco + IOL	Nil
IOP (mmHg) before erosion	13.7	9.5	12	7.4	10.3	7.5	11.4	12.2
Time to erosion (months)	17	7	12	11	3	24	10	14
Follow-up (months)	39	14	103	34	39	31	27	43
Pre-operative BCVA(logMAR)	1.4	2.9	1.5	2	0.7	2	1.1	1.6
Final BCVA (logMAR)	1.6	2.9	2.0	2.3	0.9	2.3	1.1	2.0
Final IOP (mmHg)	18	18.8	16.4	12.5	16	16	17.1	19.1
Kinds of drugs used in the last follow-up	3	1	3	2	2	2	2	3

Abbreviations: M – male; F – female; R – right; L – left; PACG – primary angle closure glaucoma; MG – mixed glaucoma; POAG – primary open-angle glaucoma; SG – secondary glaucoma; NVG – neovascular glaucoma; DCR – fenestration and drainage for chronic dacryocystitis; Final IOP-the last IOP measurement in the follow-up period; Final BCVA-the last examination of visual acuity measurement in the follow-up period

surface. There was no conjunctival erosion, displacement of the anterior tube, or dellen formation in any eye until the last day of follow-up.

The mean IOP (mmHg) of the patients before surgery was 12.95±2.26. The mean number of previous ocular surgeries was 2.50±0.71. The mean length of time between AGV placement and the first erosion was 12.25±6.36 months (3–24 months). The mean follow-up time was 41.25±26.54 months (14–103 months).

The preoperative best corrected visual acuity was 1.65±0.94 logMAR. On the first day after surgery, the best corrected visual acuity was 1.70±0.82 (logMAR). Moreover, there was no statistically significant change in visual acuity after surgery ($p=0.654$). On the last examination of visual acuity measurement in the follow-up period, the best corrected visual acuity was 1.89±0.66 (logMAR).

None of the patients required removal of the AGV or additional surgery to control the IOP in the first year after surgery. Two patients received surgical treatment for encapsulated cystic blebs around the plate after AGV implantation at the 39th month and 27th month, one patient removed the drainage valve at the 43rd month after surgery due to corneal endothelial decompensation and performed other anti-glaucoma operations. At 1 and 3 months postsurgery, the mean IOP was 14.5±10.1 mmHg and 15.1±3.5 mmHg, respectively. At the last follow-up examination, the final mean IOP was 16.74±2.09 mmHg (12.5–16.49.1 mmHg), which was a significant change ($p=0.03$). Table 1.

Discussion

Tube erosion is a rare complication of AGV surgery that is potentially vision threatening and has many causes, such as immunologic and mechanically caused exposure of the shunt [13]. In one study [14], the use of antifibrotic agents such as mitomycin-C for subsequent filtering surgeries adversely affected conjunctival health. Excessive conjunctival tension over the shunt, tube malpositioning, a lack of smooth ocular lubrication, younger age, and black race are also significant risk factors for tube exposure [15]. According to some surgeons [16], the key factor for tube erosion is direct contact between the tube and the conjunctiva, which can cause conjunctival erosion. Physiologically, the conjunctiva must stand on the Tenon tissue. If direct contact occurs between the conjunctiva and the silicon tube, immunological responses may occur, and the overlying conjunctiva may erode. During the first implantation surgery, we utilized a curved 22G needle to create a scleral tunnel 3 mm posterior to the corneo-scleral limbus, Subsequently, the trimmed AGV tube was inserted into the anterior chamber along the 22G needle track, leaving approximately 5 mm of the tube near the AGV plate exposed on the scleral surface.This exposed portion was then covered with the Tenon capsule and conjunctiva to prevent direct contact between the tube and conjunctiva. the tube follows better the contour of the globe before entering the anterior chamber, the risk of protrusion from the adjacent sclera is much lower. There is an interesting commonality among all patients, the exposed portions are the part just be covered by Tenon capsule and conjunctiva.

Many surgeons prefer to use a scleral graft of suitable thickness to cover the exposed tube, and many types of tissue can be used as patch grafts for covering eroded AGV tubes [4, 12, 17]. There is little evidence that one treatment is more effective and safer than the other treatment [10, 18]. Several researchers have focused on how to prevent AGV tube erosion rather than how to treat it in scleral tunnels [7–9], but we have not found a study that used the scleral tunnel technique to repair eroded AGV tubes.

We cannot change patient race or age, but we can change patient AGV tube malposition, conjunctival tension, or the use of antifibrotic agents by improving surgical procedures. This paper reports results on the late repair of eroded AGV tubes using a new scleral tunnel technique in which the scleral tunnel was cut with a curved 22G needle rather than with a bevel-up lancet [8], a crescent knife [9], or a satin crescent knife [7]. For patients with eroded AGV tubes, scleral thinning is a common problem. The conjunctiva adheres to the sclera where the tube is exposed, so the superficial sclera must be attached for conjunctival integrity during separation. Therefore, creating a scleral tunnel with a blade in these patients will be more difficult than doing so with a 22G needle. Ozdamar et al. [9] described the use of a long scleral tunnel for the implantation of anterior-tube GDDs, but there are limitations regarding the length of the tunnel because it is difficult to follow the curved contour of the sclera more than a certain length. Conjunctival erosion did not occur in Ozdamar et al.'s [9] study, but Ozdamar's technique was not used for the repair of eroded AGV tubes. Brouzas et al. [8] described the use of a bevel-up lancet to prepare a distal limbus tunnel between the two scleral incisions. In their study, AGV tube erosion occurred in 7.1% of the patients, which was comparable to previously reported rates of AGV tube erosion with various surgical techniques. The two aforementioned surgical procedures are much more traumatic than our proposed technique because they involve lacerations rather than our technique's needle injury, and because of the greater risk of tube malpositioning in such procedures.

We combined the advantages of Brouzas et al.'s [8] and Ozdamar et al.'s [9] methods and integrated them into our proposed technique, as its two main features. First, we did not need to make a scleral graft, regardless of whether autologous tissue or a patch graft was used. This procedure produced fewer immunological responses and no immune rejection. Second, improper or loose fixation of the tube could also lead to micro movements, creating constant friction and conjunctival erosion, and ultimately causing extrusion of the tube. The scleral tunnel made with a 22G needle limited the movement of the tube, improving its stability and preventing its migration in the scleral tunnel. Additionally, the tight fit of the tunnel and the fixation of the drainage tube reduced the mechanical friction caused by drainage tube movement. There was no tube exposure in the patients who underwent this technique, even after a mean follow-up period of 16.88±14.89 months. This is encouraging, but this study has several important limitations, especially its small sample size because AGV tube erosion is a rare complication. Thus, to determine the long-term safety and success rates of our proposed surgical technique for the repair of eroded AGV tubes, it must be performed by different surgeons.

In conclusion, the procedure described in this report for repairing eroded AGV tubes was successful, with a 100% success rate on the last day of follow-up. However, there still some problems: firstly, continue to observe these patients over a long period to see if the drainage tube exposure recurs. Secondly, in case of encountering such situations, continue to adopt this surgical method, expand the sample size, and further verify the superiority of this surgical approach. Thirdly, this study suggests that for patients with systemic immune system diseases, uveitis, and thin bulbar conjunctiva, adopting this scleral tunnel technique may help reduce the incidence of drainage tube exposure. This technique does not require making additional tissue for superficial coverage of eroded AGV tubes, and we recommend its usage as an alternative surgical option.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12886-024-03694-1.

Supplementary Material 1

Acknowledgements
The authors are grateful to Yuzhou Zhen for her Computer assistance on this manuscript.

Author contributions
XG, WP were responsible for the design of the study and interpretation ofthe results. JY, XD and XC conducted the study and collected the data. WPwere responsible for the operations. JY and XG analyzed the data. JY was amajor contributor in writing the manuscript. XG, WP, JY, XD and XC reviewedthe article. All authors read and approved the final manuscript.

Funding
This study was Supported by the Science Research Foundation of Aier Eye Hospital Group (Grant No. AR2204D2).

Data availability
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This study is approved by the Ethics Committee of Ningbo Aier Eye Hospital (Number: IRN-2023-07). The written informed consents were achieved from all patients.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Received: 11 May 2024 / Accepted: 23 September 2024
Published online: 04 October 2024

Reference list

1. Sastre-Ibáñez M, et al. Efficacy of Ologen matrix implant in Ahmed glaucoma valve implantation. Sci Rep. 2019;9(1):3178.
2. Heuer DK, Budenz D, Coleman A. Aqueous shunt tube erosion. J Glaucoma. 2001;10:493–6.
3. Al-Torbak AA, et al. Endophthalmitis associated with the Ahmed glaucoma valve implant. Br J Ophthalmol. 2005;89(4):454–8.
4. Gedde SJ, Scott IU. H tabandeh late endophthalmitis associated with glaucoma drainage implants. Ophthalmology. 2001;108:1323–7.
5. Freedman J. Scleral patch grafts with Molteno setons. Ophthalmic Surg Lasers. 1987;18:532–4.
6. Ainsworth G. A novel use of amniotic membrane in the management of tube exposure following glaucoma tube shunt surgery. Br J Ophthalmol. 2006;90(4):417–9.
7. Ollila M, Falck A, Airaksinen PJ. Placing the Molteno implant in a long scleral tunnel to prevent postoperative tube exposure. Acta Ophthalmol Scand. 2005;83(3):302–5.
8. Brouzas D, et al. Double scleral tunnel in tandem technique for glaucoma drainage tube implants. Int Ophthalmol. 2017;38(6):2349–56.
9. Ozdamar A, et al. Scleral tunnel for the implantation of glaucoma seton devices. Ophthalmic Surg Lasers. 2001;32(5):432–5.
10. Einan-Lifshitz A, et al. Repair of exposed Ahmed glaucoma valve tubes: long-term outcomes. J Glaucoma. 2018;27(6):532–6.
11. Rootman DB, Trope GE, Rootman DS. Glaucoma aqueous drainage device erosion repair with buccal mucous membrane grafts. J Glaucoma. 2009;18(8):618–22.
12. Lifshitz AE, Trope GE, Rootman DS. Repair of exposed Ahmed glaucoma valve tubes: long-term outcomes. J Glaucoma. 2018;27:532–6.
13. Smith MF, Doyle JW. Results of another modality for extending glaucoma drainage tubes. J Glaucoma. 1999;8:310–4.
14. Grover DS, Kornmann HL, Fellman RL. Historical considerations and innovations in the perioperative use of mitomycin C for glaucoma filtration surgery and bleb revisions. J Glaucoma. 2020;29(3):226–35.
15. Chaku M, et al. Risk factors for tube exposure as a late complication of glaucoma drainage implant surgery. Clin Ophthalmol. 2016;10:547–53.
16. Tamçelik N, et al. A novel surgical technique to prevent postoperative Ahmed valve™ tube exposure through conjunctiva: Tenon advancement and duplication. Ophthalmic Surg Lasers Imaging Retina. 2010;41(3):370–4.
17. Roy AK, Senthil S. Management of implant plate exposure of silicone Ahmed glaucoma valve: a review of six cases. GMS Ophthalmol Cases. 2016;6:Doc10.
18. Smith MF, Doyle JW, Ticrney JW Jr. A comparison of glaucoma drainage implant tube coverage. J Glaucoma. 2002;11(2):143–7.