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Article

XEN®-63 Compared to XEN®-45 Gel Stents to Reduce Intraocular Pressure in Glaucoma

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Abstract: The XEN® gel stent reduces intraocular pressure (IOP) in glaucoma. XEN®-45 is widely used while the newer XEN®-63 has a larger lumen that may lower IOP more. We retrospectively compared the first 15 XEN®-63 cases to 15 matched XEN®-45 controls. With a preoperative IOP of 18.1 ± 3.9 mmHg (mean ± SD) and a final IOP of 9.2 ± 4.2 mmHg, XEN®-63 implantation resulted in an IOP reduction of 48.0 ± 23.3%. Similarly, with a preoperative IOP of 18.3 ± 4.5 mmHg and a final IOP of 10.5 ± 2.3 mmHg, XEN®-45 implantation resulted in an IOP reduction of 39.5 ± 17.81%. The median follow-up period was 57 days for the XEN®-63 group and 183 days for the XEN®-45 group. 5/15 eyes of each group underwent open conjunctival bleb revision within the period of observation. Two eyes of the XEN®-63 group also had secondary glaucoma surgery. In both groups only one eye required restart of antiglaucomatous medication. XEN®-63 and XEN®-45 effectively lower IOP and medication. XEN-63 achieved lower IOP over a short follow-up. Complication and revision rates were similar.

Keywords: XEN®-63 gel stent; glaucoma; bleb revision

1. Introduction

XEN® gel stent is a hollow cylindrical implant made of cross-linked collagen derived from porcine gelatin. Implanted ab interno through the sclera, the stent drains fluid from the anterior chamber to the subconjunctival space [1]. XEN®-45 gel stent has been used successfully to treat primary open angle glaucoma [2–7], as well as other forms of glaucoma [2–7] by reducing intraocular pressure (IOP) and the number of antiglaucomatous medications required. Compared to classic glaucoma filtration surgery, XEN® implantation is less invasive and may have a better safety profile [8]. However, most studies show a high rate for needling [2,7,9–11] or bleb revision [4,12,13] after XEN®-45 implantation. In the long run, trabeculectomy can achieve lower IOP values [14]. XEN®-45 has a lumen of 45 µm and XEN®-63 a lumen of 63 µm. Both are 6 mm long, and are implanted with a 27G injector. XEN®-45 has an outer diameter of 150 µm while XEN®-63 has an outer diameter of 170 µm. Real-world data for XEN®-45 implantation after 1-3 years show postoperative mean IOP levels of 14-16 mmHg [2–4,7,9–11,13,15]. Due to its lower outflow resistance compared to XEN®-45 (2-3 mmHg for XEN®-63 versus 6-8 mmHg for XEN®-45), XEN®-63 was designed to achieve a lower IOP level. So far, there are few studies on the current version of XEN®-63. Previously, studies reported on an earlier, non-marketed version with an inner diameter of 63 µm, but an outer diameter of 240 µm, implanted with a 25G injector [16–18]. Fea et al. were the first to report on the newly marketed XEN®-63 [19,20]. We herein present our data of XEN®-63 compared to XEN®-45 for different types of glaucoma in a tertiary center in Germany.

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2. Materials and Methods

We conducted a retrospective analysis of the first 15 consecutive XEN®-63 implantations at our tertiary Eye Center at the University of Freiburg, Germany, compared to a matched group of XEN®-45 implantations. This study was performed in accordance with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of the University of Freiburg (No 21-1202_02).

Study patients: XEN®-63 gel stent (Allergan, an AbbVie company, Irvine, CA, USA) was implanted in 15 eyes of 13 patients with medically uncontrolled glaucoma. The control group consisted of 15 eyes of 15 patients who had received XEN®-45 gel stent (Allergan, an AbbVie company, Irvine, CA, USA) implantation. Both groups were matched for age and type of glaucoma. Eyes with XEN®-45 implantation were selected from a quality control database using propensity matching on the basis of age and type of glaucoma.

Surgical technique: Either XEN®-45 or XEN®-63 gel stent was implanted ab interno via a clear corneal incision without conjunctival dissection. At the end of the procedure, 4 mg of dexamethasone was administered intracamerally and 0.1 ml of 0.2% mitomycin C was injected subconjunctivally. Postoperative treatment consisted of glucocorticoid eye drops (usually 1 mg/ml dexamethasone) 5 times daily, which were gradually reduced depending on the degree of postoperative conjunctival injection and intraocular inflammation (usually fortnightly reduction). IOP-lowering drugs were stopped on the day of surgery. In cases requiring open conjunctival bleb revision, patients received postoperative subconjunctival 5-fluorouracil injections (1 ml of 1% 5-fluorouracil) for three consecutive days following surgery and again glucocorticoid eye drops (usually 1 mg/ml dexamethasone) 5 times daily tapered fortnightly by one drop.

Statistics: The success of XEN®-63 versus XEN®-45 implantation was determined using descriptive statistics, including mean values, standard deviation, range and median, if differing substantially from mean. Furthermore, we included Kaplan-Meier survival estimations. Criteria for failure were revision surgery with conjunctival dissection or secondary glaucoma intervention. To compare results between XEN®-63 and XEN®-45, an unpaired two-tailed t-test was performed.

3. Results

3.1. Patient age and type of glaucoma:

At the time of XEN® implantation, patients in the XEN®-63 group were between 55 and 86 years old (mean age ± standard deviation: 75.3 ± 9.4 years) and patients in the XEN®-45 group were between 54 and 86 years old (mean age ± standard deviation: 74.8 ± 8.6 years).

The XEN®-63 group comprised 5 male patients (38.5%), 2 of whom received XEN®-63 implantation in both eyes and 8 female patients (61.5%) who underwent XEN®-63 implantation in one eye. The XEN®-45 group comprised 6 male (40.0%) and 9 female (60.0%) patients. Only one eye of each patient in this group was included in the study.

In both groups, 9/15 (60%) eyes had normal tension glaucoma, 2/15 (13.3%) had primary open-angle glaucoma, 3/15 (20%) had pseudoexfoliation glaucoma, and 1/15 (6.6%) had uveitic glaucoma.

3.2. Preoperative IOP, medications and previous glaucoma treatment:

The mean preoperative IOP was 18.1 ± 3.9 mmHg (range 11-25 mmHg) in the XEN®-63 group and 18.3 ± 4.5 mmHg (range 13-29.2 mmHg) in the XEN®-45 group (no statistically significant difference, $t = -0.12$; $df = 28$; $p = 0.9$).

Preoperatively, all eyes in both groups were on topical hypotensive agents. Eyes in the XEN®-63 group were on an average of 3.3 substances and eyes in the XEN®-45 group were on an average of 2.5 substances. In 2/15 cases (13.3 %) in the XEN®-63 group and 1/15 cases (0.1%) in the XEN®-45 group, patients received additional oral acetazolamide in varying dosages.

In the XEN®-63 group, 6/15 eyes (40 %) had previous glaucoma surgery, some with multiple interventions, including 4 Trabectome® surgeries, 2 MINIject® implantations, 2 cyclophotocoagulations, and 3x selective laser trabeculoplasties.

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In the XEN®-45 group, 4/15 eyes (27%) had previous glaucoma surgery. Two eyes had only selective laser trabeculoplasty. Another two eyes had selective laser trabeculoplasty and Trabectome® surgery prior to XEN®-45 implantation.

In both groups 10 eyes were pseudophakic and 5 eyes were phakic.

3.3. Postoperative outcomes:

The mean IOP during the first few days after XEN®-63 implantation was 7.7 mmHg (range 4.2-12.5 mmHg). XEN®-63 implantation resulted in a mean IOP reduction of 10.4 mmHg (range 3.3-14.8 mmHg), or 56.5% (range 22.0-77.9%).

The mean IOP during the first few days after XEN®-45 implantation was 8.5 mmHg (range 3.3-13.1 mmHg). XEN®-45 implantation resulted in a mean IOP reduction of 9.7 mmHg (range 0.9-22.6 mmHg), or 50.4% (range 6.43-86.6%).

Furthermore, IOP-lowering medication could be discontinued in all eyes in both groups.

In 10/15 eyes (66.7%) in the XEN®-63 group, the postoperative IOP was < 6 mmHg at least once, and in four eyes (26.7%) this lasted for over 1 week. In the XEN®-45 group, 8/15 eyes (53.3%) had a postoperative IOP < 6 mmHg, but in only one eye (0.07%) did this last for over 1 week.

Postoperative anterior chamber hemorrhage was observed in 8/15 eyes (53.3%) in the XEN®-63 group and 10/15 eyes (66.7%) in the XEN®-45 group.

One patient in the XEN®-63 group had suprachoroidal hemorrhage, which occurred on the first postoperative day. As a result, the IOP increased from 3 mmHg initially to a maximum of 46 mmHg, and antiglaucomatous treatment was restarted. Twelve days after surgery, choroidal drainage was performed in this patient. In addition, 40 days after surgery, the patient received secondary glaucoma intervention in the form of cyclophotocoagulation. Suprachoroidal hemorrhage did not occur in any of the matched XEN®-45 eyes.

There were no cases of choroidal effusion in the XEN®-63-group. In the XEN®-45 group two cases showed transitional choroidal effusion immediately postoperatively associated with an IOP < 6 mmHg. In each group, there was one case of transient choroidal folds in the macular area.

3.4. Follow-up period:

The mean postoperative follow-up period was 70.1 ± 52.4 days (range 12-190 days; median 57 days) for the XEN®-63 group and 457.4 ± 535.9 days (range 18-1688 days; median 183 days) for the XEN®-45 group.

3.5. Post-XEN® interventions (Figure 1):

In the XEN®-63 group, 5/15 eyes (33.3%) underwent open conjunctival bleb revision an average of 45 days after surgery (range 28-74 days; median 39 days) due to impaired drainage from occlusion of the stent lumen with Tenon's fascia or subconjunctival scarring. One of these patients had previous unsuccessful needling 6 days before bleb revision (50 days after XEN implantation).

In the XEN®-45 group, the same percentage of eyes (33.3%) underwent open conjunctival bleb revision an average of 330 days after surgery (range 39-1624 days; median 70 days). Only one of these bleb revisions took place more than four months after XEN®-45 implantation (namely 1624 days or about 4.5 years) and was due to impending perforation of the conjunctiva by the XEN® stent. Furthermore, there was one case of a successful needling 63 days after XEN®-45 implantation.

Apart from the aforementioned patient with suprachoroidal hemorrhage, who subsequently underwent cyclophotocoagulation, one other patient in the XEN®-63 group underwent PreserFlo® surgery as secondary glaucoma intervention 32 days after XEN® implantation. Four days before PreserFlo® implantation, this patient underwent XEN® revision for an encapsulated bleb. After this bleb revision IOP increased to 45 mmHg due to XEN® obstruction by iris incarceration. The XEN®-63 implant was then replaced with a PreserFlo®. None of the XEN®-45 patients required secondary glaucoma intervention within the follow-up period.

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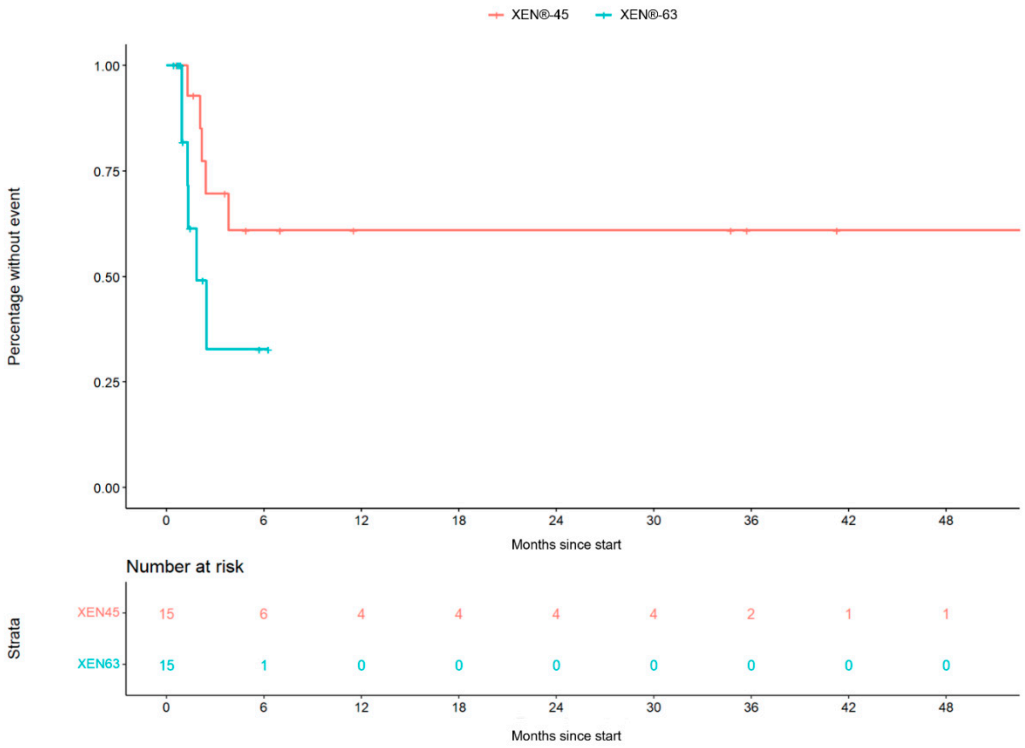

Figure 1. Kaplan-Meier curve for time to bleb revision or secondary glaucoma intervention over time. Steps indicate events, and ticks indicate eyes lost to follow-up. The follow-up period in this graphic is limited to 48 months. There was one additional open conjunctival bleb revision around 4.5 years after surgery in the XEN®-45 group. All other interventions occurred within 4 months of XEN® implantation.

3.6. Re-start of topical treatment:

In no other patient in the XEN®-63 group besides the aforementioned one with suprachoroidal hemorrhage was antiglaucomatous treatment restarted within the follow-up period (three topical drugs plus oral acetazolamide). In the XEN®-45 group, there was one patient who had to restart topical antiglaucomatous treatment (two drugs) 302 days after XEN® implantation or 263 days after bleb revision. The mean number of topical antiglaucomatous agents at the end of follow-up was 0.2 ± 0.8 in the XEN® 63 group and 0.1 ± 0.5 in the XEN®-45 group. Compared to baseline, the mean number of topical antiglaucomatous agents was reduced by 3.1 ± 0.9 agents (93.0%) in the XEN®-63 group and by -2.4 ± 1.1 agents (94.7%) in the XEN®-45 group.

3.7. IOP at final follow-up:

At the final follow-up visit, the mean IOP in the XEN®-63 group was 9.2 mmHg (range 4-18 mmHg). The mean IOP reduction was 8.9 mmHg (range 0.8-15.2 mmHg), or 48.0% (range 5.4-79.2%) in the XEN®-63 group. In the XEN®-45 group, the mean IOP at final follow-up was 10.5 mmHg (range 7-14 mmHg). The mean IOP reduction was 7.7 mmHg (range 2-16.7 mmHg), or 39.5% (range 15.4-67.9%).

The following tables provide a summary of the main results for IOP values (Table 1), topical antiglaucomatous medication (Table 2) and postoperative interventions (Table 3).

There was no statistically significant difference of baseline and final IOP or IOP reduction between the two groups (Table 4). This may be due to the small sample size.

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Table 1. IOP values.

	XEN®-63 (15 eyes of 13 patients)		**XEN®-45** (15 eyes of 15 patients)	
	Mean	Range	Mean	Range
IOP at baseline	18.1 mmHg	11-25 mmHg	18.3 mmHg	13-29.2 mmHg
IOP within a few days after XEN® implantation	7.7 mmHg	4.2-12.5 mmHg	8.5 mmHg	3.3-13.1 mmHg
IOP reduction within a few days after XEN® implantation	10.4 mmHg 56.5%	3.3-14.8 mmHg 22.0-77.9%	9.7 mmHg 50.4%	0.9-22.6 mmHg 6.43-86.6%
Follow-up period	70.1 ± 52.4 days (median 57 days)	12-190 days	457.4 ± 535.9 days (median 183 days)	18-1688 days
IOP at final follow-up	9.2 mmHg	4-18 mmHg	10.5 mmHg	7-14 mmHg
IOP reduction at final follow-up	8.9 mmHg 48.0%	0.8-15.2 mmHg 5.4-79.2%	7.7 mmHg 39.5%	2-16.7 mmHg 15.4-67.9%

Table 2. Topical antiglaucomatous medication.

	XEN®-63 (15 eyes of 13 patients)	**XEN®-45** (15 eyes of 15 patients)
before XEN® implantation:		
• mean number of topical antiglaucomatous agents	3.3 agents	2.5 agents
• eyes on topical treatment	15/15 eyes (100%)	15/15 eyes (100%)
at the end of follow-up:		
• mean number of topical antiglaucomatous agents	0.2 agents	0.1 agents
• eyes on topical treatment	1/15 eyes (6.7%)	1/15 eyes (6.7%)
• reduction of topical treatment	-3.1 ± 0.9 (-93.9%)	-2.4 ± 1.1 (-94.74%)

Table 3. Postoperative interventions.

	XEN®-63 (15 eyes of 13 patients)		**XEN®-45** (15 eyes of 15 patients)	
• bleb revision	5/15 eyes	33.3%	5/15 eyes	33.3%
• bleb revision within 6 months	5/15 eyes	33.3%	4/15 eyes	26.7%
• Interval between XEN® implantation and bleb revision	45 days (mean) 39 days (median)	range 28-74 days	330 days (mean) 70 days (median)	range 39-1624 days
• secondary glaucoma surgery	2/15 patients	13.3%	--	--
• Interval between XEN® implantation and secondary glaucoma surgery	36 days	range 32-40 days	--	--

Table 4. Results of unpaired t-test comparing IOP outcomes between XEN®-63 and XEN®-45.

	t	**df**	**p**
• IOP at baseline	-0.12	28	0.90
• IOP within a few days after XEN® implantation	-0.74	28	0.47
• IOP reduction within a few days after XEN® implantation (total)	0.35	28	0.72

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• IOP reduction within a few days after XEN® implantation (percentage)	0.87	28	0.39
• IOP at final follow-up	- 1.06	28	0.3
• IOP reduction at final follow-up (total)	0.65	28	0.52
• IOP reduction at final follow-up (percentage)	1.12	28	0.27

4. Discussion

Effectivity

Our study shows effective IOP reduction after XEN®-63 implantation with mitomycin C. Compared to XEN®-45, the percentage IOP reduction at the end of follow-up was more pronounced (48.0% versus 39.5%) and the absolute IOP at the last visit was slightly lower (mean IOP of 9.2 mmHg versus 10.5 mmHg). These results are clinically relevant and favor XEN®-63, but due to the small sample size, they are not statistically significant. Furthermore, both XEN®-63 and XEN®-45 in our study showed a similarly high effectiveness in reducing medical treatment, with all but one patient off treatment at the end of follow-up in each group.

However, the follow-up period was short and differed between the two groups, with a median of 57 days (range 12-190 days) in the XEN®-63 group and a median of 183 days (range 18-1688 days) in the in the XEN®-45 group, which may influence the comparability of the two groups.

Fea et al. [19] in a retrospective study of XEN®-63 implantation with mitomycin C (n=23) for primary open angle glaucoma found similar results after 3 months, with a slightly higher mean IOP (12.2 ± 3.4 mmHg) and slightly lower IOP reduction (40.8 ± 23.5%) at the end of follow-up (baseline IOP 27.0 ± 7.8 mmHg). They also found an effective reduction in the number of hypotensive medications. After 18 months [20], they reported a mean IOP of 14.1 ± 3.4 mmHg without hypotensive medication.

Safety

We observed more cases of hypotony < 6 mmHg lasting over one week after XEN®-63 implantation (4/15, 26.7%) compared to XEN®-45 implantation (1/15, 6.7%). Associated with hypotony, in the XEN®-45 group 2/15 eyes (13.3%) showed transient choroidal effusion. In the XEN®-63 group, there was one case of suprachoroidal hemorrhage, a rare sight-threatening complication after XEN® implantation, for which there are only few case reports in the literature following or during XEN®-45 implantation [21–23].

Fea et al. [19,20] reported a rate of 17.4% for both transient hypotony and choroidal detachment.

Needling/revision/secondary surgery

In both of our study groups, one-third of the eyes underwent open conjunctival bleb revision. In 9/10 eyes, this bleb revision was due to impaired drainage and occurred 2-4 months after XEN® implantation. Therefore, impaired outflow in our study frequently occurred after implantation of both XEN® types and quite early after XEN® implantation (within 4 months). Only in one eye of the XEN®-45 group did it occur several years after implantation and was due to impending conjunctival perforation. Therefore, the short and differing follow-up periods may not be as relevant in this regard. A high revision rate has been reported for XEN®-45 in the literature [2,4,7,9–13].

Secondary glaucoma intervention in this study was more frequent in the XEN®-63 group. However, this was due to rare complications that can also occur after XEN®-45 implantation. Given the small sample size, this difference cannot be considered evidence of a significant difference between the two XEN® types.

In the study by Fea et al. [20], 17.4% underwent needling after a mean of 42.9 ± 11.2 days (one due to elevated IOP). Furthermore, 17.4% in their study required additional surgery: two trabeculectomies (8.7%), one XEN® replacement with XEN®-45 (4.3%), one high-intensity focused

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ultrasound cyclodestruction (HIFU), and one more patient needed needling or additional surgery at the final follow-up.

There are several studies reporting promising results for needling or bleb revision after XEN®-45 implantation [24–28], some favoring bleb revision over needling [27,28]. Studies on an older, non-marketed version of XEN®-63 after 1-5 years of follow-up reported an IOP reduction of 18-40% and a needling rate of 0-53% [16–18,29].

Limitations

Our study is limited by its retrospective nature and relatively small sample size. The follow-up period was short and differed between the two groups. Our study may serve as orientation guide for designing a prospective study comparing XEN®-63 versus XEN®-45.

5. Conclusions

XEN®-63 implantation with mitomycin C may lead to even lower IOP levels compared to XEN®-45 implantation over a short follow-up period. Larger studies with longer follow-up are needed to confirm if this difference persists over time. The rates of complications and required revisions appear to be largely comparable. Further research is needed to evaluate the safety, efficacy, and role of XEN®-63 relative to XEN®-45 and other glaucoma procedures.

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Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Ethics Committee of the University of Freiburg (No 21-1202_02).

Informed Consent Statement: Patient consent was waived, because it was not required by law for this study.

Conflicts of Interest: CE has received a travel grant and JL has received honorary from Allergan/Abbvie. All other authors declare no conflict of interest.

References

1. Lewis, R.A. Ab Interno Approach to the Subconjunctival Space Using a Collagen Glaucoma Stent. *J Cataract Refract Surg* **2014**, *40*, 1301–1306, doi:10.1016/j.jcrs.2014.01.032.
2. Hengerer, F.H.; Auffarth, G.U.; Yildirim, T.M.; Conrad-Hengerer, I. Ab Interno Gel Implant in Patients with Primary Open Angle Glaucoma and Pseudoexfoliation Glaucoma. *BMC Ophthalmol* **2018**, *18*, 339, doi:10.1186/s12886-018-0989-6.
3. Mansouri, K.; Gillmann, K.; Rao, H.L.; Guidotti, J.; Mermoud, A. Prospective Evaluation of XEN Gel Implant in Eyes With Pseudoexfoliative Glaucoma. *J Glaucoma* **2018**, *27*, 869–873, doi:10.1097/IJG.0000000000001045.
4. Widder, R.A.; Dietlein, T.S.; Dinslage, S.; Kühnrich, P.; Rennings, C.; Rössler, G. The XEN45 Gel Stent as a Minimally Invasive Procedure in Glaucoma Surgery: Success Rates, Risk Profile, and Rates of Re-Surgery after 261 Surgeries. *Graefes Arch Clin Exp Ophthalmol* **2018**, *256*, 765–771, doi:10.1007/s00417-018-3899-7.
5. Sng, C.C.; Wang, J.; Hau, S.; Htoon, H.M.; Barton, K. XEN-45 Collagen Implant for the Treatment of Uveitic Glaucoma. *Clin Exp Ophthalmol* **2018**, *46*, 339–345, doi:10.1111/ceo.13087.
6. Qureshi, A.; Jones, N.P.; Au, L. Urgent Management of Secondary Glaucoma in Uveitis Using the Xen-45 Gel Stent. *J Glaucoma* **2019**, *28*, 1061–1066, doi:10.1097/IJG.0000000000001389.

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 7 June 2023 doi:10.20944/preprints202306.0527.v1

7. Schargus, M.; Theilig, T.; Rehak, M.; Busch, C.; Bormann, C.; Unterlauft, J.D. Outcome of a Single XEN Microstent Implant for Glaucoma Patients with Different Types of Glaucoma. *BMC Ophthalmol* **2020**, *20*, 490, doi:10.1186/s12886-020-01764-8.
8. Marcos Parra, M.T.; Salinas López, J.A.; López Grau, N.S.; Ceausescu, A.M.; Pérez Santonja, J.J. XEN Implant Device versus Trabeculectomy, Either Alone or in Combination with Phacoemulsification, in Open-Angle Glaucoma Patients. *Graefes Arch Clin Exp Ophthalmol* **2019**, *257*, 1741–1750, doi:10.1007/s00417-019-04341-y.
9. Galal, A.; Bilgic, A.; Eltanamly, R.; Osman, A. XEN Glaucoma Implant with Mitomycin C 1-Year Follow-Up: Result and Complications. *J Ophthalmol* **2017**, *2017*, 5457246, doi:10.1155/2017/5457246.
10. Reitsamer, H.; Sng, C.; Vera, V.; Lenzhofer, M.; Barton, K.; Stalmans, I.; Apex Study Group Two-Year Results of a Multicenter Study of the Ab Interno Gelatin Implant in Medically Uncontrolled Primary Open-Angle Glaucoma. *Graefes Arch Clin Exp Ophthalmol* **2019**, *257*, 983–996, doi:10.1007/s00417-019-04251-z.
11. Reitsamer, H.; Vera, V.; Ruben, S.; Au, L.; Vila-Arteaga, J.; Teus, M.; Lenzhofer, M.; Shirlaw, A.; Bai, Z.; Balaram, M.; et al. Three-Year Effectiveness and Safety of the XEN Gel Stent as a Solo Procedure or in Combination with Phacoemulsification in Open-Angle Glaucoma: A Multicentre Study. *Acta Ophthalmol* **2022**, *100*, e233–e245, doi:10.1111/aos.14886.
12. Schlenker, M.B.; Gulamhusein, H.; Conrad-Hengerer, I.; Somers, A.; Lenzhofer, M.; Stalmans, I.; Reitsamer, H.; Hengerer, F.H.; Ahmed, I.I.K. Efficacy, Safety, and Risk Factors for Failure of Standalone Ab Interno Gelatin Microstent Implantation versus Standalone Trabeculectomy. *Ophthalmology* **2017**, *124*, 1579–1588, doi:10.1016/j.ophtha.2017.05.004.
13. Tan, S.Z.; Walkden, A.; Au, L. One-Year Result of XEN45 Implant for Glaucoma: Efficacy, Safety, and Postoperative Management. *Eye (Lond)* **2018**, *32*, 324–332, doi:10.1038/eye.2017.162.
14. Marcos-Parra, M.T.; Mendoza-Moreira, A.L.; Moreno-Castro, L.; Mateos-Marcos, C.; Salinas-López, J.A.; Figuerola-García, M.B.; González-Alonso, Á.; Pérez-Santonja, J.J. 3-Year Outcomes of XEN Implant Compared With Trabeculectomy, With or Without Phacoemulsification for Open Angle Glaucoma. *J Glaucoma* **2022**, *31*, 826–833, doi:10.1097/IJG.0000000000002090.
15. Poelman, H.J.; Pals, J.; Rostamzad, P.; Bramer, W.M.; Wolfs, R.C.W.; Ramdas, W.D. Efficacy of the XEN-Implant in Glaucoma and a Meta-Analysis of the Literature. *J Clin Med* **2021**, *10*, 1118, doi:10.3390/jcm10051118.
16. Sheybani, A.; Lenzhofer, M.; Hohensinn, M.; Reitsamer, H.; Ahmed, I.I.K. Phacoemulsification Combined with a New Ab Interno Gel Stent to Treat Open-Angle Glaucoma: Pilot Study. *J Cataract Refract Surg* **2015**, *41*, 1905–1909, doi:10.1016/j.jcrs.2015.01.019.
17. Lenzhofer, M.; Kersten-Gomez, I.; Sheybani, A.; Gulamhusein, H.; Strohmaier, C.; Hohensinn, M.; Burkhard Dick, H.; Hitzl, W.; Eisenkopf, L.; Sedarous, F.; et al. Four-Year Results of a Minimally Invasive Transscleral Glaucoma Gel Stent Implantation in a Prospective Multi-Centre Study. *Clin Exp Ophthalmol* **2019**, *47*, 581–587, doi:10.1111/ceo.13463.
18. Lavin-Dapena, C.; Cordero-Ros, R.; D'Anna, O.; Mogollón, I. XEN 63 Gel Stent Device in Glaucoma Surgery: A 5-Years Follow-up Prospective Study. *Eur J Ophthalmol* **2021**, *31*, 1829–1835, doi:10.1177/1120672120952033.
19. Fea, A.M.; Menchini, M.; Rossi, A.; Posarelli, C.; Malinverni, L.; Figus, M. Early Experience with the New XEN63 Implant in Primary Open-Angle Glaucoma Patients: Clinical Outcomes. *J Clin Med* **2021**, *10*, 1628, doi:10.3390/jcm10081628.
20. Fea, A.M.; Menchini, M.; Rossi, A.; Posarelli, C.; Malinverni, L.; Figus, M. Outcomes of XEN 63 Device at 18-Month Follow-Up in Glaucoma Patients: A Two-Center Retrospective Study. *J Clin Med* **2022**, *11*, 3801, doi:10.3390/jcm11133801.
21. Prokosch-Willing, V.; Vossmerbaeumer, U.; Hoffmann, E.; Pfeiffer, N. Suprachoroidal Bleeding After XEN Gel Implantation. *J Glaucoma* **2017**, *26*, e261–e263, doi:10.1097/IJG.0000000000000795.
22. Liu, J.C.; Green, W.; Sheybani, A.; Lind, J.T. Intraoperative Suprachoroidal Hemorrhage during Xen Gel Stent Implantation. *Am J Ophthalmol Case Rep* **2020**, *17*, 100600, doi:10.1016/j.ajoc.2020.100600.
23. Wang, K.; Wang, J.C.; Sarrafpour, S. Suprachoroidal Hemorrhage after XEN Gel Implant Requiring Surgical Drainage. *J Curr Glaucoma Pract* **2022**, *16*, 132–135, doi:10.5005/jp-journals-10078-1378.
24. Linton, E.; Au, L. Technique of Xen Implant Revision Surgery and the Surgical Outcomes: A Retrospective Interventional Case Series. *Ophthalmol Ther* **2020**, *9*, 149–157, doi:10.1007/s40123-020-00234-0.

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25. Midha, N.; Gillmann, K.; Chaudhary, A.; Mermoud, A.; Mansouri, K. Efficacy of Needling Revision After XEN Gel Stent Implantation: A Prospective Study. *J Glaucoma* **2020**, *29*, 11–14, doi:10.1097/IJG.0000000000001394.
26. José, P.; Teixeira, F.J.; Barão, R.C.; Sens, P.; Abegão Pinto, L. Needling after XEN Gel Implant: What's the Efficacy? A 1-Year Analysis. *Eur J Ophthalmol* **2021**, *31*, 3087–3092, doi:10.1177/1120672120963447.
27. Ventura-Abreu, N.; Dotti-Boada, M.; Muniesa-Royo, M.J.; Izquierdo-Serra, J.; González-Ventosa, A.; Millá, E.; Pazos, M. XEN45 Real-Life Evaluation: Survival Analysis with Bleb Needling and Major Revision Outcomes. *Eur J Ophthalmol* **2021**, 11206721211012848, doi:10.1177/11206721211012847.
28. Steiner, S.; Resch, H.; Kiss, B.; Buda, D.; Vass, C. Needling and Open Filtering Bleb Revision after XEN-45 Implantation-a Retrospective Outcome Comparison. *Graefes Arch Clin Exp Ophthalmol* **2021**, *259*, 2761–2770, doi:10.1007/s00417-021-05204-1.
29. Fernández-García, A.; Zhou, Y.; García-Alonso, M.; Andrango, H.D.; Poyales, F.; Garzón, N. Comparing Medium-Term Clinical Outcomes Following XEN® 45 and XEN® 63 Device Implantation. *J Ophthalmol* **2020**, *2020*, 4796548, doi:10.1155/2020/4796548.

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