• Brief Report •

Different compression sutures combined with intracameral air injection for acute corneal hydrops

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Abstract

● **AIM:** To evaluate the efficacy and safety of full-thickness sutures combined with intracameral air injection (FTS-AI) versus pre-Descemet's membrane sutures combined with intracameral air injection (PDS-AI) in the management of acute corneal hydrops in keratoconus.

● **METHODS:** The research included 8 patients (8 eyes) suffering from acute corneal hydrops caused by keratoconus. Four patients were randomly assigned to FTS-AI. And the other four were randomly assigned to PDS-AI. Corneal oedema, visual acuity, corneal thickness were assessed during follow-up.

● **RESULTS:** The demographics, preoperative duration of symptoms and severity of corneal hydrops between the two groups were not significantly different. The mean corneal oedema resolution time after FTS-AI and PDS-AI were 11±1.15 and 15±1.41d, respectively (P=0.005). The maximum corneal thickness of the scarred region decreased in both groups at one week postoperatively (P<0.05). No obvious difference was found in the mean maximal corneal thickness between the two groups postoperatively. The BCVA improved significantly after FTS-AI and PDS-AI at three months postoperatively. No obvious difference was found in the BCVA after FTS-AI and PDS-AI at three months postoperatively.

● **CONCLUSION:** FTS-AI and PDS-AI are safe and effective therapies to accelerate the resolution of corneal oedema in acute corneal hydrops secondary to keratoconus. Despite faster resolution of corneal oedema in the FTS-AI group, we recommend PDS-AI to avoid potential endothelium cell damage.

● **KEYWORDS:** keratoconus; acute corneal hydrops; full-thickness sutures; pre-Descemet's membrane sutures; intracameral air injection

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INTRODUCTION

As a component of ectatic corneal disorders, acute corneal hydrops is brought by rupture of Descemet's membrane (DM) and endothelium. Corneal hydrops occurred in approximately 2.6%-2.8% of patients with keratoconus[1-2]. It is hard for acute corneal hydrops to regress spontaneously, and long-lasting oedema may cause many potential complications, such as infection, pseudocyst formation, malignant glaucoma, corneal perforation, neovascularization, and a high risk of graft rejection[3-5]. Eventually, leaving a visual-impairing scar, which needs keratoplasty to restore visual function. The traditional treatment regimen includes topical eye drops, such as hypertonic saline, antibiotics, cycloplegics and corticosteroids[5]. In the last ten years, repeated intracameral injection of air/gas had been reported to accelerate the resolution of oedema, but this procedure may increase the risk of pupillary block glaucoma, intrastromal migration of gas, and endothelium dysfunction[6-8]. Sometimes, the air/gas bubble can get access to the potential space and stop re-apposition of the edges in patients with large gaping tears and stromal clefts. Based on the above situations, compression sutures, including full-thickness sutures (FTS) and pre-DM sutures (PDS) combined with intracameral air/gas injection have been reported effective in the administration of acute corneal hydrops[9-11]. In this study, we aim to compare the efficacy and safety of FTS combined with intracameral air injection (FTS-AI) versus PDS combined with intracameral air injection (PDS-AI) in acute corneal hydrops caused by keratoconus. For all we know, no research compares the clinical results between FTS-AI and PDS-AI.

SUBJECTS AND METHODS

Ethical Approval Approved by the Institutional Review

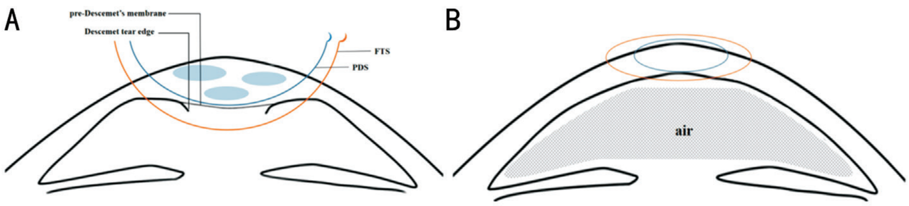

Figure 1 Illustration of the surgical procedure A: An FTS or PDS suture was applied at the margin of the oedematous cornea and clear cornea, and retrieved from the opposite clear cornea; B: An air bubble was injected to fill half of the AC. FTS: Full-thickness sutures; PDS: Pre-Descemet's membrane sutures; AC: Anterior chamber.

Board of Guizhou Provincial People's Hospital, this retrospective case series research met the tenets of the Declaration of Helsinki. All patients have given informed consent and did not received a stipend.

Eight patients (8 eyes) with acute corneal hydrops caused by keratoconus presented to our institute between January 2019 and December 2020, who was randomly assigned to received FTS-AI or PDS-AI, were included. All the patients were men. The mean age was 18.4±2.45y (range, 14-22y). All patients suffered from spontaneous and sudden onset of reduced visual acuity, pain, redness, and epiphora in the eyes within 2wk.

The collection of data was made preoperatively and at 1d, 1wk, 1mo (±3d), and 3mo (±3d) postoperatively. Best-corrected visual acuity (BCVA), slit-lamp examination, intraocular pressure (IOP) and the maximum corneal thickness, measured by anterior segment optical coherence tomography (AS-OCT; Visante OCT; Carl Zeiss Meditec, Germany), were noted.

The entire elimination of epithelial and stromal oedema on slit-lamp examination were regarded as hydrops resolution[12].

Surgical Procedure Surgeries were carried out by a single experienced surgeon under peribulbar anaesthesia. First, after removing the epithelium, the surgeon marked the rupture site and delineated the torn edges of DM. If it is difficult to distinguish the torn edges of DM, a limbal paracentesis was conducted at the 10-o'clock position, and an injection of an air bubble into the anterior chamber (AC) was made to improve the visibility. Then, an FTS or PDS using 10-0 nylon suture was applied at the margin of the oedematous cornea and clear cornea, and retrieved from the opposite clear cornea. At the end of the procedure, an injection of an air bubble to fill half of the AC was made (Figure 1). Patients shall lie down in supine position for at least 8h postoperatively. Postoperative therapy included 1% prednisolone acetate eye drops (Allergan, Ireland) three times a day, 0.5% levofloxacin eye drops (Santen Pharmaceutical, Japan) four times a day, and 0.5% tropicamide phenylephrine eye drops (Santen Pharmaceutical, Japan) to dilate the pupil four times a day until the air bubble in the AC completely absorbed. Compression sutures were removed when they received keratoplasty.

Statistical Analysis IBM SPSS version 20 was adopted to conduct all statistical analyses. The independent samples *t*-test was used to compare the age and symptom duration between the two groups, after confirmation of normality by the Kolmogorov-Smirnov test. The BCVA and maximum corneal thickness between the two groups were compared by applying the related-samples Friedman's two-way analysis of variance by ranks. Visual acuity was converted to the logarithm of the minimum angle of resolution acuity (logMAR). The standards below were adopted: counting fingers = decimal acuity of 0.014 and examining hand motion = decimal acuity of 0.005[12]. It was recognized that P values <0.05 were statistically significant.

RESULTS

No significant differences were found in the demographics, preoperative duration of symptoms and severity of corneal hydrops between the two groups (Table 1). The mean age of participants in FTS-AI and PDS-AI groups was 19±2.16y (range 17-22y) and 17.75±2.87y (range 14-21y), respectively (P=0.51). The mean duration of symptoms before FTS-AI and PDS-AI was 9.50±2.08 and 9.25±2.06d, respectively (P=0.87). The mean maximal corneal thickness, evaluated by AS-OCT, before FTS-AI and PDS-AI was 2.04±0.20 and 1.95±0.23 mm, respectively (P=0.686). No complication happened and all participants completed the follow-up.

No one needed repeated air injection. The mean corneal oedema resolution time after FTS-AI and PDS-AI were 11±1.15 and 15±1.41d, respectively (P=0.005). The maximum corneal thickness of the scarred area, assessed by AS-OCT, reduced in both groups after surgery (Figures 2 and 3). Three months after surgery, the maximum corneal thickness of the scarred area assessed by AS-OCT in FTS-AI and PDS-AI groups were 0.44±0.07 and 0.45±0.03 mm, respectively (P=0.486; Table 2). BCVA was significantly improved after FTS-AI and PDS-AI at 3mo postoperatively (P<0.05). No obvious difference was found in the BCVA after FTS-AI and PDS-AI postoperatively (P>0.05; Table 3).

DISCUSSION

The DM rupture in keratoconus is used to be considered as the cause of corneal hydrops. There are two conditions necessary

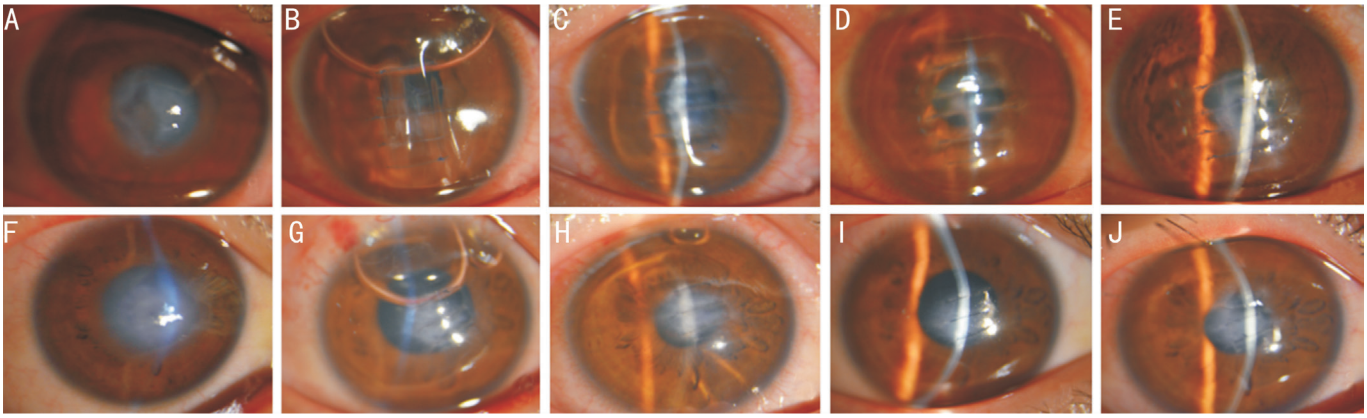

Figure 2 Preoperative and postoperative photos of the eyes following FTS-AI and PDS-AI A-E: The images following FTS-AI. A: Preoperative image; B: 1d after FTS-AI; C: 1wk after FTS-AI; D: 1mo after FTS-AI; E: 3mo after FTS-AI. F-J: The images following PDS-AI. F: Preoperative image; G: 1d after PDS-AI; H: 1wk after PDS-AI; I: 1mo after PDS-AI; J: 3mo after PDS-AI. FTS-AI: Full-thickness sutures combined with intracameral air injection; PDS-AI: Pre-Descemet's membrane sutures combined with intracameral air injection.

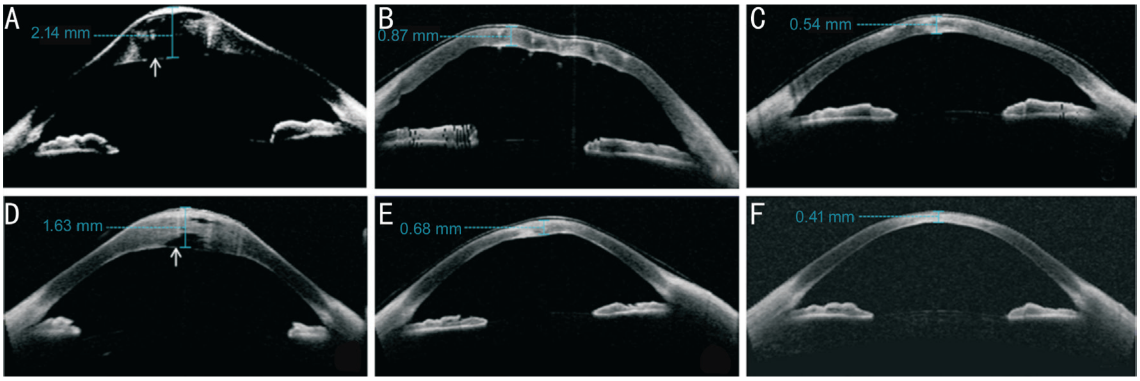

Figure 3 Preoperative and postoperative AS-OCT photos of the eyes following FTS-AI and PDS-AI A-C: The images following FTS-AI. A: Preoperative image displays Descemet's tear and serious oedema; B: 1wk after FTS-AI, shows reduced corneal oedema and attached Descemet's membrane; C: 3mo after FTS-AI. D-F: The images following PDS-AI. The images of prepoerative (D), 1wk after PDS-AI (E), 3mo after PDS-AI (F), respectively. AS-OCT: Anterior segment optical coherence tomography; FTS-AI: Full-thickness sutures combined with intracameral air injection; PDS-AI: Pre-Descemet's membrane sutures combined with intracameral air injection.

Table 1 Baseline and postoperative data of all patients

Patient	Age (y)	Duration of the oedema (d)		Oedema diameter (mm)	Surgery type	BCVA (logMAR)				Corneal thickness (mm)			
		Before	After			Pre	1wk	1mo	3mo	Pre	1wk	1mo	3mo
1	17	9	12	5	FTS-AI	2.30	1.22	0.82	0.82	2.14	0.87	0.70	0.54
2	19	7	10	3	FTS-AI	2.30	1.40	1.22	1.00	1.94	0.91	0.53	0.40
3	22	10	12	5	FTS-AI	2.30	1.22	0.60	0.40	2.26	0.96	0.58	0.43
4	18	12	10	5	FTS-AI	1.85	1.22	1.0	0.70	1.82	0.86	0.53	0.40
5	21	12	17	3	PDS-AI	1.85	1.16	0.82	0.60	1.63	0.68	0.63	0.41
6	14	7	14	5	PDS-AI	1.85	1.40	0.82	0.70	2.08	0.87	0.61	0.48
7	18	9	14	5	PDS-AI	1.85	1.22	0.7	0.52	1.91	0.89	0.52	0.46
8	18	9	15	5	PDS-AI	2.30	1.40	1.00	0.60	2.16	0.97	0.68	0.44

BCVA: Best-corrected visual acuity; FTS-AI: Full-thickness sutures combined with intracameral air injection; PDS-AI: Pre-Descemet's membrane sutures combined with intracameral air injection.

for the healing process: first, it is necessary to reattach the retracted or rolled DM to the stroma, and afterwards, the endothelium cells must enlarge and slowly migrate to cover the whole flaw.

In recent years, more and more surgical interventions have emerged to accelerate the resolution for corneal hydrops. As early as 1988, Zusman *et al*[13] proposed that intracameral sulfur hexafluoride (SF_6) injection could repair DM detachment.

Table 2 Baseline and postoperative stands for maximum corneal thickness

Group	Baseline (mm)	1wk (mm)	1mo (mm)	3mo (mm)
FTS-AI	2.04 (1.82, 2.26)	0.9 (0.86, 0.96)	0.59 (0.53, 0.7)	0.44 (0.4, 0.54)
P^a	-	1.000	0.171	0.006
PDS-AI	1.95 (1.63, 2.16)	0.9 (0.86, 0.96)	0.61 (0.52,0.68)	0.45 (0.41, 0.48)
P^a	-	1.000	0.086	0.001
P^b	0.686	0.886	1.000	0.486

FTS-AI: Full-thickness sutures combined with intracameral air injection; PDS-AI: Pre-Descemet's membrane sutures combined with intracameral air injection. Bonferroni-modified *P* value was reported to occupy various comparisons. [a]Intragroup comparison with baseline; [b]Intergroup comparison.

Table 3 Baseline and postoperative best modified visual acuity (logMAR)

Group	Baseline	1wk	1mo	3mo
FTS	2.19 (1.85, 2.3)	1.27 (1.22, 1.40)	0.91 (0.6, 1.22)	0.73 (0.40, 1.00)
P^a	-	1.000	0.120	0.001
PDS	1.96 (1.85, 2.30)	1.30 (1.16, 1.40)	0.84 (0.70, 1.00)	0.61 (0.52, 0.70)
P^a	-	1.000	0.171	0.006
P^b	0.343	1.000	0.686	0.343

FTS-AI: Full-thickness sutures combined with intracameral air injection; PDS-AI: Pre-Descemet's membrane sutures combined with intracameral air injection. Bonferroni-modified *P* value was reported to occupy various comparisons. [a]Intragroup comparison with baseline; [b]Intergroup comparison.

Afterwards, various kinds of agents like air[14-15], SF_6[16], perfluoropropane (C_3F_8)[17-18], sodium hyaluronate[19], intrastromal fluid drainage with air tamponade[20], tissue glue[21], intracameral platelet-rich plasma injection[22], and descemet membrane endothelial keratoplasty (DMEK)[23-24] have been proven effective in treating acute corneal hydrops. Among these techniques, intracameral air/gas injection has been widely proven for the acceleration of the resolution of corneal oedema[25-26]. In 2008, Vanathi *et a*l[16] reported that through intracameral air injection, corneal oedema subsided within 20.1±9.0d versus 64.7±34.6d who received conventional treatment in patients with corneal hydrops. However, the nonexpansibility and rapid absorption of air limit the usage in such patients. Undiluted C_3F_8 expands 4 times in 4d, and 14% dilution persists in the AC for about 6wk. SF_6 expands twice in 24 to 48h, and it takes 2wk for entire absorption from the AC[16]. Nevertheless, there are some limits to these approaches: first, C_3F_8 may be toxic to the endothelium cells[27]; second, the long duration of the gas increases the possibility of secondary glaucoma[3]; third, some tiny bubbles can penetrate the stroma, which can prevent the re-apposition of intrastromal clefts; what's more, Basu *et al*[28] found that even after injection of C_3F_8, a gap between the two ends of the split DM could be found histopathologically after the edema subsided.

Based on the above reasons, compression sutures combined with intracameral air/gas injection have emerged these years. Compression sutures can shorten the edges of the DM tear and facilitate anatomical re-apposition. Rajaraman *et al*[10] proposed using intracameral C_3F_8 injection and FTS can effectively hasten the resolution of oedema compared to simply C_3F_8 intracameral injection. In 2015, Yahia Chérif *et al*[9] found that intracameral air injection and PDS also could hasten the corneal oedema resolution, and theorized that the source of the corneal hydrops were posterior stromal breaks. In 2019, Parker *et al*[29] found that the entire elimination of DM did not generate hydrops in patients with keratoconus. In contrast, eyes underwent Bowman layer transplantation complicated by accidental perforation of posterior corneal stroma and DM elicited a typical corneal hydrops. This research further demonstrated the pathophysiological mechanism of corneal hydrops, indicating that it is not sufficient for a flaw at the level of DM for the elicitation of an acute corneal hydrops, unless accompanied by a flaw in the most posterior stroma layers (the so-called Dua's layer) at the same time[29].

Mohebbi *et al*[30] raised that FTS combined intracameral SF_6 injection was effective and safe in treating corneal hydrops. Zhao *et al*[14] found that PDS-AI possessing superior clinical outcomes than thermokeratoplasty for administrating acute corneal hydrops in keratoconus[31]. From aforementioned researches, the meantime for resolving corneal oedema was longer in Yahia Chérif *et al*[9] and Zhao *et al*'s[14] research than Rajaraman *et al*'s[10] and Mohebbi *et al*'s[30] research (15 and 14 *vs* 8.87±4.98 and 11.5±6.5d). From the above statistics, it is hard for us to distinguish that is the suture depth or the injection agents the decisive factor for accelerating corneal oedema resolution. Because the PDS group used air while the FTS group used gas. So in our study, all patients were injected air in the AC. The result showed that the meantime for corneal oedema resolution is still longer in the PDS-AI group than the FTS-AI group (15±1.41 *vs* 11±1.15d). Hence, we suspect this is related to the early recovery of corneal endothelium pump. On the other hand, no obvious difference was found in BCVA and the maximum corneal thickness of the scarred area at 3mo after surgery. Considering the potential damage to the endothelium cells in the FTS group, just a few days earlier oedema resolution time and the similar outcomes of BCVA and corneal thickness, we prefer PDS-AI management in treating acute corneal hydrops to avoid unnecessary endothelium cell damage.

This research has several limitations such as small sample size and retrospective nature. Besides, using a slit-lamp to estimate the corneal oedema resolution is subjective. Nevertheless, because both groups have the same difference, this may not be a great concern. Additionally, we did not evaluate the status of endothelium cells before or after the operation. In future study, if possible, comparing the clinical and histopathological correlation between the two surgical procedures may be more instructive.

FTS-AI and PDS-AI are safe and effective therapies to reduce the period of corneal oedema in acute hydrops secondary to keratoconus. Despite the less time for corneal oedema resolution in the FTS-AI group, we recommend PDS-AI to avoid potential endothelium cell damage.

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