

Selective retina therapy (SRT) of chronic subfoveal fluid after surgery of rhegmatogenous retinal detachment: three case reports

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Abstract

Background Shallow subfoveal fluid accumulation after successful surgery for retinal detachment can be the reason for compromised visual acuity. To date, therapeutical options to tackle this problem have not been established. Selective retina therapy (SRT) is a new laser technology that uses a train of μ s-laser pulses to selectively damage retinal pigment epithelial (RPE) cells while sparing retinal structures.

Methods We treated three patients with chronic subfoveal fluid accumulation after retinal detachment surgery. The median period between retinal surgery and SRT treatment was 7 months. For SRT, we used a prototype frequency-doubled, Q-switched Nd:YLF laser ($\lambda=527$ nm). Each laser exposition contained 30 pulses ($t=1,7$ μ s, 100 Hz, $E=100$ – 400 μ J). Two of the three patients were treated subfoveally. OCT III (optical coherence tomography) examinations were performed to evaluate changes in subretinal fluid accumulation.

Results In all three patients, we observed complete resolu-

tion of subfoveal fluid within 1–5 months. Follow-up has been 16 months to 2 years. Visual acuity improved in all patients. In one patient, cystoid macular edema developed 3 months after treatment. Additional SRT treatments were not necessary.

Conclusion SRT is a safe treatment. Visual acuity improved after SRT, even in subfoveal irradiations. SRT is an option to support subretinal fluid reabsorption. In this situation where no other therapeutical options are established, SRT may be a beneficial treatment for chronic subfoveal fluid accumulation after retinal detachment surgery.

Keywords Retinal detachment · Chronic subretinal fluid · Optical coherence tomography · OCT · Pulsed laser · Nanosecond laser · Subthreshold laser · Selective retina therapy · SRT · Selective photocoagulation · Retinal pigment epithelium · RPE · Foveal reattachment

Introduction

Optical coherence tomography (OCT) examinations have shown that chronic subfoveal fluid can be a reason for compromised visual acuity after surgery of retinal detachment [1–4].

Since longstanding shallow detachment of the neurosensory retina leads to chronic degenerative changes with subsequent functional impairment, it is desirable to achieve subretinal fluid reabsorption as soon as possible. Although other investigators are working on a pharmacological enhancement of the retinal pigment epithelium (RPE) outflow capabilities, no established therapy is available.

Selective retina therapy (SRT) is a new laser-based method that selectively damages the RPE and spares

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neurosensory retinal tissue [5–9]. SRT has already been performed in patients with drusen due to age-related macula degeneration [10], in patients with diabetic maculopathy [11] and in patients with central serous chorioretinopathy [12]. It has been shown to be safe. Microperimetry using the Rodenstock SLO 101 has proven that SRT does not cause microscotoma [13, 14].

Because the RPE lesions are ophthalmoscopically invisible during and after treatment, a dosimetry control is achieved optoacoustically [15]. The selective destruction of the RPE cells originates from microbubbles forming around the intracellular melanosomes after the vaporisation temperature at the melanosome surface is exceeded. Owing to microbubble expansion and dynamics, the cell is disintegrated thermo-mechanically.

Considering its concept, SRT seems to be an option to treat chronic subretinal fluid. We hypothesise that SRT stimulates RPE metabolism and enhances RPE outflow capability. We retrospectively evaluated the effects of SRT treatment in three patients with chronic subretinal fluid accumulation after retinal detachment surgery.

Material and methods

Patients

Chart reviews of three patients with chronic subfoveal fluid after retinal detachment surgery were performed. All patients were treated with SRT after having signed written informed consent.

Clinical examination

Each patient underwent a complete ophthalmological examination including Snellen visual acuity, refraction, slit-lamp biomicroscopy with a 78 diopter indirect lens and indirect ophthalmoscopy.

Fluorescence angiographies (FLA) were performed using the Heidelberg Retina Angiograph, HRA 2 (Heidelberg Engineering GmbH, Germany). For OCT we used the OCT-3 (Zeiss Humphrey, Dublin, CA, USA).

Treatment

SRT was performed with a non-commercial prototype (Medical Laser Center Lübeck GmbH, Lübeck, Germany, in cooperation with Lumenis Ltd., Santa Clara, CA, USA), manufactured in accordance with the essential requirements of the medical device directive 93/42EEC of the European Community. The system consists of a frequency-doubled Q-switched Nd:YLF laser, which emits at a wavelength of 527 nm in a 100 Hz pulsed mode. Each SRT pulse has a

duration of 1.7 μ s. During each SRT exposition, a train of 30 pulses is applied. The laser spot size in air is 200 μ m. Single pulse energies ranged from 100 to 400 μ J. The SRT system is a slit-lamp-adapted device, where we used a Mainster contact lens for laser transmission (magnification 1.05 fold). Prior to treatment, test expositions of different energies were placed close to an arcade in order to generate optoacoustic data. An ultrasonic transducer located in the contact lens detected this data. After computerized data processing, the adequate laser pulse energy was calculated (details of the method and algorithm were published by Schüle et al. [15]). The area of subretinal fluid accumulation was treated in a grid pattern. One hour after SRT, fluorescein and ICG angiographies were performed to verify SRT lesions. If the angiographies had shown no laser effect, retreatment with higher energy levels would have been performed. Due to accurate dosimetry, one single SRT session was sufficient in all patients.

Results

Case 1

A 67-year-old female patient received buckling surgery at our clinic because of a macula-off retinal detachment on the right eye. Visual acuity prior to surgery was 20/400 on the right and 20/30 on the left eye. Five months after surgery, visual acuity of the right eye had improved to 20/120, but on OCT, and funduscopically, shallow subfoveal fluid was detected extending from the fovea to the scleral buckle (Figs. 1, 2a,b). SRT was performed treating the elevated area (12 test expositions, 61 therapeutical expositions, 300–400 μ J, Fig. 2 c). Five months later, subretinal fluid had

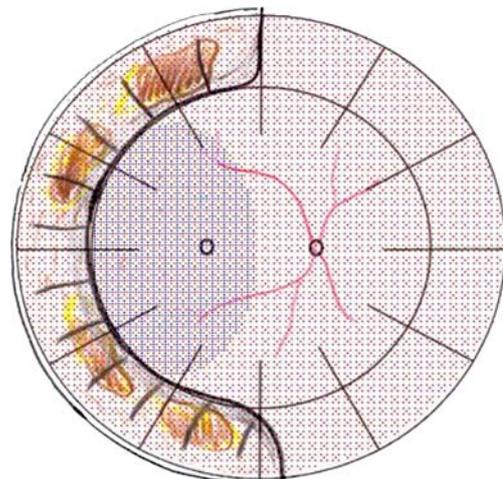
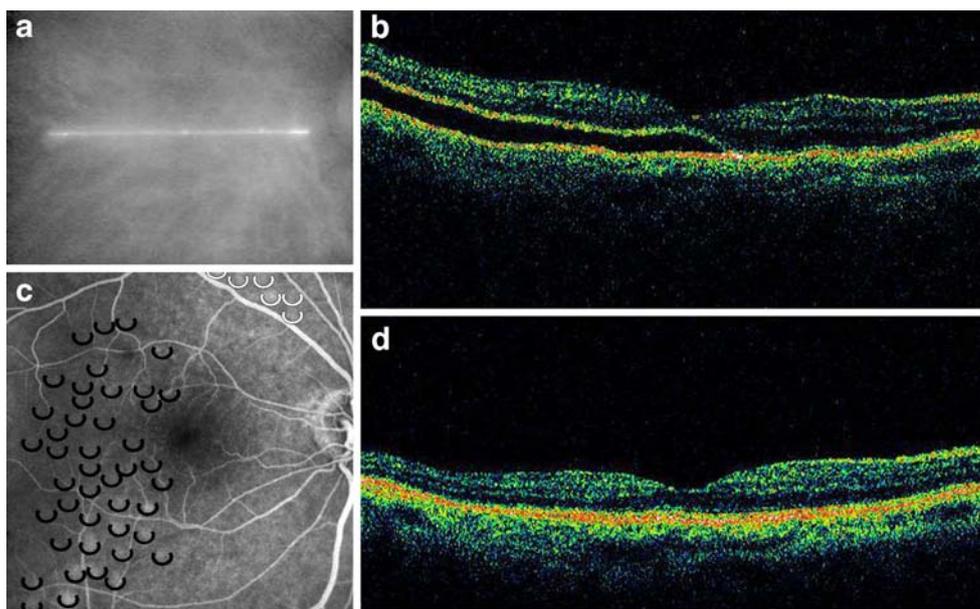


Fig. 1 Fundus drawing of case 1, showing shallow subretinal fluid accumulation as discovered on OCT affecting the fovea after buckling surgery

Fig. 2 Composite of findings - patient 1. **a** OCT section plane of **b** and **d**. **b** OCT before SRT treatment. **c** FLA late phase 1 hour after SRT treatment; test expositions are demarcated by a *white bow* ($n=12$), treatment spots are demarcated by a *black bow* ($n=61$). Not all expositions are located within the picture. **d** OCT 5 months after SRT treatment



resolved (Fig. 2a,d). Sixteen months after the SRT treatment, visual acuity had improved to 20/80.

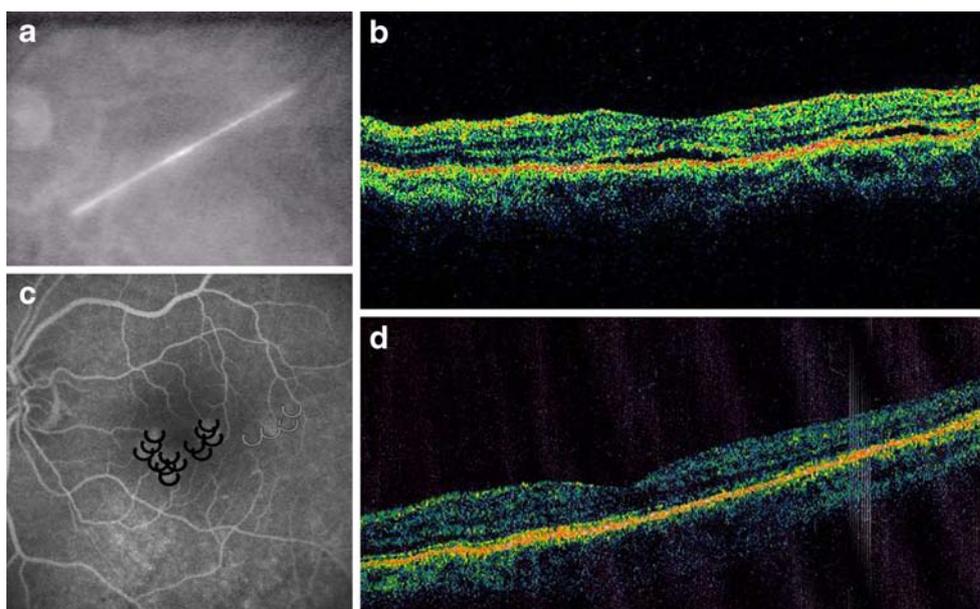
Case 2

A 35-year-old male patient was referred to our clinic 7 months after buckling surgery because of macula-off retinal detachment on the left eye. Visual acuity prior to surgery had been 20/200. Myopia was present in both eyes (OD $-3,75/-0,5/61^\circ$; OS $-5,25$). During childhood, the patient had undergone surgery for strabismus, but there was no known amblyopia.

Visual acuity at the first presentation was 25/20 on the right and 20/100 on the left eye. In the right eye, a

peripheral retinal detachment was present. It was demarcated by argon laser scars. In the left eye, OCT showed some subretinal fluid located subfoveally and temporal to the fovea (Fig. 3a,b). SRT treatment was performed sub- and extrafoveally. In this case, test expositions were applied to the extrafoveal pathology and had a therapeutical effect as well (total 17 spots, 100–200 μJ , Fig. 3c). One month later, the subretinal fluid had resolved, but visual acuity was still 20/100 (Fig. 3b,d) and the patient reported persistently reduced visual acuity and disturbed color perception. An OCT picture taken 9 months after SRT showed no subretinal fluid. Twenty-two months after SRT, visual acuity on the left eye had improved to 20/60.

Fig. 3 Composite of findings - patient 2. **a** OCT section plane of **b** and **d**. **b** OCT before SRT treatment. **c** FLA late phase 1 hour after SRT treatment; test expositions were used to treat an area of extrafoveal subretinal fluid and are demarcated by a *grey bow* ($n=4$), foveal treatment spots are demarcated by a *black bow* ($n=13$). **d** OCT 1 month after SRT treatment



Case 3

This 67-year-old patient was referred to our clinic 9 months after primary surgery on the left eye. Initially, a sectoral scleral buckle had been implanted because of retinal detachment. Due to infection, the scleral buckle had to be removed 2 weeks later. In spite of persistent peripheral retinal detachment, the macula was still attached at that time, and visual acuity in the left eye was 20/40. After 1 week of anti-infectious therapy, an encircling procedure and pars plana vitrectomy with silicone oil tamponade were performed. The detachment nearly reached the fovea at that time, and postoperative visual acuity remained at 20/80. Silicon oil was removed 4 months later, and cataract surgery was performed. On the first visit to our clinic, visual acuity was 20/20 on the right eye and 20/200 on the left eye, where shallow subfoveal fluid accumulation was present (Fig. 4a,b). SRT treatment was performed on the left eye (six test expositions, 22 therapeutic spots, 180–

200 μ J, Fig. 4c). OCT follow-up at close intervals showed an increase in subretinal fluid 1 day after SRT, with complete disappearance after 3 months (Fig. 4a,d-f). Cystoid macular edema developed. During that time, visual function in the left eye was subjectively unchanged, and visual acuity remained 20/200. The cystoid macular edema was successfully treated by intravitreal triamcinolone externally. Four months after SRT and 1 month after triamcinolone, the fovea was completely dry in OCT. 18 months later, visual acuity was 20/100.

Discussion

From clinical experience, we know that visual recovery after retinal detachment surgery can be prolonged. This is especially true for patients with rhegmatogenous retinal detachment presenting preoperatively with a macula-off situation.

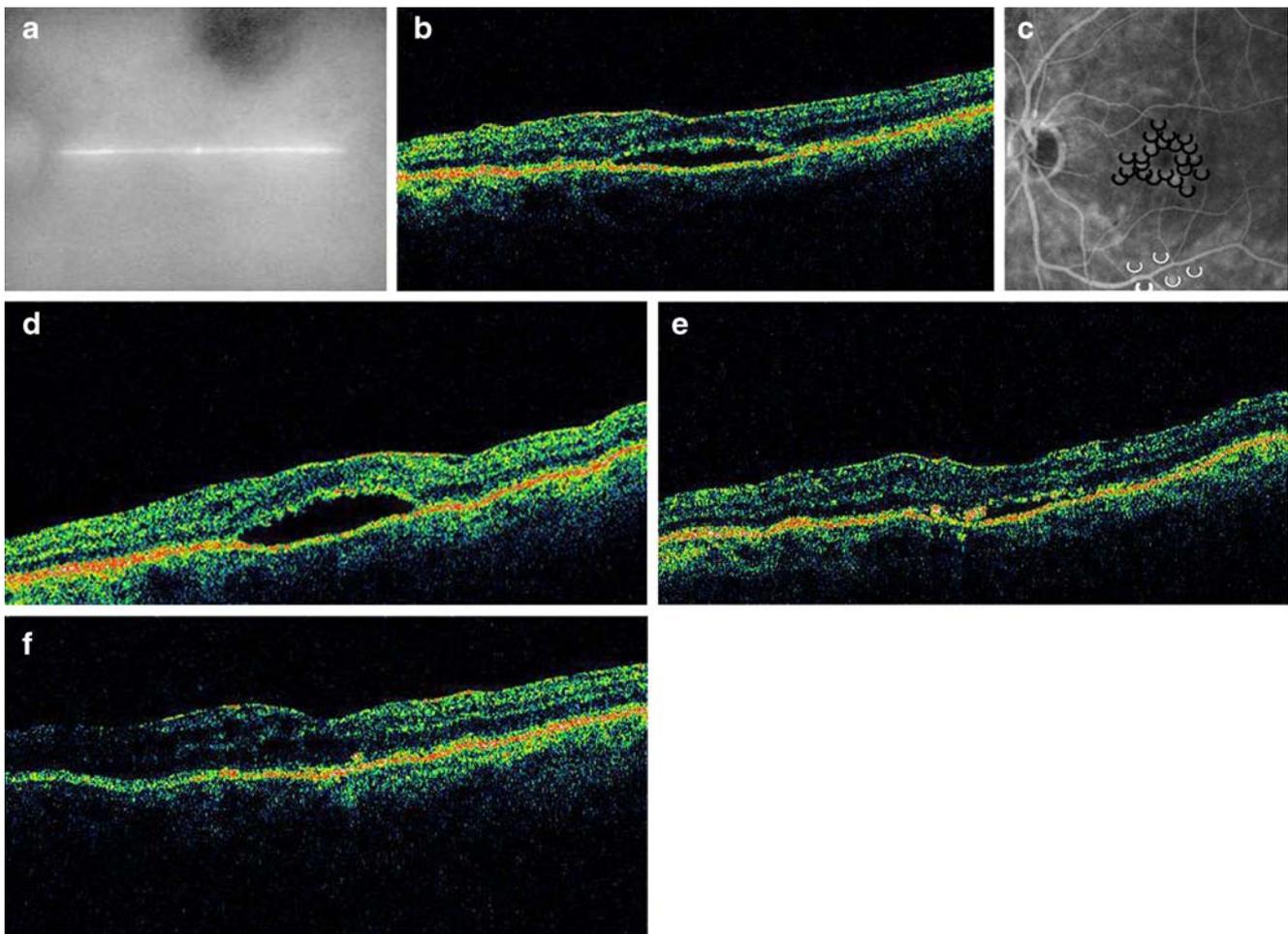


Fig. 4 Composite of findings - patient 3. **a** OCT section plane of **b**, **d**, **e** and **f**. **b** OCT before SRT treatment. **c** FLA late phase 1 hour after SRT treatment; test expositions are demarcated by a *white bow* ($n=6$), treatment spots are demarcated by a *black bow* ($n=22$). Not all

expositions are located within the picture. **d-f** OCT follow-up after 1 day (**d**), 1 month (**e**) and 3 months (**f**) Subretinal fluid increased 1 day after treatment and subsequently faded over 3 months, but cystoid macular edema developed

The three cases described above all received buckling surgery, partly combined with vitrectomy, two of them because of macula-off retinal detachment. Postoperative complete retinal reattachment was achieved as confirmed by funduscopy in cases 2 and 3. In case 1, shallow neurosensory detachment persisted temporal to the fovea, but the fovea itself appeared to be attached. Visual acuity remained reduced during a 5 to 9 month period, and in OCT shallow subfoveal fluid was present in all cases. These findings are in accordance with the findings of other investigators, who found shallow subfoveal fluid accumulation in cases with compromised visual acuity by OCT [3, 4]. There is a higher risk for prolonged subfoveal fluid accumulation after buckle surgery than after vitrectomy [1, 16]. The subfoveal fluid after retinal detachment, unlike the majority of macular edema, is mostly subclinical, and is hardly detectable by indirect ophthalmoscopy or in FLA [3, 17, 18]. For this reason, it has mainly become a matter of debate since OCT was broadly established in clinical routine.

Why subfoveal fluid accumulates in certain patients after retinal detachment surgery is not quite clear. Three major forces drain subretinal fluid. The most important under physiological conditions is an active net outward secretion of ions and water by the RPE cells. Other outward forces are hydrostatic pressure and an osmotic gradient from the subretinal space to the choriocapillaris, both becoming important in outer blood retina barrier (BRB)-damage [21]. Damage to the RPE cells and localized ischemia of the choriocapillaris favor a serous retinal detachment.

In the area of shallow subretinal fluid accumulation, there is no leakage in FLA. A greater mechanical damage to the RPE cells can be excluded. However, the tight adhesion of foveal photoreceptors via a specialized foveal interphotoreceptor matrix could explain a subtle damage to the RPE cells in macula-off retinal detachment. On the other hand, since subfoveal fluid accumulates after buckling surgery rather than after vitrectomy alone [1, 16], some alteration of choriocapillaris perfusion seems to play a role as well. After SRT treatment, a thermo-mechanical damage to RPE cells causes a break in the outer BRB, indicated by leakage in FLA. This BRB interruption facilitates passive egress of subretinal fluid [22]. Furthermore, RPE wound healing may cause replacement of dysfunctional RPE-cells by intact ones that sufficiently drain the subretinal space after SRT treatment.

The three cases described above suffered from prolonged reduced visual acuity after repair of retinal detachment. We were able to successfully drain subfoveal fluid by SRT therapy. Visual acuity improved significantly in cases 1 (20/120 to 20/80) and 2 (20/100 to 20/60), and slightly in case 3 (20/200 to 20/100). However, it remained worse than in the fellow eyes. In all cases, long-standing subfoveal fluid or structural photoreceptor damage might have disturbed visual recovery. Most other investigators found a correla-

tion of shallow subfoveal fluid and reduced visual acuity during a 1-year follow up after retinal detachment repair [2, 3, 18]. However, compromised visual acuity may also be due to structural photoreceptor damage. Ultrahigh resolution OCT and histopathologic examinations revealed anatomical changes in the central retinal architecture after retinal detachment (macula-on or macula-off), including damage to photoreceptor outer segments [19, 20]. Nevertheless, drainage of subretinal fluid is desirable, because it hampers proper photoreceptor function through a diminished metabolism. Subretinal fluid disappeared after SRT treatment in all three cases described above. The fast fading of subretinal fluid in case 2 within 1 month after SRT indicates that the treatment caused subfoveal fluid reabsorption. The detailed OCT follow-up in case 3 (Fig. 4a,d-f) reveals that subretinal fluid increased 1 day after SRT, but faded 1 month later and completely disappeared after 3 months. These findings yield evidence that subretinal fluid drainage did not appear spontaneously, but was caused by SRT treatment. SRT seems to be an effective treatment of chronic subretinal fluid after retinal detachment repair.

Conventional (continuous-wave) argon laser irradiation is absorbed in the pigmented RPE cells, and causes heat-induced coagulation of RPE cells and the adjacent tissues as well, e.g., underlying choriocapillaris and overlying photoreceptor cells. It is contraindicated in the fovea, since it causes microscotoma. The SRT laser uses multiple short laser pulses (30 pulses per spot, pulse duration 1,7 μ s, repetition rate 100 Hz, wavelength 527 nm), causing a high temperature rise around the absorbing melanosomes, where the formation of micro bubbles leads to thermo-mechanical disintegration of the RPE cells. The temperature rise in the RPE cells does not spread to the adjacent tissues, therefore leaving choriocapillaris, photoreceptors and nerve fibres intact. Since the SRT exposition does not cause a nerve-fibre edema like conventional laser irradiation, it is funduscopically invisible. However, in FLA the SRT spots may be visualized as spots of slight leakage. Histopathologically, debris of destroyed RPE cells is removed during a 2-week healing period, and the lesion is covered by a monolayer of RPE cells originating from the surrounding RPE. Bruch's Membrane remains unbroken [7]. In previous studies, SRT has been used to treat diabetic maculopathy and central serous chorioretinopathy [11, 12]. In all these patients, SRT has proven to be safe. The optoacoustic dosimetry control guarantees safe and reproducible placement of SRT lesions. Even subfoveal treatment is possible. None of the patients presented above lost visual acuity due to SRT. SRT appears to be a safe therapy of chronic subfoveal fluid after retinal detachment.

The best point of time and criteria of patient selection for SRT therapy still need to be investigated. As the literature has shown, spontaneous subretinal fluid resorption occurs

within 12 months in the majority of patients [2, 3, 18]. However, the studies do not include enough patients to make out a point in time when photoreceptors have not suffered permanent damage but spontaneous fluid resorption is unlikely. Whether longstanding subfoveal fluid causes photoreceptor damage beyond that which is caused by retinal detachment, and which duration of shallow macular edema is critical, cannot be judged at this point. A 6-month waiting period for spontaneous fluid resorption appears reasonable, and was applied in our case series. Only ultrahigh-resolution OCT could detect if photoreceptor outer segment damage is present which will not allow further visual recovery [19], but this new method has not yet been investigated sufficiently.

The conclusions we can draw are limited due to the small number of patients. However, we observed that subretinal fluid was reabsorbed in relation to SRT, and that visual acuity improved in long-term follow-up. Obviously, SRT-induced reabsorption of subfoveal fluid ameliorates the chances of photoreceptor recovery. These results encourage the continuation of the treatment of chronic subfoveal fluid by SRT, and the collection of data in larger studies.

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