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Electrolytic removal of recurrence of granular corneal dystrophy

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Abstract

Aims **To report the efficacy of corneal electrolysis for the treatment of recurrent corneal opacities at the subepithelial region or at the host–graft interface of the stroma in granular corneal dystrophy (GCD).**

Methods **In patients with recurrences of opacities at the host–graft interface of the stroma after lamellar keratoplasty, the deep aspect of the graft was partially separated from host tissue to expose the deposits. The graft was everted, and electrolysis was applied directly to remove the deposits attached to both surfaces of the host and the graft. Then the graft was returned to its place and sutured. In patients with diffuse subepithelial opacities following penetrating keratoplasty, electrolysis was applied directly to the corneal surface.**

Results **Deposits in the subepithelial region or at the host–graft interface of the stroma disappeared following treatment, and vision recovered. However, GCD recurred 2–3 years after the treatment.**

Conclusions **Corneal electrolysis is a simple, easy, and inexpensive way to remove deposits that recur after lamellar or penetrating keratoplasty for GCD.**

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Keywords: cornea; electrolysis; granular corneal dystrophy; recurrence

Introduction

Granular corneal dystrophy (GCD) is characterized by the deposition of small, discrete, sharply demarcated, greyish white opacities in the anterior stroma. A number of subtypes of GCD have been described that have the same histological features of bright red staining with Masson's trichrome stain and electron-dense rod-like bodies ultrastructurally.[1] GCD, associated with mutations of the *TGFBI* gene, can be classified into three types based on the overall appearance of the cornea:[2] the classic form of Groenouw type 1 associated with an R555W mutation;[3] Avellino corneal dystrophy (ACD), associated with an R124H mutation;[3] and the superficial variant of GCD, associated with an R124L mutation.[4] ACD is the most common form of the three types of GCD in Japan, while GCD Groenouw type 1 is rare,[5] although it is common in Europe or the United States of America.

Lamellar keratoplasty (LKP) or penetrating keratoplasty (PKP) has been performed to treat GCD. Presently, phototherapeutic keratectomy (PTK) is used as a first-line therapy in all three types.[6–8] However, GCDs are known to recur within the graft over several years following keratoplasty[9] or PTK.[10] The recurrences often take the form of diffuse subepithelial deposits after keratoplasty[11] or PTK,[10] and recurrences at the host–graft interface of the stroma are also sometimes observed after LKP.[1] The superficial nature of recurrences may make these amenable to surgical removal by lamellar excision.

In Japan, corneal electrolysis was first used to treat corneal dystrophy by Sato in 1917,[12] and this procedure has sometimes been chosen to be the first treatment of GCD as an alternative to superficial keratectomy.[13–15] Thus, superficial recurrences of GCDs make them amenable to electrolytic removal.

We shall describe the use of this technique to treat diffuse corneal opacities that developed at the subepithelial region of the graft or at the stromal host–graft interface after keratoplasty, thus avoiding regrafting. We shall show that electrolysis is a simple and easy way to remove opacities recurring after the keratoplasty.[16]

Methods and materials

Corneal electrolysis was performed with a digital electrolyser (Figure 1; TE-500: Tagawa Electronic Research Institute, Tokyo, Japan).

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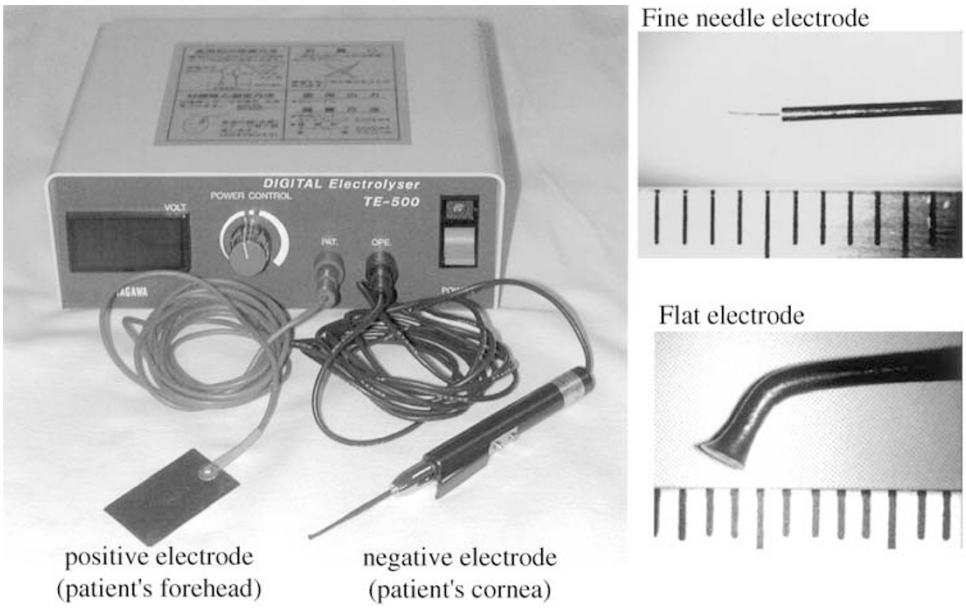

Figure 1 Digital electrolyser and a flat electrode for corneal electrolysis.

This device was originally used for removing inverted eyelashes with fine-needle electrodes. We used a flat electrode that is commercially available in Japan for the treatment of corneal opacities. During the current application in physiologic saline solution, hydrogen gas (H_2) bubbles emerged from the area of the negative electrode (Figure 2). The electric current probably attracted Na^+ to the negative electrode, where it reacts with water producing NaOH and H_2 ($2Na + 2H_2O \rightarrow 2NaOH + H_2$). The NaOH probably dissolved the corneal deposits.

The positive electrode covered with gauze was immersed in isotonic sodium chloride solution (physiologic saline) and taped on the forehead. Xylocaine (2%) was instilled over the surface of the eye for anaesthesia. The flat electrode, as the negative electrode, was placed directly on the surface of the anaesthetized cornea to remove corneal deposits as physiologic saline was dropped on the cornea. During the current application, the whitish, sticky, and tiny bubbles (H_2) emerged around the flat electrode (Figure 3) and were vigorously washed off the surface of the eye with physiologic saline solution. The output voltage and treatment duration were adjusted to clear the opacities. Usually the output voltage was 4–6 V, and the duration of current flow was 3–4 s. This application was repeated until the opacity had essentially cleared, usually about 8–10 times.

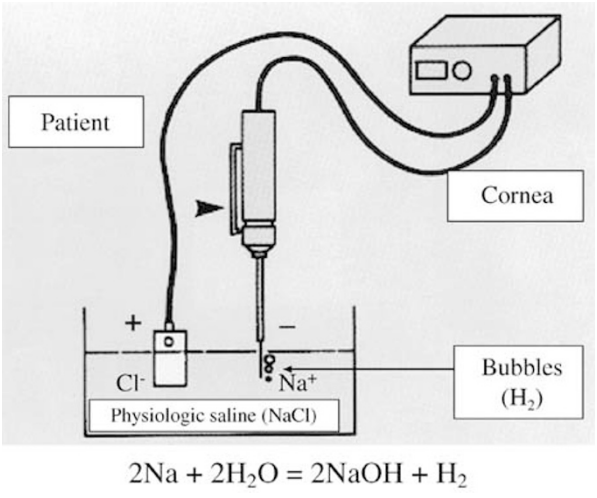

Figure 2 Principle of electrolysis.

Case reports

Patients 1 and 2. Electrolysis was performed on the surfaces of grafts with subepithelial opacities by placing the flat probe directly to the epithelial surface (Figure 3a). As an epithelial defect was present after treatment, a medical soft contact lens was used until corneal epithelialization was completed.

Patient 3. The graft was separated at the level of the host–graft interface using a Crescent Knife (StainCrescent™; Alcon) with one-third of the host–graft junction left intact. The graft was then everted, and corneal electrolysis was performed directly upon the host surface (Figure 3b) and the graft inner surface (Figure 3c). The graft was then returned to its place and sutured with 12 sutures of 10-0 nylon.

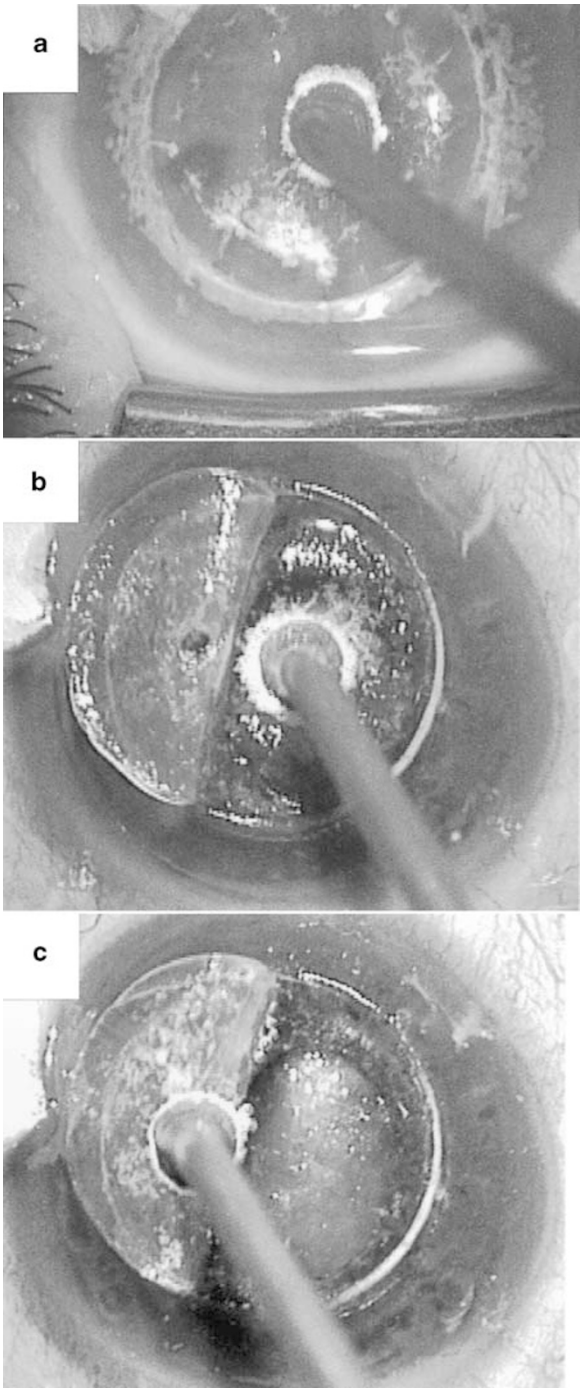

Figure 3 Corneal electrolysis for recurrent granular deposits. During the current application, the whitish, sticky, and tiny bubbles emerged around the flat electrode. Electrolysis was performed directly on the surfaces of grafts with subepithelial opacities (a) (patients 1 and 2), or at the host surface of the host–graft junction of the stroma (b) and at the graft inner surface on the host–graft junction of the stroma (c) (patient 3).

Results

Patient 1

A 63-year-old woman described as Case 3 in Mashima *et al*[17] presented to Keio University Hospital in 1989 with decreased visual acuity in both eyes from a severe recurrence of opacities after LKP was performed on the right eye at the age of 21 years and at 24 years in the left eye (Figure 4a). The visual acuity was reduced to finger counting in the right eye, and was 0.01 in the left. The patient underwent PKP in the left eye at the age of 52 years in June 1991. Postoperatively, the left visual acuity was 0.9. Genetic analysis showed that she was homozygous for the R124 H mutation associated with a severe form of ACD. There was recurrence of diffuse subepithelial opacities in the graft in 1993, and these gradually increased (Figure 4b), until visual acuity was reduced to 0.1 in 1998 at the age of 59.

Corneal electrolysis was applied to the surface of the graft, and the subepithelial opacities were nearly completely cleared (Figure 4c). Visual acuity recovered to 0.7. At 3 years after the treatment, fine subepithelial opacities began to develop (Figure 4d), and visual acuity was reduced to 0.3 in February 2002. Additional electrolysis was applied to the surface of the graft, and the subepithelial opacities nearly disappeared (Figure 4e). Visual acuity recovered to 0.7.

Patient 2

A 68-year-old woman with the superficial variant of GCD and the R124L mutation was described as the proband in Mashima *et al*.[4] She underwent PKP in the left eye in 1987, and her corrected visual acuity improved to 0.6. In 1991 fine opacities appeared on the subepithelial layer. Diffuse subepithelial opacities gradually developed (Figure 5a), and visual acuity was reduced to 0.08. In 1999 at the age of 65, the patient underwent corneal electrolysis which was applied to the surface of the graft (Figure 5b). The subepithelial opacities almost disappeared, and visual acuity recovered to 0.3. The patient developed a senile cataract in addition to the macular degeneration. At 1 year after the treatment, fine subepithelial opacities had begun to develop (Figure 5c), and diffuse subepithelial opacities developed 2 years after the treatment (Figure 5d).

Patient 3

A 77-year-old man with ACD described as Case 22 in Konishi *et al*[18] underwent LKP in 1996 at the age of 71 years. At 4 years after the operation, diffuse opacities developed at the host–graft interface of the stroma in the pupillary area, and visual acuity decreased to 0.3 (Figure

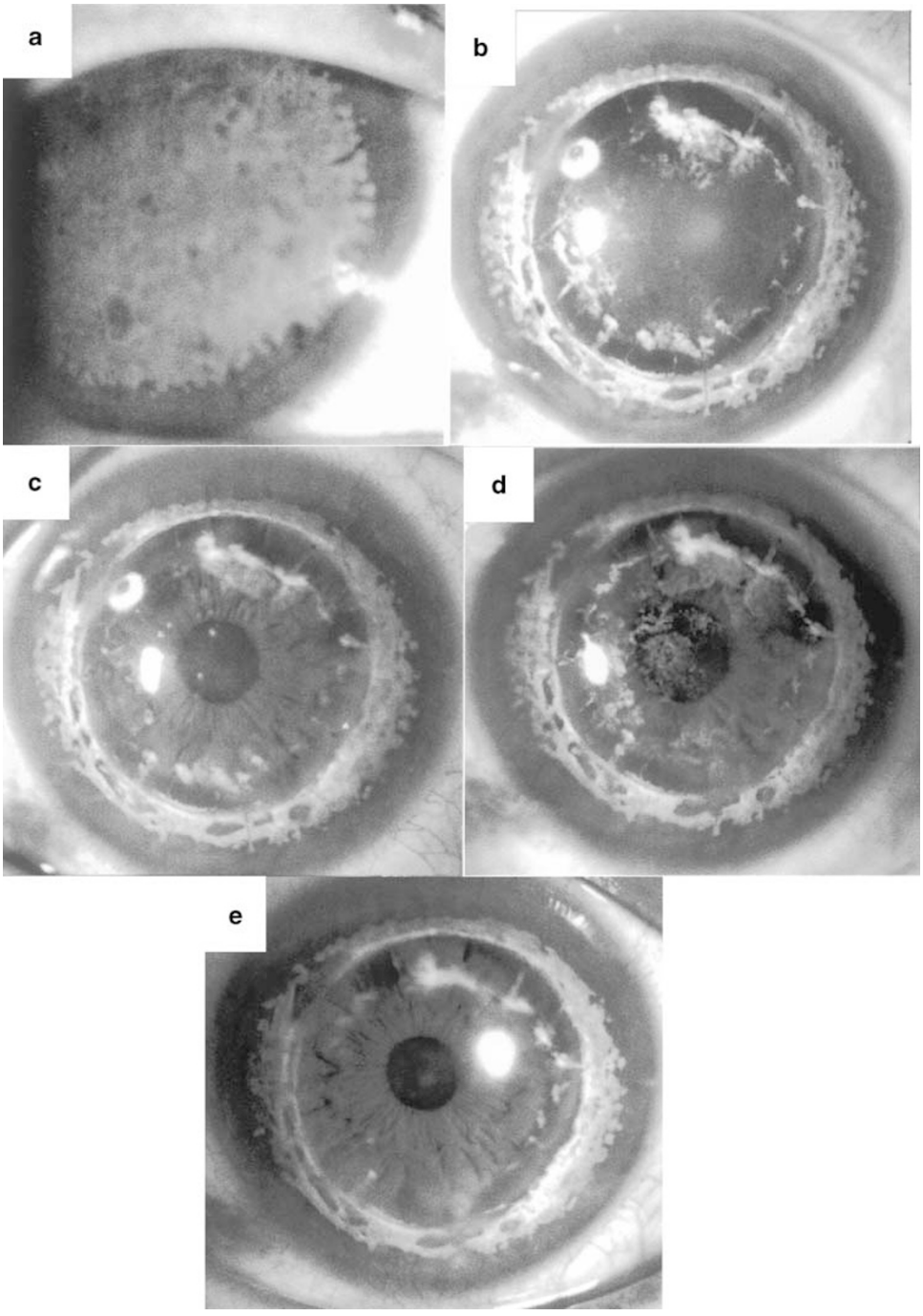

Figure 4 Slit-lamp photographs of corneas of patient 1 with homozygous Avellino corneal dystrophy. (a) Diffuse stromal opacities have recurred after previous keratoplasty (9/26/1989). Penetrating keratoplasty (PKP) was performed. (b) Diffuse subepithelial opacities recurred 7 years after PKP (11/10/1998). The first corneal electrolysis was performed. (c) Cornea 1 week after corneal electrolysis (11/17/1998). (d) Preoperative second corneal electrolysis for diffuse subepithelial opacities 3 years after the previous treatment (2/4/2002). (e) Cornea 3 months after treatment (5/14/2002).

6a). In June 2000, at the age of 75, the patient underwent electrolysis directly to the host–graft interface of the stroma after dissection of the graft as described. On the day following the operation, the stromal opacities had completely disappeared, and visual acuity had recovered to 0.5 (Figure 6b). At 3 months after the operation, his visual acuity had recovered to 0.7. A senile cataract was present. In 2002, 2 years after the treatment, fine opacities

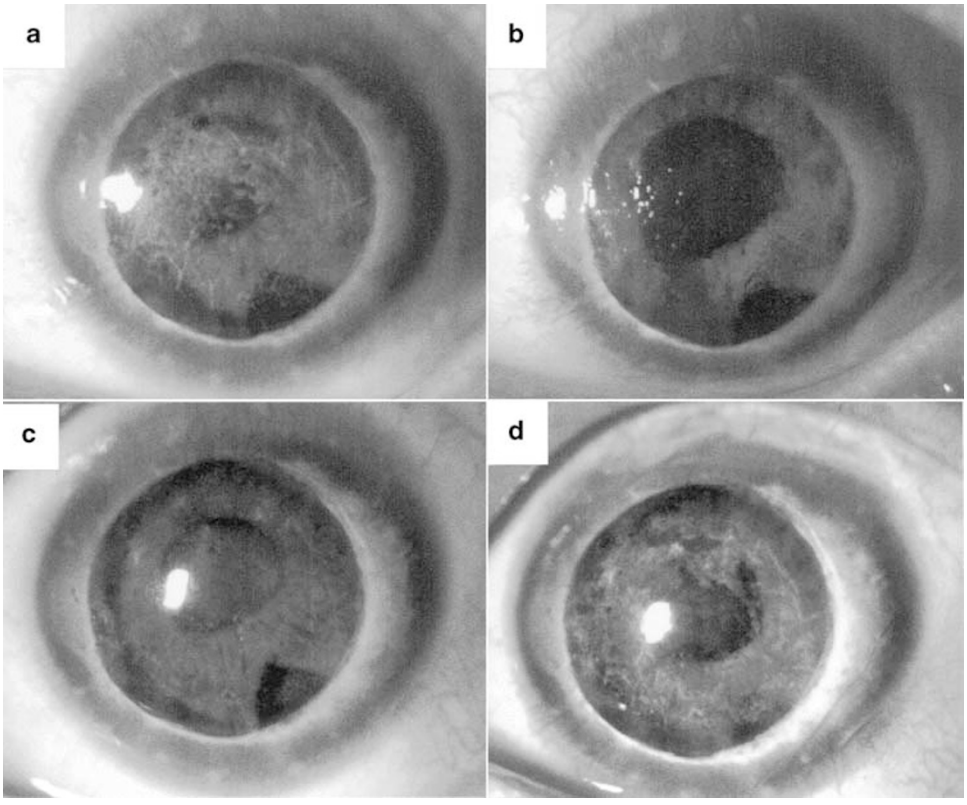

Figure 5 Slit-lamp photographs of corneas of patient 2 with the superficial variant of granular corneal dystrophy. (a) Diffuse subepithelial opacities preoperatively (4/1/1999). (b) Cornea 1 day after corneal electrolysis (4/3/1999). (c) Fine subepithelial opacities recurred 1 year after the treatment (4/11/2000). (d) Diffuse subepithelial opacities 2 years after the treatment (8/7/2002).

had begun to develop again at the host-graft interface of the stroma (Figure 6c).

Discussion

The recurrence of corneal opacities in the graft after keratoplasty in GCD patients is common, and recurrence of the dystrophy within a graft is almost universal within 4 years after keratoplasty.[9] Recurrences of GCD following keratoplasty initially occur in the subepithelial region of the graft or at the host–graft interface of the stroma.

Recently, PTK has been used as the initial treatment of GCD with good results.[6–8] Superficial lesions recurring after previous keratoplasties also can be removed by PTK with restoration of good vision.[19] Recurrences of corneal opacities are common after treatment by PTK in patients with GCD.[10] Postoperatively, the corneal thickness is approximately 80 μm thinner than before treatment, and postoperative refraction induces hyperopic changes of 3–4 D. In patients with GCD who have undergone PTK at least two times, additional PTK treatment is not recommended because of the corneal thinning.

Electrolysis could be a safe and effective alternative procedure for recurrent opacities after PTK, superficial keratectomy, or keratoplasty. Most notably, when opacification occurs at the donor–host interface after LKP, electrolysis can successfully remove opacities deposited at the interface without requiring a new donor cornea.

In 1917, Sato[12] reported on the effectiveness of electrolysis in Japanese patients with GCD, and during the past 10 years the effectiveness of corneal electrolysis as an initial treatment for GCD has been reported in Japan.[13–15] This method has some advantages over keratoplasty or PTK; it is a simple, easy, and inexpensive way of removing superficial corneal opacities in patients with recurrent GCD. This procedure can be performed repeatedly on an outpatient basis without causing changes in corneal thickness. Umeno *et al*[15] reported that equivalent spherical refraction after treatment was within ± 1.0 D in 19 (86%) of 22 treated eyes. Recently, PTK has been used as the initial therapy, and recurrences may follow. Before repeating PTK, corneal electrolysis may be used because it does not reduce corneal thickness.

However, electrolysis has some disadvantages. First, electrolysis is not effective for opacities in the anterior to middle stroma. In the initial treated cases, the average

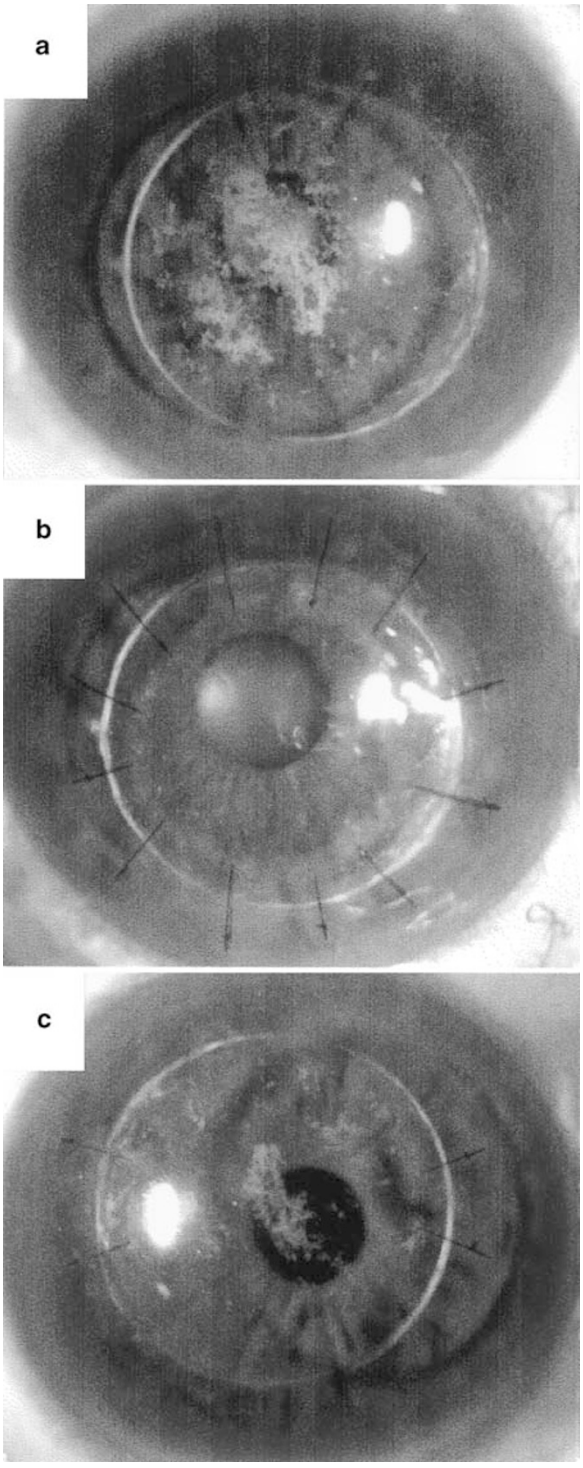

Figure 6 Slit-lamp photographs of corneas of patient 3 with Avellino cornal dystrophy. (a) Preoperative recurrent deposits at the host–graft junction of the stroma. (b) Cornea 1 day after corneal electrolysis (7/8/2000). (c) Cornea 2 years after corneal electrolysis (9/17/2002).

visual acuity improved from 0.33 to 0.57.[15] Second, GCD recurs relatively earlier after this treatment than after keratoplasty. In Umeno's series,[15] the period between previous electrolysis and recurrence was 1–72 months (mean 27.8 months) in retreated patients with GCD. Homozygous ACD (patient 1) and the superficial variant of GCD (patient 2) patients are more inclined to have recurrence in the graft.

If this technique is applied to corneal opacities as the initial treatment, it may be effective for subepithelial opacities as seen in patients with a superficial variant of GCD or original Reis- Bücklers corneal dystrophy. These patients suffer from visual deterioration in the first or second decade of life, and need several treatments.[4,20]

Corneal electrolysis is an effective treatment for recurrent diffuse opacities in the subepithelial layer of the cornea or at the host–graft junction of the stroma. This technique proved particularly effective for the latter type of recurrences because opacities can be directly removed without the use of a new donor cornea.

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