SCIENTIFIC CORRESPONDENCE

Corneal electrolysis for recurrence of corneal stromal dystrophy after keratoplasty

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Br J Ophthalmol 2002;**86**:273–275

Aims: To evaluate corneal electrolysis as a treatment for recurrent diffuse corneal opacities at the host-graft interface of the stroma or at the subepithelial region in two types of granular corneal dystrophy (GCD).
Methods: Recurrence developed at the host-graft interface of the stroma after lamellar keratoplasty in a patient with Avellino corneal dystrophy (ACD). At surgery, the deep aspect of the graft in this patient was partially separated from host tissue to expose the deposits, with one third of the host-graft junction left intact. 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 two patients with homozygous ACD and one patient with the superficial variant of GCD, diffuse subepithelial opacities developed following penetrating keratoplasty. Electrolysis was applied directly to the corneal surface.
Results: Deposits at the host-graft interface of the stroma and in the subepithelial region disappeared following treatment, and vision recovered in all patients.
Conclusions: This method is a simple, easy, and inexpensive way to remove deposits that recur after lamellar or penetrating keratoplasty.

Granular corneal dystrophy (GCD) can be classified into three types based on the overall appearance of the cornea in association with mutations of the *TGFBI* gene: the classic form associated with R555W mutation[1]; Avellino corneal dystrophy (ACD) associated with R124H mutation[1]; and the superficial variant of GCD associated with R124L mutation.[2] Histologically, all types show bright red staining with Masson's trichrome stain and, ultrastructurally, electron dense rod-like bodies are seen.[3]

Lamellar keratoplasty (LKP) or penetrating keratoplasty (PKP) has been performed for the treatment of GCD, ACD, and the superficial variant of GCD. Currently, phototherapeutic keratectomy (PTK) is used as a first line therapy in all three types.[4–6] However, these dystrophies are known to recur within the graft over several years following keratoplasty[7] or PTK.[8] In Japan, corneal electrolysis was first used to treat corneal dystrophy by Sato in 1917[9]; this procedure has sometimes been chosen to be the first treatment of GCD as an alternative to superficial keratectomy.[10–12] Recurrences of corneal dystrophies usually are superficial,[13] making them amenable to electrolytic removal.

In this report we describe the use of this technique to treat diffuse corneal opacities that developed at the stromal host-graft interface after LKP, thus avoiding regrafting. We also describe the treatment of diffuse subepithelial opacities in patients with recurrence of dystrophy after PKP. Electrolysis proves to be a simple and easy way to remove opacities recurring after the keratoplasty.

METHODS AND MATERIALS

Patients

Four patients were included in the present study. Details of their clinical courses before treatment have been described elsewhere. Recurrences were observed at the host-graft interface of the stroma in the pupillary area in patient 1 (described as case 22 in Konishi *et al*[14]), while diffuse subepithelial lesions were seen in patients 2, 3, and 4 (respectively described as cases 4 and 5 in Mashima *et al*[15], and the proband in Mashima *et al*[2]).

METHODS

Corneal electrolysis was performed using a digital electrolyser (Fig 1; TE-500: Tagawa Electronic Research Institute, Tokyo, Japan). This device was originally used for removing inverted eyelashes using fine needle electrodes. We substituted a flat electrode that is commercially available in Japan for the treatment of corneal opacity (Fig 1, inset). The positive electrode covered with gauze was immersed in isotonic sodium chloride solution (physiological saline) and taped on the forehead. Lignocaine (2%) (lidocaine, Xylocaine) 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 anaesthetised cornea to remove corneal deposits as physiological saline was dropped on the cornea (Fig 2E). The output voltage and treatment duration were adjusted to produce tiny white hydrogen gas bubbles and to clear the opacities. Usually the output voltage was 4–6 V, and the duration of current flow was 3–5 seconds. This application was repeated until the opacity had essentially cleared, usually about 10 times. During the current application, hydrogen gas bubbles emerged from the area of the negative electrode, and the whitish, sticky, and tiny bubbles

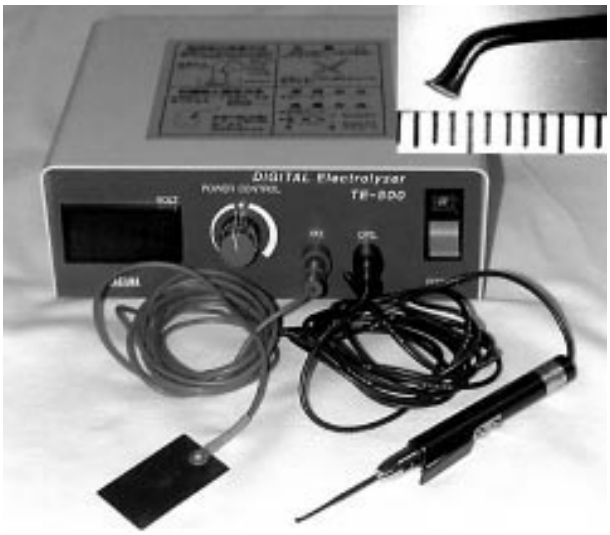

Figure 1 Digital electrolyser and a flat electrode for corneal electrolysis (inset, one division is 1mm).

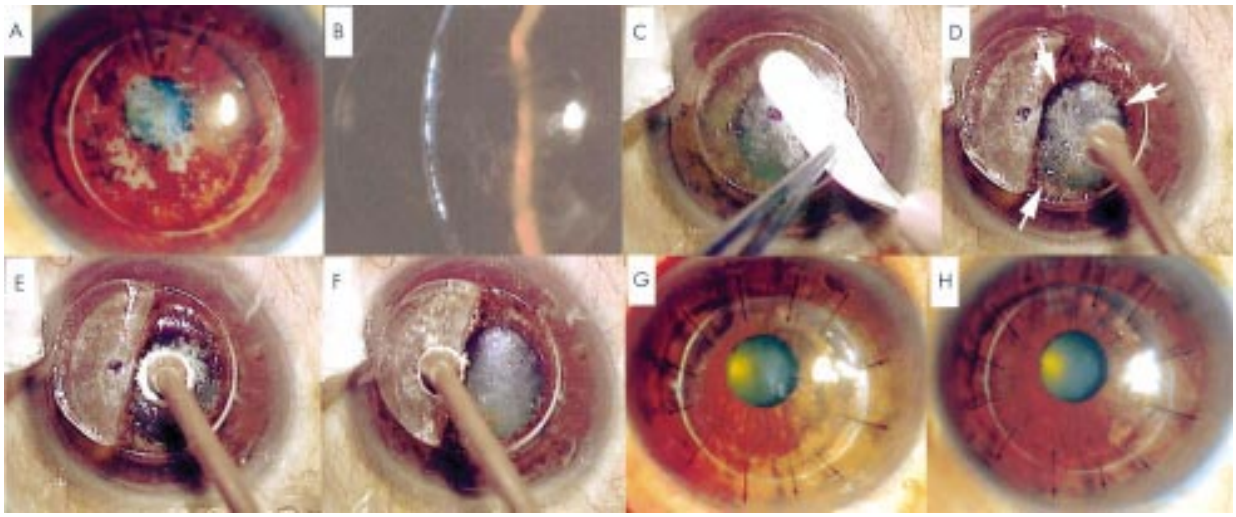

Figure 2 Slit lamp photographs of the cornea and electrolysis for recurrent deposits at the host-graft junction of the stroma (patient 1). Preoperative deposits are apparent in the centre of the graft (A) and at the host-graft junction of the stroma (B). The graft was separated at the level of the host-graft interface (C). Interface deposits are indicated by arrows (D). Electrolysis was performed on both the host (E) and graft inner surface (F). (G) and (H) show the cornea 1 day and 6 months, respectively, after treatment.

were vigorously washed off the surface of the eye with physiological saline solution. Under these conditions, it is likely that the electric current attracted Na^+ to the negative electrode where it reacts with water producing NaOH and H_2 ($2Na + 2 H_2O = 2NaOH + H_2$). The NaOH probably dissolved the corneal deposits because in a preliminary study, an alkaline reaction was detected around the flat probe by litmus paper (litmus test) during the electrolysis.

In patient 1, 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 (Fig 2C). The graft was then everted (Fig 2D), and corneal electrolysis was performed directly upon the host surface (Fig 2E) and the graft inner surface (Fig 2F). The graft then was returned to its place and sutured with 12 sutures of 10-0 nylon. In patients 2, 3, and 4, electrolysis was performed on the surfaces of grafts with subepithelial opacities. The flat probe was applied directly to the epithelial surface. As an epithelial defect was present after treatment, a medical soft contact lens was placed until corneal epithelialisation was completed. It usually takes a week to heal the defects.

RESULTS

Patient 1

A 71 year old man with ACD, who was heterozygous for the R124H mutation of the *TGFBI* gene, underwent LKP in 1996. Four years after the operation, diffuse opacities developed at the host-graft interface of the stroma in the pupillary area, and visual acuity declined to 0.3 (Fig 2A and B). In 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 (Fig 2G). At 6 months after the operation, his visual acuity recovered to 0.7 (Fig 2H). A senile cataract was present.

Patient 2

A 50 year old woman presented to Keio University Hospital in 1989 with decreased visual acuity in both eyes as a result of severe recurrence of opacities after grafting. The visual acuity was reduced to counting fingers in the right eye, and was 0.01 in the left. The patient underwent penetrating keratoplasty in the left eye at the age of 52 years in June 1991. Postoperatively, the left visual acuity was 0.9. She was homozygous for the R124H mutation. There was recurrence of subepithelial opacities in the graft in 1993, and these gradually increased (Fig 3A), 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 nearly disappeared (Fig

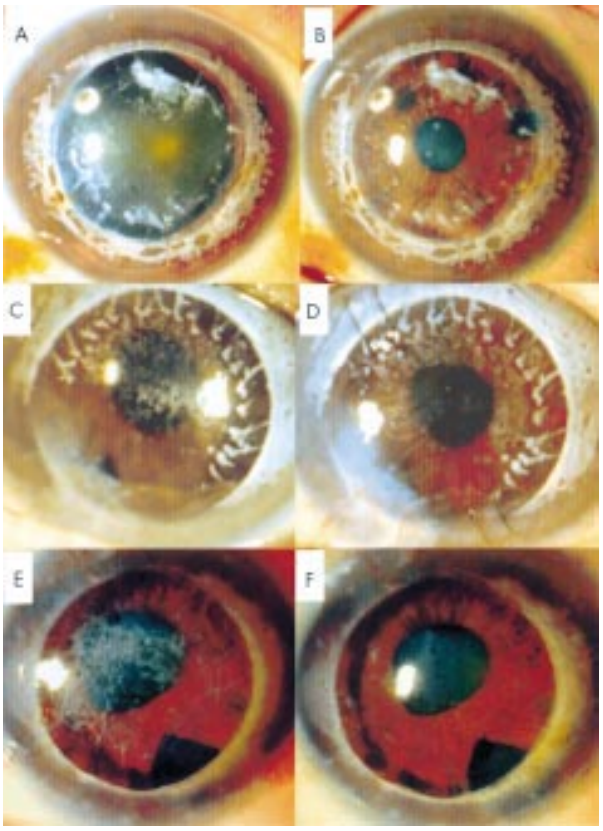

Figure 3 Slit lamp photographs of corneas of patients 2, 3, and 4. (A) Diffuse subepithelial opacities preoperatively in patient 2. (B) The cornea 1 month after treatment in patient 2. (C) Diffuse subepithelial opacities in the pupillary area preoperatively in patient 3. (D) Cornea 1 week after treatment in patient 3. (E) Diffuse subepithelial opacities in the pupillary area preoperatively in patient 4. (F) Cornea 2 years after treatment in patient 4.

3B). Visual acuity recovered to 0.7. Three years after the treatment, fine subepithelial opacities have begun to develop.

Patient 3

A 74 year old woman was referred to Keio University Hospital in September 1997 for severe corneal opacities that substantially impaired vision in both eyes. Visual acuity was 0.1 in both eyes, as a result of recurrence after PKP and the presence of senile cataract. She was homozygous for the R124H mutation. In 1998, electrolysis was applied to the surface of the graft in the left eye which had diffuse subepithelial opacities in the pupillary area (Fig 3C). At the same time, compression sutures were placed to correct marked corneal astigmatism. The diffuse subepithelial opacities disappeared, but some opacities remained in the anterior stroma (Fig 3D). Visual acuity recovered to 0.3. Three years after the treatment, fine subepithelial opacities have begun to develop.

Patient 4

A 53 year old woman underwent PKP in the left eye in 1987. She had marked myopic macular degeneration in the left eye and a visual acuity of 0.6 in her left eye. She also had superficial GCD and the R124L mutation. In 1991 fine opacities appeared on the subepithelial layer. Diffuse subepithelial opacities gradually developed (Fig 3E), 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. The subepithelial opacities almost disappeared, and visual acuity recovered to 0.3. The patient developed a senile cataract in addition to the macular degeneration. Two years after the treatment, fine subepithelial opacities have begun to develop (Fig 3F).

DISCUSSION

GCD recurrence in a graft after keratoplasty is common. Initially, these recurrences often take the form of diffuse subepithelial deposits. We also observed recurrence of GCD at the host-graft interface of the stroma. Recurrence of the dystrophy within a graft is almost universal within 4 years after keratoplasty.[7] The superficial variant of GCD, Reis-Bücklers corneal dystrophy, and homozygous GCD are more inclined to recurrence in the graft. Repeated PKP was required for a severe form of juvenile corneal stromal dystrophy associated with homozygosity for the R124H mutation.[15] Recurrences of GCD following PKP initially occur in the subepithelial region of the graft.

Recently PTK with an argon-fluoride excimer laser has been used as the initial treatment of GCD with good results.[4–6] Superficial lesions recurring after previous keratoplasties also can be removed by PTK with restoration of good vision.[16] However, recurrence is also common after treatment by PTK in this type of dystrophy.[8] Postoperatively, the corneal thickness is approximately 100 μm thinner than before treatment, and postoperative refraction induces hyperopic changes of 3–4 dioptres. In patients with GCD who have undergone PTK two or three times, additional PTK treatment is not recommended because of the corneal thinning.

Electrolysis is a safe and effective alternative procedure for recurrent opacities after PTK or keratoplasty, most notably, when opacification occurs at the donor-host interface after LKP, and electrolysis can successfully remove opacities deposited at the interface without requiring a new donor cornea. In 1917, Sato reported on the effectiveness of electrolysis in Japanese patients with GCD.[9] During the past 10 years, the effectiveness of corneal electrolysis as an initial treatment for GCD has been reported in Japan.[10–12] This method has several advantages over keratoplasty; it is a simple, easy, and inexpensive way to remove superficial corneal opacities. This procedure can be performed repeatedly on outpatients without causing changes in corneal thickness. Umeno *et al*[12] reported that equivalent spherical refraction after treatment was within plus or minus 1.0 dioptre in 19 (86%) of 22 treated eyes.

However, electrolysis has some disadvantages. Firstly, GCD recurs relatively earlier after this treatment than after keratoplasty. In Umeno's series, the period between previous electrolysis and recurrence was 1–72 months (mean 27.8 months) in retreated patients with GCD.[12] Secondly, electrolysis is not effective for opacities in the anterior to middle stroma. In the initial treated cases, the average visual acuity improved from 0.33 to 0.57.[12] In another report, 73% of the initial treated cases had an improvement of visual acuity of more than two lines.[11] When 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 Reis-Bücklers corneal dystrophy. These patients suffer from visual deterioration in the first or second decade of life, and need several treatments.[2]

Thus, 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 recurrence. Opacities can be directly removed without use of a new donor cornea. 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.

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Accepted for publication 31 October 2001

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