

Phototherapeutic keratectomy for bullous keratopathy

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Abstract

Aims—This study was designed to investigate the therapeutic potential of excimer laser for recurrent painful erosions in patients not suited to treatment with penetrating keratoplasty.

Methods—Phototherapeutic keratectomy (PTK) with the excimer laser was performed prospectively on a series of 13 eyes of 12 patients with recurrent corneal erosions in connection with bullous keratopathy of varied aetiology. The main complaint of the patients before the treatment was frequent attacks of pain. The patients selected either refused corneal grafting or could not for a variety of reasons expect to profit visually from an operation. The treatment was performed with the MEL 60 Aesculap Meditec excimer laser using either a spot mode (five cases), a scanning mode (three cases), or a combination of both (five cases).

Results—All patients responded well to the treatment, and the pain subsided after a couple of weeks. In five cases (38.5%) a second treatment was necessary because of persistent pain, which was, however, much less than before the initial treatment. In four of these five patients small corneal bullae persisted. The visual performance of the seven patients with visual acuity better than 20/200 ameliorated in two cases and remained unchanged in four cases. One patient lost two Snellen lines after the laser treatment for terminal glaucoma. The mean follow up was 14.1 months (range 1–28 months). No complications were seen so far.

Conclusion—It was concluded that PTK is a very promising and effective outpatient treatment for patients with bullous keratopathy. This therapeutic approach is not thought to have been described before.

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Since 1983, when Trokel *et al*¹ introduced argon fluoride excimer laser (193 nm) into ophthalmology, it has been used increasingly, especially to treat myopic refractive error.^{2–10} This laser emits radiation in the far ultraviolet spectrum, and each photon has an energy of 6.4 eV. This energy exceeds the bonding energy of carbon-carbon bonds, which are therefore dissociated, ablating only several molecules of the corneal thickness per pulse.¹¹ The energy of a laser pulse is absorbed within the first micrometres of the corneal surface, and tissue damage outside the treated zone is

very limited.^{12 13} In the past few years an increasing number of different lesions of the anterior corneal surface have been treated phototherapeutically with success.^{11 14–21}

Hitherto, the following pathological conditions have been treated with the excimer laser: recurrent erosions,^{17 18 20} persistent epithelial defects,¹⁸ pterygium,^{15 18–20} melanoma,¹⁸ scars,^{15 20 21} anterior corneal dystrophies,^{16 20 21} epithelial herpes simplex,^{18 20} and band keratopathy.^{11 20}

The treatment of choice for bullous keratopathy is perforating keratoplasty. With this procedure, visual acuity can be improved, together with successful prevention of pain. This study was designed to investigate the therapeutic potential of excimer laser for recurrent painful erosions in connection with bullous keratopathy for patients not suitable for treatment with penetrating keratoplasty either because they were too ill or too old, or because an improvement in visual acuity could not be expected, owing to other ocular morbidity such as glaucoma. The main goal of the therapy was to relieve patients of pain. Successful treatment of recurrent erosions in this disorder also helps in the prevention of infectious keratitis.

Patients and methods

Between August 1991 and December 1993 we performed phototherapeutic keratectomy (PTK) on 13 eyes of 12 patients with the diagnosis of bullous keratopathy of different origin (see Table 1). Five patients were treated twice in the same eye, because of persistent pain, which was, however, much less severe than before the first laser therapy. One patient was treated in both eyes. All these patients were not suitable for treatment with penetrating keratoplasty because they were either too old, did not have the potential for better visual acuity, or were not willing to undergo another surgical procedure. All patients had a complete ophthalmic examination before the treatment and were followed carefully postoperatively until the end of the follow up period in December 1993.

Frequent aetiologies for endothelial decompensation with development of bullous keratopathy in our patients were Fuchs' dystrophy, perforating trauma, and prior multiple surgical procedures (see Table 1).

Table 1 Aetiology for bullous keratopathy in 13 eyes

After several intraocular operations	6
After perforating injury	3
Fuchs' dystrophy	4

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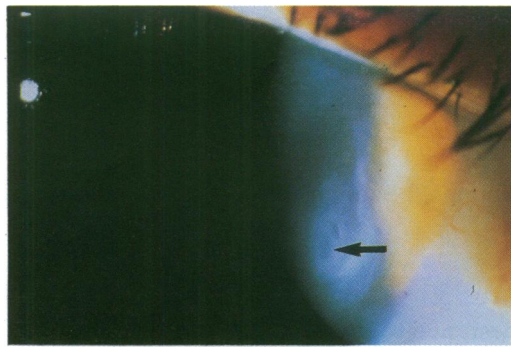


Figure 1 Bullous keratopathy of the peripheral cornea in an aphakic left eye of a 56-year-old patient before laser treatment. Two large bullae (see arrow) can be seen.

The mean age of the patients was 62.1 (range 35–88) years, and the mean follow up was 14.1 (range 1–28) months.

All therapy was performed with the MEL 60 Aesculap Meditec excimer laser (193 nm). This laser offers the choice of switching between the spot and the scanning (slit) modes. The frequency of the pulses can be varied between 1 and 30 Hz. The spot has a diameter of 1.5 mm and can be aimed manually. The scanning mode works as a scanning slit over the area to be treated. In the spot mode we usually treated with radiant exposures of 800–1200 mJ/cm² and a pulse frequency of 3 Hz. Therapy in the scanning mode was performed with the same pulse frequency (22 Hz) and the same energy which is used for photorefractive keratectomy, in accordance with the manufacturer's calibration recommendations in the user's manual. This corresponds to a flux of 250 mJ. In the scanning mode the computer of the laser was set on '0' dioptres, and the corneal surface was treated in the diseased area.

Treatment was carried out under topical anaesthesia (oxybuprocaine 0.4%), which was applied several times before treatment. Patients were told that there would be a smell of burning during the therapy. A lid speculum was inserted and, after ablation of the epithelium in the area of the bullous changes, the laser treatment was performed.

Different principles have already been described concerning the ablation of the epithelium before the treatment.^{15 17 18 20 21} In our cases we debrided the epithelium before the laser application. In all cases it was very poorly attached and could be easily removed with a sponge.



Figure 2 The same eye as Figure 1, 7 months after laser therapy. An epithelial oedema without bullae persists.

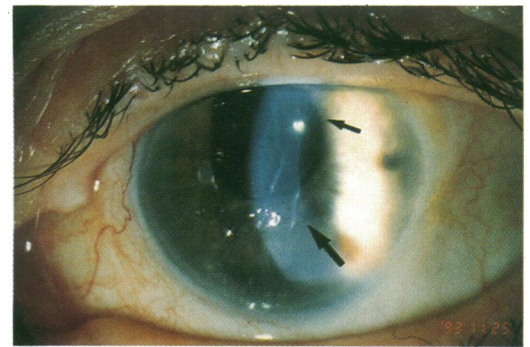


Figure 3 Bullous keratopathy after several surgical procedures in the left eye of a 76-year-old patient before laser therapy. Several bullae (see arrows) are visible.

Small areas were treated in the spot mode and larger areas in the scanning mode or in a combined procedure. The treatment method depended only on the size of area to be treated and not on the initial cause of the bullous keratopathy. Ten treatment applications were made in the spot mode, three in the scanning mode, and five in a combined procedure. Only the bullous area was treated.

In one patient 0.4% sodium hyaluronate was used as a masking substance to smooth the surface, which was abnormally rough.

Postoperative treatment in the first six patients consisted of antibiotic ointment (neomycin, bacitracin) together with a pressure patch. Since experience with PRK showed marked relief of pain through the use of therapeutic contact lenses, the subsequent patients were treated with drops (neomycin, gramicidin, polymyxin B) and therapeutic contact lenses. The last two patients used diclofenac eye drops, again with the hope of reducing pain. Lubricants were used where necessary. Therapy was stopped when the epithelium has healed.

Results

All patients could be considerably relieved from pain after the first treatment. In five cases (38.5%) a second treatment was performed at the patients' request because of persistent but milder irritation. After this second treatment all patients felt comfortable, and no third treatment was necessary. Four patients did not complain of any more attacks of pain at all. The remaining four patients continued to have very little pain; however, they did not seek

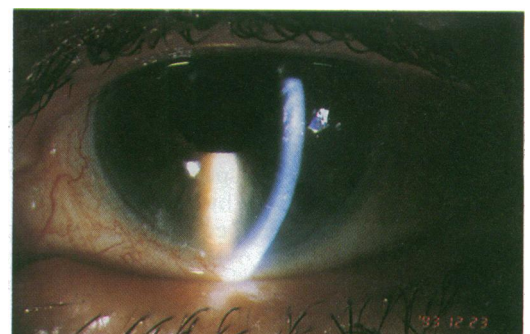


Figure 4 The same eye as in Figure 3 but 1 month after PTK. No bullae are visible. This patient needed another PTK because of recurrence of the bullae; however, these were fewer than before the first PTK.

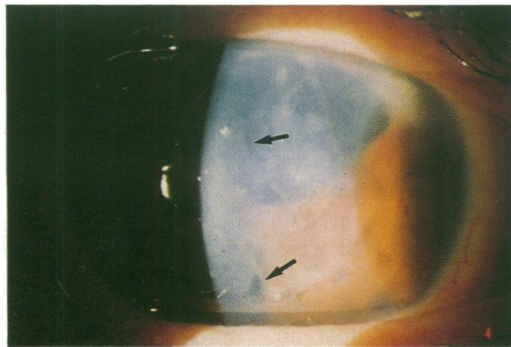


Figure 5 Bullous keratopathy after perforating trauma and anterior chamber lens in the left eye of a 38-year-old patient. Bullae (see arrows) are easily visible.

ophthalmic consultation, and no other laser therapy was necessary. Two of them showed persistent bullae but to a lesser extent. Healing of the epithelial oedema did not occur, but we could prevent or at least significantly reduce the genesis of bullae (see Figs 1–6).

Preoperatively six of 13 eyes (46.2%) had very poor visual performance – that is, equal or less than finger counting. In these patients there was no change of visual acuity after PTK; seven of 13 eye (53.8%) had a visual acuity of 20/200 or better. In two patients bullae were not located centrally and did not interfere with visual performance; four patients had a diagnosis of Fuchs' dystrophy, and bullae did not reduce visual acuity to less than 20/200.

After treatment one patient lost 2 Snellen lines, but he also suffered from a terminal glaucoma and an ocular pemphigoid. In this case, therefore, the visual loss is very probably not due to the laser treatment.

Four eyes remained unchanged, and two eyes improved visual performance by two lines.

In most cases pain was present during the first 24 hours after the treatment and subsided thereafter. No other complications were observed.

Discussion

PTK is effective in the treatment of several corneal diseases, including recurrent erosions,^{17 18 20–22} persistent epithelial defects,¹⁸ anterior corneal dystrophies and degenerations,^{16 20 21} including Reis-Bückler,¹⁶ granular,²⁰ macular and lattice dystrophy,²¹ Salzmann's degeneration,^{20 21} pterygium,^{15 19 20} and band keratopathy.^{11 20} It seems likely that other indications will become apparent.

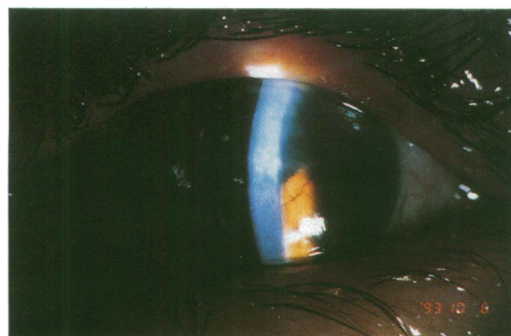


Figure 6 The same eye as in Figure 6 but 1 month after the second PTK. No more bullae can be seen.

In bullous keratopathy the corneal endothelium is no longer able to maintain the corneal stroma in a dehydrated state, which means counterbalancing the swelling pressure; stromal oedema results. Because of the barrier effect of the corneal epithelium for water soluble substances, intra- and intercellular oedema results. This leads to fluid accumulation in the extra- and intraepithelial spaces. If the intercellular cysts fuse, bullae emerge, and the epithelial cells lose contact with their basement membrane. These bullae can rupture and cause considerable pain.

The hypothesis has been advanced that in some cases epithelial wound healing can be enhanced by excimer laser removal of abnormal basement membrane.²³ This mechanism has been the reason for offering PTK to patients with severe recurrent erosion syndrome. The immunohistological studies of Hsu *et al*²⁴ suggest that the promotion of the matrix glycoproteins, such as laminin, fibronectin, and type IV collagen, after anterior stromal puncture is possibly a factor promoting better epithelial adherence to the basement membrane. A similar effect might be responsible for the success of the laser treatment in bullous keratopathy. However, the precise anatomical details of the mechanism of action of PTK in painful epithelial disorders remain hypothetical at present.^{17 18}

For patients who, for different reasons, cannot profit from another surgical procedure, it would represent considerable progress to inhibit the genesis of these bullae and to reduce the attacks of pain they cause. At the same time, potential infective keratitis can be avoided.

In our study the patients with recurrent painful erosions in connection with bullous keratopathy responded well to the treatment, and the pain subsided after one or two applications. Removal of the epithelium before the laser treatment seems to be necessary for the therapy of this condition by treating the basement membrane to strengthen the adhesions between it and the epithelial cells.

In a number of our patients (10/13), bullae persisted for weeks after treatment. Only five patients, though, complained of severe pain, and, after 1–2 months, bullae became rare in most patients. Healing, which results in a better adherence of the basal cells to the basement membrane, seems to take some time.

Compared with other treatments such as corneal stromal puncture,^{24 25} an important advantage of excimer laser therapy for recurrent erosions is the lack of stromal scarring, as laser treatment should not go beyond Bowman's membrane. In long standing bullous keratopathy there is a marked subepithelial fibrosis,²⁴ which is totally removed by PTK. This might be one reason for the good visual performance after PTK. Compared with corneal puncture there is no danger of perforation, and it is possible to treat large areas of bullous keratopathy in the scanning mode.

Our patients suffered frequent attacks of pain refractory to conservative therapy,

including contact lenses, which affected their quality of life. This leaves only a penetrating keratoplasty or a conjunctival flap as therapeutic options. However, many such patients were not suitable candidates for penetrating keratoplasty because they did not have the potential of regaining useful vision after such an operation. Others could not be motivated to undergo another surgical procedure or were too old.

Our experience with complaints of post-PTK pain is in agreement with almost all studies which reported severe pain to be almost universally experienced the first 24–48 hours after PTK and PRK. As with PRK, we found a marked reduction of pain in the patients in whom a therapeutic contact lens had been applied instead of a patch.

In conclusion, we demonstrated that excimer laser keratectomy is a safe and effective treatment for bullous keratopathy, independent of the causative disease. Especially in patients who refuse an operation, who cannot be operated on, or who would not profit from another surgical procedure for a variety of reasons, this treatment has the advantage of being a safe, easy, and quick outpatient procedure which may increase the quality of life for such patients. We strongly recommend this new therapeutic option for appropriately selected cases. To our knowledge this is the first study describing successful PTK for bullous keratopathy.

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