

# Excimer laser superficial keratectomy for proud nebulae in keratoconus

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## Abstract

Contact lens intolerance in keratoconus may be due to the formation of a proud nebula at or near the apex of the cone. Excimer laser superficial keratectomy was performed as an outpatient procedure in 10 eyes of 10 keratoconic patients with proud nebulae as treatment for their contact lens intolerance. The mean period of contact lens wear before the development of intolerance was 13.4 years (range 2 to 27 years). Following the development of intolerance, three patients abandoned contact lens wear in the affected eye while the remainder experienced a reduction in comfortable wearing time (mean=3.75 hours; range: 0-14 hours). All patients had good potential Snellen visual acuity with a contact lens of 6/9 (nine eyes) and 6/12 (one eye). The proud nebulae were directly ablated with a 193 nm ArF excimer laser using a 1 mm diameter beam. Between 100-150 pulses were sufficient to ablate the raised area. Patients experienced no pain during the procedure and reported minimal discomfort postoperatively. In all cases flattening of the proud nebulae was achieved. Seven patients were able to resume regular contact lens wear (mean wearing time =10.17 hours; range 8 to 16 hours). In three patients, resumption of contact lens wear was unsuccessful because of cone steepness. All patients achieved postoperative Snellen visual acuity of 6/12 or better with a contact lens. Four patients experienced a loss of one line in Snellen acuity. The mean follow up period was 8.3 months (range 2 to 17 months). Excimer laser superficial keratectomy is a useful technique for the treatment of contact lens intolerance caused by proud nebulae in patients with keratoconus. Penetrating keratoplasty is thus avoided.

(*Br J Ophthalmol* 1994; 78: 454-457)

The majority of patients with keratoconus are dependent upon rigid contact lens wear for visual



Figure 1B Fluorescein pooling around the proud nebula demonstrates its raised profile.

rehabilitation.<sup>1</sup> Contact lens intolerance in keratoconus is sometimes due to the formation of a proud nebula at or near the apex of the cone. A proud nebula is a raised, localised area of superficial cornea and is small (usually <1 mm diameter). Proud nebulae are usually solitary but occasionally occur in groups. They resemble Salzmann degeneration both macroscopically and histologically (unpublished observation) (Figs 1A and B).

Contact lens wear usually abrades the surface of the proud nebula and the patient may be unable to continue lens wear because of discomfort. Although the erosion heals after a period without lens wear, the nebula remains elevated and may persist even after prolonged periods without lens wear or following modification of contact lens material and fit.<sup>2</sup> Proud nebulae have rarely been observed in patients who have never worn contact lenses, or in non-keratoconic contact lens wearers. They should be distinguished from areas of chronic corneal oedema related to contact lens wear. In these cases, the cornea flattens on discontinuing contact lens wear, on refitting the contact lens in a more oxygen permeable material, or reducing any excess cone pressure by refitting a lens with a steeper central curve.

In patients with proud nebulae the surrounding cornea may be virtually unscarred. The visual acuity with a contact lens is therefore good, making penetrating keratoplasty an inappropriate choice as a method of visual rehabilitation. In order to regain contact lens tolerance and thus avoid corneal transplantation, surgical superficial keratectomy of proud nebulae can be undertaken; we reported on this technique in six eyes.<sup>2</sup> Although successful, the technique had a number of disadvantages. Firstly, the patients had to be admitted to hospital and the procedure performed in the operating theatre. Secondly, the technique appeared crude for the size of the lesion in that

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Accepted for publication 10 January 1994

Figure 1A Slit-lamp appearance of a proud nebula in case 3.

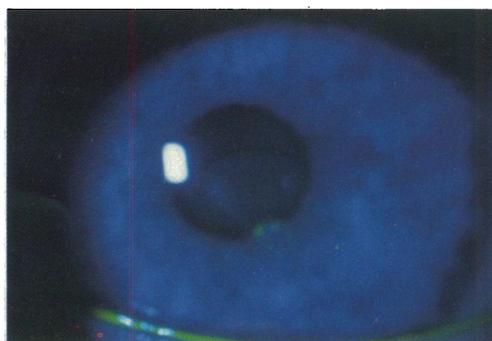


Table 1 Preoperative patient data

Case No	Contact lens wear (years)	Average maximum wearing time (hours)	Wearing time at presentation (hours)	Pre-op keratometry (mm)*	Contact lens material	BOZR (mm)‡	Potential visual acuity (with contact lens)
1	18	16	No wear	<6.50† 6.65	Boston IV	6.90	6/9-
2	5	16	3	7.20 6.60	Boston IV	7.40	6/9
3	27	16	4	6.30 6.40	Boston IV	7.00	6/9
4	7	15	No wear	5.81 <4.95†	XL20	7.10	6/9
5	12	16	4-5	<6.50† <6.50†	FL5	6.25	6/12
6	15	16	2	Not recorded	XL20	6.80	6/9
7	12	15	4	5.27 5.80	FL5	6.90	6/9
8	2	14	14	<5.50† 5.65	LD30	6.00	6/9-
9	16	8	No wear	6.90 7.10	CAB	7.10	6/9
10	20	10	6 intermittent	Not recorded	LD50	6.80	6/9-

\*Not necessarily immediately preoperatively. †Lower limit of keratometer range. ‡BOZR=back optic zone radius of contact lens.

most nebulae were 1 mm or less in diameter and even using a 2 mm trephine, the area of excision was larger than required; also the resultant wound was irregular. Thirdly, patients reported considerable postoperative pain for 12-24 hours following the procedure despite the use of a therapeutic soft contact lens. Fourthly, the proud nebula was often difficult to identify under the operating microscope.

Phototherapeutic keratectomy (PTK) using an excimer laser is a well established technique for the treatment of corneal surface pathology.<sup>3-11</sup> We therefore applied this technique to the treatment of proud nebulae in keratoconus in order to determine whether it had advantages over the surgical method.

### Patients and methods

Ten eyes (10 patients) with proud nebulae in association with keratoconus were recruited from the keratoconus clinic of the contact lens and prosthesis department of Moorfields Eye Hospital, London. All the patients were either wearing or had worn a contact lens in the affected eye. In all cases, the nebulae had failed to flatten either on refitting or on discontinuing contact

lens wear. Contact lenses were fitted according to the three point touch technique with light apical touch.

The preoperative patient data are summarised in Table 1. The mean period of contact lens wear before the development of intolerance was 13.4 years (range 2 to 27 years). The mean wearing time during successful contact lens wear was 14.2 hours (range 8 to 16 hours). Following the development of intolerance, three patients abandoned contact lens wear in the affected eye while the remainder experienced a reduction in comfortable wearing time (mean 3.75 hours; range 0-14 hours). The patients had been wearing gas permeable contact lenses of various transmissibilities. All patients had good potential Snellen visual acuity with a contact lens of 6/9 (nine eyes) and 6/12 (one eye).

Corneal topography using a photokeratoscope, TMS-1 Computed Anatomy, was performed in each case. However, owing to the irregularity of the tear film and epithelium at the apex of the cone, little useful data could be obtained. Corneal topography is unreliable when performed on a grossly abnormal cornea.<sup>12</sup>

Informed consent was obtained from all patients.

Excimer laser superficial keratectomy (phototherapeutic keratectomy) was performed as an outpatient procedure at St Thomas's Hospital, London and patients attended for follow up at the contact lens and prosthesis department of Moorfields Eye Hospital. A Summit Technology UV200 excimer laser was used with a spectral emission of 193 nm. The pulse energy resulted in a radiant exposure of 180 mJ/cm<sup>2</sup> and the pulse frequency was fixed at 10 Hz. The beam configuration was circular in cross section with a diameter of 1 mm, in all cases.

A local anaesthetic (amethocaine 1% drops) was instilled. The patient was taught to fixate on the target light for the predicted duration of the procedure of approximately 15 seconds. The noise associated with the laser was demonstrated and each patient was warned to expect a faint smell of burning during the treatment. A lid speculum was inserted and the procedure performed.

Table 2 Postoperative patient data

Case No	Contact lens wear resumed (days)	Follow up in contact lens (months)	Maximum wearing time achieved (hours)	Visual acuity in contact lens	Number of procedures	Post-op keratometry (mm)	BOZR (mm)	Outcome
1	14	17	14	6/12-	1	5.70 6.72	6.90	Continue contact lens wear
2	42*	12	10	6/6	1	6.93 6.29	7.20	Continue contact lens wear
3	14	11	12	6/12	1	6.39 6.85	6.80	Continue contact lens wear
4	50*	10	2	6/9	1	<5.50 <5.50	5.90	Limited contact lens wear. PK recommended‡
5	21	9	5 then 0	6/9-	1	<5.50 <5.50	6.25	Contact lens intolerance. PK recommended
6	14	10	Not available	6/12	2	Not recorded	6.80	Continue contact lens wear. Failed follow up
7	14	4	2	6/9	1	<5.50 <5.50	6.30	Intermittent contact lens wear. PK recommended
8	28	5	16†	6/12	1	<5.50 <5.50	5.80	Alternate day contact lens wear. PK recommended
9	42*	3	9	6/5	2	6.94 7.14	7.10	Continue contact lens wear
10	21	2	8	6/9-	2	≈5.50 ≈5.50	6.80	Continue contact lens wear

\*Delay due to extraneous factors. †Alternate day. ‡PK=penetrating keratoplasty.

Figure 2 Slit-lamp appearance of cornea following excimer laser superficial keratectomy.



The proud nebulae were directly ablated using the 1 mm diameter beam, with 2 HeNe aiming beams allowing accurate alignment. Usually, between 100–150 pulses were sufficient to ablate the raised area. Care was taken to use the minimum number of laser pulses. Peri- and intraoperative slit-lamp examination with a slit beam at high magnification was useful in assessing whether ablation had been adequate.

Fixation was maintained throughout the procedure in all cases and the ablation of tissue outside the area of the nebulae did not occur.

Postoperatively, a mydriatic drop and chloramphenicol ointment were instilled into the conjunctival sac and the eye was padded for 24 hours. Oral analgesia was provided for use during the first 48 hours and chloramphenicol 0.5% drops were instilled four times a day for a period of 10 days.

### Results

Excimer laser superficial keratectomy of proud nebulae was performed on 10 eyes of 10 patients between August 1991 and December 1992. Patients experienced no pain during the procedure and reported minimal discomfort postoperatively for up to 48 hours. Few required the oral analgesics provided. The postoperative patient data are summarised in Table 2.

In all cases, successful removal of the proud nebulae was achieved. Three patients (cases 6, 9, and 10) required a second procedure as there was residual elevation after the first procedure. The second procedure was performed within a month of the first. The reintroduction of contact lens wear was not attempted until the treatment was complete.

Seven patients (cases 1, 3, 5, 6, 7, 8, and 10) were able to attempt contact lens wear within 1 month of completion of treatment. The reintroduction of contact lens wear was delayed in the other three patients (cases 2, 4, and 9) because of non-clinical factors. Re-epithelialisation of the wound had taken place in all the patients we were able to review at 1 week after the procedure. The profile of the wound continued to flatten for up to 1 month postoperatively (Fig 2).

Seven patients (cases 1, 2, 3, 6, 8, 9, and 10) were able to resume regular contact lens wear (mean wearing time 10.17 hours, range 8 to 16 hours). Wearing times of 8 hours or more were achieved within 1 month of the procedure except in cases 2 and 9 whose follow up appointments had been delayed by extraneous factors. In three cases (cases 4, 5, and 7), resumption of contact

lens wear was unsuccessful despite flattening of the proud nebulae. In these, successful refitting of contact lenses proved impossible because of excessive steepness and/or unfavourable profile of the cornea.

All patients achieved postoperative Snellen visual acuity of 6/12 or better with a contact lens. Six patients achieved visual acuities equal to or better than their preoperative acuities. Cases 1, 3, 6, and 8 experienced a loss of one line in Snellen acuity. Case 8 developed a depression at the treatment site in an area of already thinned cornea. When wearing a contact lens, a bubble of air was trapped in the depression resulting in a reduction of visual acuity. In view of this, contact lens wearing time was restricted until the depression gradually filled over a period of 1 month.

The mean follow up period was 8.3 months (range 2 to 17 months).

### Discussion

The formation of a proud nebula does not appear to be related to the duration of lens wear (range 2 to 27 years) or to any particular lens material (Table 1). The fact that proud nebulae are rarely seen in non-keratoconic contact lens wearers suggests that their formation may be linked to the condition itself or that they may be the product of contact lens/cornea interaction at an irregular surface, the bearing area of the contact lens being distributed over a smaller surface at the apex of the cone compared with a spherical surface.

Excimer laser superficial keratectomy has several advantages over surgical excision. Laser patients experienced much less postoperative pain and the resultant wound was much smaller. The laser therapy was performed as an out-patient procedure causing less inconvenience to the patient and saving valuable theatre time.

Following laser treatment re-epithelialisation was usually complete after 1–2 weeks. However, in those patients who experienced a delay before attempting contact lens wear, we observed that the wound continued to flatten for up to 1 month post-treatment. The optimum time to resume contact lens wear following treatment is thus difficult to determine but 2 weeks would appear to be the minimum time required.

In five cases (cases 1, 5, 6, 9, 10) wear was resumed using the preoperative contact lens (that is, same back optic zone radius (BOZR)). However, if the interval between cessation of contact lens wear and treatment was long and the cornea had steepened during that time, refitting was required.

The hyperopic shift induced by PTK observed in some patients<sup>6,7,10,13</sup> is not an issue in keratoconus patients as the tear lens negates any such effect once a contact lens is worn.

When comparing pre- and postoperative keratometry values and contact lens BOZR it would appear that the cones in half the patients (cases 2, 3, 4, 7, and 8) had steepened post-treatment. However, 'preoperative' keratometry and BOZR were not always measured immediately before treatment, some readings being up to 1 year pretreatment. We do not believe that the

cone steepening was induced by the laser treatment but that it was due to the natural progression of the disease that had occurred during that period. It follows that postoperative keratometry readings and BOZR values would be a more accurate assessment of the immediate preoperative status. The BOZR is a better indicator of cone steepening than keratometry as the latter lacks accuracy in irregular steep cones.

In this study, three patients (case 4, 5, and 7) were unable to resume successful lens wear despite flattening of the proud nebulae. All three had postoperative BOZR values of 6.5 mm or less and keratometry readings of <5.50 mm. Case 8 also had readings within this range but was managing contact lens wear with difficulty on an alternate day basis.

If future studies confirm that PTK does not cause cone steepening then preoperative keratometry and BOZR values can be used to predict the likelihood of success in resuming contact lens wear following laser treatment. It would seem that success is unlikely if the BOZR is 6.5 mm or less. However, this should not be a contraindication for treatment but an indication for a guarded prognosis. Also, we would consider a trial of scleral contact lens wear postoperatively if corneal contact lens wear was unsuccessful.<sup>14</sup> These patients have little to lose in trying this procedure as the alternatives for visual rehabilitation such as epikeratoplasty and penetrating keratoplasty are far more complex, hazardous, and time consuming.

Four eyes (cases 1, 3, 6, and 8) experienced a loss of one line of Snellen visual acuity. Again it is difficult to determine whether this was due to treatment or to natural progression of the disease, as cone steepening can lead to a reduction in visual acuity. In this study, the end point of treatment was taken to be flattening of the proud nebula at slit-lamp examination. It was often difficult to assess the amount of treatment required to achieve this. The thickness of the epithelium over the proud nebula is variable, therefore it cannot be assumed that a fixed number of pulses would ablate through it. The depth of ablation is difficult to assess with the operating microscope making peri- and intra-operative slit-lamp examination with a slit beam at high magnification very useful.

Undertreatment resulted in cases 3, 9, and 10 requiring repeat procedures. Overtreatment (case 8) resulted in a depression in an already thinned cornea which subsequently filled. We would recommend minimal treatment followed by a trial of contact lens wear before re-treatment as complete flattening may not be essential for successful contact lens wear.

In summary, we would recommend excimer laser PTK in preference to surgical superficial keratectomy for keratoconic patients with contact lens intolerance caused by proud nebulae because it is a less painful procedure, it produces a smaller, neater wound, and it can be performed on an outpatient basis with equal success.

We are indebted to the Iris Fund for the provision of a research fellowship for Mr O'Brart. We are grateful to sister A Welch for invaluable help and Dr Douglas Newman for helpful comments on the manuscript.

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