hotorefractive keratectomy (PRK) was introduced in the late 1980s, and is the oldest excimer surface ablation procedure.1-3 Intrastromal refractive procedures were developed due to significant postoperative pain and complications such as regression and haze development, especially when treating high myopia. However, surface ablation of the cornea is often still considered the overall safest procedure for treatment of low myopia, especially to avoid corneal ectasia and flap-related complications.4-7 Technological advances such as the introduction of high-frequency flying-spot lasers have improved predictability of outcomes after corneal surface refractive procedures and minimized patient discomfort and risk of haze.8-10

Although an increasing number of patients have undergone refractive surgery for the past three decades, few studies with a follow-up period of more than 10 years have been published, and often with a limited number of patients.11-14 However, for all surgical procedures, evaluation of long-term results is of utmost importance to monitor safety, stability, and efficacy. The aim of this study was to evaluate outcomes up to 19 years after PRK for all degrees of myopia for a large number of patients.

Long-term Outcomes of Photorefractive Keratectomy for Low to High Myopia: 13 to 19 Years of Follow-Up

Anders H. Vestergaard, MD; Jesper Ø. Hjortdal, MD, DMSc, PhD; Anders Ivarsen, MD, PhD; Kresten Work, MD, DMSc; Jakob Grauslund, MD, DMSc, PhD; Anne Katrin Sjølie, MD, DMSc†

ABSTRACT

PURPOSE: To evaluate long-term outcomes after photorefractive keratectomy (PRK).

METHODS: A retrospective follow-up study of patients who received PRK at 5.0- to 6.5-mm optical zones, using the Summit broad beam excimer laser (Summit Technology, Inc., Waltham, MA) at Odense University Hospital, Odense, Denmark, between 1992 and 1998. One randomly selected eye of each patient was used in the statistical analyses. Re-treated eyes were excluded.

RESULTS: One hundred sixty eyes were included. Mean follow-up time was 16 years (range: 13 to 19 years). Mean preoperative spherical equivalent was -4.84 ± 2.95 diopters (D) (range: -20.25 to -1.25 D). At last follow-up examination, achieved refraction was -1.00 ± 1.56 D (range: -10.75 to +1.00 D) from attempted refraction, and the change in mean refractive error from 6 months postoperatively was less than 1.00 D. Results from a subgroup of unilateral treated patients indicated that myopic progression was the main reason for the residual refractive error. For eyes with low myopia (n = 124), the proportion of eyes within ±1.0 D of attempted refraction was 72%, and for eyes with high myopia (-6.00 D or more, n = 36) it was 47%. Forty-five percent had uncorrected distance visual acuity of 20/20 or better at last follow-up examination. Three eyes (2%) lost two or more lines and 13 eyes (8%) gained two or more lines of corrected distance visual acuity. Fourteen percent had haze (grade 0.5 to 2). Eighty-one percent were satisfied with the surgery.

CONCLUSION: PRK for low degrees of myopia seemed safe and effective up to 19 years after surgery with conventional broad beam laser ablation. Refractive predictability was significantly lower and the occurrence of haze was higher in eyes with high myopia.


Photorefractive keratectomy (PRK) was introduced in the late 1980s, and is the oldest excimer surface ablation procedure.1-3 Intrastromal refractive procedures were developed due to significant postoperative pain and complications such as regression and haze development, especially when treating high myopia. However, surface ablation of the cornea is often still considered the overall safest procedure for treatment of low myopia, especially to avoid corneal ectasia and flap-related complications.4-7 Technological advances such as the introduction of high-frequency flying-spot lasers have improved predictability of outcomes after corneal surface refractive procedures and minimized patient discomfort and risk of haze.8-10

Although an increasing number of patients have undergone refractive surgery for the past three decades, few studies with a follow-up period of more than 10 years have been published, and often with a limited number of patients.11-14 However, for all surgical procedures, evaluation of long-term results is of utmost importance to monitor safety, stability, and efficacy. The aim of this study was to evaluate outcomes up to 19 years after PRK for all degrees of myopia for a large number of patients.

From the Department of Ophthalmology, Odense University Hospital, Odense, Denmark (AHV, KW, JG, AKS); and the Department of Ophthalmology, Aarhus University Hospital, Aarhus, Denmark (AHV, JØH, AI).

Submitted: August 21, 2012; Accepted: February 25, 2013


The authors have no financial or proprietary interest in the materials presented herein.

†Deceased.

Correspondence: Anders H. Vestergaard, MD, Department of Ophthalmology, Odense University Hospital, Eye Department E, OUH, Sdr. Boulevard 29, Odense C, 5000, Denmark. E-mail: vestergaard_anders@hotmail.com

doi:10.3928/1081597X-20130415-02
PATIENTS AND METHODS

A retrospective follow-up study was conducted of the first cohort of patients treated with PRK for myopia from 1992 to 1998 at the Department of Ophthalmology, Odense University Hospital, Odense, Denmark. This study was approved by the Danish Data Protection Agency and the local ethical committee, and was conducted in agreement with the tenets of the Declaration of Helsinki. All participants were thoroughly informed and gave oral and written consent before follow-up examination.

Preoperative and initial postoperative data from patient charts were collected, and visual acuity data were converted from Snellen equivalent to logMAR. The inclusion criteria for patients treated with PRK in this retrospective study were: age between 19 and 30 years at the time of surgery of the first eye, stable myopia at least 1 year before surgery, a corrected distance visual acuity (CDVA) of 20/40 or better on the Snellen chart, and no other ocular conditions except myopia with or without astigmatism. Patients with amblyopia or who were pregnant or breastfeeding were excluded from surgery. Patients had to discontinue wearing contact lenses for at least 2 weeks (soft lenses) or 4 weeks (hard lenses) prior to assessment. Objective keratometry and central corneal thickness were not assessed.

All patients were treated by the same surgeon (KW) and with the same broad beam laser (SVS Apex laser system; Summit Technology, Inc., Waltham, MA), receiving either a single zone ablation (5 or 6 mm), a multi-zone ablation (5.0, 5.5, 6.0, and 6.5 mm), or a combined spherical and torical ablation. There was no use of topical mitomycin C and the epithelium was removed with a Beaver blade without the use of alcohol. Postoperative treatment included chloramphenicol drops or ointment three times a day for 1 week, dexamethasone drops three times a day for a minimum of 3 months, homatropine or cyclopentholate three times a day for 1 week, and systemic nonsteroidal anti-inflammatory drugs and benzodiazepines for the first three nights. If there was steroid-induced intraocular pressure rise after treatment of the first eye, prophylactic treatment was routinely given after treatment of the second eye.

Patients were preoperatively and postoperatively examined by the surgeon for 3 to 6 months, but patients with complications were often examined for several years. At these initial follow-up examinations, patients underwent a standard eye examination, including measurement of CDVA and uncorrected distance visual acuity (UDVA), subjective refraction, Goldmann applanation tonometry, and slit-lamp examination including haze grading and funduscopy. In total, 751 patient charts were reviewed. After inclusion and exclusion criteria, the cohort consisted of 365 patients, of which 276 patients were invited to a last follow-up examination. The remaining patients had either died, moved abroad, or were under “research protection” (n = 73), which meant that we were not allowed to contact them.

At last follow-up examination, 13 to 19 years after PRK, patients underwent a thorough eye examination: history of eye diseases, CDVA and UDVA measurement, objective and subjective refraction, slit-lamp examination including haze grading, funduscopy, Pentacam HR tomography (Oculus, Berlin, Germany), and Goldmann applanation tonometry. Refraction at last follow-up examination was performed by an ophthalmologist (AHV) with a custom clip-on trial frame with glasses and the Jackson cross-cylinder with guidance from a calibrated auto-refractor (RK-2 auto ref-keratometer; Canon, Tokyo, Japan), and an Early Treatment of Diabetic Retinopathy Study chart. Patient satisfaction was also evaluated with a question taken from a translated version of a previously validated questionnaire for patients treated with PRK. The question was based on a visual linear scale from 0 to 10 anchored at each end by adjectival descriptors. The patients were asked at follow-up examination “Are you satisfied with your laser surgery for near-sightedness?” on a scale from 0 to 10, and results were divided into four subgroups.

Results from patients with unilateral PRK were separately analyzed, and results from both untreated and PRK-treated eyes in these patients were compared with each other and also with the entire cohort.

When presenting results, eyes with less than -6.0 diopters (D) spherical equivalent (SE) preoperatively were referred to as having low myopia and eyes with -6.0 D or more SE as having high myopia.

STATISTICAL ANALYSIS

Statistical analyses were performed using Microsoft Excel 2007 (Microsoft Corporation, Redmond, WA) and Systat SigmaPlot 12 (Systat Software Inc., San Jose, CA). Statistical analysis of visual acuity was based on logMAR units. For repeated measurements, the paired Student’s t test was used for normally distributed data and Wilcoxon signed rank test was used for non-normally distributed data. For proportions, Fisher’s exact test was used. A P value less than .05 was considered statistically significant. Because the two eyes of one subject are not independent, only results from one randomly chosen eye of each patient were used in the statistical analyses (n = number of patients = number of eyes), unless otherwise stated. Eyes were randomly chosen using the random number generator in Micro-
soft Excel 2007. However, concerning safety and complications, results from both eyes were also stated to avoid masking of important events and complications, due to the halving of data for statistical reasons.

**RESULTS**

One hundred sixty-four patients (59%) completed the last follow-up examination 13 to 19 years after their PRK procedure with an average follow-up time of 16 years. Four (2%) of the 164 eyes had undergone retreatment when attending follow-up examination and were excluded from the data analyses, giving a total of 160 eyes for analyses.

The maximum degree of myopic correction was -15.0 D (in the one eye with SE = -20.25 D). Eyes with high degrees of myopia were deliberately under-corrected. Only 2 eyes received torical ablation. Therefore, subgroup data analyses were not made for these few eyes concerning the refractive predictability of torical ablation.

**PREDICTABILITY**

Preoperative data for the last follow-up examination are presented in Table 1, and the difference in achieved versus attempted refraction is presented in Table 2. Predictability was highly related to the degree of myopia corrected (Table 2, Figures 1 and 2).

The predictability of the mean refractive SE was better when correcting low myopia than high myopia ($P = .015$). This was also the case when comparing the proportion of eyes within ±1.00 D of attempted correction ($P = .009$), but not when comparing eyes within ±0.50 D of attempted correction ($P = .087$, Figure 2). When excluding eyes with corneal haze, the achieved refraction was -0.73 ± 1.11 D from the attempted refraction. There was no difference when comparing refractive predictability in single zone versus multi-zone ablation ($P = .859$). The mean refractive error was unchanged ($P = .771$) when excluding eyes with cataract (n = 7). Refractive astigmatism is presented in Figure 3.

Results from 21 patients with unilateral PRK are presented in Table 3. The degree and distribution of myopia was different when comparing treated and untreated eyes and also when compared to the entire cohort. Three of the untreated eyes had a preoperative SE of -0.50 D or less, and these patients had initially not wanted surgery in that eye. The remaining patients had rejected surgery in the second eye due to dissatisfaction with the surgical result of the first eye.

**STABILITY**

A difference of approximately 1 D was found when comparing the mean refractive error after 6 months and at the last follow-up examination ($P < .001$, Figure 4). The difference in SE for the 21 patients with unilateral PRK is presented in Table 3.

**EFFICACY**

UDVA of 20/40 or better was achieved in 97% of eyes after 3 months, 96% after 6 months, and 79% at the last follow-up examination ($P < .001$, Figure 5). Half of the patients with low myopia and 22% of patients with high myopia had UDVA of 20/20 or better at the follow-up examination ($P = .020$).

**SAFETY**

Mean CDVA improved slightly but statistically significantly, both preoperatively to 6 months ($P < .001$, Table 1 and 2) and from 6 months postoperatively to the last follow-up examination ($P < .001$, Table 2). The improvement was greatest in eyes having received single zone ablation ($P = .011$). The proportion of patients with a CDVA of 20/40 or better was 99% both 6 months after surgery and at the last follow-up examination ($P = 1.00$).

The loss/gain of lines of CDVA is illustrated in Figure 6. None of the eyes with low myopia lost two or more lines, and all but one of the eyes gaining two or more lines of CDVA were categorized as having low myopia before surgery. When including both eyes of all

---

**TABLE 1**

Baseline Characteristics for Study Group

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients/no. of eyes* (sex)</td>
<td>160 (46.9% male)</td>
</tr>
<tr>
<td>Mean follow-up examination (y)</td>
<td>16.0 (range: 13 to 19)</td>
</tr>
<tr>
<td>Age at time of surgery on the first eye (y) (SD)</td>
<td>26.2 (range: 19 to 30)</td>
</tr>
<tr>
<td>IOP (mm Hg) (SD)</td>
<td>13.4 ± 2.1 (range: 9 to 19)</td>
</tr>
<tr>
<td>CDVA of all eyes (logMAR) (SD)</td>
<td>0.01 ± 0.06 (range: -0.20 to 0.30)</td>
</tr>
<tr>
<td>Sphere (D) (SD)</td>
<td>-4.73 ± 2.85 (range: -19.00 to -1.25)</td>
</tr>
<tr>
<td>Cylinder (SD)</td>
<td>-0.21 ± 0.50 (range: -2.50 to 0.00)</td>
</tr>
<tr>
<td>SE of all eyes (D) (SD)</td>
<td>-4.84 ± 2.95 (range: -20.25 to -1.25)</td>
</tr>
</tbody>
</table>

Distribution SE (%)

| Less than -6.0 D of myopia          | 78    |
| -6.0 to -10.0 D                     | 16    |
| More than -10.0 D of myopia         | 6     |

SD = standard deviation; IOP = intraocular pressure; CDVA = corrected distance visual acuity; D = diopters; SE = spherical equivalent

*Because the two eyes of one patient are not independent, only one eye of each patient was used in the statistical analyses, unless otherwise stated.

---
# TABLE 2

<table>
<thead>
<tr>
<th>Variable</th>
<th>Attempted vs Achieved SE (D)</th>
<th>CDVA (logMAR)</th>
<th>UDVA (^a) (logMAR)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n = 150</td>
<td>n = 150</td>
<td>n = 107</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>0.10 ± 1.01</td>
<td>0.00 ± 0.12</td>
<td>0.00 ± 0.18</td>
</tr>
<tr>
<td>(range: -9.00 to +4.00)</td>
<td>(range: -0.20 to +0.50)</td>
<td>(range: -0.20 to +1.30)</td>
<td></td>
</tr>
<tr>
<td>After 6 months</td>
<td>n = 126</td>
<td>n = 126</td>
<td>n = 88</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>-0.02 ± 0.58</td>
<td>0.00 ± 0.12</td>
<td>-0.01 ± 0.17</td>
</tr>
<tr>
<td>(range: -2.50 to 2.60)</td>
<td>(range: -0.20 to +0.50)</td>
<td>(range: -0.20 to +0.90)</td>
<td></td>
</tr>
<tr>
<td>After 13 to 19 years (all eyes)</td>
<td>n = 160</td>
<td>n = 160</td>
<td>n = 126</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>-1.00 ± 1.56</td>
<td>-0.08 ± 0.11</td>
<td>0.16 ± 0.34</td>
</tr>
<tr>
<td>(range: -10.75 to +1.00)</td>
<td>(range: -0.30 to +0.52)</td>
<td>(range: -0.26 to +1.50)</td>
<td></td>
</tr>
</tbody>
</table>

**Subgroups analyses after 13 to 19 years**

| Eyes with SE more than -6 D     | n = 124                      | n = 124       | n = 103              |
| Mean ± SD                       | -0.74 ± 1.07                 | -0.11 ± 0.07  | 0.12 ± 0.32           |
| Eyes with SE from -6 to -10 D   | n = 25                       | n = 25        | n = 17               |
| Mean ± SD                       | -1.79 ± 2.68                 | -0.02 ± 0.12  | 0.27 ± 0.40           |
| Eyes with SE more than -10 D    | n = 11                       | n = 11        | n = 6                |
| Mean ± SD                       | -2.06 ± 1.99                 | 0.14 ± 0.19   | 0.46 ± 0.36           |
| Eyes with single zone ablation\(^b\) | n = 103                      | n = 103       | n = 80               |
| Mean ± SD                       | -1.00 ± 1.62                 | -0.10 ± 0.09  | 0.13 ± 0.33           |
| Eyes with multi-zone ablation\(^b\) | n = 55                       | n = 55        | n = 45               |
| Mean ± SD                       | -0.99 ± 1.50                 | -0.04 ± 0.15  | 0.20 ± 0.38           |

\(^a\) For UDVA, only eyes with emmetropia as target refraction were included. Because the two eyes of one patient are not independent, only one eye of each patient was used in the statistical analyses.

\(^b\) Two of the 160 eyes received torical ablation; therefore, the numbers for single zone and multi-zone ablation do not add up to n = 160 and n = 126.

---

**CDVA** = corrected distance visual acuity; **UDVA** = uncorrected distance visual acuity; **SE** = spherical equivalent; **D** = diopters; **SD** = standard deviation

---

**Figure 1.** Predictability for 160 eyes treated with photorefractive keratectomy (PRK). Scatter plot and linear regression analysis of the attempted spherical equivalent (SE) refractive change plotted against the achieved SE refractive change at last follow-up examination. Mean follow-up time was 18 years.

**Figure 2.** Predictability. Subgroup analyses of spherical equivalent (SE) refractive accuracy at last follow-up examination. The percentage of eyes attaining specified differences in attempted versus achieved correction, divided in two subgroups: eyes with preoperative SE less than -6 diopters (D) (n = 124) and eyes with -6 D or more (n = 36).
patients in the analysis (n = 289 eyes), 6 eyes (2%) had lost two or more lines of CDVA, and 27 eyes (9%) had gained two lines of CDVA at follow-up examination.

Fourteen percent (n = 22) had haze at the last follow-up examination, compared to 22% having haze 3 and 6 months after PRK. Half (n = 11) had clinically insignificant trace haze (grade 0.5). The degree of haze improved from 6 months to the last follow-up examination, with fewer eyes having high degrees of haze (>1), although this was not statistically significant (P = .150).

In the majority of eyes with haze, refraction was not affected, and only 5 eyes (all with high myopia) had haze grade 2. Haze was present in 70% of eyes with more than -10.0 D of myopia, 36% of eyes with myopia from -6.0 to -10.0 D, and 5% of eyes with low myopia at follow-up examination. There were no occurrences of haze at the last follow-up examination in eyes with attempted corrections of less than -4.0 D. When including both eyes of all patients in the analysis, 12% had haze at the last follow-up examination.

Concomitant eye diseases for all 289 eyes at follow-up examination included 2% (n = 7) with cataract, of which only one eye with haze grade 0.5 could not be explained by either systemic use of steroids due to comorbidity or prolonged use of steroid eye drops (more than 1 year) due to haze. Also, 3% (n = 8) had myopic macular atrophy, 1% (n = 2) had glaucoma, and 1% (n = 4) had cup–disc changes susceptible to glaucoma and were referred for further diagnostic examinations. Twenty-seven patients had received intraocular pressure-lowering drops after PRK either as prophylactic treatment or because of increased intraocular pressure. None of these patients were diagnosed as having glaucoma at the follow-up examination. Mean treatment

TABLE 3
Baseline Characteristics and Refraction at Last Follow-Up Examination for Patients With PRK in Only 1 Eye

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No. of patients</th>
<th>Preoperative</th>
<th>Last Follow-Up Examination</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td>21 (47.6% male)</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Mean follow-up examination (y)</td>
<td>16.7 (range: 14 to 19)</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Age at time of surgery of the first eye (y) (SD)</td>
<td>26.1 (range: 22 to 30)</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Untreated eyes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SE of all eyes (D) (SD)</td>
<td>–</td>
<td>-3.48 ± 2.91 (range: -12.25 to -0.50)</td>
<td>-4.70 ± 3.17 (range: -12.25 to -0.50)</td>
</tr>
<tr>
<td>PRK-treated eyes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SE of all eyes (D) (SD)</td>
<td>–</td>
<td>-4.87 ± 2.69 (range: -12.50 to -1.75)</td>
<td>-1.82 ± 1.95 (range: -8.25 to 0.38)</td>
</tr>
<tr>
<td>Difference in SE (D)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preoperative to last follow-up examination of untreated eyes</td>
<td>-1.22 ± 1.06</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>6 months postoperatively to last follow-up examination of PRK-treated eyes</td>
<td>-1.57 ± 1.99</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

PRK = photorefractive keratectomy; SD = standard deviation; D = diopters; SE = spherical equivalent

*In total, 35 of 160 patients had unilateral PRK, and of these, 21 patients still had an untreated eye when attending last follow-up. The rest had undergone refractive surgery after 1998 and were therefore not included in the cohort or they were excluded from the control group because of other causes of vision loss such as extensive eye trauma or retinal detachment. No 6-month data existed for the untreated eyes. The mean refractive error in SE for the PRK-treated group of eyes after 6 months was 0.25 ± 0.72 D.
time with steroid drops was approximately 4 months, with a maximum of 19 months.

No signs of postoperative corneal ectasia were noted at follow-up, clinically or tomographically. Mean central corneal thickness was 516 ± 39 μm (range: 384 to 619 μm), and mean corneal power was 40.11 ± 2.35 D (range: 32.45 to 44.75 D) at the last follow-up examination.

**PATIENT SATISFACTION**

Patient responses are presented in Figure 7. Mean satisfaction score at the last follow-up examination was 7.4 ± 2.9 (range: 0 to 10). Eighty-one percent scored more than 5 on the scale, meaning that the patient was satisfied or very satisfied. Results were highly correlated to spectacle independence because 98% of patients free from distance spectacles scored more than 5, as compared to 61% in the group of patients who still needed glasses or contact lenses at the last follow-up examination \( (P < .001) \). In total, 54% of the patients felt no need for distance spectacles at the follow-up examination. More patients with low than high myopia scored more than 5 on the scale \( (P = 0.089) \), and their
mean satisfaction score was higher ($P = .076$), although the differences were not statistically significant.

**DISCUSSION**

To our knowledge, this is one of the longest follow-up studies of patients having undergone PRK for myopia and including more patients than most other long-term studies. In contrast to the majority of other publications, and after statistical guidance, we only included one randomly chosen eye of each patient due to the correlations between eyes. We excluded patients having undergone re-treatment and we also separately included analysis of data from a group of patients with only unilateral PRK. This was done for further interpretation of refractive results and in some degree to be able to take account of the myopic progression over time when analyzing predictability.

Our results underline that even “early PRK treatments,” without mitomycin C, without eye-tracker, and without high-frequency flying-spot excimer lasers still produced reasonable results, especially when limiting treatment to patients with low degrees of myopia. Our results seem comparable with other long-term prospective and retrospective results 8 to 16 years after PRK.

Concerning refractive predictability and stability, Alio et al. reported 75% of eyes (with less than -6 D) and 58% of eyes (with more than -6 D) being within ±1.0 D 10 years after PRK. Bricola et al. reported no late regression after 14 years, and Guerin et al. found a mean SE error of -0.69 ± 0.79 in 23 patients after 16 years. The mean degree of myopia was slightly different in these studies; they consisted of fewer patients and the rates of patients completing follow-up examination were different. In our study, the mean error in SE at last follow-up examination was less than a quarter of a diopter from the change in SE refraction in the group of untreated eyes, which may indicate that the refractive result of PRK was almost unchanged and stable from 6 months postoperatively. Comparison of refraction among treated and untreated eyes of the 21 patients also supports that the change in refraction 6 months postoperatively to follow-up examination was primarily due to myopic progression. However, the “control group of untreated eyes” was not perfectly matched to the entire cohort, and preoperative and postoperative axial length measurements and keratometry would have been helpful in analyzing just how much of the change in SE over time was due to natural myopic progression. Also, the change in correction planes (from spectacles to the cornea) and its effect on peripheral refraction is speculated to affect the development and progression of myopia.

The safety of PRK was high overall, especially for treatment of low myopia. There were no cases of corneal ectasia despite a small percentage of eyes that were treated for values not considerable for surface ablation techniques today (more than -10.0 D). The small 5-mm ablation zones, and therefore low ablation depth, are speculated to have reduced the risk of development of ectasia. The average improvement in CDVA was to be expected due to the image magnification effect of corneal refractive procedures for myopia. Our result of 12% of all eyes ending up with haze was comparable to other studies, 10 to 16 years after PRK.

Preoperative information is always important to balance patient expectations. Because this was a relatively new type of surgery at the time, all patients were told the known risks, that there was no guarantee of spectacle independence, and that long-term outcomes were unknown. Therefore, patient satisfaction should be evaluated under these terms. Because the most important reason for undergoing refractive surgery in most patients is to improve unaided vision and avoid spectacles, it was not surprising that satisfaction scores were highly related to spectacle independence. In contrast, the amount of myopia corrected only affected patient satisfaction to a small degree, and not significantly.

This study had several limitations. First, this was a retrospective study with the risk of different kinds of bias, especially selection bias in both the follow-up cohort and the group of unilaterally treated patients and especially when data from these groups were compared. Perhaps patients who attended follow-up were less satisfied and had more complications after PRK than the entire cohort, or vice versa. A best case/worst case scenario can be calculated, for example concerning percentage of patients with haze, as an interval from 49% to 8% if all patients (including the remaining 41% who failed to complete follow-up) had haze or none of them had haze. Also, the inclusion of only young patients to minimize age-related eye diseases affecting refraction and visual acuity could have induced the risk of including patients with less stable refractions. Second, cycloplegic eye drops had not been used because a pseudomyopic component had not been noticed preoperatively and cycloplegic refraction was not of great importance due to the small optical zones used in “early PRK treatments.” Third, this was the first cohort of patients treated at the department and results incorporate the learning curve of the surgeon. Fourth, it is important to remember that data were based on a now outdated broad beam laser and treatment algorithms, and cannot be directly compared with contemporary techniques.
PRK for low degrees of myopia seemed safe and effective, even up to 19 years after surgery. Refractive predictability was lower and the occurrence of haze was significantly higher in eyes with high myopia. Patient satisfaction was high, especially when freedom from spectacles was obtained. Subgroup analyses of unilateral treated patients indicated that myopic progression was the main reason for the remaining refractive error at the last follow-up examination.

AUTHOR CONTRIBUTIONS
Study concept and design (AHV, AKS); data collection (AHV); analysis and interpretation of data (AHV, JOH, AI, KW, JG); drafting of the manuscript (AHV); critical revision of the manuscript (AHV, JOH, AI, KW, JG, AKS); statistical expertise (AHV); obtained funding (AHV); administrative, technical, or material support (AHV, KW); supervision (JG, AKS)

REFERENCES