Topographically guided two-step LASIK and standard LASIK in the correction of refractive errors after penetrating keratoplasty

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PURPOSE. *To evaluate in a long-term period the effectiveness and safety of topographically guided two-step laser in situ keratomileusis (LASIK) and standard LASIK technique in the correction of refractive errors after successful penetrating keratoplasty (PKP) for keratoconus.*

METHODS. *At least 2 years after PKP and 6 months after removal of all sutures, 15 eyes of 15 patients (Group 1; mean manifest refraction spherical equivalent (MRSE) –7.23 D ± 3.42 SD) were submitted to standard LASIK and 15 eyes of 15 patients (Group 2; mean MRSE –4.37 D ± 1.97 SD) to a topographically guided two-step LASIK procedure (first the flap and at least 2 weeks later the laser ablation). In all cases, a superior hinged corneal flap (160 µm/9.5 mm) was created.*

RESULTS. *After a follow-up of 36 months, in Group 1 the mean uncorrected visual acuity (UCVA) was 0.51 logarithm of the minimum angle of resolution (logMAR) ± 0.41 SD and the mean best-corrected visual acuity (BCVA) was 0.03 logMAR ± 0.05 SD, with a mean MRSE of –1.57 D ± 2.65 SD. In Group 2, the mean UCVA was 0.28 logMAR ± 0.24 SD and the mean BCVA was 0.01 logMAR ± 0.03 SD, with a mean MRSE of –0.07 D ± 1.00 SD. In both groups, no complications were observed.*

CONCLUSIONS. *After a long follow-up period, both topographically guided two-step LASIK and standard LASIK could be considered effective and safe tools in the correction of refractive errors after successful PKP for keratoconus. (Eur J Ophthalmol 2009; 19:)*

KEY WORDS. *Laser in situ keratomileusis, Topographically guided two-step LASIK, Standard LASIK, Penetrating keratoplasty, Keratoconus*

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INTRODUCTION

Visual rehabilitation after penetrating keratoplasty (PKP) in keratoconus is often difficult because of the residual postoperative ametropia, invalidating the good result of corneal transplantation even with a clear corneal graft (1, 2). Anisometropia and high degrees of refractive errors can give problems with spectacles and contact lenses. In fact, contact lenses may induce an intolerance, graft neovascularization, and endothelial changes in the postoperative follow-up of PKP (3, 4). Because of the limitations of contact lenses correction, several surgical options for correcting post-PKP ametropia have been described; these include suture adjustment, selective suture removal, compression suture, radial keratotomy, relaxing incisions, and wedge resection. These are surgical alternatives that have been demonstrating their utility in the correction of post-PKP refractive defect, with a limitation in the stability and predictability of their results (5-7).

Recently, excimer laser techniques have been used by

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several authors in PKP cases. Because of the poor predictability and the high risk of complications observed after photorefractive keratectomy, laser in situ keratomileusis (LASIK) has been used for the correction of post-PKP refractive errors (2, 5-14). Unfortunately, in some cases, standard LASIK procedure in the correction of post-PKP refractive defects may result in irregular astigmatism and hypocorrection (15). Therefore, two-step LASIK procedure (first to create the hinged flap and later to perform refractive excimer laser ablation) was proposed with good results (2,16, 17).

Topographically guided excimer laser ablation procedures (customized photoablation) have been demonstrated to treat irregular astigmatism and corneal irregularities successfully, also after PKP cases (18-21). We performed this study with the aim to evaluate in a long-term period the effectiveness and safety in the correction of irregular astigmatism and refractive errors after PKP for keratoconus of topographically guided two-step LASIK and of standard LASIK.

METHODS

After the local ethical committee approved the study protocol, patients were enrolled in a consecutive prospective noncomparative case series since the aim of our study is a simple analysis of the potentiality of two different LASIK procedures after PKP. Thirty eyes of 30 patients that underwent successfully PKP for primary keratoconus; secondary ectasia and/or pellucid marginal degeneration were not included, were submitted to LASIK procedure in two strategies: 15 eyes of 15 patients (6 men and 9 women; mean age 38.2 years ± 9.4 SD) were submitted to standard LASIK (Group 1); 15 eyes of 15 patients (9 men and 6 women; mean age 36.7 years ± 6.90 SD) were submitted to topographically guided two-step LASIK (Group 2) **[QUERY: Please clarify preceding sentence]**. All the eyes included in this study were phakic and had a follow-up of 3 years after PKP and a minimum of 6 months after the removal of all sutures with stable refractive and corneal topographic patterns.

The preoperative examination included uncorrected visual acuity (UCVA) and best-corrected visual acuity (BCVA). All patients were contact lens intolerant. In the 2 months before LASIK treatment, the refraction was stable, as ascertained in two consecutive visits within one month that included manifest and cycloplegic refractions, slit-lamp biomicroscopy, measurement of intraocular pressure (IOP), and fundus examination. Corneal topography was analyzed using computerized videokeratoscopy (TMS-3 videokeratography unit, Tomey Inc., Nagoya, Japan): four keratoscopic images were obtained from each eye, and the best one was chosen. Two consecutive topography examinations, within 15 days of each other, were performed to check topographic stability. The data listed as the keratometric difference at 3 mm were considered the keratometric astigmatism. To evaluate the changes in corneal surface regularity, two topographic indexes were analyzed: the surface asymmetry index (SAI), which measures the differences in corneal powers at every ring (180° apart) over the entire corneal surface, and the surface regularity index (SRI), correlated with the potential visual acuity and measuring the local fluctuation of the central corneal power; when the SRI is elevated, the central corneal surface in front of the pupil is irregular, leading to a reduction in BCVA. Preoperative corneal thickness was evaluated using a 50-MHz ultrasound pachymeter (Corneo Gage^{TM} Plus, Sonogage, Inc., Cleveland, OH). Corneas with less than 480 m of corneal thickness were excluded. Corneal endothelial pattern, using a noncontact specular microscope (SEED SP 500, SEED Co, Ltd., Tokyo, Japan) adapted to a video digitization image-analysis system (Computerized Corneal Analyzer V.3.0.2, Alfa Intes & Graftek, Italy), was evaluated. The endothelium was analyzed for both quantitative (endothelial cell density [ECD = number of cells/mm^2]) and qualitative parameters (coefficient of variation [CoV = standard deviation cell area/mean cell area]). All parameters were automatically calculated by computer software. Corneas with less than 800 cells/mm^2 in the central cornea were also excluded.

Surgical procedure

The LASIK technique was performed by one surgeon (L.S.) under topical anesthesia (lidocaine 4% drops). A 160-μm-thick, 9.5 mm diameter, superior hinged corneal flap was created with an automated microkeratome (Hansatome, Baush & Lomb, Irvine, CA).

In Group 1, after the flap creation, an Argon Fluoride excimer laser (MEL-70 excimer laser, Carl Zeiss-Meditec, Jena, Germany) was used to carry out the ablation on dry stroma. Laser settings were as follows: 193-nm wavelength, constant energy settled at 35-Hz frequency, 180 mJ/cm^2 fluence, and 0.25-μm ablation rate. The laser us-

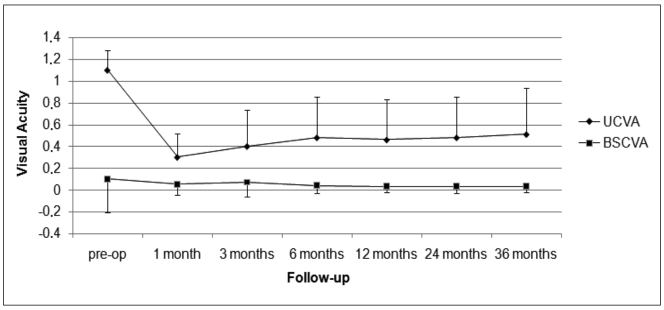

Fig. 1 - *Change in visual acuity (uncorrected visual acuity and best-corrected visual acuity) in logarithm of the minimum angle of resolution over time after standard laser-assisted in situ keratomileusis (Group 1).*

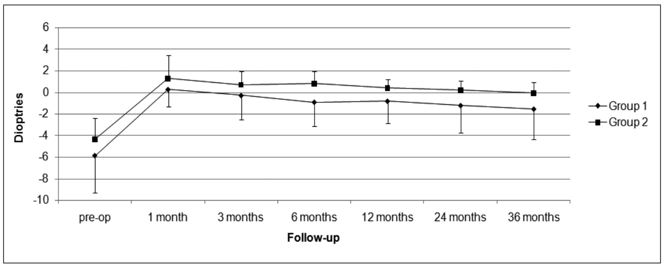

Fig. 2 - *Change in manifest refraction spherical equivalent over time in the two groups.*

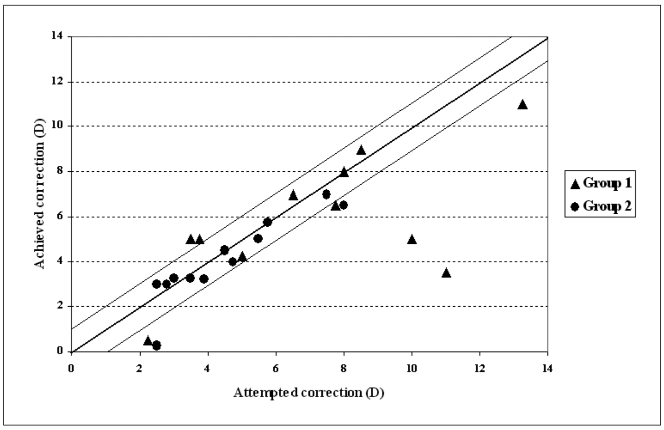

Fig. 3 - *Attempted vs achieved correction (manifest refraction spherical equivalent) in the two groups.*

es a 1.8-mm-diameter flaying spot with a gaussian profile. An active eye-tracking system oriented to a metal ring acted as an artificial limbus and maintained the centration. A cone for controlled atmosphere was added to the laser output to extract smoke or particles from the air without creating a draft and to remove all obstacles in the path of the laser beam. At the end of the photoablation, the corneal flap was repositioned in place without the aid of sutures.

In Group 2, the corneal flap was created as in Group 1 and then, after an irrigation of the interface, was repositioned back in place without using sutures. After at least

TABLE I - PREOPERATIVE DATA OF GROUP 1 (STANDARD LASIK)

Patient	UCVA	BCVA	Kerat ast	Refr cyl	MRSE	ECD	CCT	SRI	SAI
C.S.	1.1	0.1	4.53	–4.50	–13.25	1781	483	0.86	0.97
L.G.	1.0	0	1.89	0.00	–8.00	2102	587	0.87	0.8
D.L.R.	1.4	0.1	10.79	–10.00	–5.00	1965	594	0.82	0.86
F.P.	1.1	0.1	6.89	–7.00	–3.50	2045	535	0.76	0.88
G.A.M.	0.7	0	4.34	4.50	–3.75	2142	568	0.91	0.9
G.D.	1.2	0	6.37	–6.50	–2.25	1895	494	0.81	1.1
P.N.	1.3	0	2.67	–3.00	–8.50	1780	525	0.84	1.1
S.T.	1.1	0.4	7.90	–6.00	–11.00	1989	503	0.80	1.26
T.E.	1.1	0	11.33	–11.00	–10.00	1755	481	0.75	0.78
S.C.	1.0	0.3	10.21	–3.50	–7.75	1450	482	0.85	0.88
M.M.	1.1	0.1	4.50	–4.00	–6.50	879	510	0.86	0.91
F.L.	1	0.1	2.86	–1.75	–4.25	2106	474	0.85	0.86
A.A.	1.2	0.2	9.45	–8.00	–10.00	2198	559	0.72	0.82
L.S.	1.3	0.2	10.05	–8.75	–11.25	1530	574	0.80	0.84
M.B.	0.9	0	1.80	–1.25	–3.50	1354	481	0.82	0.84
Mean	1.10	0.10	6.40	–4.72	–7.23	1798.07	522.04	0.83	0.91
SD	0.17	0.13	3.41	4.12	3.42	362.28	44.57	0.05	0.12

LASIK = laser-assisted in situ keratomileusis; UCVA = uncorrected visual acuity (logMAR); BCVA = best-corrected visual acuity (logMAR); Kerat ast = keratometric astigmatism evaluated by corneal topographer; Refr cyl = refractive cylinder of manifest refraction; MRSE = manifest refraction spherical equivalent; ECD = endothelial cell density; CCT = minimum central corneal thickness measured by ultrasonographic pachymetry; SRI = topographic quality index of surface regularity index; SAI = topographic quality index of surface asymmetry index.

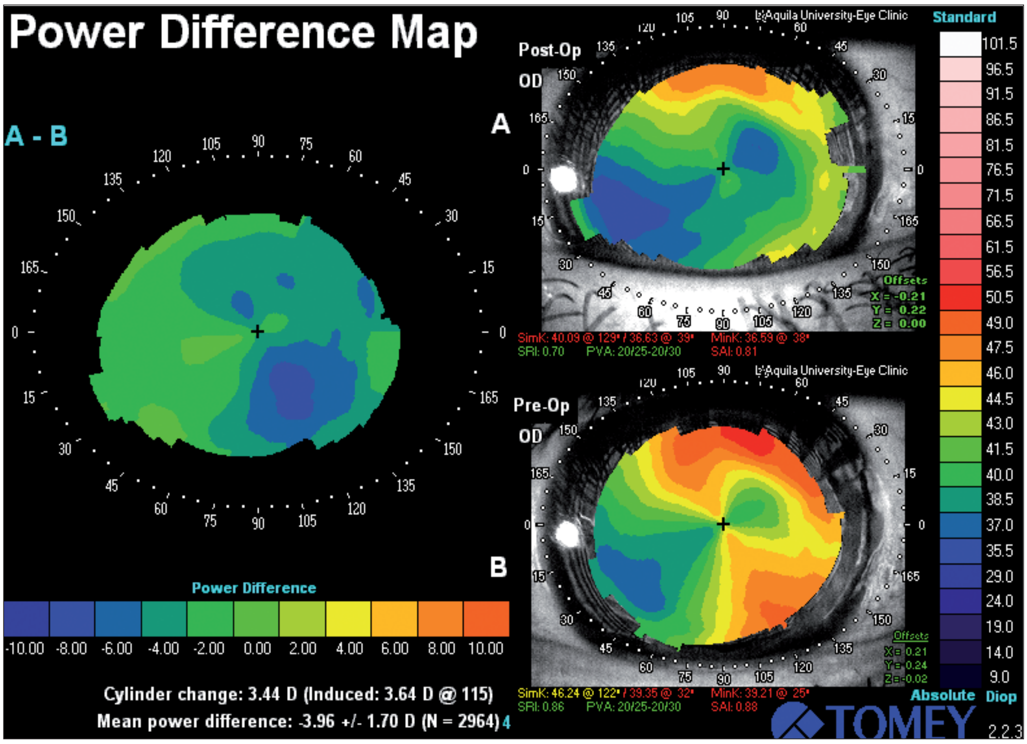

Fig. 4 - *Patient F.P., female, 43 years old. The differential map (left) highlights the light improved corneal profile obtained from before (bottom right) and 36 months after (top right) standard laser-assisted in situ keratomileusis for treatment of post–penetrating keratoplasty refractive error. Preoperative keratometric astigmatism and manifest refraction spherical equivalent (MRSE) were, respectively, 6.89 D and –3.50 D, with an uncorrected visual acuity (UCVA) and a best-corrected visual acuity (BCVA), respectively, of 1.1 and 0.1 logMAR. The final postoperative keratometric astigmatism and MRSE were, respectively, 3.46 D and 0.50 D, with a UCVA and a BCVA, respectively, of 0.4 and 0.0 logMAR. D = diopters; MinK = minimum keratometry value; PVA = potential visual acuity; SAI = surface asymmetry index; SimK = simulated keratometry value; SRI = surface regularity index.*

TABLE II - POSTOPERATIVE DATA OF GROUP 1 (STANDARD LASIK) AT 36-MONTH FOLLOW-UP

Patient	UCVA	BCVA	Kerat ast	Refr cyl	MRSE	ECD	CCT	SRI	SAI
C.S.	0.2	0.0	4.47	–2.50	–2.25	1674	382	0.81	0.73
L.G.	0.0	0.0	1.51	0.00	0.00	1955	471	0.77	0.79
D.L.R.	1.0	0.1	5.67	–3.50	–0.75	1803	533	0.79	0.85
F.P.	0.4	0.0	3.46	–4.00	0.50	1920	457	0.75	0.81
G.A.M.	1.0	0.0	0.22	1.50	1.25	2098	480	0.77	0.71
G.D.	1.0	0.0	2.34	–2.25	–3.13	1789	451	0.77	1.00
P.N.	0.0	0.0	1.37	1.00	0.50	1690	409	0.81	0.95
S.T.	1.0	0.1	2.27	–3.00	–7.50	1854	458	0.51	0.78
T.E.	0.5	0.0	3.00	–4.50	–5.00	1632	420	0.75	0.75
S.C.	0.4	0.1	3.75	–2.75	–1.38	1408	405	0.81	0.82
M.M.	0.1	0.0	2.46	0.00	0.50	834	435	0.82	0.71
F.L.	0.1	0	1.15	–0.25	–0.50	2003	439	0.85	0.83
A.A.	0.8	0.1	3.65	–3.25	–3.25	2061	440	0.75	0.81
L.S.	1	0.1	4.05	–4.25	–4.50	1430	461	0.79	0.80
M.B.	0.2	0	1.25	0.50	1.00	1297	425	0.80	0.81
Mean	0.51	0.03	2.77	–1.82	–1.57	1696.53	443.07	0.78	0.84
SD	0.41	0.05	1.53	2.05	2.65	339.32	38.88	0.09	0.08

LASIK = laser-assisted in situ keratomileusis; UCVA = uncorrected visual acuity (logMAR); BCVA = best-corrected visual acuity (logMAR); Kerat ast = keratometric astigmatism evaluated by corneal topographer; Refr cyl = refractive cylinder of manifest refraction; MRSE = manifest refraction spherical equivalent; ECD = endothelial cell density; CCT = minimum central corneal thickness measured by ultrasonographic pachymetry; SRI = topographic quality index of surface regularity index; SAI = topographic quality index of surface asymmetry index.

15 days (mean 23.3 days ± 5.1 SD), when videokeratographic patterns had been stable, the corneal flap was lifted up and laser ablation was performed, directly on the dry stroma, using the MEL-70 excimer laser linked to computerized videokeratographer TMS-3 with topographically supported customized ablation workstation (TOSCA). TOSCA is a system that allows performance of topography-supported refractive surgery in which the in-

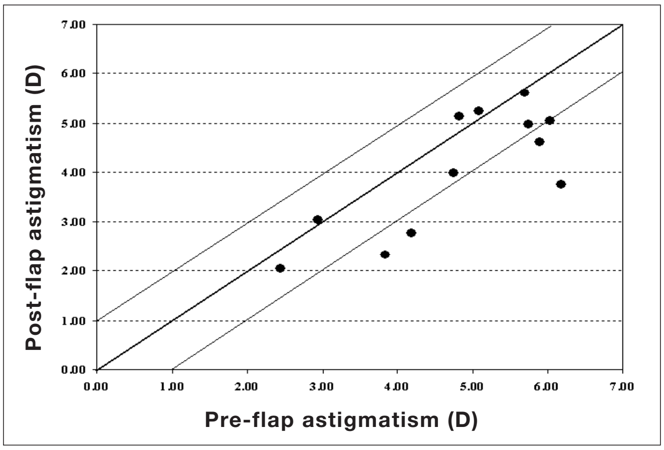

Fig. 5 - *Keratometric astigmatism (D) evaluated by computerized videokeratoscopy before and after corneal flap creation in Group 2 (topographically guided two-step laser-assisted in situ keratomileusis).*

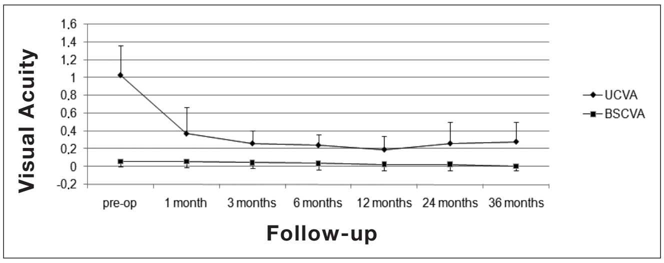

Fig. 6 - *Change in visual acuity (uncorrected visual acuity and best-corrected visual acuity) in logarithm of the minimum angle resolution over time after topographically guided two-step laser-assisted in situ keratomileusis (Group 2).*

dividual patient's corneal topography is measured and converted in a customized ablation profile (21-23). TMS-3 allows the viewing of an axial map and of an elevation map, which is useful for the planned calculation of the ablation pattern (23).

In both groups, no contact lenses were used in the postoperative period, and eye protection with a hard shield was advised for the day after surgery. All patients were instructed not to rub the eye. Patients received for the first 15 days ofloxacin 0.3% drops and butyrate clobetasone 0.1% drops 3 times a day. Then they received only butyrate clobetasone 0.1% drops once a day for 15 days. Preservative-free artificial tears (sodium hyaluronate 0.2%) were used up to 6 months in each case. Each patient was examined starting from the first hour after the treatment and after 1 and 15 days, and 1, 3, 6, 12, 24, and 36 months.

Data were collected postoperatively and entered into an Excel spreadsheet for subsequent analysis (Microsoft Inc.). Data are reported as mean ± SD. Statistical analysis was performed using Student *t* test.

TABLE III - PREOPERATIVE DATA OF GROUP 2 (TOPOGRAPHICALLY GUIDED TWO-STEP LASIK)

Patient	UCVA	BCVA	Kerat ast	Refr cyl	MRSE	ECD	CCT	SRI	SAI
C.V.	0.3	0.1	8.40	–5.00	–1.50	1446	593	1.10	1.65
R.P.	1.2	0.1	2.94	–4.50	–5.25	1697	545	0.85	0.98
D.L.	1	0.1	3.83	–6.00	–2.50	1664	571	0.75	0.81
T.E.	0.5	0.1	5.08	–4.50	–2.75	1123	567	0.97	1.23
A.R.	0.5	0.1	6.04	–4.75	–2.50	1029	572	0.94	1.45
C.L.	1.2	0	6.58	–6.75	–5.50	1906	496	1.03	0.53
R.T.	1	0.1	4.83	–7.00	–2.50	1456	584	0.78	0.82
N.P.	1.3	0	5.75	–3.75	–7.75	1605	520	0.91	1.03
O.M.	1.2	0	6.18	–5.00	–5.25	1888	547	0.85	0.90
C.D.	1.3	0	2.40	–1.25	–6.25	1900	530	0.46	0.74
B.R.	1.1	0	5.90	–3.50	–3.25	1954	578	0.81	0.88
S.E.	1.1	0	5.70	–5.00	–3.50	1898	580	0.86	0.88
B.L.	1.3	0.2	10.56	–8.50	–4.25	2095	510	1.23	0.70
P.R.	1.3	0	4.75	–4.00	–8.00	1595	531	0.89	1.10
M.P.	1.2	0.1	2.44	–3.25	–4.75	1742	565	0.81	0.95
Mean	1.03	0.06	5.27	–4.85	–4.37	1666.53	552.60	0.87	0.99
SD	0.33	0.06	2.16	1.74	1.97	303.68	29.57	0.17	0.24

LASIK = laser-assisted in situ keratomileusis; UCVA = uncorrected visual acuity (logMAR); BCVA = best-corrected visual acuity (logMAR); Kerat ast = keratometric astigmatism evaluated by corneal topographer; Refr cyl = refractive cylinder of manifest refraction; MRSE = manifest refraction spherical equivalent; ECD = endothelial cell density; CCT = minimum central corneal thickness measured by ultrasonographic pachymetry; SRI = topographic quality index of surface regularity index; SAI = topographic quality index of surface asymmetry index.

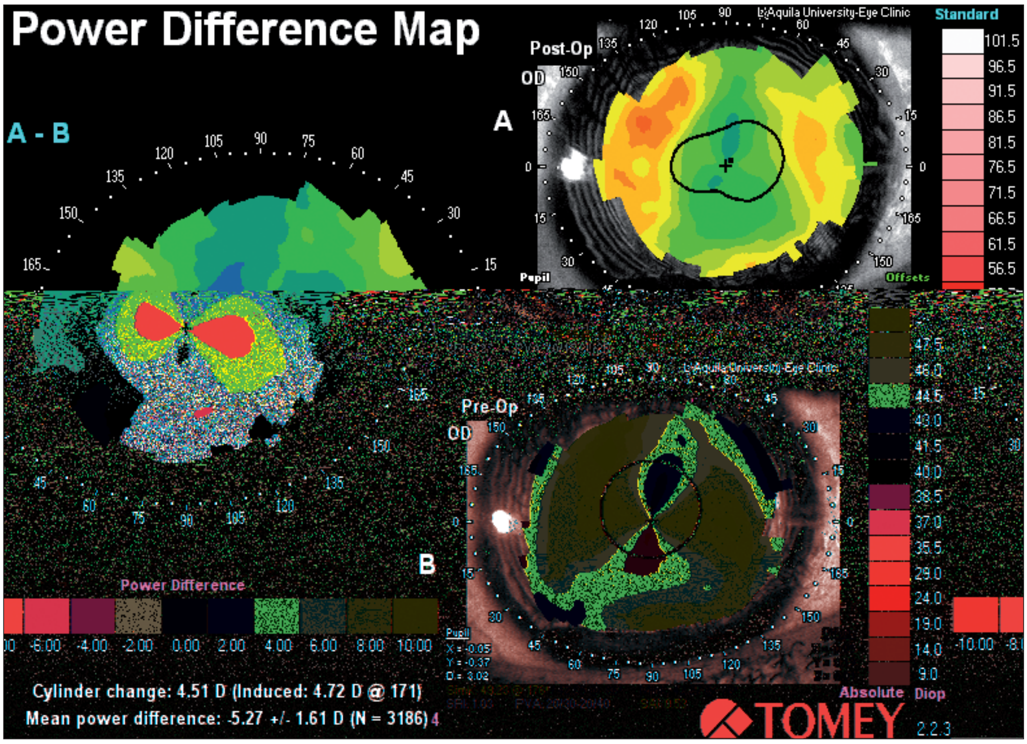

Fig. 7 - *Patient C.L., male, 49 years old. The differential map (left) highlights the improved corneal profile obtained from before (bottom right) and 3 years after (top right) topographically guided two-step laser-assisted in situ keratomileusis for treatment of post–penetrating keratoplasty refractive error. Preoperative keratometric astigmatism and MRSE were, respectively, 6.58 D and –5.50 D, with an uncorrected visual acuity (UCVA) and a best-corrected visual acuity (BCVA), respectively, of 1.2 and 0.0 logMAR. The final postoperative keratometric astigmatism and MRSE were, respectively, 2.07 D and –0.50 D, with UCVA and BCVA, respectively, of 0.1 and 0.0 logMAR. D = diopters; MinK = minimum keratometry value; PVA = potential visual acuity; SAI = surface asymmetry index; SimK = simulated keratometry value; SRI = surface regularity index.*

RESULTS

All patients had been treated once, and no significant intraoperative or postoperative complications, such as free-cap, button hole, epithelial ingrowth, flap striae and haze, or immunologic rejection, were observed. In both groups, postoperative slit lamp microscopy examination showed a clear graft in all eyes, with the flap clinging so

TABLE IV - POSTOPERATIVE DATA OF GROUP 2 (TOPOGRAPHICALLY GUIDED TWO-STEP LASIK) AT 36-MONTH FOLLOW-UP

Patient	UCVA	BCVA	Kerat ast	Refr cyl	MRSE	ECD	CCT	SRI	SAI
C.V.	0.1	0	2.56	2.00	1.00	1390	510	0.85	0.87
R.P.	0.4	0	1.90	–1.00	–1.00	1589	486	0.78	0.70
D.L.	0.5	0	0.12	–1.50	–0.50	1515	548	0.71	0.80
T.E.	0.7	0	1.90	–0.50	–1.00	1045	538	0.87	0.95
A.R.	0.7	0	2.76	–2.25	–2.25	902	552	0.87	0.85
C.L.	0.1	0	2.07	–1.75	–0.50	1845	432	0.27	0.51
R.T.	0.5	0.1	0.05	1.00	0.50	1344	550	0.72	0.79
N.P.	0.2	0	2.00	–0.75	0.75	1467	411	0.81	0.90
O.M.	0.1	0	3.10	–1.00	0.50	1757	470	0.31	0.74
C.D.	0.2	0	1.10	0.25	1.00	1818	405	0.29	0.40
B.R.	0	0	1.90	–0.75	–0.50	1865	537	0.75	0.91
S.E.	0	0	1.89	–0.50	–0.25	1770	549	0.78	0.85
B.L.	0.1	0	2.41	0	0.50	1690	445	0.50	0.55
P.R.	0.2	0	2.19	–1.00	1.50	1389	404	0.77	0.87
M.P.	0.4	0	1.94	–1.50	–0.75	1678	513	0.79	0.63
Mean	0.28	0.01	1.86	–0.57	–0.07	1537.60	489.00	0.67	0.78
SD	0.24	0.03	0.83	1.05	1.00	288.04	59.26	0.21	0.18

LASIK = laser-assisted in situ keratomileusis; UCVA = uncorrected visual acuity (logMAR); BCVA = best-corrected visual acuity (logMAR); Kerat ast = keratometric astigmatism evaluated by corneal topographer; Refr cyl = refractive cylinder of manifest refraction; MRSE = manifest refraction spherical equivalent; ECD = endothelial cell density; CCT = minimum central corneal thickness measured by ultrasonographic pachymetry; SRI = topographic quality index of surface regularity index; SAI = topographic quality index of surface asymmetry index.

well to the corneal surface that after a few days it was difficult to detect.

Group 1 (standard LASIK)

The preoperative UCVA, BCVA, keratometric astigmatism, refractive cylinder, manifest refraction spherical equivalent (MRSE), endothelial cell density, central corneal pachymetry, and topographic indexes (SRI and SAI) are shown in Table I.

The mean postoperative UCVA changes were statistically significant (p<0.001), with 53% of the eyes with a UCVA of 0.4 logarithm of the minimum angle of resolution (logMAR) or greater (mean 0.51 logMAR ± 0.41 SD), while mean BCVA did not change (mean 0.03 logMAR ± 0.05 SD; p=0.062) (Fig. 1). At 36 months follow-up, no patient lost lines of UCVA or BCVA, 7 eyes (46%) gained lines of BCVA, mean keratometric astigmatism was reduced 2.77 D ± 1.53 SD (p<0.001), mean refractive cylinder –1.82 D ± 2.05 SD (p=0.021), and mean MRSE –1.57 D ± 2.65 SD (p<0.001) (Tab. II) (Fig. 2). Seven eyes (46 %) were within ±1 D of the attempted correction (Fig. 3). The mean corneal pachymetry was reduced 78.97 μm (p<0.001), while the mean ECD (–102 cells/mm^2) and CoV (preop 45.9 ± 5.2 vs post-p 47.1±4.8) were statistically unchanged (p=0.43 and p=0.85, respectively). At the end of the follow-up, the topographic patterns did not improve; in fact, the changes, both for SRI and for SAI indexes, did not reach statistical significance (p=0.07 and p= 0.071, respectively) (Tab. II) (Fig. 4).

Group 2 (topographically guided two-step LASIK)

The preoperative UCVA, BCVA, keratometric astigmatism, refractive cylinder, MRSE, endothelial cell density, central corneal pachymetry, and topographic indexes (SRI and SAI) are shown in Table III. After the lamellar cut (i.e., the first stage), the astigmatism was modified more than 1 D in 5 cases (33 %) (Fig. 5). The mean 36-month postoperative UCVA (mean 0.28 logMAR ± 0.24 SD) and BCVA (mean 0.01 logMAR ± 0.03 SD) changes were statistically significant (p<0.001 and p=0.007, respectively), with 73% of eyes with an UCVA 0.4 logMAR or greater (Fig. 6). At 36 months follow-up, no patient lost lines of UCVA or BCVA, 7 eyes (46 %) gained lines of BCVA, mean keratometric astigmatism was reduced 1.86 D ± 0.83 SD (p<0.001), mean refractive cylinder– 0.57 D ± 1.05 SD (p<0.001), and mean MRSE– 0.07 D ± 1 SD (p<0.001) (Tab. IV) (Fig. 2). Thirteen eyes (86 %) were within ±1 D of the attempted correction (Fig. 3). The mean corneal pachymetry was reduced 63.6 μm (p<0.001), while the mean ECD (–129 cells/mm^2) and CoV (preop 44.9±5.1 vs postop 46.5±4.6) were statistically unchanged (p=0.24 and p=0.65, respectively). At the end of follow-up, the topographic patterns improved in all eyes for each of the two statistic evaluated indexes (SRI p=0.008 and SAI p=0.011) (Tab. IV) (Fig. 7).

DISCUSSION

Often, a successful PKP presents a clear graft, but this good anatomic result could be invalidated by scarce visual function due to an irregular astigmatism or high anisometropia (15). In fact, contact lenses in some cases are not effective or tolerated (4). The use of excimer laser technology to treat refractive errors after PKP has been reported by several authors, with LASIK achieving better results (2). However, in the past, the results of LASIK performed on eyes with high and irregular astigmatism after PKP have not been decisively satisfactory (5, 6). Recently, two-step LASIK was attempted to improve refractive results in the correction of ametropia after PKP, increasing LASIK predictability (16, 17). It was demonstrated that intraoperative changes up to almost 4 D in absolute value of astigmatism may be caused by simply performing a hinged lamellar flap in PKP eyes (25). In our study, after the lamellar cut the astigmatism was modified more than 1 D in 33% of cases. These changes are secondary to the irregular peripheral fibrosis of the scar line and to the biomechanics of the cornea undergoing this type of procedure. The main change induced by hinged flap creation was found immediately after the lamellar cut during the first postoperative day, but can continue for some days or weeks (25). The appropriate time between the lamellar cut and the laser ablation has not been determined; however, in our experience, a 2-week period is sufficient to obtain a stabilization of the topographic pattern.

Standard excimer laser ablation nomograms were often considered not effective in correcting irregular astigmatism resulting from PKP wound healing. In these years, several topography-linked systems have been developed, taking into account corneal irregularity in the attempt to treat irregular astigmatism; the use of a customized ablation was more effective in corneal irregularities correction from scarring and irregular astigmatism, especially in PKP eyes (18-24). These good results may be explained by the nature of irregular astigmatism. The latter consists of a localized abnormality of the cornea. Ablating the localized abnormality involves improved regularity of the corneal surface shape, with better visual performance.

In recent studies, the two-stage strategy and the customized ablation, linked together in LASIK treatment, achieved good results in the correction of astigmatism after penetrating keratoplasty (26, 27). The main disadvantage to the two-step LASIK approach in post-PKP eyes is in the intrinsic need for repeat surgery, with a theoretically higher risk of immunologic rejection or epithelial ingrowth (16).

In the present study, after 3 years of follow-up, both of the two tested LASIK strategies proved to be effective and safe tools in the correction of refractive errors after successful PKP for keratoconus, but in the topographic guided two-step LASIK group the maximal UCVA was obtained in 13.3% of eyes and the maximal BCVA in 93.3%, while in standard LASIK group the postoperative maximal UCVA was obtained in 13.3% of eyes and maximal BCVA in 66.6%. Moreover, in the topographically guided two-step LASIK group, the BCVA and the topographic patterns (SAI and SRI indexes) improved in all eyes, while in the standard LASIK group these changes were not evidenced.

In conclusion, our study indicates that the two-step approach is probably the most advantageous solution for eyes with post penetrating keratoplasty astigmatism and this approach increases the predictability of LASIK in these cases.

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