

Conductive Keratoplasty for Presbyopia: 1-year Results

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ABSTRACT

PURPOSE: To assess the safety, efficacy, and stability of conductive keratoplasty (CK) in the treatment of presbyopia.

METHODS: Ten near plano presbyopic patients (6 women and 4 men) underwent unilateral CK in the non-dominant eye to improve their near vision. Mean age was 51 ± 3.1 years (range: 46 to 56 years). The surgeries were the author's first 10 CK procedures performed. The postoperative target for these eyes ranged from -1.25 to -1.75 diopters (D).

RESULTS: Preoperative mean manifest refraction spherical equivalent (MRSE) was -0.18 ± 0.27 D (range: -0.75 to -0.25 D), yielding a mean near uncorrected visual acuity (UCVA) of J10 (range: J12 to J5). Twelve months after CK, the mean near UCVA was J1 (range: J3 to J1) with 90% (9/10) eyes J1 and 100% (10/10) eyes J3 or better. The mean MRSE was -1.31 ± 0.53 D (range: -2.25 to -0.75 D). Treated eyes lost an average of 2.2 ± 2 lines (range: 0 to 5) of distance UCVA but gained an average of 8.7 ± 2 lines (range: 4 to 11) of near UCVA. No eye lost best spectacle-corrected visual acuity or had induced cylinder ≥ 0.75 D. Nine (90%) of 10 patients had binocular distance UCVA $\leq 20/20$ and near UCVA $\leq J1$ and all 10 (100%) patients had binocular distance UCVA $\leq 20/25$ and near UCVA $\leq J3$.

CONCLUSIONS: Conductive keratoplasty for the treatment of presbyopia provided safe and effective results 1 year following the initial surgery. Longer follow-up will be needed to describe refractive stability. The mean near and distance UCVA results were better than expected for the amount of refractive change observed during this study. [*J Refract Surg.* 2006;22:137-144.]

Conductive keratoplasty (CK) is a radiofrequency-based collagen shrinkage procedure. The ViewPoint CK system (Refractec Inc, Irvine, Calif) uses a probe to deliver low energy, high frequency (350 kHz) current directly into the paracentral corneal stroma at 8 to 32 treatment spots. Striae form between the spots as the collagen contracts, producing a band of tightening that increases the central corneal curvature, thereby reducing spherical hyperopia.

Conductive keratoplasty uses the conductive properties of the cornea. As controlled-released energy flows through the stainless steel Keratoplast tip (Refractec Inc), the surrounding corneal tissue creates resistance to the energy, resulting in heat production to a temperature of 65°C , causing collagen shrinkage (unpublished data, 1999, Refractec Inc, Irvine, Calif). The Keratoplast tip, with a diameter of $90 \mu\text{m}$ and length of $450 \mu\text{m}$, penetrates the cornea, delivering the current equally from the corneal surface to the end of the tip. The collagen surrounding the entire length of the tip is exposed to the same temperature, creating a column or cylindrical footprint that extends deep into the stroma at approximately 80% depth (unpublished data, 1999, Refractec Inc, Irvine, Calif).

Conductive keratoplasty has US Food and Drug Administration (FDA) approval for the treatment of 0.75 to 3.00 diopters (D) of spherical hyperopia in patients aged ≥ 40 years. The CK procedure has also been performed, off-label, to treat presbyopic symptoms of emmetropic patients by using the system to produce a low to moderate level of myopia, usually in the non-dominant eye. In March 2004, the FDA granted approval to the NearVision CK system (Refractec Inc) for the reduction of presbyopic symptoms of presbyopic hyperopes ($+1.00$ to $+2.25$ D) or emmetropes aged ≥ 40 years through induction of 1.00 to 2.00 D of myopia in the non-dominant

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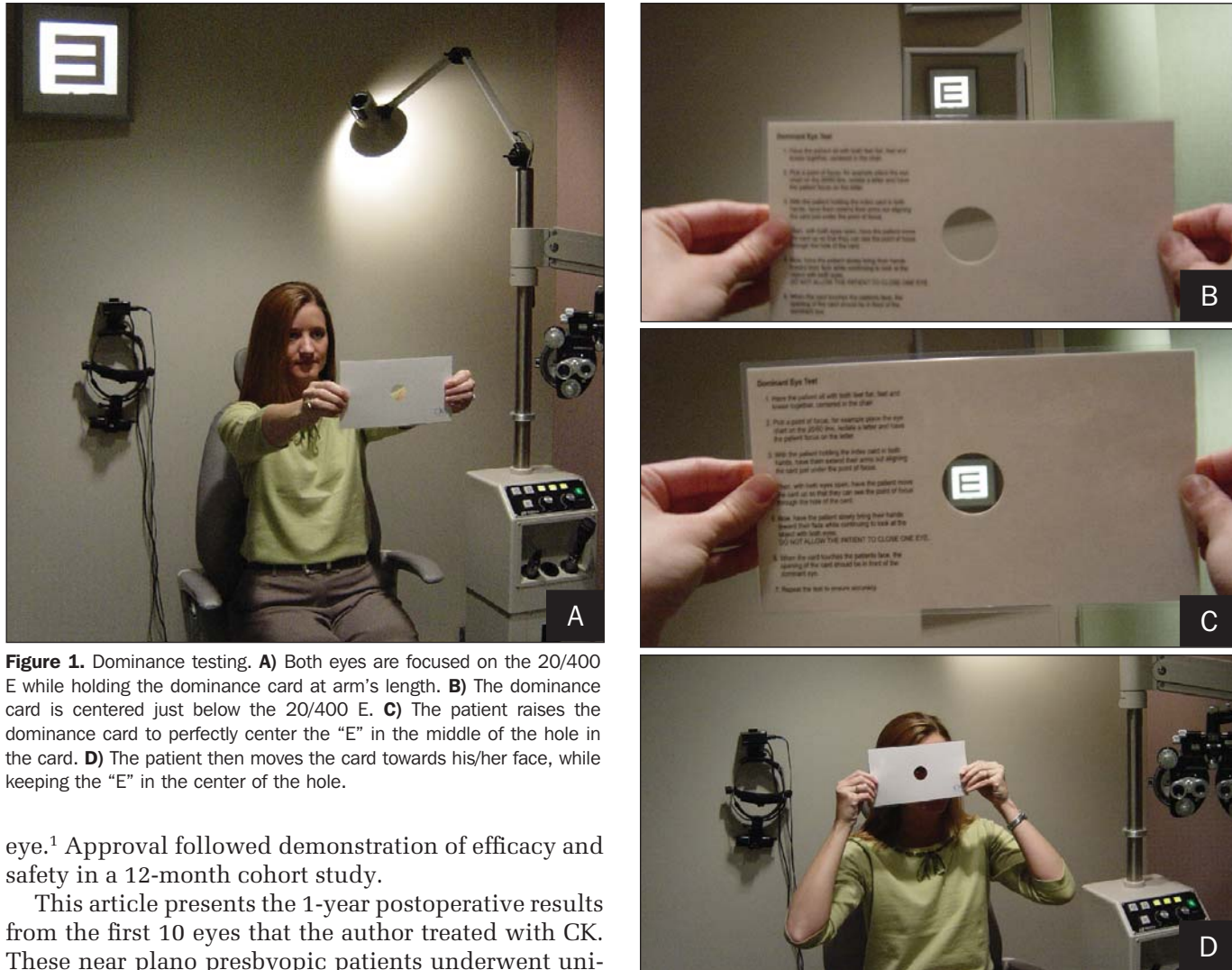


Figure 1. Dominance testing. **A)** Both eyes are focused on the 20/400 E while holding the dominance card at arm's length. **B)** The dominance card is centered just below the 20/400 E. **C)** The patient raises the dominance card to perfectly center the "E" in the middle of the hole in the card. **D)** The patient then moves the card towards his/her face, while keeping the "E" in the center of the hole.

eye.¹ Approval followed demonstration of efficacy and safety in a 12-month cohort study.

This article presents the 1-year postoperative results from the first 10 eyes that the author treated with CK. These near plano presbyopic patients underwent unilateral CK in the non-dominant eye to improve near vision.

PATIENTS AND METHODS

In this prospective, consecutive case series, single-center clinical study, 10 eyes of 10 patients (6 women and 4 men) were treated for presbyopia with CK. Surgeries were performed between March and May 2003. The treatment was performed with the ViewPoint CK system (Refractec Inc). Informed consent was obtained from each patient prior to surgery. Mean patient age was 51 ± 3.1 years (range: 46 to 56 years).

Eligibility criteria included binocular distance uncorrected visual acuity (UCVA) no worse than 20/30, a manifest refraction spherical equivalent (MRSE) ranging from +0.75 D to -0.75 D, and ≤1.00 D of cylinder. Manifest refraction spherical equivalent had to be stable within 1.00 D over the 6 months preceding enrollment. Patients also had to be healthy and have no significant medical history. Patients with residual,

recurrent, or active ocular disease or corneal abnormalities were excluded from study participation. One patient had undergone hyperopic LASIK 2 years prior to CK treatment whereas all of the remaining patients had no history of previous eye surgery.

Sighting dominance testing determined the patient's eye dominance. In this test, patients are instructed to sit with shoulders and feet square to the 20/400 Snellen E in the examination room. They are given an 8¾ × 4¾-inch card containing a 1¼-inch hole in the center. Keeping both eyes open and observing the 20/400 E (Fig 1A), the patient holds the card horizontally at arm's length and centers the card just below the target (Fig 1B). The patient then raises the card so that the distance target is perfectly centered in the middle of the hole in the card (Fig 1C). The patient then moves the card towards his/her face, all the while keeping the "E" in the center of the hole (Fig 1D). The patient repeats these steps several times. The dominant eye is

Preoperative, Surgical, and 1-year Postoperative Data on 10 Eyes Treated With Conductive Keratoplasty for Presbyopia

TABLE

Patient/ Sex/Age (y)	Eye	Preoperative Data			Surgery			1-year Postoperative Data					
		UCVA Distance	UCVA Near	Manifest Refraction	BSCVA	SE (D)	CK Spots	Target SE (D)	UCVA Distance	UCVA Near	Manifest Refraction	BSCVA	SE (D)
1/F/53	OS	20/20	J8	-0.25-0.25×45	20/20	-0.375	16	-1.25	20/60	J1	-1.00-0.50×131	20/20	-1.25
2/F/56	OS	20/25	J8	+0.50-1.00×67	20/20	Plano	16	-1.25	20/30	J1	-1.00-1.00×87	20/20	-1.50
3/F/53	OD	20/20	J10	Plano sphere	20/20	Plano	16	-1.25	20/40	J1	-1.00-0.50×70	20/20	-1.25
4/M/46	OS	20/20	J10	+0.25-0.50×176	20/20	Plano	16	-1.25	20/20	J1	-0.50-0.50×125	20/20	-0.75
5/M/48	OD	20/30	J12	+0.50-0.50×105	20/20	0.25	16	-1.25	20/30	J1	-0.75-0.50×75	20/20	-1.00
6/F/53	OS	20/25	J5	-0.50-0.50×82	20/20	-0.75	16	-1.75	20/60	J1	-1.75-1.00×69	20/20	-2.25
7/F/54	OS	20/20	J12	-0.25 sphere	20/20	-0.25	16	-1.25	20/25	J3	-0.50-0.50×85	20/20	-0.75
8/F/51	OD	20/20	J12	Plano-0.50×180	20/20	-0.25	16	-1.25	20/50	J1	-1.75-0.50×180	20/20	-2.00
9/M/48	OD	20/20	J10	Plano-0.25×175	20/20	-0.125	16	-1.25	20/25	J1	-0.75-0.50×160	20/20	-1.00
10/M/51	OS	20/20	J12	-0.25 sphere	20/20	-0.25	8	-1.25	20/40	J1	-1.25-0.25×90	20/20	-1.38

UCVA = uncorrected visual acuity; BSCVA = best spectacle-corrected visual acuity; SE = spherical equivalent; CK = conductive keratoplasty; OS = left eye; OD = right eye

determined to be the eye the patient repeatedly used at distance with the card. The patient was then asked to observe which eye was used so he/she would know which eye was the dominant one. This is important in monovision procedures for patients of this plano presbyopic group since they have excellent distance UCVA and they will be using their dominant eye for distance viewing.

Each patient's near UCVA was measured at 14 inches using the Alza near vision card (Palo Alto, Calif). Loose lens (+0.75 to +1.50 D) testing of the non-dominant eye determined how many rings of treatment (1 or 2) would be performed. The loose lens is held in front of the non-dominant eye while binocularly viewing first the near card and then the distance chart to determine patient satisfaction with both near and distance visual acuity.

CONDUCTIVE KERATOPLASTY SURGICAL PROCEDURE

Preoperatively, one drop of Ocuflax (Allergan Inc, Irvine, Calif), Acular (Allergan Inc), and 0.5% tetracaine was administered two times at 5-minute intervals. The patient was transferred to the clinic procedure room and placed in a supine position. The eye was prepped with betadine and a lid speculum was placed to obtain maximal exposure and provide the electrical return path. The operating microscope was centered over the eye and focused. All procedures were performed using the Endure ProCart and microscope (Endure Medical Inc, Cumming, Ga) without a patient fixation light. The surface of the cornea was dried with a fiber-free sponge to avoid dissipation of applied energy through a damp surface. While the patient fixated on the light from the surgical microscope, the cornea was marked with a gentian-violet-dampened, eight-intersection CK marker that marks the 7-mm treatment zone and makes radial marks that extend from the 6- to 8-mm treatment zone.

The Keratoplast tip was placed on the cornea at the treatment markings, perpendicular to the corneal surface. Light pressure was applied until the tip penetrated the stroma to its insulator stop. Energy was applied by depressing the foot pedal. All eyes were treated at the default setting of 350 kHz, 60% power, for 0.6 seconds. Nine eyes received a total of 16 spots with 8 spots placed at both the 6- and 7-mm treatment zones. One eye received a total of 8 spots at the 6-mm treatment zone (history of hyperopic LASIK). A target refraction of -1.25 to -1.75 D in the non-dominant was selected depending on the patient's near visual needs.

POSTOPERATIVE CARE

After surgery, one drop of Ocuflax and one drop of Acular were instilled. For 1 week patients used Ocu-

CK for Presbyopia/Stahl

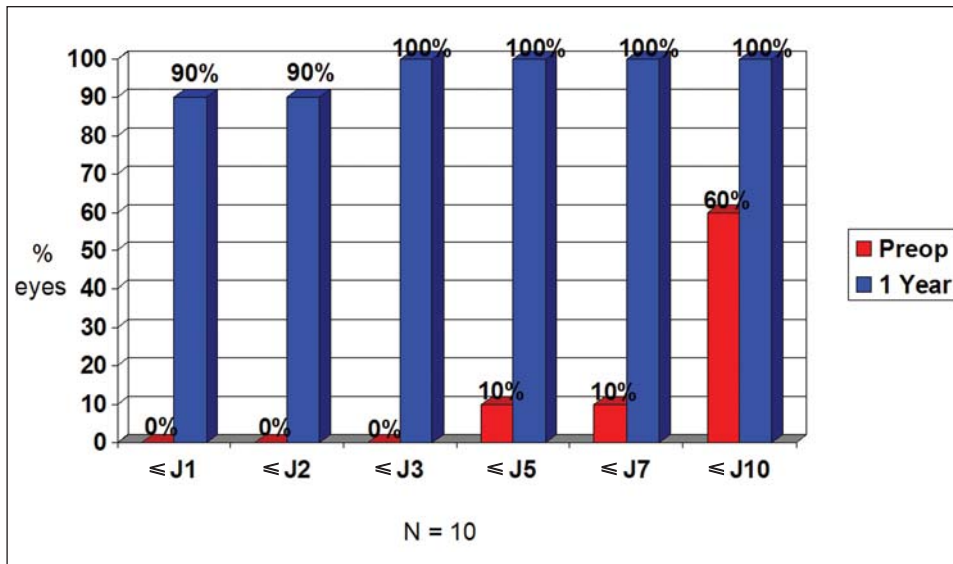


Figure 2. Preoperative and 1-year postoperative uncorrected near visual acuity (Jaeger) in 10 patients who underwent CK for near vision improvement.

flox and Pred Forte (Allergan Inc) four times a day. Unpreserved artificial tears were used as needed. Postoperative examinations were performed at 1 and 7 days and 1, 3, and 12 months. Patients were asked to subjectively evaluate the quality of their vision, report their level of satisfaction, and indicate whether spectacle-correction was need for near or distance vision.

RESULTS

In this study, 10 eyes of 10 near plano presbyopic patients treated with CK for near vision improvement were followed for 12 months (Table). All eyes were available for follow-up examination at 12 months. No retreatments were performed.

UNCORRECTED VISUAL ACUITY

Near UCVA measurements for the treated eyes before and 12 months after surgery are shown in Figure 2. Before surgery, mean near UCVA was J10 (range: J12 to J5). At 12 months after surgery, mean near UCVA was J1 (range: J3 to J1), with 90% of eyes J1 and 100% of eyes J3.

Preoperatively, mean logMAR distance UCVA was $20/22 \pm 0.06$ (range: 20/30 to 20/20). At 12 months postoperatively, mean distance UCVA was $20/36 \pm 0.17$ (range: 20/60 to 20/20). Treated eyes lost an average of 2.2 ± 2 lines (range: 0 to 5 lines) of distance UCVA but gained an average of 8.7 ± 2 lines (range: 4 to 11 lines) of near UCVA.

Preoperatively, 1 (10%) patient had binocular distance UCVA $\geq 20/30$ and near vision $\geq J5$. At 12 months after surgery, 90% (9/10) of patients had binocular distance UCVA $\geq 20/20$ and near vision $\geq J1$; all 10 (100%) patients had binocular distance UCVA $\geq 20/25$ and near vision $\geq J3$ (Fig 3). The mean logMAR binocular distance

UCVA was 20/20 in all 10 patients before surgery and 12 months after surgery.

REFRACTIVE OUTCOME AND SAFETY

Preoperatively, the mean MRSE was -0.18 ± 0.27 D (range: -0.75 to $+0.25$ D), the mean sphere was $\text{plano} \pm 0.33$ D (range: -0.25 to $+0.25$ D), and mean cylinder was -0.35 ± 0.32 D (range: plano to -1.00 D). At 1 year, mean MRSE was -1.31 ± 0.53 D (range: -2.25 to -0.75 D), the mean sphere was -1.00 ± 0.47 D (range: -1.75 to -0.50 D), and mean cylinder was -0.61 ± 0.22 D (range: -0.25 to -1.00 D). The absolute change in refractive cylinder 12 months after CK was 0.22 D (range: 0 to 0.50 D). No eyes had an increase in cylinder >0.50 D at 1 year following surgery. The logMAR best spectacle-corrected visual acuity (BSCVA) was 20/20 for all eyes prior to surgery, and at 1-year postoperative follow-up, no eye had lost lines of BSCVA.

STABILITY

All 10 CK-treated eyes were evaluated for stability (mean diopter change in MRSE over time; Fig 4). At 1 month, an overcorrection was observed with a mean MRSE of -2.24 D for the 9 eyes targeted for a final correction of -1.25 D. At 3 months, the mean MRSE was -1.60 D, representing a decrease of the mean MRSE of 0.64 D from 1 month. The 1-year mean MRSE was -1.19 D, which reflected a 5% regression from the intended -1.25 D target and a 44% regression from the 1-month overcorrection. The rate of regression (as indicated by the change in diopters per month) was low between 3 and 12 months with the mean MRSE changing 0.046 D per month.

The one eye targeted for -1.75 D was also overcorrected at 1 month with an MRSE of -2.87 D. The MRSE decreased to -2.40 D at 3 months, representing

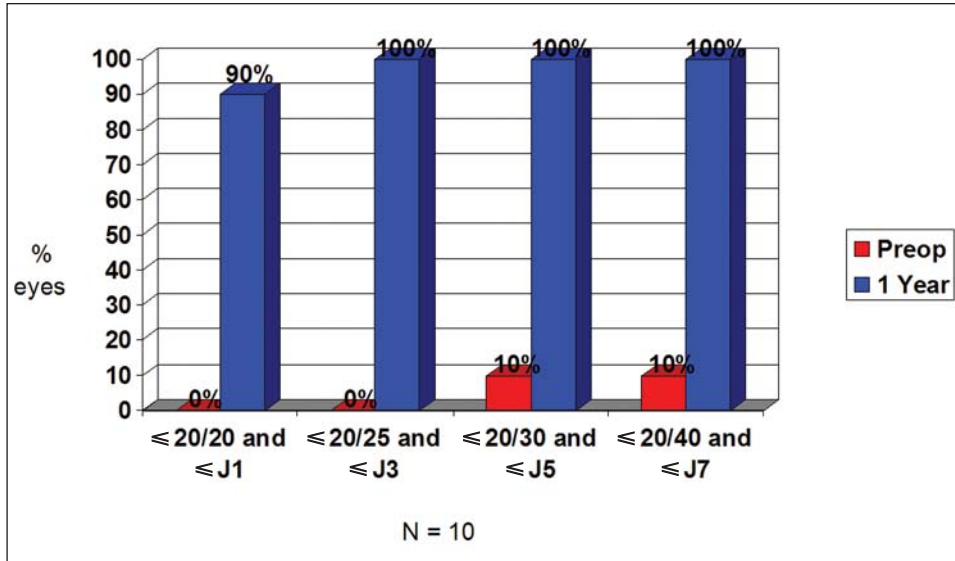


Figure 3. Preoperative and 1-year postoperative binocular uncorrected visual acuity at near (Jaeger) and distance (Snellen) for 10 eyes that underwent CK for presbyopia.

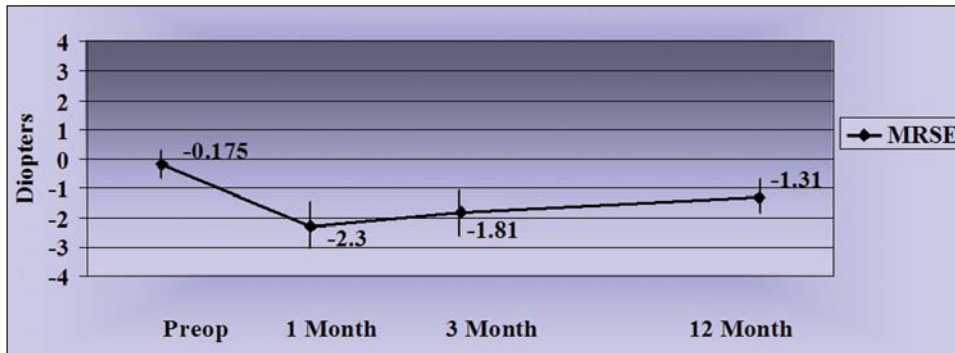


Figure 4. Mean diopter change in MRSE over 1-year follow-up for all 10 eyes that underwent CK.

a change of 0.47 D from 1 month. At 1 year, the MRSE was -2.25 D, which represented a 33% regression from 1 month but is still 0.50 D overcorrected. The rate of regression in this eye was lower with the MRSE changing 0.017 D per month between 3 and 12 months.

PREDICTABILITY

All eyes were targeted for -1.25 D postoperative refraction except one eye that was targeted for -1.75 D. The target was based on loose lens testing and patient satisfaction with near vision during this test. One year after surgery, 100% of eyes were within ± 0.75 D, 90% of eyes were within ± 0.50 D, and 60% of eyes were within ± 0.25 D of intended correction.

TOPOGRAPHY AND KERATOMETRY

Corneal topography revealed postoperative central corneal steepening surrounded by mid-peripheral flattening (Fig 5). Before surgery, the mean central power on videokeratography was 43.68 ± 1.71 D (range: 41.30 to 45.90 D). At the 1-year follow-up, mean central power was 44.9 ± 1.94 D (range: 42.30 to 48.70 D). The mean change in central power was 1.30 D of steepening, which resulted in a mean refractive effect (postop-

erative mean MRSE minus preoperative mean MRSE) of -1.13 D.

SLIT-LAMP FINDINGS

Conductive keratoplasty spots (leukomas) that extend approximately 80% to 90% of the corneal thickness are produced during the treatment. Striae are visible between the spots resulting from collagen concentration. Initially, the spots are fairly dense but gradually fade and are not cosmetically visible. At 1 year, faint CK spots and striae were still present on slit-lamp examination. The spots were less dense but the stromal depth was still approximately 80% to 90% of corneal thickness (Fig 6).

COMPLICATIONS

No complications occurred during the surgeries or postoperatively in the study.

PATIENT COMMENTS

All patients reported some degree of glare and/or halo at night during the early postoperative period. However, at 1-year follow-up, all 10 patients reported satisfaction with their vision and were spectacle-free for

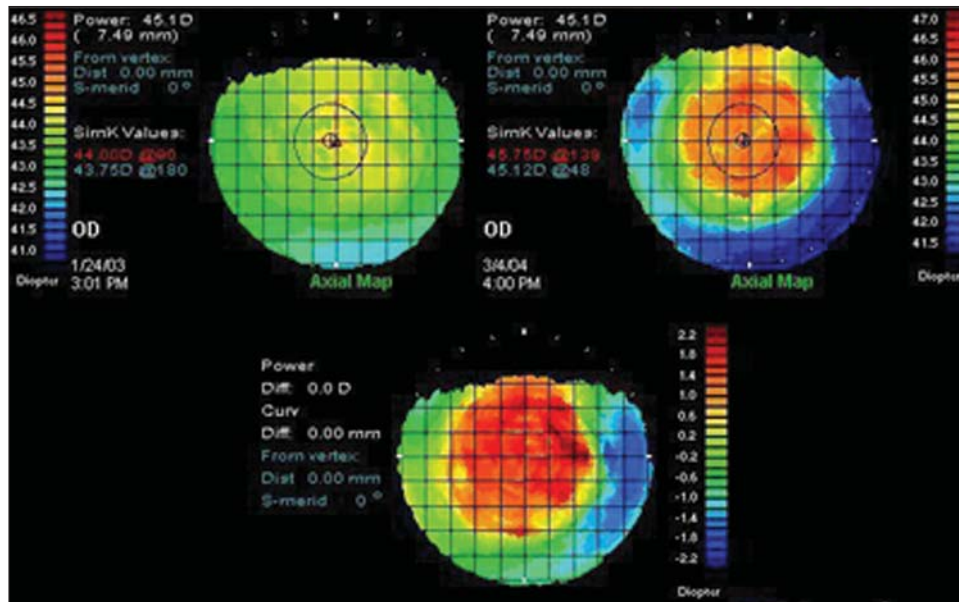


Figure 5. Corneal topography demonstrating before (upper left) and 12 months after (upper right) CK treatment with 16 spots. The difference map is also shown (lower center). Notice the postoperative central steepening surrounded by mid-peripheral flattening.

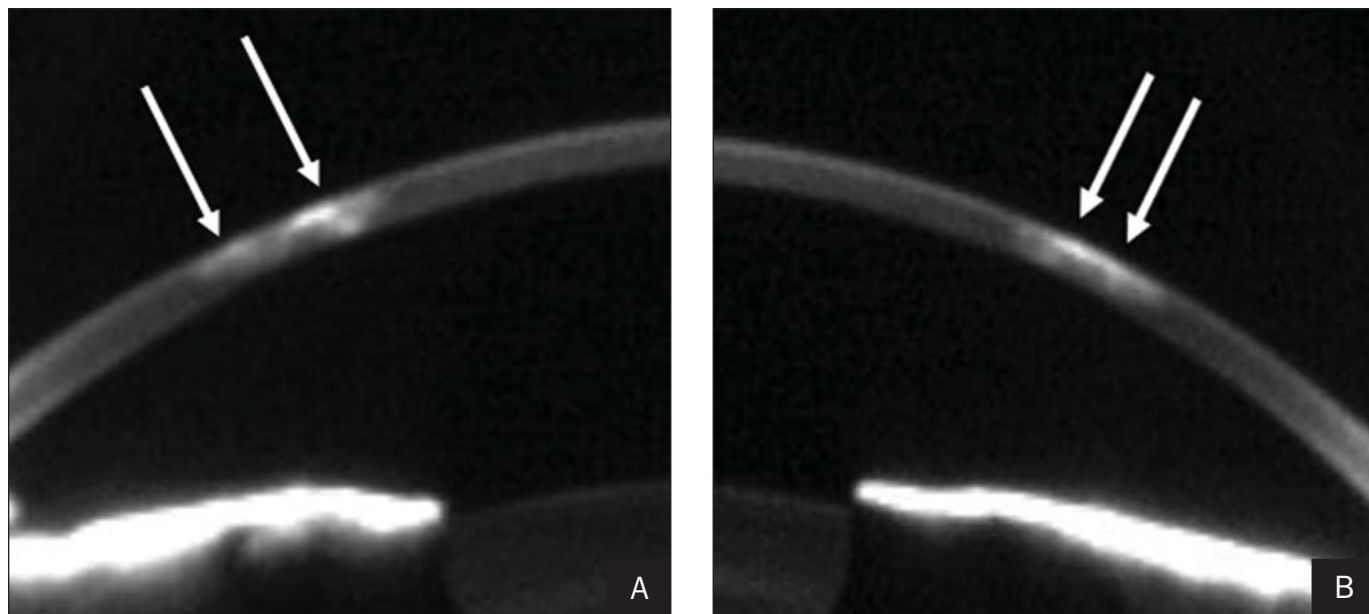


Figure 6. A, B) Scheimpflug images of different areas of the same cornea demonstrating adjacent CK spots (arrows) that extend approximately 80% to 90% of stromal thickness in this eye 1 year following surgery.

all near (ie, small print, menu, prolonged reading, shaving, make-up), intermediate (ie, computer screen), and distance (ie, street signs, driving at night) activities.

DISCUSSION

The 10 participating patients, ranging in age from 46 to 56 years, had all presented seeking decreased dependence on reading glasses. Their spherical and cylindrical refractive error was low, placing them in the category of plano presbyopes, defined as having an MRSE of ± 0.75 D of emmetropia with ≤ 1.00 D cylinder, who are at least 45 years of age, and have significant pres-

byopic symptoms. None of the patients in this study required distance correction. Their binocular distance UCVA was 20/20 in all cases but their binocular near UCVA confirmed their presbyopic condition.

Plano presbyopes are a unique subgroup that currently constitutes 20.5% of persons aged >40 years, a large segment of the baby-boomer population.² Additionally, refractive surgery procedures, such as laser in situ keratomileusis (LASIK), photorefractive keratectomy (PRK), and laser subepithelial keratectomy (LASEK), create a growing number of patients with a plano refraction who will become presbyopic from

natural aging. Cataract surgery also produces plano presbyopes when the postoperative target selected is for distance viewing in both eyes.

Whether naturally occurring or due to surgical procedures, plano presbyopes comprise a growing portion of the population. These patients are accustomed to excellent vision without correction and are less tolerant of spectacles or contact lenses.

EFFICACY

All patients achieved improved uncorrected near vision after CK treatment that continued during the 12 months of this study. The achieved efficacy of J3 or better near UCVA in 100% of patients with 90% of patients reading J1 was accomplished while maintaining binocular distance UCVA of 20/20 in 100% of patients at 1-year follow-up.

PREDICTABILITY AND STABILITY

An overcorrection was initially observed following CK treatment. This overcorrection was reduced by early hyperopic regression. The rate of regression decreased between 3 months and 1 year after surgery. One hundred percent of eyes were within ± 0.75 D, 90% of eyes were within ± 0.50 D, and 60% of eyes were within ± 0.25 D of intended correction. Pallikaris et al³ reported that CK for low to moderate hyperopia had demonstrated more stable results than PRK and similar stability as LASIK for hyperopic correction. McDonald et al⁴ reported the MRSE changed 0.05 D in 89% of eyes between 3 and 6 months postoperatively in the CK presbyopia FDA clinical trials. The stability of CK for the correction of presbyopia should be similar to CK for the correction of hyperopia but longer follow-up is needed to further characterize the refractive stability of CK for presbyopia.

SAFETY

No intra- or postoperative complications occurred in this study. No eyes lost lines of BSCVA. No eyes had an increase in cylinder >0.50 D 1 year following surgery. Conductive keratoplasty for presbyopia appears to be a safe procedure.

PATIENT SELECTION/EXPECTATIONS

Patient selection involves setting realistic patient expectations. The patient must realize that vision for "daily life" is the goal of this procedure. In other words, the patient will need to accept a functional vision surgical endpoint and the likelihood of needing reading glasses for detailed work. Patients must be screened regarding their occupation and/or hobbies, for these must be compatible with monovision. Patients must also be

aware of the naturally progressive nature of hyperopia and presbyopia, and that this progression will, with time, increase their need for reading glasses. However, they will not lose the visual benefit they gained from the CK procedure.

LOOSE LENS TESTING

A monovision simulation is performed to assess monovision tolerance and to determine the amount of correction required to finalize the surgical plan. Monovision simulation strategies include a contact lens trial or loose lens testing. The contact lens trial was required during the FDA CK presbyopia clinical study. However, I prefer a loose lens test at the initial evaluation to determine if the patient is a good candidate for CK near vision correction.

The loose lens test preference resulted from my experience using holmium laser thermal keratoplasty (LTK) for near vision correction in 2001. I would perform the loose lens test at the initial evaluation to determine if the patient was a potential candidate for LTK monovision treatment. If the patient passed the loose lens test, a contact lens would be fit for the monovision contact lens trial. A large portion of these patients failed the contact lens trial due to 1) difficulty handling the lens (ie, insertion, removal, cleaning), 2) ocular irritation from the lens and/or dryness, and 3) unsatisfactory vision. However, patients who initially passed the loose lens test but subsequently failed the contact lens trial who still requested LTK treatment, adapted to monovision nicely and were satisfied with their result. Because of these findings, I abandoned routine contact lens trials before monovision surgical procedures (LTK, LASIK, PRK and CK), unless requested by the patient.

The loose lens test determines binocular near and distance visual acuity, demonstrates monovision tolerance, clarifies expectations for informed consent, and helps determine the final surgical plan. During the test, loose lenses ranging from $+0.75$ to $+2.00$ are placed in front of the non-dominant eye while the patient binocularly views a near vision chart, to achieve a comfortable J3 near acuity. Then with the loose lens still in place the patient binocularly views the distance chart to evaluate acuity and determine tolerance. The patient must maintain excellent binocular distance visual acuity to be considered for unilateral CK in the non-dominant eye. If distance correction in the dominant eye is needed to maintain excellent distance vision, bilateral CK or LASIK may be considered. If a patient cannot find a satisfactory endpoint during the loose lens test, surgery should not be considered.

The power of the loose lens used to achieve satisfac-

tory binocularly near and distance visual acuity equals the magnitude of the intended refractive treatment (8, 16, or 24 treatment spots) for near vision. Generally, a target refraction of -1.25 to -1.75 D in the non-dominant eye is planned. Most patients will initially only need 16 treatment spots, which leaves room for additional rings of treatment if needed.

The loose lens test is valuable for informed consent as it demonstrates the limitations of the surgical correction of presbyopia. The test demonstrates that the effect depends on the use of both eyes and that the two eyes have a different focal point. Most importantly, the loose lens test underestimates postoperative visual results and thus the results of the procedure often exceed patient expectations.

TECHNIQUE

Conductive keratoplasty appears to be a straightforward procedure consisting of two basic components—centration and spot placement/creation. However, both of these components are surgeon dependent. If the treatment is not centered properly and/or the CK treatment spots are not created correctly, the results will be suboptimal.

Centration. A CK centration study by Durrie⁵ found that centering over either the pupil or corneal light reflex was acceptable but the pupil group had slightly less induced cylinder. Properly centering the CK marker over the pupil is critical in preventing induction of cylinder. However, poor centration can lead to significant degrees of postoperative cylinder (>2.00 D). When centering the marker, patient fixation is improved by having a fixation light in the operating microscope and occluding the nonoperative eye with tape. However, one does not need a fixation light system in the microscope to properly center the CK marker. All cases in this study were performed in the clinic using the Endure ProCart and microscope (Endure Medical Inc) without a patient fixation light.

Spot Placement/Creation. When marking the cornea with ink for centration and spot placement, indentations in the epithelium at the 6-, 7-, and 8-mm treatment zones are also produced within the ink marks. Treatment at the 6-mm treatment zone produces the greatest amount of effect thus spot placement is most critical at this optical zone. I focus on the indentations present at 6 mm and treat there first while the indentations are visible. Then I use the ink mark to treat at 7 mm and 8 mm as planned.

Consistency with the angle of probe penetration, the pressure applied, and the timing during treatment spot creation is critical. Just as varying the tension of corneal sutures during penetrating keratoplasty results

in asymmetry so will inconsistency with CK treatment spot creation. During CK spot creation, directing the probe perpendicular to the corneal surface before penetrating the cornea is the angle that is the easiest to consistently perform. Uniform downward pressure that dimples the cornea is applied and maintained to ensure that the tip of the probe is fully seated. The surgeon should wait approximately 1 second before applying energy by depressing and holding the foot pedal until the audible tone ceases. After the energy has been delivered, the surgeon should again wait 1 second before pulling the tip straight out of the cornea. Asymmetric stromal shrinkage will result if the energy is applied during insertion and/or removal of the tip. Keeping a rhythm during the procedure (insert tip, wait, apply energy, wait, remove tip) facilitates proper energy delivery during spot creation.

NEAR AND DISTANCE RESULTS

In this study, the patient's mean near UCVA of J1 is better than expected for the amount of refractive change (mean refractive effect of -1.13 D) observed 12 months after surgery. In other words, preoperatively this group of presbyopes with a mean age of 51 years would not have been expected to read J1 at near with only a $+1.00$ to $+1.25$ D reading add. It is also interesting that the mean distance UCVA (20/36) is better than expected for the amount of mean MRSE (-1.31 D) measured 12 months postoperatively. Treated eyes lost an average of 2.0 ± 2 lines (range: 0 to 5) of distance UCVA but gained an average of 8.7 ± 2 lines (range: 4 to 11) of near UCVA. How do we explain these results? Does CK produce a multifocal cornea and/or beneficial corneal aberrations (ie, spherical aberration) that are responsible for these results? Further study is needed to determine the specific corneal biomechanical changes responsible for the success of CK for presbyopia.

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