·Monograph·

Conductive keratoplasty: an approach for the correction of residual hyperopia in post –lasik pseudophakia

Pan-Pan Ye, Wen Xu, He-Sheng Xu, Zhao-Chun Li, Jun-Ting Shi, Feng-Ying He, Ke Yao

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Eye Center, Second Affiliated Hospital, Zhejiang University, No.88 Jiefang Road, Hangzhou 310009, Zhejiang Province, China

Correspondence to: Wen Xu. Eye Center, the Second Affiliated Hospital, Zhejiang University, No.88 Jiefang Road, Hangzhou 310009, Zhejiang Province, China. xuwenhz2002@yahoo.com.cn

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Abstract

• Although there are many formulae for the calculation of intraocular lens power in the eyes with previous kerato-refractive surgeries, unexpected refractive bias still exists. Hyperopic bias is particularly disliked because it affects both uncorrected distance and near visual acuity. Surgical treatment of the residual hyperopia for the eyes with both laser *in situ* keratomileusis and cataract surgery remains to be a big problem. Conductive keratoplasty has been shown to be an effective, safe and predictable method for low and moderate hyperopia in the pseudophakic eyes or in the eyes with kerato-refractive surgeries. However, the efficacy and safety of conductive keratoplasty in the correction of residual hyperopia after both corneal and lens refractive surgeries has not been reported. Herein, we reported the surgical correction with conductive keratoplasty for cases of residual hyperopia with/without astigmatism after previous laser *in situ* keratomileusis for high myopia and following phacoemulsification combined with posterior intraocular lens implantation for complicated cataract.

• KEYWORDS: conductive keratoplasty; hyperopia; laser *in situ* keratomileusis; pseudophakia

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INTRODUCTION

The attempt for accurate calculation of intraocular lens (IOL) power in the eyes with kerato-refractive surgeries has been well documented [1]. Although some formulae for the calculation were available, unexpected refractive bias still existed. Ordinary, the incidence of underestimation of IOL power prediction is higher than that of overestimation, which leads to the post-operative hyperopic errors. Hyperopic bias is particularly important because it influences both uncorrected distance and near visual acuity. Patients seeking spectacle-independent corrections do not prefer wearing spectacles. Therefore, surgical intervention represents a strong alternative for those patients with residual hyperopia after both laser in situ keratomileusis (LASIK) and cataract surgery.

Surgical treatment of the residual hyperopia for the eyes with both LASIK and cataract surgery remains a big problem. Additional keratorefractive surgery is limited by the decreased corneal thickness due to the previous LASIK operation on the stroma. IOL exchange or piggyback IOL implantation may be considered as alternatives. However, intraocular procedures have the risk of surgical complications for the eyes with high myopia.

Conductive keratoplasty (CK) is a keratorefractive surgery in which the radio-frequency pulse was applied to adjust the corneal contour by shrinking the peripheral cornea [2]. Although it appears to be an effective and safe surgical procedure to correct low and moderate hyperopia, hyperopic astigmatism and presbyopia in untreated eyes, pseudophakic eyes, or post-LASIK eyes, respectively [3-8], fewer reports are available on the experiences of CK treatment for the correction of residual hyperopia with/without astigmatism in the eyes with both LASIK and cataract surgeries. In this study, we performed CK for 3 patients to correct residual hyperopia with/without astigmatism after previous LASIK for high myopia and following cataract surgery. The outcomes of CK treatment were reported below.

SUBJECTS AND METHODS

Subjects CK was performed for a 44-year-old woman to treat the residual hyperopia with astigmatism in the right eye 38 months ago. This patient underwent bilateral LASIK for

the treatment of high myopia 12 years ago. Phacoemulsification combined with posterior chamber-intraocular lens (PC-IOL) implantation was performed for the complication of cataract in the right eye 6 years ago and in the left eye 3 years ago. The refractive status of the right eye before CK was +5.75 DS -1.50 DC×150. CK treatment of 24-spot at 6mm, 7mm and 8mm and 1-spot at 7mm×150° optical zone of cornea was applied. The pre-operative and post-operative topographies were shown in Figure 1 and the slit-lamp microscopy in 1 month after CK treatment was shown in Figure 2.

A 39-year-old woman was treated with CK for the residual hyperopia of +4.50 DS in the right eye 32 months ago. This patient underwent bilateral LASIK for the treatment of high myopia 10 years ago. Phacoemulsification combined with PC-IOL implantation was performed for the right eye due to the complication of cataract 4 years ago and neodymium: yttrium aluminum garnet (Nd:YAG) laser capsulotomy was performed for posterior capsular opacity (PCO) 3 years ago. A 16-spot treatment of CK was applied at 7mm and 8mm optical zone of cornea.

The third case was a 50-year-old woman who had bilateral LASIK for the treatment of high myopia 12 years ago and cataract surgery in the right eye 1.5 years ago. The refractive status of the right eye before CK was +2.25 DS -1.50 DC×105°. CK treatment of 16-spot at 7mm and 8mm and 4-spot at 8mm ×105° optical zone were applied to correct the residual hyperopia and astigmatism 1 year ago.

Methods Prior to CK treatment, systemic history inquiry and physical examination were performed for all the 3 patients to exclude autoimmune disease, connective tissue disease, systemic disease, implantation of electric instruments (e.g. cochlear implant, pacemaker), or scar physique (a person tends to have hyper-proliferation of scar tissue on the wound). The basic information of the patients, the schematic diagram of CK operation and the clinical data for the efficacy and safety of the treatment for all the 3 cases were shown in Table 1 and Table 2.

DISCUSSION

Residual Hyperopia in Post-LASIK Pseudophakia The incidence of eyes with phacoemulsification of cataract and a history of LASIK have been increased recently. The determining of IOL power in the post- LASIK/PRK eyes is more difficult than that in the conventional eyes because the changed refraction of anterior corneal surface for the eyes with keratorefractive surgeries. In this study, all the 3 cases had undergone LASIK for the treatment of high myopia and following phacoemulsification combined with PC-IOL implantation.

Surgical Treatment Intraocular refractive surgeries including IOL exchange and piggyback IOL implantation provides an effective, predictable and stable visual rehabilitation. However, these procedures have a risk of intraocular complications, *e.g*, posterior capsule rupture, retinal detachment, intraocular bleeding and infection [9,10]. Although LASIK is currently popular for correction of low and moderate hyperopia, CK may offer the advantages of both safety and easiness. As a minimally invasive technique,

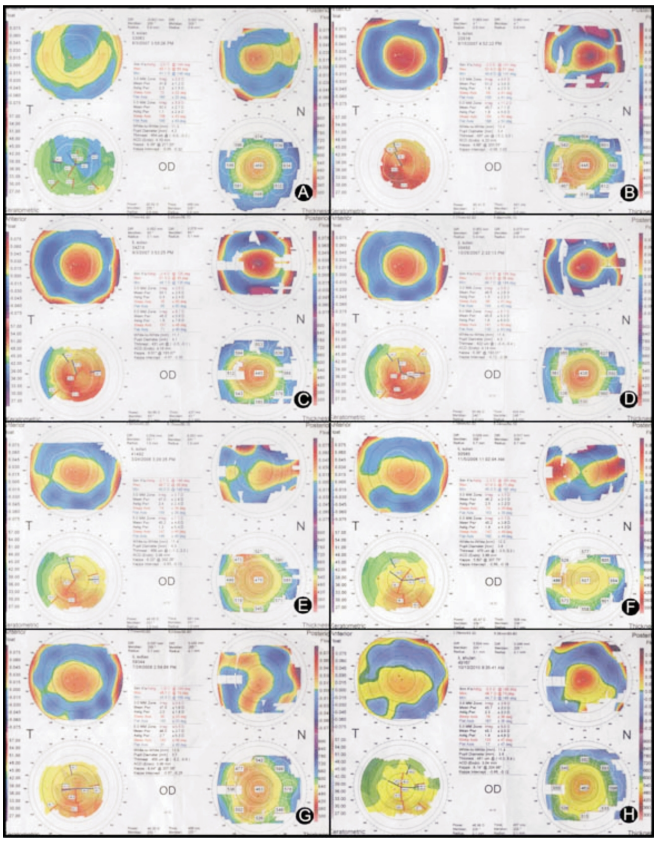


Figure 1 The pre-operative and post-operative corneal topographies of case No. 1 detected by Orbscan II A: topography of patients with LASIK and phacoemulsification combined with PC-IOL implantation before CK; B: topography of patient 1 week after CK; C: topography of patient 1 month after CK; D: topography of patient 3 months after CK; E: topography of patient 7.5 months after CK; F: topography of patient 15 months after CK; G: topography of patient 24 months after CK; H: topography of patient 38 months after CK.

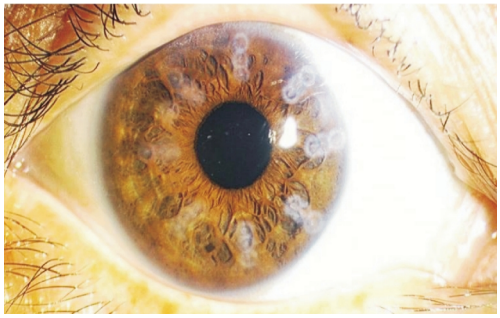
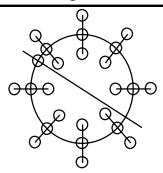
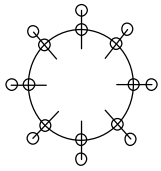
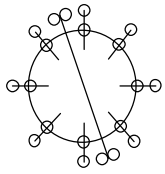


Figure 2 The slit-lamp microscopy of case No. 1 in 1 month after CK. The corneal maculae indicated the sites of treatment of 24-spot at 6mm, 7mm and 8mm for hyperopia correction and 1-spot at 7mm ×150° optical zone for hyperopic astigmatism correction.

Table 1 The common information of the patients, the schematic diagram of CK operation and the clinical data for efficacy observation of the 3 cases before and after conductive keratoplasty

No.	Age, Gender	Diagnosis Before CK	Schematic diagram of CK treatment		Time	UCDVA	UCNVA	BSCVA	Manifest Refraction	Keratometric Astigmatism
1	44, Female	OU High myopia OU Post-LASIK OU Pseudophakia OD Residual Hyperopia with Astigmatism	 24spots@6+7+8mm 1spot@7mm×150°	OD	Pre-CK	0.08	J10	1.0	+5.75DS, -1.50DC×150°	-2.0DC×149°
					1 w	0.5	J4	0.8	+1.50DS -3.25DC×136°	-3.0DC×141°
					1 m	0.6	J4	0.9	+1.50DS -3.00DC×125°	-2.5DC×125°
					3 m	0.6	J4	1.0	+1.00DS -2.00DC×120°	-2.1DC×148°
					$7^1/_2$ m	0.6	J4	1.0	+1.75DS -2.00DC×135°	-2.7DC×146°
					15 m	0.5	J5	1.0	+2.00DS -2.00DC×159°	-2.3DC×161°
					24 m	0.5	J5	1.0	+2.00DS -1.50DC×160°	-1.9DC×166°
					38 m	0.4	J5	1.0	+3.00DS -1.00DC×160°	-2.0DC×165°
				OS		1.0	J5	1.0	+0.75DS	-1.3DC×178°
2	39, Female	OU High myopia OU Post-LASIK OU Macular Degenaration OD Pseudophakia OD Post-Nd:YAG laser capsulotomy OD Residual Hyperopia OS Complicated Cataract	 16spots@7+8mm	OD	Pre-CK	0.2	J9	0.5	+4.50DS	-1.2DC×137°
					1 w	0.2	J2	0.5	-3.50DS -.50DC×53°	-1.9DC×65°
					1 m	0.3	J2	0.7	-2.50DS -1.50DC×85°	-1.50DC×90°
					3 m	0.3	J3	0.7	-1.50DS -1.75DC×80°	-0.8DC×92°
					6 m	0.5	J3	0.7	-0.75DS -1.00DC×75°	-0.7DC×78°
					32 m	0.5	J4	0.7	+0.25 DS -0.75DC×85°	-0.9DC×92°
				OS		0.25	J7	0.25	-1.00DC×90°	-0.7DC×37°
3	50, Female	OU High myopia OU Post-LASIK OD Pseudophakia OD Residual Hyperopia with Astigmatism	 16spots@7+8mm 4spots@8mm×105°	OD	Pre-CK	0.4	J6	0.7	+2.25DS -1.50DC×105°	-0.9DC×125°
					1 m	0.1	J2	0.6	-4.50DS -2.00DC×54°	-1.8DC×49°
					3 m	0.3	J3	0.7	-2.00DS -2.00DC×86°	-2.0DC×81°
					6 m	0.4	J3	0.7	-1.75DS -1.50DC×90°	-1.4DC×89°
					12 m	0.5	J4	0.7	-0.75DS -1.25DC×85°	-1.1DC×83°
				OS		1.0	J5	1.0	-0.25DS -0.50DC×170°	-0.3DC×134°

CK: conductive keratoplasty; UCDVA: uncorrected distance visual acuity; UCNVA: uncorrected near visual acuity; BSCVA: best spherical-corrected visual acuity; LASIK: Laser in Situ Keratomileusis; Nd:YAG: neodymium:yttrium aluminum garnet; OD: right eye; OS: left eye; OU: both eyes.

Table 2 The clinical data for safety observation of the 3 cases before and after conductive keratoplasty

No.	Time	IOP (mmHg)	TBUT (sec)	ECD (/mm^2)	CCT (μm)	PCT (μm)	Visual angle (°)	6.3	4.0	2.5	1.6	1.0	0.7	Duration of symptoms		
														Foreign body	Blurred vision	Night halo
1	Pre-CK	11.3	9	2439	462	568	CS	0.014	0.014	0.03	0.04	0.11	0.32	3 days	2 months	3 months
							GS	0.014	0.02	0.03	0.04	0.11	0.32			
	38 w	10.5	8.5	2188	458	556	CS	0.02	0.014	0.04	0.11	0.23	0.45			
							GS	0.014	0.014	0.03	0.11	0.16	0.45			
2	Pre-CK	8.0	10	2512	416	580	CS	0.06	0.06	0.11	0.16	0.32	0.45	2 days	1 month	1 month
							GS	0.06	0.11	0.16	0.16	0.32	0.45			
	32 w	9.5	10	1996	398	569	CS	0.04	0.06	0.16	0.23	0.32	0.45			
							GS	0.06	0.08	0.16	0.16	0.23	0.45			
3	Pre-CK	12.5	9	2336	482	644	CS	0.01	0.02	0.04	0.08	0.23	0.32	2 days	1 month	1 month
							GS	0.014	0.02	0.06	0.11	0.23	0.32			
	12 m	13.0	9.5	2028	489	627	CS	0.01	0.02	0.04	0.06	0.11	0.32			
							GS	0.014	0.04	0.08	0.11	0.23	0.45			

CK: conductive keratoplasty; IOP: intraocular pressure; TBUT: tear break-up time; ECD: endothelial cell density; CCT: central corneal thickness; PCT: peripheral corneal thickness; CS: contrast sensitivity; GS: glare sensitivity.

CK is promising for the correction of residual hyperopia after refractive corneal or cataract surgeries. Operation of CK is not restricted by the thickness of cornea and flap-related complications. In addition, the central cornea is maintained during the CK procedure. During the process of CK treatment, the energy is delivered deeply into the stroma without the long-term disturbance of ophthalmic surface.

In present study, the efficacy and safety of CK treatment were evaluated for 1-3 years post operation. Our results showed that uncorrected distance visual acuity (UCDVA), uncorrected near visual acuity (UCNVA) and best spectacle-corrected visual acuity (BSCVA) of the 3 cases were improved. The contrast sensitivity, glare sensitivity, intraocular pressure, central and peripheral corneal thickness, tear break-up time, endothelial cell density and pupil size in the patients before CK treatment were not significantly different from those after CK treatment. Sight-threatening complications did not occur during the follow-up examinations.

Regression after Conductive Keratoplasty Treatment

Previous studies have shown that regression is one of the most unavoidable shortcomings after CK treatment. With technical improvement of CK treatment, regression was slowed down during short-term follow-up examinations[11,12]. However, regression after CK treatment of the patients who had previous corneal refractive surgery and cataract surgery is different from those who received only CK surgery because of the pseudophakia without the aging crystalline

lens and the thinner central cornea. Surgical predictability is one of the other advantages associated with CK treatment. For example, Claramonte *et al*[5],reported a stable refraction of 6 months after cataract surgery followed by CK treatment. In present study, we observed regression in Case 1 and relatively stable UCDVA in other two cases. Long-term follow-ups are necessary to further evaluate the the stability and predictability of CK treatment.

Surgical -induced Astigmatism The artificial central corneal steepening and corneal collagen remodeling may be one of the reasons causing post-operative surgical-induced astigmatism (SIA). The degree of SIA depends on many factors, e.g., the experience of the operator, corneal thickness, cataract surgery incision, type of IOL, and the corneal condition (including arcus senilis and scar). It is particularly challenging to perform CK on the corneas with abnormal central thickness and incision scars after cataract surgery. The protocol of CK procedure for such a patient should be more deliberate and adjust with the accumulation of the experiences.

In conclusion, the present study showed that CK is an effective and safe treatment for the correction of residual hyperopia in pseudophakia after previous LASIK. However, the refractive regression should be monitored and the predictive algorithms should be modified.

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