ORIGINAL PAPER
DOI: 10.5603/OJ.2016.0015

Evaluating the safety and efficacy of photorefractive keratectomy combined with corneal collagen crosslinking for the treatment of myopia and myopic astigmatism

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ABSTRACT

INTRODUCTION. The purpose of the study was to evaluate the safety and efficacy of photorefractive keratectomy (PRK) combined with corneal collagen crosslinking (CXL) in patients with potential risk of developing postoperative ectasia, who were not good candidates for LASIK.

MATERIALS AND METHODS. Twenty eyes were treated with transepithelial PRK combined with CXL. Patients were evaluated preoperatively for best corrected visual acuity (BCVA), refraction, keratometry, topography, and endothelial cell count. All eyes were treated with Amaris 750s Excimer Laser and KXL system for 90 seconds at 30 mW/cm^2.

RESULTS. Mean BCVA was improved from 0.0075 ± 0.08 logMAR to 0.025 ± 0.05 logMAR postoperatively. Average keratometry reduced from 44.9 ± 1.9 D to 39.8 ± 3.9 D. Mean minimal corneal thickness reduced from 504 ± 16.7 μm to 405 ± 41 μm. None of the cases developed regression, corneal ectasia, or corneal haze.

CONCLUSIONS. Photorefractive keratectomy combined with high-fluence corneal collagen crosslinking (PRK XTRA) appears to be a safe and effective treatment for patients who are not good candidates for LASIK.

KEY WORDS: PRK, PRK-XTRA, PRK+CXL, crosslinking, high-risk patients, ectasia

Ophthalmol J 2016; Vol. 1, No. 3, 79–82

INTRODUCTION

Corneal ectasia is one of the most severe complications after refractive surgery, especially LASIK [1]. Although it is very rare, there are reports in the literature of patients who developed iatrogenic ectasia after PRK. In such cases, patients develop increasing myopia [2], with or without increasing astigmatism. Keratometric steepening, with or without central and paracentral corneal thinning, can occur and there is often loss of uncorrected visual acuity (UCVA) and best corrected visual acuity (BCVA).

For these reasons, ophthalmologists should evaluate patients according to criteria [3, 4] designed specially to avoid potential post-operative ectasia. These criteria [2] are:

- abnormal preoperative topography;
- low residual stromal bed (RSB);
- young age;
- low preoperative corneal thickness;
- high myopia.

A number of treatments [5, 6] to avoid or stabilise corneal ectasia have been described, the most recent of them being collagen crosslinking.

The purpose of this study is to evaluate the safety and efficacy of transepithelial PRK combined with corneal collagen crosslinking (PRK XTRA). The

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group of patients that underwent PRK XTRA did not fit the criteria to proceed to LASIK surgery due to low preoperative corneal thickness (< 530 μm), RSB < 300 μm, and/or abnormal corneal topography. All patients were thoroughly screened by Dr. Ioannis Mallias, who then performed the surgeries.

MATERIALS AND METHODS

Ten patients (20 eyes) were included in the study. They all had myopia and/or myopic astigmatism. The mean spherical equivalent of their refractive error was –5.50 dioptres. All patients were given a thorough slit lamp examination. They were also subjected to Scheimpflug-generated corneal topography (Pentacam HR, Oculus, Germany) and Endothelial Cell Count (EM-3000, Tomey, Germany). All patients were examined postoperatively by Corneal Optical Coherence Tomography (Spectralis, Heidelberg Engineering, Germany). Preoperatively we evaluated uncorrected visual acuity, best corrected distance visual acuity (BCVA), and subjective refraction with and without the use of cycloplegic drops. The inclusion criteria were: no previous ocular surgery, refractive stability for at least one year and discontinuation of contact lenses for at least one month. The exclusion criteria were: systemic or ocular diseases, eyes with herpetic eye disease or history of corneal dystrophy, epithelial warpage from contact lens use, corneal scarring, severe dry eye, and glaucoma. All surgeries were performed with a Excimer Laser Amaris 750s (Schwind, Germany) and KXL System (Avedro, USA). Prior to the operation, all surgical risks were explained to patients and informed consent was signed by each of them.

SURGICAL TECHNIQUE

In all cases, laser ablation was performed by Schwind Amaris 750s using a transepithelial PRK module (the excimer laser removed the corneal epithelium). Following the ablation riboflavin (Vibex Xtra, 0.22% Riboflavin, Saline, Isotonic, Avedro, USA) was instilled onto the cornea for 90 seconds and then rinsed thoroughly. The KXL system (Avedro, USA) was then employed to provide UVA exposure for 90 seconds at 30 mW/cm^2. Finally, a soft bandage contact lens was applied for four days, until complete corneal re-epithelisation was achieved. Patients were prescribed ofloxacin four times daily, dexamethasone four times daily, and preservative free artificial tears every two hours for the first postoperative week. After the first week, ofloxacin and dexamethasone were discontinued. Loteprednol was prescribed four times daily and was slowly tapered over a period of three months. Preservative free artificial tears were continued for the first postoperative months as needed. Follow-up examinations were performed four days, one month, six months, one year, and two years after the surgery.

RESULTS

The mean age of the patients was 22.5 ± 3 years. Mean BCVA preoperatively was 0.0075 ± 0.08 logMAR. Improvement of visual acuity was achieved. Postoperative mean visual acuity was 0.025 ± 0.05 logMAR. Average cornea keratometry was 44.9 ± 1.9 D preoperatively, and it was reduced to 39.8 ± 3.9 D postoperatively. Mean minimal corneal thickness evaluated by Scheimpflug topography was 504 ± 16 μm preoperatively and 405 ± 41 μm 12 months after surgery. Specular microscopy was performed to evaluate endothelium cells, which did not seem to have undergone any changes after surgery. None of the patients had regression of myopia or corneal ectasia at mean 2 ± 0.6 years. None of the patients developed corneal haze after the surgery.

In 85% (17 eyes) of treated eyes BCVA remained the same. In 10% (2 eyes) of treated eyes, visual acuity was improved by one Snellen line and in 5% (1 eye) of treated eyes, visual acuity improved by 2 Snellen lines (Fig. 1).

DISCUSSION

PRK combined with corneal crosslinking is an excellent choice for patients with high myopia and

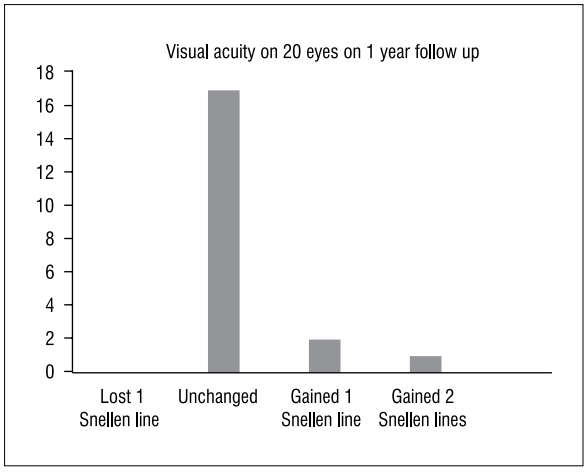

FIGURE 1. Visual acuity gained in Snellen lines

low preoperative corneal thickness as well as young age. It is also a good option for patients who have some irregularity in the preoperative topography, without topographic signs of keratoconus. This procedure provides keratometric and refractive stability. Postoperative visual acuity can be even better than BCVA, as shown in this study. This procedure also has the advantage of excluding all flap-related complications that may occur in a LASIK procedure.

It is well documented [7–9] that ectasia after refractive surgery can occur. As noted earlier, there are some precautions [10, 11] that ophthalmologists should consider in order to avoid any unpleasant outcomes. It is well known and established [12, 13] that collagen crosslinking increases corneal stromal rigidity in keratoconic patients. There are also previous reports that combining collagen crosslinking with refractive surgery can enhance corneal stromal rigidity up to 130% [13].

Until now, many papers have been published regarding LASIK surgery combined with CXL. The reason is that LASIK surgery weakens the cornea [14, 15] much more than PRK, due to penetration into deeper corneal layers.

Nowadays LASIK tends to be the most popular refractive surgery because of the fast visual rehabilitation and low postoperative pain. However, as already mentioned, not all patients are good LASIK candidates. In such cases one can proceed with PRK combined with CXL. Photorefractive Keratectomy combined with collagen crosslinking is preferred for younger patients with low preoperative corneal thickness [16] and/or abnormal preoperative topography.

Our study is the first investigating the stability and efficacy of PRK combined with CXL (Fig. 2). It should also be noted that none of the patients was presented with corneal haze after surgery. We attribute that to the fact that due to CXL there was apoptosis of keratocytes from the anterior stroma. Because of the apoptosis, keratocytes did not produce the extracellular substance that is responsible for the development of corneal haze.

The instillation of riboflavin is done after the photo-ablation of the corneal epithelium and Bowman's membrane. As a result, the diffusion of riboflavin into the corneal stroma is faster, which is why the soak time of riboflavin is only 90 seconds, which is enough to achieve corneal crosslinking in comparison with the keratoconus treatment protocol, which requires 10 minutes of soak time. What should also be mentioned is that Vibex Xtra

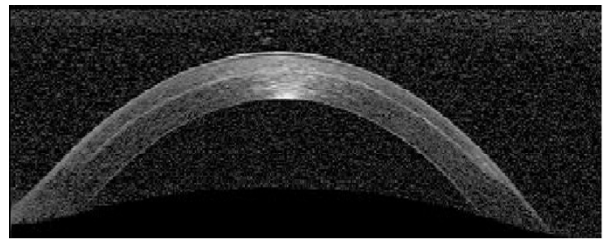

FIGURE 2. Demarcation line after PRK XTRA

is quickly diffused due to its low viscosity. It is mentioned in the literature [17] that high fluence UVA is completely safe, since what should be taken into consideration is the product of energy with exposure time.

It should be mentioned that none of the patients in our study developed severe dry eye after the surgery, even though there are studies [18] that indicate abnormal corneal innervation and dry eye after collagen crosslinking.

In some keratoconus patients that have undergone crosslinking in order to stabilise the progression of the disease, it has been observed that after months, or even years postoperatively their cornea tends to flatten progressively. However, in our study at the end of the follow up period, we did not observe long-term topographic changes of the cornea, apart from those induced by laser ablation. We believe that this observation is due to the fact that a different treatment protocol is used in keratoconus patients than the one we used in our patients. The total amount of energy used in PRK XTRA is 2.7 J/cm^2, which is almost half the energy used to treat keratoconus patients. Since there were not any refractive surprises in our study, we believe that there is no need for nomogram alteration.

Our results show that PRK&CXL should be considered as a weapon in the ophthalmologist's armoury in order to avoid iatrogenic ectasia.

It is worth mentioning that the risk factors that lead to postoperative ectasia are yet to be fully understood. In the publication by Hodge et al. [19], a patient who had LASIK surgery in one eye and PRK in the other, who did not have risk for ectasia and scored low on Randleman's risk factor score, developed postoperative ectasia in the eye that underwent LASIK. Although we should consider the fact that there is only one patient who developed that kind of ectasia, there is an underlying question about the indications we take into consideration in order to decide which surgery is more suitable for each patient.

Another issue that should be investigated in the future is whether we could treat > 10 dioptres with PRK&CXL, since the risk of corneal haze and iatrogenic ectasia is significantly minimised with PRK XTRA.

CONFLICT OF INTEREST

None declared.

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