EXPERIENCE IN TREATMENT OF PATIENTS WITH KERATOCONUS AND KERATECTASIA

UDC 617.713–007.64–08
Received 2.10.2012

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The aim of the investigation was to analyze experimental and clinical functional results of treatment of patients with keratoconus and secondary keratectasia using modern techniques.

Materials and Methods. We carried out experimental researches on 15 eyes of experimental animals. The animals underwent corneal cross-linking according to Zurich protocol. We used laser radiation of 0.37 J. Further, on day 3 to 10, the animals were sacrificed, and we performed light and electron microscopy of the operated corneas.

Clinical functional study was carried out on 108 eyes of 54 patients with primary keratoconus and secondary keratectasia.

Conclusion. The findings suggest the following approach to treatment of patients with primary keratoconus and surgery-induced keratectasias:

1) patients with I and II stages of primary keratoconus and stages I–III keratectasias — personalized cross-linking, and no earlier than 4 months later — implantation of intracorneal implants; after surgery — correction by soft contact lenses;

2) stage III keratoconus patients — cross-linking according to Zurich protocol, with no guarantee of significant improvement of acuity of vision — implantation of stromal rings in 4 months; correction by soft contact lenses. A patient is to be warned of possible keratoplasty;

3) in complicated III–IV stage keratoconus and secondary ectasia — planned penetrating keratoplasty.

Key words: keratoconus; keratectasia; corneal cross-linking.

Currently, the number of patients with keratoconus is steadily increasing worldwide [1]. And this tendency is related to the primary incidence rate increase, as well as the appearance of patients with secondary corneal ectasia followed after previous Lasik operations, and these patients relying on similar clinical and functional disorders are also referred to keratoconus patients (secondary). The development of new approaches to the treatment of these groups of patients is topical due to the advent of new physiotherapeutic techniques (corneal cross-linking — CCL) [2], and the enhancement of contact correction and intracorneal implantation [3–5].

The aim of the investigation was to analyze experimental and clinical functional results of treatment of patients with keratoconus and secondary keratectasia using modern techniques.

Materials and Methods. We carried out experimental researches on 15 eyes of experimental animals. The animals underwent CCL according to Zurich protocol. When carrying out the investigations, ethical principles were kept inviolate according to European Convention for the protection of vertebrata used for experimental and other scientific purposes (the Convention was passed in Strasburg, 18.03.1986, and adopted in Strasburg, 15.06.2006).

We used laser radiation of 0.37 J. Further, on day 3–10, the animals were sacrificed, and we performed light and electron microscopy of the operated corneas.

Clinical functional study was carried out on 108 eyes of 54 patients with primary keratoconus and secondary keratectasia (See the Table). The most operated patients with primary keratoconus (40%) were at the age of 21–40; the patients with secondary keratectasia (70%) aged from 31 to 40 years.

All patients underwent routine and special clinical functional examinations. Special investigations included optical and ultrasound keratopachymetry, keratotopography, corneal hysteresis determination. The latter enabled to estimate corneal strength and mechanical characteristics in relative units: normal value — 9 units.

Results and Discussion. The analysis of experimental findings showed that structural changes in stromal collagen fibrils began to form at the declared exposure rate on day 3–5 in cornea of the test animals. There were the changes in all stromal parts and resulted in the formation of interfibre “end-to-end”, “end-to-side”, and “side-to-side” bridges. Moreover, we found no burn or dystrophic changes in operated tissues [6].

The age analysis showed the increase in the number of the operated patients over 50 with primary keratocous. There is visible tendency of nosology “ageing” in the past decade. The clinical progression in these patients is characterized by long maintaining of normal or subnormal values of corneal thickness in the center (470–530 μm), regular astigmatism axis formation (>3.5 D according to

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Age and gender composition of the operated patients

Pathology type	Age, years													
	>20		21–30		31–40		41–50		51–60		61–70		>70	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Primary keratoconus	5	4	6	5	4	2	7	4	3	0	1	0	2	0
Secondary corneal ectasia	0	0	1	2	3	5	0	0	0	0	0	0	0	0

keratotopography findings) without marked local ectasia, decrement in visual acuity unrelated to the character and intensity of refractive disorders.

The growth or reduction of corneal hysteresis indicates the increase or decrease of corneal tissue elasticity and compliance. Hysteresis changes in the operated patients before and after cross-linking suggest corneal hysteresis values to increase in immediate postoperative period after CCL. In our opinion, this is due to maximum tightening of collagen fibers and gain in mechanical strength of the entire cornea [7]. In late postoperative period corneal hysteresis values remained the same, or slightly decreased compared to the similar parameters in immediate postoperative period. We believe these changes to be related to insignificant separation of corneal collagen fibers and reduced corneal mechanical strength [7, 8].

It should be emphasized that corneal hysteresis values in both immediate, and late postoperative periods after CCL in all patients were higher than those before the operation. We believe corneal hysteresis index to be an additional evidence of the efficiency of the provided treatment in these patients.

CCL was performed on the eyes of patients with primary keratoconus and secondary keratectasia. We used personalized CCL. This modified technology due to the formation of optical masks enables to expose to radiation only ectatic corneal areas, with perifocal parts being intact; it reduces the procedure traumatism.

The analysis of maximum vision values in all patients after CCL indicates the index increase (Fig. 2). However, the acuity of vision recovered statistically significantly better in patients with secondary corneal ectasia. The index reached its maximum values 4–6 month after the operation, i.e. after total haze disappearance, and the improvement of anterior

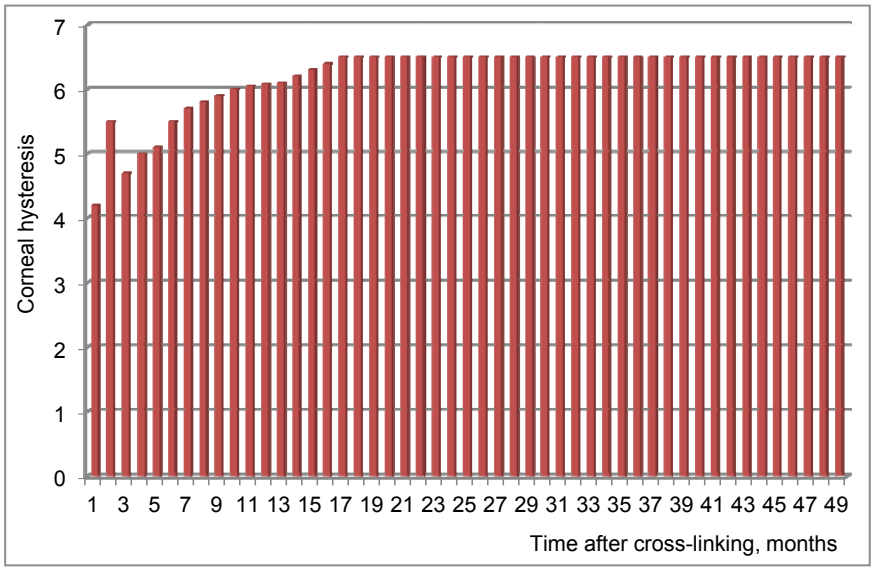

Fig. 1. Corneal hysteresis changes in patients before the operation, in immediate, and late postoperative periods after cross-linking

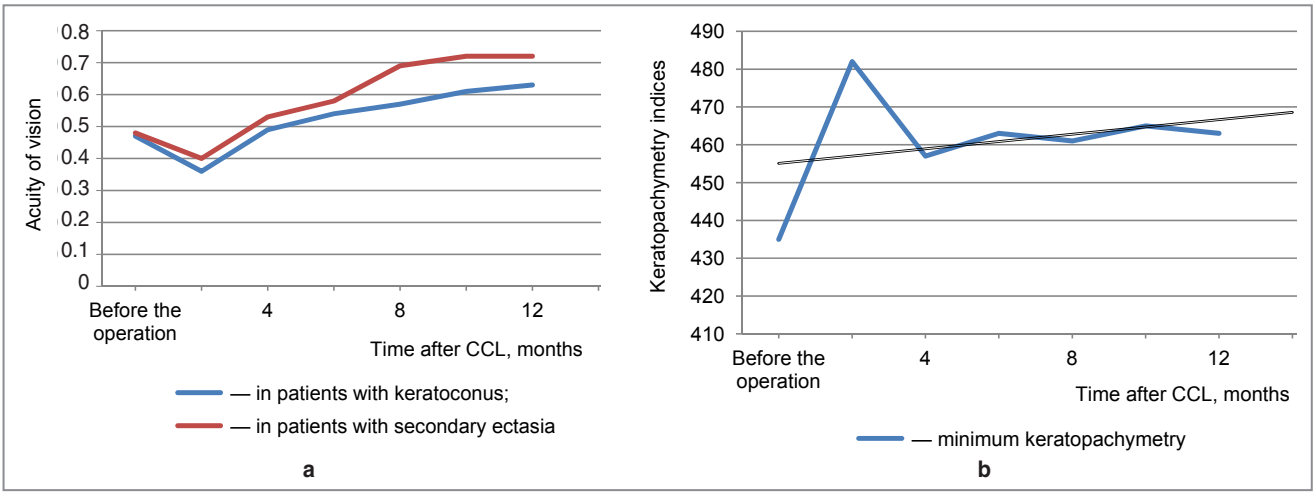

Fig. 2. Maximum vision dynamics after CCL (*a*) and minimum keratopachymetry (*b*) in operated patients. Minimum keratopachymetry is the parameter value at the peak of ectasia

corneal surface condition. The corneal thickness increased significantly immediately after CCL (up to 2 months) that may be due to a short-term stromal interstitial edema. However, further, the index reached the increased values compared to initial ones: it increased of 12–25%. It should be noted, that corneal refractive indices were stable for 36-month follow-up period after CCL.

Stromal implants were implanted in 52 eyes of 37 patients. We implanted 120° semi-rings, 180–240 μm in thickness. The tunnel was formed manually in accordance with the accepted practice [9]. The assessment of vision recovery degree in operated patients (Fig. 3) showed the patients with I–II stage keratoconus and secondary keratectasia to have maximum vision increase. The implantation of stromal segments was not so effective in patients with III stage keratoconus. One of the complications of this technique was the bearing of stromal segments in the period from 1 to 5 months (9 eyes). All patients with primary keratoconus had implant protrusion. We consider implant removal not to be a complication in the period 3–4 months after the operation due to the fact that within this period a cicatricial encasement forms around the implants, and it supports the fixed shape of the cornea even without an implant.

Thus, the findings indicate primary keratoconus and secondary ectasias of cornea to be different clinical entities. Despite the fact that both pathologies have similar clinical and functional manifestations, they have different etiopathogenesis. Primary keratoconus is congenital corneal dystrophic disease, probably, allelically determined. In these patients the structure of all corneal stroma is destroyed, and due they have mechanical strength failure over the whole surface. In the area of the maximum changes the apex of conus ectasia forms. CCL and implantation of stromal implants cannot significantly improve the vision in these patients, especially in those with developed III stage conus. The corneal structure is slightly changed in patients with secondary ectasias. In these patients the change of the cornea is surgically induced, while its perifocal part is scarcely changed. Therefore, the treatment of keratectasia is more effective than that of primary keratoconus.

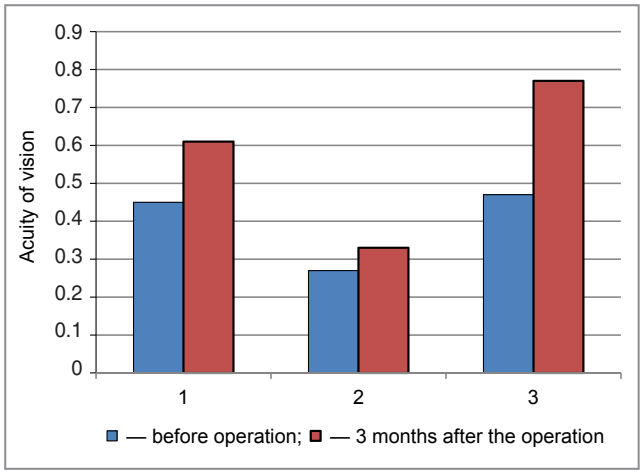

Fig. 3. Maximum vision in the periods over 2 months after the implantation of stromal segments: *1* — in patients with I–II stage keratoconus; *2* — in patients with III stage keratoconus; *3* — in patients with secondary keratectasia

In case of ineffectiveness of the mentioned techniques and intolerance to contact correction, the patients underwent penetrating subtotal keratoplasty [10]. As donor materials we used preserved tissues. The donors were selected from the deceased of not older than 75, without eye diseases. Donor materials were taken within the 12-hour period after death. Concurrently with enucleation, venous blood was taken to carry out instant HIV, hepatitis B and C, RW diagnosis. Only the tissues from noninfected donors were preserved. An eye-bulb was sterilized in 1% betadine solution, and then preserved aseptically, using sterile surgical instruments. We resected a corneoscleral part, 14–15 mm in diameter, put it into a special container with a flap bed, added synthetic preservative solution Eusol-C, sealed the container, and kept at +2…+8°C for 14 days.

The analysis of the transplant showed that during the whole storage period there was no tissue swelling: according to keratopachymetry, the thickness was not more than 600 μm (587.0±0.11). Moreover, the transplant had high endothelial density — 2578.0±136.0 cells per mm^2.

Totally we performed 53 penetrating keratoplastic operations in patients with primary keratoconus. All operations were made in accordance with the accepted practice using Baron trepans, 4.5–6.5 mm in diameter [11]. The operations had no complications. In one patient an acute transplant disease developed, and on the third day he was reoperated. In all operated patients the transparent graft was accepted during a follow-up period up to 1.5 years.

Keratoplasty development in our country is being retarded due to the donor material absence. We believe the creation of eye banks to preserve tissues will help to overcome the difficulties. Preserved cornea, as well as sclera, will find their application in any ophthalmological clinic.

Conclusion. The findings suggest the following approach to treatment of patients with primary keratoconus and surgery-induced keratectasias:

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References

1. Stephen Tuft. Epidemiology of keratoconus. In: *EuroKeratoConus II congress. Abstracts*. France; 2011; p. 84–86.

2. Caporossi A., Baiocchi S., Mazzotta C., Traversi C., Caporossi T. Parasurgical therapy for keratoconus by riboflavin-ultraviolet type A rays induced cross-linking of corneal collagen: preliminary refractive

results in an Italian study. *J Cataract Refract Surg* 2006 May; 32(5): 837–845.

3. Michael Belin. Role of corneal tomography and biomechanics for diagnosis, prognosis and treatment planning of ectatic diseases. In: *EuroKeratoConus II congress. Abstracts.* France; 2011; p. 35–37.

4. Egorova G.B. Kontaktnaya korrektsiya keratokonusa i otsenka ee effektivnosti [Contact correction of keratoconus and its efficiency assessment]. *Vestnik optometrii — Optometry Reporter* 2004; 2: 31–33.

5. Murova L.Kh. *Korrektsiya keratokonusa zhestkimi kontaktnymi linzami.* Avtoref. dis. … kand. med. nauk [Keratoconus correction by rigid contact lenses. Abstract for Dissertation for the degree of Candidate of Medical Science]. Ufa; 2005.

6. Wollensak G., Spoerl E., Wilsch M., Seiler T. Keratocyte apoptosis after corneal collagen cross-linking using riboflavin/UVA treatment. *Cornea* 2004 Jan; 23(1): 43–49.

7. Spoerl E., Wollensak G., Seiler T. Increased resistance of crosslinked cornea against enzymatic digestion. *Curr Eye Ress* 2004 Jul; 29(1): 35–40.

8. Seiler T. Corneal cross-linking-induced stromal demarcation line. *Cornea* 2006 Oct; 25(9): 1057–1059.

9. Jorge Alio. Refractive surgery in the keratoconic patients. In: *EuroKeratoConus II. Congress. Abstracts.* France; 2011.

10. Gorskova E.N., Sevost'yanov E.N. Vizual'nye iskhody skvoznoy keratoplastiki u bol'nykh keratokonusom na raznykh stadiyakh zabolevaniya [Visual outcomes of penetrating keratoplasty in patients with keratoconus at various stages of the disease]. *Glaz — Eye* 1998; 3: 6–11.

11. Kasparova E.A. Osobennosti postoperatsionnoy terapii u patsientov, perenesshikh skvoznuyu keratoplastiku po povodu keratokonusa. V kn.: *Aktual'nye voprosy oftal'mologii. Materialy yubil. vseros. konf., posvyashch. 100-letiyu gorodskoy glaznoy bol'nitsy im. Alekseevykh* [Characteristics of postoperative therapy in patients after penetrating keratoplasty for keratoconuc. In: Topical ophthalmological issues. Proceedings of jubilee all-Russian conference on centenary of city eye hospital named after V.A. and A.A. Alekseev]. Moscow: NII glaznykh bolezney im. Gel'mgol'tsa; 2002; Part 2; p. 17–20.