

Cataract Surgery Results after Penetrating Keratoplasty

M.A. Tanash¹M.A. Frolov¹V. Kumar^{1,2}L.T. Ababneh³, A.A. Alqudah³¹Department of Eye diseases, medical institute of Peoples' Friendship University of Russia (RUDN University)
Mikluho-Maklaya str., 6, Moscow, 117198, Russian Federation²Centre for eye microsurgery "Pro zrenie"
Gorshina str., 1, Khimki, Moskovsky district, 141407, Russian Federation³School of Medicine, Jordan University of Science and Technology (JUST University), King Abdullah University Hospital
Ar Ramtha 3030, Irbid, Jordan

ABSTRACT

Ophthalmology in Russia. 2022;19(1):104–109

Objective. To compare clinical and refractive outcomes of cataract surgery by phacoemulsification and by extracapsular cataract extraction with implantation of foldable and rigid intraocular lenses in patients previously having undergone penetrating keratoplasty (PK). **Patients and methods.** This is a retrospective study. Medical records of all patients admitted for cataract surgery between 2010 and 2018 to the King Abdullah University Hospital (HAUH) were reviewed and medical records of patients who underwent cataract surgery after PK were analyzed. Medical records of 95 patients (58 males and 37 females; average age 40.0 ± 19.9 years) were selected. Depending upon the type of surgical technique applied, the cases were divided into two groups: first group included 60 patients who underwent cataract surgery by phacoemulsification with implantation of different foldable intraocular lenses (IOL), the second group included 35 patients who underwent cataract surgery by extracapsular cataract extraction (ECCE) with implantation of a polymethylmethacrylate (PMMA) IOL. The choice of ECCE technique with implantation of rigid IOLs was made if the endothelial cell density after PK was less than 2200 cells/mm² and cataracts were of 4 and 5 grades to exclude additional trauma to the endothelium by ultrasound energy. Demographic and clinical data were collected. The R statistical program and SPSS were used for data analysis. The P value < 0.05 was considered statistically significant. **Results.** Analysis showed that PK was performed mainly due to 4 indications: keratoconus (KC) — 77 % cases, herpetic keratopathy — 7 % cases, Eye trauma — 5 % cases, previous graft rejection — 5 % cases and Stevens–Johnson syndrome — 1 % cases. The mean best corrected visual acuity (BCVA) in the first group improved from 0.40 ± 0.05 to 0.80 ± 0.05 postoperatively. The mean BCVA in the second group improved from 0.30 ± 0.05 to 0.70 ± 0.05 . In the late postoperative period BCVA with foldable IOLs was higher by 0.10 ± 0.05 , as compared with the results obtained with the rigid IOLs. Mean intraocular pressure (IOP) changed from 15.1 ± 4.9 before PK to 16.3 ± 5.3 after PK. **Conclusion.** KC was the most common indication for PK in Jordan. Results of our analysis showed that cataract surgery could be successfully performed in eyes after PK with favorable results and improvement in patients' quality of life. Cataract surgery by phacoemulsification with implantation of foldable IOLs results in higher (BCVA) compared to ECCE with implantation of PMMA IOLs. Unless contraindicated otherwise, phacoemulsification technique with foldable IOL implantation should be given preference over ECCE with implantation of rigid PMMA IOLs in visual rehabilitation of cataract patients after PK.

Keywords: cataract extraction, keratoconus, penetrating, keratoplasty, intraocular lens**For citation:** Tanash M.A., Frolov M.A., Kumar V., Ababneh L.T., Alqudah A.A. Cataract Surgery Results after Penetrating Keratoplasty. *Ophthalmology in Russia*. 2022;19(1):104–109. https://doi.org/10.18008/1816-5095-2022-1-104-109**Financial Disclosure:** No author has a financial or property interest in any material or method mentioned**There is no conflict of interests**

Результаты хирургии катаракты после сквозной кератопластики

М.А. Танаш¹, М.А. Фролов¹, В. Нумар^{1,2}, Л.Т. Абабнех³, А.А. Алькудах³

¹ ФГАОУ ВО «Российский университет дружбы народов»

ул. Миклухо-Маклая, 6, Москва, 117198, Российская Федерация

² ООО «Центр микрохирургии глаза “Про зрение”»

ул. Горшина, 1, Химки, Московская область, 141407, Российская Федерация

³ Иорданский научно-технологический университет,

Больница научно-технологического университета имени короля Абдуллы

Ар-Рамта 3030, Ирбид, Иордания

РЕЗЮМЕ

Офтальмология. 2022;19(1):104–109

Цель: сравнить клинические и рефракционные результаты хирургии катаракты при фаноземульсификации и экстракапсулярной экстракции катаракты с имплантацией эластичных и жестких интраокулярных линз (ИОЛ) у пациентов, ранее перенесших сквозную кератопластику (СКП). **Пациенты и методы.** Данное ретроспективное исследование проведено в офтальмологическом отделении Университетской больницы им. короля Абдаллы (КАУН) в Иордании. Медицинские карты всех пациентов, госпитализированных для операции по удалению катаракты в период с 2010 по 2018 год, были изучены и проанализированы. Были отобраны истории болезни 95 пациентов (58 мужчин и 37 женщин; средний возраст $40,0 \pm 19,9$ года), перенесших операцию по удалению катаракты после СКП. В зависимости от типа применяемой хирургической техники пациенты были разделены на две группы: в первую группу вошли 60 пациентов, перенесших операцию по удалению катаракты путем фаноземульсификации с имплантацией различных эластичных ИОЛ; во вторую группу вошли 35 пациентов, перенесших операцию по удалению катаракты методом экстракапсулярной экстракции катаракты (ЭЭК) с имплантацией ИОЛ из полиметилметакрилата (ПММА). ЭЭК с имплантацией жестких ИОЛ производили в случае, если плотность эндотелиальных клеток после СКП была менее 2200 клеток/мм², а плотность ядра хрусталика была 4-й и 5-й степени для исключения дополнительной травмы эндотелия роговицы ультразвуковой энергией фаноземульсификатора. Были собраны демографические и клинические данные. Для анализа данных использована статистическая программа R и SPSS. Значение $p < 0,05$ считалось статистически значимым. **Результаты.** Анализ показал, что СКП выполняли в основном по 4 показаниям: кератоконус — 77 % случаев, герпетическая кератопатия — 7 %, травма глаза — 5 %, предшествующее отторжение трансплантата — 5 % и синдром Стивенса — Джонсона — 1 %. Среднее значение максимальной остроты зрения с коррекцией (МКОЗ) в первой группе улучшилось с $0,40 \pm 0,05$ до $0,80 \pm 0,05$ после операции. Среднее значение МКОЗ во второй группе улучшилось с $0,30 \pm 0,05$ до $0,70 \pm 0,05$. В позднем послеоперационном периоде показатели остроты зрения при имплантации эластичных ИОЛ дали более высокие показатели по сравнению с результатами, полученными при применении жестких ИОЛ, на $0,10 \pm 0,05$. Внутриглазное давление (ВГД) изменилось с $15,1 \pm 4,9$ до СКП до $16,3 \pm 5,3$ после СКП. **Заключение.** Кератоконус являлся наиболее частым показанием для СКП в Иордании. Операция по удалению катаракты может быть успешно выполнена на глазах после СКП с благоприятными исходами и улучшением качества жизни пациента. Хирургия катаракты путем фаноземульсификации с имплантацией эластичных ИОЛ приводит к более высокой МКОЗ по сравнению с ЭЭК и имплантацией жестких ИОЛ. При отсутствии иных противопоказаний пациентам с катарактой после СКП рекомендуется оперировать по технике фаноземульсификации с имплантацией эластичной ИОЛ, а не ЭЭК с жесткой ИОЛ.

Ключевые слова: экстракция катаракты, кератоконус, сквозная кератопластика, интраокулярная линза

Для цитирования: Танаш М.А., Фролов М.А., Нумар В., Абабнех Л.Т., Алькудах А.А. Результаты хирургии катаракты после сквозной кератопластики. Офтальмология. 2022;19(1):104–109. <https://doi.org/10.18008/1816-5095-2022-1-104-109>

Прозрачность финансовой деятельности: Никто из авторов не имеет финансовой заинтересованности в представленных материалах или методах

Конфликт интересов отсутствует

INTRODUCTION

Corneal blindness is among the top three causes of curable blindness worldwide with an incidence rate varying from 1/250 to 1/250,000 and PK is the method of choice for vision restoration among these patients [1].

When Eduard Konrad Zirm performed the first successful, full-thickness penetrating keratoplasty (PK) on a human in 1905, he became the first person to perform a solid organ transplantation [2]. This significant achievement has played a major role in the wide spread use PK globally [2]. Research results presented by Moorfields Eye Bank suggests that one pair of donated eyes can be used in 10 sight-saving operations. Additionally, the use of procedures that match donors

to recipients through specific antigenic complexes in the Human Leukocyte Antigen (HLA) system has decreased the rate of corneal tissue rejection in the United Kingdom [3].

The authors of the Global Corneal Transplant Survey and eye bank data show that Jordan ranks fourth (after the USA, Canada and Lebanon) in the world in terms of successful PK in 2019 [1]. Various studies have been conducted to investigate indications for performing PK [4]. In Jordan, a keratoconus-endemic country, annual statistics from the Jordan Eye Bank show that PK operations have increased due to the increase in local corneal donations in the Jordanian community [5].

Currently, there exists consensus among researchers and clinicians that crosslinking is the “gold standard” in order to stop the progression of KC with possible long-term positive

M.A. Tanash, M.A. Frolov, V. Kumar, L.T. Ababneh, A.A. Alqudah

Contact information: Tanash Mohammed A. dr.mohammedtanash@gmail.com

Cataract Surgery Results after Penetrating Keratoplasty

results from three to ten years. It allows the best clinical efficacy while maintaining the maximum safety indicators [6, 7]. However, this classical technique cannot be used in patients with corneal thickness less than 400 microns. In such cases, penetrating keratoplasty is the method of choice.

Cataract surgery after PK needs special considerations. There are certain pathological phenomena after PK which can negatively affect the subsequent surgical treatment of the eye, especially during cataract extraction. Meanwhile, cataracts that occur after penetrating keratoplasty are not included in the list of complicated cataracts; this indicates some underestimation of this problem and may indirectly affect the results of this optic-reconstructive surgery [8].

Cataract surgery in patients with PK poses many challenges, like residual corneal astigmatism after PK, the type of IOL to be selected, and the technique of cataract surgery to be selected [8]. Patients with previous PK have altered corneal parameters, which make it necessary to carry out additional diagnostics procedures like specular microscopy to estimate the endothelial cell density, keratotopography to analyze corneal astigmatism and use of high-precision methods for IOL power calculation [9]. The induced corneal astigmatism as a result of PK is an important factor to be considered when performing cataract extraction with IOL implantation. According to a survey from the American Society of Cataract and Refractive Surgery, investigating refractive errors in patients' eyes after PK is an important practice for cataract surgeons. This study also advised surgeons to use an aggressive steroid regimen postoperatively. This is an important concept as surgery can induce inflammation that may trigger graft rejection [3].

Currently, cataract surgery by phacoemulsification is considered the "gold standard". However, ultrasound exposure to the corneal endothelium sometimes compels the specialist to use other techniques of cataract surgery like ECCE [3]. The present study was conducted at KAUH with the purpose to compare the clinical and refractive outcomes of cataract surgery by phacoemulsification and by ECCE with implantation of foldable and rigid IOLs in patients previously having undergone PK.

PATIENTS AND METHODS

This is a retrospective study. Before conducting this study, approval from the Institutional Review Board (IRB) committee at the KAUH was obtained (Reference 13/3/122). Medical records of all patients admitted for cataract surgery between 2010 and 2018 to the King Abdullah University Hospital were reviewed and medical records of patients who underwent cataract surgery after PK were studied and analyzed.

Medical records of 95 patients (58 males and 37 females; average age 40.0 ± 19.9 years) were selected. Depending upon the type of surgical technique applied, the cases were divided into two groups: the first group included 60 patients who underwent cataract surgery by phacoemulsification through a 2.4-mm clear corneal incision with implantation of different kinds of foldable IOL, the second group included 35 patients who underwent cataract surgery by ECCE with implantation

of a PMMA IOL through a 6-mm corneoscleral incision. Indications for phacoemulsification was lens opacity with normal corneal endothelial cell count (not less than 2200 cells/mm²), while indications for ECCE were 4th and 5th grade of nuclear sclerosis using Buratto cataract classification [19] with low endothelial cell count (less than 2200 cells/mm²) to exclude additional trauma to the endothelium by ultrasound. Following demographic and clinical data were collected for all patients: age, sex, reason for PK, date of PK performed, complications occurred during and after PK, reasons for cataract progression, whether it was due to PK or it was a cataract progression, uncorrected and best corrected visual acuity (BCVA), IOP before PK and after PK, hypotensive regimen, IOP before and after cataract surgery (measured by Goldmann Applanation Tonometer), corneal astigmatism, graft condition, results of keratotopography. Zeiss IOL Master was used for IOL power calculation. Pentacam (OCULUS Optikgeräte GmbH) testing was used to detect graft position and corneal astigmatism. Endothelial cell counting was done by Eye bank specular microscope (Konan Medical, Irvine, CA). Patient follow-up (18–24 months) included determining the post-surgical BCVA with the Snellen visual acuity chart, slit lamp biomicroscopy, applanation tonometry (when applicable), and corneal topography. No additional surgeries were required after cataract surgery. R software version 3.6 and SPSS software (version 25; SPSS, Inc., Chicago, IL, USA) were used for data analysis. Descriptive statistics were used to summarize categorical variables by frequencies and proportions and continuous variables by medians. Distribution differences of BCVA of first and second groups were compared using the Wilcoxon rank sum test. The P value <0.05 was considered statistically significant.

Patients' inclusion criteria:

- patients who underwent cataract extraction after PK in the period from 2010 to 2018 with a minimum of 2-year follow-up after PK and cataract surgery.

Patients' exclusion criteria:

- severe somatic condition of the patient;
- PK performed for chemical corneal burn;
- triple procedure including PK with cataract extraction surgery and IOL implantation;
- patients with concomitant ocular pathology, which does not give prospects for improving vision; and
- age under 14 years.

All corneas were obtained from the National Eye Bank in Jordan (located in Amman). Only those corneas from donors, who were negative for HIV, S. VDRL, S.HCV, and S.HbsAg who have endothelial cell count not less than 2200 cells/mm² and clear corneal zone >8 mm were considered as suitable for corneal transplantation.

In the first group the following foldable IOLs were implanted: Akreos¹ — 26 cases, Alcon² — 8, Acriva³ — 10, and Artisan⁴ (foldable version) — 16 cases.

¹ Bausch & Lomb Surgical, St. Louis, MO, USA.

² Bausch & Lomb Surgical, Texas, USA.

³ VSY Biotechnology, Amsterdam, the Netherlands.

⁴ Ophtec Inc., FL, USA.

Table 1. Indications for penetrating keratoplasty by etiology and gender**Табл. 1.** Распределение пациентов по полу и по этиологическому фактору для проведения сквозной кератопластики

Etiological factors / Этиологические факторы	Males / Мужчины	Females / Женщины	Total / Всего
1. Keratoconus / Кератоконус	49	28	77
2. Herpetic Keratopathy / Герпетическая кератопатия	4	3	7
3. Eye trauma / Травма глаза	3	2	5
4. Stevens-Johnson syndrome / Синдром Стивенса — Джонсона	0	1	1
5. Previous graft rejection / Отторжение трансплантата	3	2	5
Total / Итого	59 (61.1 %)	36 (38.9 %)	95 (100 %)

Table 2. Best corrected visual acuity before and after cataract surgery**Табл. 2.** Максимально скорректированная острота зрения до и после удаления катаракты

	Group 1 / Группа 1		Group 2 / Группа 2	
	before cataract surgery до хирургии катаракты	after cataract surgery после хирургии катаракты	before cataract surgery до хирургии катаракты	after cataract surgery после хирургии катаракты
BCVA МКОЗ	number of cases (%) количество пациентов (%)	number of cases (%) количество пациентов (%)	number of cases (%) количество пациентов (%)	number of cases (%) количество пациентов (%)
≤0.05	39 (65.0)	13 (21.7)	29 (82.9)	10 (28.6)
0.06–0.10	15 (25.0)	8 (13.3)	5 (14.3)	5 (14.3)
0.11–0.20	3 (5.0)	12 (20.1)	1 (2.8)	6 (17.1)
0.21–0.30	2 (3.3)	8 (13.3)	0 (0)	5 (14.3)
0.31–0.40	1 (1.7)	8 (13.3)	0 (0)	6 (17.1)
>0.4	0 (0)	10 (18.3)	0 (0)	3 (8.6)

Note: BCVA — best corrected visual acuity.

Примечание: МКОЗ — максимально скорректированная острота зрения.

RESULTS

Various etiological factors for which patients underwent PK are presented in table 1. As can be seen from the table, KC was the most common indication for PK in both males (83.1 %) and females (77.8 %), followed by herpetic keratopathy and graft rejection.

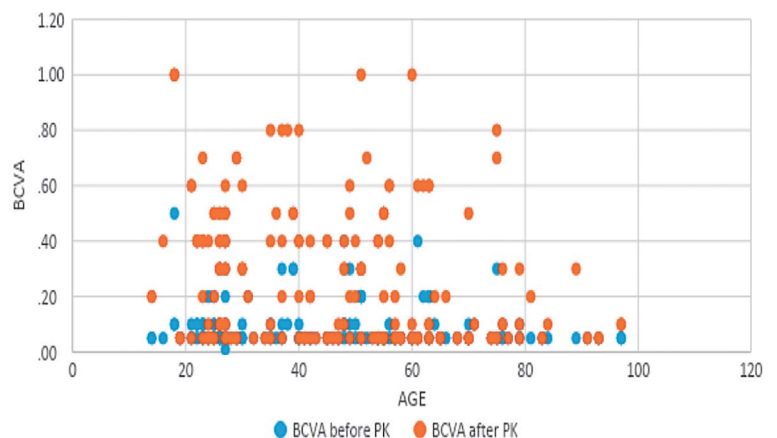
Mean values of BCVA before and after PK with a follow-up of 18–24 months are presented in Figure 1. BCVA after PK in all patients improved from 0.08 ± 0.07 to 0.25 ± 0.24 , the difference being statistically significant ($p \leq 0.05$). Mean IOP before and after PK was 15.1 ± 4.9 and 16.3 ± 5.3 respectively. There was not a single case in our sample, where IOP was more than 21 mm Hg in the postoperative period.

The graph shows that almost all patients have improved BCVA after PK, that indicates that PK was helpful, safe, and effective, but required adherence to preventive measures and systems, intra and post-operative measures.

There were 95 patients who underwent cataract extraction with IOL implantation within 18 months or more after PK. In 71 patients lens opacity developed due to age-related changes (74.7 %), in 10 cases it was due to previous surgical trauma (10.6 %), in 14 cases it was because of prolonged use of steroid drugs (14.7 %). The mean BCVA in the first group before cataract surgery was 0.08 ± 0.05 (ranged from 0.05 to 0.4). The mean BCVA

of the second group after PK 0.07 ± 0.06 (ranged from 0.05 to 0.3). After cataract surgery mean BCVA in the first group improved to 0.23 ± 0.05 (ranged from 0.05 to 0.8) and in the second group it improved to 0.17 ± 1.8 (ranged from 0.05 to 0.7). The results are shown in table 2.

In order to compare the mean BCVA between the first and second groups, Wilcoxon Rank test was applied, which showed that the true location shift is not equal to 0 ($W = 1271$, p value = 0.07). In the first group patients had a significant improvement in their visual acuity. Analysis shows that

**Fig. 1.** Diagrammatic representation of BCVA before and after PK (before cataract surgery)**Рис. 1.** Графическое изображение МКОЗ до и после СКП (до операции по удалению катаракты)

ECCE method gives a lower visual acuity outcome postoperatively in comparison to phacoemulsification. Similar results have been obtained by other authors [16].

DISCUSSION

PK is the most common technique for corneal transplantation in several countries [4], and in Jordan, it is the most performed procedure for the treatment of corneal diseases. Vision loss resulting from corneal opacities or corneal shape may have several causes including KC, burns and injuries, primary and secondary dystrophies, and corneal ulcers.

One of the most common diseases in the Mediterranean, Gulf, and Central Asian regions is KC, with a prevalence of 1 per 100 people. Statistics have shown that countries in the Mediterranean Basin have a high number of patients with KC due to genetic and environmental factors in this region [5].

Studies involving Middle Eastern populations reported that the main indication for PK was KC [10]. KC was also the most common indication for PK in our study, and a further study conducted by Gharaibeh et al. at the University of Jordan also found that the most common indication for PK in Jordan was keratoconus [11].

However, a gradual decrease in vision due to lens opacity limits the social opportunities of patients of working age after PK, who are accustomed to an active lifestyle [12]. Cataract surgery in patients after PK poses many challenges, like residual corneal astigmatism after PK, type of IOL to be selected, and technique of cataract surgery to be selected.

In our study, patients in both groups underwent sequential surgery — PK followed by cataract extraction either by phacoemulsification with IOL implantation of a foldable IOL in first group or by ECCE with implantation of a PMMA IOL. Most comparative studies suggest that sequential surgery results in more reliable visual and refractive outcomes compared to a triple procedure surgery. However, sequential surgery may not be appropriate for all patients [13].

The question of the timing to perform cataract extraction in patients after PK has never been easy for both the patient and the surgeon. The problem of cataract removal in this category of patients remains relevant due to the high risk of developing corneal decompensation and possible subsequent re-PK [14]. However, modern small incision cataract surgery, the development of foldable IOLs, and safer viscoelastics have minimized the risk of surgical complications.

In this regard, our study showed that surgical treatment of patients with complicated cataracts in the eyes after PK in the early stages of its development expands the possibilities of their medical and social rehabilitation; these results fully correlate with other research conducted in single cases [14].

Javadi et al. [13] demonstrated that the triple procedure is a safe and effective approach to restore vision in patients with coexisting corneal pathologies and cataracts. However, findings suggested that unacceptable postoperative refractive errors can occur during this procedure. It is worth noting that to correct high post-keratoplasty astigmatism, the type of IOL used is important as the induced astigmatism can be

corrected with an appropriately chosen IOL (e.g., the Toric IOL) [15].

In a comparative study between foldable and rigid IOLs conducted by Hennig et al., the authors reported that the surgical cost of consumables and overall surgical time were similar in both groups, but the cost of the foldable IOL was eight times higher than that of the rigid PMMA IOL, which is an important social factor to be considered in the developing world. Posterior capsule opacification was more common in the rigid IOL group at 12 months (36.1 % vs 23.3 %); however, this did not affect post-operative vision [16].

Performing phacoemulsification after PK is difficult. Several intraoperative and postoperative complications may arise. For successful cataract surgery results after PK, the initial density of endothelial cells is of fundamental importance. Phacoemulsification may cause significant endothelial injury and affect long term graft survival. The transparency of the cornea is maintained by a stable endothelial cell density of at least 700–800 cells/mm². The yearly average cell loss during phacoemulsification with the use of modern viscoelastics according to the literature is 5–6 % [14].

In addition, when assessing the preoperative state of the cornea, it is necessary to take into account that a significant decrease in the population of endothelial cells, as well as qualitative changes in the endothelial mosaic may cause a greater sensitivity of the cornea to surgical trauma [7, 8].

A study by Kim et al. [18] reported that phacoemulsification-related endothelial cell loss in transplanted corneas is higher than that in normal corneas. Therefore, surgeons should practice caution when performing phacoemulsification in patients that have undergone PK and approach the management of treatment of each patient individually. A study conducted by Ventura et al. [9] showed that moderate damage to the corneal endothelium during cataract surgery may lead to a transient increase in corneal thickness, although the data supporting this increase are contradictory. Some authors reported that all patients regained preoperative values of corneal thickness after 4 weeks, whereas others found increases of these values to be sustained for six months to one year postoperatively [17]. These discrepancies may reflect inaccuracies in the measurement of the central corneal thickness (by ultrasonic pachymetry) and in the estimation of the endothelial cell density.

CONCLUSIONS

Results of our study proved that in most of the PK cases, cataracts can be safely operated upon using the phacoemulsification technique. Results of this study revealed that KC is the most common indication for PK in our sample. PK was found to be the most generally utilized technique for these patients, and additional cataract extraction following PK was found to be effective and safe. Moreover, the use of foldable IOLs in these patients provides higher visual acuity than does the use of rigid IOLs, and postoperative visual acuity was found to be dependent on the type of implantable IOL used.

LIMITATIONS

The sample size of this study was not adequate to show a significant difference between the foldable and rigid IOLs. Future studies should have a larger sample size.

FUNDING

No relevant funding.

AUTHOR CONTRIBUTIONS:

M.A. Tanash — data collection, manuscript draft, data analysis.
M.A. Frolov — revision, supervision.
V. Kumar — data analysis, revision, supervision.
L.T. Ababneh — revision, supervision.
A.A. Alqudah — revision, supervision.

REFERENCES / ЛИТЕРАТУРА

- Philippe G., Rémy J., Zhiguo H., Aldossary M., Acquart S., Cognasse F., Thuret G. Global survey of corneal transplantation and eye banking. *Jama Ophthalmol.* 2015;134(2):1–8. DOI: 10.1001/jamaophthalmol.2015.4776
- Panthagani J., Barua A. Reevaluating the relationship between keratoplasty and intraocular lenses. *Eye (Lond)*. 2020;34(10):1722–1725. DOI: 10.1038/s41433-020-0870-8
- Tanash M., Gonchar P.A., Ababneh L., Mohidat H. Clinical and refractive outcomes of cataract extraction after penetrating keratoplasty (PKP). *Modern Technologies in Ophthalmology* 2018;25(5):312–314. DOI: DOI: 10.25276/2312-4911-2018-5-312-314
- Wang J.Y., Xie L.X., Song X.S., Zhao J. Trends in the indications for penetrating keratoplasty in Shandong, 2005–2010. *Int J Ophthalmol* 2011;4:492–497. DOI: 10.3980/j.issn.2222-3959.2011.05.07
- Gain P., Jullienne R., He Z., Aldossary M., Acquart S., Cognasse F., Thuret G. Global survey of corneal transplantation and eye banking. *JAMA Ophthalmol.* 2015;134(2):1–8. DOI: 10.1001/jamaophthalmol.2015.4776
- Spoerl E., Mrochen M., Sliney D., Stephen T., Theo S. Safety of UVA-Riboflavin cross-linking of the cornea. *Cornea*. 2007;26(4):385–389. DOI: 10.1097/ICO.0b013e3180334f78
- Малюгин Б.Е., Борсук С.А., Мороз З.И., Шацких А.В., Горохов М.В. Экспериментальное исследование ферментативной стабильности донорской роговицы, обработанной методом УФ кроссликинга. *Офтальмохирургия*. 2014;1:20–23. [Malyugin B. E., Borsook S. A., Moroz Z. I., Shatskikh A.V., Gorokhov M. V. Experimental investigation of the enzymatic stability of the donor cornea, treated by the method of UV cross-linking. *Ophthalmosurgery = Oftalmokhirurgiya*. 2014;1:20–23. (in Russ.)]
- Hennig A., Puri L.R., Sharma H., Evans J.R., Yorston D. Foldable vs rigid lenses after phacoemulsification for cataract surgery: a randomised controlled trial. *Eye*. 2014;28:567–575. DOI: 10.1038/eye.2014.26
- Ventura A.C., Wälti R., Böhnke M. Corneal thickness and endothelial density before and after cataract surgery. *British Journal of Ophthalmology*. 2001;85:18–20. DOI: 10.1136/bjo.85.1.18
- Altay Y., Burcu A., Aksoy G., Singar Ozdemir E., Ornek F. Changing indications and techniques for corneal transplantations at a tertiary referral center in Turkey, from 1995 to 2014. *Clin Ophthalmol*. 2016;10:1007–1013. DOI: 10.2147/OPTH.S102315
- Gharaiheh A., Atasi M., Alfoqahaa M., AbuKhader I. Visual outcome of allogenic penetrating keratoplasty. *Jordan Medical Journal*. 2017;51(4):147–157. <https://journals.ju.edu.jo/JMJ/article/view/100898>
- Ioshin I.E., Tolchinskaya A.I., Kalinnikov Yu.Yu. The cataract's phacoemulsification in the patients after keratoplasty of keratoconus. *Kremlin Medicine Journal*. 2014;2:108–111.
- Javadi M.A., Feizi S., Moein H.R. Simultaneous penetrating keratoplasty and cataract surgery. *J Ophthalmic Vis Res*. 2013;8(1):39–46. PMID: 23825711. PMCID: PMC3691977
- Bourne W.M., Carey B.E., Kaufman H.E. Clinical specular microscopy. *Trans. Amer. Acad. Ophthalmol. Otolaryng.* 1976;81:743–753.
- De Sanctis U., Eandi C., Gringolo F. Phacoemulsification and customized toric intraocular lens implantation in eyes with cataract and high astigmatism after penetrating keratoplasty. *J Cataract Refract Surg*. 2011;37(4):781–785. DOI: 10.5455/medarh.2017.71.226-228
- Hennig A., Puri L.R., Sharma H., Evans J.R., Yorston D. Foldable vs rigid lenses after phacoemulsification for cataract surgery: a randomised controlled trial. *Eye*. 2014;28:567–575. DOI: 10.1038/eye.2014.26
- Cabric E., Jusufovic V., Salihefendic N., Vodencarevic A.N. Phacoemulsification after penetrating keratoplasty due war injury at young adult. *Med Arch*. 2017;71(3):226–228. DOI: 10.5455/medarh.2017.71.226-228
- Kim E.C., Kim M.S. A comparison of endothelial cell loss after phacoemulsification in penetrating keratoplasty patients and normal patients. *Cornea*. 2010;29(5):510–515. DOI: 10.1097/ICO.0b013e3181c11e0e
- Zanini M., Savini G., Buratto L. *Physical principles of phacoemulsification*. In: Buratto L., Werner L., Zanini M., Apple D.J., editors. *Phacoemulsification. Principles and Techniques*. 2nd ed. Thorofare, NJ: Slack Inc; 2003. P. 41–43.

ABOUT THE AUTHORS

Peoples' Friendship University of Russia
Mohammed A. Tanash
Postgraduate of the Ophthalmology Department
Miklukho-Maklaya str., 6, Moscow, 117198, Russian Federation
<https://orcid.org/0000-0002-3540-0683>

Peoples' Friendship University of Russia
Frolov Mikhail A.
MD, Professor, Head of the Ophthalmology Department
Miklukho-Maklaya str., 6, Moscow, 117198, Russian Federation
<https://orcid.org/0000-0002-9833-6236>

Peoples' Friendship University of Russia
Centre for eye microsurgery "Pro zrenie"
Vinod Kumar
MD, Professor
General director
Miklukho-Maklaya str., 6, Moscow, 117198, Russian Federation
Gorshina str., 1, Khimki, Moscow District, 141400, Russian Federation
<https://orcid.org/0000-0002-5489-4607>

School of Medicine, Jordan University of Science and Technology (JUST University),
King Abdullah University Hospital
Laila T. Ababneh
Assistant Professor in the Ophthalmology Service, Ophthalmology consultant/ Department of Special Surgery/King Abdullah University Hospital (KAUH)/Jordan University of Science and Technology (JUST).
Ar Ramtha 3030, Irbid, Jordan
<https://orcid.org/0000-0001-5668-0736>

School of Medicine, Jordan University of Science and Technology (JUST University),
King Abdullah University Hospital
Asem A. Alqudah
Assistant Professor in the Ophthalmology Service, Ophthalmology consultant/ Department of Special Surgery/King Abdullah University Hospital (KAUH)/Jordan University of Science and Technology (JUST)
Ar Ramtha 3030, Irbid, Jordan
<https://orcid.org/0000-0002-8321-2572>

СВЕДЕНИЯ ОБ АВТОРАХ

ФГАОУ ВО «Российский университет дружбы народов»
Танаш Мохаммед Ахмед Мустафа
аспирант кафедры глазных болезней
ул. Миклухо-Маклая, 6, Москва, 117198, Российская Федерация
<https://orcid.org/0000-0002-3540-0683>

ФГАОУ ВО «Российский университет дружбы народов»
Фролов Михаил Александрович
доктор медицинских наук, профессор, заведующий кафедрой глазных болезней
ул. Миклухо-Маклая, 6, Москва, 117198, Российская Федерация
<https://orcid.org/0000-0002-9833-6236>

ФГАОУ ВО «Российский университет дружбы народов»
ООО «Центр микрохирургии глаза «Про зрение»
Кумар Винод
доктор медицинских наук, доцент, профессор кафедры глазных болезней РУДН
генеральный директор Центра микрохирургии глаза «Про зрение»
ул. Миклухо-Маклая, 6, Москва, 117198, Российская Федерация
ул. Горшина, 1, Химки, Московская область, 141407, Российская Федерация
<https://orcid.org/0000-0002-5489-4607>

Иорданский научно-технологический университет, Больница научно-технологического университета имени короля Абдуллы
Абабнех Лейла Таха
доцент кафедры глазных болезней Иорданского научно-технического университета
Ар-Рамта 3030, Ирбид, Иордания
<https://orcid.org/0000-0001-5668-0736>

Иорданский научно-технологический университет, Больница научно-технологического университета имени короля Абдуллы
Алькудах Асем Ахмад
доцент кафедры глазных болезней Иорданского научно-технического университета
Ар-Рамта 3030, Ирбид, Иордания
<https://orcid.org/0000-0002-8321-2572>