ISSN 1816-5095 (print); ISSN 2500-0845 (online)
https://doi.org/10.18008/1816-5095-2023-3-456-459

поступила 15.12.22
was received 15.12.22

Evaluation of Corneal Topography Changes Following Deep Anterior Lamellar Keratoplasty in Patients with Keratoconus

Neslihan Sevimli[1]

Ümit Çallı[1], Ferhat Evliyaoğlu[2], Selim Genç[3]

[1] Fatih Sultan Mehmet Training and Research Hospital, Ataşehir, İstanbul, Turkey
İçerenköy, D100 Üzeri D:İ, 34752 Ataşehir/İstanbul, Turkey

[2] Emory University, Atlanta
USA 201 Dowman Dr, Atlanta, GA 30322

[3] Beyoğlu Eye Research and Training Hospital
Istanbul, Türkiye Beyoğlu, Asmalı Mescit Mah., Meşrutiyet Cad., 58

ABSTRACT **Ophthalmology in Russia. 2023;20(3):456–459**

Background. The aim of this study is to evaluate the morphologic changes of the cornea and anterior chamber by using corneal topography (CT) in patients undergoing deep anterior lamellar keratoplasty (DALK) due to keratoconus. **Patients and methods.** This observational case-control study included total 53 eyes of 53 patients with keratoconus and underwent DALK surgery. All patients were evaluated preoperatively and 3 months after suture removal with CT. In CT, anterior chamber depth (ACD), iridocorneal angle (ICA), anterior chamber volume (ACV), central corneal thickness (CCT), maximum keratometric value (Kmax), flattest simulated meridian keratometry (SimK1), steepest simulated meridian keratometry (SimK2) and simulated keratometry average (SimKavg) results were compared before and after DALK surgery. **Results.** A significant increase was observed in CCT values after DALK surgery ($p < 0.001$). Patients showed statistically significant decrease in Kmax, SimK1, SimK2 and SimKavg values ($p < 0.001$ for all). Postoperative ACD and ACV values were significantly lower ($p < 0.001$). The ICA values showed no significant difference ($p = 0.183$) between preoperative and postoperative values (49,95 ± 5,85 and 46,30 ± 11,33 respectively). **Conclusion.** We determined a dramatic decrease in keratometric values, ACD and ACV values and an increase of corneal thickness after DALK surgery. Although DALK can be performed without interfering with the anterior chamber, has a significant effect in anterior chamber.

Keywords: Anterior chamber depth, deep anterior lamellar keratoplasty, iridocorneal angle, keratoconus, corneal topography

For citation: Neslihan Sevimli, Ümit Çallı, Ferhat Evliyaoğlu, Selim Genç. Evaluation of Corneal Topography Changes Following Deep Anterior Lamellar Keratoplasty in Patients with Keratoconus. *Ophthalmology in Russia*. 2023;20(3):456–459. https://doi.org/10.18008/1816-5095-2023-3-456-459

Financial Disclosure: no author has a financial or property interest in any material or method mentioned.

There is no conflict of interests

Изменения топографии роговицы после глубокой передней послойной кератопластики у пациентов с кератоконусом

Неслихан Куте[1], Умит Чалли[1], Ферхат Эвлияоглу[2], Селим Генч[3]

[1] Стамбульское провинциальное управление здравоохранения, учебно-исследовательская больница Фати Султан Мехмет
İçerenköy, D100 Üzeri D:İ, 34752 Ataşehir/İstanbul, Turkey

[2] Университет Эмори, Атланта
USA 201 Dowman Dr, Atlanta, GA 30322

[3] Бейоглу, глазной госпиталь
Стамбул, Бейоглу, махалле Асмалы-Месджит, улица Мешрутиет, 58

РЕЗЮМЕ

Офтальмология. 2023;20(3):456–459

Целью данного исследования является оценка морфологических изменений роговицы и передней камеры у пациентов, перенесших глубокую переднюю послойную кератопластику (DALK) по поводу кератоконуса. **Пациенты и методы.** Было проведено обсервационное исследование «случай — контроль», которое включало 53 глаза 53 пациентов с кератоконусом, перенесших операцию DALK. Все пациенты были обследованы до операции и через 3 месяца после снятия швов с помощью КТ. На КТ оценивали глубину передней камеры (ACD), иридокорнеальный угол (ICA), объем передней камеры (ACV), центральную толщину роговицы (CCT), максимальное кератометрическое значение (Kmax), кератометрию по самому плоскому меридиану (SimK1), кератометрия по самому крутому меридиану (SimK2) и средние результаты кератометрии (SimKavg). Сравнение проводили до и после операции DALK. **Результаты.** После операции DALK наблюдалось значительное увеличение значений CCT ($p < 0,001$). У пациентов отмечено статистически значимое снижение значений Kmax, SimK1, SimK2 и SimKavg ($p < 0,001$ для всех показателей). Послеоперационные значения ACD и ACV были значительно ниже ($p < 0,001$). Значения ICA не показали достоверной разницы ($p = 0,183$) между дооперационными и послеоперационными значениями (49,95 ± 5,85 и 46,30 ± 11,33 соответственно). **Заключение.** Определено резкое снижение кератометрических значений, значений ACD и ACV и увеличение толщины роговицы после операции DALK. Таким образом, DALK может оказывать значительное влияние на переднюю камеру глаза.

Ключевые слова: глубина передней камеры, глубокая передняя послойная кератопластика, иридокорнеальный угол, кератоконус, топография роговицы

Для цитирования: Неслихан Куте, Умит Чалли, Фехрат Эвлияоглу, Селим Генч Изменения топографии роговицы после глубокой передней послойной кератопластики у пациентов с кератоконусом. *Офтальмология.* 2023;20(3):456–459. https://doi.org/10.18008/1816-5095-2023-3-456-459

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

Конфликт интересов отсутствует

INTRODUCTION

Keratoconus is a bilateral progressive non-inflammatory disease of the cornea which can present as corneal stromal thinning and lead to severe vision reduction and blindness due to high myopia, irregular astigmatism, and corneal scarring. A well-known classification system for KC is Amsler-Krumeich system that uses the patient's refractive error, central keratometry readings, central corneal thickness and, the presence or absence of scarring [1]. Various methods are available for the treatment of keratoconus: eyeglasses and contact lenses in the early stages, cross-linking for stabilizing disease progression, intrastromal corneal ring segments (ICRS) for reducing refractive errors or flattening the cornea, and penetrating keratoplasty (PK) and deep anterior lamellar keratoplasty (DALK) in advanced stages of the disease [1].

DALK currently is accepted as the first-line surgical treatment option in patients with corneal disease that is not involving the endothelium, such as corneal ecstasies, stromal scars, and stromal dystrophies [2]. DALK is a partial corneal transplantation technique, alternative to PK, in patients with a healthy Descemet's membrane (DM). It requires the removal of only stromal part of the cornea and replaces it with a full-thickness stromal bed, spares endothelium and DM. The main advantage of DALK technique over PK is to minimize graft rejection risk. Since the DALK technique leaves the host endothelium intact, DALK reduces the risk of immune rejection and endothelial cell loss and therefore it can provide graft longevity potentially for the life of the patient and reduce the dose of steroids and the risk of secondary glaucoma [1]. Since it is a closed surgery, it also causes less problems related to the anterior chamber [3].

In the postoperative period, DALK patients can be followed by biomicroscopic examination and corneal topography (CT). CT is a non-contact imaging technique that images the corneal surface. The Sirius system (Sirius®) is a Scheimpflug-Placido topographer that combines a single-Scheimpflug rotating camera with Placido disk topography to measure and image the anterior segment. It provides a variety of information about the anterior eye segment [4].

There are some studies regarding the changes in anterior chamber depth (ACD) and iridocorneal angle (ICA) after penetrating keratoplasty [5–7]. Keratometric changes after DALK is also evaluated in plenty of studies [8]. However, to our knowledge, there is no study that evaluates the ACD and ICA parameters by using CT in DALK.

The aim of this study is to evaluate the morphological changes of the cornea and anterior chamber in patients after DALK surgery by using CT.

PATIENTS AND METHODS

This retrospective study was approved by the local ethics committee and conducted according to the criteria set by the declaration of Helsinki. All patients have been provided with information and their written consent was obtained.

All patients who underwent DALK surgery for KC disease between 2014 and 2015 were screened from the hospitals' patient databases. Patients with glaucoma or other ocular diseases that may affect the cornea and anterior chamber and patients with postoperative complications were excluded from the study. All clinical data concerning the diagnosis and clinical course of KC disease were obtained by consulting patients records. All data including age, gender, systemic and ocular diseases, previous KC treatment, best corrected visual acuity (BCVA) and intraocular pressure (IOP) values were recorded. CT analysis was performed by an expert physician who used Sirius topography device (Sirius; Costruzione Strumenti Oftalmici [CSO], Scandicci, Florence, Italy) which enable to combine Placido disk topography with Sheimpflug tomography.

The value of the ACD, ICA, anterior chamber volume (ACV), central corneal thickness (CCT), maximum kerato-

metric value (Kmax), flattest simulated meridian keratometry (SimK1), steepest simulated meridian keratometry (SimK2) and simulated keratometry average (SimKavg) were assessed on Sirius topography preoperatively and following 3 months after sutures removal.

All patients underwent the same surgical procedure with the same surgeon. Air bubble technique is used to separate corneal stromal bed from DM. Following injection of air through a trephine, a flap usually with a 7–7.5 mm diameter carefully removed. Injected air accesses the plane between pre-Descemet's layer and Descemet's membrane by passing through tiny fenestrations along the corneal periphery, central to the attachment of the DM is exposed.

The primary endpoint was a difference in the topography variables before and after DALK surgery on cornea and anterior chamber parameters.

All statistical analyses were conducted using SPSS V.19.0 (SPSS, Chicago, IL). The Kolmogorov–Smirnov normality test was used to determine the normal distribution of continuous variables. Continuous variables are presented as mean and standard deviation (SD). Numbers and percentages are used to define categorical variables. Categorical data were analyzed with the chi-square test. Paired sample *t* test was used for the Statistical analysis of measurements before and after surgery. *p*-value below 0.05 was accepted as statistically significant.

RESULTS

In our study, we screened 53 eyes of 53 patients. Among the 53 patients included, 32 patients (60%) were male and 22 patients (40%) were female. The mean age of the patients was 29,75 ± 5,01 at the time of surgery (range: 21–38 years old).

All patients were diagnosed with KC. According to the Amsler-Krumeich classification, 5 patients (9.2%) were in stage 2, 16 patients (29.6%) were in stage 3, and 33 patients (61.1%) were in stage 4 KC. Patients in stages 2 and 3 were patients who could not tolerate or benefit from contact lenses.

Table 1 shows the distribution and analysis of the preoperative and postoperative topographic parameters. The average CCT value was 340,15 ± 50,3 μm preoperatively and 541,60 ± 45,2 μm postoperatively. Postoperative CCT value showed statistically significant increase ($p < 0.001$).

The values of the mean Kmax, SimK1, SimK2 and SimKavg were 84,32 ± 15,17 D, 60,93 ± 8,33 D, 66,62 ± 8,50 D, 63,64 ± 8,38 D respectively preoperatively and 69,46 ± 9,59 D, 39,80 ± 5,41 D, 45,91 ± 5,78 D, 42,60 ± 5,40 D respectively postoperatively. Keratometric parameters showed a statistically significant decrease postoperatively ($p < 0.001$ for all).

Preoperative ACD was 4,01 ± 0,38 mm and it decreased to 3,29 ± 0,41 mm postoperatively. This decrease was also found statistically significant ($p < 0.001$). Preoperative ACV was 191,05 ± 20,58 microL and it was 166,55 ± 20,55 microL postoperatively. This change was also found statistically significant ($p < 0.001$).

The ICA values showed no significant difference ($p = 0.183$) between preoperative and postoperative values (49,95 ± 5,85 and 46,30 ± 11,33 respectively).

DISCUSSION

With progress in corneal surgery, demands for excellence have increased among both doctors and patients. Keratoplasty can restore vision and improving quality of life in patients with corneal problems. Although penetrating keratoplasty is still the most widely applied method for the treatment of KC, with low rejection rates, the popularity of lamellar keratoplasty has started to increase among surgeons, in recent years [9].

Cornea contributes to two-thirds of the refractive power of the eye. It has a vital role in the refractive system. DALK surgery has a huge effect on corneal anatomy which eventually affects the morphology of the anterior chamber. These changes affect patient's final vision as well as the quality of life. Yüksel et al. reported that DALK provides an earlier visual improvement, but long-term results are equal to PK. However, postoperative complications including rejection and IOP elevation are more frequent in PK [8]. In a systemic review it is reported that there is decreased rejection and refractive astigmatism with DALK but better visual outcomes with PK [10].

CT gives useful and detailed information both for cornea and anterior chamber. Therefore, to evaluate topographic parameters following DALK surgery can facilitate patient follow-up. Also, it may decrease complication rates in consecutive surgeries.

In this study, we aimed to compare topographic data changes of DALK patients preoperatively and 3 months after suture removal. Similar to the studies in the literature, we found a significant increase in corneal thickness with a statistically significant decrease in Kmax and Kavg values [5, 11–13]. The increase in CCT was about 59 % postoperatively and final CCT was found in the desired level in comparison to the normal population (427–620 μm) [14]. Similar to our study, Riss et al. also found a significant increase in CCT levels in comparison to preoperative level. (452 μm to 554 μm) [11]. When compared to this study, the increase in our study was more dramatic due to keratoconus stages of patients.

Following DALK surgery, 3 months after suture removal we observed significant decrease in the mean value of Kmax, SimK1, SimK2and SimKavg obtained by Sirius topography device. There were dramatic changes in all keratometric values which is a predictable outcome of DALK surgery in keratoconus patients. In a similar study, Arentes et al. reported that the Kmax value was 47.20 ± 2.50 D postoperatively [12]. Our postoperative Kmax value was higher than the results of that study. In the present study, 90 % of patients diagnosed with stage 3–4 keratoconus according to Amsler-Krumeich which causes higher keratometric values. Keratometric values give information about the anterior curvature of the central cornea so many factors can affect post keratometric values. Preoperative curvature, surgical technique, suture tightness has a clear effect on postoperative keratometric values. In our study higher keratometry values may be caused by steeper corneal bed and looseness of sutures.

In the present study, we found that ACD values significantly decreased postoperatively. The mean ACD was 4,01 ± 0,38 mm preoperatively and 3,29 ± 0,41 mm postoperatively. It was found to be 18 % less than preoperatively.

Qin et al. reported that the ACD value decreased after the phakic toric intraocular collamer lens (TICL) implantation in treating ametropia in the patient who had previously undergone DALK surgery. The average ACD value was 3,12 ± 0,03 mm two years after surgery, but the difference had no statistical significance [13].

In a study, Ort et al. reported a significant decrease in ACD following PK similar to our study [5]. In our study, the reduction in ACD levels was greater in comparison to their study. Presumably, the reason for the greater reduction in ACD values may be because most of our cases had more advanced KC in this study.

In the literature, there are studies showing no significant change in ICA after PK [5, 6]. Ort et al. also reported that there were no significant changes in ICA values following PK in 68 eyes of 68 patients [5]. In line with this study, we also reported no significant changes in ICA following DALK surgery.

Technically, entry into the AC is extremely rare in DALK surgery [3]. DALK surgery does not effect the iridocorneal angle so that outcome is predictable. However, in a case report, acute angle-closure glaucoma following DALK surgery have been reported due to double anterior chamber following DM detachment [15]. Suture techniques or side-port inputs to evacuate air from AC may be changing AC parameters and causing the ACD value to decrease.

This study has some limitations which have to be pointed out. The small patient population and the retrospective nature of the study do not allow us to draw any conclusion about the topographic effect of DALK. Furthermore, the follow-up was limited and full morphological changes should be investigated in larger groups.

Along with the above limitations, in our study, we determined a dramatic decrease in keratometric values and an increase of corneal thickness. ACD also decreased significantly and there was no significant change in ICA. As a common corneal surgical procedure, DALK has a significant effect in anterior chamber anatomy. To our knowledge, it is the first study investigating the ACD and ICA parameters besides the corneal topographic changes in DALK surgery, therefore for the more successful surgical outcomes it should be investigated in larger patient groups.

REFERENCES / ЛИТЕРАТУРА

1. Mohammadpour M, Heidari Z, Hashemi H. Updates on Managements for Keratoconus. J Curr Ophthalmol. 2017 Dec 6;30(2):110-124. doi: 10.1016/j.joco.2017.11.002.
2. Spadea L, De Rosa V. Current techniques of lamellar keratoplasty for keratoconus. Saudi Med J. 2016 Feb;37(2):127-36. doi: 10.15537/smj.2016.2.12985.
3. Doctor K, Vunnava KP, Shroff R, Kaweri L, Lalgudi VG, Gupta K, Kundu G. Simplifying and understanding various topographic indices for keratoconus using Scheimpflug based topographers. Indian J Ophthalmol. 2020 Dec;68(12):2732-2743. doi: 10.4103/ijo.IJO_2111_20.
4. Doctor K, Vunnava KP, Shroff R, Kaweri L, Lalgudi VG, Gupta K, Kundu G. Simplifying and understanding various topographic indices for keratoconus using Scheimpflug based topographers. Indian J Ophthalmol. 2020 Dec;68(12):2732-2743. doi: 10.4103/ijo.IJO_2111_20.
5. Ort A, Gunes A, Kandemir B, Calisir K, Kalayci M, Genc O, et al. Ort A, Gunes A, Kandemir B, Calısır K, Kalaycı M, Genc O, Ozerturk Y. Evaluation of the Cornea and Anterior Chamber Morphologic Changes After Penetrating Keratoplasty in Patients With Keratoconus. Eye Contact Lens. 2017 Jul;43(4):236-239. doi: 10.1097/ICL.0000000000000260. doi: 10.1097/ICL.0000000000000260
6. Italon C, Pieh S, Hanselmayer G, Kahraman G, Kaminski S, Skorpik C, Dejaco-Ruhswurm I. Changes of axial length and keratometry after keratoplasty for keratoconus using the guided trephine system. Am J Ophthalmol. 2002 Nov;134(5):696-700. doi: 10.1016/s0002-9394(02)01674-4.7.
7. Ruhswurm I, Scholz U, Pfleger T, Zehetmayer M, Hanselmayer G, Skorpik C. Three-year clinical outcome after penetrating keratoplasty for keratoconus with the guided trephine system. Am J Ophthalmol. 1999 Jun;127(6):666-73. doi: 10.1016/s0002-9394(99)00036-7.
8. Yüksel B, Kandemir B, Uzunel UD, Çelik O, Ceylan S, Küsbeci T. Comparison of visual and topographic outcomes of deep-anterior lamellar keratoplasty and penetrating keratoplasty in keratoconus. Int J Ophthalmol. 2017 Mar 18;10(3):385-390. doi: 10.18240/ijo.2017.03.10.
9. Liu H, Chen Y, Wang P, Li B, Wang W, Su Y, Sheng M. Efficacy and safety of deep anterior lamellar keratoplasty vs. penetrating keratoplasty for keratoconus: a meta-analysis. PLoS One. 2015 Jan 29;10(1):e0113332. doi: 10.1371/journal.pone.0113332.
10. Henein C, Nanavaty MA. Systematic review comparing penetrating keratoplasty and deep anterior lamellar keratoplasty for management of keratoconus. Cont Lens Anterior Eye. 2017 Feb;40(1):3-14. doi: 10.1016/j.clae.2016.10.001.
11. Riss S, Heindl LM, Bachmann BO, Kruse FE, Cursiefen C. Pentacam-based big bubble deep anterior lamellar keratoplasty in patients with keratoconus. Cornea. 2012 Jun;31(6):627-32. doi: 10.1097/ICO.0b013e31823f8c85.
12. Arantes JCD, Coscarelli S, Ferrara P, Araújo LPN, Ávila M, Torquetti L. Intrastromal Corneal Ring Segments for Astigmatism Correction after Deep Anterior Lamellar Keratoplasty. J Ophthalmol. 2017;2017:8689017. doi: 10.1155/2017/8689017.
13. Qin Q, Yang L, He Z, Huang Z. Clinical application of TICL implantation for ametropia following deep anterior lamellar keratoplasty for keratoconus: A CONSORT-compliant article. Medicine (Baltimore). 2017 Feb;96(8):e6118. doi: 10.1097/MD.0000000000006118.
14. Wolfs RC, Klaver CC, Vingerling JR, Grobbee DE, Hofman A, de Jong PT. Distribution of central corneal thickness and its association with intraocular pressure: The Rotterdam Study. Am J Ophthalmol. 1997 Jun;123(6):767-72. doi: 10.1016/s0002-9394(14)71125-0.
15. J Jabbour S, Muzychuk A, Agoumi Y, Harissi-Dagher M. An unusual case of acute angle-closure glaucoma following deep anterior lamellar keratoplasty using the "big bubble" technique. Am J Ophthalmol Case Rep. 2017 Jun 22;7:126-128. doi: 10.1016/j.ajoc.2017.06.013.

ABOUT THE AUTHORS

Fatih Sultan Mehmet Training and Research Hospital, Ataşehir, İstanbul, Turkey
Neslihan Sevimli
MD, Assistant Professor, Department of Ophthalmology,
İçerenköy, D100 Üzeri D:İ, 34752 Ataşehir/İstanbul, Turkey
https://orcid.org/0000-0002-8557-4673

Fatih Sultan Mehmet Training and Research Hospital, Ataşehir, İstanbul, Turkey
Ümit Çallı
MD, Department of Ophthalmology,
İçerenköy, D100 Üzeri D:İ, 34752 Ataşehir/İstanbul, Turkey
https://orcid.org/0000-0003-0931-8157

Emory University, Atlanta
Ferhat Evliyaoğlu
MD, Pediatric Ophthalmologist
USA 201 Dowman Dr, Atlanta, GA 30322,
https://orcid.org/0000-0003-3260-686X

Beyoğlu Eye Research and Training Hospital
Selim Genç
MD, Professor, Department of Ophthalmology,
Istanbul, Türkiye Beyoğlu, Asmalı Mescit Mah., Meşrutiyet Cad., 58
https://orcid.org/0000-0003-3049-2571