ARTYKUŁ ORYGINALNY ORIGINAL RESEARCH STUDY

DOI: 10.24292/01.OT.320726

Article ID: A0015

Cationic nanoemulsion and dexpanthenol versus dexpanthenol and hypromellose in the healing process following Epi-Bowman Keratectomy

Natalia Kwaśniewska[1], Przemysław Ciszewski[1], Beata Bubała-Stachowicz[3], Sebastian Sirek[2, 3], Dorota Wyględowska-Promieńska[2, 3]

[1] Students' Scientific Society, Department of Ophthalmology, Faculty of Medical Sciences, Medical University of Silesia in Katowice
Head: prof. Dorota Wyględowska-Promieńska, MD, PhD

[2] Department of Ophthalmology, Faculty of Medical Sciences, Medical University of Silesia in Katowice
Head: prof. Dorota Wyględowska-Promieńska, MD, PhD

[3] Department of Adult Ophthalmology, Prof. Kornel Gibinski University Clinical Center, Medical University of Silesia in Katowice
Head: prof. Dorota Wyględowska-Promieńska, MD, PhD

HIGHLIGHTS

The article compares the effects of two types of eye drops on early corneal healing after EBK and evaluates their impact on patient comfort and treatment adherence.

ABSTRACT

The aim of this study was to evaluate the effect of eye drops containing cationic nanoemulsion with dexpanthenol versus dexpanthenol with hypromellose on early healing after Epi-Bowman Keratectomy. The study included 32 patients (63 eyes). UCVA, BCVA, pachymetry, corneal epithelization, visual blur, and eye irritation were assessed preoperatively and one week postoperatively. No significant differences were found between groups in age, refractive error, UCVA, pain, or blurry vision. Both treatments resulted in similar postoperative UCVA. Using a single product may improve patient comfort and treatment adherence.

Key words: Epi-Bowman Keratectomy, myopia, cationic nanoemulsion, dexpanthenol

INTRODUCTION

Laser keratorefractive surgery has evolved over the last decade, making it an excellent choice for patients with low to moderate amounts of ametropia seeking vision correction [1]. The Epi-Bowman Keratectomy (EBK) is a surface ablation technique performed using Epi-clear™ epikeratome (Orca Surgical, Ashkelon, Israel), which is a single-use polymer device that allows flapless epithelium surface removal by gently sweeping the epithelial surface leaving the Bowman membrane intact [2]. This step prepares the treatment zone for laser photoablation in refractive surgery. Unfortunately, EBK just like other types of refractive surgery, decreases the population of goblet cells and impairs the corneal sensory nerves that drive tear secretion, inducing ocular surface inflammation. These findings can lead to reduced tear secretion and blinking. These changes contribute to the development of dry eye disease (DED) [3]. The occurrence of DED is estimated to be approximately 8.9–34.8% of patients after photorefractive keratectomy (PRK) [4]. There is no gold standard treatment for this condition. Treatment usually includes topical application of eye drops containing active ingredients. Cationorm® (CN) – cationic nanoemulsion – is a preservative-free cationic nanoemulsion containing mineral oils, surfactants (cetalkonium chloride, tyloxapol, poloxamer), and glycerin and also well-established lipid treatment for DED [5]. Dexpanthenol is the alcohol form of pantothenic acid (vitamin B_5). It has been used in dermatology as a moisturizer and for epithelial healing in ophthalmology [6]. Hypromellose (hydroxypropyl methylcellulose/HPMC) is a cellulose derivative that is widely used in eye drops due to its solubility in water, biocompatibility, transparency, and rheological properties [7]. This study was an attempt to investigate the influence of eye drops containing cationic nanoemulsion, dexpanthenol, and eye drops with dexpanthenol, hypromellose on postoperative early-stage healing of corneal epithelium after EBK.

PATIENTS AND METHODS

Thirty-two patients (63 eyes) with myopia or myopic astigmatism were included in the study. Patients scheduled for the procedure were split into two subsets. The first group received cationic nanoemulsion and dexpanthenol (42 eyes) as separate products. The second one received dexpanthenol and hypromellose (21 eyes), administered as a combined product. All the eye drops used in the study are available over-the-counter and are an adjuvant treatment enhancing corneal epithelium regeneration that is recommended by many ophthalmologists but is not mandatory. Because of that the study did not require approval from the Bioethics Committee.

Inclusion criteria were myopia, myopic astigmatism, age >21 years, stable refractive error for more than 2 years, and consent to undergo EBK. Exclusion criteria were ocular trauma or previous intraocular surgery, active inflammatory eye disease, and significant ophthalmic pathology. Informed consent to participate in the study was obtained from all individual participants included in the study. The study was conducted in accordance with the Declaration of Helsinki.

Preoperative examination

Adult patients seeking vision correction were included in the study. Before the procedure, a comprehensive preoperative examination was conducted for each patient, including a detailed medical history and medication use. All patients underwent standard ocular examination before the procedure, including refraction, uncorrected visual acuity (UCVA) and best-corrected visual acuity (BCVA), slit-lamp examination, intraocular pressure (IOP) measurement, and fundus examination after pupil dilation.

Surgical technique

All procedures were carried out in full compliance with the sterility requirements of the operating theater. The procedures were performed under local anesthesia after instilling 0.5% alcaine solution into the conjunctival sac several times (Alcon). The surgical field was disinfected with Dodesept alcohol preparation (Johnson & Johnson) and covered with sterile foil. After inserting the Barraquer Eye Speculum and rinsing the palpebral fissure with a povidone-iodine solution, the corneal epithelium was removed using an epikeratome. Photoablation was then performed according to a predefined program. The next step involved rinsing the cornea with an irrigation solution. Finally, a contact bandage lens was inserted. The Barraquer Eye Speculum was then removed, and antibiotic drops were applied.

Antibiotic drops and artificial tears (AT) were instilled into the conjunctival sac every 2 h for the first 24 h and 4 times a day in the following days. The procedures were performed by surgeons with excimer laser MEL 80 G-Scan (Asclepion, Meditec).

Postoperative protocol

After surgery, a bandage contact lens was applied for 7 days. The postoperative regimen included 0.5% levofloxacin drops twice daily, dexamethasone drops two times per day and chosen eye drops every 2 h for the first week. Levofloxacin was stopped after 7 days. In the second and third week dexamethasone drops were applied 4 times per day and eye drops 5 times daily. During the fourth and fifth week, dexamethasone drops were applied 3 times daily and eye drops 5 times daily. In the sixth and seventh dexamethasone drops were applied 2 times per day and eye drops 5 times per day and in the eighth and ninth week dexamethasone drops were applied once daily and eye drops 5 times

per day oral analgesics (dexketoprofen) were prescribed to be taken as needed. Oral ascorbic acid 1000 mg was recommended to be taken daily.

Postoperative follow-up visits were scheduled at 7 days, 1 month, and 3 months. UCVA and BCVA and pachymetry thinnest were assessed before and one week after the procedure. Additionally, corneal epithelization and subjective assessment of visual blur, and eye irritation were evaluated one week postoperatively. The size of the epithelial defect was assessed during the slit-lamp examination and described as "large", when it covered >2 mm^2, "small" when it covered up to 1 mm^2, and "none" in cases with completed epithelization.

The mean age for the CN and dexpanthenol group was 29 years, and for the dexpanthenol and hypromellose group, it was 32 years. No statistically significant differences between the two groups in age, spherical equivalent, and pachymetry thinnest were found.

Statistical analysis

Statistical analysis was performed with R software and Excel. A non-parametric Mann–Whitney U-test was performed to test for differences in distribution between the groups in preoperative data, postoperative visual acuity, pain level, epithelial defect, blurry vision, and spherical aberration. A paired Wilcoxon signed-rank test was performed to compare preoperative and postoperative spherical aberrations. A p-value less than 0.05 was considered statistically significant.

RESULTS

All patients were available for follow-up visits after one week. Baseline demographic and refractive data are shown in table 1. The composition of both groups was comparable in terms of age.

There was no statistically significant difference between the groups in UCVA (fig. 1), pachymetry thinnest, and spherical aberration one week after the procedure. There was also no statistically significant difference between the groups in size of corneal erosion (fig. 2).

FIGURE 1

Comparison of the UCVA results one week after the procedure.

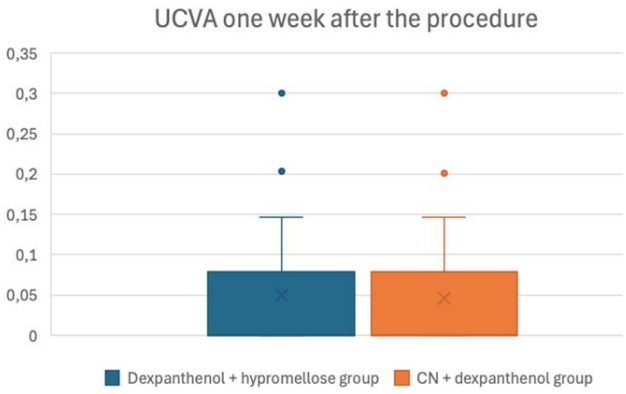

FIGURE 2

Comparison of the size of corneal erosions one week after the procedure between the groups.

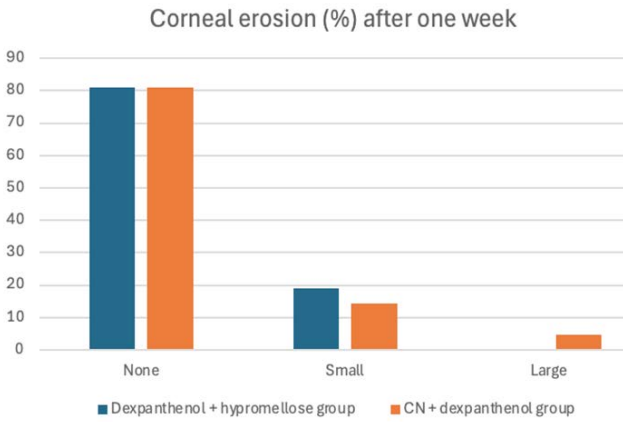

TABLE 1

Demographic and other baseline characteristics.

	CN + dexpanthenol (N = 42)	Dexpanthenol + hypromellose (N = 21)	p-value
Mean age [years] (range)	29 (21–38)	32 (21–46)	0.184
Mean sphere [D] (±SD)	-3.25 (±1.67)	-2.15 (±1.86)	0.029
Mean cylinder [D] (±SD)	-1.21(±1.09)	-1.71 (±1.13)	0.026
SE [D] (±SD)	-2.93 (±2.13)	-2.90 (±1.62)	0.212
UCVA [logMAR] (±SD)	1.33 (±0.47)	0.92 (±0.49)	0.002
Pachymetry thinnest [µm] (±SD)	537.08 (±27.89)	547.48 (±42.74)	0.646
BCVA			
Sphere [D] (±SD)	-3.25 (±1.67)	-2.15 (±1.86)	0.029
Cylinder [D] (±SD)	-1.21 (±1.67)	-1.71 (±1.86)	0.026

BCVA – best-corrected visual acuity; CN – Cationorm®; SD – standard deviation; SE – spherical equivalent; UCVA – uncorrected visual acuity.

Both groups had the same percentage of no defects in corneal epithelium. Dexpanthenol, hypromellose group had a slightly higher percentage of small corneal erosions in comparison to the cationic nanoemulsion, dexpanthenol group. However the dexpanthenol, hypromellose group had no large erosions whereas the cationic nanoemulsion and hypromellose had a few (tab. 2).

TABLE 2

Analysis of UCVA, corneal erosion and other characteristics.

	CN + dexpanthenol (N = 42)	Dexpanthenol + hypromellose (N = 21)	p-value
Mean UCVA [logMAR] (±SD)	0.05 (±0.08)	0.05 (±0.08)	0.801
Ablation depth [µm] (±SD)	97.02 (±22.35)	86.86 (±17.39)	0.057
Pachymetry thinnest [µm] (±SD)	474.10 (±28.66)	521.64 (±57.96)	0.131
Corneal erosion (%) None Small Large	 34 (81) 6 (14.3) 2 (4.8)	 17 (81) 4 (19) 0 (0)	
Blurry vision (%)	2 (5)	4 (19)	
Pain (%)	2 (5)	0 (0)	
Spherical aberration Sphere [D] (±SD) Cylinder [D] (±SD)	 0.28 (±0.68) -0.54 (±0.67)	 0.94 (±1.52) -0.88 (±1.63)	 0.802 0.410

CN – Cationorm®; SD – standard deviation; UCVA – uncorrected visual acuity.

In the cationic nanoemulsion, dexpanthenol group had a slightly higher percentage of pain occurrence, and the dexpanthenol, hypromellose group had a higher percentage of blurry vision occurrence.

DISCUSSION

After EBK patients may experience symptoms of DED. In DED, dysfunction of certain ocular structures causes a qualitative and quantitative tear deficiency. This leads to ocular surface inflammation and impairs patients' quality of life and vision [8]. Novel types of AT, including CN and others are designed to address this concern. CN is a preservative-free cationic nanoemulsion containing mineral oils, surfactants (cetalkonium chloride, tyloxapol, poloxamer), and glycerin. It also includes Novasorb, which is an aqueous emulsion produced by cationic nanoemulsion technology and containing positively charged lipid nanodroplets. These nanodroplets are a cause of attraction to the negatively charged ocular surface [5, 9]. This action is responsible for resolving the symptoms of DED. Patients with dry eye syndrome should not be qualified for laser procedures until their eyes are sufficiently hydrated. This is particularly important, as such procedures themselves can worsen eye dryness – a condition that is not uncommon among patients after laser treatments [10].

The primary aim of the present study was to compare the effect of AT containing cationic nanoemulsion and dexpanthenol with AT containing dexpanthenol and hypromellose in terms of DED symptoms and corneal epithelium healing after surface refractive surgery. Previous studies have shown that preoperative dry eye symptoms may be associated with postoperative discomfort, epiphora, and photophobia. They may negatively influence patient satisfaction because of reduced tear secretion, blinking rate, DED, and impaired healing [11, 12].

Khodaparast et al. reported faster thickening and healing of corneal epithelium in patients using AT then those who abstein from their usage after PRK [13].

Jaworski et al. compared the efficiency of AT containing either CN or sodium hyaluronate on early postoperative healing after modern surface refractive surgery. They found that both groups had similar postoperative UCVA but Ocular Surface Disease Index (OSDI) scores and blurry vision occurrence suggested better subjective outcomes for the CN group [4]. Our results confirm these observations, as the group treated with dexpanthenol and hypromellose reported a higher incidence of blurred vision (19%) compared to the group using cationic nanoemulsion (5%). This can be explained by the rheological properties of the drops. Ridder et al. showed that AT with higher viscosity, such as those containing HPMC, cause a significant reduction in contrast sensitivity and visual acuity immediately after application. The return of visual acuity took significantly longer with viscous drops compared to saline or low-viscosity solutions. This is due to a temporary disturbance in the optical quality of the tear film before it stabilizes [14]. The better subjective results in the CN group can be explained by the fact that cationic emulsions mimic the natural tear film and

stabilize its lipid layer. Positively charged nanodrops spread evenly over the corneal surface due to electrostatic interactions. This prolongs tear retention time without compromising optical quality and without the blurring effect that is typical of high-viscosity preparations [15].

Previous studies have shown the potency of commercially available ATs containing hyaluronic acid, HPMC, hydroxyethylcellulose, carboxymethyl cellulose, polyethylene glycol, propylene glycol, or glycerine [8, 16].

Gagliano et al. compared the efficacy of AT containing lipidure and hypromellose (HPMC) with efficacy of AT HPMC-based in the treatment of DED. Both ATs were found to be effective solution to DED [17].

The results of the present and previously mentioned studies suggest that both cationic nanoemulsion and hypromellose are beneficial in the healing process of corneal epithelium.

We had similar epithelial defect size on day 7 in both groups. Ebner et al. demonstrated that dexpanthenol stimulates fibroblast proliferation and accelerates re-epithelialization, which is crucial in the wound healing process. Since both groups received this ingredient, this explains the similar results in terms of epithelial defect closure [18]. However, the outcome may be influenced by the significantly larger UCVA in CN, dexpanthenol group.

Bowman's layer (BL) is an acellular layer located between the epithelial basement membrane and the anterior corneal stroma. It seems to promote healing of corneal epithelium after surgery [19, 20]. EBK leaves BL intact, which could be beneficial in accelerating wound healing and re-epithalization.

This study has some limitations. Firstly, the comparison was made between 2 uneven groups, which could potentially affect the results. Secondly, the follow-up period was short. Although we focused on the crucial first week of the healing process, complete corneal healing can take up to 12 months [4]. The dosing regimen may also have been a significant factor. It has been shown that maintaining an interval of at least 5 min between the application of 2 different eye drops significantly increases their pharmacological efficacy. Administering the preparations immediately after each other leads to the first dose being washed out by the second, which weakens the therapeutic effect. Therefore, the group using the combination preparation (one bottle) was not at risk of application error, which may have contributed to better treatment efficacy compared to patients using two separate drugs [21].

CONCLUSIONS

The CN with dexpanthenol and dexpanthenol with hypromellose groups showed similar postoperative UCVA and degrees of corneal erosion. However, using only one product instead of two can enhance patient comfort and may improve treatment adherence.

CORRESPONDENCE
med. stud. Natalia Kwaśniewska
Students' Scientific Society, Department of Ophthalmology, Faculty of Medical Sciences, Medical University of Silesia in Katowice
40-752 Katowice, ul. Medyków 18
e-mail: nkwasniewska1@gmail.com
phone: +48 694 840 460

ORCID
Natalia Kwaśniewska – ID – http://orcid.org/0009-0001-1909-9376
Sebastian Sirek – ID – http://orcid.org/0000-0002-3138-3011
Dorota Wyględowska-Promieńska – ID – http://orcid.org/0000-0001-5336-3460

Cite as: Kwaśniewska N, Ciszewski P, Bubała-Stachowicz B et al. Cationic nanoemulsion and dexpanthenol versus dexpanthenol and hypromellose in the healing process following Epi-Bowman Keratectomy. Ophthatherapy. 2026; 13(2): A0015.

References

1. Kim T, Alió del Barrio JL, Wilkins M et al. Refractive surgery. Lancet. 2019; 393(10185): 2085-98. http://doi.org/10.1016/S0140-6736(18)33209-4.
2. Shetty R, Nagaraja H, Pahuja NK et al. Safety and Efficacy of Epi-Bowman Keratectomy in Photorefractive Keratectomy and Corneal Collagen Cross-Linking: A Pilot Study. Curr Eye Res. 2016; 41(5): 623-9. http://doi.org/10.3109/02713683.2015.1045082.

3. Ryan DS, Bower KS, Sia RK et al. Goblet cell response after photorefractive keratectomy and laser in situ keratomileusis. J Cataract Refract Surg. 2016; 42(8): 1181-9. http://doi.org/10.1016/j.jcrs.2016.05.008.
4. Jaworski D, Cieślińska-Rypolc A, Jadczyk-Sorek K et al. Cationic nanoemulsion vs. 0.15% sodium hyaluronate artificial tears in the healing process following modern surface keratorefractive surgery. Eur J Ophthalmol. 2023; 33(6): 2178-84. http://doi.org/10.1177/11206721231169540.
5. Fogagnolo P, Quisisana C, Caretti A et al. Efficacy and Safety of VisuEvo® and Cationorm® for the Treatment of Evaporative and Non-Evaporative Dry Eye Disease: A Multicenter, Double-Blind, Cross-Over, Randomized Clinical Trial. Clin Ophthalmol. 2020; 14: 1651-63. http://doi.org/ 10.2147/OPTH.S258081.
6. Sabur H, Acar M. Dexpanthenol/sodium hyaluronate eye drops for corneal epithelial healing following corneal cross-linking in patients with keratoconus. Int Ophthalmol. 2023; 43(10): 3461-9. http://doi.org/10.1007/s10792-023-02751-w.
7. Tundisi LL, Mostaço GB, Carricondo PC et al. Hydroxypropyl methylcellulose: Physicochemical properties and ocular drug delivery formulations. Eur J Pharm Sci. 2021; 159: 105736. http://doi.org/10.1016/j.ejps.2021.105736.
8. Sheppard J, Shen Lee B, Periman LM. Dry eye disease: identification and therapeutic strategies for primary care clinicians and clinical specialists. Ann Med. 2023; 55(1): 241-52. http://doi.org/10.1080/07853890.2022.2157477.
9. Lallemand F, Daull P, Benita S et al. Successfully improving ocular drug delivery using the cationic nanoemulsion, novasorb. J Drug Deliv. 2012; 2012: 604204. http://doi.org/10.1155/2012/604204.
10. Wong AHY, Cheung RKY, Kua WN et al. Dry Eyes After SMILE. Asia Pac J Ophthalmol (Phila). 2019; 8(5): 397-405. http://doi.org/10.1097/01.APO.0000580136.80338.d0.
11. Shehadeh-Mashor R, Mimouni M, Shapira Y et al. Risk Factors for Dry Eye After Refractive Surgery. Cornea. 2019; 38(12): 1495-9. http://doi.org/10.1097/ICO.0000000000002152.
12. Rabina G, Boguslavsky II, Mimouni M et al. The Association between Preoperative Dry Eye Symptoms and Postoperative Discomfort in Patients Underwent Photorefractive Keratectomy. J Ophthalmol. 2019; 2019: 7029858. http://doi.org/10.1155/2019/7029858.
13. Khodaparast M, Ambrósio R Jr, Ahmadzadeh H et al. Evaluation of the effect of artificial tears on corneal epithelial thickness changes after photorefractive keratectomy. Indian J Ophthalmol. 2024; 72(1): 66-72. http://doi.org/10.4103/IJO.IJO_1354_23.
14. Ridder WH, Tomlinson A, Paugh J. Effect of artificial tears on visual performance in subjects with dry eye. Optom Vision Sci. 2005; 82(9): 835-42. http://doi.org/10.1097/01.opx.0000177803.74120.6f.
15. Daull P, Amrane M, Ismail D et al. Cationic Emulsion-Based artificial tears as a mimic of functional healthy tear film for restoration of ocular surface homeostasis in dry eye disease. J Ocul Pharmacol Ther. 2020; 36(6): 355-65. http://doi.org/10.1089/jop.2020.0011.
16. Labetoulle M, Benitez-Del-Castillo JM, Barabino S et al. Artificial Tears: Biological Role of Their Ingredients in the Management of Dry Eye Disease. Int J Mol Sci. 2022; 23(5): 2434. http://doi.org/10.3390/ijms23052434.
17. Gagliano C, Zeppieri M, Longo A et al. Efficacy and Safety of Artificial Tears Containing Lipidure and Hypromellose for the Treatment of Moderate Dry Eye Disease in Contact Lens Wearers. Medicina (Kaunas). 2024; 60(2): 287. http://doi.org/10.3390/medicina60020287.
18. Ebner F, Heller A, Rippke F et al. Topical use of dexpanthenol in skin disorders. Am J Clin Dermatol. 2002; 3(6): 427-33. http://doi.org/10.2165/00128071-200203060-00005.
19. Lagali N, Germundsson J, Fagerholm P. The role of Bowman's layer in corneal regeneration after phototherapeutic keratectomy: a prospective study using in vivo confocal microscopy. Invest Ophthalmol Vis Sci. 2009; 50(9): 4192-8. http://doi.org/10.1167/iovs.09-3781.
20. Taneri S, Kießler S, Rost A et al. Epi-Bowman keratectomy versus alcohol-assisted photorefractive keratectomy: wound healing and complications. Ther Adv Ophthalmol. 2021; 13: 2515841420988215. http://doi.org/10.1177/2515841420988215.
21. Denion E, Charlot F, Béraud G. A 5-Minute Interval between Two Dilating Eye Drops Increases Their Effect. Optom Vis Sci. 2017; 94(8): 838-44. http://doi.org/10.1097/opx.0000000000001104.

Authors' contributions:
All authors have equal contribution to the paper.

Conflict of interest:
None.

Financial support:
None.

Ethics:
The content presented in the article complies with the principles of the Helsinki Declaration, EU directives and harmonized requirements for biomedical journals.