Correlation of corneal thickness, endothelial cell density and anterior chamber depth with ocular surface temperature in normal subjects

Johanna Pattmöller[1], **Jiong Wang**[1,2], **Elena Zemova**[1], **Berthold Seitz**[1], **Timo Eppig**[3], **Achim Langenbucher**[3,*], **Nóra Szentmáry**[1]

[1] Department of Ophthalmology, Saarland University Medical Center, Homburg/Saar, Germany
[2] Department of Ophthalmology, Renmin Hospital of Wuhan University, Wuhan, China
[3] Experimental Ophthalmology, Saarland University, Homburg/Saar, Germany

Received 20 June 2014; accepted 16 September 2014

Abstract

Purpose: *To analyze corneal surface temperature profile in a young and healthy study population and to determine the impact of corneal thickness (CT), anterior chamber depth (ACD), and endothelial cell density (ECD) on surface temperature.*

Methods: *In this prospective, single-center study 61 healthy right eyes of 61 subjects without tear film pathologies (mean age 24.9 ± 6.7 years) were recruited. Ocular surface temperature (OST) was measured with the Ocular Surface Thermographer TG-1000. From Pentacam HR CT and ACD, and from specular microscopy ECD and central corneal thickness (CCT) were acquired. From the raw measurement data (OST, CT and ACD) we extracted a) local OST the corneal center and 3 mm away from the center at the 3, 6, and 9 o'clock positions, and b) Zernike parameters Z1, Z2 and Z3 to evaluate the general temperature profile within a 6 mm circular area around the center.*

Results: *Overall, there was no correlation between OST and CT, ACD or ECD. Local OST did not correlate with CT at any measurement position. On average local OST was highest at measurement positions where CT was lowest, but without reaching statistical significance. Baseline OST was highest at thin corneal regions and temperature decay over time was smallest in those regions. Z1, Z2 and Z3 correlated well with CT.*

Zusammenhang von Hornhautdicke, Endothelzelldichte und Vorderkammertiefe mit der kornealen Oberflächentemperatur bei gesunden Probanden

Zusammenfassung

Ziel: *Anhand der Analyse der Oberflächentemperatur der Hornhaut von jungen, gesunden Probanden sollen potentielle Einflussfaktoren wie Hornhautdicke (CT), Vorderkammertiefe (ACD) und Endothelzelldichte (ECD) untersucht werden.*

Methoden: *Im Rahmen dieser prospektiven Studie wurden 61 gesunde rechte Augen von 61 Probanden (Alter: 24,9± 6,7 Jahre) ohne manifeste Tränenfilmproblematik rekrutiert. Die Oberflächentemperatur des Auges wurde mit dem Ocular Surface Thermograph TG-1000 gemessen. Zusätzlich wurden mit der Pentacam HR die CT und ACD sowie mit dem Endothelzellmikroskop EM-3000 die ECD und zentrale Hornhautdicke (CCT) bestimmt. Aus den Rohdaten von OST, CT und ACD wurden a) die lokale OST im Zentrum und 3 mm außerhalb des Zentrums in den 3, 6, und 9 Uhr Positionen extrahiert, sowie b) Zernike Parameter Z1, Z2 und Z3 zur Untersuchung des globalen Temperaturprofils innerhalb der 6-mm-Zone um das Zentrum berechnet.*

Ergebnisse: *Insgesamt konnte keine Korrelation zwischen OST, CCT, ACD oder ECD gefunden werden. Die*

* Corresponding author. Achim Langenbucher, Experimental Ophthalmology, Saarland University, Kirrberger Strasse 100, 66421 Homburg/Saar, Germany. Tel.: +49-6841-1621218; Fax: +49-6841-1621241.
E-mail: achim.langenbucher@uks.eu (A. Langenbucher).

Conclusions: *In healthy subjects corneal thickness, endothelial cell density and anterior chamber depth have no effect on corneal surface temperature. The general temperature profile seems to be influenced by the corneal thickness profile effecting a higher temperature and lower decay at thinner corneal regions.*

Keywords: Corneal surface thermography, noncontact measurement, temperature profile, temperature change, corneal thickness, anterior chamber depth, endothelial cell density

lokale OST zeigt in keiner Messposition eine Korrelation mit der CT. Es zeigte sich eine Tendenz zu höheren OST-Werten an Messpositionen mit geringer CT, jedoch ohne statistische Signifikanz. Die OST am Beginn der Messung war am höchsten an Stellen mit dünner Hornhaut und der Temperaturabfall über die Messdauer war an diesen Stellen am geringsten. Die Zernike-Parameter Z1, Z2 und Z3 korrelierten gut mit der CT.

Schlussfolgerung: *In gesunden Augen zeigte sich kein Einfluss von Hornhautdicke, Endothelzelldichte oder Vorderkammertiefe auf die Oberflächentemperatur des Auges. Das Temperaturprofil scheint jedoch durch die Hornhautdicke beeinflusst zu sein, wobei dünne Stellen eine höhere Temperatur und geringen Temperaturabfall zeigen.*

Schlüsselwörter: Oberflächentemperatur des Auges, Nonkontaktmessung, Temperaturprofil, Temperaturänderung, Hornhautdicke, Vorderkammertiefe, Endothelzelldichte

Introduction

All metabolic events produce heat that is dissipated by conduction and convection. Therefore, temperature is an important parameter of tissue metabolism. In the beginning of the 20th century, ocular temperature was measured in topical anesthesia using contact techniques, which may lack in accuracy. The acquisition of infrared images for detection of temperatures – called thermography – has been developed in the beginning of the 20th century and provides a quick and reliable method for spatially resolved temperature measurement [1]. In the 1960's Mapstone was the first who introduced infrared thermal imaging in the field of ophthalmology [2]. With the development of infrared thermography it was possible to detect physiological and pathological changes of the eye by non-contact measurement of the ocular surface temperature (OST). In the meanwhile, different instruments have been used in ophthalmology for analyzing OST, but up to now this technique has not been well established to clinical routine. In addition, the potential influencing factors on OST are not clear; therefore the clinical interpretation of the results might be difficult.

Central corneal thickness (CCT) slightly changes with refraction and is associated with gender, while it is not correlated with age. However, findings on CCT association with age differ. Hashemi et al. found a significant negative correlation with age, whereas Hoffmann et al found no significant correlation}[3,4]. In general, corneal thickness increases from center to periphery, however the peripheral corneal thickness decreases with age and therefore the thickness profile from center to periphery is changing. The thinnest point of the cornea in healthy subjects is usually located inferior-temporally and the thickest point superiorly [3,5,6].

The corneal endothelium is a hexagonal cell monolayer and with its barrier and pump function it maintains the corneal clarity by regulation of corneal hydration. The number of endothelial cells is stable at birth and decreases with age. The mean endothelial cell density/mm^2 in normal adults ranges between 2000 and 3500 cells /mm^2. Below a critical density of about 500 cells /mm^2 an irreversible corneal swelling occurs [7]. Elderly people with a decreased pump function of the corneal endothelium and hyperopic eyes may show a larger central corneal thickness.

OST measurement has been applied to dry eye disease [8–12], contact lens wear [13,14], laser refractive surgery, infectious eye disease and others [15–20]. Nevertheless, to the best of our knowledge, the impact of corneal thickness (CT), endothelial cell density (ECD) anterior chamber depth (ACD) on ocular surface temperature (OST) has not been investigated, yet.

The purpose of our study was to determine potential influencing factors such as corneal thickness (CT), endothelial cell density (ECD) anterior chamber depth (ACD) on local ocular surface temperature (OST) and the spatial OST profile in a cohort of young healthy subjects.

Patients and methods

Sixty-one right eyes of 61 Caucasian subjects (57% females) were recruited in this study (mean age 24.9 ± 6.7 years, 20-34 years). None showed any ocular pathology or dry eye disease. Dry eye syndrome was excluded using