# Τρισδιάστατη κατανομή επιθηλιακού πάχους με OCT: Συγκριτική μελέτη σε Κερατοκωνικούς και Φυσιολογικούς οφθαλμούς

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# Financial Disclosures

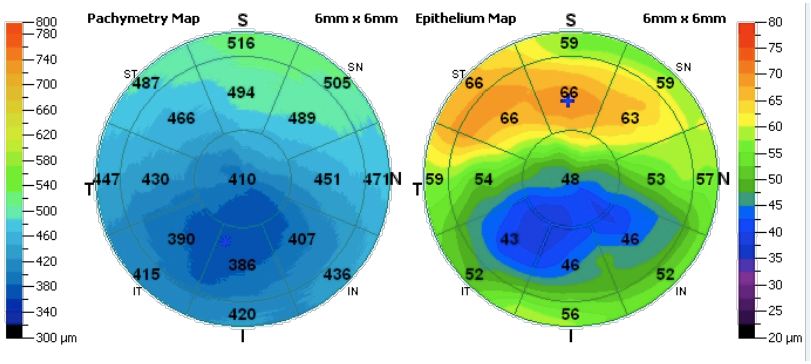
- AJK:
  - Alcon/WaveLight
  - Avedro
  - OptoVue
  - i-Optics

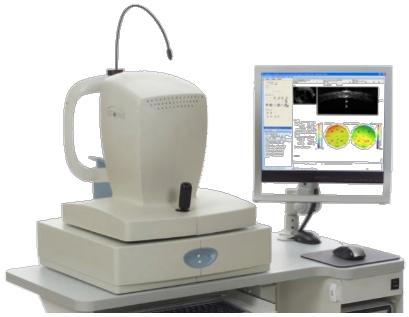
- Costas Karabatsas:
  - Allergan

- Georgios Chatzilaou: κανένα.

# Δείκτες επιθηλίου με Προσθίου Θαλάμου OCT

- Δείκτες ασυμμετρίας Επιθηλιακού πάχους
  - Τοπογραφική μεταβλητικότητα (Stdev of 17 points);
  - Εύρος παχυμετρίας (Max – Min).



- Συνολικό πάχος επιθηλίου
  - Μέσο επιθηλιακό πάχος;
  - Ανώτερη και κατώτερη διαφορά.

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# In Vivo Three-Dimensional Corneal Epithelium Imaging in Normal Eyes by Anterior-Segment Optical Coherence Tomography: A Clinical Reference Study

*Anastasios John Kanellopoulos, MD,*† and George Asimellis, PhD**

**Purpose:** To evaluate the safety and efficacy of real-time measurement of corneal epithelial thickness and investigate the distribution characteristics in a large normal-eye population using a clinically available spectral-domain anterior-segment optical coherence tomography (AS OCT) system.

**Methods:** Corneal epithelial thickness distribution and topographic thickness variability were clinically investigated using AS OCT imaging in 373 patients with normal, healthy eyes. Descriptive statistics investigated 3 sets of subgroups, male (n = 171) and female (n = 202), younger (n = 194) and older (n = 179), right eyes (n = 195) and left eyes (n = 197).

**Results:** Pupil center epithelial thickness repeatability was an average 0.88 ± 0.71 μm; a similar repeatability was noted for the superior, inferior, maximum, and minimum epithelial thickness. On average, the pupil center epithelial thickness was 53.28 ± 3.34 μm, superior 51.86 ± 3.78 μm, inferior 53.81 ± 3.44 μm, minimum 48.65 ± 4.54 μm, maximum 56.35 ± 3.80 μm, and topographic variability was 1.78 ± 0.78 μm. Small differences were noted between male (average center 54.10 ± 3.34 μm) and female (52.58 ± 3.19 μm) subjects. The topographic thickness variability seems to increase with age: younger group, 1.65 ± 0.83 μm; older group, 1.93 ± 0.90 μm ($P = 0.173$).

**Conclusions:** We present a comprehensive investigation of corneal epithelial thickness distribution characteristics in a healthy, untreated human eye population by using in vivo, clinically available Fourier-domain AS OCT. The 3-dimensional epithelial maps reveal epithelial nonuniformity and provide a novel benchmark for future and comparative studies.

**Key Words:** anterior-segment optical coherence tomography, epithelium imaging, epithelial thickness distribution, epithelial layer thickness topography

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The distribution of the corneal epithelial layer thickness can be very useful in clinical[1] and in basic research.[2,3] Epithelial thickness maps may be valuable in making close-call clinical decisions and can aid in a safer screening of excimer-laser corneal refractive surgery candidates. The reason for this is the epithelial average thickness differences, and the topographic thickness irregularities,[4] which may contribute unevenly to the total corneal refractive power.

Several clinically available modalities may facilitate in vivo corneal epithelial thickness measurement, including scanning high-frequency ultrasound (HF-UBM),[5] confocal microscopy,[5,6] and anterior-segment optical coherence tomography (AS OCT),[7,8] complementing corneal cross-sectional imaging[9,10] and pachymetry.[11,12] The recent availability of corneal epithelial imaging by AS OCT presents a practical tool for clinical in vivo epithelial mapping, with the speed of optical imaging and ease of use due to the noncontact nature.[13–15]

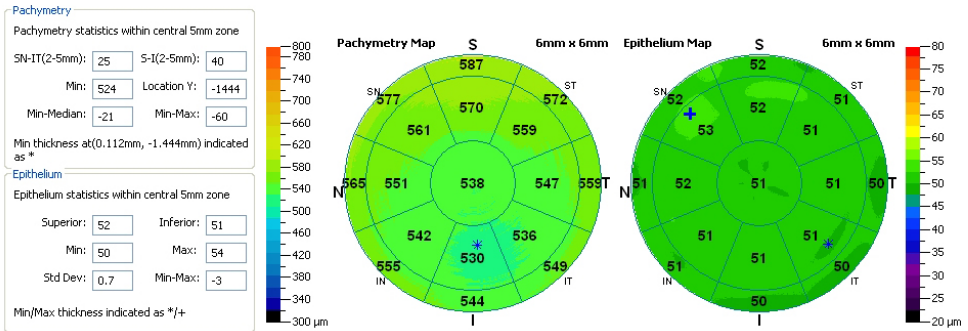
This study evaluates the clinical quantitative and qualitative 3-dimensional imaging of the corneal epithelial layer in a large number of normal eyes by means of AS OCT. We report here clinical results regarding epithelial thickness mapping in normal corneas with a commercially available AS OCT system. This study aims to investigate the accuracy and precision of the epithelial thickness distribution in a large pool of healthy eyes, and investigate gender and age specifics.

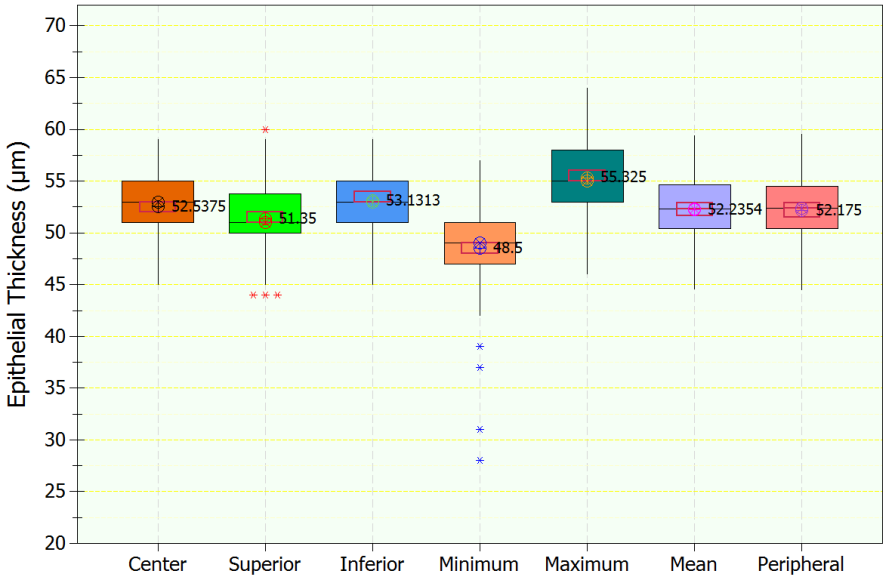
## MATERIALS AND METHODS

This prospective study received the approval of the Ethics Committee of our Institution, adherent to the tenets of the Declaration of Helsinki. Informed written consent was obtained from each subject at the time of the first clinical visit.

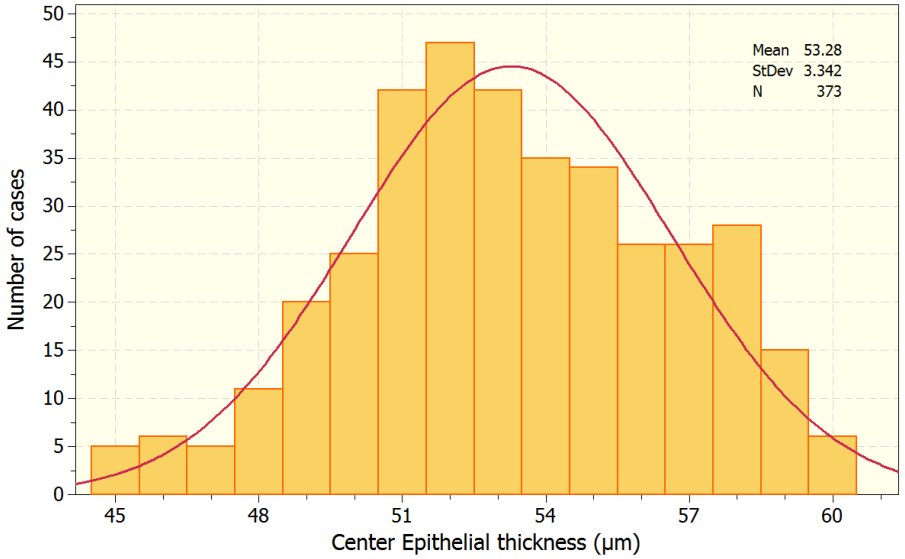
The study group (n = 373 different cases) consisted of patients with unoperated, normal eyes with no current or past ocular pathology other than refractive error, no previous surgery, and no present irritation or dry eye disorder, all confirmed by a complete ophthalmologic evaluation. Contact lens wearers were excluded. To avoid potential artifacts (eg, because of possible drop instillation), OCT imaging preceded the ocular clinical examination.

The Fourier-domain AS OCT system RTVue-100 (Optovue Inc, Fremont, CA), running on analysis and report software version A6 (9.0.27), was used in the study. Data output included total corneal and epithelial thickness maps corresponding to a 6-mm diameter area. The settings were L-Cam lens, 8 meridional B-scans per acquisition, consisting

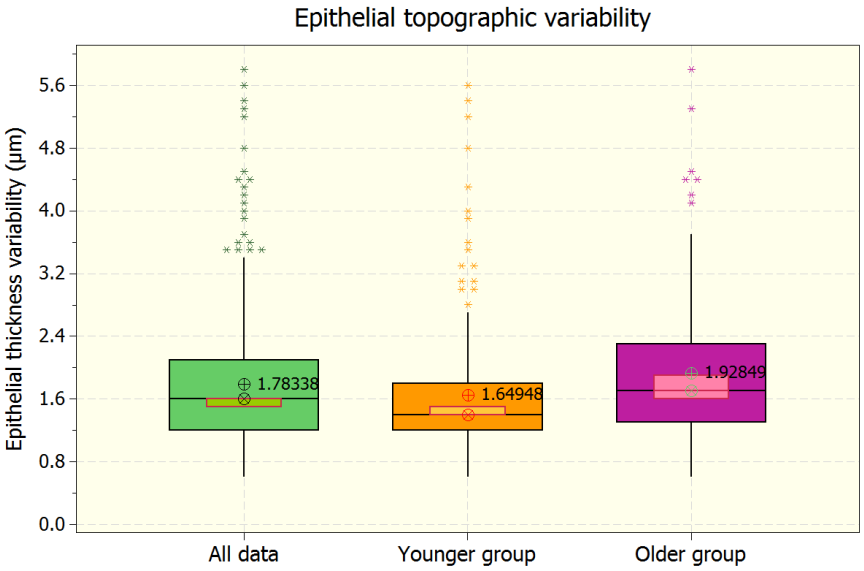


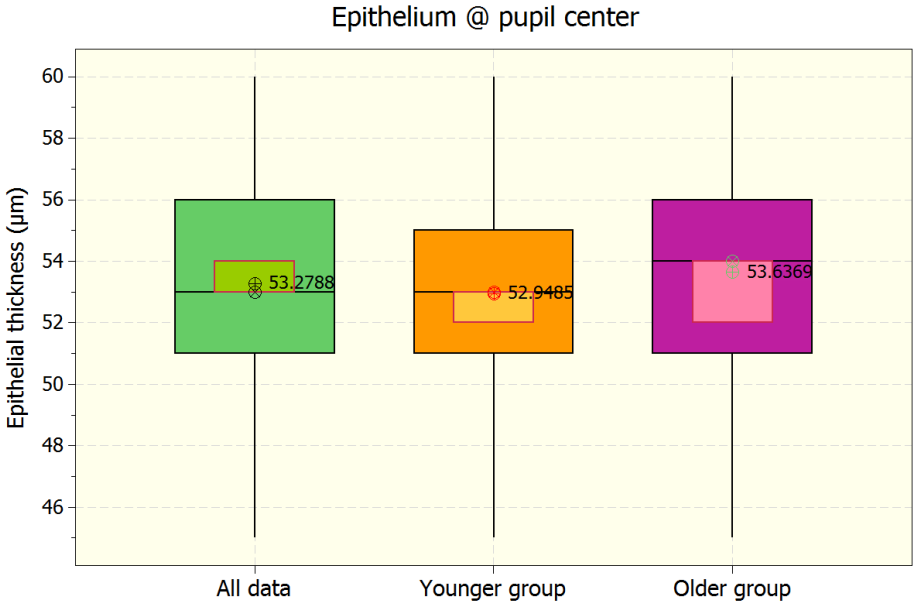



# Κατανομή επιθηλιακού πάχους Στον γενικό πληθυσμό------→




## Μικρή αλλαγή με την ηλικία

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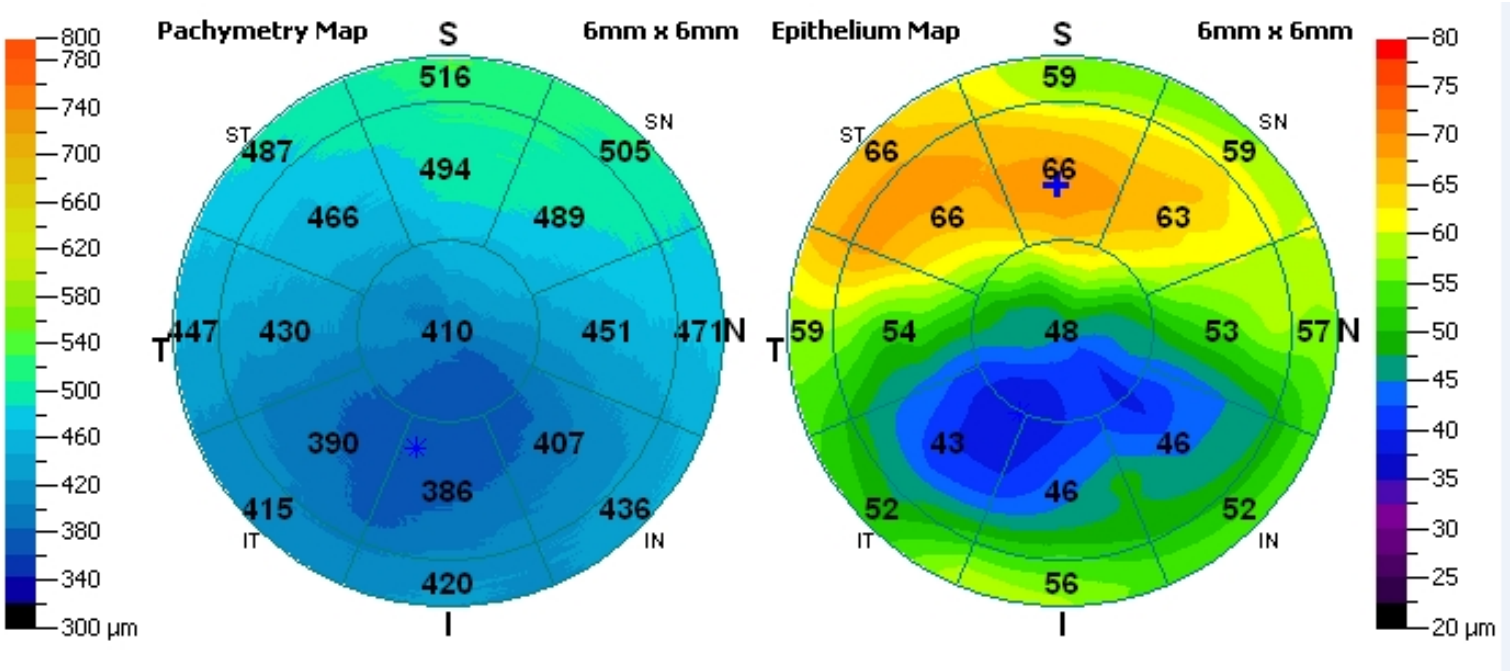


Ακόμη: Το συνολικό πάχος αυξάνει,
Πιθανόν ως ένδειξη βιομηχανικής αστάθειας.

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# Πολύ διαφορετικό από τη ΄φυσιολογική΄ κατανομή του επιθηλίου

**Pachymetry**

Pachymetry statistics within central 5mm zone

| | | | |
|---|---|---|---|
| SN-IT(2-5mm): | 25 | S-I(2-5mm): | 40 |
| Min: | 524 | Location Y: | -1444 |
| Min-Median: | -21 | Min-Max: | -60 |

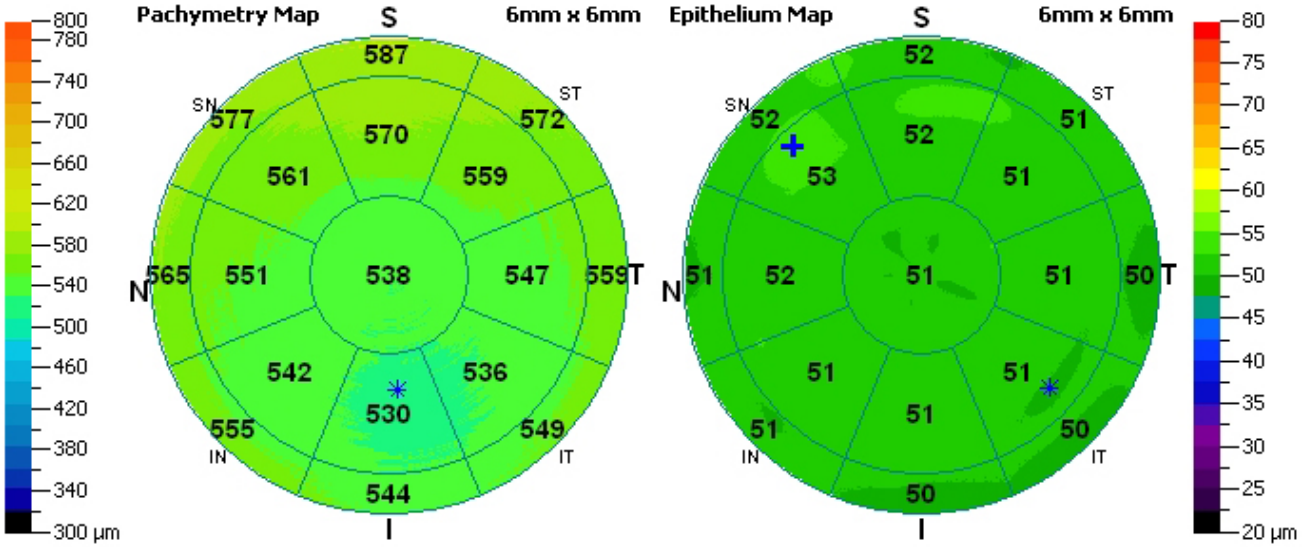
Min thickness at(0.112mm, -1.444mm) indicated as *

**Epithelium**

Epithelium statistics within central 5mm zone

| | | | |
|---|---|---|---|
| Superior: | 52 | Inferior: | 51 |
| Min: | 50 | Max: | 54 |
| Std Dev: | 0.7 | Min-Max: | -3 |

Min/Max thickness indicated as */+




Kanellopoulos AJ, Asimellis G. *In vivo three-dimensional epithelial imaging of corneal epithelium in normal eyes by anterior segment optical coherence tomography: a clinical reference study*. Cornea 2013;32(11):1493-8

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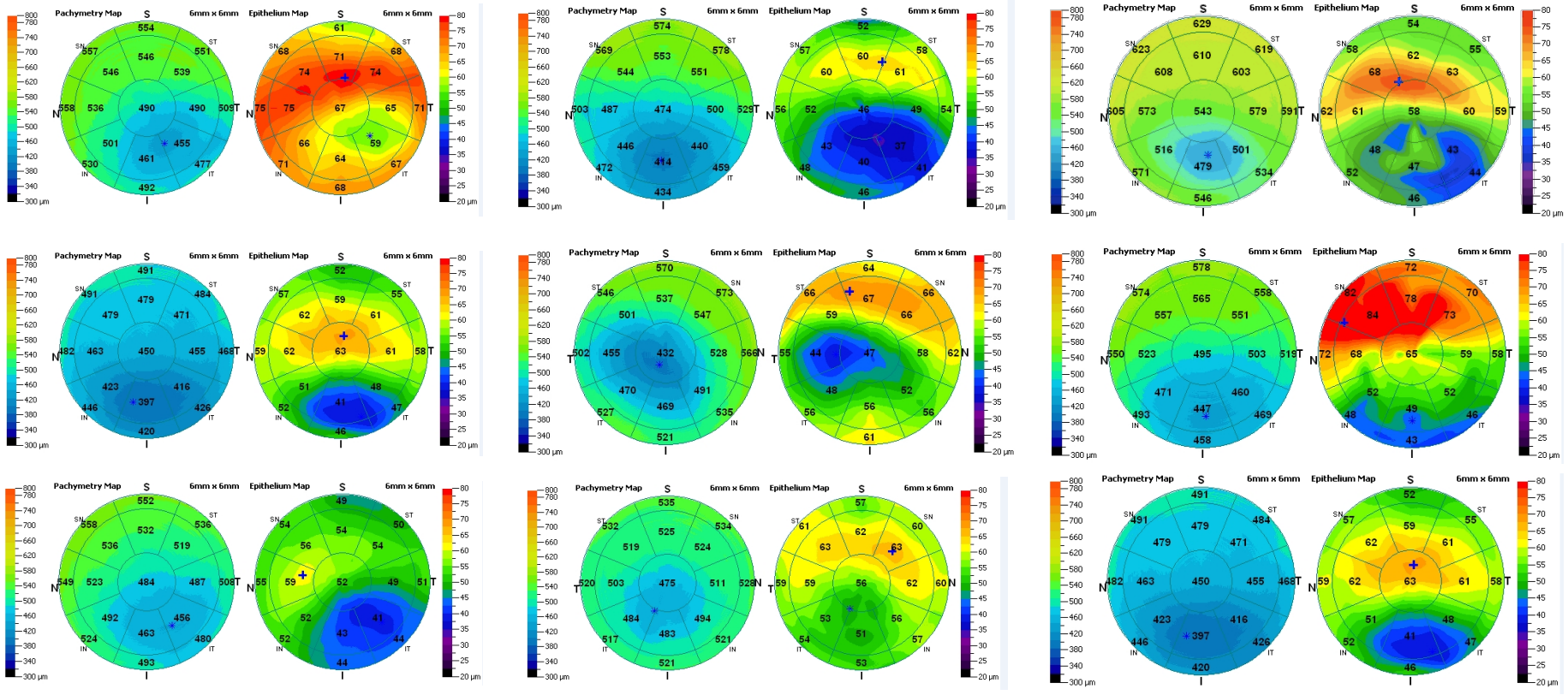


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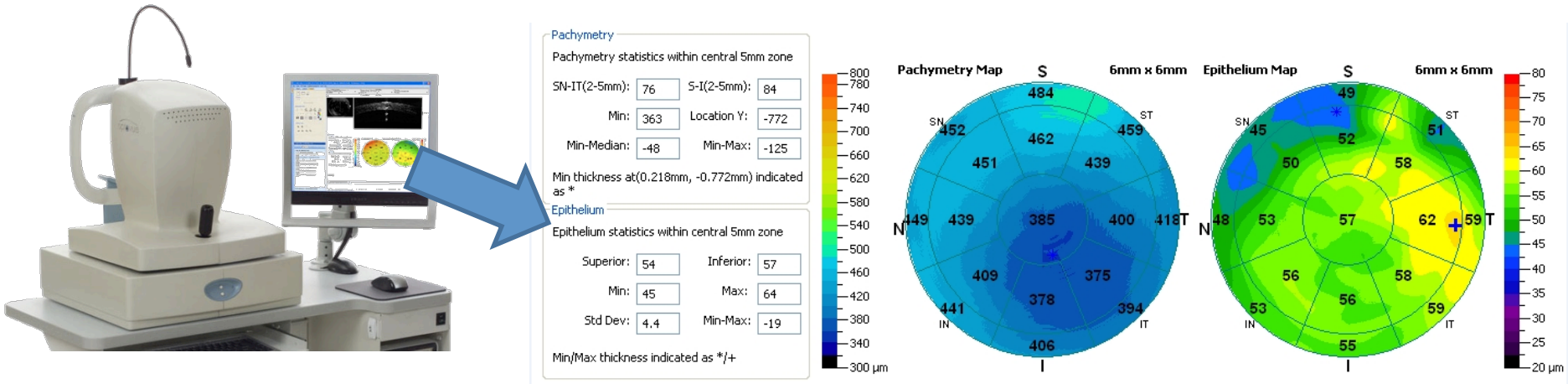
# Σκοπός

- Να αξιολογήσουμε την ασφάλεια, την αποτελεσματικότητα και ευκολία μέτρησης του επιθηλιακού πάχους, και
- Να μελετήσουμε την μορφολογική και στατιστική ανάλυση της κατανομής του επιθηλιακού πάχους σε Κερατοκωνικούς ασθενείς
- Χρησιμοποιώντας προσθίου θαλάμου Οπτική Τομογραφία Συνοχής (AS OCT).




Kanellopoulos AJ and Asimellis G, *Optical Coherence Tomography Epithelial Thickness and Scheimpflug Imaging Topographic Irregularity Indices in 160 Keratoconus Cases*. Ophthalmology. 2013; submitted to JCRS

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# Αρχικά αποτελέσματα στην Απεικόνιση του Επιθηλίου με OCT στον Κερατόκωνο

Case Reports in Ophthalmology

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## Anterior Segment Optical Coherence Tomography: Assisted Topographic Corneal Epithelial Thickness Distribution Imaging of a Keratoconus Patient

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**Key Words**
Anterior segment optical coherence tomography · Keratoconus · Epithelial imaging · Pentacam HR

**Abstract**
***Purpose:*** To evaluate safety, efficacy and ease of measurement of epithelial thickness in a keratoconic patient based on anterior segment optical coherence tomography (AS-OCT). ***Methods:*** A 25-year-old male patient, previously diagnosed with keratoconus, with highly asymmetric manifestation among the two eyes, was subjected to AS-OCT corneal epithelial imaging. We investigated epithelial thickness and epithelial topographic thickness distribution. ***Results:*** Mean epithelial thickness was 51.97 ± 0.70 for the less affected right eye (OD), and 55.65 ± 1.22 for the more affected left eye (OS). Topographic epithelial thickness variability for the OD was 1.53 ± 0.21 μm, while for the OS it was 9.80 ± 0.41 μm. ***Conclusions:*** This case further supports our previous findings with high-frequency ultrasound measurements of the increase in overall epithelial thickness in keratoconic eyes in comparison with normal eyes. AS-OCT further offers ease of use and possibly higher predictability of measurement. This case report, based on AS-OCT imaging, verifies increased overall epithelial thickness in keratoconic eyes, as introduced by a previous study [Kanellopoulos et al.: Clin Ophthalmol 2012;6:789–800], based on high-frequency scanning ultrasound biomicroscopy imaging.

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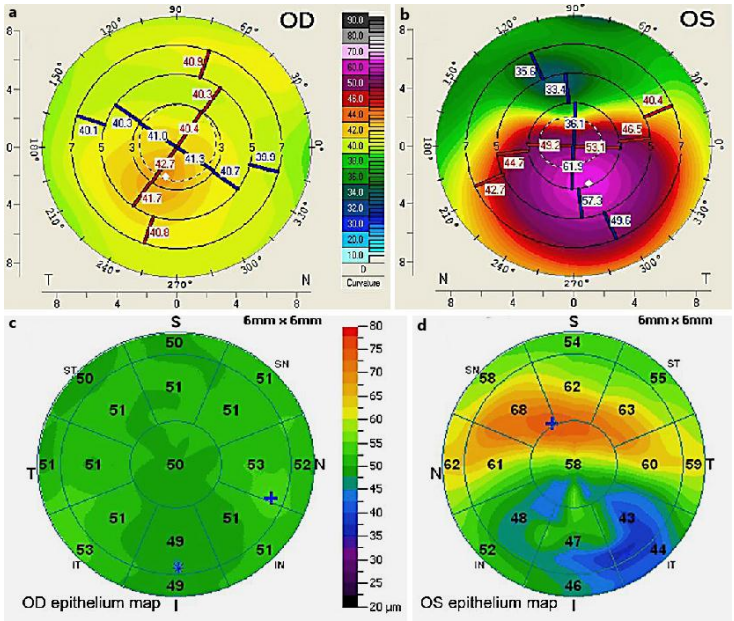
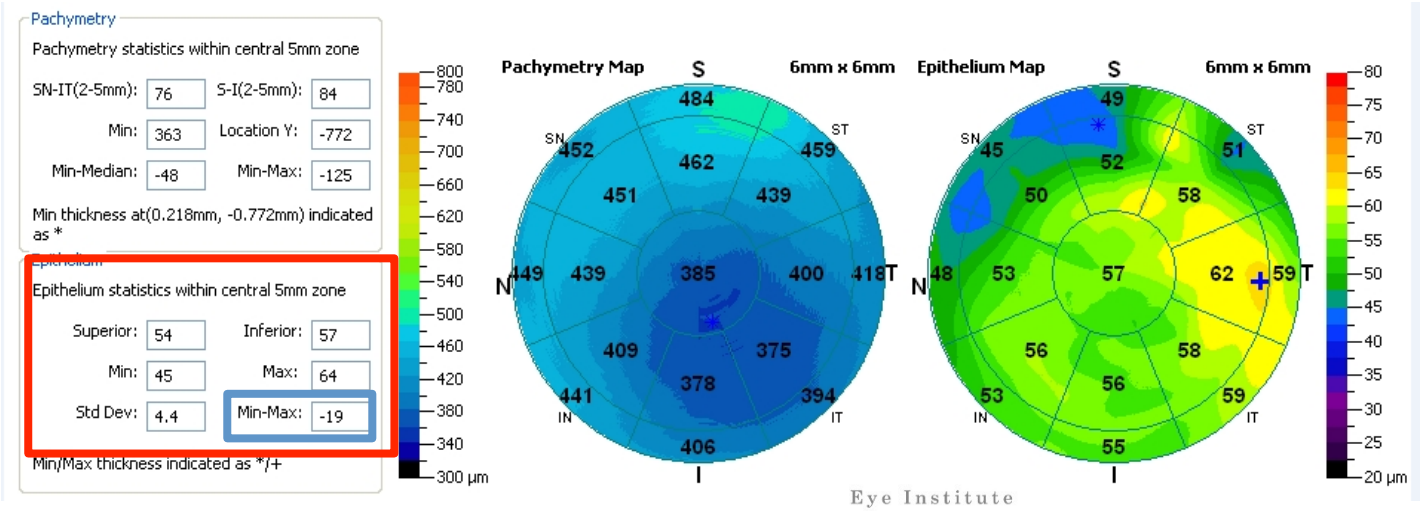



**Fig. 1.** **a** Tomographic anterior corneal sagittal curvature map for OD. **b** Tomographic anterior corneal sagittal curvature map for OS. **c** AS-OCT epithelial thickness map for OD. **d** AS-OCT epithelial thickness map for OS.

# Μέθοδοι

- Δύο συγκρινόμενες ομάδες, ανάλογα το φύλο και την ηλικία:
- Κερατόκωνος (ομάδα Α, n = 160 οφθαλμοί) και
- Φυσιολογικό (ομάδα Β, n = 160 οφθαλμοί).
- Μελετήσαμε το πάχος του επιθηλίου (συνολικό,κεντρικό,ανώτερο,κατώτερο,ελάχιστο,μέγιστο) και την τοπογραφική κατανομή του πάχους του επιθηλίου.

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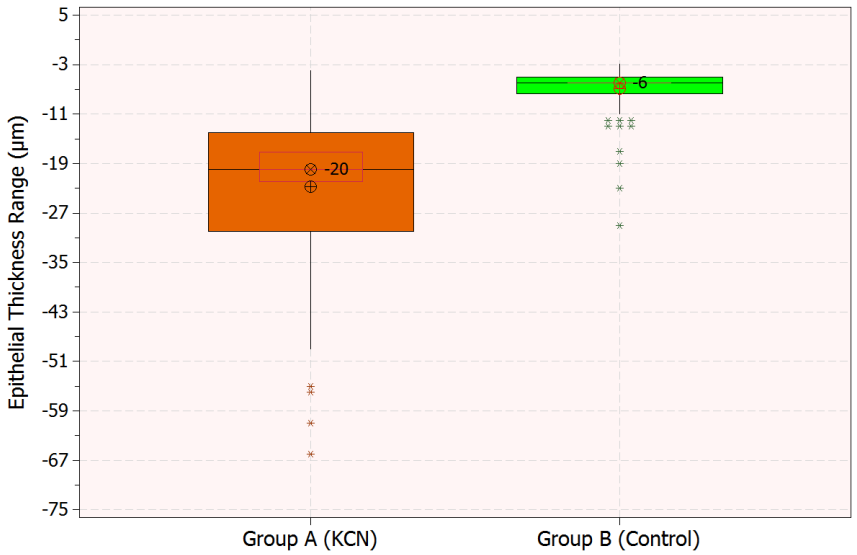
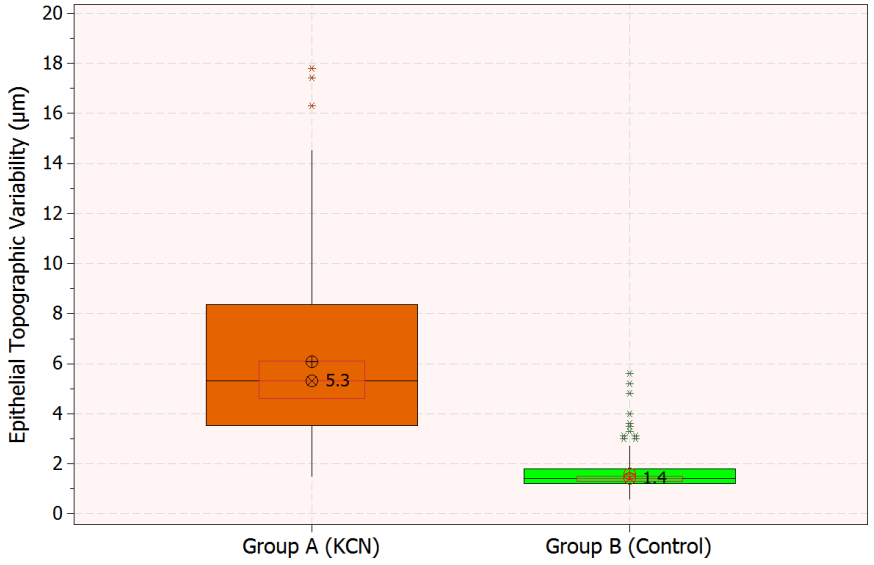
# Μέθοδοι

- **160 κερατοκωνικοί (ομάδα Α)** και **160 φυσιολογικοί (ομάδα Β)** οφθαλμοί υποβλήθηκαν σε τρισδιάστατη απεικόνιση του πάχους του επιθηλίου με προσθίου θαλάμου OCT.
- Επαναληψιμότητα μετρήσεων του πάχους του επιθηλίου.
- Πραγματοποιήθηκε συγκριτική στατιστική ανάλυση των αποτελεσμάτων μελετώντας την κεντρική, ελάχιστη, μέγιστη, κατώτερη, ανώτερη και τοπογραφική διαφοροποίηση του πάχους του επιθηλίου.

# Επιθηλιακοί Δείκτες

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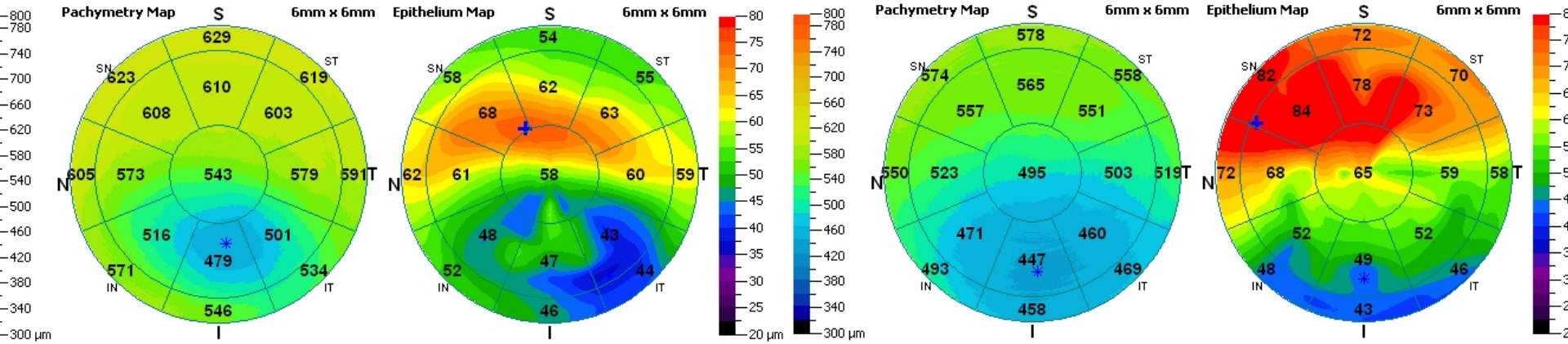


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# Αποτελέσματα

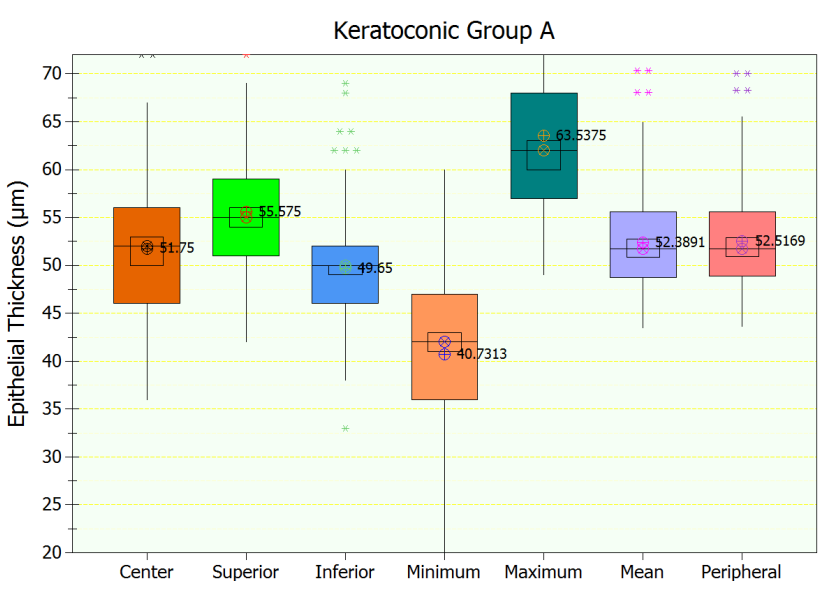
- Η επαναληψιμότητα των μετρήσεων του πάχους του επιθηλίου ήταν για την ομάδα Α ±1.13 μm, για την ομάδα Β ±1.78 μm

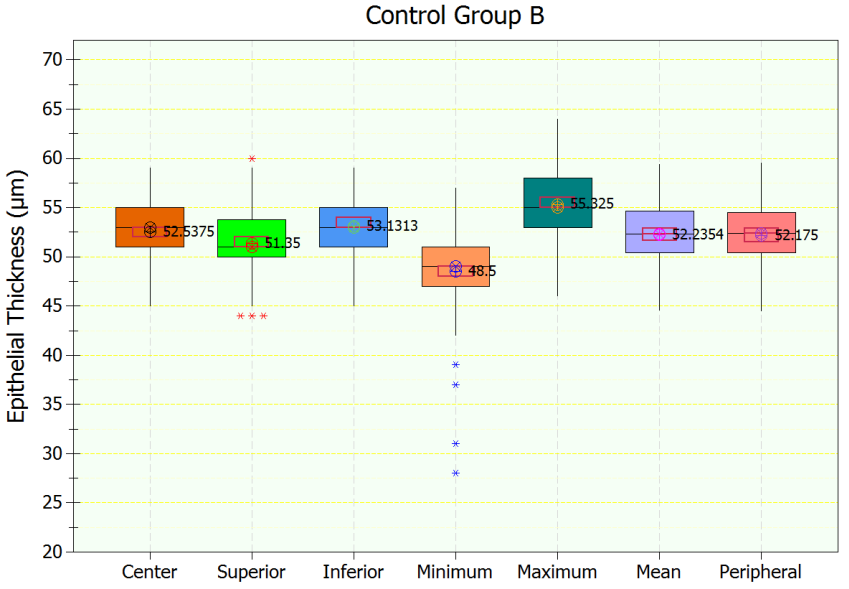
- **Ομάδα Α** (Κερατόκωνος)**:** κεντρική παχυμετρία 51.75±7.02 μm,
- μέγιστο 63.54±8.85 μm και ελάχιστο 40.73±8.51 μm.
- Μεταβλητικότητα 6.07±3.55 μm (εύρος -22.81±12.55 μm)

- **Ομάδα Β** (φυσιολογικό): κεντρικό επιθήλιο 52.54±3.23 μm,
- μέγιστο 55.33±3.27 μm
- ελάχιστο 48.50±3.98 μm.
- Μεταβλητικότητα: 1.59±0.79 μm (-6.86±3.33 μm)

- **Και τα δύο, μεταβλητικότητα πάχους του επιθηλίου και εύρος, αυξήθηκαν ανάλογα με τη σοβαρότητα του κερατόκωνου και συνδέονται με αυτήν.**

# Παχυμετρία επιθηλίου
# KC vs controls

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# Συμπεράσματα

- Η απεικόνιση του επιθηλίου με προσθίου θαλάμου OCT στηρίζει τα προηγούμενα ευρήματα μας με υψηλής συχνότητας υπερήχους (Artemis), σε αυξημένα επίπεδα επιθηλιακού πάχους σε κερατοκωνικούς οφθαλμούς σε σύγκριση με τους φυσιολογικούς.

- Η ανωμαλία στο επιθηλιακό πάχος με τις μετρήσεις OCT συνδέονται ορθά με τις μετρήσεις Scheimpflug για την κατηγοριοποίηση του Κερατόκωνου.

- Το OCT ακόμη προσφέρει, εύκολο χειρισμό και πιθανόν υψηλότερη ακρίβεια μέτρησης, που ίσως είναι ένα σημαντικό πλεονέκτημα.