المؤتمر السنوي الدولي للجمعية الرمدية المصرية
INTERNATIONAL CONGRESS OF THE
EGYPTIAN OPHTHALMOLOGICAL SOCIETY
EOS 2023

A Novel Multi-Model Artificial Intelligence Suite for the Diagnosis of corneal diseases

Presented by
Taher K. Eleiwa, MD, PhD
Lecturer of Ophthalmology, Benha Univ, Egypt
Former Fellow of Bascom Palmer Eye Institute, USA

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Take Home Message

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Bascom Palmer Cornea-AI team

Members of the Artificial Intelligence and Computer Augmented Vision Laboratory

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Financial Disclosure

- This study was supported by NEI K23 award K23EY026118 (MAS), NEI core center grant to the University of Miami (P30 EY014801), and unrestricted grant from Research to Prevent Blindness, NY.
- MAS is an equity holder and sits on the Board of Directors for Resolve Ophthalmics, LLC.

Research to Prevent Blindness

National Eye Institute

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Artificial Intelligence in Medicine

- Deep learning networks coupled with imaging have been created and proven accurate in diagnosing:

- ❑ Eye: Diabetic retinopathy
- ❑ Skin cancer
- ❑ Breast cancer
- ❑ Lung cancer

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EDITORIAL

Artificial Intelligence With Deep Learning Technology Looks Into Diabetic Retinopathy Screening

Tien Yin Wong, MD, PhD; Neil M. Bressler, MD

Retina

Prediction of Individual Disease Conversion in Early AMD Using Artificial Intelligence

Ursula Schmidt-Erfurth,[1] Sebastian M. Waldstein,[1] Sophie Klimscha,[1] Amir Sadeghipour,[1] Xiaofeng Hu,[1] Bianca S. Gerendas,[1] Aaron Osborne,[2] and Hrvoje Bogunović[1]

[1]Christian Doppler Laboratory for Ophthalmic Image Analysis, Vienna Reading Center, Department of Ophthalmology, Medical University of Vienna, Vienna, Austria
[2]Genentech, Inc., South San Francisco, California, United States

AMERICAN ACADEMY OF OPHTHALMOLOGY

The Future of Keratoconus Screening with Artificial Intelligence

Stephen D. Klyce, PhD, FARVO - *Port Washington, New York*

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First project: Corneal diseases

- Keratoconus
- Fuchs dystrophy
- Dry eye disease

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Why these diseases?!

Dry Eye Disease

Decrease in quality of life and damage to the cornea

Costs $700,000 per million patients

No gold standard for clinical testing

Keratoconus

Third most common indication for corneal transplantation.

Prevalence of 54.5 per 100,000 individuals in the US

Fuchs' Dystrophy

Prevalence ranges from 3.8% to 11% in ages 40 and older

Responsible for 36% of performed corneal transplants in the US

Waduthantri S, Yong SS, Tan CH, et al. Cost of dry eye treatment in an Asian clinic setting. *PloS one*. 2012;7(6):e37711-e37711.

Stapleton F, Alves M, Bunya VY, et al. TFOS DEWS II Epidemiology Report. *Ocul Surf*. 2017;15(3):334-365.

Matthaei M, Sandhaeger H, Hermel M, et al. Changing Indications in Penetrating Keratoplasty: A Systematic Review of 34 Years of Global Reporting. *Transplantation*. 2017;101(6):1387-1399.

Hamill CE, Schmedt T, Jurkunas U. Fuchs endothelial cornea dystrophy: a review of the genetics behind disease development. *Semin Ophthalmol*. 2013;28(5-6):281-286.

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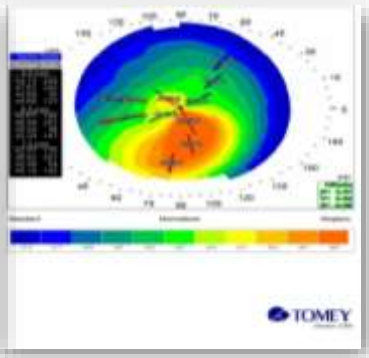
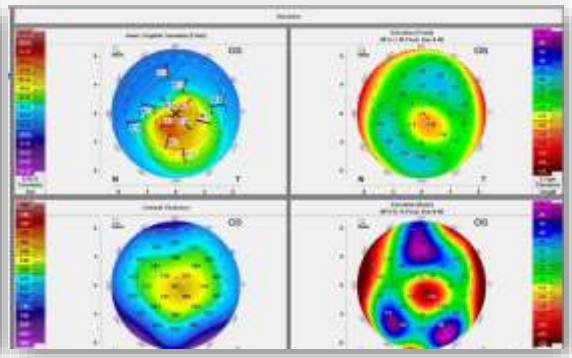
Keratoconus: Diagnostic tools





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Fuchs dystrophy: Tools for diagnosis

https://upload.wikimedia.org/wikipedia/commons/thumb/b/bd/Retina_Group_slit_lamp_%28side_view%29.jpg/250px-Retina_Group_slit_lamp_%28side_view%29.jpg

https://img.medicalexpo.com/images_me/photo-g/70682-3973457.jpg

https://www.nidek-intl.com/archives/004/201705/5de5d918b5788.jpg

https://cdn.dotmed.com/images/listingpics/2667122.jpg

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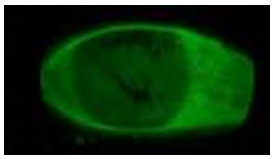
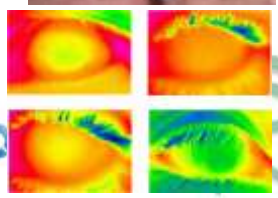
Dry eye: Current Clinical Testing



- Traditional testing includes tear break-up time (TBUT), Schirmers test, corneal staining, conjunctival staining, and questionnaires
- Newer testing includes tear osmolarity, ocular surface thermography, and tear film biomarkers
- Many different tests available, but no gold standard!



OCT features

Corneal diseases

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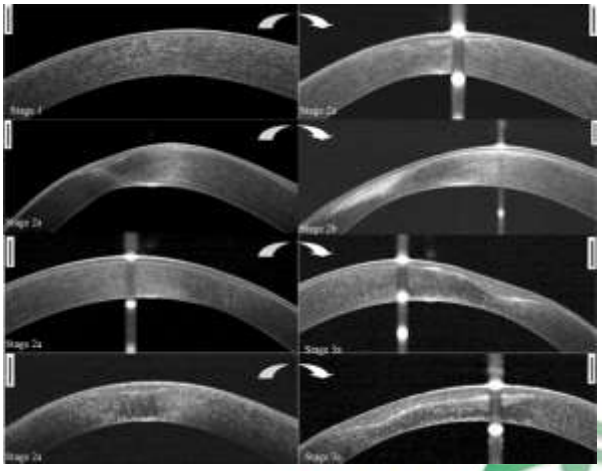
High Definition OCT in Keratoconus

Ophthalmology
Volume 120, Issue 12, December 2013, Pages 2403-2412

Original article

Fourier-Domain Optical Coherence Tomography Imaging in Keratoconus: A Corneal Structural Classification

Ehsan Sandali MD [1,2,3], Mohamed El Sanharawi MD, MPH [1,2], Cyril Temstet MD [1], Taous Hamiche BOpt [1], Alice Galan BOpt [1], Wajdene Ghrissi MD [1], Isabelle Goemaere BOpt [1], Elena Basli MD [1], Vincent Borderie MD, PhD [1], Laurent Laroche MD [1]



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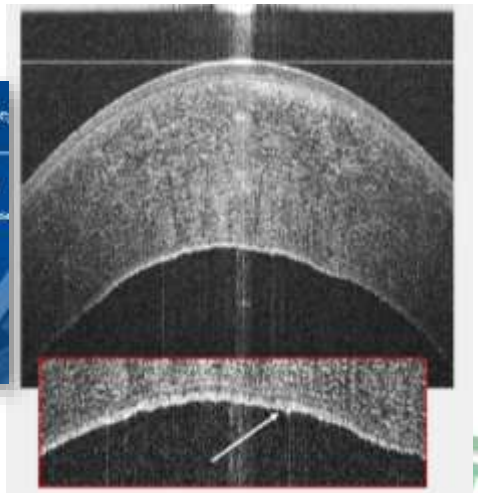
High Definition OCT in Fuchs

Ophthalmology
Submit Log in
ORIGINAL ARTICLE | VOLUME 127, ISSUE 7, P874-887, JULY 2020

Diagnostic Performance of 3-Dimensional Thickness of the Endothelium–Descemet Complex in Fuchs' Endothelial Cell Corneal Dystrophy

Taher Eleiwa, MD, MSc • Amr Elsawy, MSc • Mohamed Tolba, MD • William Feuer, MS • Sonia Yoo, MD • Mohamed Abou Shousha, MD, PhD



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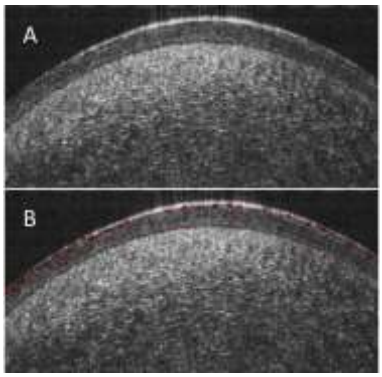
High Definition OCT in Dry eye



Article | Published: 01 October 2019

Corneal epithelial thickness profile in dry-eye disease

Mohamed Abou Shousha, Jianhua Wang, George Kontadakis, William Feuer, Ana P. Canto, Rodrigo Hoffmann & Victor L. Perez

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Methods

- We used transfer learning with VGG19 network architecture.
- We **trained** the model to predict the diagnosis **per image**, but in testing it is used to predict the diagnosis per image and per eye.

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Data Collection

- AS-OCT scans were taken using Envisu R2210, Bioptigen (Buffalo Grove, IL)
- 180 images were captured per scan using a 6 mm central corneal radial scan pattern
- The clinical diagnosis was performed on every patient
- Healthy patient was defined as no corneal ICD-10 diagnoses

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Observational case-control study

351 eyes

HD-OCT
(Envisu R2210, Bioptigen)

46,179 OCT images (11,830 dry eye, 11,440 FED, 11,469 keratoconus and 11,440 controls)

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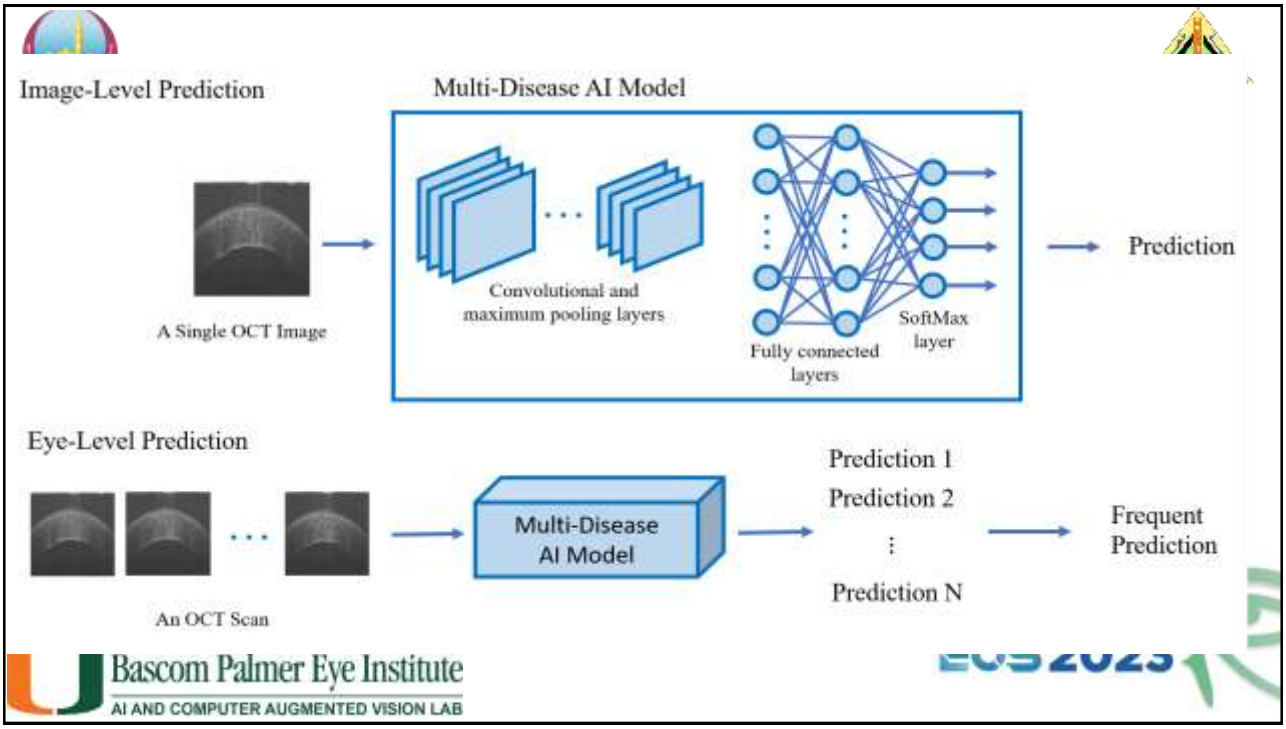
Image-Level Prediction
Multi-Disease AI Model
A Single OCT Image
Convolutional and maximum pooling layers
Fully connected layers
SoftMax layer
Prediction
Eye-Level Prediction
An OCT Scan
Multi-Disease AI Model
Prediction 1
Prediction 2
Prediction N
Frequent Prediction
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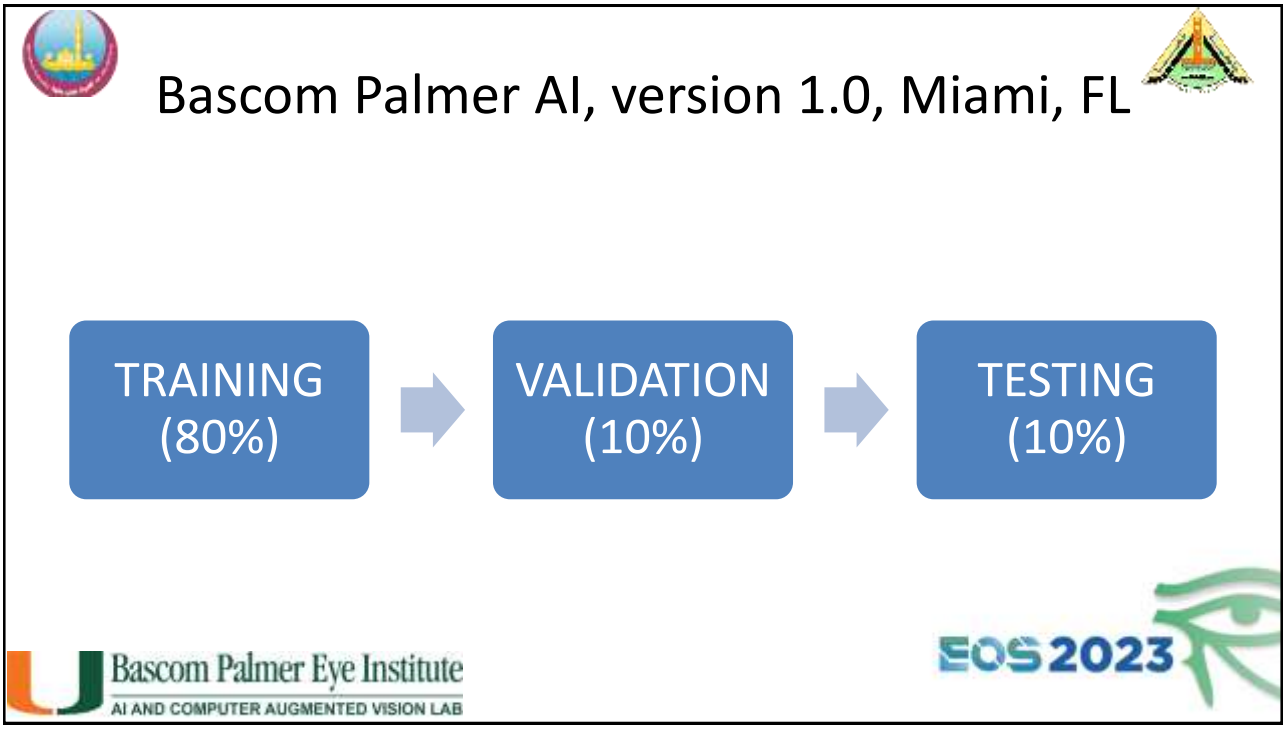
Bascom Palmer AI, version 1.0, Miami, FL
TRAINING (80%)
VALIDATION (10%)
TESTING (10%)
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Results

- The AI algorithm was able to achieve a testing classification accuracy of:
  - 99.2% for dry eye,
  - 99.9% for keratoconus,
  - 100% for FED,
  - 98.7% for normal controls,
  - overall accuracy of 99.51%.

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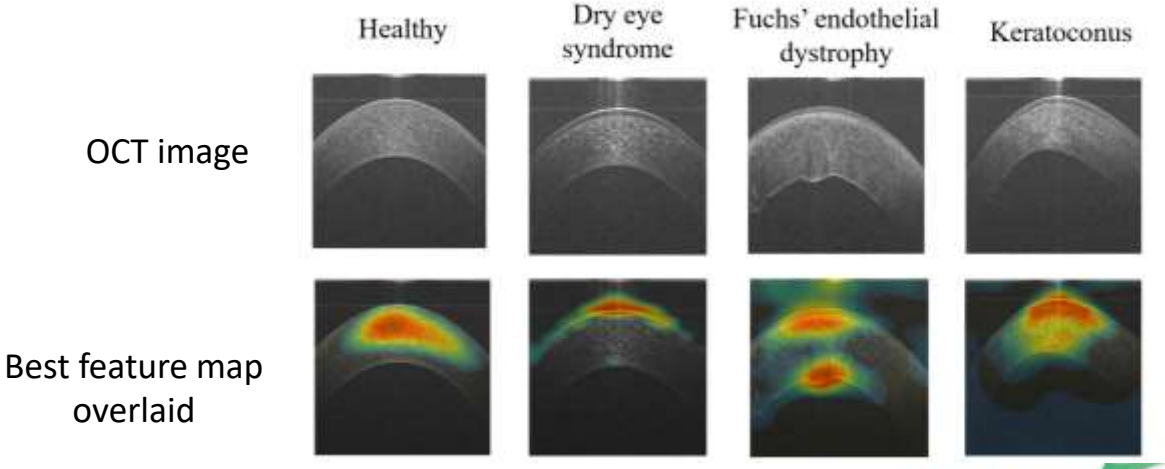
Visualizations



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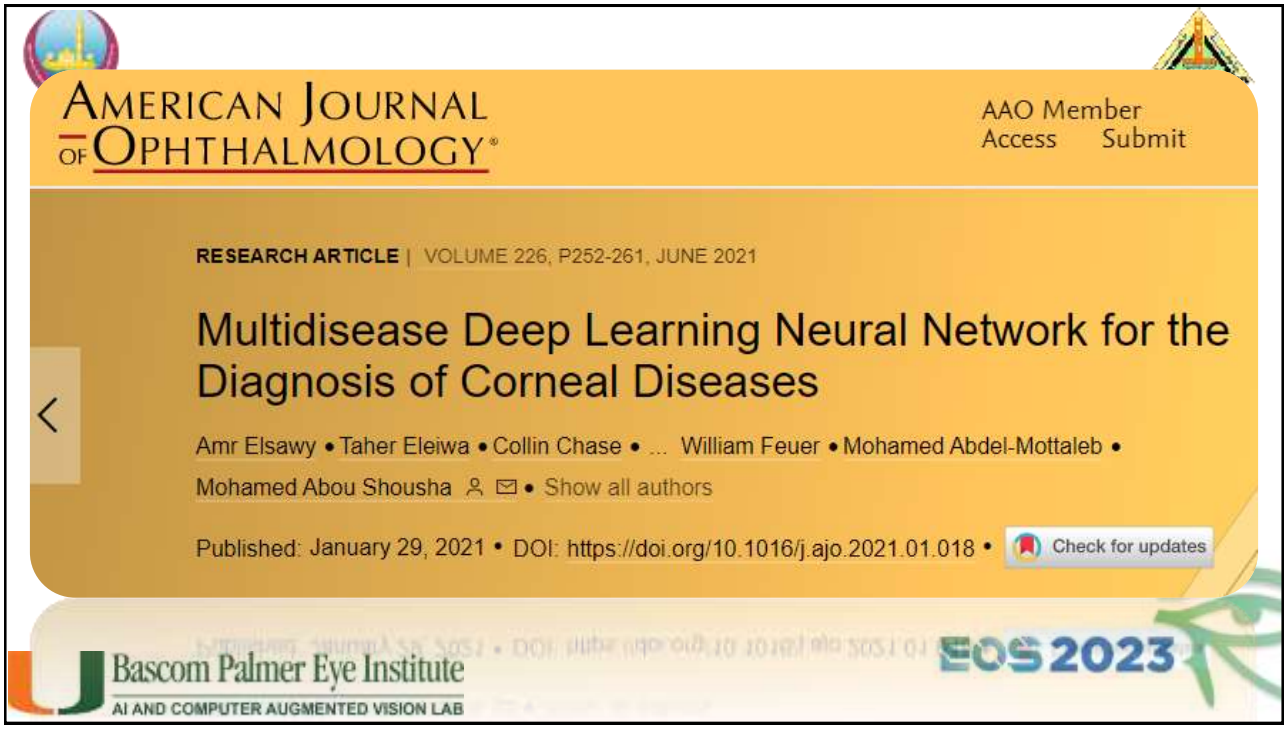
AMERICAN JOURNAL OF OPHTHALMOLOGY
AAO Member Access Submit
RESEARCH ARTICLE | VOLUME 226, P252-261, JUNE 2021
Multidisease Deep Learning Neural Network for the Diagnosis of Corneal Diseases
Amr Elsawy • Taher Eleiwa • Collin Chase • ... William Feuer • Mohamed Abdel-Mottaleb • Mohamed Abou Shousha • Show all authors
Published: January 29, 2021 • DOI: https://doi.org/10.1016/j.ajo.2021.01.018 • Check for updates
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Original Research
Comparison of Autonomous AS-OCT Deep Learning Algorithm and Clinical Dry Eye Tests in Diagnosis of Dry Eye Disease
Collin Chase, Amr Elsawy, Taher Eleiwa, Eyup Ozcan, Mohamed Tolba & Mohamed Abou Shousha
Pages 4281-4289 | Published online: 19 Nov 2022
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IOVS investigative ophthalmology & visual science — ISSUES TOPICS FOR AUTHORS ABOUT

FREE

ARVO Annual Meeting Abstract | June 2020

Artificial Intelligence Algorithm for the Diagnosis of Corneal Graft Rejection

Mohamed Abou Shousha; Amr Elsawy; Taher Kamel Eleiwa; Mohamed Tolba; Collin Chase; Eyub Ozcan; Mohamed Abdel-Mottaleb

+ Author Affiliations & Notes

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Deep-Keratitis AI

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Infectious keratitis Burden

- The silent epidemic
- 5th cause of Blindness
- 2 million monocular blindness/year
- >1 million cases of FK/year

- Ung L, Acharya NR, Agarwal T, et al. Infectious corneal ulceration: a proposal for neglected tropical disease status. Bull World Health Organ 2019;97:854–6.
- Brown L, Leck AK, Gichangi M, et al. The global incidence and diagnosis of fungal keratitis. Lancet Infect Dis 2021;21:e49–57

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Diagnosis

- CLINICAL EXPERTISE
- GOLD STANDARD: MICROBIOLOGY (SMEAR, C&S, BIOPSY, PCR)
- IMAGING: AS-OCT, IVCM

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Challenges

- Unavailability (equipments) → expertise + empiric ttt
- Poorly differentiated clinical features
- Low yield
- Long turnaround time
- Polymicrobial infection

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IVCM

- Cost
- Expertise
- Fungal
- Acanthameba
- No bacteria
- No viruses

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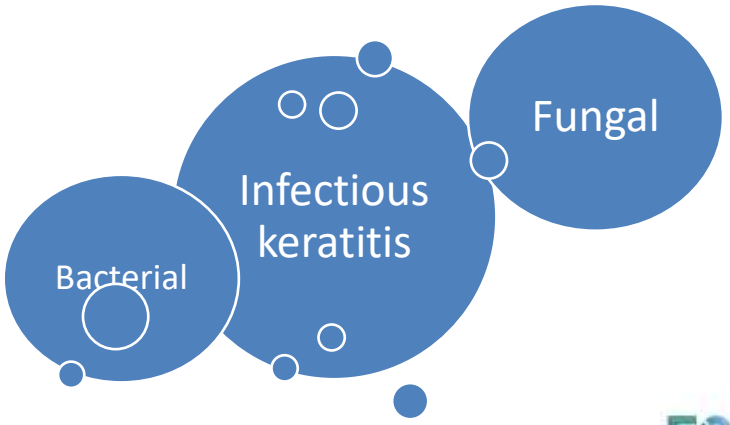
- Cornea specialists: 66%



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Dalmon C, et al. The clinical differentiation of bacterial and fungal keratitis: A photographic survey. *Invest. Ophthalmol. Vis. Sci.* 2012;**53**:1787–1791.

Typical ccc

30%

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Dahlgren MA, Lingappan A, Wilhelmus KR. The clinical diagnosis of microbial keratitis. *Am. J. Ophthalmol.* 2007;**143**:940–944.

Same organism “different severity”

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Not fungal!!

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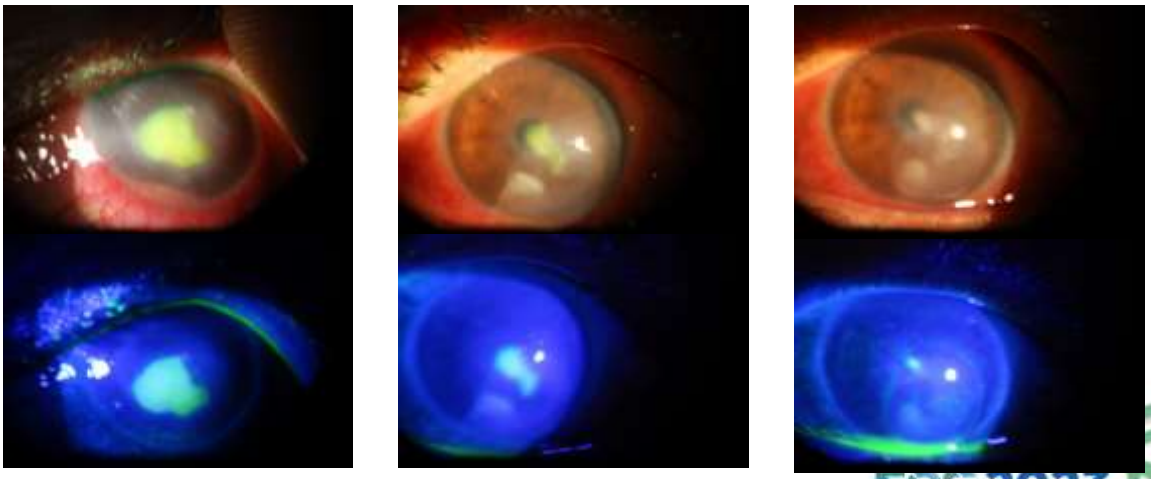
Bimicrobial



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Polymicrobial

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No one-size-fits-all diagnostic approach for IK

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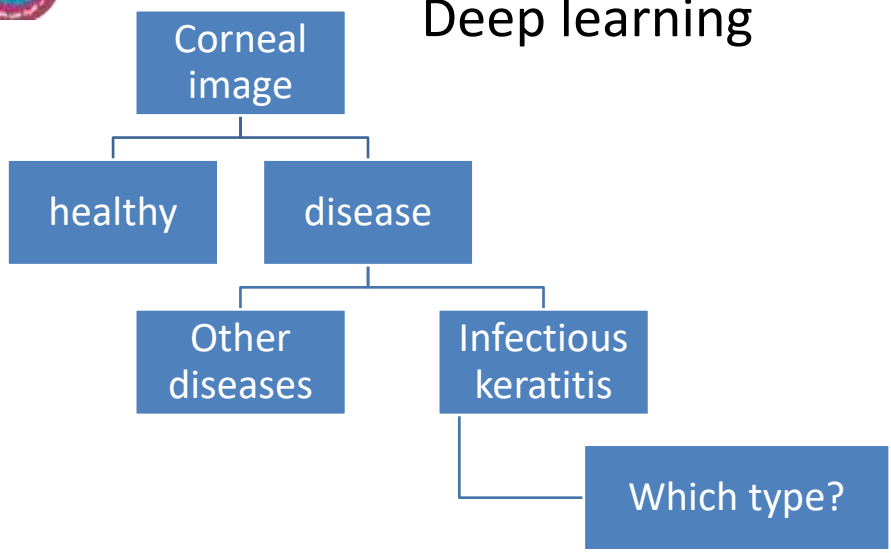
Deep learning



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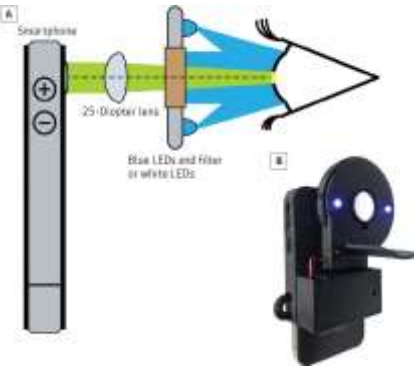
Tool selection



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Based on SLE photos

SCIENTIFIC REPORTS
nature research

Sci Rep. 2020; 10: 14424.
Published online 2020 Sep 2. doi: 10.1038/s41598-020-71425-9
PMCID: PMC7468230
PMID: 32879364

A deep learning approach in diagnosing fungal keratitis based on corneal photographs

Ming-Tse Kuo,[#1] Benny Wei-Yun Hsu,[#2] Yu-Kai Yin,[2] Po-Chiung Fang,[1] Hung-Yin Lai,[1] Alexander Chen,[1] Meng-Shan Yu,[1] and Vincent S. Tseng[#2]

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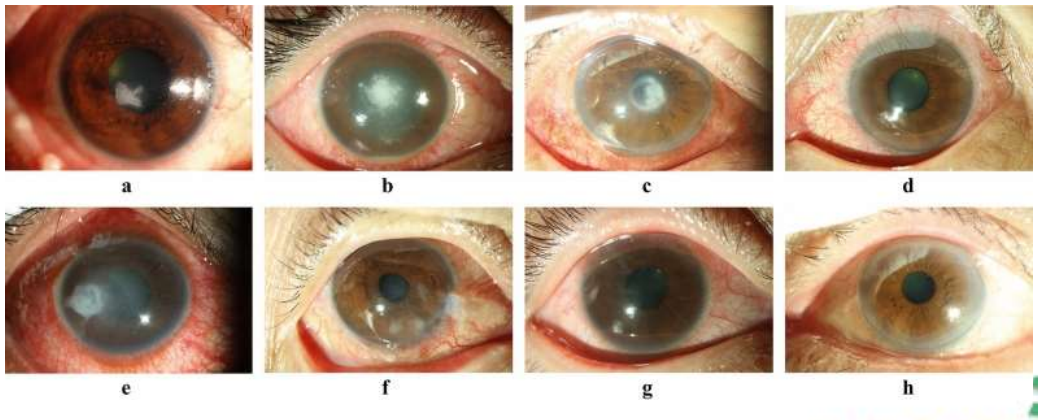

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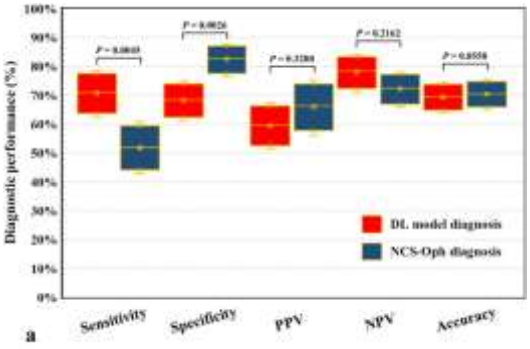
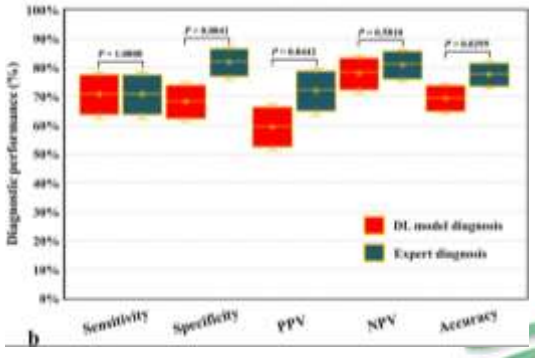
70%





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Computer Methods and Programs in Biomedicine
Volume 187, April 2020, 105019

Automatic diagnosis of fungal keratitis using data augmentation and image fusion with deep convolutional neural network

Liu Zhi [a 1], Cao Yankun [a 1], Li Yujun [a], Xiao Xiaoyan [b], Qiu Qingchen [a], Yang Meijun [a], Zhao Yuefeng [c], Cui Lizhen [d]

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Hyphae Detection in Fungal Keratitis Images With Adaptive Robust Binary Pattern

Publisher: IEEE

Cite This PDF

Xuelian Wu ; Qingchen Qiu ; Zhi Liu ; Yuefeng Zhao ; Bin Zhang ; Yong Zhang ; Xinyi Wu ; Jianmi... All Authors

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Conclusion

- AI is an accurate autonomous technique for the diagnosis of corneal diseases
- Validations in the setting of prospective multi-center clinical studies are warranted.
- AI technologies are likely to refine and shape the diagnostic landscape of IK in the near future.

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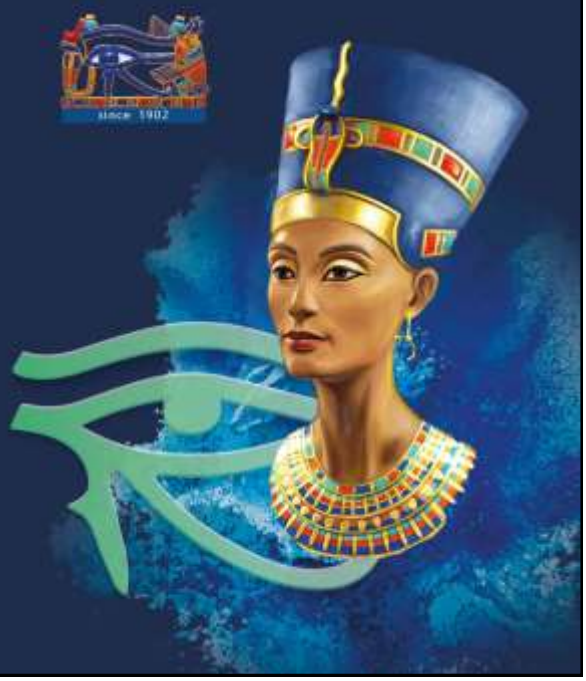

Thank you