

University: The University of Hong Kong (HKU)
Unit of Assessment (UoA): 03 Clinical Medicine
Faculty: Medicine
Title of case study: Global implementation of retinal nerve fiber layer optical texture analysis (ROTA) for early detection of glaucoma
Has this case study been submitted for RAE 2020? (Y/N)
Will this case study be submitted for RAE 2026? (Y/N)
Is this case study <u>continued</u> from a case study submitted in RAE 2020? (Y/N)
<p>1. Summary of the impact (indicative maximum 100 words)</p> <p>Christopher Leung developed Retinal nerve fiber layer (RNFL) Optical Texture Analysis (ROTA) using optical coherence tomography (OCT) to revolutionise detection of glaucoma – the leading cause of irreversible blindness. ROTA has been integrated into the Asia Pacific Glaucoma Guidelines 2024 and EyeWiki (an international eye encyclopedia), and licensed to three multinational OCT companies. Deployed in Hong Kong Southern District Signature Project and Orbis (an international non-profit organisation) screening programmes examining over 25,000 residents, ROTA revealed 7% had glaucoma, mostly undiagnosed. The demonstrated impact prompted the HKSAR Government to invest HK\$39.8 million in community-based eye care services to prevent blindness.</p>
<p>2. Underpinning research (indicative maximum 500 words)</p> <p><i>Glaucoma: The Silent Threat to Vision</i></p> <p>Glaucoma represents the most prevalent neurodegenerative disease of the central nervous system and remains the leading cause of irreversible blindness worldwide. This chronic, progressive optic neuropathy demands early diagnosis and therapeutic intervention to prevent vision loss and curb the growing burden of glaucoma blindness.</p> <p><i>Evolution from Circumpapillary to Topographic RNFL Analysis</i></p> <p>Professor Leung and his research team have pioneered the application of optical coherence tomography (OCT) for topographic evaluation of the retinal nerve fiber layer (RNFL), fundamentally transforming glaucoma detection and monitoring. Traditionally, clinicians relied on circumpapillary RNFL thickness measurements – a single circular scan around the optic nerve head – to identify and monitor glaucoma. However, this conventional approach had significant limitations in sensitivity and specificity. The team demonstrated that topographic RNFL thickness analysis (4.1, 4.2), which evaluates regions surrounding the optic nerve head rather than just a circular cross-section, achieved markedly superior diagnostic performance. This approach yielded high sensitivity and specificity for early glaucoma detection and progression monitoring and predicted subsequent visual impairment (4.1, 4.3).</p> <p><i>The Revolutionary ROTA Algorithm</i></p> <p>Despite these advances, topographic RNFL thickness analysis still struggled with detecting focal RNFL defects in early glaucoma and monitoring progressive changes in advanced disease. Recognizing these limitations, the team engineered and patented ROTA (Retinal nerve fiber layer Optical Texture Analysis) – a groundbreaking algorithm that revolutionises glaucoma assessment (US Patent No. US10918275B2; 4.4). ROTA integrates both thickness and reflectance measurements from standard OCT scans, unveiling the trajectorial patterns and optical textural details of individual axonal fiber bundles across a wide retinal field. This approach enables intuitive visualization of RNFL defects that remain invisible to conventional topographic RNFL thickness analysis and red-free RNFL photography. The algorithm essentially transforms OCT data into detailed maps revealing the precise trajectories of axonal fiber bundles, substantively enhancing detection of focal RNFL defects in early glaucoma, as well as diffuse RNFL loss in advanced glaucoma.</p> <p><i>Clinical Impact and Paradigm Shift</i></p>

Diagnostic performance studies conclusively established ROTA's superiority over conventional OCT analysis. Using visual field testing and red-free photography as reference standards, ROTA consistently outperformed traditional methods in detecting RNFL defects (4.4). Most remarkably, ROTA challenged longstanding clinical dogma about glaucoma progression patterns. Contrary to conventional belief that foveal and macular regions remain unaffected until late stages of glaucoma, ROTA revealed that 70% of early glaucoma patients exhibited papillomacular and/or papillofoveal bundle defects (4.5). This finding fundamentally altered understanding of early glaucomatous damage patterns. Furthermore, in patients with ocular hypertension presenting no clinical signs of optic disc abnormalities or RNFL thickness changes on standard clinical examination and OCT, ROTA detected RNFL defects in 10.8% of cases (4.6). The capability to identify subclinical RNFL damage positions ROTA as an invaluable tool for early disease detection and intervention, potentially preventing irreversible vision loss in high-risk patients.

3. Period when the underpinning research was undertaken:

Since 2010 – Investigation of topographic RNFL imaging using OCT

Since 2021 – Development of ROTA

4. References to the research (indicative maximum of six references)

* Corresponding Author

4.1 ***Leung CKS**, Lam S, Weinreb RN, Liu S, Ye C, Liu N, He J, Lai G, Li T, Lam DS. Retinal Nerve Fiber Layer Imaging with Spectral-Domain Optical Coherence Tomography – Analysis of the RNFL Map for Glaucoma Detection. *Ophthalmology*. 2010; 117:1684-91.

4.2 ***Leung CKS**, Yu M, Weinreb RN, Lai G, Xu G, Lam DS. Retinal nerve fiber layer imaging with spectral-domain optical coherence tomography: patterns of retinal nerve fiber layer progression. *Ophthalmology*. 2012;119:1858-66.

4.3 Yu M, Lin C, Weinreb RN, Lai G, Chiu V, ***Leung CKS**. Risk of Visual Field Progression in Glaucoma Patients with Progressive Retinal Nerve Fiber Layer Thinning: A 5-Year Prospective Study. *Ophthalmology*. 2016;123:1201-10.

4.4 ***Leung CKS**, Lam AKN, Weinreb RN, Garway-Heath DF, Yu M, Guo PY, Chiu VSM, Wan KHN, Wong M, Wu KZ, Cheung CYL, Lin C, Chan CKM, Chan NCY, Kam KW, Lai GWK. Diagnostic assessment of glaucoma and non-glaucomatous optic neuropathies via optical texture analysis of the retinal nerve fibre layer. *Nat Biomed Eng*. 2022;6:593-604.

4.5 ***Leung CKS**, Guo PY, Lam AKN. Retinal Nerve Fiber Layer Optical Texture Analysis: Involvement of the Papillomacular Bundle and Papillofoveal Bundle in Early Glaucoma. *Ophthalmology*. 2022;129:1043-1055.

4.6 Su CK, Guo PY, Chan PPM, Lam AK, ***Leung CKS**. Retinal Nerve Fiber Layer Optical Texture Analysis: Detecting Axonal Fiber Bundle Defects in Patients with Ocular Hypertension. *Ophthalmology*. 2023;130:1080-1089.

5. Details of the impact (indicative maximum 750 words)

The importance of early detection of glaucoma and its progression is underscored by the irreversible nature of optic nerve degeneration, the poor inter-observer agreement in clinical evaluation of the optic disc even among experienced glaucoma specialists, and the staggering load of 80 million glaucoma population worldwide. Professor Christopher Leung and his team at HKU have pioneered wide-field retinal nerve fiber layer (RNFL) imaging and developed RNFL Optical Texture Analysis (ROTA) which demonstrably transformed glaucoma detection capabilities worldwide.

Recognition and Clinical Integration

The clinical impact of ROTA has achieved worldwide recognition within the ophthalmology community beyond academia. Wide-field topographic RNFL analysis, which includes ROTA, has been integrated into the Asia Pacific Glaucoma Guidelines 2024 for glaucoma detection and monitoring, representing a landmark achievement toward standardizing the diagnostic assessment of glaucoma in clinical practice across the Asia-Pacific region [A]. These guidelines explicitly

highlight the advantages of wide-field RNFL analysis and ROTA in detecting RNFL defects missed by conventional analyses. The transformative potential of ROTA has been championed by leading international authorities, most notably Professor Robert Weinreb, whose credentials underscore the weight of his endorsement. As Distinguished Professor and Chair in Ophthalmology at the University of California San Diego, and Past President of both the World Glaucoma Association (the largest professional organization for glaucoma specialists worldwide) and the Association for Research in Vision and Ophthalmology (the preeminent organization for ophthalmologists and vision scientists), Professor Weinreb represents the pinnacle of glaucoma expertise. His unequivocal statement carries exceptional authority: "In my experience, the use of ROTA has proven to be a highly sensitive and specific method for detection of glaucoma. I strongly believe that the integration of ROTA into clinical practice would be a significant step forward in reducing the burden of glaucoma blindness" [B]. Furthermore, ROTA's inclusion in EyeWiki – the official eye encyclopedia of the American Academy of Ophthalmology – establishes it as a recognised standard reference accessible to eye care professionals, patients, and the general public worldwide [C]. This digital platform serves as the authoritative repository for comprehensive, evidence-based information on eye disease diagnosis and treatment, cementing ROTA within mainstream ophthalmology practice.

Commercialization and Global Deployment

Supported by the Hong Kong Science and Technology Parks with an investment of HK\$4M from the Incu-Bio Program, a startup company AIROTA Diagnostics was established by co-founders Christopher Leung and Alexander Lam to commercialise ROTA and its related applications. This company holds the license of ROTA (U.S. Patent No. US10918275B2 – Optical Texture Analysis of the Inner Retina) and has strategically expanded its intellectual property portfolio with additional patents covering critical applications, including Methods and Systems for Estimating Visual Field Sensitivities from ROTA Maps (U.S. Patent No. 17845852) and Methods and Systems for Enhancing Optical Textural Details of Retinal Features Relevant to a Health Condition (U.S. Patent Application No. 18/755,338) [D]. In 2023-25, ROTA was licensed non-exclusively to Heidelberg Engineering (Heidelberg, Germany), Carl Zeiss Meditec (Dublin, CA, USA), and Topcon (Tokyo, Japan) for deployment in the Spectralis OCT, the Cirrus OCT, and the Triton/Maestro OCT, respectively [E], to improve the detection and monitoring of RNFL defects in glaucoma worldwide. The total value of this licensing is approximately US\$800,000. With more than 50,000 OCT systems worldwide utilising these platforms, ROTA now possesses the infrastructure to enhance glaucoma detection for millions of patients globally.

Population-Level Impact and Government Response

ROTA's real-world impact is most powerfully demonstrated through its deployment in large-scale screening programs. Orbis, an international non-governmental organization dedicated to eliminating preventable blindness, adopted ROTA for its territory-wide "Vision Matters: Glaucoma AI-ROTA Screening Project for 50+" initiative [F]. Between June 2023 and May 2025, this programme screened 5,844 Hong Kong residents, diagnosing glaucoma in 403 individuals (6.9%), a striking revelation of previously undetected disease burden [G]. Equally significant outcomes emerged from the Southern District Signature Project, a comprehensive community eye care initiative backed by the Hong Kong Southern District Council with HK\$50 million funding. From July 2019 to July 2025, 21,637 residents underwent ROTA examination, revealing patients with or at risk of glaucoma in 10.8% (2338 individuals) [H]. These patients received prompt referrals to Hospital Authority specialist outpatient clinics or private clinics for treatment, potentially preventing irreversible vision loss. The compelling evidence from these programmes catalysed decisive government action. The HKSAR Government committed HK\$39.8 million to expand community-based eye care services, ensuring broader population access to ROTA and related applications [I]. This investment represents not just financial support but governmental validation of ROTA's transformative potential in public health ophthalmology.

6. Sources to corroborate the impact (indicative maximum of 10 references)

- A. [The Asia Pacific Glaucoma Guidelines 2024 \(4th Edition\)](#)
- B. [Support letter from Professor Robert Weinreb](#), Distinguished Professor and Chair in Ophthalmology at University of California San Diego (UCSD).
- C. ROTA on [EyeWiki](#) – an eye encyclopedia and service of the American Academy of Ophthalmology.
- D. i) Leung CK, Lam AKN. Optical Texture Analysis of the Inner Retina ([U.S. Patent 10918275B2](#)); (ii) Leung CK, Lam AKN. Methods and Systems for Estimating Visual Field Sensitivities from Retinal Optical Texture Analysis (ROTA) Maps (US patent no. [17845852](#)); (iii) Leung CKS, Lam AKN. Methods and Systems for Enhancing Optical Textural Details of Retinal Features Relevant to a Health Condition ([U.S. Patent Application No: 18/755,338](#)).
- E. Support letters: i) [Heidelberg Engineering](#); ii) [Carl Zeiss Meditec](#) and iii) [Topcon Healthcare](#)
- F. Deployment in screening programme: [Vision Matters: Glaucoma AI-ROTA Screening Project for 50+](#)
- G. HKUMed Ophthalmology x Orbis project outcomes: HKU x Orbis press releases, news articles and TV broadcasts reporting that 5,844 Hong Kong residents were screened, among whom 403 were diagnosed with glaucoma:
 - i. [Hi-tech eye tests to be introduced in Hong Kong to spot disease that can cause blindness earlier. South China Morning Post \(May 30, 2023\)](#)
 - ii. [眼睛健康 | 奧比斯及港大醫學院眼科學系 公布「免費青光眼篩查計劃」擴至全港 香港經濟日報 TOPick \(2024 年 10 月 15 日\)](#)
 - iii. [奧比斯及港大醫學院公布「視」不宜遲免費青光眼篩查計劃擴至全港 | am730 \(2024 年 10 月 10 日\)](#)
 - iv. [港大與奧比斯開展次階段驗眼計劃 惠及千名 50 歲或以上公屋戶 | 無綫新聞 TVB News \(2024 年 10 月 10 日\)](#)
 - v. [奧比斯、港大醫學院推第二階段青光眼篩查計畫 料 1,000 名 50 歲以上公屋市民受惠 - 有線寬頻 i-CABLE \(2024 年 10 月 10 日\)](#)
 - vi. HKU press release on “[HK’s largest community eye-screening project by HKUMed Ophthalmology and Orbis reveals higher-than expected glaucoma prevalence among older adults](#)” (August 14, 2025)
 - vii. [Media coverage report](#) on the HKUMed Ophthalmology x Orbis community eye-screening project (August 2025)
- H. HKUMed Ophthalmology x Southern District Eye Signature Project outcomes: HKUMed Ophthalmology press releases, news articles and TV broadcasts reporting that 21,637 Hong Kong residents underwent ROTA examination, among whom 2,338 were diagnosed with or at risk of glaucoma:
 - i. HKU press release on “[HKUMed’s landmark eye screening study: Over one fourth of Hong Kong Residents aged 50+ face mild visual impairment – most cases treatable](#)” (September 29, 2025)
 - ii. [眼科檢查 | 港大南區社區檢查 50 歲以上 27%患輕度視力障礙 香港經濟日報 HKET \(2025 年 9 月 29 日\)](#)
 - iii. [2.1 萬名 50 歲以上南區居民眼科檢查 港大揭 27.2%有輕度視力障礙 | 即時新聞 | 中港台 | on.cc 東網 \(2025 年 9 月 29 日\)](#)
 - iv. [近三成 50 歲或以上港人被發現雙眼患輕度視力障礙 信報財經新聞 \(2025 年 9 月 29 日\)](#)
 - v. [HKUMed: Most mild visual impairment cases are treatable](#) TVB News (September 29, 2025)

- vi. [港大醫學院完成南區社區大型眼科檢查計劃](#) HOY TV (2025 年 9 月 29 日)
- I. Community eye services grant: Implementation of ROTA and related applications in “[Development and deployment of a community-based eye care model for provision of primary eye care services](#)” supported by the Hong Kong Strategic Topics Grant (HK\$39.8M) (2025-2030) (PI: Christopher Leung)