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Research Article

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Post Hoc Evaluation of Low-Cost Glaucoma Risk Calculator in Screening for Angle-Closure Risk in High- Risk Groups

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ABSTRACT
In this post hoc analysis, we evaluated the Laroche Glaucoma Risk Calculator as a screening tool to identify patients requiring gonioscopy to detect primary angle-closure glaucoma (PACG) within a high-risk, community-based cohort. The calculator, which incorporates age, intraocular pressure, and central corneal thickness, was originally designed as an affordable screening tool for use in under-resourced settings and is now implemented in routine clinical screening to stratify glaucoma risk and guide further evaluation. Iridotrabecular contact can lead to IOP elevation and glaucoma preceding glaucomatous optic neuropathy. We did a retrospective analysis of 149 patients identified as high risk, of which 9 (6.04%, p-value) were diagnosed with primary angle closure glaucoma PACG and 2 (1.34%, p-value) were classified as angle-closure suspects (PACS); these individuals were more often older with a mean age of 72.2 and female (54.5%), showing narrow angles on slit-lamp examination or optic nerve cupping on fundus evaluation. The prevalence of angle-closure disease in this high risk screened cohort exceeded global estimates, particularly among Black and Hispanic patients, who represented most of the study population (95%). These findings suggest that the Laroche glaucoma risk calculator can help triage patients who may benefit from gonioscopy, potentially facilitating earlier detection of PACG in underserved populations where gonioscopy remains underutilized.

Keywords: Community-Based Screening, Glaucoma Risk Calculator, Gonioscopy, Early Detection, Affordable Screening Tools

Introduction

Glaucoma remains a leading cause of irreversible blindness worldwide and is characterized by several subtypes, including primary angle closure disease (PACD). Among these, primary angle closure glaucoma (PACG) accounts for nearly half of all causes of glaucoma-related blindness and arises from obstruction of the anterior chamber angle, impeding aqueous humor outflow and elevating intraocular pressure[1]. The classification of primary angle closure suspect (PACS) is the presence of iridotrabecular contact > 180 degrees but no peripheral anterior synechiae, elevated intraocular pressure, or optic nerve damage. Primary angle closure (PAC) is defined as iridotrabecular contact > 180 degrees with elevated intraocular pressure or peripheral anterior synechiae but no optic nerve damage. Primary angle closure glaucoma (PACG) is defined as PAC with glaucomatous optic neuropathy. During comprehensive eye examinations, gonioscopy is the gold standard for assessing the anterior chamber angle and detecting angle closure. However, PACG often goes unrecognized because patients remain asymptomatic until advanced stages of vision loss occur and gonioscopy is underutilized, even among those receiving routine eye care[2].

To address disparities in glaucoma detection, the Laroche Glaucoma Risk Calculator was introduced in 2022 as an affordable glaucoma screening tool for under-resourced settings[3]. It was designed for use by both physicians and trained non-physician personnel in underserved and remote settings. This calculator used three variables age, intraocular pressure (IOP), and central corneal thickness (CCT) to assess glaucoma risk. In its initial validation, it identified patients as high risk (glaucoma or glaucoma suspect) or low risk (no glaucoma) with high sensitivity (93.5%) and specificity (91.3%)[4]. Since its introduction, it has become an important part of risk assessment in our clinical practice to, guiding which individuals require further evaluation with gonioscopy, optical coherence tomography, visual field and fundus photography. As we have continued using the Laroche calculator in clinical practice, we identified not only patients with open-angle glaucoma, but also a high number of patients with angle-closure glaucoma, prompting us to examine this study retrospectively.

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A Study by Shah et al. (2024), reported from the Intelligent Research in Sight (IRIS) registry that Black and Hispanic patients were at the highest risk for blindness from newly diagnosed PACG compared to non-Hispanic white patients, even after adjusting for comorbidities[5]. PACG is frequently underdiagnosed in non-Asian populations and showcases the need for greater awareness and more accessible tools to aid in the early detection of PACG[6].

Angle-closure detection is more challenging in non-Asian populations primarily because the disease is less prevalent and presents with different anatomical characteristics, leading to lower clinical suspicion and potentially different screening thresholds. The lower prevalence in non-Asian populations fundamentally affects detection. While angle-closure glaucoma affects 0.7% of people over 40 globally, most cases (15.5 million of 20.2 million in 2013) occur in Asia[7].

European and European-derived populations have substantially lower rates compared to Chinese and other Asian populations. European and European-derived populations have substantially lower rates compared to Chinese and other Asian populations European and European-derived populations have substantially lower rates compared to Chinese and other Asian populations[8]. This lower baseline prevalence reduces the pre-test probability, making screening less cost-effective and potentially leading to less routine gonioscopy in these populations.

Anatomical and biometric differences between populations may contribute to detection challenges. While both Caucasians and Chinese with occludable angles share certain features (smaller anterior chamber depth and width, larger lens vault), important differences exist. In a comparative study, Chinese eyes with occludable angles had significantly smaller anterior chamber depth and width than Caucasian eyes with occludable angles. More critically, the predictive factors differ: in Caucasians, occludable angles were associated with lens vault, anterior chamber depth, iris thickness, age, and sex, whereas in Chinese populations, iris thickness was not a significant predictor. This suggests potentially different mechanisms of angle closure development between racial groups[8].

Black individuals without angle-closure glaucoma have significantly thinner lenses compared to both Black patients with angle-closure glaucoma and Danish control participants. This suggests that lens thickness is a critical anatomical factor protecting against acute angle-closure attacks in the Black population[9].

In the study by Clemmesen and Luntz, Black participants without angle-closure had thinner lenses than both Black patients with angle-closure glaucoma and Danish control individuals, whereas the latter two groups had similar lens thickness. This finding indicates that Black individuals who develop angle-closure glaucoma lose the protective effect of a thinner lens and instead have lens dimensions comparable to populations with higher acute attack rates[9,10].

This anatomical difference may explain why angle-closure in Black populations is predominantly chronic rather than acute. When Black individuals do develop angle-closure, they typically have lost the protective thin lens characteristic and instead have lens parameters similar to other populations prone to angle closure. The chronic presentation suggests a different pathophysiologic pathway that develops more gradually, possibly through progressive lens thickening with age or other mechanisms that don't trigger the acute pupillary block seen more commonly in Asian and Caucasian populations.

Genetic factors also differ across populations. Recent genome-wide association studies have identified distinct genetic loci associated with primary angle-closure glaucoma in different ancestries. While eight loci have been identified in Asian populations, only GLIS3 rs736893 showed association in both Asian and European individuals. A European-focused GWAS identified genetic factors associated with darker iris color and hypermetropia as risk factors, highlighting ancestry-specific genetic architecture that may influence both disease presentation and detection strategies[11].

The combination of lower prevalence, different anatomical predictors, and distinct genetic profiles means that screening approaches optimized for Asian populations may not translate effectively to non-Asian populations, potentially contributing to missed diagnoses.

The present post hoc analysis evaluates whether the Laroche Glaucoma Risk Calculator can also identify patients at risk for PACG and PACGS. Specifically, we examine whether a tool originally developed for open-angle glaucoma detection may flag individuals who would benefit from gonioscopic assessment. Within this context, the calculator could serve as a practical screening tool, facilitating earlier detection of angle-closure disease in populations where gonioscopy remains underused. No measurements of anterior chamber depth, lens thickness, axial length were performed.

Methods

This study was approved by the BRANY IRB 25-08-696 and adheres to the Tenets of the Declaration of Helsinki. A waiver of informed consent was granted since this was a retrospective chart review.

Participant Selection

Participants included in this post hoc analysis were selected from the original cohort and were previously identified as high risk using the Laroche Glaucoma Risk Calculator between September 2022 and September 2024. Detailed methods risk stratification are reported in prior publications.3,4 Briefly, the calculator generates a sum of point values from the participants age, IOP, and CCT to determine a total glaucoma risk score ranging from 0-18. Those with a glaucoma risk score of 6-18 were categorized as high risk and were included in this current analysis. The calculator assigns points as follows: Age contributes points based on decade of life, with older age receiving more points. IOP contributes points proportional to the measured pressure, with higher IOP values receiving more points. CCT contributes negative points (protective effect) for thicker corneas and positive points (risk factor) for thinner corneas. The specific mathematical formula combines these three variables into a composite metric[3].

A score of ≥6 optimizes diagnostic accuracy, with sensitivity of 90.74%, specificity of 64.00%, and overall correct classification of 77.88% in the original validation cohort of 104 eyes. The subsequent 2024 community-based validation study of 716 participants demonstrated improved performance with 93.5% sensitivity and 91.3% specificity[4].

The Laroche glaucoma scoring algorithm was applied as originally described by Laroche et al.[3]. The complete scoring criteria are detailed in the original publication. A publicly available version of the calculator was used to verify score calculations. Eligible charts reviewed were aged ≥ 40 or older and completed the initial screening with the Laroche Glaucoma Risk calculator, recorded to be high risk and had completed a comprehensive ophthalmic exam by an ophthalmologist (D.L). Gonioscopy was performed on all high risk patients by glaucoma specialist DL. Gonioscopy was performed in a dark room with a bright, short beam that did not pass through the pupil to avoid inducing pupillary constriction, which can artificially widen the angle. Compression (indentation) gonioscopy was performed to distinguish appositional closure from permanent synechial closure and determine the extent of peripheral anterior synechia.

Primary angle-closure suspect (PACS) was identified when ≥180 degrees of iridotrabecular contact (ITC) is present on dark-room gonioscopy without compression, with no peripheral anterior synechiae (PAS) and normal intraocular pressure (IOP). Primary angle-closure glaucoma (PACG) requires the same ≥180 degrees of ITC plus evidence of optic nerve damage. The intermediate stage, primary angle closure (PAC), has ≥180 degrees of ITC with either elevated IOP or PAS present, but without optic nerve damage. The Schaffer grading system (grades 0-4 based on angle width) was also used to complement this assessment by describing the degree of angle opening, but the formal angle closure disease classification relied on the presence and extent of ITC, IOP elevation, PAS formation, and optic nerve damage rather than Shaffer grades alone. All high risk patients had standardized gonioscopy with consistent criteria. All patients received a complete optic nerve examination, fundus photography, Optical coherence tomography and visual field examination. During follow-up exam, participants were subcategorized into glaucoma, glaucoma suspects, or no glaucoma groups. Glaucoma suspects included individuals with elevated intraocular pressure (ocular hypertension), as well as those with optic nerve or retinal nerve fiber layer findings suggestive of early glaucomatous damage, but without definitive visual field loss or optic nerve atrophy.

Data Collection

Data were analyzed retrospectively through a medical chart review from September 2022-September 2024. Data were collected from initial screening to determine risk categorization and from follow-up comprehensive eye examination within one month of the initial screening. To assess for primary angle-closure glaucoma, participants had to have received this diagnosis from DL at the initial complete eye examination.

Data Analysis

Demographic and clinical variables were summarized in Table 1 and reported as either mean (± standard deviation), median (interquartile range) or number (percentage). Descriptive statistics were used to characterize age, sex, race/ethnicity, and glaucoma diagnosis category. Subgroup analyses were conducted within the high-risk cohort to explore patterns related to angle status, including the distribution of patients diagnosed with PACG or identified as angle-closure suspects.

Table 1: Baseline Demographics of Study Population

Characteristic	Value
Age, years (mean ± SD)	72.2 ± 10.5
Sex	
Female	89 (59.7%)
Male	60 (40.3%)
Race	
Black	135 (90.1%)
White	8 (5.4%)
Asian	4 (2.7%)
American Indian or Alaskan	2 (1.3%)
Ethnicity	
Not Hispanic or Latino	127 (85.2%)
Hispanic or Latino	22 (14.8%)
Glaucoma Diagnosis	
Primary Angle Closure	9 (6.0%)
Angle Closure Suspect	2 (1.3%)
Primary Open Angle Glaucoma	45 (30.2%)
Open Angle Glaucoma Suspect	93 (62.4%)

Results

Among 716 participants screened using the Laroche Glaucoma Risk Calculator, 231 (32.3%) were categorized as high-risk, of whom 199 (27.8%) had confirmed glaucoma or were glaucoma suspects. Medical records were available for 149 of these high-risk patients included in this analysis. As noted in table 1, the cohort was composed of 60 (40.3%) men and 89 (59.8%) women. By race, 135 (90.1%) identified as Black, 8 (5.4%) as White, 4 (2.7%) as Asian, and 2 (1.3%) as American Indian/Alaska Native. For ethnicity, 127 (85.2%) self-identified as non-Hispanic/Latino and 22 (14.8%) as Hispanic/Latino.

Among the participants, 9 (6.0%) were diagnosed with primary angle-closure glaucoma, 2 (1.3%) were identified as angle-closure suspects, 93 (62.4%) were classified as open-angle glaucoma suspects, and 45 (30.2%) had primary open-angle glaucoma. Among the 9.

individuals with primary angle-closure glaucoma, 5 (45.5%) self-identified as Black non-Hispanic/Latino, 3 (27.3%) as Black Hispanic/Latino, and 1 (9.1%) as Asian non-Hispanic/Latino. The two angle-closure suspects included one Black participant and one White participant. Overall, 6 of these 11 individuals were female and 5 were male.

Discussion

The findings from this post hoc analysis presents a descriptive prevalence study of an enriched high risk sample suggest that the Laroche Glaucoma Risk Calculator may help identify patients at increased risk for primary angle-closure glaucoma (PACG) within

community-based screening settings. In our high-risk cohort, the combined prevalence of confirmed PACG and suspected angle-closure (6.0%) exceed widely reported prevalence estimates in this enriched high risk sample. Our study only analyzed the 149 high-risk patients (score ≥6), creating spectrum bias that inflates apparent disease prevalence. The 6.0% PACG prevalence among this group cannot be compared to population-based estimates (0.5-1.09%) because our denominator excludes the 485 low-risk patients who were screened but not analyzed. To report the true screening prevalence we would have to calculate PACG prevalence among all 716 screened participants, not just the high-risk subset. We do acknowledge the spectrum bias explicitly by analyzing only high-risk patients creates an enriched cohort that overestimates disease prevalence compared to unselected populations. Recent epidemiologic studies from Tham et al. (2014) report a worldwide PACG prevalence of approximately 0.5%, with regional variation ranging from 0.16–1.48% in Africa, 1.09% in Asia, 0.13–0.98% in Europe, and 0.14–3.00% in Latin America and the Caribbean (Table 2)[12]. Although Asia carries the highest burden, accounting for nearly three-quarters of global cases, PACG remains a significant but under-recognized cause of blindness in African, Hispanic, and other underrepresented populations where gonioscopy is underutilized.6 The elevated proportion of PACG and angle-closure suspects identified by the Laroche calculator emphasizes the importance of accessible, low-cost screening tools capable of flagging at-risk individuals for further angle evaluation and improving early detection in these settings.

Table 2: Global Prevalence of Primary-Angle Closure Glaucoma

Region	PACG Prevalence (%)	Number of People (Millions)
Africa	0.6	1.26
Asia	1.09	15.47
Europe	0.4	1.41
Latin America & the Caribbean	0.85	1.14
North America	0.25	0.39
World Total	0.6	20.17

Few studies have examined PACG prevalence outside of Asian populations. A recent systematic review by Asiamah et al. reported a PACG prevalence of 0.98% across 29,606 African participants, while Apolo et al. found that over 70% of PACG cases in the United States were diagnosed without a preceding identification of anatomically narrow angles[13,14]. Their analysis further revealed significantly higher odds of late detection among males, Black individuals, and adults over 80 years[14]. Similarly, a study by Shah et al. reported from the Intelligent Research in Sight (IRIS) registry that Black and Hispanic patients were at the highest risk for blindness from newly diagnosed PACG compared to non-Hispanic white patients, even after adjusting for comorbidities[5]. Collectively, these studies indicate that PACG is frequently underdiagnosed in non-Asian populations and showcases the need for greater awareness and more accessible tools to aid in the early detection of PACG.

Within this cohort of patients identified as high risk by the Laroche calculator, a subset demonstrated findings consistent with definite or suspected angle-closure disease. This correlation between risk-score elevation and angle-closure disease supports the calculator's potential role as an initial screening tool. Its simplicity and reliance on three readily obtainable parameters (age, IOP, and CCT), allow use by trained non-physician personnel in community settings. Its ability to flag patients who might otherwise go undetected could be valuable in community and resource limited settings, and in ophthalmology and optometric offices where gonioscopy is often underutilized due to time, expertise, or equipment constraints.

By prompting targeted gonioscopy among those identified as high risk via the screening, the calculator could enhance early detection of PACG and PACGS. Early identification is clinically important, as timely intervention can prevent irreversible optic nerve damage and preserve vision. These findings show the potential utility of incorporating such risk calculators into routine practice to triage patients for further angle evaluation.

The implications are particularly relevant given the long-standing debate over the value of population-based glaucoma screening. The U.S Preventive Services Task Force recommended against routine population-level glaucoma screening citing concerns about cost-effectiveness, and need for specialized medical personnel[15]. However, the findings of our current report demonstrate that using the low-cost Laroche Glaucoma Risk Calculator for targeted screening in high-risk populations over the age of 50 offers substantial benefits to help screen for angle closure. The simplicity of the Laroche Calculator, which does not require visual field testing or optic nerve evaluation by a glaucoma specialist, allows for efficient identification of higher-risk individuals within the general population, thereby facilitating targeted comprehensive examinations that include gonioscopy for angle-closure screening. By enabling non-physician personnel to flag at-risk patients in resource-limited settings, this model overcomes many hurdles highlighted in earlier screening critiques, as well as supports a more cost-effective approach in populations where the burden of angle-closure glaucoma is high and early detection can significantly impact outcomes. These findings emphasize that strategic, targeted glaucoma screening using affordable tools like the Laroche calculator may be justified and effective in older, high-risk groups, despite prior concerns raised in major reviews.

Limitations

The analysis was limited to patients identified as high risk by the Laroche calculator, without comparison to lower-risk individuals. Consequently, diagnostic metrics such as sensitivity or specificity could not be recalculated for angle-closure detection. Selection bias in the Laroche calculator validation study should be addressed through careful consideration of the enriched sampling strategy, potential verification bias, and generalizability limitations inherent in community-based screening of high-risk populations.

The 68% Black participant proportion represents oversampling of a high-risk population due to the location of the screenings and practices rather than a representative sample of the general U.S. population. While Black individuals have 3-4 times higher prevalence of primary open-angle glaucoma compared to non-Hispanic whites and are diagnosed at younger ages

with more severe disease, they comprise only approximately 13% of the U.S. population[16]. This methodology appropriately targets populations with the highest disease burden over age 50 but limits direct generalizability of the calculator's performance metrics (93.5% sensitivity, 91.3% specificity) to younger lower-risk populations. Verification bias likely inflates the reported diagnostic accuracy because only 716 of 823 screened participants (87%) completed the comprehensive ophthalmologic examination required to confirm glaucoma status. Participants who screened positive on the calculator may have been more motivated to complete follow-up than those who screened negative, potentially overestimating sensitivity. Conversely, if participants with false-negative screens were less likely to pursue comprehensive examination, specificity could be overestimated.

Addressing these biases requires several analytical approaches: stratified analysis by race/ethnicity to assess whether calculator performance varies across groups; sensitivity analyses accounting for missing follow-up data using multiple imputation or inverse probability weighting; and external validation in population-based cohorts with lower glaucoma prevalence to establish performance in average-risk screening scenarios. The study's focus on "high-risk communities" can create geographic clustering that may further limit generalizability beyond urban, predominantly minority populations.

Research team diversity may have influenced participation rates and completion of follow-up examinations. Evidence demonstrates that racial and ethnic concordance between patients and research personnel significantly improves consent rates for clinical studies, potentially affecting both the initial screening participation and the 87% follow-up completion rate[17]. This concordance effect could introduce selection bias if certain demographic subgroups were systematically more or less likely to complete the validation process.

Prospective validation across a larger and more representative sample, ideally with confirmed gonioscopy findings, is needed to determine the true clinical utility of the calculator in detecting angle-closure disease. Potential confounders such as variability in input data such as accuracy of IOP or central corneal thickness measurements, and incomplete clinical documentation and selection bias in a high-risk only cohort may have influenced results. These limitations highlight the need for future studies to more rigorously evaluate the calculator's role in glaucoma risk stratification.

Conclusion

These findings contribute to the expanding literature on glaucoma risk stratification tools aimed at identifying patients at increased risk during screening for angle-closure glaucoma. Similar to post hoc validation studies of the Ocular Hypertension Treatment Study (OHTS) risk calculator, which has demonstrated value in estimating the risk of progression to primary open-angle glaucoma and guiding management in ocular hypertension. The results for this study show that a simple, low-cost tool can effectively identify patients at elevated risk who might otherwise be overlooked in routine care for both open-angle and angle-closure glaucoma. Unlike the OHTS calculator, which requires professional optic nerve and visual field evaluation,18 the Laroche Glaucoma Risk Calculator uses only three readily available variables, which include age, intraocular pressure, and central corneal thickness, making it accessible for use in optometric, ophthalmology, and community screening settings. Incorporating this calculator into new patient evaluations, particularly by ophthalmic technicians, can help optimize clinical efficiency, conserve resources, and support effective triage of patients over age 50 for further glaucoma assessment. Angle-closure disease remains under diagnosed and is often detected late in many populations, applying the Laroche calculator as a screening aid aligns with best practices in population eye health and may significantly enhance early detection and outcomes through timely gonioscopy and comprehensive glaucoma examination in high risk patients..

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Author Contribution

J.O. drafted the manuscript and analyzed the data.
D.L. conceived the study, analyzed the data, and edited the manuscript.
K.G. analyzed the original data, edited the manuscript
All authors reviewed and approved the final version of the manuscript.

Conflict of Interest

The authors declare no conflicts of interest related to this work.

Ethics Statement

This study was approved by the BRANY IRB and adheres to the Tenets of the Declaration of
Helsinki. A waiver of informed consent was granted since this was a retrospective chart review.

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