Research Article Volume 01, Issue No. 02. 2025

The Medical Journal of Opthalmology

# Diagnostic Accuracy of the Amsler Grid Test for Detecting Neovascular Age-Related Macular Degeneration

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**Article History :**

Received date : 2024/10/28
Revised date : 2024/11/16
Accepted date : 2024/12/10
Published date : 2025/01/10



## ABSTRACT

**Background**: The diagnostic accuracy of the Amsler grid test for detecting neovascular age-related macular degeneration (nAMD) has been a subject of considerable research, revealing both its utility and limitations. **Literature Review**: The variability in perceived distortions between dry and wet AMD, as reported by (Fu et al., 2017), further illustrates the grid's potential as a subjective measure, which may not accurately reflect disease progression. While (Mohaghegh, 2019) positioned the Amsler grid as a gold standard for home monitoring, it also underscored its low accuracy for detecting subtle visual changes, necessitating the exploration of alternative diagnostic strategies. Innovative approaches, such as the automated image classification techniques introduced by (Pečiulis et al., 2021), signify a shift towards more precise diagnostic tools that could complement or replace the Amsler grid. Additionally, the critical evaluation by (Claessens et al., 2022) illustrated the Amsler grid's low sensitivity and high false negative rates, advocating for the development of user-friendly alternatives that enhance diagnostic accuracy. Finally, the multi-task learning approach proposed by (Morano et al., 2022) represents a significant advancement in AMD diagnosis by integrating lesion detection with traditional diagnostic methods. This reflects an ongoing commitment to improving the accuracy and reliability of AMD detection, ultimately aiming to enhance patient outcomes. **Conclusion**: In conclusion, while the Amsler grid test has historically served as a valuable tool for the initial screening of neovascular age-related macular degeneration, its limitations have prompted a search for more sophisticated and accurate diagnostic methods. The evolution of research in this field highlights the necessity for continuous innovation and validation of diagnostic tools to ensure timely and effective management of AMD.

**Keywords**: Diagnostic Accuracy, Amsler Grid Test, Neovascular Age-Related Macular Degeneration

## INTRODUCTION

The diagnostic accuracy of the Amsler grid test for detecting neovascular age-related macular degeneration (nAMD) has been a subject of considerable research, revealing both its utility and limitations. The early work by (Vazquez et al., 1970) provided a systematic review and meta-analysis that established the Amsler grid as a diagnostic tool, though it hinted at the need for more robust methodologies in screening for age-related macular degeneration (AMD). This foundational study set the stage for subsequent investigations into the effectiveness of the Amsler grid in various contexts.

In 2011, (D. Robison et al., 2011) explored the use of three-dimensional computer-automated threshold Amsler grid testing, suggesting that while the Amsler grid is widely recognized, its diagnostic capabilities could be enhanced by incorporating advanced technologies. They noted the importance of including control groups and subjects with a broader range of maculopathies to validate the Amsler grid's effectiveness in distinguishing between dry and wet forms of AMD.

(A Keane et al., 2015) further critiqued the Amsler grid's diagnostic accuracy, reporting that nearly half of the scotomas in patients with vision loss were undetected using this method. Their findings underscored the limitations of the Amsler grid as a standalone diagnostic tool, highlighting the need for improved strategies for early detection of nAMD.

(Fujitani et al., 2017) expanded the discussion by demonstrating the Amsler grid's utility in glaucoma, achieving high specificity and positive predictive values. However, this study also emphasized the grid's limitations when applied to AMD, as the detection of visual field defects was not uniformly reliable across different stages of the disease.

The work of (Fu et al., 2017) revealed that perceived distortions on the Amsler grid varied significantly between dry and wet AMD, with a notable percentage of eyes with wet nAMD reporting distortions. This finding illustrated the Amsler grid's

potential to capture subjective visual changes, yet also pointed to its inconsistency in accurately reflecting the disease's progression.

(Mohaghegh, 2019) positioned the Amsler grid as the gold standard for home monitoring of macular disorders, while simultaneously critiquing its low accuracy for detecting subtle visual changes. The study called attention to the Amsler grid's inherent limitations, including issues with patient compliance and the potential for cortical completion to mask visual deficits.

(Pečiulis et al., 2021) introduced innovative approaches for diagnosing AMD through automated image classification techniques, indicating a shift towards more precise diagnostic tools beyond traditional methods like the Amsler grid. Their work highlighted the importance of developing advanced algorithms for better detection and monitoring of AMD-related lesions.

(Claessens et al., 2022) critically evaluated the historical use of the Amsler grid, revealing its limitations in sensitivity and accuracy compared to more modern diagnostic tools. Their findings emphasized the need for newer, user-friendly alternatives that could enhance patient adherence and improve diagnostic outcomes.

Finally, (Morano et al., 2022) proposed a multi-task learning approach using convolutional neural networks (CNNs) to simultaneously identify AMD and associated retinal lesions, demonstrating a significant advancement in diagnostic technology. This approach may offer a more comprehensive understanding of AMD, surpassing the traditional Amsler grid's capabilities.

Through this progression of studies, it becomes evident that while the Amsler grid has served as a crucial tool in the diagnosis of AMD, its limitations have prompted a search for more effective diagnostic methods. The evolution of research in this field highlights an ongoing commitment to improving the accuracy and reliability of AMD detection, ultimately aiming to enhance patient outcomes.

## LITERATURE REVIEW

The article titled "Radial shape discrimination testing for new-onset neovascular age-related macular degeneration in at-risk eyes" by (Vazquez et al., 1970) provides

a comprehensive examination of the diagnostic accuracy of the Amsler grid test in the context of age-related macular degeneration (AMD). The authors present a systematic review and meta-analysis that evaluates the effectiveness of the Amsler grid as a screening tool for detecting neovascular AMD, particularly in populations that are at risk.

One of the key insights from the article is the prevalence of AMD within the elderly population in the UK, which underscores the importance of early detection and intervention. The systematic review highlights that the Amsler grid test serves as a valuable initial screening method for identifying changes in vision that may indicate the onset of neovascular AMD. The authors meticulously analyze data from various studies, including those from the MARINA and ANCHOR trials, which provide evidence of the incidence of new choroidal neovascularization in patients with AMD.

Furthermore, the article discusses the incidence of choroidal neovascularization in fellow eyes, which is crucial for understanding the progression of the disease and the risks associated with unilateral AMD. The findings suggest that the Amsler grid can be an effective tool for monitoring patients, particularly those with a history of AMD in one eye, as it may facilitate timely referrals for further diagnostic testing and treatment.

The critical evaluation of the material reveals that while the Amsler grid is a widely used screening tool, its diagnostic accuracy can be influenced by various factors, including the patient's understanding of how to use the grid and the subjective nature of the test. The article effectively emphasizes the need for further research to enhance the diagnostic capabilities of the Amsler grid and to explore complementary methods that could improve detection rates of neovascular AMD.

The article "Distinguishing wet from dry age-related macular degeneration using three-dimensional computer-automated threshold Amsler grid testing" by (D. Robison et al., 2011) presents a significant advancement in the diagnostic accuracy of the Amsler grid test, particularly in differentiating between wet and dry forms of age-related macular degeneration (AMD). The authors introduce a three-

dimensional computer-automated threshold Amsler grid (3D-CTAG) as a novel approach that enhances the traditional Amsler grid method, which has been widely used but often criticized for its subjective nature and limitations in sensitivity and specificity.

The study's main findings suggest that the 3D-CTAG can provide improved diagnostic capabilities compared to conventional methods. This is particularly relevant for clinicians seeking to accurately identify neovascular AMD, which requires timely intervention to prevent vision loss. The authors emphasize the potential of 3D-CTAG in clinical settings, noting that it could facilitate more precise assessments of visual distortions associated with wet AMD.

However, the article also acknowledges certain limitations that warrant further investigation. Notably, the study's cohort consisted solely of subjects with either normal vision, dry AMD, or wet AMD, which raises concerns regarding the generalizability of the findings. The authors suggest that future research should include a control group with similar visual acuity but without macular disease to establish a more comprehensive understanding of the test's diagnostic accuracy (D. Robison et al., 2011). This would help clarify the effectiveness of 3D-CTAG in distinguishing between the various stages of AMD and potentially refine its application in clinical practice.

Moreover, the authors highlight the need for subsequent studies to evaluate the efficacy of therapy for wet AMD using the 3D-CTAG. This could pave the way for a more dynamic approach to monitoring disease progression and treatment response, ultimately enhancing patient outcomes. The mention of competing interests related to the proprietary nature of the 3D-CTAG underscores the importance of transparency in research, particularly when evaluating new diagnostic tools.

The article titled "Strategies for improving early detection and diagnosis of neovascular age-related macular degeneration" by (A Keane et al., 2015) presents a critical examination of the Amsler grid test's efficacy in diagnosing neovascular age-related macular degeneration (AMD). The authors highlight a significant gap

in the literature regarding the effectiveness of Amsler charts as a diagnostic tool, noting that existing evidence suggests a limited diagnostic accuracy.

In their study, (A Keane et al., 2015) evaluated 55 patients experiencing vision loss in the macular region alongside ten healthy volunteers without visual impairment. This comparative analysis underscores the potential shortcomings of the Amsler grid test, particularly under varying lighting conditions. The findings reveal that nearly 50% of scotomas—areas of partial or complete loss of vision—went undetected when assessed using the Amsler chart. This statistic raises critical questions about the reliability of the Amsler grid as a standalone diagnostic measure for neovascular AMD.

The authors argue that while the Amsler grid is widely used in clinical settings, its limitations necessitate a reevaluation of its role in the early detection of AMD. The study suggests that reliance on this tool could lead to missed diagnoses, thereby delaying treatment and potentially worsening patient outcomes. This critical evaluation points to a need for enhanced diagnostic strategies that could complement or replace the Amsler grid, particularly in light of the high stakes associated with timely intervention in cases of neovascular AMD.

The article titled "Assessment of patient perception of glaucomatous visual field loss and its association with disease severity using Amsler grid" by (Fujitani et al., 2017) presents a thorough investigation into the effectiveness of the Amsler grid test in identifying visual field (VF) defects specifically within the central 10 degrees of vision in patients with glaucoma. The study highlights the Amsler grid's notable specificity of 92% and a positive predictive value of 97%, indicating its potential utility in clinical settings for early detection of visual impairments associated with glaucoma.

The methodology employed in this study is robust, involving the enrollment of patients who exhibited abnormal results on the 10–2 SITA standard VF test either on the date of enrollment or within the preceding three months. By administering the Amsler grid test under controlled conditions—correcting for near refractive error and requiring patients to maintain fixation on the central point—the authors

ensured that the results would accurately reflect the patients' visual field capabilities. The use of an eye patch to occlude the non-tested eye further strengthens the reliability of the results, minimizing the risk of distraction or visual interference.

(Fujitani et al., 2017) effectively contextualize their findings within the broader scope of visual field testing, suggesting that the Amsler grid may serve as a valuable tool not only for glaucoma patients but potentially for those with neovascular age-related macular degeneration (AMD) as well. The implications of their findings could extend to enhancing patient self-monitoring practices, as the Amsler grid is a simple and accessible tool that patients can use at home to detect changes in their vision.

However, while the study presents compelling data, it is essential to consider the limitations inherent in the Amsler grid test. The reliance on patient perception introduces a subjective element that may lead to variability in results. Additionally, the study predominantly focuses on a specific patient population (those with glaucoma), which may limit the generalizability of the findings to other conditions such as neovascular AMD. Further research is warranted to evaluate the Amsler grid's diagnostic accuracy across a broader range of ocular conditions and to establish standardized protocols for its use in clinical practice.

The article "Relationships of orientation discrimination threshold and visual acuity with macular lesions in age-related macular degeneration" by (Fu et al., 2017) provides significant insights into the diagnostic utility of the Amsler grid test in the context of age-related macular degeneration (AMD). The authors report that perceived distortion on the Amsler grid was observed in 42.9% of eyes affected by AMD, which highlights the test's potential as a screening tool for detecting visual abnormalities associated with this condition.

The findings indicate a notable variance in the perception of distortion across different types of AMD. Specifically, the study reveals that 20.0% of patients with dry AMD reported distortions, while this figure increased to 56.3% in those with wet neovascular AMD (Wet-NA) and 35.7% in patients with wet atrophic AMD

(Wet-A). This gradient underscores the Amsler grid's sensitivity to detect visual changes that may correlate with the progression of AMD. The absence of reported abnormalities in the normal group further validates the test's specificity, suggesting that it can effectively differentiate between healthy and affected eyes.

Critically, while the Amsler grid test is a simple and accessible tool, the study emphasizes the necessity of understanding its limitations. The reliance on subjective reports of distortion may lead to variability in results, and the test may not capture all visual impairments associated with AMD. Furthermore, the authors suggest that while the Amsler grid is a valuable preliminary screening tool, it should ideally be complemented by more comprehensive ophthalmic evaluations to ascertain the full extent of macular damage.

The article "Open Platform to Detect and Monitor Macular Disorders" by (Mohaghegh, 2019) provides a comprehensive examination of the Amsler Grid (AG) test as a tool for monitoring age-related macular degeneration (AMD). (Mohaghegh, 2019) highlights the limitations of visual acuity tests, which, despite their widespread use, fail to adequately assess the presence and progression of macular disorders, including AMD. This critique underscores the need for more effective monitoring tools, particularly in the context of early detection and ongoing management of AMD.

The Amsler Grid, developed by Marc Amsler in 1947, has become the gold standard for home monitoring among patients with macular disorders. (Mohaghegh, 2019) emphasizes the AG's ability to detect metamorphopsia and scotomas, which are critical indicators of visual disturbances associated with AMD. However, the article also points out significant shortcomings in the AG's diagnostic accuracy. Specifically, it notes that the Amsler Grid struggles to detect visual distortion changes that are smaller than the spacing between the grid's horizontal or vertical lines. This limitation is particularly concerning, as it may lead to missed early signs of disease progression in patients.

Furthermore, the article addresses several methodological challenges associated with the Amsler Grid. Issues such as cortical completion—where the brain fills in

gaps in visual input—can lead to misinterpretations of the grid's patterns. Additionally, the necessity for accurate central fixation during testing is crucial, yet often difficult for patients to maintain. The article also discusses the phenomenon of line crowding, which can further complicate the accuracy of the test results. Poor patient compliance is another critical factor, as the effectiveness of the Amsler Grid relies heavily on patients consistently performing the test at home.

The article "Automated age-related macular degeneration area estimation - first results" by (Pečiulis et al., 2021) presents a comprehensive approach to the automated detection and segmentation of age-related macular degeneration (AMD) using advanced image processing techniques. The authors detail their methodology involving the collection of 44 sets of AMD examination images, which include cases of varying severity, alongside 15 healthy fundus images sourced from an online database. This diverse dataset is crucial for developing a robust neural network model capable of distinguishing between healthy and AMD-affected images.

A key aspect of the study is the meticulous process of preparing the image data for neural network training. The authors describe the challenges related to image misalignment, including variations in position, rotation, and scaling. By utilizing the most visible vascular structures as reference points for image matching, they ensure a higher quality dataset that enhances the model's learning capabilities. The creation of a uniform training set, which includes RGB images, contrast-enhanced images, and grayscale mask images, is an essential step that underscores the importance of accurate ground truth labeling in machine learning applications for medical diagnostics.

The article also outlines the development of a custom convolutional neural network specifically designed for the classification of degeneration and the segmentation of AMD lesions. The authors employed multiple well-known neural network architectures to optimize the segmentation algorithm, demonstrating a thorough exploration of existing technologies to achieve the best possible outcomes. The use of a confusion matrix and derived measures for assessing detection quality adds a

layer of rigor to their evaluation process, allowing for a clear understanding of the model's performance.

However, while the article provides valuable insights into the methodology and initial results, it would benefit from a more detailed discussion on the implications of these findings for clinical practice. The authors could elaborate on how their automated approach compares with traditional diagnostic methods, such as the Amsler Grid Test, particularly in terms of diagnostic accuracy and practical application in ophthalmology settings. Additionally, addressing potential limitations of their study, such as the size and diversity of the dataset or the generalizability of the results to broader populations, would enhance the critical evaluation of their work.

The article "MacuFix® versus Amsler grid for metamorphopsia categorization for macular diseases" by (Claessens et al., 2022) provides a comprehensive evaluation of the Amsler grid test, a traditional method used for detecting visual distortions associated with age-related macular degeneration (AMD). The authors highlight the Amsler grid's longstanding role in identifying scotomas and metamorphopsia within the central 20° of the visual field, which is critical for diagnosing various maculopathies, including AMD.

Despite its accessibility and low cost, the article critically addresses the limitations inherent in the Amsler grid test. The reported sensitivity of the Amsler grid is notably low, with figures as low as 56% when compared to fundus microperimetry, which is a more precise diagnostic tool (Claessens et al., 2022). Furthermore, the false negative rate is alarmingly high for patients with smaller scotomas, reaching 77%. This raises significant concerns regarding the reliability of the Amsler grid in clinical settings, particularly for early detection of AMD. The variability in detection rates for AMD—ranging from 9% in early cases to 34% in late cases with choroidal neovascularization—further underscores the necessity for improved diagnostic methods.

The authors advocate for the development of more sensitive and user-friendly tools, which is exemplified by their assessment of MacuFix®, an innovative software

designed for mobile platforms. The study not only evaluates the efficacy of MacuFix® in detecting metamorphopsia but also incorporates user experience metrics through the System Usability Score questionnaire. This dual approach emphasizes the importance of both diagnostic accuracy and patient engagement in self-monitoring practices.

The article "Improving AMD diagnosis by the simultaneous identification of associated retinal lesions" by (Morano et al., 2022) presents a novel approach to the diagnosis of Age-Related Macular Degeneration (AMD) through the use of a convolutional neural network (CNN) that is pretrained on ImageNet. This study is particularly significant as it addresses a gap in the existing methodologies by simultaneously detecting AMD and its associated retinal lesions, a task that has not been previously tackled in this field.

The authors propose a multi-task learning framework that leverages image-level lesion labels alongside diagnosis labels to enhance the diagnostic accuracy of AMD detection. This approach is grounded in the premise that the simultaneous identification of related tasks can facilitate better generalization of the model, ultimately leading to improved diagnostic performance. The findings suggest that the CNN not only identifies the presence of AMD but also provides valuable insights into the associated retinal lesions, which can be indicative of the disease's stage or the presence of other ocular conditions (Morano et al., 2022).

The methodology employed in this study is robust, involving the training of the CNN with retinographies and image-level labels sourced from a public dataset, followed by evaluations on two additional public datasets. The article includes comprehensive ablation studies and comparative experiments, demonstrating that the proposed model achieves state-of-the-art performance, surpassing traditional AMD diagnostic methods. This is a noteworthy advancement as it underscores the potential of integrating lesion detection with AMD diagnosis, which could lead to more informed clinical decision-making.

However, while the results are promising, the article could benefit from a more detailed discussion on the limitations of the study. For instance, the generalizability

of the model across diverse populations and varying imaging conditions could be explored further. Additionally, the clinical implications of the lesion detection capabilities should be examined in a real-world context, as the transition from a controlled research environment to clinical practice can present challenges.

## CONCLUSION

The diagnostic accuracy of the Amsler grid test for detecting neovascular age-related macular degeneration (nAMD) has been extensively studied, revealing both its practical applications and significant limitations. The foundational work by (Vazquez et al., 1970) established the Amsler grid as a preliminary screening tool for nAMD, emphasizing the necessity for more robust methodologies to enhance its diagnostic efficacy. Subsequent studies, such as the one conducted by (D. Robison et al., 2011), introduced advanced technologies like three-dimensional computer-automated threshold Amsler grid testing, suggesting that these innovations could improve the grid's capabilities in differentiating between dry and wet forms of AMD.

Further critiques, particularly from (A Keane et al., 2015), highlighted the Amsler grid's limitations, noting that nearly 50% of scotomas in patients with vision loss went undetected. This finding calls into question the grid's reliability as a standalone diagnostic tool. The study by (Fujitani et al., 2017) demonstrated high specificity for detecting visual field defects in glaucoma patients, yet it also pointed out that the Amsler grid's effectiveness in AMD is inconsistent across various disease stages.

The variability in perceived distortions between dry and wet AMD, as reported by (Fu et al., 2017), further illustrates the grid's potential as a subjective measure, which may not accurately reflect disease progression. While (Mohaghegh, 2019) positioned the Amsler grid as a gold standard for home monitoring, it also underscored its low accuracy for detecting subtle visual changes, necessitating the exploration of alternative diagnostic strategies.

Innovative approaches, such as the automated image classification techniques introduced by (Pečiulis et al., 2021), signify a shift towards more precise diagnostic

tools that could complement or replace the Amsler grid. Additionally, the critical evaluation by (Claessens et al., 2022) illustrated the Amsler grid's low sensitivity and high false negative rates, advocating for the development of user-friendly alternatives that enhance diagnostic accuracy.

Finally, the multi-task learning approach proposed by (Morano et al., 2022) represents a significant advancement in AMD diagnosis by integrating lesion detection with traditional diagnostic methods. This reflects an ongoing commitment to improving the accuracy and reliability of AMD detection, ultimately aiming to enhance patient outcomes.

In conclusion, while the Amsler grid test has historically served as a valuable tool for the initial screening of neovascular age-related macular degeneration, its limitations have prompted a search for more sophisticated and accurate diagnostic methods. The evolution of research in this field highlights the necessity for continuous innovation and validation of diagnostic tools to ensure timely and effective management of AMD.

## DISCLOSURE STATEMENT


- Disclosure Statement : The authors have no conflicts of Interest to declare
- Funding Sources : None
- Acknowledgements : -
- Author Contribution : All authors discussed and contributed the final content for journal submission and publication


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