Point-wise comparison of Suprathreshold Virtual Reality perimetry and microperimetry in AMD patients

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Introduction

Age-related macular degeneration (AMD) is a leading cause of central vision loss in older adults, affecting essential daily activities like reading and face recognition. Microperimetry (MP) is commonly used to assess retinal sensitivity, but its reliability in AMD patients is limited due to poor fixation stability.

Traditional MP can be time-consuming and stressful, leading to fatigue and variability in results. **This study investigates the feasibility of a novel virtual reality (VR) perimetry test as a more accessible and efficient alternative.**

Methodology

We developed a suprathreshold VR perimetry test using the Pico Neo 3 Pro Eye headset to detect areas of complete vision loss. To support patients with impaired central vision, a cross was shown on the VR display to help them infer the central fixation point. The methodology is summarized below:

- **Participants:** 24 eyes diagnosed with AMD.
- **Devices:** VR results were compared with the Macular Integrity Assessment (MAIA; CenterVue S.p.A., Padova, Italy).
- **Test Pattern:** Both tests used a 37-point grid spanning the central 10°, conducted on the same day.
- **Sensitivity Threshold:** MP values below 0 dB were labeled *not seen*; all others were labeled *seen* to match the binary output of the VR test.
- **Agreement Metric:** The agreement rate was defined as the percentage of locations where both tests gave the same result.
- **Exclusion Criteria:** Patients were excluded if they failed MP due to poor foveal centering (10 eyes) or had VR fixation loss >25% (3 eyes).
- The study followed the ethical standards of the Declaration of Helsinki.
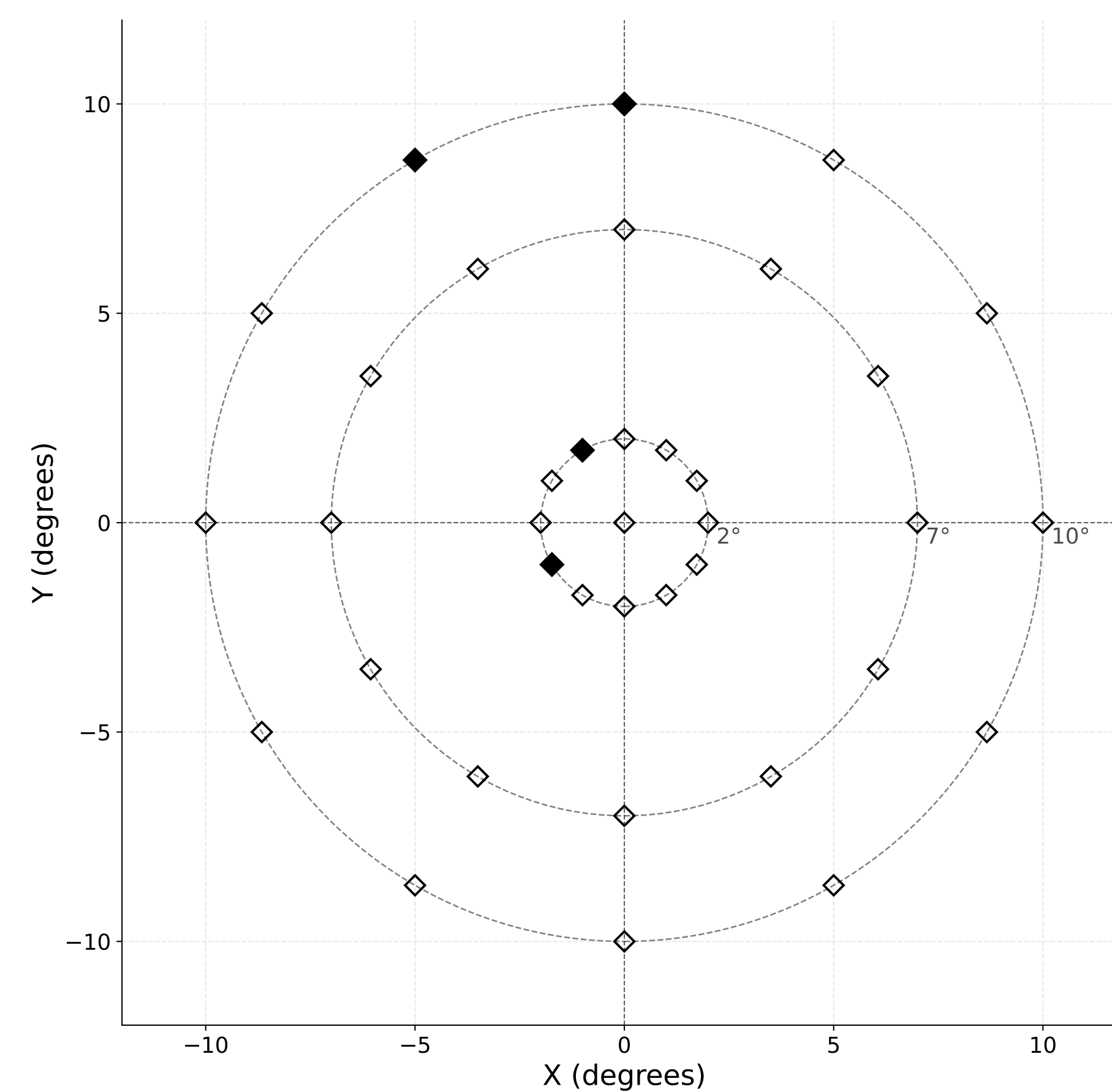
Results

The VR perimetry showed strong concordance with MP, with an **average agreement of 83.3%** (SD: 20.3%, range: 40.5–100%).

The **VR test duration was significantly shorter (p < 0.05)**, averaging 2.67 minutes (SD: 0.56; range: 2.1–4.25 minutes), compared to 5.37 minutes for MP (SD: 0.59; range: 4.55–6.47 minutes). Notably, MP test durations exclude time spent on repetitions or foveal alignment, which can extend total testing time to 20 minutes.

Importantly, all subjects who were excluded from MP due to fixation instability successfully completed the VR test.

Individual Subject Performance in VR and MP

Figure 1 shows similar patterns of vision loss between the two modalities. During the VR test, the subject had a mean response time of 28.42 seconds and completed the test in 2.80 minutes, including 9 catch trials. Both false positive and false negative rates were under 25%.

(a) Virtual Reality Result
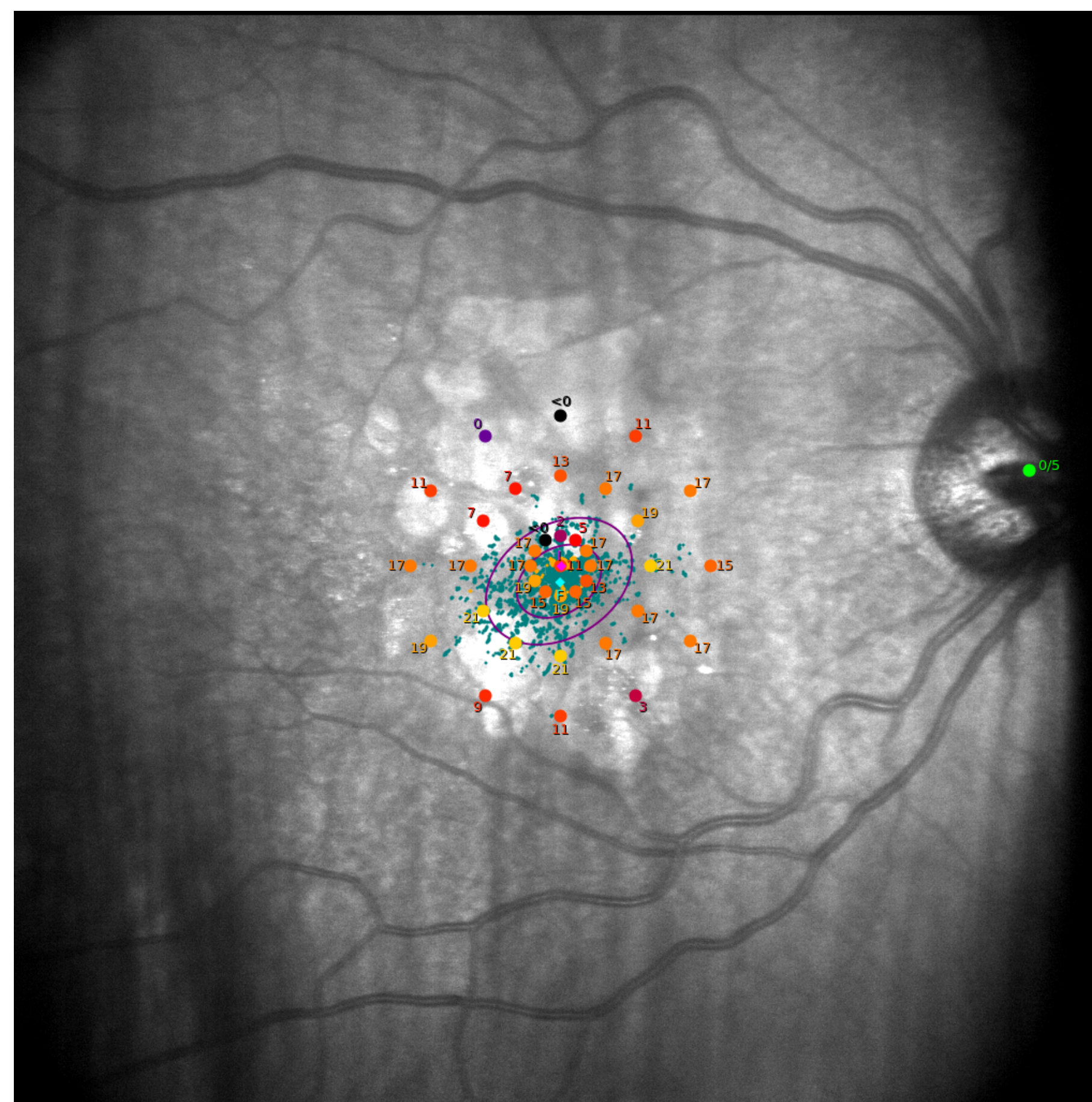
(b) Microperimetry Result

Figure 1. Comparison of defect maps. (a) Suprathreshold VR with empty diamonds for seen locations and filled diamonds for unseen ones. (b) MP test result, with sensitivity values from 0 dB (black) to 21 dB (yellow).

The MP test lasted 5.15 minutes, with the patient exhibiting reduced macular sensitivity (mean threshold: 13.3 dB) and fixation stability of 63% within 5° and 95% within 15°. In contrast, the VR test exhibited significantly better fixation behavior than the MP test, with 100% stability within both 5° and 15° (Figure 2). The distance mean deviation was 3.06° (SD: 1.07).
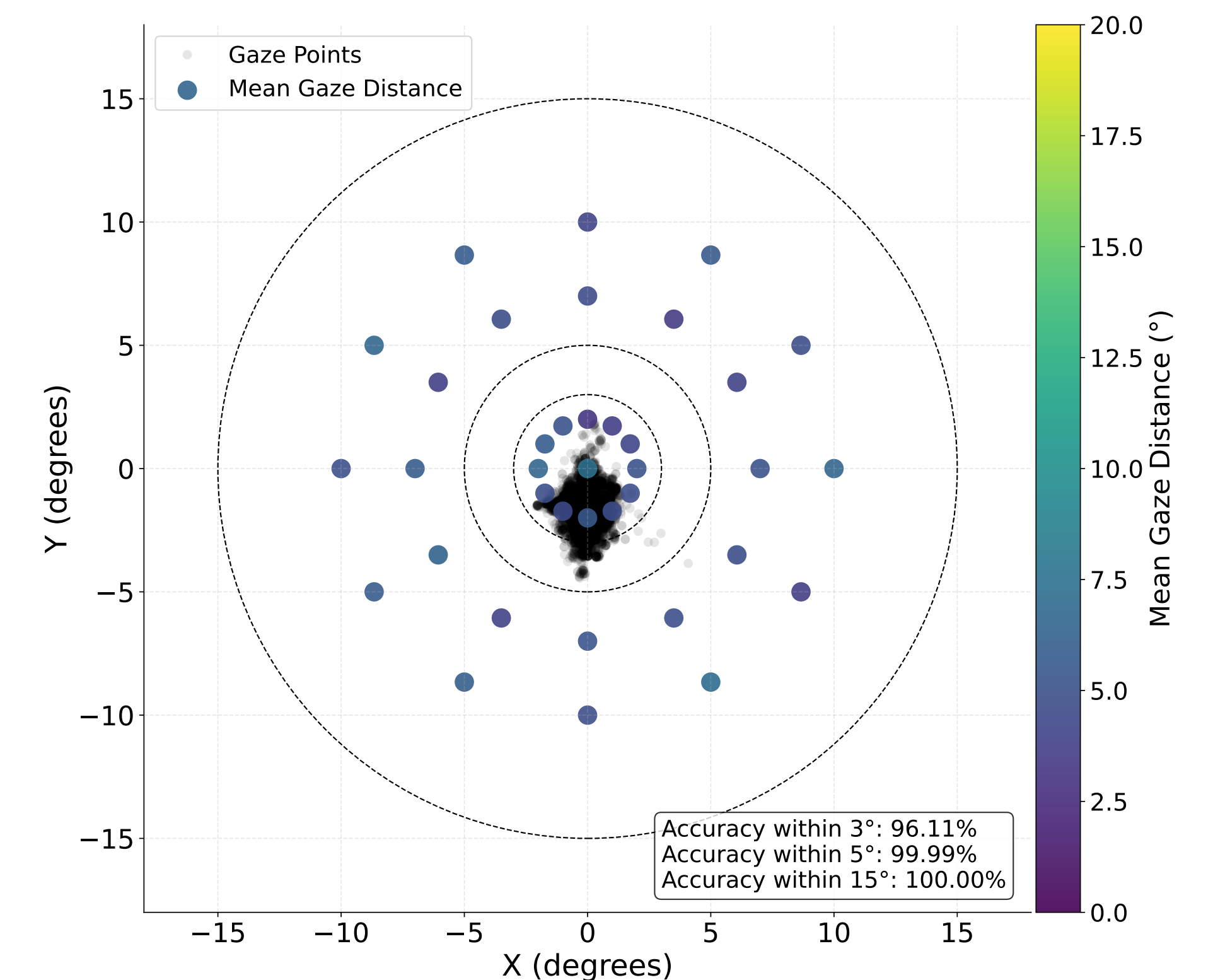

Figure 2. The plot shows calibrated gaze positions from gaze tracking data in VR, with overlaid circles representing accuracy ranges at 3°, 5°, and 15°. Mean gaze distances are indicated by a color gradient from blue (shorter distances) to yellow (longer distances).

Limitations and Future Work

Limitations:

- Difficulty in comparing VR and MP results due to differences in fixation and test centering.
- Calibration was based on a cohort of healthy individuals, as it could not be performed for AMD patients.

Future Work:

- Improve real-time fixation feedback using gaze-contingent control.
- Explore longitudinal studies to assess test-retest reliability and track disease progression over time.

Conclusion

The novel suprathreshold VR test demonstrated high agreement with MP while significantly reducing test duration. It offers a practical and efficient alternative, especially for patients with fixation difficulties who are unable to complete conventional MP.