Identification of Preferred Retinal Loci during Binocular Viewing in Patients with Central Vision Loss

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Purpose

Until now, the absolute location of the preferred retinal locus (PRL) of patients with central vision loss could only be identified monocularly.

The purpose of this study was to test a new method to predict the location of the PRL in each eye in patients with central vision loss when viewing binocularly.

The method uses OrthoMagic (OM), a unique remote eye-tracking system that estimates the optical axes of both eyes without user calibration.[1]

[1] Model D, Eizenman M. *IEEE*, 2010;57:1031-9

Participants

- 5 participants with normal vision
- 6 patients with bilateral central vision loss

Methods

Fixation was recorded:

1) monocularly with both Nidek MP-1 and OM
2) binocularly with OM

OM measured the direction of the optical axis and the angle between the PRL (fovea for control subjects) and the optical axis in each eye (Figure 1).

MP-1 measured the location of the PRL relative to the optic disk (absolute location).

Using the monocular measurements of the OM and the MP-1, in control subjects, a transformation from eye-tracking measurements to MP-1 measurements was created and used to predict the absolute location of the PRLs in patients (Figure 2)

Data Analysis

The predicted values for monocular viewing for each eye recorded with OM were compared with the measured MP-1 values.

The same transformation was then used with measurements of the eye-tracker's PRLs under binocular viewing, to obtain the absolute locations of the PRLs relative to the middle of the optic disc.
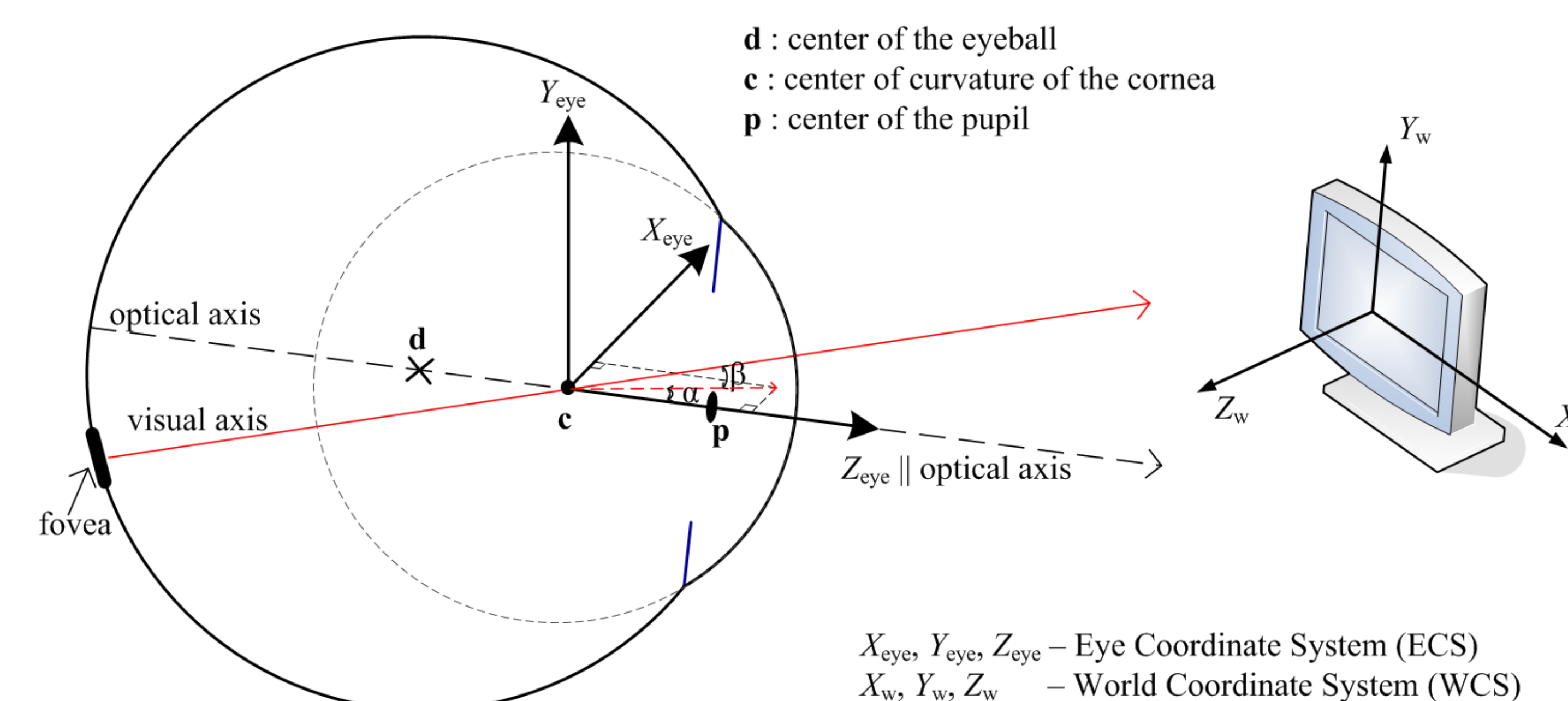

d : center of the eyeball
c : center of curvature of the cornea
p : center of the pupil

X_{eye}, Y_{eye}, Z_{eye} — Eye Coordinate System (ECS)
X_w, Y_w, Z_w — World Coordinate System (WCS)

Fig. 1. The optical axis connects the center of the pupil with the center of curvature of the cornea. Gaze is directed along the visual axis, which connects the fovea or the PRL with the center of curvature of the cornea.[1] From Model & Eizenman, *IEEE*, 2010
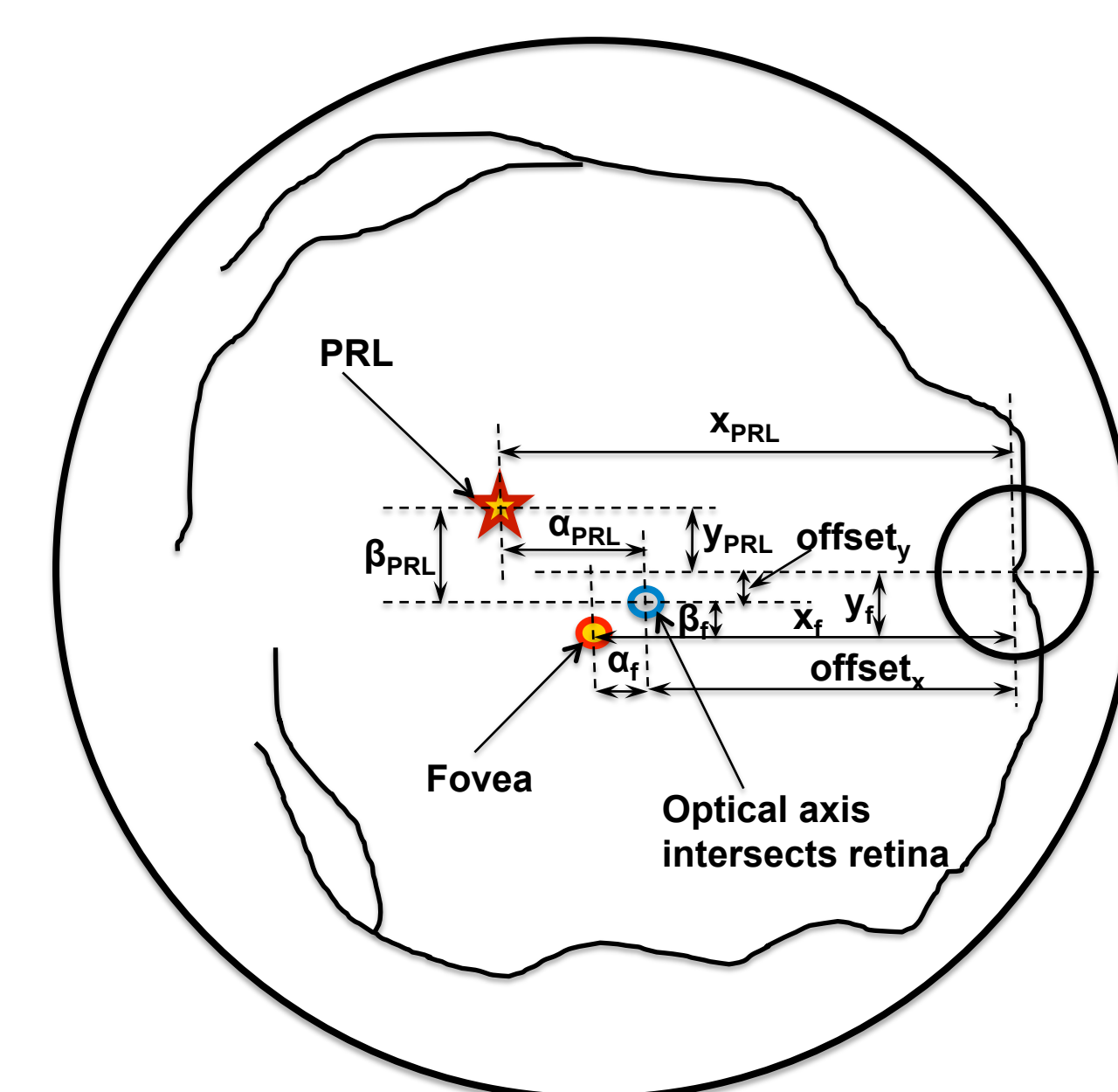

Transformation from the eye coordinate system (OM) to the MP-1 (middle of the optic disc) coordinate system:

$$X_{PRL} = k * \alpha_{PRL} + offset_x$$

$$Y_{PRL} = k * \beta_{PRL} + offset_y$$

Fig. 2. OM to MP-1 transformation.

Results

	OD		OS	
	X_{Error}	Y_{Error}	X_{Error}	Y_{Error}
Mean ± SD	-0.1 ± 0.7	0.8 ± 0.9	0.4 ± 1.5	0.2 ± 0.8

Monocular prediction errors of the PRL's coordinates (deg)

The transformation was applied to binocular viewing condition.

	OD		OS	
	X	Y	X	Y
P1	15.1	-0.2	12.4	-1.0
P2	16.7	3.0	12.8	2.5
P3	14.8	-5.3	17.6	-6.6
P4	16.0	-1.2	15.2	-1.5
P5[†]	19.4	-2.5	18.1	-3.0
P6	16.1	1.0	14.7	-0.1

[†]Patient experienced diplopia during testing

PRL coordinates during binocular viewing relative to the middle of the optic disc, recorded simultaneously for the two eyes.
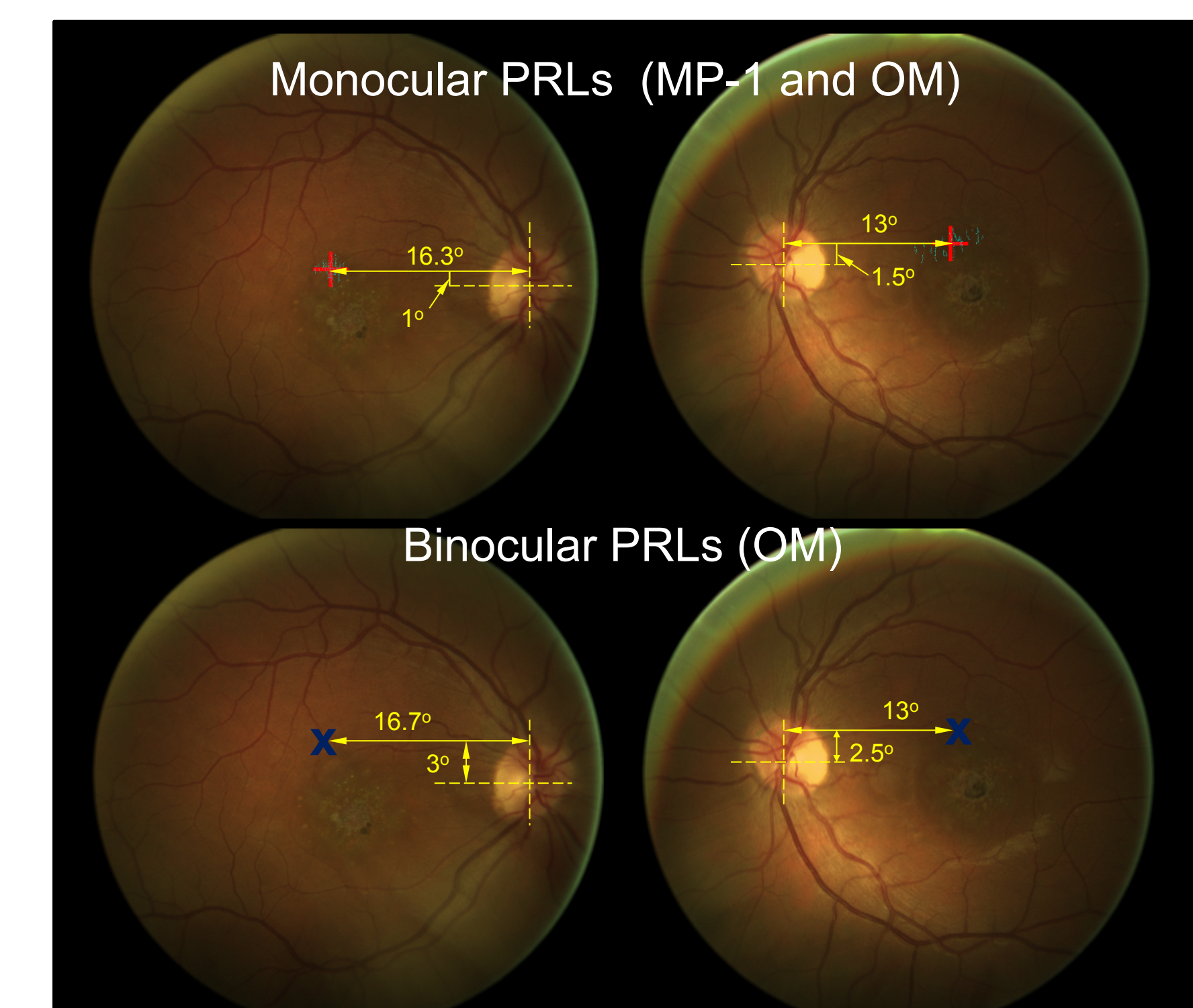
Case P2: Monocular and binocular PRLs are the same

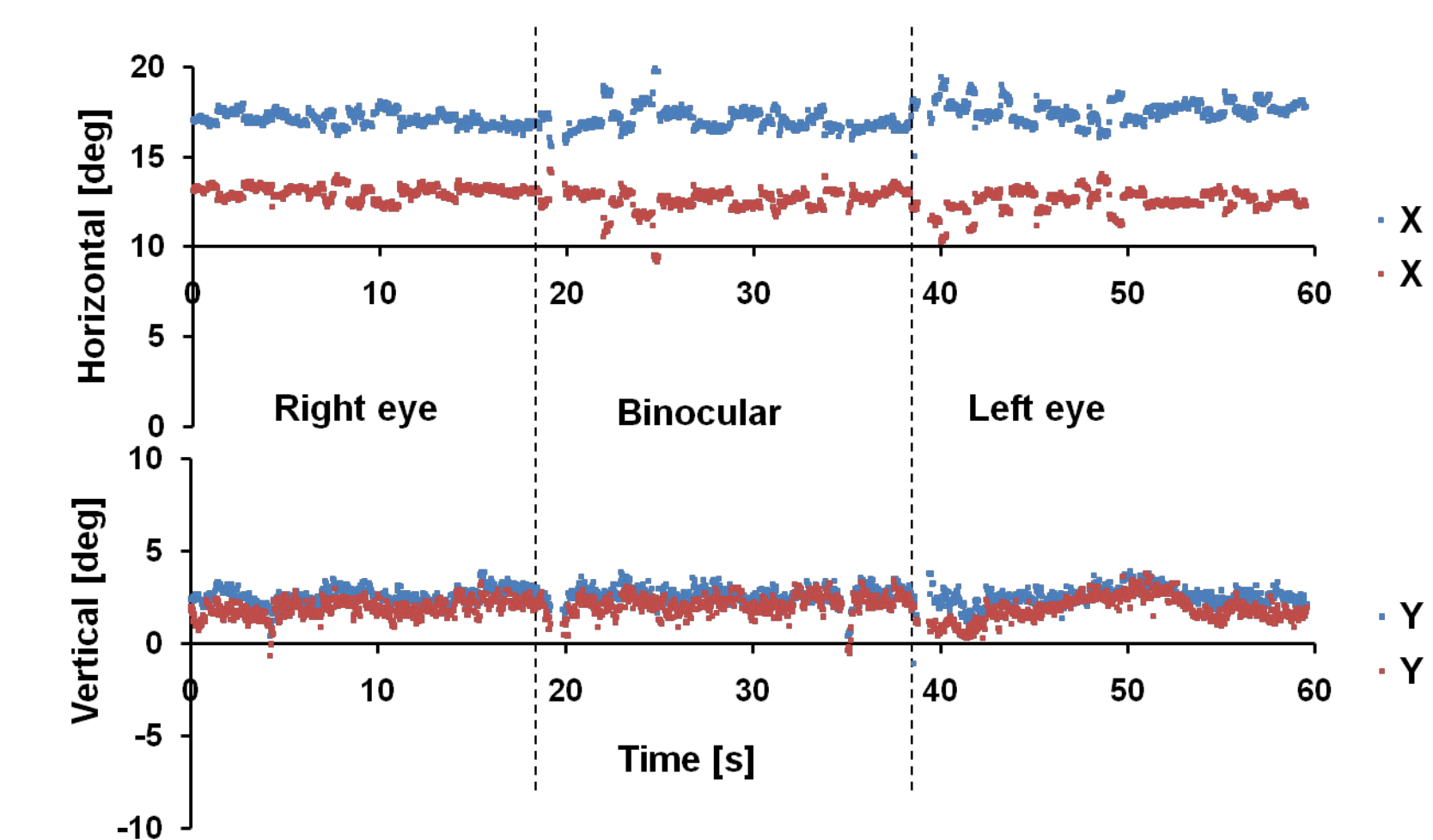**Eye position in the eye (OM) coordinate system**
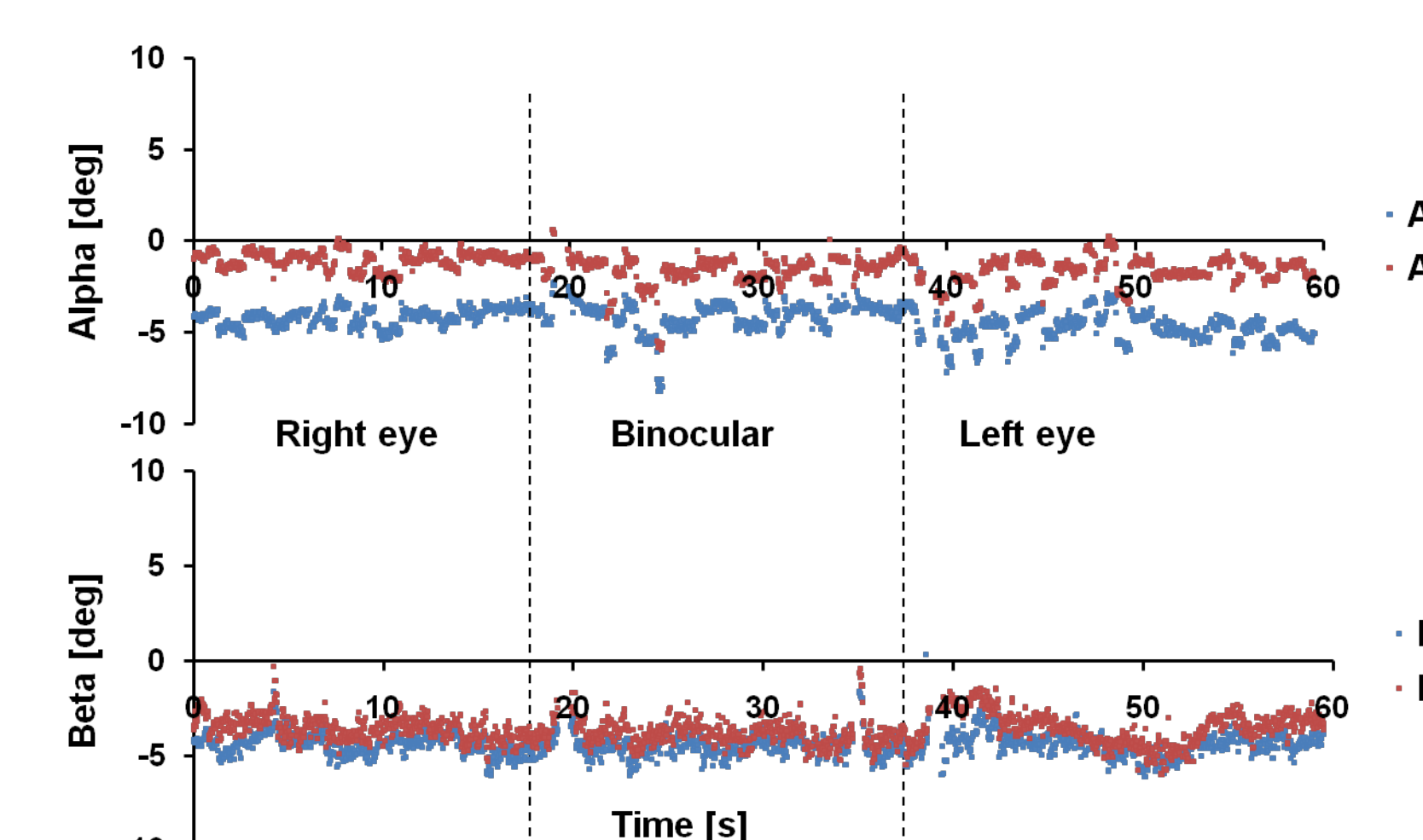
PRL location from the middle of the optic disc [deg]

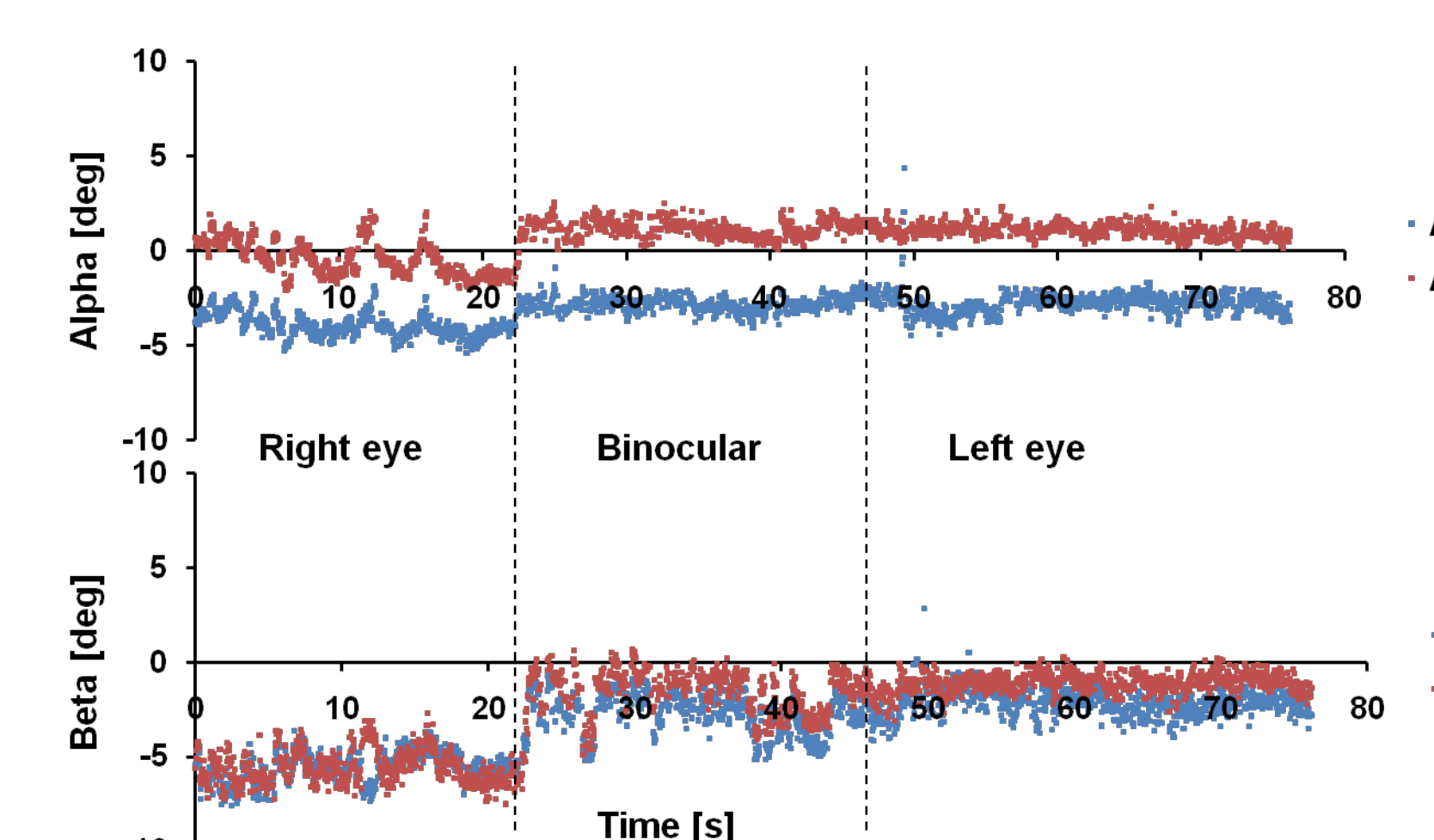|	OD		OS	
	X	Y	X	Y
Monocular MP-1	16.3	1.0	12.8	1.5
Monocular OM	16.7	2.6	13.4	2.1
Binocular OM	16.7	3.0	12.8	2.5

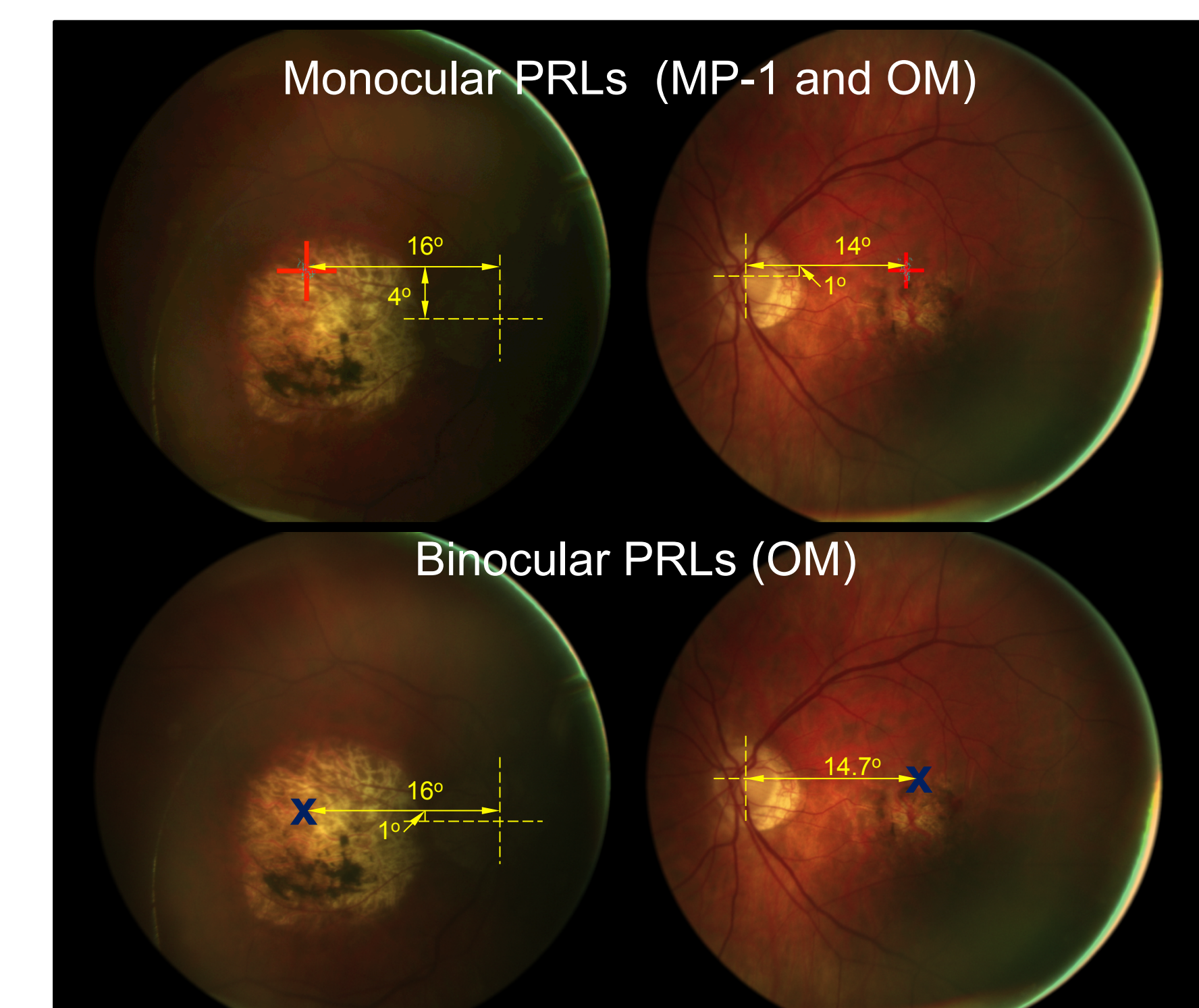**Eye position relative to the middle of the optic disc (MP-1)**

Case P6: Monocular and binocular PRLs are different
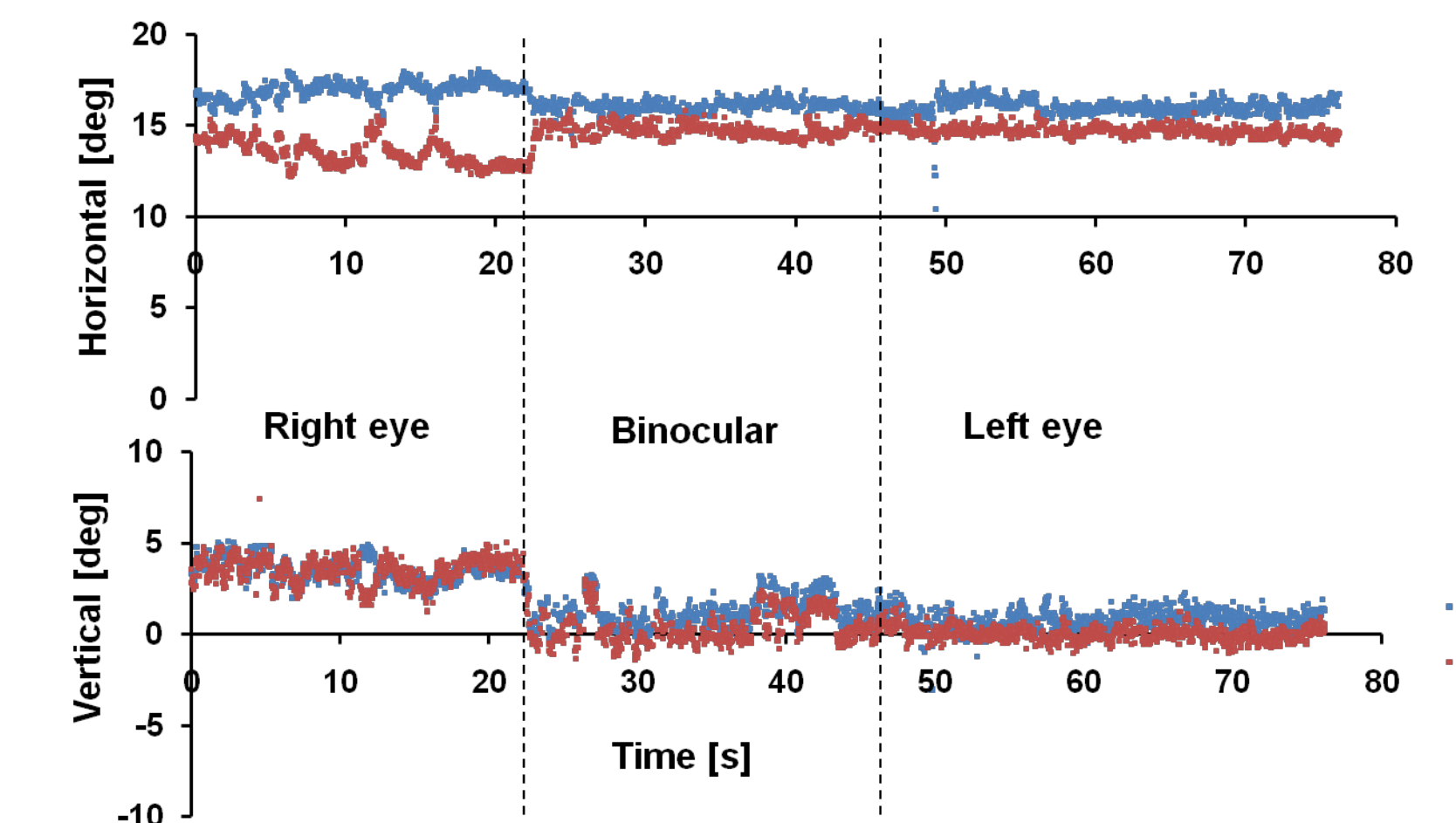
Eye position in the eye (OM) coordinate system

PRL location from the middle of the optic disc [deg]

	OD		OS	
	X	Y	X	Y
Monocular MP-1	16.0	4.2	14.0	1.2
Monocular OM	16.3	4.0	14.4	0.3
Binocular OM	16.1	1.0	14.7	-0.1

Eye position relative to the middle of the optic disc (MP-1)

Conclusions

By transforming the measurements of the PRL location from an eye tracking coordinate system to the MP-1 coordinate system, the absolute location of the PRLs (i.e., relative to the optic disk) during binocular viewing can be predicted with an acceptable accuracy.