EPJ Web of Conferences **287**, 09041 (2023) https://doi.org/10.1051/epjconf/202328709041
EOSAM 2023

Wavefront sensing for objective assessment of vision therapy efficacy: preliminary results

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Abstract. The aim of this study was to use wavefront sensing to objectively evaluate the effects of vision therapy in subjects with insufficiency (AI) and infacility of accommodation (AINF). Aberrometry was performed with a Shack-Hartmann wavefront aberrometer for different accommodative stimuli in one subject with AI and one with AINF before and after treatment with vision therapy (VT). A control subject received a placebo treatment. Real-time accommodative response, accommodation and disaccommodation reaction time, accommodative microfluctuations and root mean square of higher order aberrations were compared before and after VT/placebo. VT was effective and wavefront sensing can be used to detect AI and AINF and evaluate these subjects during VT.

1 Introduction

Assessment of the optical quality of the eye using the Shack-Hartmann wavefront sensor has been used clinically and has proven to be a valuable diagnostic and assessment tool. This technique can be applied during accommodation and it is possible to calculate the accommodative response through the defocus aberration. Real-time wavefront aberrometry can be used to obtain the detailed behaviour of the accommodative response, such as the response time and fluctuations of the accommodative response (AR), and then to detect anomalies of accommodation that lead to symptomatology.[1] In this study, real-time wavefront aberrometry was used to evaluate patients with accommodative dysfunction before and after vision therapy, one of the treatments used for this type of vision problem.

2 Methods

2.1 Subjects

Two eyes with accommodative insufficiency (AI) and accommodative infacility (AINF) were treated with vision therapy (VT) and analysed before and after it. One control subject received a placebo treatment.
The study adhered to the tenets of the Declaration of Helsinki and was approved by the Ethical Sub-Commission of Life and Health Sciences of the University of Minho.

2.2 Experimental set-up and procedure

Dynamic accommodation was obtained by real-time wavefront aberrometry, using an in-house Shack-Hartman aberrometer (Thorlabs WF150-7AR). Its resolution was 1280x1024 with 39x31 lens lets working with a frequency of 15Hz. The power of the super luminescent diode, used to generate the optical beam, was 12µm at the eye and had a spectral maximum at 830 nm.
Aberrometry was performed in real-time while accommodation was being stimulated with negative lenses placed in front of the subject's eye in the following order: 0D » 1.00D » 0D » 2.39D » 0D » 4.56D » 0D, causing different cycles of accommodation and disaccommodation.
AR was obtained from the defocus aberration and a sigmoid function [2] was fitted to the data:

$$AR = (Af–Ai)/(1+e^{((-x-x_0)/w)})+Ai \qquad (1)$$

Where x is the time in seconds, Af and Ai are the initial and final asymptotic values, w is the width of the x values between these two asymptotes and x_0 is located roughly at the centre of w. AR times were also obtained.
To quantify the magnitude of accommodative microfluctuations, it was calculated the root mean square deviation using the following formula [3]:

$$RMSdeviation = \sqrt{(1/n \sum(xi–\bar{x})^2)} \qquad (1)$$

Where n is the number of accommodation values, x_i is each individual accommodative value and $\bar{x}$ is the mean accommodative value.
Root-mean-square (RMS) of high-order aberrations (HOA) was also calculated [3].

3 Results

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The AR of the subject with AI increased after VT. Before VT, the subjects with AI and AINF had difficulty maintaining relaxed accommodation after stimulation, which was not observed after VT (fig. 1).

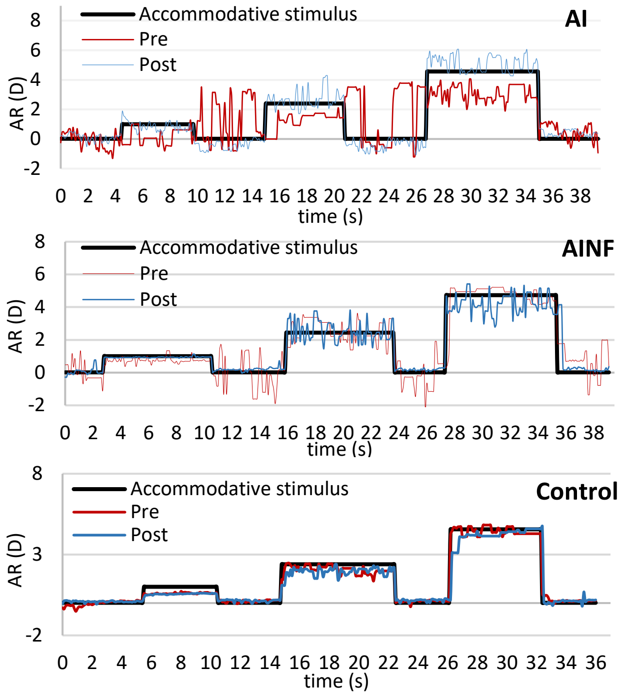

Fig. 1. Accommodative response over time of the subjects AI, AINF and subject control for different accommodative stimuli pre and post VT/placebo.

The AR times of accommodation and disaccommodation decreased for most of the stimuli in both subjects (fig. 2).

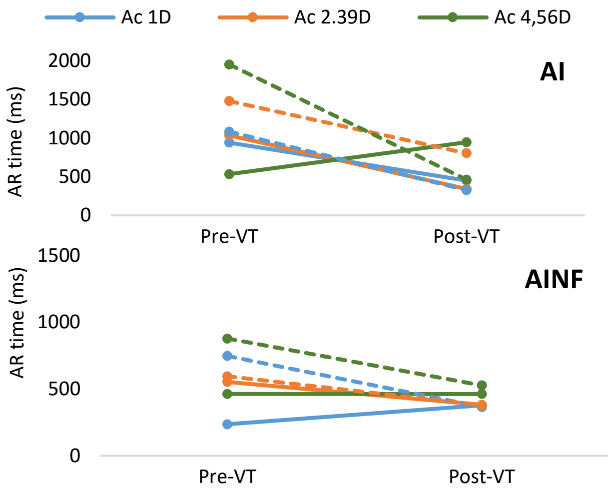

Figure 2. Accommodative (Ac) and disaccommodative (DicAc) response times of AI and AINF subjects.

The subjects with AI and AINF had high RMS deviations before VT, indicating more accommodative fluctuations, and then a more unstable AR. This is especially observed when they try to disaccommodate. In general, the RMS deviation decreased after VT and was also more evident in the disaccommodated state (fig. 3).
The control subject showed no differences in AR before and after the placebo treatment.

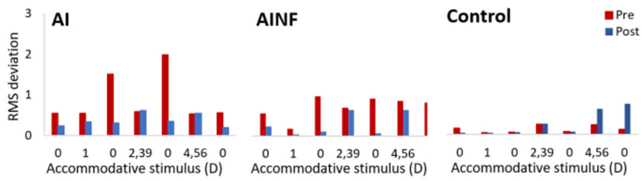

Fig. 3. RMS deviation of accommodative micro fluctuations of the subjects with AI, AINF and the subject control for different accommodative stimuli pre and post VT/placebo.

The values of the RMS HOA for the stimuli 0D, 1D, 2.39D and 4.56D of all subjects are shown in Table 1. There is no clear trend in the effect of VT on RMS HOA. However, it is worth noting the lower values in the control subject compared to those with AI and AINF.

Table 1. RMS HOA in all subject pre and post VT.

		0D	1D	2.39D	4.56D
AI	Pre	0.59	0.74	0.38	0.26
	Post	0.42	0.51	0.44	0.19
AINF	Pre	0.41	0.09	0.62	0.19
	Post	0.18	0.11	0.33	0.43
Control	Pre	0.16	0.03	0.20	0.41
	Post	0.08	0.03	0.25	0.34

4 Conclusions

The use of wavefront sensing allows detailed analysis of the accommodative response in subjects with AI and AINF. It is possible to objectively observe characteristics of the AR and optical quality of the eye that are not possible with the subjective methods currently used in clinical practice. Objective methods are more independent of patient cooperation and perception and can save time during eye examination. In addition, VT was efficient in these subjects, and this technique allowed us to observe that. Wavefront sensing can be used to detect and monitor AI and AINF during the treatment with VT.

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Funding

This work was supported by the Portuguese Foundation for Science and Technology (FCT) in the framework of the Strategic Funding UID/FIS/04650/2019 and by the project PTDC/FISOTI/31486/2017 and POCI-01-0145-FEDER-031486. The author Jessica Gomes is also supported by the PhD grant 2020.08737.BD from FCT.