DYNAMIC VITREOMACULAR TRACTION

Cigánek P.[1], **Matoušková L.**[1], **Kousal B.**[2,3]

[1] Department of Ophthalmology, Central Moravian Hospital – Prostějov branch, Head MUDr. Petr Frgál
[2] Department of Ophthalmology, 1st Faculty of Medicine, Charles University in Prague and General University Hospital, Prague, Head doc. MUDr. Bohdana Kalvodová, CSc.
[3] Institute of Inherited Metabolic Disorders, 1st Faculty of Medicine, Charles University in Prague and General University Hospital, Prague , Head prof. MUDr. Viktor Kožich, CSc.

MUDr. Bohdan Kousal
Oční klinika
1. LF UK a VFN v Praze
U Nemocnice 2
128 08 Praha 2
e-mail: bohdan.kousal@vfn.cz

SUMMARY

Purpose: To describe clinical findings in patient with dynamic changes of vitreomacular interface and retina. To provide summary of findings about mechanism of accommodation and its potential impact on vitreous and retina.
Methods: In 57 year old patient we performed comprehensive ophtalmological examination including spectral domain optical coherent tomography (SD-OCT). We observed the impact of accommodative effort, head-downward position, combination of accommodative effort and head-downward position and influence of light reflex on vitreomacular interface and retina and change of minimal foveal thickness.
Results: On SD-OCT we could observe vitreofoveal adhesion on both eyes. During accommodative effort in combination with head-downward position we could observe symptomatic dynamic vitreomacular traction with temporary elevation of minimal foveal thickness. We could not observe impact of only head-downward posture, reading with spectacle correction of presbyopia or light reflex on change of vitreomacular interface or retina.
Conclusion: We should suspect dynamic changes of vitreomacular interface and retina when we see fluctuating impairment of central visual acuity particularly when it is in connection with accommodation and head-downward posture.
Key words: accommodation, head-downward position, vitreomacular interface, SD-OCT

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INTRODUCTION

Vitreomacular traction is the result of incomplete detachment of the posterior surface of the vitreous body. In 2009, Mellington and Benjamin published a case report in which they observed symptomatic, dynamic vitreomacular traction preceding definitive vitreomacular traction syndrome (22). Predominant amongst the subjective complaints of the proband were flashing images, later a darker ring at the centre of the visual field of both eyes during work at short distances. The patient we observed stated similar subjective symptoms, as a result of which we performed various exertion examinations.

Work at short distances is accompanied by accommodation, in which a contraction of the fibres of the ciliary muscle takes place, as well as a tension or release of certain types of zonula adherens, a forward movement of the vitreous body, a forward shift of the ciliary muscle, choroid and zonular fibres, and with age also a cambering of the sclera in the region of the limbus in an inward direction (3). The lens alters the radiuses of curvature upon accommodation, and is also shifted forward. A head-downward position, in comparison with other postures, supports a greater movement of the lens in accommodation, and at the same time supports a forward shift of the vitreous body. Upon pronounced accommodation the lens moves in the direction of gravity. Enlargement of the volume and the increasing mass of the lens during the course of life have an influence on increasing the flaccidity of the zonular fibres, the result of which is greater mobility of the lens (9, 22). Because only 3% of the fibres of the postganglionic short ciliary nerves are pupillomotor fibres, and all the others are directed towards the ciliary muscle, a constriction of the pupil occurs upon looking into the light, and undoubtedly also an accommodation followed by a forward movement and traction of the vitreous body (25).

METHOD

In a 57 year old female patient we observed the influence of accommodative effort, head-downward position and the influence of light reflex on the vitreomacular interface and retina, and on the change of the minimal thickness of the fovea. The accommodative effort was developed by reading at a distance of 33 cm with optimal correction for distance vision. The control was examination after reading with the object close up, which was stipulated by a method according to age and according to the amplitude of accommodation. Upon an examination of the influence of head-downward position, the position was maintained by flexion of the neck. The reaction to light was developed by shining a flashlight into the eye for a period of 1 minute. Examination by spectral domain optical coherence tomography (SD-OCT, RTVue, Optovue Inc., USA), displaying the individual layers of the retina with an axial resolution of 5 µm, was performed at rest before exertion, immediately after exertion and if applicable until the disappearance of morphological changes of the centre of the retina. Change of the vitreomacular interface and retina were monitored with a length of duration of exertion of 20 minutes. Values exceeding the absolute value of axial resolution of the SD-OCT instrument (± 5 µm) were considered to be significant. It was necessary to commence the examination by SD-OCT immediately following exertion, in the opposite case there was a gradual subsidence of the changes on the retina due to the time delay. Measurement of the minimum thickness of the fovea, thus the smallest distance between the line of the internal limiting membrane and the hyperreflexive line of the interface of the retinal pigment epithelium and the choroid, was performed manually on horizontal scans of SD-OCT. The tested eye was the right eye, for verification of the results redundant tests of the same character were performed on the left eye.
Examination of visual acuity was performed on ETDRS optotypes (logarithmic examination chart according to the Early Treatment

Diabetic Retinopathy Study), examination of close-up vision with the help of two Jäger tables with a range from smallest to largest text of 1-12. Refraction of both eyes was measured subjectively and objectively by an automatic refractometer (CX-500, G. Rodenstock Instrumente GmbH, Germany) in cycloplegia.

RESULTS

The 57 year old female patient described a circular black spot in the centre of the visual field upon accommodative effort, without metamorphopsia. The first subjective complaints appeared at the age of 52 years. The symptoms were dependent upon the activity being performed, they appeared most often in the afternoon when reading in a sitting position with a slight head-downward position, when knitting and sewing, occasionally during ironing, when the head-downward position predominated. When reading in a horizontal position on her back or in a semi-sitting position, no subjective symptoms were ever recorded. The duration of the exertion which led to deteriorated vision was gradually shortened from 30 minutes to the present 10 minutes. The time until complete disappearance of the symptoms after the end of the exertion corresponded to the period of duration of the previous activity which brought on the symptoms.

Best corrected visual acuity for distance vision was 1.0, bilaterally with correction of -4.25 D. The patient read number 1 on a Jäger chart with both eyes, with correction of -1.25 D.

Upon SD-OCT examination, vitreofoveal adhesion was present in both eyes (fig. 1a), the diameter of its base in the right eye was 491 µm, in the left eye 517 µm. Upon accommodative effort persisting for 20 minutes the minimal thickness of the fovea of the right eye increased on average by 21 µm (fig. 1b). After 20 minutes of accommodative effort in combination with head-downward position, we recorded an increase in the minimal thickness of the fovea of 47 µm (fig. 1c), and structural changes of the internal layers of the neuroretina, with the formation of pseudocysts. No influence was recorded of the actual head-downward position (fig. 1d), reading with the object close up (fig. 1e) or illumination of the eye (fig. 1f) on the change of the vitreomacular interface and retina. Redundant tests on the left eye were identical (table 1). On horizontal SD-OCT scans, the dynamic of regression of vitreomacular traction was also identified after 20 minutes of accommodative effort with head-downward position at a time when the disappearance of the morphological changes of the centre of the retina occurred within 20 minutes of the end of the exertion (fig. 2a-e).

Best corrected visual acuity in both eyes immediately after accommodative effort in combination with head-downward position was 0.5.

DISCUSSION

The accommodative effort and especially the combination of accommodation and head-downward position led to dynamic vitreomacular traction in the afflicted eyes, with variable symptoms of the character of a circular blind spot in the central part of the visual field, without metamorphopsia.

The vitreous body is normally attached to the surrounding structures in areas with greater density of the collagen fibrils of its peripheral cortex, and with the thinnest internal limiting membrane of the retina. The strongest adhesion is at the front, at the base of the vitreous body, there is a very strong attachment of the anterior surface of the vitreous body to the posterior surface of the lens by means of the Wieger's hyaloideocapsular ligament, with a diameter of 8-9 mm, circling the Berger and Erggelet space (28). There is a lesser force of adhesion at the perimeter of the disc of the optic nerve and in the macula. The vitreous body adheres here in the fove-

Tab. 1 Changes of minimal thickness of fovea in both eyes in 57 year old patient with dynamic vitreomacular traction.

Measurement / exertion	Accommodative effort		Accommodative effort with head-downward position		Head-downward position		Reading with object close up		Illumination of eye	
	RE	LE	RE	LE	RE	LE	RE	LE	RE	LE
Minimal thickness of fovea before exertion (µm)	240	237	240	237	240	237	240	237	240	237
Minimal thickness of fovea after exertion (µm)	261	259	287	286	245	240	240	238	240	239
Change of minimal thickness of fovea (µm)	+21	+22	+47	+49	+5	+3	0	+1	0	+2

Significant changes shown in bold. RE: right eye, LE: left eye

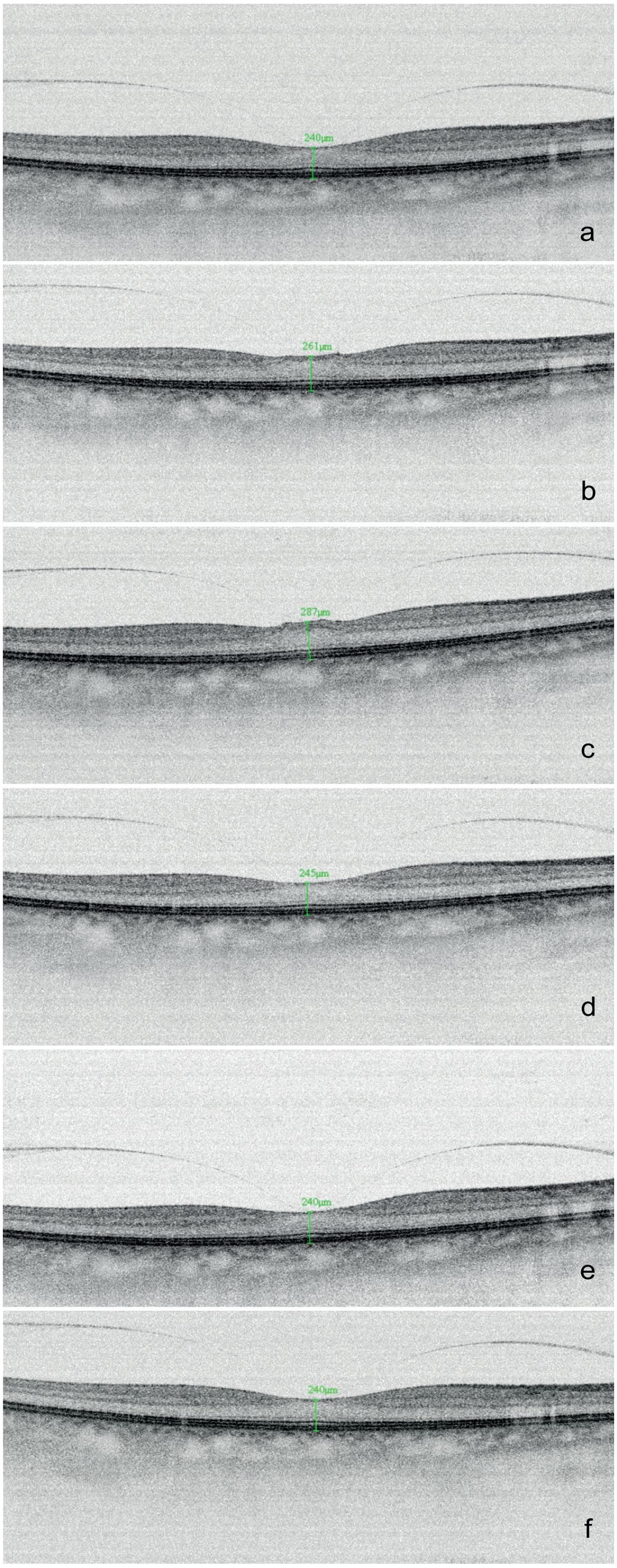

Fig. 1 Changes of minimal thickness of fovea and structure of vitreomacular interface and retina on horizontal SD-OCT scans of right eye before exertion a), after 20 minutes of accommodative effort b), after 20 minutes of accommodative effort in combination with head-downward position c), after 20 minutes of head-downward position d), after 20 minutes of reading with object close up e) and after illumination of eye for 1 minute f)

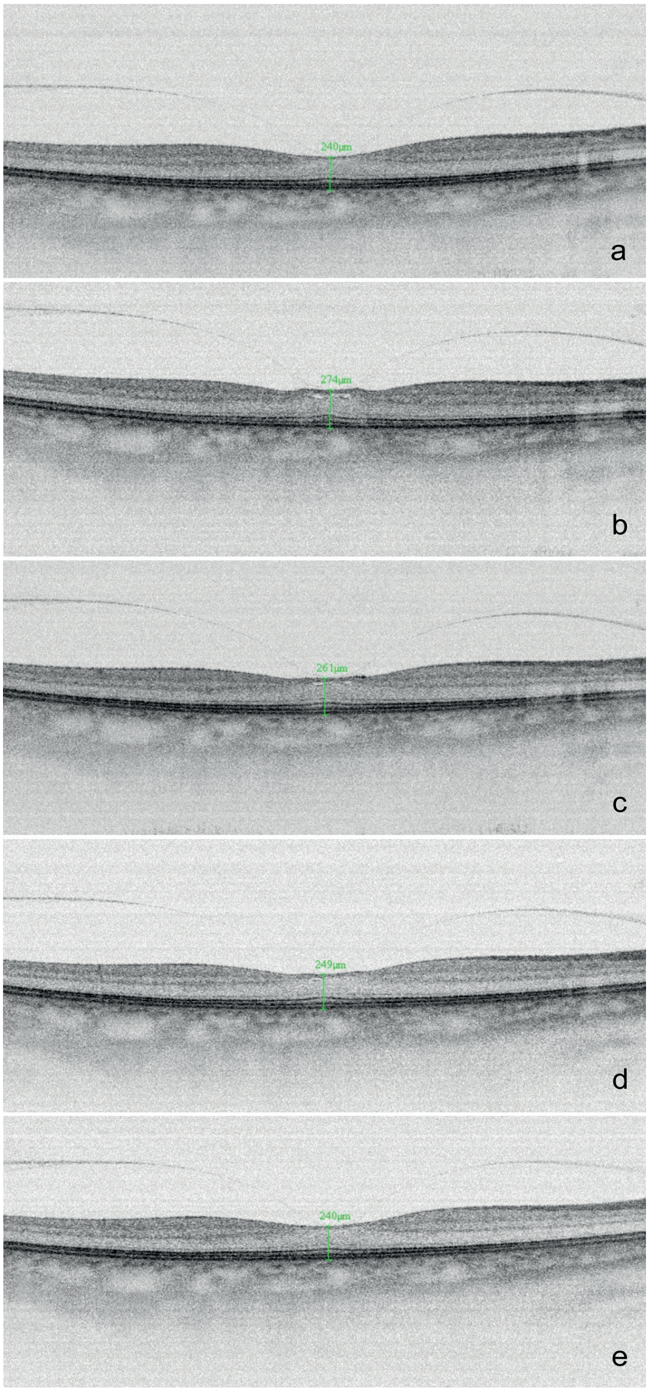

Fig. 2 Dynamic of changes of vitreomacular interface and retina of right eye on horizontal SD-OCT scans before exertion a), after 20 minutes of accommodative effort in combination with head-downward position b), gradual subsidence of vitreomacular traction following discontinuation of exertion in 5th minute c), 12th minute d) and 20th minute e)

ola, on a surface with a diameter of 500 µm, and also along the perimeter of the fovea by means of a ringed attachment with a diameter of 1500 µm (14). Adhesion is weakest and most variable to the large retinal capillaries. In other areas the vitreous body is loosely attached to the retina.

With age there is a reduction in the volume of vitreous gel, its liquefaction and the generation of lacunae, beginning in the middle of the vitreous body. At the same time, the traction force acting on the vitreoretinal and vitreopapillary adhesion increases, and the cortex of the vitreous body condenses. There is a weakening of adhesions between the internal limiting membrane of the retina and the posterior vitreous membrane. Age related changes include progressive ablation of the posterior vitreous membrane. The loosening of vitreoretinal adhesions takes place in the following order: temporal perifoveal region, followed by nasal, then the region of the upper and lower vascular arcade, foveola and detachment of the vitreous body from the central periphery of the retina, ending with loosening of adhesion from the perimeter of the disc of the optic nerve (6, 23).

Incomplete ablation of the vitreous body from the macula may result in vitreomacular adhesion, which is not dangerous in itself, and does not cause changes to the shape of the fovea or the morphology of the retina. However, subsequent vitremacular traction may be the cause of anatomic damage to the vitreomacular interface and the retina, depending on the force and size of attachment. Upon a size of attachment of up to 500 µm, tractional forces predominate with a risk of formation of a macular hole or cystoid changes to the fovea. Upon a greater extent of attachment, in particular above 1500 µm, thickening of the macula and vitreomacular traction syndrome predominate, and associations are known with wet form age-related macular degeneration, diabetic macular edema or retinal vein occlusions (6, 23). In patients with a macular hole, the incidence of vitreomacular adhesion is over 84%, whilst it is present in 100% of patients with vitreomacular traction syndrome and in 56% of patients with an idiopathic epimacular membrane. The above disorders occur more frequently in women (17).

The risk of ablation of the posterior vitreous membrane is higher in myopic eyes at all ages, and increases with a larger value of refractive error. In the case of myopia above -6 D, the risk is more than three times higher (29).

The cause of dynamic changes to the vitreomacular interface and retina, with the occurrence of subjective symptoms, may be the movement of the vitreous body upon accommodative effort, which may be further contributed to by a head-downward position (22). Evidence attesting to the movement of the vitreous body upon accommodation and head-downward position has been submitted by a number of authors using animal models (18, 20, 32). In 2013, Croft et al. described a forward movement of the ciliary muscle by approximately 1 mm during accommodation in the eyes of Barbary apes. This movement was linked to a forward traction of the choroid, retina, the group of posterior zonular fibres and the neighbouring vitreous body (3).

The most widely accepted theory of the mechanism of accommodation at present is Helmholtz's theory from 1855 (11), which has been verified by studies conducted by Glasser (9). Upon accommodation there is a contraction of the ciliary muscle and a relaxation of the tension of the zonular fibres between the lens and the ciliary muscle. Fincham (5) supplemented the assertion regarding the variable thickness of the lens capsule, which is thinner than at the periphery at the front and particularly at the back. Thanks to the elasticity of the capsule, the anterior surface of the lens bulges upon accommodation, causing an increase in the dioptric force of the eye. The posterior capsule is weakened to such an extent that it is already substantially bulged before accommodation (19).

A healthy human body is capable of altering the optical density of the lens by 12-15 D at pre-school age, with a decline to 1 D by around the age of 60 years. Upon an accommodation of 5 D there is a reduction in the equatorial dimension of the lens by 3.5% (8, 31, 33), the thickness of the lens increases by 300 µm, the anterior pole of the lens shifts in a direction towards the cornea by 250 µm, and the posterior pole towards the retina by 50 µm (2, 24). The centre of the lens thus shifts forward by 100 µm. There is a reduction in the radius of the curvature of the anterior surface, and also slightly of the posterior surface of the lens (4, 27).

Despite the fact that a loss of elasticity of the lens occurs with increasing age, together with changes to the integrity, elasticity and attachments of zonular fibres, the function of the ciliary muscle can be preserved. Accommodation is performed by means of a convergence of the optical axes of both eyes and a constriction of the pupils (21). Even in a presbyopic eye, each effort to sharpen vision at a short distance causes constriction of the pupils and contraction of the ciliary muscle, even though the lens is no longer capable of changing shape (30). For this reason it is improbable that the ciliary muscle would become entirely atrophied or ineffective with age. Age-related loss of contractility of the ciliary muscle (26) was not demonstrated in Barbary apes. The ciliary muscle was capable of accommodative effort even in a pseudophakic eye (31).

As has been stated, upon accommodation there is a forward shift of the ciliary muscle, the suspension apparatus, lens and choroid, as well as a forward movement of the vitreous body. A head-downward position allows greater movement of the lens and vitreous body upon accommodation in comparison with other positions. Hess (13) described that upon pronounced accommodation and a head-downward position, the lens shifts a further 0.15 mm towards the cornea in the direction of gravity. Further works have confirmed a shortening of the distance of the lens from the cornea by 0.2 mm upon accommodation and a head-downward position in comparison with a head-upward position (1, 5). In accordance with the Hess-Gullstrand theory of presbyopia, the age-related increasing size of the lens has an influence on increasing the flaccidity of the zonular fibres upon accommodative effort. The flaccidity of the zonula adherens allows greater mobility of the lens according to the influence of gravity (12, 15). The zonular fibres form a structural and functional unit. The individual groups release the tension of the lens during accommodation, maintain the lens and attached vitreous body in a stable position, and transfer the tension onto the elastic choroid (10).

Upon looking into the light there is a constriction of the cornea together with accommodation, evidently followed by a forward movement of the vitreous body, because 97% of the fibres of the postganglionic short ciliary nerves are directed towards the ciliary muscle and only 3% comprise pupillomotor fibres (22, 25). However, our examination did not demonstrate dynamic changes of the vitreomacular interface upon light reflex with contraction of the ciliary muscle.

Examination by SD-OCT with sufficient resolution substantially eases the diagnosis of dynamic vitreomacular traction. It is suitable to consider this upon inconstant impairment of central visual acuity, and to conduct an examination upon the engagement and relaxation of accommodation. By this method it is possible to reduce superfluous examinations for patients.

Patients with symptomatic vitreomacular traction with morphological changes to the retina who are left without treatment do not have a good prognosis, the majority suffer a reduction of central visual acuity, in certain cases there is also a development of other pathologies of the vitreomacular interface (7). A restoration of the foveolar anatomy and visual functions virtually to the norm can be achieved by successful pars plana vitrectomy (19). Another option is intraocular use of ocriplasmin, which has been demonstrated to be effective in dissolving adhesions between the vitreous body and the retina, thus reducing the necessity of surgical intervention (16).

CONCLUSION

It is appropriate to consider dynamic changes to the vitreomacular interface and retina in the case of fluctuating deterioration of central visual acuity with subjective symptoms, in particular if they are connected with accommodation and head-downward position. Diagnosis is based on SD-OCT examination. We recommend the examination of refractive errors with relaxation of accommodation in cycloplegia, and correction using glasses, in the case of presbyopia we recommend the selection of a suitable object for close-up vision. Symptomatic vitreomacular traction can be treated by pars plana vitrectomy or the application of ocriplasmin.

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