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REVIEW

Age related strabismus

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Abstract

Age related binocular vision disorders (age related strabismus) could include all types of spontaneous strabismus appearing along the lifetime, which are directly connected with the aging process. Neurological strabismus is excluded. Functional and structural changes related to the aging process can induce phoria decompensation, convergence insufficiency decompensation and new onset strabismus as distance esotropia or vertical strabismus induced by the sagging eye syndrome. MRI studies sustain the hypothesis of age related structural changes of extraocular muscles pulleys and their influence on the eye position and motility nominated as sagging eye. Age Related Distance Esotropia, Age Related Divergence Insufficiency Esotropia are probably different names for the same type of strabismus. All types of age related binocular disorders require treatment because of the accompanying diplopia. Prisms or/ and surgery can improve the patients' life quality by eliminating diplopia in primary position and main gazes.

Keywords: age related binocularity disorders, phoria decompensation, sagging eye, diplopia, prisms, surgical treatment

Introduction

Aging was defined as the process of becoming older, the accumulation of all changes in a person over time. It seems that we have a "genetic" clock in our telomeres, which is responsible for all these multidimensional changes with age, with no exception (Wikipedia).

The aging process affects all the tissues and systems and, of course, the visual system and its components are affected too.

There are tight relationships between the age related binocular disorders and the aging of Muscular, Connective tissues, Nervous System and adaptation mechanisms.

Trying to bring different types of age correlated strabismus described in the literature under the same "umbrella", this presentation will use the term "Age related strabismus" as a general term for all age related binocular disorders, meaning spontaneous adult strabismus directly connected with the aging process.

Age Related Strabismus has functional and structural causes that cannot be realistically separated, but in order to simplify the arguments, this scheme will be used.

Functional and structural age related changes

Functional changes

According to different studies, age brings

changes in the accommodative convergence and in vergence adaptation.

A study of Rosenfeld et al. performed in 1995, highlighted that "Fast fusional response showed an age-related increase in latency and decreased in peak velocity and acceleration in the binocular stimulus condition but not in the accommodative vergence" and, in the meantime "Sustained vergence showed no age-related effect in the binocular condition, but there was an age-related decrease in accommodative vergence steady-state velocity and an increase in latency" [1,2].

Another important issue was revealed in 2006 by Guyton, who talked about dynamic mechanisms involved in the regulation of the muscle length, which played a critical role in the long-term maintenance of ocular alignment [3].

In a large study, a Scandinavian research group (Bruenech et al.) demonstrated that the oculomotor system's ability to stabilize gaze and keep the image of the visual world steady on the retina declines with age [4].

The functional changes cannot be separated by the structural changes especially when talking about dynamic structures such as the Extraocular Muscles (EOMs).

Structural Changes in EOMs and Connective Tissues related to aging

"Sarcopenia" is part of the aging process in the skeletal muscles due to denervation, anabolic hormones decrease followed by the incapacity of amino acid and protein incorporation; (…) an increase in catabolic agents as interleukin 6 amplifies the rate of muscle waist [5]. The rational question coming from this is if the EOMs are affected by the similar structural changes. Certainly, the sarcomere number is affected also in the EOMs with age or different age related circumstances but probably less because of fusional vergence adaptive mechanisms [3], which remain in function as long as the visual acuity of both eyes is preserved. Different causes that affect visual acuity in one or both eyes modify the accommodative vergence amplitude and response, influencing in time the muscles structure and length. These changes produce binocular function disorders and affect the eyes position and movements.

Collagen and Elastin, the major body proteins suffer profound changes in their structure and biochemical functionality with consecutive significant changes [6,7].

The Extraocular Muscles and Pulley's changes related to aging process

In the last 15-20 years, imaging brought enormously valuable data in order to explain different types of strabismus. The age related strabismus is one of the items in which MRI studies of Demer and his co-workers gave new and essential data.

In 2002, Clark and Demer showed that "The horizontal rectus EOMs are displaced inferiorly in the elderly relative to the globe centre.(…) This may contribute to the observed impairment of elevation in older people and predispose them to a characteristic pattern of incomitant strabismus." [8]. Few years later (2007), another study done by Lerdlum brought new data using CT measurements as it follows: there is "...no statistically significant correlation between age, diameter of each EOM and the sum of all four muscles" [9]. So, it seems that the age related orbital changes, mostly pulleys changes play the most significant role in age related new strabismus onset in patients without previous binocular imbalance. In 2009, Rutar and Demer introduced a new term, the "sagging eye syndrome", which defined the LR muscle "slippage" inferiorly due to age-related Lateral Rectus-Superior Rectus band degeneration [10], and later on, after years of research and multiple studies, in 2013, Chauduri and Demer concluded that "Connective Tissue Involution as a Cause of Horizontal and Vertical Strabismus in Older Patients" [11].

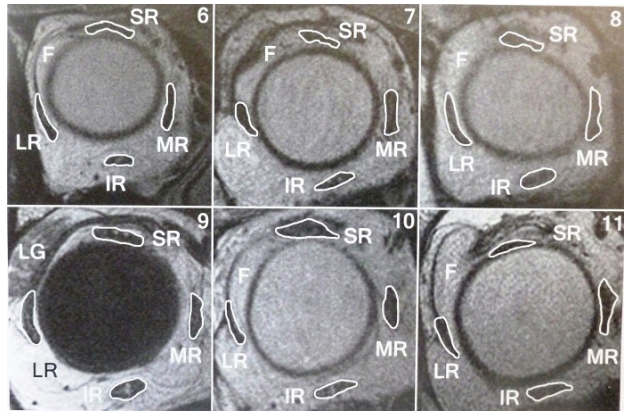

Fig. 1 Quasicoronal MRI images of the right orbit showing fat (F) and lacrimal gland (LG) tissue migrating superotemporal orbit under the degenerated LR-SR band with inferior displacement of the lateral rectus muscle. The lateral rectus muscle distracted from the globe [12

Sagging eye - clinical aspects

According to Demer, "Patients with sagging eye exhibit blepharoptosis, superior

sulcus defect and inferolateral displacement of rectus pulleys with elongation of extraocular muscles that followed curved paths". As a clinical manifestation, symmetrical LR pulley sag is associated with "divergence palsy esotropia". The term was contested by Mittelman who published several studies that clinically recognized the Age-Related Distance Esotropia (ARDE) as being the same thing but without explaining the causes [13]. Several other authors have been described the same type of strabismus on different names [14,15].

Finally, it seemed that "age related divergence palsy esotropia", "age related distance esotropia", "age related divergence insufficiency esotropia" and "age related divergence palsy esotropia" represent the same clinical manifestation of symmetrical sagging eye syndrome which develops distance esotropia.

A series of other unexplained age related non-neurological forms of strabismus were also explained by Demer as being associated with asymmetrical LRM sag larger than 1 mm and producing cyclovertical strabismus. In the mean time, the "Absence of strabismus in older people with mild symmetrical sagging eye shows at least limited compensatory mechanisms for age related degeneration" [16].

Age related binocular disorders-clinical aspects

In summary, few types of age related binocular disorders were certainly identified, which should be recognized and diagnosed because they produce invalidating diplopia.

It is well known that heterophoria decompensation (exophoria, decompensated Congenital SO Palsy) is common in elderly and it can spontaneously appear or it can be connected with long standing visual deprivation such as cataract or after refractive surgery. The consequence of decompensation is diplopia, which affects the patient's life quality and very often is confounded with different neurological types of strabismus.

The Convergence Insufficiency decompensation is also common in old patients but it is easier to be identified because, usually, the patient has a known history. This decompensation is responsible for diplopia at near [17]. All these situations are mostly connected with age related changes in fusional accommodative response capacity.

The sagging eye can produce horizontal strabismus such as "Age Related Distance (Divergence) Esotropia" (ARDET) and/ or cyclovertical deviations. The main clinical manifestation is more prominent diplopia or only at distance.

Fig. 2 Sagging eye with Intermittent Esotropia. Normal Neurological Exam

According to Demer, even the delicate manipulation during cataract, refractive of eyelid surgery can produce the tenuous LR-SR band rupture having as a direct consequence new strabismus acute onset with diplopia [16].

Fig. 3 Left eye Restrictive Hypotropia with cyclotorsion after peribulbar anesthesia for cataract surgery

The treatment is imperiously necessary in all these situations because fusion deterioration produces intermittent or permanent DIPLOPIA, which consecutively affects profoundly the old patients' life quality.

Diplopia diagnosis in old patients

Any diplopia in elderly should be carefully investigated. Phoria presence or convergence insufficiency diagnosis in the patient history can be a good clue for a quick diagnosis but strabismus history cannot exclude an acquired neurologic disorder. Decompensated strabismus or sagging eye can co-exist with paralytic strabismus.

In most of the situations, diplopia onset, type, and evolution impose a careful investigation of

binocular function and eye movement. Significant limitation of gazes and slow saccades are usually connected with paretic or paralytic strabismus. Slight movement limitations, unusual types of small cyclovertical deviations are most probably connected with non-neurological strabismus. Eye Fundus torsion should be examined because it can differentiate a decompensated congenital Superior Oblique Palsy from a cyclovertical strabismus produced by sagging eye in which the extorted eye is the hypotropia eye [16].

Imaging is helpful in identifying cerebral tumors, vascular or degenerative processes that can induce diplopia such as acquired VI or IV nerve palsy, acquired divergence palsy or acquired accommodation and convergence palsy. Imaging is also useful in identifying "sagging-eye" for a ***differential diagnosis***.

DIFFERENTIAL DIAGNOSIS

Age Related Binocular Disorders	Neurological Strabismus
Age Related Divergence Esotropia (Symmetrical Sag of LRM): good abduction, normal saccadic velocity [13,16] (ET ''> ET ')	*≠ Acquired VI Nerve Palsy (limited abduction, slow abduction saccades)*
	≠ Acquired Divergence Palsy due to supranuclear lesions (divergence paralysis)
Age Related Cyclovertical Strabismus (asymmetric sagging eye)- exciclotorsion developed by the hypotropic eye [15] (Eye Fundus Torsion Examination !)	*≠ Acquired IV Nerve Palsy (exciclotorsion of the Hypertropic eye, positive Bielschowschi)*
Decompensated Convergence Insufficiency [16]	*≠ Accommodation and Convergence Palsy due to cerebral lesions (MRI can identify lesions) [17]*

Fig. 4 Identifying "sagging-eye" for a differential diagnosis

Treatment

The age related strabismus requests treatment in order to restore binocularity and to eliminate acquired diplopia, which creates huge problems to all patients. However, in this category of patients, diplopia can be a source of trauma risk more than in the other age groups.

Unfortunately, not all these patients refer to the strabismus specialist and probably many of them are misdiagnosed. Generally speaking, probably the age related strabismus is more or less under diagnosed because the general ophthalmologist suspects a neurological cause or prefers to recommend a patch considering that the patient is "too old" for prisms or surgery.

Hoping that these patients are always referred to the strabismologist, there are a few possibilities of treatment for diplopia.

Prisms can be successfully used with excellent results in small deviations <10 PD as prisms included in glasses. The prisms can restore binocular single vision in the primary position and enlarge the field of binocular single vision [18,19].

Fresnell Prisms foils can be used as a temporary or permanent solution in larger deviation but they have the following inconveniences: they are not always well tolerated, represent a temporary solution as long as the glasses are on, and can produce a visual impairment in patients with mild cataract, Age Related Macular Degeneration or other problems that affect visual acuity.

Surgical treatment is addressed to larger deviations, over 10 PD but can be used even in small deviations when prisms are not tolerated. Surgery under adjustable sutures is desirable but not absolutely necessary. Topical anesthesia is preferable but all types of anesthesia can be used, including general anesthesia, which can also be safely used in some cases after an appropriate investigation of the patient.

Heterophoria decompensation needs a conventional surgery. As far as the convergence insufficiency is concerned, if prisms or active therapy by fusional amplitude stimulation fails, small bilateral MR Resection can be used with a possible risk of consecutive diplopia at distance.

Sagging eye related binocular disorders can be surgically treated as it follows:

Age Related Distance Esotropia: Bilateral MR Recession (augmented) and Bilateral LR Resection – both effective in restoring binocularity. Different studies showed similar results using different techniques [20,21].

Demer suggested that recessions should be targeted from standard to twice the maximum distance esotropia measured in central or lateral gaze [16].

Yadav S et al. showed good results while using a single LR resection using nonadjustable sutures with excellent results [20].

Sagging eye cyclovertical diplopia can be successfully treated by partial vertical rectus tenotomy at the scleral insertion. Demer proposed 40% tenotomy for 2PD to 80-90% for 6 PD [16].

Horizontal Recti tenotomy can be also used according to the preoperatory incomitance and torsional aspect [13].

Conclusions

Age Related Diplopia can be successfully treated if an accurate diagnosis is provided.

If possible, Neurologic Disorders producing diplopia in aged people should be excluded by clinical meticulous approaches and imaging. Prisms are very helpful in small deviations in the sense that they acceptably restore binocularity. When needed, surgery is possible and can substantially improve the patient's life.

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