Form Deprivation Myopia (FDM) Effect in Sclera Layer of Animal Model: A Literature Review

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Abstract

Myopia as an abnormal eye condition that gives blurry vision due to the image lies in front of the retina. It becomes an epidemic case in the world as the prevalence keeps increasing over time. Experimental studies using animals are useful to understand the establishment of myopia so that it can be used for further study in preventing myopia. Form deprivation myopia (FDM) is one of the most common methods to make a myopic condition in the eye of the animal model with many parameters to measure, hence the purpose of this article is to review the form deprivation myopia effect in the sclera layer of the animal model's eye.

Keywords: Form Deprivation Myopia; Animal Model; Sclera Layer; Literature Review

1. Introduction

Myopia is a condition where the error of the refraction occurs with the sign of blurry vision. This happens because of the image that lies in front of the photoreceptors located in the retina (Carr and Stell, 2017) as a result of the abnormal growth of the eye (Baird et al., 2020) and causing the optical power and the eyeball length unsynchronized (Ganesan and Wildsoet., 2010) Myopia shown by a minus sign and the magnitude shown with diopters (D), more than -6.0 D is considered as high myopia (Fredrick., 2002) The myopia occurrence in the world keeps increasing and becomes the epidemic case (Baird et al., 2020).

According to the American Academy of Ophthalmology, the prevalence of myopia increasing by over 80 million and occur in over 28% total from the global population (Wong et al., 2020) Many risk factors play important role in the growth of myopia for instance genetic factors and environmental factors. The genetic factors inherited from parents who also have myopia, it was also found that the Asian race for instance Chinese has a higher prevalence compared to others. Lifestyle also plays a big role in the establishment of myopia conditions such as higher education people with near work activity, hence it is always related to highly educated people, university students, and workers (Cooper and Tkatchenko., 2018), the risk for students to become myopia is lesser in students who time in outdoor more than indoor (Karouta and Ashby., 2015). The basic causes of myopia are still unclearly understood, despite mounting evidence that environmental variables play a significant role in its development (Aller., 2014) Microenvironment and inflammatory processes also play role in myopia growth (Coviltir et al., 2019) However, myopia can cause a serious problem because it can lead into irreversible vision disorders (Jonas et al., 2019)

Research using animal models are now used as the focus to treat myopia in further case. (Cooper and Tkatchenko, 2018) The mechanism behind the development of myopia and the impact of prospective treatments have both been extensively studied using animal models (Wang et al., 2021) deprivation myopia also refers to several diseases in the human eye for instance ptosis, retinal hemorrhages, and inflammatory keratitis (Fredrick., 2002) Form deprivation myopia and lens-induced myopia are the two experimental myopia that is commonly done by altering the normal vision of the animal. Form deprivation myopia (FDM) works by blocking the animal to see, while lens-induced myopia (LIM) alters the animal's normal vision by using applying the lens, this method had been applied to many types of animals such as guinea pigs, chicks, mouse, primate, and tree shrews.

Although the mechanism of form deprivation myopia and lens-induced myopia is different, the result is the same which is the refraction error in myopic condition (Xiao et al., 2014) shown by the abnormal growth of the eye (Chakraborty et al., 2020) Many parameters can be measured to find the myopic condition such as axial length, refraction status, choroidal layer thinning, and sclera layer thinning (Schaeffel and Feldkaemper., 2015) these parameters can be seen clearly in humans, hence the study of the form deprivation in the animal study can be useful for further treatment in myopia condition in a human (Cooper and Tkatchenko., 2018)

2. Anatomy of the Eye and Sclera Layer

Anatomically the eyeball of the vertebrates can be seen in the one-sixth part only, the rest of it can't be seen because it was buried inside. The eyeball consists of three layers that have their own part and role, the innermost layer is called the retina which consists of the pigmented layer and also the neural layer. The middle part is called the uvea or the vascular tunic, this vascular tunic consists of three important parts the choroid, ciliary body, and iris. The choroid gives the eye nutrient vascularly to the retina and sclera (Rehman et al., 2021) The outer part which is called a fibrous tunic is to maintain the shape of the eyeball and also gives protection. It consists of the anterior part of the cornea and the posterior part of the sclera.

The eyes of the vertebrates are spherical in shape with the sclera as the white part that is avascular and dominantly covers all the eye layers except for the retina. The sclera is covered by the uncolored mucoid membrane called conjunctiva (Awh et al., 2022). The function of the sclera gives an important role to the eyeball such as being the safeguard for the internal structures of the eye, shaping the eyeball, and also maintaining its rigidity, as the main role of the sclera can be seen as a growth rate control of the eye (Wang et al., 2021). This is also supported by the fact that the sclera is composed mainly of collagen and elastic fibers. (Zhu et al., 2002; Rehman et al., 2021) A modest number of fibroblasts and a significant amount of ECM make up the majority of the sclera in mammals. Collagen, which makes up 90% of the dry weight of the sclera and is the main component of the ECM, is produced by fibroblasts (Kusumawardhany et al., 2019)

Three layers fuse to form sclera such as episclera, stroma, and suprachoroid that have their own functions. A thin, floppy layer of collagenous connective tissue makes up the episclera. The stroma is a thick layer of dense, collagenous connective tissue composed of networks of elastic fibers and types I collagen fibers that interlace. A thin layer of connective tissue called the suprachoroid lamina contains fibroblasts and melanocytes. (Awh et al., 2022)

3. Form Deprivation Myopia Effect in Sclera Layer

The deprivation of the eye can be done in several methods by suturing both palpebrae or occluding with the diffusers (Troilo et al., 2018) tattooing the cornea, and applying the contact lenses in the scleral-corneal cup (Verolino et al., 1999) and it has done in a certain period of time. The mechanism of form deprivation myopia works by blocking the normal visual pathway and animal sight (Xiao et al., 2014) hence it caused the drawback in the normal emmetropization process (Rada et al., 2000) and it induces myopic condition due to the unclear image that the eye receives (Wang et al., 2021) the deprivation can only be done in the infant or juvenile animal. Several studies that did in the adult animal shows no effect of the deprivation in myopic condition (Verolino et al., 1999)

A previous study by Xiao et al on the guinea pigs that underwent 14 days of deprivation shows that there are changes in the sclera of the eye that can be seen using the electronic microscope. It is shown with the diameter layer of the sclera becoming thin, sclera fibers disorganization, and increased fiber disassociation. A myopic condition caused by the deprivation in the guinea pig eyes can be seen in the remodeling of the sclera due to the tissue loss and proteoglycan synthesis decrease that will cause the elongation of the eye. (Xiao et al., 2014). The sclera thickness was also reduced in the rabbit study by Kusumawardhany et al in 2019 which can be seen in the decrement of the amount of extracellular matrix (ECM) of the sclera or delayed synthesis of the ECM that contains collagen as a part of the sclera layer, hence the rigidity of the eyeball decreased and cause the abnormal eye growth (Kusumawardhany et al., 2019)

Myopia condition that affected the anatomy of the eye such as the sclera, however, the posterior part of the sclera is the most affected in the sclera layer (Wang et al., 2021) Nie et al previous experimental study was conducted in ten days old rabbit that underwent lid suture for a month, the result of the deprivation was the thinning layer of the sclera after examined with the electron microscope (Nie et al., 2012) This statement is supported by the previously conducted experimentally in tree shrews. It can be seen the thinning layer of the posterior part of the sclera. This thinning process may cause myopic condition due to eye growth. Experimental myopia in deprivation may cause the intraocular pressure increase (IOP), hence due to the thinning of the posterior part of the sclera, the resistance of the sclera layer in maintaining the IOP is reduced and it becomes extensible (Phillips and McBrien., 1995) Another study stated that the occlusion in the eye can cause the choroid layer become thin as the thickness decreasing. With the main function of the choroid as an oxygen supply in both retina and also sclera, the deprivation can cause the sclera hypoxia due to the vascularization of choroid layer and the choroidal blood flow decreasing (Zhou et al., 2020).

4. Conclusion

It can be concluded by the studies that the form deprivation myopia (FDM) as a method of experimental in animal models can cause the thinning of the sclera layer due to the alteration of the normal visual pathway by the deprivation. The thinning of the sclera layer can cause abnormal growth of the axial length and defined as the myopic condition.

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