



## **Novel theory for treatment of presbyopia: Rejuvenation of zonular fibers by capsular anterior annular peripheral shrinkage (CAPS)**

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### **Abstract**

Presbyopia is the gradual age-related loss of accommodation. The precise mechanism responsible for presbyopia has not been clearly defined. Recently, Schachar has proposed a radically different theory of accommodation. Schachar theorizes that presbyopia could be corrected if the ciliary muscles could be stretched a small amount to allow them to function on the lens. We propose laser correction of presbyopia with capsular anterior annular peripheral shrinkage is a possible treatment for augmenting the transmission of the contraction force of the ciliary muscle through the zonular fibers to the lens capsule. The resulted shrinkage increase the distance between the lens equator and ciliary muscle leading to restoring the adequate zonular fibers tension and reversing the effect of age-related lens growth on the near vision.

### **Keywords**

*presbyopia, treatment, Laser therapy*

### **Introduction**

As age advances, the lens gradually loses its accommodative ability resulting in near vision disturbances. This condition is known as presbyopia [1, 2]. Presbyopia is considered as the most common physiological implications of aging on the eyes. There is still no satisfactory treatment for presbyo-

pia, despite of countless research studies on this subject [3].

The precise mechanism responsible for presbyopia has not been clearly defined. Presbyopia has very complex theory and controversial. Numerous research studies have been conducted to disclose the exact reasons for the development of presbyopia [4-14].

Recently, Schachar has proposed a radically different theory of accommodation. Schachar theorizes that presbyopia could be corrected if the ciliary muscles could be stretched a small amount to allow them to function on the lens. The Schachar Accommodative Scleral Implant (SASI) has been developed. From the Schachar hypothesis of accommodation it could be deduced that if one were able to increase the distance between the lens equator and the ciliary muscle, one could again stretch the zonules and reverse the effect of lens growth and to narrow this distance [10, 11].

A lenticular approach to restore accommodation to the presbyopic lens is the use of laser energy to 'treat' or 'soften' the lens. Preliminary studies [15–17] have investigated this approach in living and excised animal and human cadaver lenses. These studies suggest that femtosecond laser does not produce cataract and can soften the lens and increase the accommodative potential of presbyopic lenses. Challenges faced by this procedure include the fact that the older, presbyopic lens is larger and thicker than a young lens due to the continued growth and it is not clear that laser-induced mechanical changes would allow this larger lens to undergo accommodative changes.

Laser cuts in the lens would be at a multicellular rather than at a single cell or subcellular level and although this may produce mechanically advantageous changes to the lens, it will not do so by reversing the cellular and subcellular changes that result in the age-related stiffening of the lens. Further, studies show that the accommodative changes in curvature in the natural young lens occur due to an increase in thickness of the nucleus rather than the cortex [18, 19] and the aging lens nucleus undergoes a greater increase in stiffness than the cortex. [20, 21] Therefore, laser treatments would need to be directed at the lens nucleus for maximum effect but would have to avoid inducing opacities, if vision is to remain uncompromised. If this is achieved, one benefit of laser treatment is that it is non-invasive. Provided the lens capsule is not affected and phacoemulsification can still be performed when required, it is potentially a benign procedure because a cataractous lens would ultimately be removed anyway [22].

### **The Hypotheses**

Hardening of the lens with time individually differs for people when they reach the approximate age of 40, while getting presbyopic is almost universal for people of 40 years old, and thus, is not the only reason behind the phenomenon of presbyopia. We are theorized that the zonular filaments are never loose and lax because that would render the lens dynamically unstable. Zonular filaments are always under compression like the filaments in a soft hairbrush rather than tension. In accommodative state, ciliary muscle is exerting a hoop stress on the

lens capsule through compressive action of the zonular filaments. With progressive hardening and the loss of elasticity of the lens, and its ectodermal growth it will become harder and harder for the ciliary muscle to accommodate by contraction. This is because, on the one hand, the lens and the lens capsule are harder to deform, and on the other hand, the growth of the lens causes the zonular filaments to buckle as they press against the ciliary body. Thus, zonules in this bent and buckled state cannot directly transmit the constricting force of the ciliary muscle to the lens capsule.

We propose our novel hypothesis for treatment of presbyopia, based on the recent findings [9, 13, 14]. The space between the lens and ciliary muscles gradually diminishes with aging due to the anterior lens growth. As a result, the zonular fibers steadily crinkle and lose their ability to effectively pass the accommodative forces from the ciliary muscles on the lens capsule.

Thus, the best solution is to reverse this buckled state with laser shrinkage of anterior peripheral part of the lens. The resulted shrinkage increases the distance between the lens equator and ciliary muscle leading to straightening out the zonular fibers. Consequently, this leads to restoring the effective zonular fibers tension during the resting accommodation and the accommodative response while focusing on near objects.

### **Evaluation of Hypotheses**

The surgical procedure proposed for testing our idea is using a cycloplagic eye drop to create a full dilated pupil. The laser energy source is a continuous wave (CW) infra-red laser, such as a diode laser. The CW laser is pulsed to provide a controlled photocoagulation effect. Our first suggestion is Diode Laser Oculight IRIDEX (USA) in the mode of transpupillary thermotherapy. The wavelength selection from 800 nm to 1,980 nm and the pulse duration of 0.01 to 1 second is preferred.

The spots are placed peripheral to the scotopic pupil position, typically along a circle with a diameter of 7 mm or more. By placing the spots closer to the equator, a greater effect is achieved. Spot size is selected in the 200-500 micron in diameter range. This is a simple procedure and easy to perform in comparison to most of the other surgical treatment for presbyopia. We will need to design more complex laser delivery equipment that can save topographic images of lens and accurately shot laser spots not manually because it can produce lenticular astigmatism if we apply without detail measurements of lens surface and so this system will work like LASIK machine tracking system.

Laser could induce anterior subcapsular cataract without unwanted effects on the central clarity or on the refractive status of the eye. We suggest some experimental animal studies in order to logically prove the safety and effectiveness of our hypothesis.

Then, next objective will be to conduct several clinical trials aimed at endorsing this procedure as a new treatment for presbyopia and long-term follow-up for possible cataract progression.

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### Overview Box

**First Question: What do we already know about the subject?**

Presbyopia is considered as the most common physiological implications of aging on the eyes. There is still no satisfactory treatment for presbyopia, despite of countless research studies on this subject.

**Second Question: What does your proposed theory add to the current knowledge available, and what benefits does it have?**

New treatment of presbyopia is leads to restoring the effective zonular fibers tension during the resting accommodation and the accommodative response while focusing on near objects. This is a simple procedure and easy to perform in comparison to most of the other surgical treatment for presbyopia.

**Third question: Among numerous available studies, what special further study is proposed for testing the idea?**

The anterior peripheral lens capsule is symmetrically shrunk by laser in order to logically prove the safety and effectiveness of our hypothesis.

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