AGE INFLUENCE ON THE BIOMECHANICAL FUNCTIONS OF THE HUMAN EYE

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Abstract:The stiffness of sclera,chochoroid, lens and lens nucleus is increasing,but of lens capsule- decreasing with age influencing the vision. Rised IOP increases the eye tissue rigidity even for young people. The tissue stiffness changes together with fall of maximal accommodation stimulate origin and development of myopia for children and presbyopia for adults. Rising power of the ciliary muscle in middle age is compensating initial vision disturbances in presbyopia,but increasing the risk of choroid - retinal detachmant.

INTRODUCTION

Age leads to considerable changes of the eye tissue (sclera [1],choroid [1.2],lens [3])mechanical properties, incidence of the eye pathology and vision. It influence the eye mechanical stability and functions with suceeding possibility of origin and development of glaucoma, myopia, choroid-retinal detachment etc.Nevertheless the age influence on the human eye biomechanical stability and functions are investigated in small scale.

MATERIAL AND METHOD

564 test specimens were obtained from 78 accident victims and fell in seven age groups: less than 2 yrs. (group I), 3-10 yrs. (II), 11-18 yrs. (III), 19-44 yrs.(IV), 45-59 yrs.(V), 60-74 yrs. (VI) and 75-89 yrs. (VII). The maximal duration from the enucleation till the investigation was less than 16 hours. The eyes were kept in the physiological solution at a temperature of 3 - 5°C.From the anterior and posterior part of the eye coats with a double-blade knife were cut out specimens (20 x 3 mm) in a anterior - posterior direction of the eye.Then the retinal - choroidal coat was removed from the sclera. The specimen thichness was determined with a cathetometer KM-6, with exactness of $\pm$0.001 mm.During the tension by a test equipment F 01 S the specimens were kept in the physiological solution at a temperature of 37.0$\pm$1.0^{o} C. The tests were carried out according to the 0.0-0.1 N scale with the scale division of 0.001 N. The strain rate $\dot{\varepsilon} = 0.6\ \%\ s^{-1}$. The test curves $\sigma - \varepsilon$ were approximated by the equation: $\sigma = D1\,\varepsilon + D2\,\varepsilon^{3}$, where σ -the real stress affects the cross section of the specimen; ε -longitudinal strain; D1 and D2 - approximation coefficients determined by the method of least square.The stress was found from the dependence $\sigma = (P/F)(1+\varepsilon)$ assuming that the material was incompressible. Here P was the tension force and F the initial area of cross-section.The initial modulus of elasticity was found to be E=D1.It was assumed than the eye coats were an isotropic material and the form of the eye was close to a spherical thin wall shell. From values of the conditional intraocular pressure IOP = 0, 20, 40 and 100 mmHg were calculated stresses and, subsequently, modulus of elasticity.

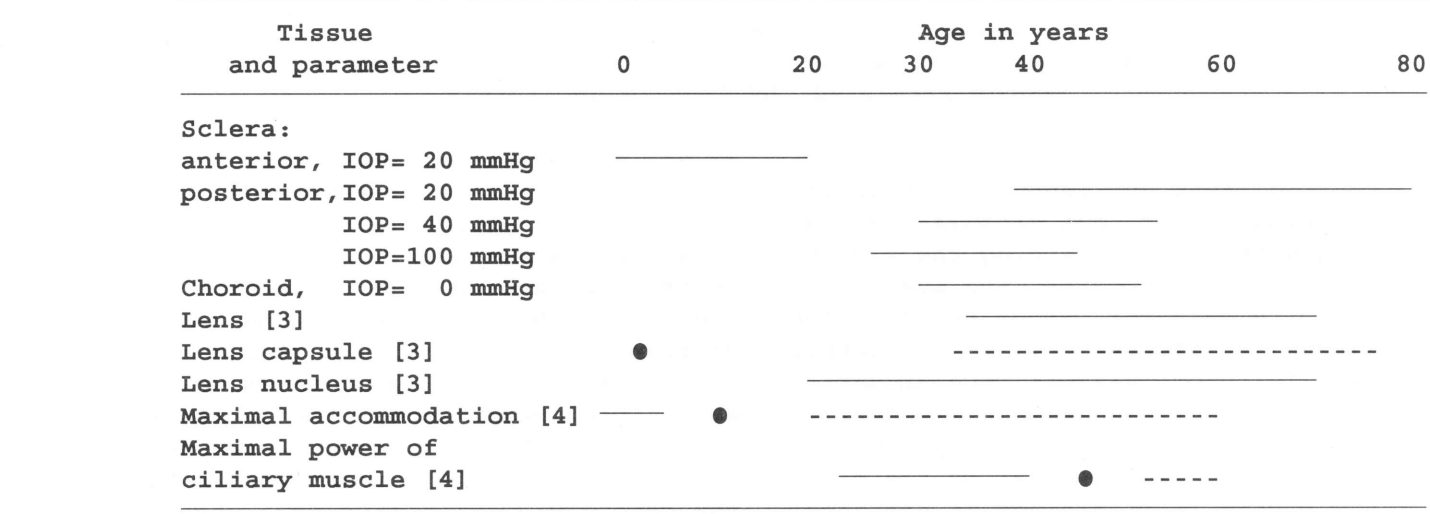
The changes of elasticity modulus of the tissue specimens with respect to age were expressed by the linear and nonlinear approximation equations.

RESULTS

The modulus E for the choroid is increasing with age and obtain stabilization at 40-45 yrs. (Table 1). For group III (11-18 yrs.) E=52.3$\pm$4.0 kPa, but for group IV (19-44 yrs.)-81.9$\pm$6.5 kPa (the difference significant; $p < 0.05$).The average modulus for the group V (45-59 yrs.), VI (60-74 yrs.) and VII (75-89 yrs.), when summed,is 85.6$\pm$ 11.0 kPa. The relationship between the age T and $E = 25.7 \cdot T^{0.31}$ kPa.

The modulus E for the anterior sclera is quickly increasing till 20 yrs., but afterwards the increasing slows down (Table 1).For the posterior sclera the modulus is increasing very slowly till 40 yrs.,but after that age the increasing speeds up.For the ante-

Table 1. Age increase —— or decrease --- (● the maximal value) of the eye tissue elasticity modulus, maximal accommodation and ciliary muscle power.



rior sclera the relationship between T and $E = 3198 \cdot T^{0.127}$, but for the posterior part - E=885.5 sign (72.08 T-5471) ! $72.08 \cdot T\text{-}5471\ !^{0.292} + 12199$ kPa. Sharp changes of modulus E for the posterior sclera appear at 76,75,41 and 40 yrs.at IOP= 0, 20, 40 and 100 mmHg, respectively.

DISCUSSION

The intensive changes of the sclera and choroid stiffness take place from the birth to 20 years and from 30 to 60 years. The anterior sclera stiffness increase in young age improve the mechanical stability of all eye systems. The posterior sclera stiffness is changing very swiftly because it is acting not only as an eye supporting element,but also as an anatomical component of refraction together with the lens providing good vision in near and far distance by elongation. The rise in the stiffness of the choroid is one of the factors which cause an increase in the force of the ciliary muscle to provide a full relaxation of the zonule fibres, when accommodating.This mechanism acting to provide normal vision at an advanced age may turn into a risk factor: an excessive increase in the activity and force of the ciliary muscle at the age of 40-50 years may damage the choroid - retinal coat of the eye.The generally accepted reason for the fall of maximal accommodation with aging is considered to be an augmentation of stiffness of the lens and the changes of its shape. However, it does not explain the ability of a person aged 45-50 years to read for short duration in near distance. The above age aspects of the mechanical properties of the choroid signify that in the first stage of presbyopia the interaction of the choroid stiffness and the possibilities of the ciliary muscle to contract is of great importance. Such sclera and choroid stiffness changes in young age could lead to the myopia by the lengthening of the eye.We suppose that the described factors are significant on formation and development of such pathologies as myopia,presbyopia,glaucoma and choroid - retinal detachment.

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