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Biomechanical patterns of stress distribution in various topographic sclera areas in children with axial myopia

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RELEVANCE

The main biomechanical parameters of normal sclera were established in vitro

Curtin BJ, 1969; Avetisov ES et al., 1971, 1978; Saulgozis Yu.J, 1979, 1981; Akpatrov AI, 1983; Iomdina EN, 1984, 2000; Gloster J, Perkins ES, 1957; Woo SL et al., 1972; Schlegel W et al., 1972; Battaglioli JL, Kamm RD, 1984; Arciniegas A et al., 1986; Friberg TR, Lace JW, 1988; Lepore D, 1996.

A wealth of facts confirm the involvement of sclera in the pathogenesis of progressive myopia

Avetisov ES et al., 1971, 1979; Bulach E.Kh., 1971; P Volkolakova R.Yu, 1980; Saulgozis Yu.J, 1981; Savitskaya N.F. et al, 1982; Iomdina EN, 1984, 2000; Saulgozis Yu.J, Volkolakova R.Yu, 1982, 1986, 1987; Arciniegas A, Amaya L, 1980, 1998

Are the results obtained with the use of isolated scleral specimens *relevant* to the characteristics of the functioning eye?

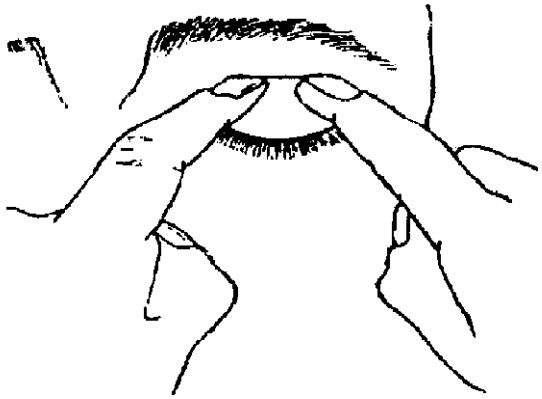
POINT OF VIEW

Lifetime assessment of the biomechanical properties of eye tissues is an almost impossible task.

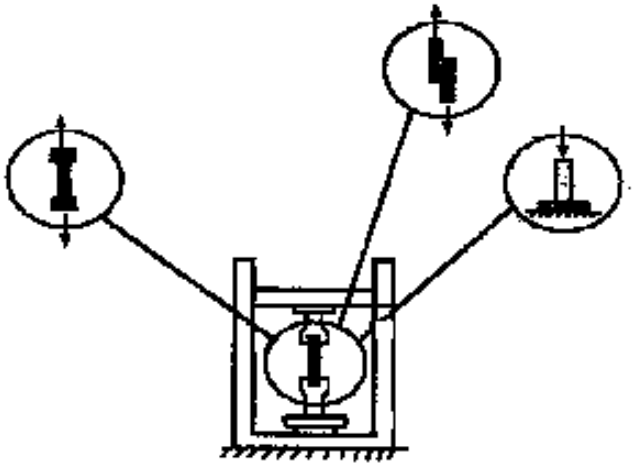
Causes:

- **deformities of various types of eye tissue**
- **the necessity to take into account a large number of parameters that characterise the functioning eye**

Approaches to assessing the biomechanical properties of eye tissues

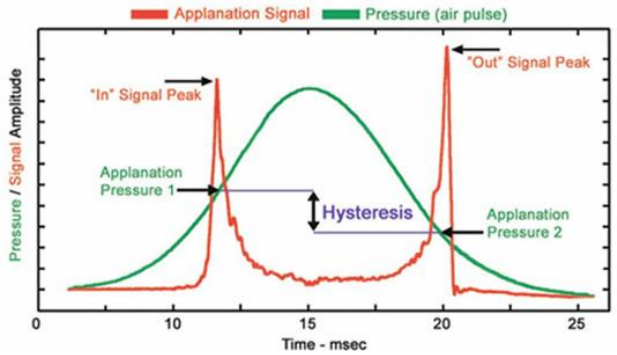


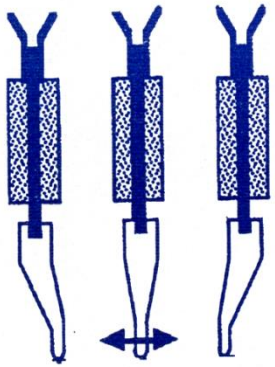
Methods based on the physician's sensations (transpalpebral palpation)



Experimental methods based on the evaluation of elastic-strength parameters for various types of deformation

Methods of lifetime assessment of biomechanical properties of eye tissues





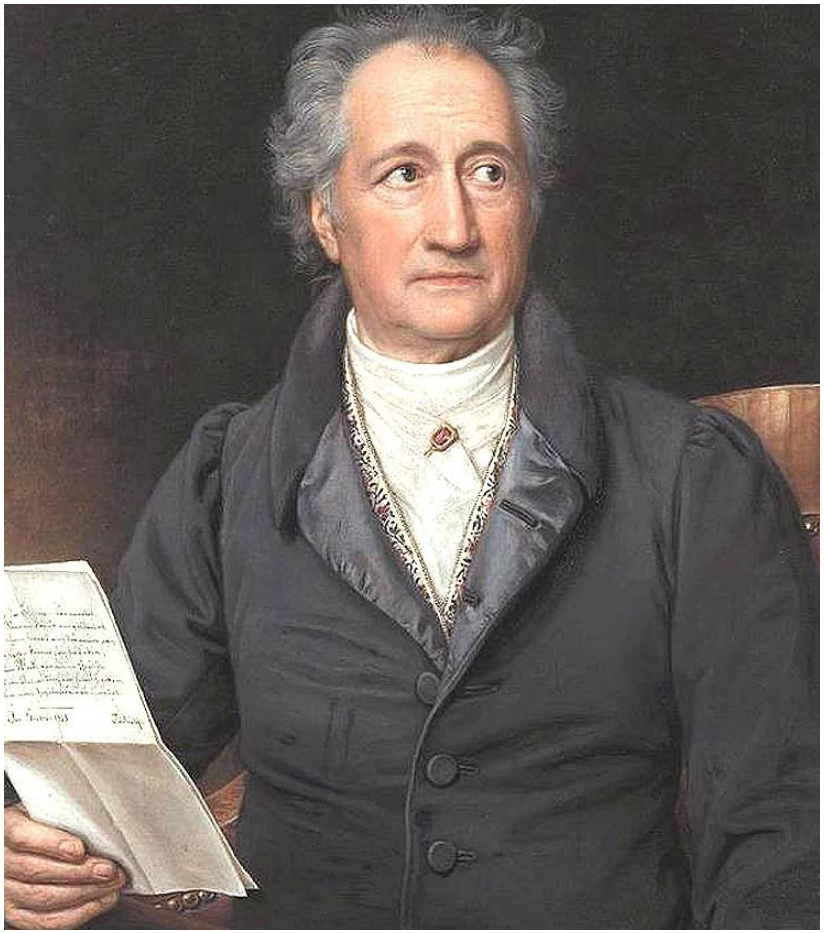
Analyser of biomechanical properties of the eye — ORA

(Ocular Response Analyzer)

— measuring corneal hysteresis

The Acoustic method

— measuring the velocity of shear waves between the radiating and receiving bending transducers

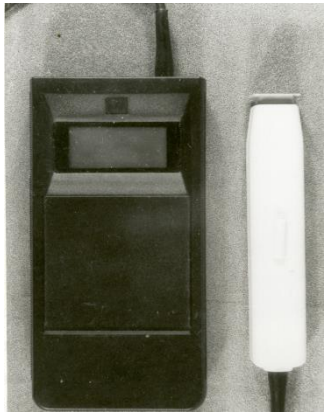


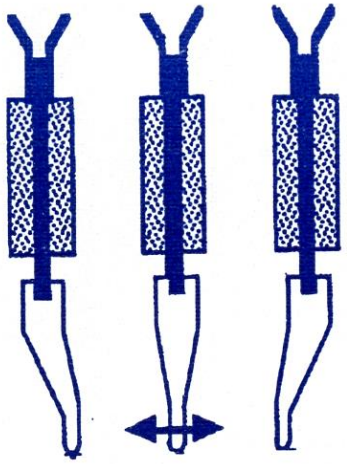
Johann Wolfgang von Goethe
(1749-1832)

«When scholars study a thing, they strive to kill it first, if it's alive; then they have the parts and the'be lost the whole, for the link that's missing was the living soul.”

Johann Wolfgang von Goethe, Faust

The Acoustic method of lifetime biomechanical investigation



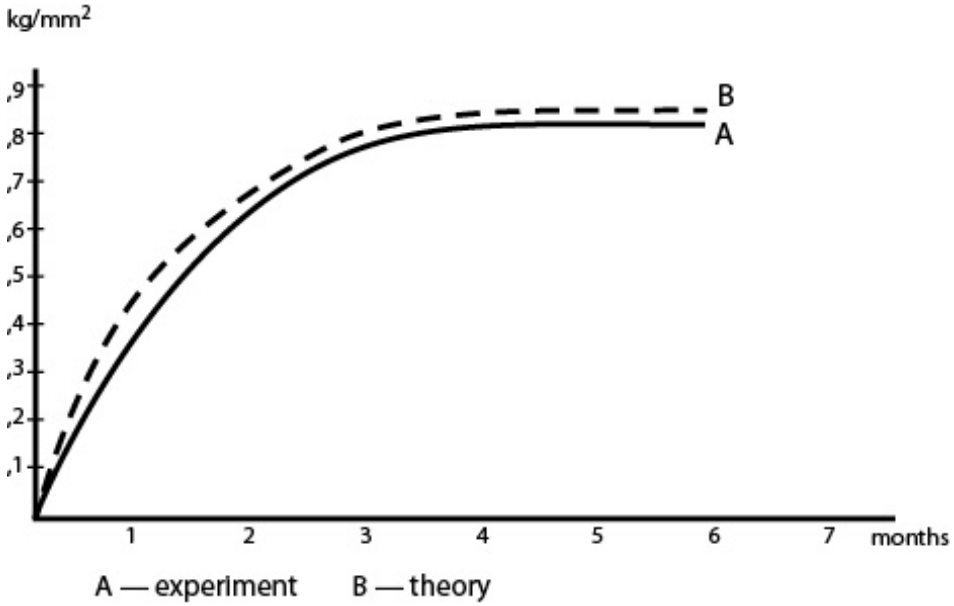


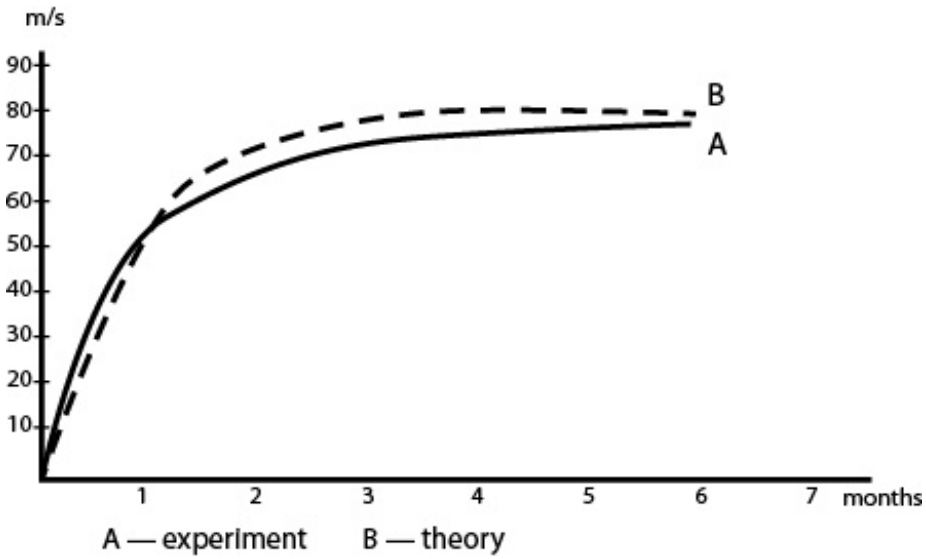
Advantages

- Non-destructive
- The intensity of acoustic waves is negligible
- Highly sensitive to structural changes in the tissue
- Allows to scan different topographic areas and find "vulnerable" spots in the sclera

Sarvazyan AP et al., 1980, 1981, 1983, 1986, 1990; Sarvazyan AP, Vucelic D,1990; Obrubov SA, Sidorenko EI, Fedorova VN, Dubovay TK, Dreval AA., 2001. (in Russian)

CHANGE OF DENSITY AND ACOUSTIC SURFACE WAVE VELOCITY IN THE SCLERA





$$C = (E/p)^{1/2}$$

E – elasticity modulus, p – density of sclera

PURPOSE OF THE STUDY

- To reveal the biomechanical properties of the pre-equatorial area of sclera

- To investigate the relationship between the severity of changes in eye fundus and biomechanical characteristics of the sclera in children with axial myopia

MATERIALS

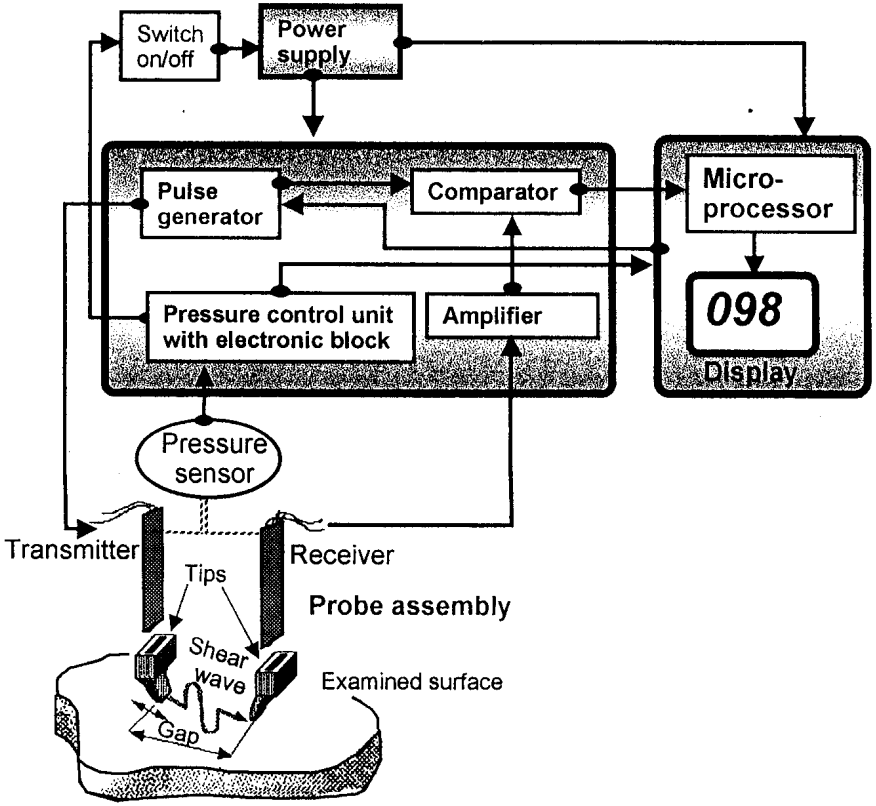
130 children (260 eyes) aged 12 to 16 with undifferentiated connective tissue dysplasia (UCTD).

- **The 1st group (MAIN) – 73 children (146 eyes) with UCTD (Reflux nephropathy, neurogenic bladder dysfunction, chronic glomerulonephritis) and myopia**
- **The 2nd group (CONTROL) – 57 children (114 eyes) with UCTD and emmetropia or low hypermetropia**

METHODS OF CLINICAL RESEARCH

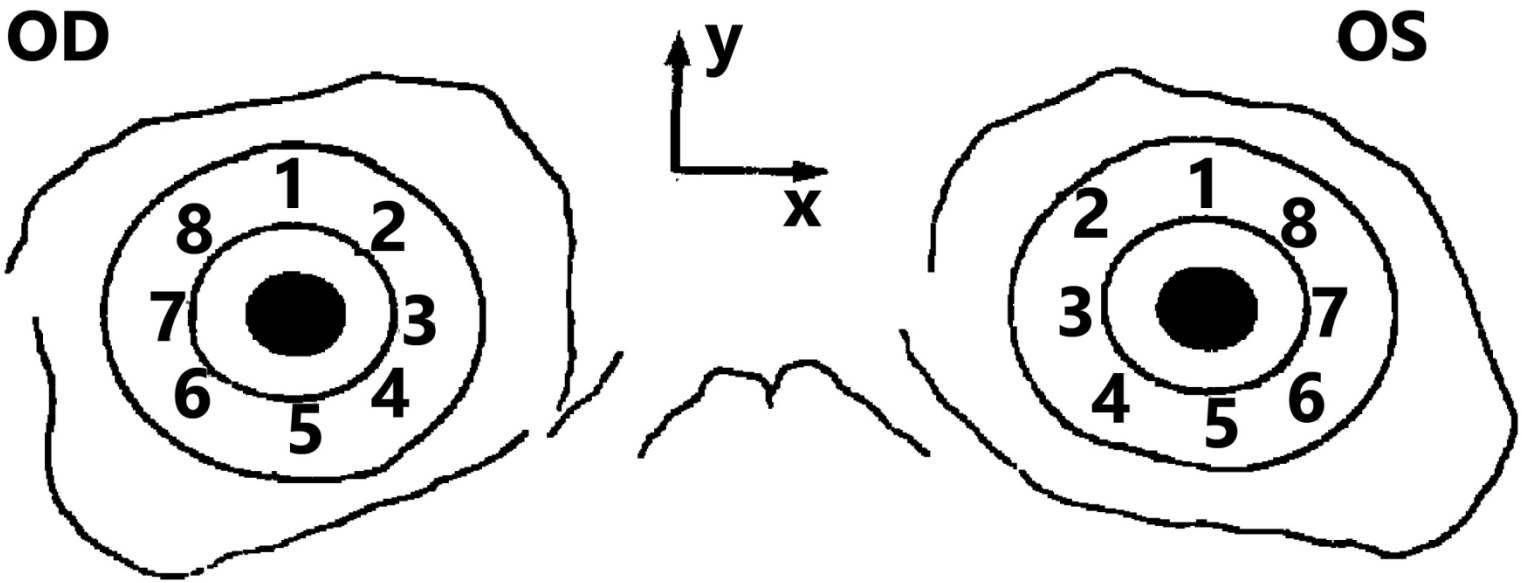
- ✓ Anamnesis
- ✓ Standard ophthalmologic examination
- ✓ Checkup, including a set of special research methods to identify external phenotypic signs of connective tissue dysplasia
- ✓ Functional research methods to identify internal phenotypic signs of connective tissue dysplasia (ultrasonic cardiography and ultrasound of the abdominal cavity organs with a Voluson 730 Expert ultrasound machine (USA)

ACOUSTIC TISSUE ANALYSER

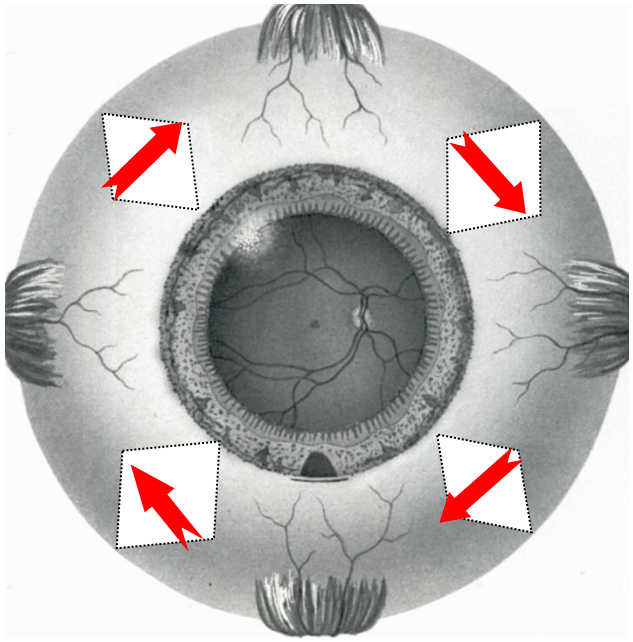


- The value range of the surface wave velocity: **15-250 m/s**
- Operating band: **5-6 khz**
- Working area: **8-20 mm^2**
- Continuous operation time: **4 h**
- Power (autonomous or from a power source): **9 volt**
- Dimensions of the electronic unit: **150x80x35 mm**
- Dimensions of the sensor: **120x20x20 mm**
- Weight: **0.42 kg**

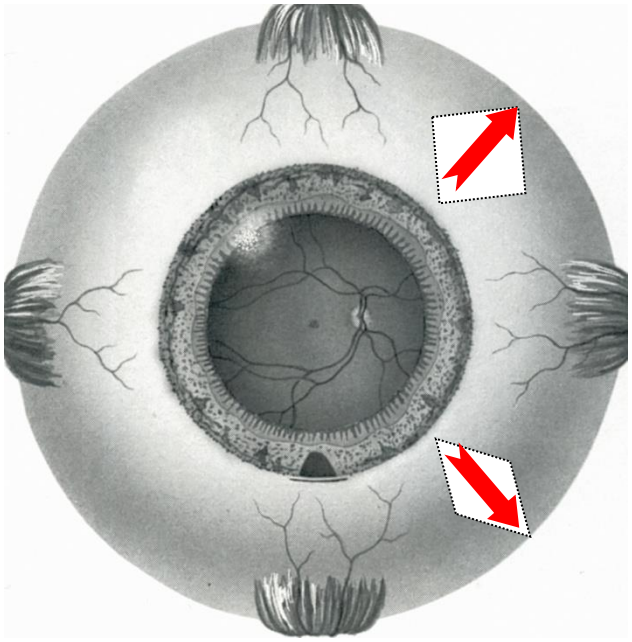
Measurement of the acoustic surface wave velocity in different quadrants of pre-equatorial scleral belt in children



The direction of stretching in the pre-equatorial area of the sclera in children in the control group and with myopia



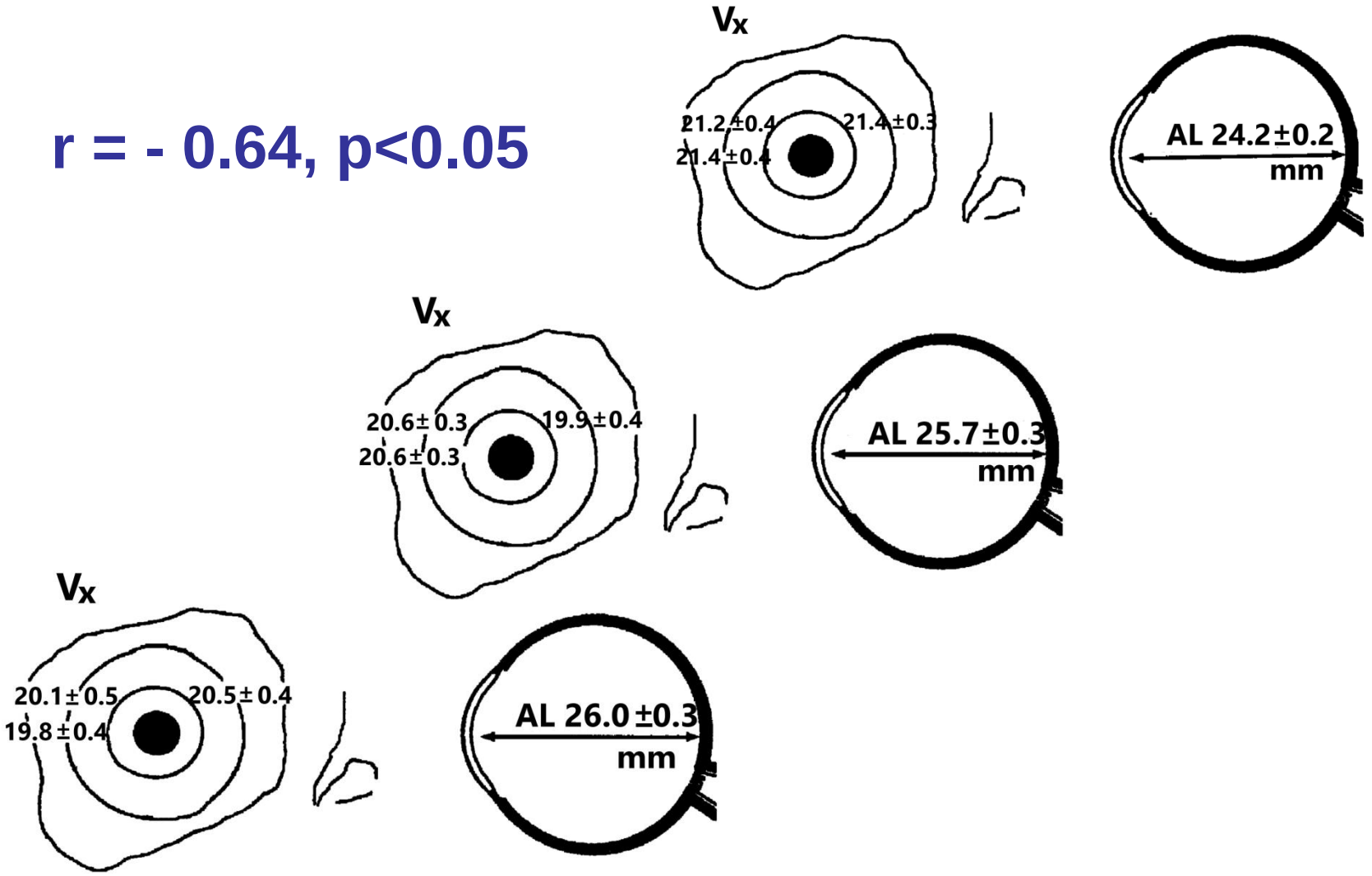
Control group



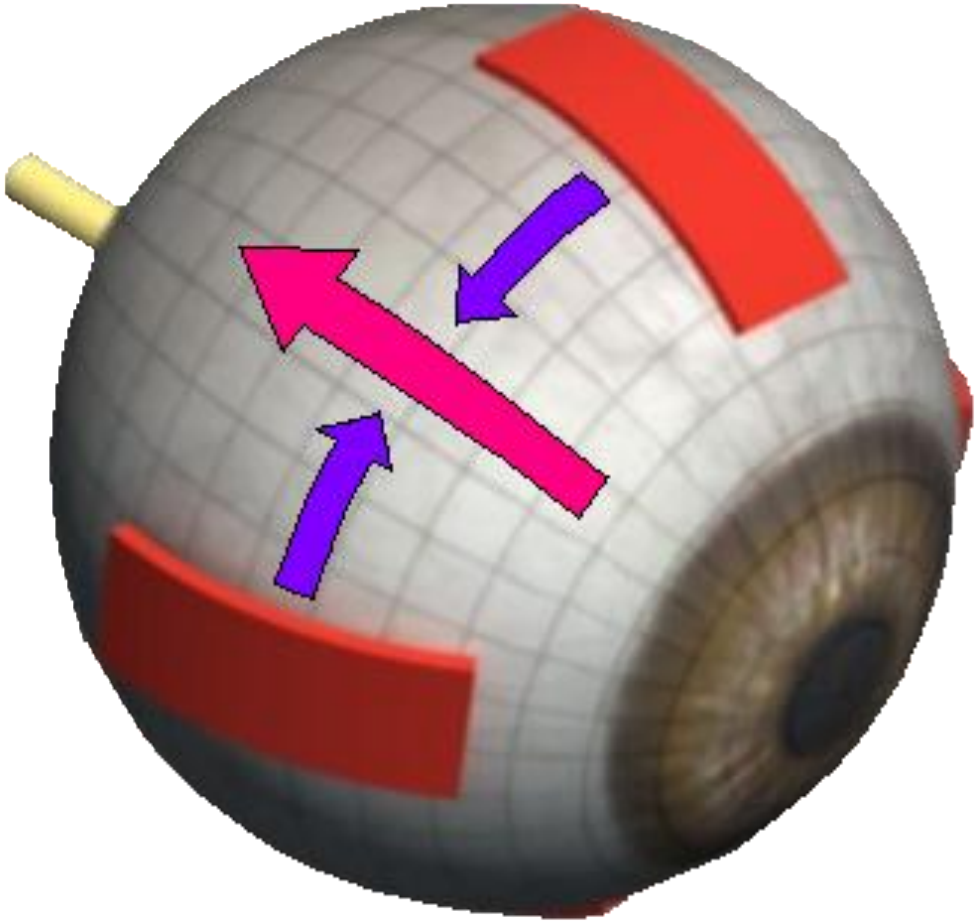
Myopia associated with UCTD

Measurement of acoustic biometrics in children with different axial length of the eye

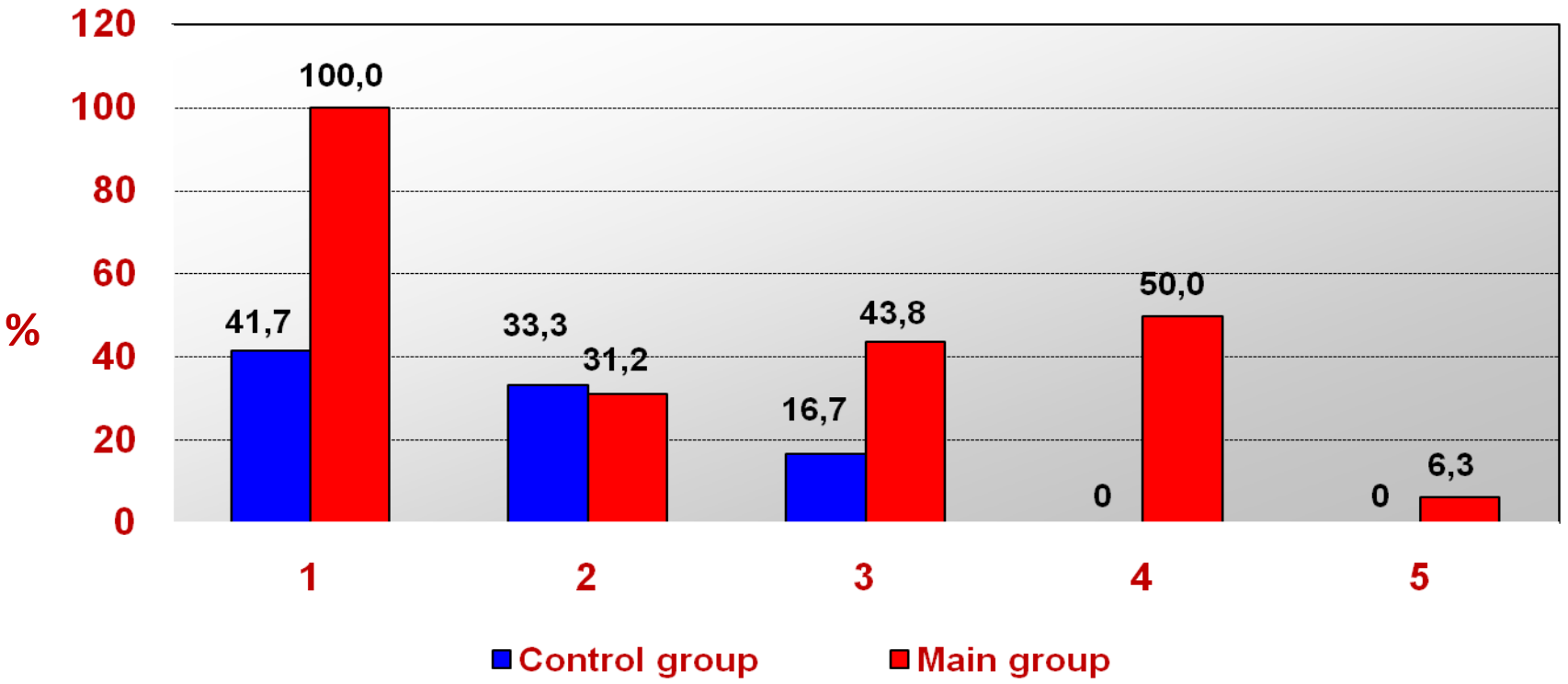
r = - 0.64, p<0.05



Patterns of changes in stress in the pre-equatorial area of sclera in myopic children



Lifetime morphological changes in the macular area (by OCT)



1 – thinning of the neuroepithelium

2 – smoothness of the macular area

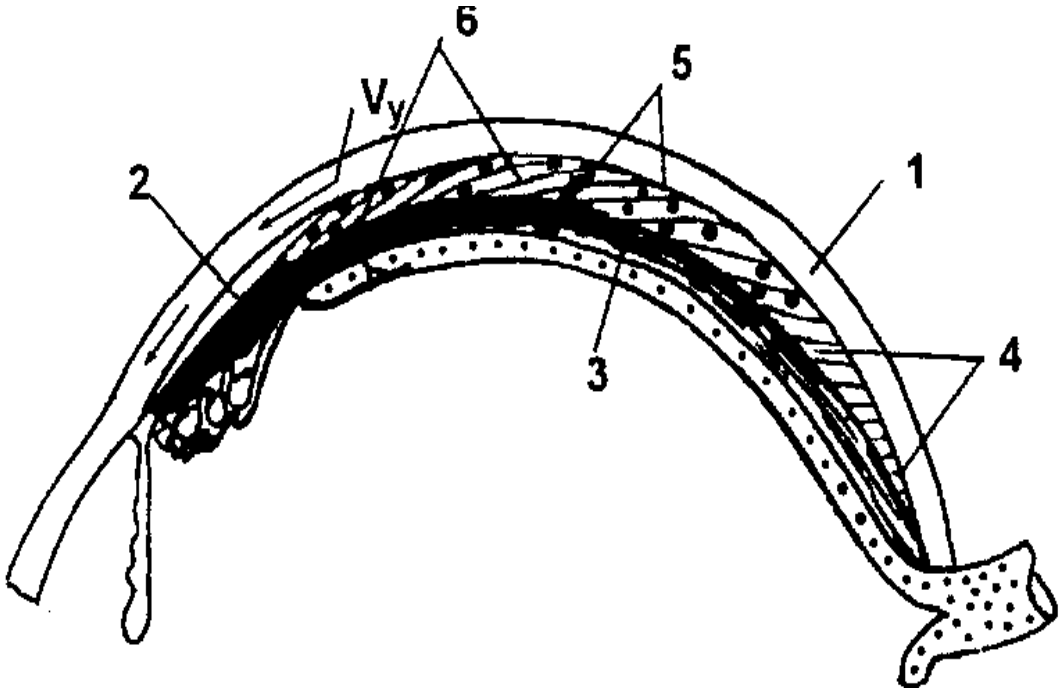
3 – defect of the integrity of the Bruch's membran

4 – dystrophic changes in retinal pigment epithelium

5 – fovea pre-break

Relations between ciliochoroidal layer and sclera

from **Gorban' A.I., Dzhaliashvili O.A.** (1993). *Mikrokhirurgiia glaza: oshibki i oslozhneniia (Miscrosurgery of the eye: Mistakes and complications)*. Saint Petersburg: Gippokrat.



1 – sclera

2 – ciliary muscle

3 – choroidea

4 – posterior lamina of suprachoroidea

5 – muscle "stars"

6 – anterior lamina of suprachoroidea

CONCLUSIONS

- In the pre-equatorial scleral belt in children with UCTD the acoustic surface wave velocity varies from 17 to 36 m/s depending on the zone and direction of scanning.

- In children with hypermetropia and emmetropia the dominant tension is the tensile stress in the horizontal direction (X axis).

- In children with acquired myopia of various degrees the frequency of the tensile stress in the vertical direction (Y axis) in the zones of the upper and lower outer quadrants of the eye increases.

CONCLUSIONS

❖ A negative correlation was established between the axial length of the eye and surface waves speed along the X axis ($r = -0.64$, $p < 0.05$)

❖ The severity of changes in the fundus in myopic eyes associated with UCTD syndrome is closely related to the biomechanical features of the pre-equatorial area of the sclera.

Thank you for your attention!