CHANGES OF VISCOUS-ELASTIC SKIN PROPERTIES IN SCLERODERMIA PROGRESSIVA PATIENTS

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Sclerodermia progressiva is a nosological unit characterized by dermal sclerosis in superficial and deeper layers. Certain changes set in affecting the organization and quantity of collagen in derma, hypoderma, superficial fasciae as well as the blood supply presented by an inflammatory infiltrate (8). These clinical manifestations induce changes of the biomechanical skin properties. It is accepted that collagen augmentation is due to the increased tropocollagen secretion by fibrocytes accompanied by its reduced dissimilation capacity (1).

The purpose of the present work is to make a quantitative evaluation of skin viscous-elastic properties in Sclerodermia progressiva patients. The objectivization of similar changes could help the more precise and earlier diagnosis of the disease and the control of the effectiveness of therapeutic methods and means.

Material and Methods

Biomechanical measurements were carried out with 5 Sclerodermia progressiva patients with a mean age of 51 years. 111 healthy subjects of both sexes aged between 20 and 60 years were examined as controls. Normal parameters corresponding to an average age of 51 years were determined by means of linear interpolation. An own method and device for measurement of skin viscous-elastic properties was used in our study (3). Skin surface in the upper third of the frontal side of the forearm was investigated. Two rectangular heels were sticked on it by tissue glue "Kanokonlit". Measurement configuration is demonstrated on fir. 1. The left heel was fixed to the corpse of the device but the right one was mobile. The value of force F as function of deformation and its size was recorded on modified electrocardiograph for 1 min long period when mobile heel was sharply removed to a preliminary determined distance $L-L_0$. This experiment
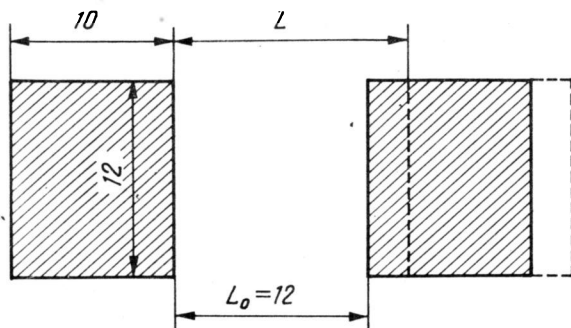

Fig. 1. Configuration of measurement field.

was repeated for $L-L_0$ = 0.25 mm; 0.5 mm; 0.75 mm; 1 mm; 1.25 mm, and 1.5 mm. Skin thickness d was also measured.

With further examinations, rationed force F* equal to the ratio between the value of force applied F and skin thickness d was used. It turned out that the following equation was valid with this relaxation experiment performed:

$$.F^* (L - L_0, t) = F_1 (L - L_0) . F_2(t),$$

i.e. it was possible to divide the dependence "rationed force — removing" from the dependence "rationed force — time". The first dependence was well approximated with the exponential function of the kind:

$$F_1 (L - L_0) = \frac{M}{k} . (\exp (k . (L - L_0)) - 1), \text{ where}$$

M (Pa) was the initial hardness of the system but $k(m^{-1})$ — a coefficient of inlinearity (2). Temporal behaviour of rationed force satisfied the following law:
$$F_2(t) = G + H.(Ei(t/T_2) - Ei(t/T_1)) . (1 - G); H . \ln(T_2/T_1) = 1,$$ where H, $T_1(s)$ and $T_2(s)$ determined the velocity of mechanical skin response but G was equal to the ratio between balanced force with time longer than 60 s and initial force thus presenting relative skin viscosity (4).

Similar measurements were performed both parallelly and perpendicularly to Langer's lines.

The values of independent parameters M, k, H, T_2 and G were determined on the basis of experimental data after the method of the smallest squares by using of an original software for personal computer "Pravetz — 82". Our method used was rapid, non-invasive and suitable for mass screening investigations.

Results and Discussion

The results from this study were presented on table 1. Individual quantities (x) and mean values (x) with their standard deviation (s) were given. A confidence interval was presented for log-nomially distributed time of relaxation T_2.

It is a noteworth fact that four patients have a significantly increased skin thickness over 50 per cent. Special attention is paid to thickened skin in Sclerodermia progressiva by numerous investigators (9—11).

The initial skin hardness M is significantly increased when both directions are concerned (parallelly and perpendicularly to Langer's lines) with all the patients studied. Some authors (6—8) report similar reduction of skin elasticity in this disease when low loadings are applied. The explanation of such a mechanical behaviour of the skin should be searched into its structural alteration. The increased skin resistance towards low loadings is due to the hampered reorientation of collagen fibres in direction to the force applied because of the links between them and with underlying fasciae as well. Collagen fibre activation sets in gradually with force increase when skin is normal. However, relatively a greater number of fibres tauten even at low values of mechanical tension applied when skin is sclerodermic. This fact explains the significantly reduced value of inlinearity coefficient for the whole group with the experiment carried out showing deformity parallel to Langer's lines.

Sclerodermia progressiva patients' skin shows difference from normal one when its temporal behaviour is also concerned. There is a delayed mechanical response of the system (parameter H is reduced). At the same time, viscous component of pathologically altered skin is considerably diminished. This phenomen is also due to the structural changes of the skin. It is known that with relaxation the force required to maintain a given deformity reduces because of reorienta-

Table 1

Results from measurements of skin biomechanical properties in Sclerodermia progressiva patients
(n = 5; control group − 111 cases)

	NoNo	Sex		Age	(mm)	Model parameters Parallelly to Langer's lines				
						$M(\times 10^5 Pa)$	$k(\times 10^3/m)$	H	T_2S	G
control group			x	51	1.29 0.26	0.428 0.10	1.70 0.33	0.151 0.04	34 ÷ 92	0.622 0.11
pati- ents	1	male	x	51	2.2**	1.58**	1.61	0.11	90	2.36**
	2	fem.	x	55	1.4	1.62**	1.14	0.11	101	0.83
	3	fem.	x	49	2.0*	4.74**	0.82**	0.12	93	0.85*
	4	fem.	x	51	2.0*	1.15**	1.22	0.15	96	0.82
	5	fem.	x	49	2.3**	3.47**	0.98*	0.14	69	0.81
			x	51	1.98** 0.35	2.51** 1.53	1.15** 0.29	0.127*** 0.016	74 ÷ 107	0.805** 0.055

	NoNo	Sex		Age	(mm)	Model parameters Perpendicularly to Langer's lines				
						$M(\times 10^5 Pa)$	$k(10^3/m)$	H	$T_2(S)$	G
control group			x	51	1.29 0.26	0.435 0.12	1.01 0.21	0.147 0.04	43 ÷ 136	0.627 0.12
pati- ents	1	male	x	51	2.2**	1.14	0.11	0.11	124	0.71
	2	fem.	x	55	1.4	2.23**	0.93	0.13	80	0.83
	3	fem.	x	49	2.0*	1.99**	0.83	0.13	78	0.87
	4	fem.	x	51	2.0*	-	-	-	-	-
	5	fem.	x	49	2.3**	2.43*(	0.68	0.13	79	0.88
			x	51	1.98** 0.35	2.26** 0.19	0.897 0.19	0.125* 0.007	67 ÷ 118	0.819** 0.08

* p < 0.05   ** p < 0.01

tion of fibres in gel-like medium of the basic substance. A similar movement is delayed not only because of the action of viscous force of rubbing between collagen fibres and the matrix but also because of transport of viscous fluid. Reduced space between fibres inhibits both processes although the quality of the basic substance is not considerably affected by the pathological process (5). Simultaneously, internal links between fibres hamper their reorientation which provides an explanation also of the predominantly elastic response of the pathologically damaged skin.

It can be concluded that by means of the method described viscous-elastic properties of human skin can be determined quantitatively in vivo not only in normal state but also in Sclero-

dermia progressiva patients. The combination of increased skin thickness and elevated values of initial hardness M in both directions can be applied as serious criterion for the presence of sclerous dermal alterations. Reaction time increase and viscous component reduction both possess an additional proof value. The quantitative objectivization of viscous-elastic skin properties has to a certain extent a diagnostic value, too, but it would be still more valuable with the evaluation of the different therapeutic means.

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ИЗМЕНЕНИЯ ВИСКОЗНО-ЭЛАСТИЧЕСКИХ СВОЙСТВ КОЖИ У БОЛЬНЫХ ПРОГРЕССИРУЮЩЕЙ СКЛЕРОДЕРМИЕЙ

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Р Е З Ю М Е

В работе сделана количественная оценка вискозно-эластических свойств кожи здоровых лиц и больных прогрессирующей склеродермией. С этой целью использованы оригинальная методика и аппарат для осуществления одноосевых релаксационных экспериментов. Установлена значительная разница в биомеханическом поведении здоровой и склерозированной кожи. Предлагаемую автором методику можно применять при диагностике прогрессирующей склеродермии и при оценке используемой терапии.