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TENSILE STRENGTH AND ELASTICITY TESTS ON HUMAN FASCIA LATA*

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The possibility of more extensive use of living sutures in surgical fields has led to a study of the tensile strength and elasticity of the one most commonly used,—namely, fascia lata. This paper presents certain test data which have been selected from the observations made.

In 1924 a pioneer study in this field was presented by Gallie and Le Mesurier[1]. They made rough tests of the tensile strength of fascia taken from the backs of rabbits. The fascial strips were used to repair the edges of the gap left by their removal. These were recovered at intervals varying from a few days to two years and again tested. "No stretching or contracture occurs and the strength of the suture is approximately the same as at the time of operation." The above research, besides confirming the viability of fascia as suture material, also showed that its strength remained unimpaired over long periods. A search of the literature did not reveal any other tests of this nature.

In 1930 the author undertook to measure with engineering accuracy the tensile strength and elasticity of human fascia lata. To summarize the results briefly, the material showed surprisingly great tensile strength comparing favorably with soft steel wire of the same weight; in addition it showed an unexpected degree of elasticity. An effort was also made to utilize the test results clinically as an approximate guide in determining the correct size of suture to be used in operative procedures.

The test material was obtained from the thighs of patients who were at the time undergoing operations in which this material was to be used, a small piece of the fascia lata being reserved for test purposes. The test piece was immediately packed in saline-moistened gauze and sent to the testing laboratory. The elapsed time between the removal of the test piece and the actual testing of the material varied from two to eighteen hours. It is of interest to note that even after eighteen hours delay the material was essentially alive at the time of testing.

The tests were conducted by the New York Testing Laboratory on the standard tension machine used for the general testing of engineering materials, under the supervision of a consulting engineer, Mr. F. J. Nankivell. We hoped in this way to have the advantage of engineering experience and equipment to aid us in the solution of these problems.

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The actual testing presented difficulties which had to be overcome before sufficiently accurate results were obtainable. The inherent difficulties were that the fascia was of a soft and slippery nature and that only a small test piece was obtainable. It was necessary to line the grips of the testing machine with emery cloth to prevent slipping, and also to pierce the fascia lata with small pins to obtain points which could be used for measuring the amount of stretch or elongation. Due care had to be exercised to apply steady tension in order to avoid fluctuations which would have resulted in excessive inaccuracies.

The following reproduction of one of the test sheets on fascia lata taken from an athletic individual is self-explanatory.

TENSILE TESTS ON SUTURE FROM LEG OF MAN

Weight in grams	1.305	Average thickness	0.014in.
Length	4.7 in.	Average area	0.0084 sq. in.
Width	0.60 in.	Dis. bet. heads no load	1.73 in.

Test No. 1		Test No. 2		Test No. 3	
Load lbs.	*Elongation reading in.*	*Load lbs.*	*Elongation reading in.*	*Load lbs.*	*Elongation reading in.*
0	1.30	0	1.30	0	1.325
5	1.31	4	1.33	7	1.34
8	1.32	8	1.34	12	1.35
12	1.34	12	1.34	16	1.36
16	1.34	16	1.35	20	1.365
20	1.34	20	1.36	25	1.37
24	1.365	24½	1.365	30	1.37
		30	1.37	36½	1.38
		36	1.38	40	1.385
		40	1.39	48	1.40
		44	1.40	52	1.40
		48	1.405	56	1.405
				62	1.405
				66	Broke
Remove load		*Remove load*			
20	1.36	40	1.39		
16	1.35	36	1.383		
12	1.34	30	1.380	Tensile	
8	1.33	23	1.37	strength lbs.	
5	1.32	16	1.36	per sq. in.,	7,860
0	1.30	10	1.355		
		5	1.35		
		0	1.325		

Remarks: Pins inserted into suture for gage marks. Emery cloth used in grips. Good break was obtained between grips. Failure was of the nature of a slippage of fibers.
Operation performed 3:00 P.M., October 6. Kept wet with saline solution. Test at 10.00 A.M., October 7.

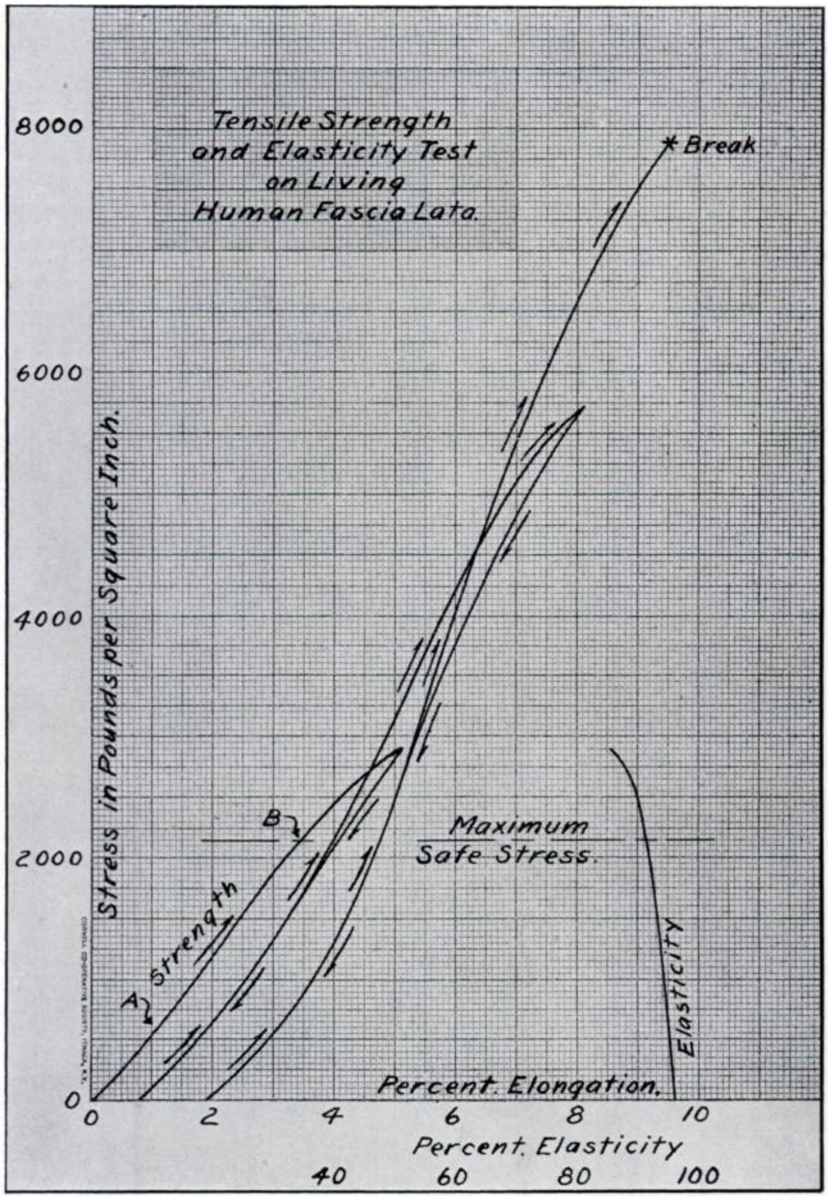

CHART I

The portion from A to B on the strength curve has been selected from an engineering standpoint as the safe working range, as it is the portion where the material shows its greatest elasticity. It will be noted that the elasticity curve within this range shows that the elasticity is well above ninety-one per cent. Above the line of maximum safe stress the strength curve bends sharply and the elasticity curve shows the same phenomenon. The position of the curve above this line shows these tests carried on to destruction. While it is of interest to know the percentage of overload which this tissue may stand, the operative technique should be so devised as to limit the stress to a point within the range indicated.
(A physiological explanation of the above phenomena is presented in the text.)

After making the necessary engineering allowances for inaccuracies in instrument readings we were able to prepare a composite of the results of data on material from several individuals, and from these to plot the accompanying graphs of tensile strength and elasticity (Chart I).

The curves in these graphs show the reaction of fascia lata to varying degrees of tension; the graph on the right shows the corresponding elasticity. As tension is applied an elongation takes place, at first quite pronounced (*O* to *A*). The material then stiffens (*A* to *B*) and finally relaxes again. Upon releasing the tension the test piece returns nearly to its original length. When subjected to tension greater than before, the same cycle is repeated except that the material is slightly stiffer and less elastic. When sufficient tension is applied the material is destroyed and a calculation of the maximum tensile strength is obtained.

It is of interest to study the above findings in relation to the structure of fascia lata as shown by microscopic study. This tissue consists of "a mass of very thick parallel fibers which runs a straight or slightly wavy course. Between these fibers are scattered a small number of connective-tissue corpuscles (tendon cells). The fibers are gathered into bundles which are separated by a small amount of areolar tissue. The parallel arrangement of heavy fiber fascia and tendon gives these tissues great strength in one direction,—that is, in the direction in which they are normally subjected to strain."[2]

A probable explanation of the phenomena observed rests in successive adjustments of the material composing fascia lata to the tension applied. The areolar tissue cells, being weaker than the fibers, are the first to break down, leaving the tension to be resisted by the stronger fibrous material. With an increase in the tension applied, the fibers begin to separate from the tendon cells. The final rupture of the material occurs with the pulling apart of the fibers one from the other. Macroscopically the fibers themselves did not appear to break. In the three materials the cohesive forces within the areolar tissue are comparatively weak. The adhesive forces between tendon cells and fibers are greater and the cohesion in the fibers themselves shows the greatest strength.

The fibers are also the elastic elements. The elasticity is interfered with to some extent by the areolar tissue, especially after it is broken down by excessive stretching. In spite of this, however, the elasticity (the capacity to return to original dimensions) of the material, under the limits of maximum safe stress, is above ninety-one per cent., as shown by the elasticity curve. The graphs in Chart II depict the result of a similar test of prepared fascia lata and demonstrate the variations in strength and elasticity between the living and dead tissues. It will be noted that the elasticity of the latter does not compare favorably with the living fascia lata, hence its maximum safe stress would be much less. The comparative strength and thickness of human fascia lata from three individuals as shown below indicates that there is a comparatively small variation in maximum strength.

	Average thickness	*Maximum tensile strength*
Adult female seventy-four years of age	.017	6222
Athletic male thirty-five years of age	.014	7860
Paralytic female fifteen years of age (both legs involved for ten years)	.030	6375

From an analysis of the above data, the following observations may be made:

Maximum load for living fascia lata sutures.

The strength of fascia lata is proportional to its area of cross section. Thickness in the specimens studied varied from one-sixty-fourth to one-thirty-second of an inch. Taking an average thickness, the breaking tension of a strip of this material three-eighths of an inch wide is about fifty-five pounds. Working under the maximum safe stress, as described in the graph, the optimum load applied to such a strip should not exceed fifteen pounds.

When it is thought that the load requirement may be in excess of the above figure, a larger or multiple suture should be used. When a suture is tied in a loop, it is approximately equivalent to a single suture of double strength provided that the technique of tying is correct. Multiple sutures are preferable to wider ones as a proper lymph supply more readily reaches the central portion. The following table is an approximate guide for the widths of sutures for clinical use, based on average thickness of .02 inches (one-fiftieth of an inch):

Width in inches	*Safe tension in pounds*	*Width in inches*	*Safe tension in pounds*
3/16	8.07	3/8	16.1
1/4	10.75	7/16	18.8
5/16	13.5	1/2	21.5

Comparative strength of fascia lata.

The specific gravity of fascia lata is about 1.31 and the average ultimate tensile strength is approximately 7,000 pounds per square inch. Soft steel has a specific gravity of 7.83 and an ultimate strength of about 45,000 pounds per square inch. Thus fascia lata is nearly as strong as soft steel, weight for weight.

Elasticity of fascia lata.

The high elastic property of this tissue is important since it tends to correct any displacement of osseous structures after operation, if the sutures are properly placed. The presence of excessive fatty tissue may interfere with their elasticity and also their viability.

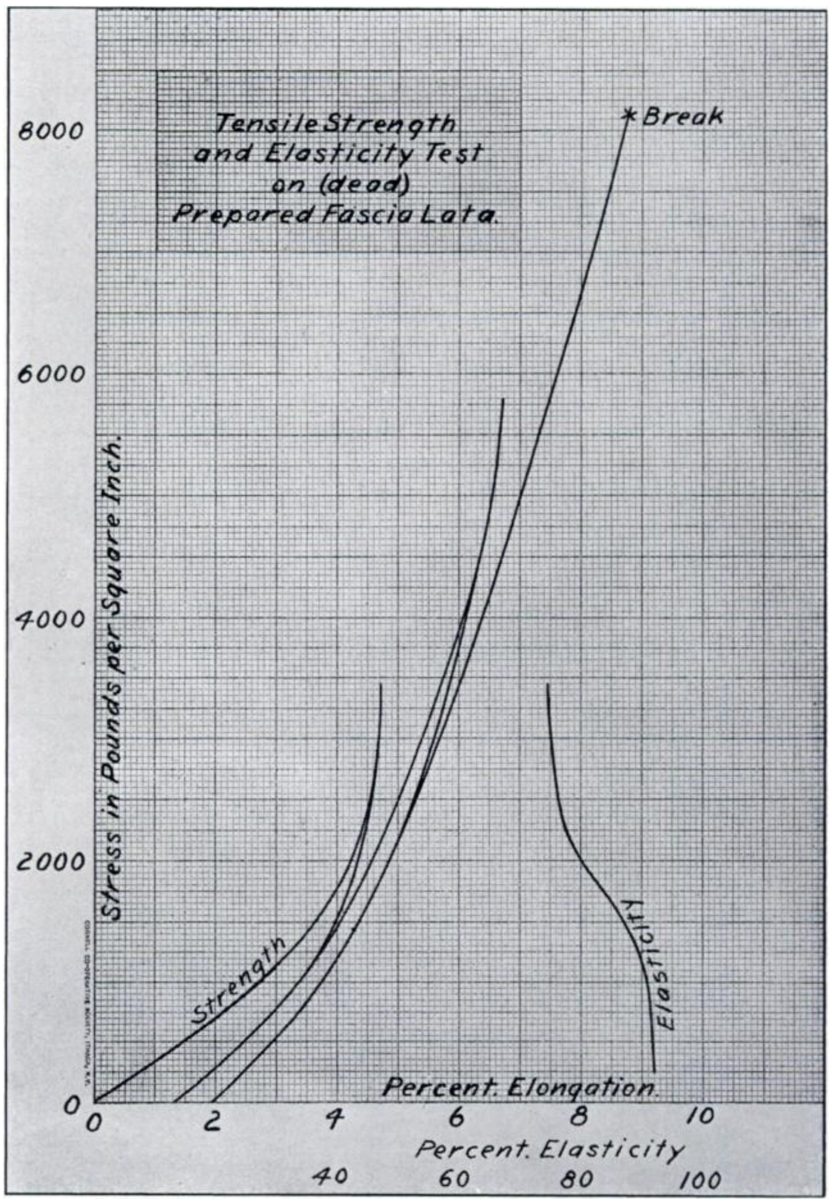

CHART II

COMMENT

The above observations presuppose that the sutures are used in such a way that the stress is placed longitudinally in the direction of the fibers, since fascia lata has very little strength in the transverse direction. Operative procedures must be so devised as to bear this in mind. It is hoped that these tests and observations may supplement previous researches and be of value in the clinical use of living suture material. Similar tests of other fascial tissues are contemplated.

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