A Study of Applied Force as Related to the Use of Elastics and Coil Springs

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The purpose of this research and subsequent report was to determine the amount of force applied in the use of elastics and coil springs in orthodontic therapy. Experimentally, the average force required to displace various elastic bands and coil springs a unit distance was studied and the results compiled into tables. As work upon the project progressed, many interesting facts developed, which it is hoped will be of value to those interested in the use of these auxiliaries to accomplish the desired movement in the treatment of orthodontic cases.

Before beginning the study an instrument had to be developed capable of registering the amount of force per millimeter displacement for each elastic, and for each unit length of coil spring tested. This was accomplished by placing millimeter graph paper upon a wooden slab 1" x 6" x 14". At one end of this slab a fixed pin was placed to serve as an anchor post for the article being tested. On the opposite end a pulley was mounted with a needle point axle, over which a .010" steel ligature passed, with one end attaching to the article, the other engaging the weights. An arm projected from this attachment, which in turn slid freely upon the millimeter graph paper, thus providing a gauge to record the relative displacements.

To obtain the most accurate results, a minimum of 35 random samples were taken of each size and brand of elastic selected for study. Each sample was then subjected to the equivalent of two tests by recording the pull as increments of 50 gram weights were added; the load was then decreased in corresponding amounts. By averaging these results it was possible to obtain correlated statistics on elastics.

A similar procedure was used in testing coil springs except that instead of 35 to 70 tests on each sample, results of early experiments indicated that sufficient accuracy was obtained in 5 to 10 selections.

The statistical data were then assembled in tables best to illustrate the results, with the following explanation offered thereof.

In Table I labeled "Elastics", the various samples of different brands of elastics are listed at the extreme left. Column I indicates the millimeter displacement per 50 gram force, that is, this represents the average displacement recorded as units of 50 grams were first added to and later subtracted from the elastic when under test. (In making the test, it was either a case of displacing the elastic a given number of millimeters for each trial or using the same weight and allowing the reading to vary. The latter system proved most reliable. However, in testing the Unitek elastic No. 253 and No. 251, it was necessary to use only 10 grams, as the displacement was too great with 50 grams; this was then converted to a 50 gram scale for uniformity when entered in Table I.)

Column II shows the lower and upper limits that were encountered in determining the measurements. With the exception of Unitek elastic No. 253 and No. 251, this variation is not so great as might have been expected.

TABLE I — ELASTICS

COLUMN	I	II	III		IV	V	
Sample	Mm. Disp. per 50 Gr. Force	Variation in Mm. Disp. per 50 Gr. Force	Force per 1 Mm. Disp.		Aver. Size at Rest Position	Actual Force Applied by Stretching Thrice Original Length	
			Gr.	Oz.		Gr.	Oz.
Ortho-Spec							
No. XXX	5.1	4.2 - 6.2	10.0	.35	13	260.0	9.1
No. XX	4.6	4.5 - 6.0	11.1	.39	11	266.4	9.4
No. X	3.7	3.0 - 4.1	14.3	.49	9	257.4	9.1
No. O	2.5	1.9 - 3.4	20.0	.74	7	280.0	9.9
Tru-Elastic							
No. 8	5.8	5.1 - 6.2	8.3	.29	21	348.6	12.3
No. 7	5.5	4.8 - 6.1	9.1	.32	17	309.4	10.9
No. 6	4.7	4.0 - 6.0	11.1	.39	13	288.6	10.1
No. 5	4.2	3.3 - 5.6	12.4	.44	10	248.0	8.7
No. 4	4.0	3.0 - 4.9	12.5	.44	8	200.0	7.1
No. 2	2.7	2.0 - 3.5	18.4	.65	6	220.8	7.8
Latex							
No. 5	2.7	1.6 - 4.8	18.5	.65	10	370.0	13.1
No. 4	2.2	1.3 - 2.9	22.8	.80	8	364.8	12.9
No. 2	2.0	1.6 - 2.6	25.0	.88	6	300.0	10.6
Unitek							
No. 253	18.5	10 - 30	2.7	.10	14	75.6	2.7
No. 251	12.5	6 - 25	4.0	.14	9	72.0	2.5

Column III is the calculated force per millimeter displacement expressed in both grams and ounces, and may be used to practical advantage if one desires to know the amount of force being applied in any particular case. To demonstrate further the practicability of using the data in Column III, the average size at rest position of each elastic was measured and listed in Column IV. Thus, if one desires to know the force applied, this may readily be figured by measuring the total length of the elastic in working position in the mouth, subtracting the rest position length, and multiplying by the figure in Column III in either grams or ounces.

Column V may be used as a quick reference to establish the actual force which is applied on the average case. This data was determined after measurements showed that it is common practice to stretch an elastic approximately three times its original length. For instance, the distance from the buccal of the lower second molar to the distal of the upper cuspid was found typically to be 34-36 millimeters; thus in the application of an Ortho-Spec XXX, with an original length of 13 mm., the elastic would be lengthened approximately three times when applied on a Cl II appliance, thereby exerting a force of 260 grams or 9.1 ounces.

The study on coil springs was conducted in a similar manner as that explained for elastics; however, a separate series of tests had to be made for given lengths of the same coil spring. Although there was remarkable consistency when like samples of coil spring were compared, the force applied per millimeter displacement was varied as com-

TABLE II — COIL SPRINGS

COLUMN	I	II	III		IV	
Material	Mm. Length	Mm. Disp. per 50 Gr. Force	Force per 1 Mm. Disp.		Actual Force Applied When Elongated or Compressed ½ Orig. Length	
			Grams	Ounces	Grams	Ounces
CLOSE WOUND						
UT 190	40	10.5	4.8	.17	96.0	3.2
.008 on .036	30	6.8	7.1	.25	106.5	3.8
	20	3.4	14.3	.50	143.0	5.0
Ret Alter	40	8.4	5.9	.21	118.0	4.2
.008 on 0.36	30	5.2	10.0	.35	150.0	5.3
	20	2.9	16.7	.59	167.0	5.9
UT 186	40	6.3	7.7	.27	154.0	5.5
.008 on .030	30	4.1	12.5	.44	187.5	6.6
	20	2.1	25.0	.88	250.0	8.8
Ret Alter	40	5.7	10.0	.35	200.0	7.1
.008 on .032	30	3.9	16.7	.59	250.5	8.8
	20	1.9	25.0	.88	250.0	8.8
Ret Alter	40	2.9	16.7	.59	334.0	11.8
.009 on .036	30	1.8	25.0	.88	375.0	13.2
	20	1.0	50.0	1.76	500.0	17.6
UT 188	40	2.5	20.0	.74	400.0	14.1
.010 on .030	30	1.8	25.0	.88	375.0	13.2
	20	1.2	50.0	1.76	500.0	17.6
Tru-Chrome	40	2.1	25.0	.88	500.0	17.6
.008 on .028	30	1.5	33.3	1.17	499.5	17.6
	20	.9	50.0	1.76	500.0	17.6
UT 250	40	1.9	25.0	.88	500.0	17.6
.008 on .022	30	1.4	33.3	1.17	499.5	17.6
	20	.7	100.0	3.53	1000.0	35.3
UT 192	40	1.7	33.3	1.17	666.0	23.5
.010 on .036	30	1.1	50.0	1.76	750.0	26.4
	20	.7	100.0	3.53	1000.0	35.3
SPACE WOUND						
UT 189	40	4.0	12.5	.44	250.0	8.8
.008 on .036	30	3.4	14.3	.50	214.5	7.6
	20	2.5	20.0	.71	200.0	7.1
Tru-Chrome	40	2.3	20.0	.71	400.0	14.1
.010 on .030	30	1.5	33.3	1.17	499.5	17.6
	20	1.0	50.0	1.76	500.0	17.6
UT 187	40	2.2	25.0	.88	500.0	17.6
.008 on .030	30	1.6	33.3	1.17	499.5	17.6
	20	1.1	50.0	1.76	500.0	17.6
UT 191	40	2.2	25.0	.88	500.0	17.6
.010 on .036	30	1.3	33.3	1.17	499.5	17.6
	20	.7	100.0	3.53	1000.0	35.3

pared to the overall length. Therefore 40, 30 and 20 millimeter lengths were chosen as being applicable to actual practice conditions, and a series of tests were performed on these specimen lengths to arrive at a reliable figure. Refer then to Table II, "Coil Springs" where listed in Column I are the given lengths of spring. Column II indicates the millimeter displacement. Column III is the calculated forces exerted per millimeter displacement, expressed in grams and ounces. These figures may be used as reference to ascertain the force applied in the mouth if the original length compares to that listed.

Column IV is based upon the assertion that it is good practice either to elongate or to compress coil springs approximately one half their original length in the mouth. Thus these figures may be used as a guide for practical reference, with the forces again expressed in grams and ounces for convenience.

In summarizing the work which has been presented, there are several points of practical interest which deserve comment. With respect to the use of elastics, it was definitely established that the action of mouth fluids could decrease their effectiveness by as much as 20% after 24 hours of constant use. It was originally intended that a series of experiments be run to determine the actual loss in efficiency at intervals of 12 to 24 hours; however, lack of cooperation and irresponsibility on the part of patients discouraged this effort. A series of tests were instead made upon samples which had been stretched constantly for periods of 12 and 24 hours in the dry state, and it was learned that prolonged pressure caused 1% or less decrease in applied force. Therefore, if it were possible to produce elastics which were not affected by the action of saliva, it might then be practical to secure them in the mouth so that the patient could not remove them, thereby expediting treatment and controlling movement as desired.

The manufacturers have succeeded in making the different sizes vary sufficiently to allow adaptability to almost any case and it was definitely established that as the size of the lumen of the elastic increases the force per millimeter displacement decreases.

When using coil springs it is advisable either to compress or to elongate the spring by one half its length, whether it is close or space wound, before placing it in the mouth. When this is done the spring will exert a dependable amount of force and may be relied upon to act constantly in the interval between appointments. Mouth fluids and long periods of use do not alter the efficiency of the steel coils.

In comparing the various samples upon which experiments were run, it was noted that the size of the arbor on which the spring is wound definitely influences the force exerted. For instance, .008 wire wound on an .022" arbor requires greater force to displace it a given distance than if wound on an .036" arbor. Also, as might be expected, the larger the wire the greater is its tendency to resist displacement. Accordingly if the greatest amount of force is desired, the largest size wire wound on the smallest arbor practical should be selected, being cautious to avoid friction loss by allowing freedom in the stabilizing arch.

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