TENSILE PROPERTIES FOR 2 DIFFERENT ELASTOMERIC CHAINS - A COMPARATIVE STUDY

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INTRODUCTION

Elastomeric chains were introduced to the orthodontic profession in the 1960s, and are now an integral part of many practices. They are used for correcting rotations, consolidating spaces, and retracting canines. Force decay in these materials is significant and has been a clinical problem.

MATERIALS AND METHOD

Two types (open and closed chains, i.e. with and without an intermodular link) of two brands of elastomeric module producing five groups were included in the study.

The specimens were prepared by cutting multiple series of specimens of each type and brand containing 5 samples each (total 10), having equal numbers of loops (six) from the spools, with the use of a sharp ligature cutter.

RESULTS

Table 1 shows the maximum force (N), tensile stress at tensile strength and tensile strain (Displacement). Table 2 shows tensile strength at break.

DISCUSSION

The mean of ORMCO e-chains is 1724.92 and the mean of RANA e-chains is 2964.17. It is evident that the mean of RANA shows higher and better results.

CONCLUSION

In vitro stretching of elastomeric chains induced permanent deformation in the form of elongation.The force of RANA e-chains was relatively higher and is subjected to give better results

KEYWORDS

RANA, e-chain, elasticity, tensile strength

INTRODUCTION

Elastomeric chains were introduced to the orthodontic profession in the 1960s, and are now an integral part of many practices. They are used for correcting rotations, consolidating spaces, and retracting canines.(1) Force decay in these materials is significant and has been a clinical problem. The polymers are not ideal elastic materials because their mechanical properties change with time and temperature. (2)This study was to evaluate the permanent elongation and tensile strength of elastomeric chains in vivo and in vitro of three commonly available brands.The poly(ether) or poly(ester) urethane elastomeric chains that are now on the market are made either through die-cut stamping or injection molding. The differences in nominally identical products' time-dependent force decay may also be attributed to differences in the manufacturing methods used to create the products, such as die-cut stamping or injection molding, effects of additives, and different morphological (ellipsoid or circular modules) or dimensional (presence or absence of an intermodular link) properties of the chains. (3)The stretching, slipping, and scission of molecular chains are the three main mechanisms for the persistent deformation of polymeric materials. The material experiences an immediate elastic deformation while being stretched.

Due to the importance of this information to the clinical usage of these materials, the tension performance of orthodontic elastomeric modules is of particular interest. When a material is stretched, some of the effort of elongation is lost as heat and some of it results in molecular reorientation and irreversible deformation. Early induction of the changes in the material's dimensions, i.e. within 24 hours of the start of the retraction, would result in an increase in the module's dimensions for the duration of the remaining intraoral use, which would negatively impact the device's effectiveness as a tooth-loading mechanism. Tensile strength testing also offers an evaluation of the chain's resistance to fracture in the opposite direction of loading.In polymeric

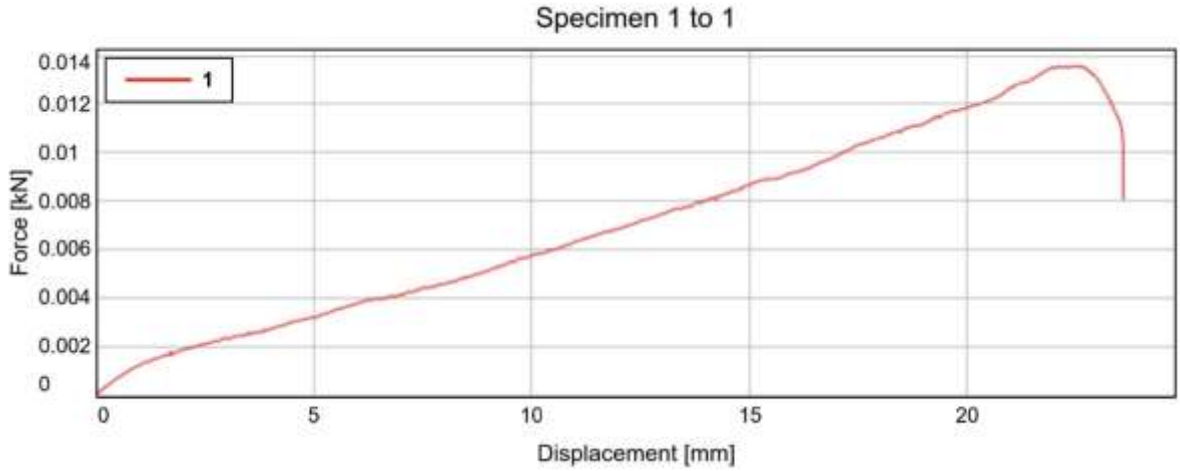
materials, molecular chain stretching, slippage between adjacent molecular chains, and molecular chain scission are the mechanisms for persistent deformation The material experiences an immediate elastic deformation while being stretched. (4)Permanent elongation results from both an irreversible viscous deformation and a delayed elastic deformation that occur as long as the load is sustained (depending on the load).(5)

MATERIALS AND METHOD

Two types (open and closed chains, i.e. with and without an intermodular link) of two brands of elastomeric module producing five groups were included in the study.

The specimens were prepared by cutting multiple series of specimens of each type and brand containing 5 samples each (total 10), having equal numbers of loops (six) from the spools, with the use of a sharp ligature cutter. Samples were subjected to tensile testing using the INSTRON E 3000 universal testing machine with a crosshead speed of 1 mm/min. Maximum force was recorded in N until failure.The choice of the number of loops as opposed to a standardized length of chain was based on the variability in shape and design noted among the brands selected. This precluded using the parameter of initial length as a reliable normalization factor for the fabrication of specimens. Care was taken to avoid extended handling during cutting as this might have incorporated stresses in the material prior to testing.

RESULTS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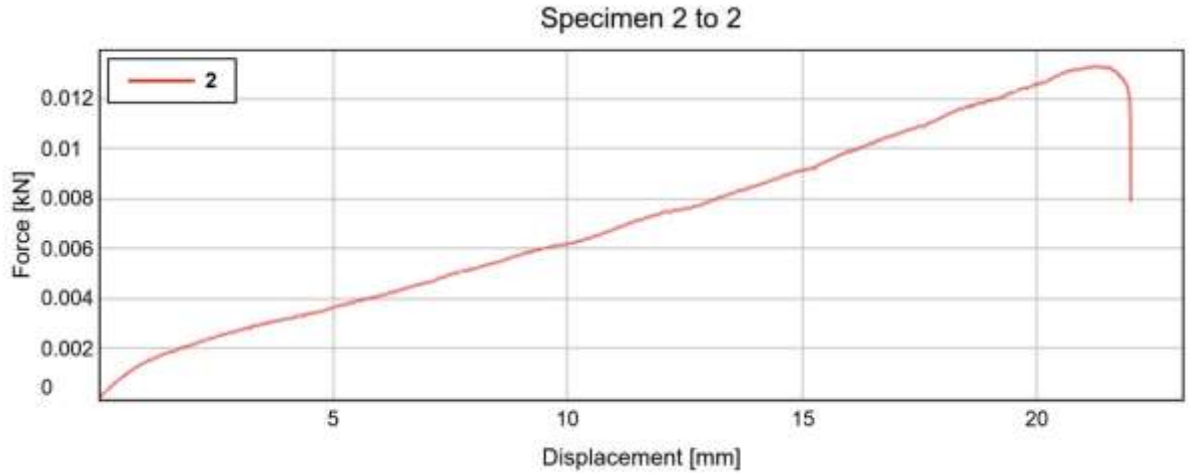
0.006
0.004
0.002
0
0
5
10
15
20
Displacement [mm]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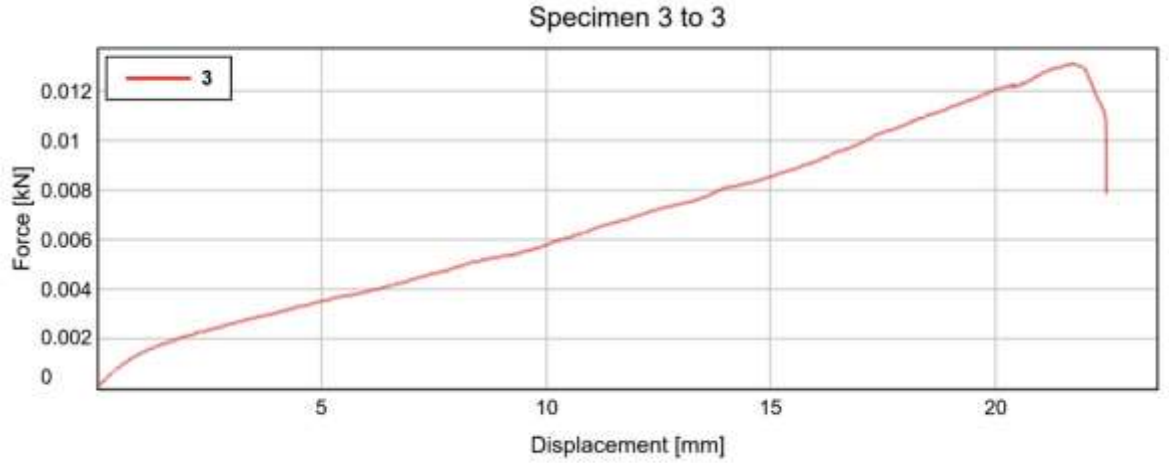
Displacement [mm]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5
10
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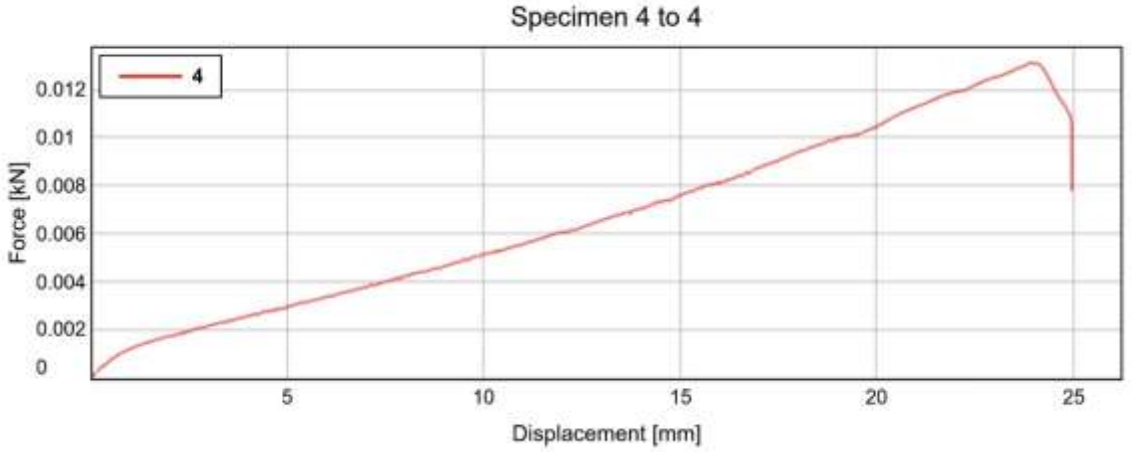
20
Displacement [mm]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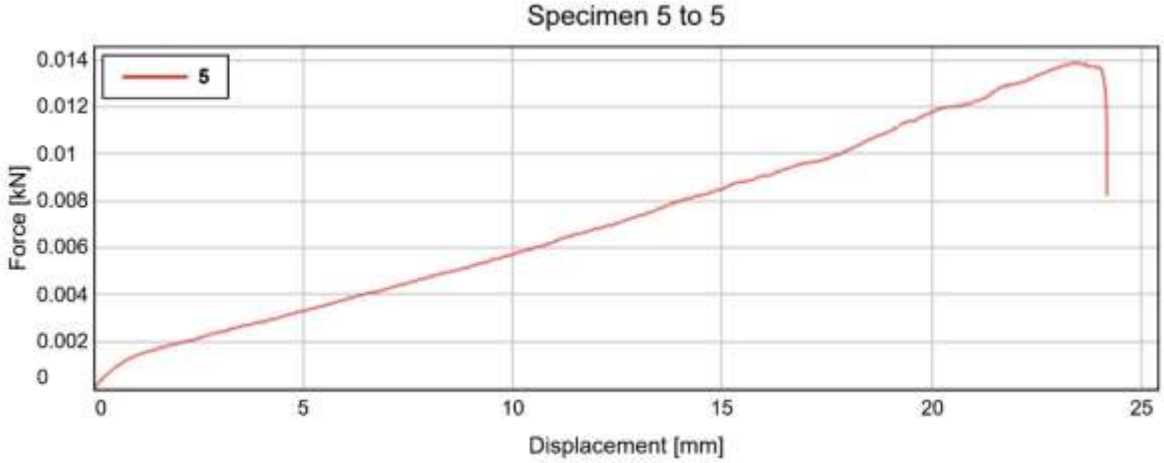
5
10
15
20
25
Displacement [mm]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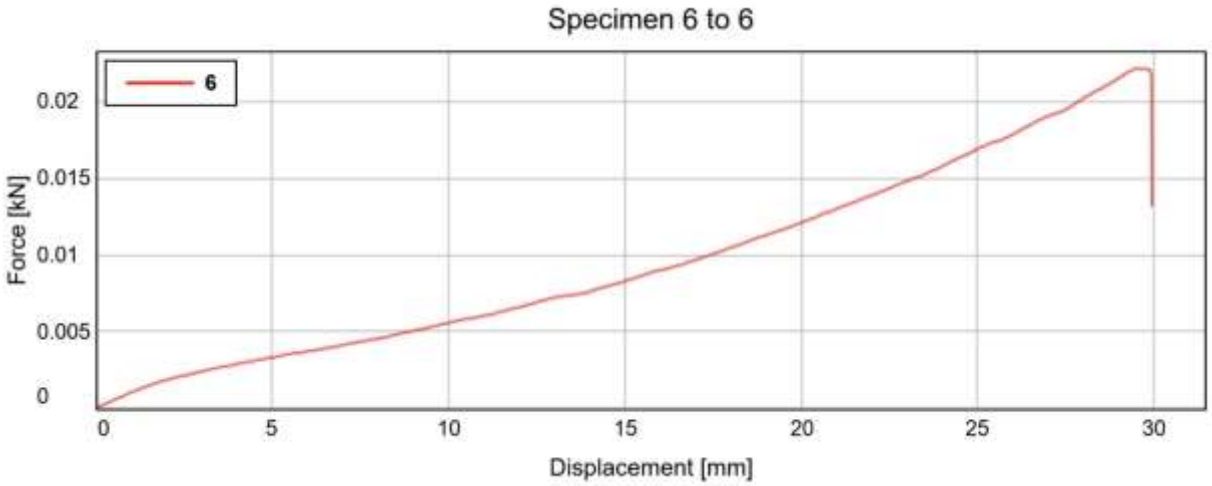
15
20
25
Displacement [mm]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Force [kN]
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0
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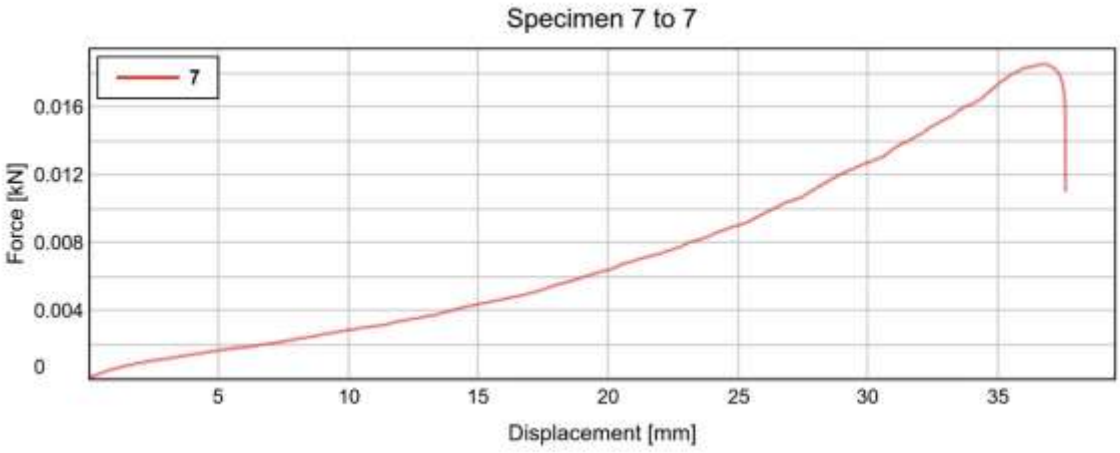
10
15
20
25
30
Displacement [mm]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Force [kN]
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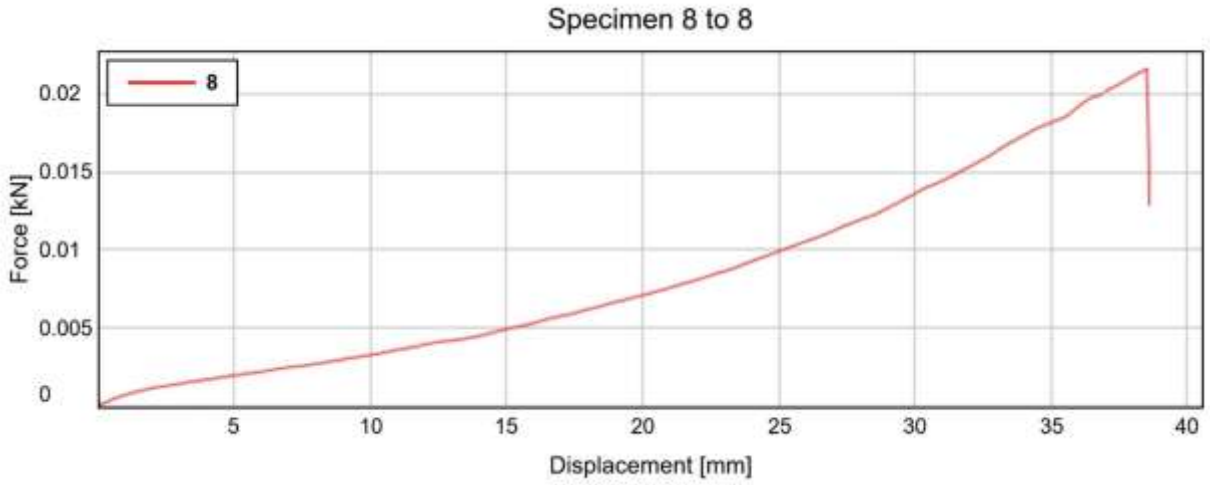
0
5
10
15
20
25
30
35
Displacement [mm]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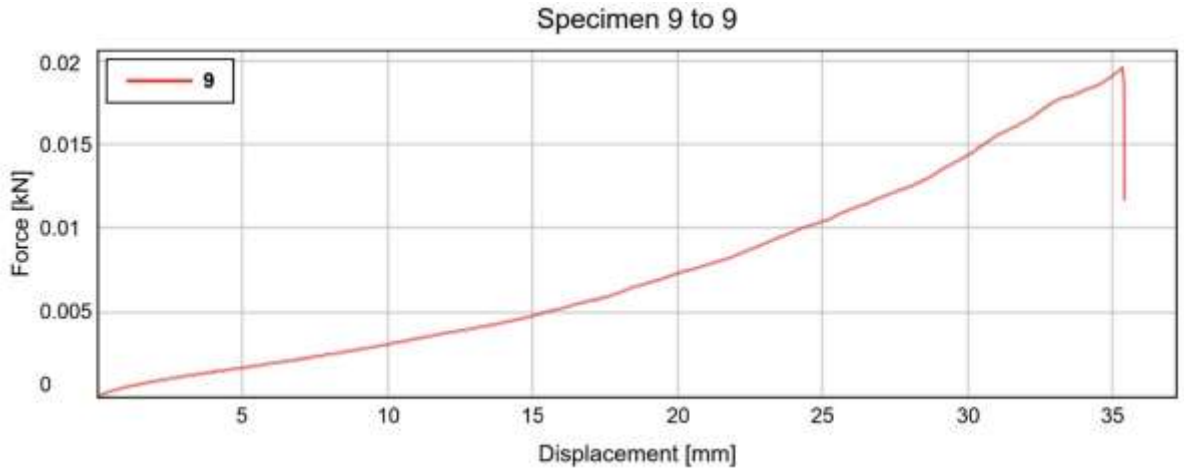
0
5
10
15
20
25
30
35
40
Displacement [mm]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Force [kN]
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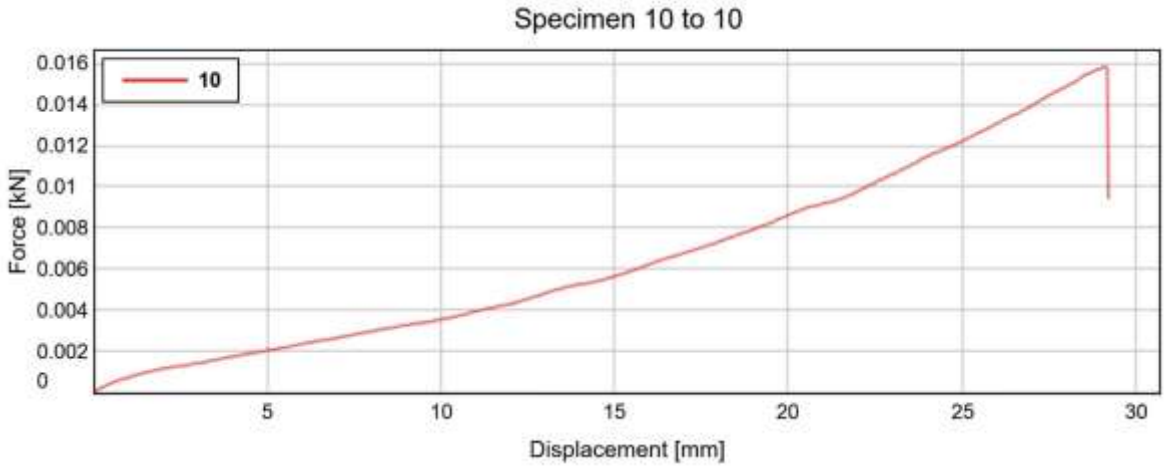
0.015
0.01
0.005
0
5
10
15
20
25
30
35
Displacement [mm]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0.012
0.01
0.008
0.006
0.004
0.002
0
5
10
15
20
25
30
Displacement [mm]

Table 1

	Maximum Force [N]	Tensile stress at Tensile strength [MPa]	Tensile strain (Displacement) at Break (Standard) [%]
1	13.61	2126.29	47.14
2	13.30	2073.70	43.97
3	13.13	2049.01	44.93
4	13.15	2054.03	49.93
5	13.89	2141.94	48.33
6	22.21	3467.60	59.85
7	18.59	2894.61	75.17
8	21.69	3382.16	77.18
9	19.66	3056.19	70.78
10	15.89	2479.14	58.39

Table 2

	Specimen label	Tensile stress at Break (Standard) [MPa]
1	Ormco	1645.87
2	Ormco	1779.70
3	Ormco	1681.40
4	Ormco	1677.17
5	Ormco	1840.44
6	RANA	3448.14
7	RANA	2456.78
8	RANA	3386.27
9	RANA	3071.32
10	RANA	2458.32

Table 1 shows the maximum force (N), tensile stress at tensile strength and tensile strain (Displacement). **Table 2** shows tensile strength at break

DISCUSSION

The results of this study suggest that as early as 24 hours following a 50 per cent fixed elongation in air, most elastomers present an unfavorable permanent deformation, which may extend up to 10 per cent of the original lengths.(2) The alteration in elastomeric chain length associated with their intraoral exposure did not allow for the determination of permanent elongation in retrieved specimens, although anecdotal clinical experience indicates that this elongation is higher in aged samples. The trend seen for the open elastomeric products(with an intermodular link) to present higher elongation may be partly explained by the increased concentration of the load and thereby elongation at the intermodular link region . This is in contrast to closed elastomeric modules were the strain developed at the modular rings is much higher. (5)Nevertheless, no statistical significance was identified among closed or open chains with respect to elongation variants. This may be partially attributed to the increased variability in the link length noted between open elastomers of various brands, with the open presenting intermodular link lengths extend-ing from 1 to 3 mm, while most modules had different shapes ranging from elliptical to circular. (6)The issue of force relaxation of elastomeric chains has attracted the interest of many investigators because of the clinical significance of the performance of materials. In spite of the extensive evidence presented on this subject, there is a lack of information on the structural changes occurring dur-ing stretching and unloading, including molecular con-formation of the polymeric material. (7)A typical stress–strain curve for an elastomeric module is characterized by a deviation from the Hookean elasticity, seen in the curved initial region of the plot. Permanent deformation is the result of irreversible displacements between the polymeric chains, possibly including chain rupturing of crosslinks. (8)The limit for entropy-driven elasticity in these materials occurs at the point of inflection where the curvature of the plot changes from concave-down to concave-up, whereas the region of elastic deformation corresponds to revers-ible changes in the separation between molecules in the polymeric structure.The differences in tensile strength found between

the reference state and the 50 per cent extension in air may reflect variations in the molecular arrangement of materials. The different rankings in tensile strength and toughness imply that some elastomers undergo different degrees of elastic and plastic deformation after pre-loading. The modes of deformation are further modified by the presence of plasticizing agents, i.e. water, oral fluids or stiffening agents, such as intraoral calcification,and depend on the intraoral conditions and intraoral exposure period.The deviation of the stress–strain plot from an ideal straight line is probably related to the low loading rate chosen, as high loading rates may modify the behavior of the material. In general, at low temperatures or high strain rates the material behaves like a stiff body because there is no time allowed for the chain segments to be mobilized and slippage is absent, thus the primary stiff valence bonds govern the profile of the material. The mean of ORMCO e-chains is 1724.92 and the mean of RANA e-chains is 2964.17. It is evident that the mean of RANA shows higher and better results. The deviation of the stress–strain plot from an ideal straight line is probably related to the low loading rate chosen , as high loading rates may modify the behavior of the material. In general, at low temperatures or high strain rates the material behaves like a stiff body because there is no time allowed for the chain segments to be mobilized and slippage is absent, thus the primary stiff valence bonds govern the profile of the material. At high temperatures or low strain rate, chain slippage dominates and the material becomes more compliant. The 5 mm/minute rate employed in this study was considered substantially low compared with the instantaneous chain stretching which occurs prior to chain placement. However, this rate is routinely used in relevant studies and also the emphasis is mostly on the long-term survival of the material, and not on the strength of the material before its engagement into the bracket, which is subject to operator control.For elastomerics subjected to strains with a λ ratio(L/L0) of less than 1.1, the stress at a fixed strain decreases with increasing temperature, while at larger λthe stress increases with increasing temperature. The Process is termed thermoelastic inversion. Three major models have been proposed to explain the behavior of elastomers on stretching and stretching from a statistical mechanical perspective. These theories assume that cross links are fixed in space; the entropy of the network is the sum of the entropies of individual chains; all different con-formational states have the same energy; the deformation at the molecular level resembles that of the macroscopic level ; and an unstressed network is isotropic. The intro-duction of many theories derives from the inability of a rigid hypothesis to explain the behavior of

elastomers,especially when deformation ratios exceed four. The reason is that all these theories integrate a number of assumptions which do not exist in reality. These include the absence of loose ends in the structure of the material,which holds true only for an infinite network, and the lack of fillers in the synthesis of the elastomers. Loose ends, or non crosslinked polymers, do not take part in the formation of the retracting force, thus reducing the number of load-carrying chain segments. Similarly, fillers in the elastomers in the form of color pigments or other substances intended to increase the strength of the materials, may have a pronounced effect on the behavior of elastomers in stretching. If the filler particle included in the polymer structure has a larger modulus than the surrounding structure, it will not extend to the same amount as the remaining material.This means that the ends of the material in contact with fillers across the direction of tension must be stretched more than the adjacent polymer fibrils to counteract the inability of fillers to stretch. Filler Content may thus be critical for the microscopic strain,as more fillers packed closely will induce larger stretching of the intervening polymer cylinders. Evidence supporting this effect has been presented illus-trating steeper force decay for coloured specimens.

CONCLUSION

In vitro stretching of elastomeric chains induced permanent deformation in the form of elongation. Chain geometry or design did not affect the permanent elongation of chains, probably because of the substantial variation in chain shape, size and link length among products of the same category (open or closed).No correlation was identified with as-received,stretched in air, and retrieved specimens of elastic chains with respect to tensile strength and toughness. The toughness of specimens was not consistent with the group rankings of tensile strength. This may be due to variations in elastic and plastic deformation of specimens on loading. The force of RANA e-chains was relatively higher and is subjected to give better results

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