REVIEW ARTICLE

Elastics and Elastomeric in Orthodontics Practice

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ABSTRACT

Elastics and elastomeric are an important part of orthodontic treatment with patients' cooperation; they are used for correction of anteroposterior and vertical discrepancies; there are many types of elastics placement in relation with treatment requirements. Elastics can be classified in many ways: according to the material, their availability, their uses, and force. Elastomer is a general term that encompasses materials that, after substantial deformation, rapidly return to their original dimensions. Natural rubber is the first known elastomeric, used by the ancient Incan and Mayan civilizations. Rubber-like materials that are made from chemicals were called synthetic rubber because they were intended as substitutes for natural rubber.

The types of elastic based on their use are class I, II, III, palatal, lingual, cross, etc.

Keywords: Elastics, Elastomeric, Natural and synthetic rubbers.

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INTRODUCTION

Elastics and elastomeric are routinely used as an active component of orthodontic therapy. Elastics have been a valuable adjunct of any orthodontic treatment for many years. Their use, combined with good patient cooperation, provides the clinician with the ability to correct both anteroposterior and vertical discrepancies.

Both natural rubber and synthetic elastomers are widely used in orthodontic therapy. Naturally produced latex elastics are used in the Begg technique to provide intermaxillary traction and intramaxillary forces. Synthetic elastomeric materials in the form of chains find their greatest application with edgewise mechanics where they are used to move the teeth along the arch wire.

The links of chain fit firmly under the wings of an edgewise bracket so that chain elastomers also serve to replace metal as the ligating force that holds the arch wire to the teeth. Since they are so positively located on the brackets, it is usual for the chains to remain in situ until replaced by the orthodontist at the next visit of the patient. This routine differs from that usually followed for latex elastics, which are changed by the patient every 1 or 2 days.[1,2]

The use of latex elastics in clinical practice is predicted on force extension values given by the manufactures for different sizes of elastics. The standard force index employed by suppliers indicates that at 3 times the original lumen size, elastics will exert the force stated on the package.

From a clinicians' point of view it would be mandatory to know not only the clinical aspect of these elastics but also their basic properties, in order to extract the most out of these polymers.[2,3]

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TERMINOLOGY

Force: It is defined as an act upon a body that changes or tends to change the state of rest or the motion of that body. Though defined in units of Newtons it is usually measured in units of grams or ounce.

Elastic: It is defined as the ability of a substance to return to its original length or shape after being stretched.

Elasticity: The property of a substance that enables it to change its length, volume, or shape in direct response to a force affecting such a change and recover its original form upon the removal of the force.

Elastic limit: The elastic limit is the maximum stress that a material can endure without undergoing permanent deformation.

Elastic modulus or modulus of elasticity: When a material is stressed it is usually found that the stress is proportional to the strain, so their ratio is constant. In other words, the material deforms linearly and elastically. This can be represented by the expression

$$E = \text{stress/strain}.$$

Resilience: (stored or spring energy) Resilience represents the energy storage capacity of a wire. It is stressed not to exceed its proportional limit.

Plasticity: It is the property by which a material can be molded into various forms and then hardened for commercial use.

Relaxation: It is defined as a decrease in force value carried or transmitted over time with the element maintained in a fixed activated state of constant strain.

Vulcanization: The process of heating sulfur–rubber mixtures is known as vulcanization

1 ounce (oz) = 28.35 gm.[1,3]

HISTORY OF ELASTICS AND ELASTOMERICS

Elastomer is a general term that encompasses materials that, after substantial deformation, rapidly return to their original dimensions.

Natural rubber was the first known elastomer, used by the ancient Incan and Mayan civilizations. It had limited use because of its unfavorable temperature behavior and water absorption properties.

With the advent of vulcanization by Charles Goodyear in 1839, uses for natural rubber greatly increased. Early advocates of using natural latex rubber in orthodontics were Baker, Case, and Angle.

Natural Rubber

When the early European explorers came to Central and South America, they saw the Indians playing with bouncing balls made of rubber.

The South American Indians called the rubber tree cahuchu, i.e., weeping wood. The drops of latex oozing from the bark made them think of big white tears.

In 1770, the English chemist Joseph Priestley discovered that the materials could be used as an eraser to rub out pencil marks. From this use we get the name rubber.

A French man JMA Strange in 1841 claimed that he used a rubber attached to some hooks on the appliance surrounding the molars for retention.

John Tomes in 1848 used the elastics springs with metal plates.

Celvin Case discussed the use of intermaxillary elastics at the Columbia Dental Congress. However, in 1893 Henry A Baker was credited with originating the use of intermaxillary elastics with rubber bands and named it Baker Anchorage. Angle in 1902 described the technique at the New York Institute of Stomatology.

Chemical analysis shows that about 30–35% of latex consists of pure rubber, while water makes up another 60–65%. The remainder consists of small amounts of other materials such as resins, proteins, sugar, and mineral matter. Latex spoils easily and must therefore be processed into crude rubber as soon as possible after it has been tapped. This is done by separating the natural rubber in the latex from water and other materials. About 99% of all natural rubber comes from the latex of Hevea brasiliensis. In laymen terms, we call it the rubber tree.

In 1860, another Englishman, Greville Williams, heated some rubber and obtained a colorless liquid that he called isoprene. Each isoprene molecule contains 5 carbon atoms and 8 hydrogen atoms (C_5H_8). The atom in the isoprene molecules always forms a definite pattern. Four of the carbon atoms form a chain. The fifth carbon atom branches off from one of the carbons in the chain.

Three hydrogen atoms surround the fifth carbon atom to form a methyl group.

Natural rubber has many unsaturated carbon atoms. Oxygen atoms from the air gradually attach themselves to these carbon atoms. This breaks down the rubber polymers so that the rubber becomes brittle or soft and loses elasticity. The addition of antioxidants during compounding prevents this action.

Scientists have not discovered all the answers to the chemistry of rubber. For example, they once believed that sulfur atoms attached themselves to unsaturated carbon atoms during vulcanization. But the sulfur reaction that makes rubber hard now seems more complicated than this. In many other ways, the chemistry of natural rubber remains a mystery.

Synthetic Rubber

Synthetic rubber polymers developed from petrochemicals in the 1920s have a weak molecular attraction consisting of primary and secondary bonds.

Elastomeric chains were introduced to the dental profession in the 1960s and have become an integral part of orthodontic practice. They are used to generate light continuous forces. They are inexpensive and relatively hygienic, can be easily applied, and require no patient cooperation.

There have been numerous advances in the manufacturing process, which have led to a significant importance in their properties; with this there has been a greater application of these elastics in clinics in a variety of uses.

Rubber-like materials that are made from chemicals were called synthetic rubbers because they were intended as substitutes for natural rubber. Chemists use the word "elastomer" for any substance, including rubber, which stretches easily to several times its length, and returns to its original shape.

Manufacturers group synthetic rubbers into two classes: General-purpose and special-purpose.

General-purpose Synthetic Rubbers

The most important general-purpose rubber is styrene-butadiene rubber (SBR). It usually consists of about 3 parts butadiene and one part styrene. Butadiene, a gas, is made from petroleum. It must be compressed or condensed into liquid form for use in making rubber. Styrene is a liquid made from coal tar or petroleum.

Special-purpose Synthetic Rubbers

Contact with petrol, oils, sunlight, and air harms natural rubber. Special-purpose synthetic rubbers resist these "enemies" better than natural rubber or SBR do. Also some of these special-purpose rubbers have greater resistance to heat and cold.

Special-purpose rubbers include butyl rubber, cis-polyisoprene rubber, neoprene rubber, nitrile rubber, polysulfide rubber, polyurethane rubber, silicon rubber, ethylene-propylene rubber, fluorocarbon rubber, and thermoplastic rubber.

Most of the elastics currently used in orthodontics are made up of polyurethane. Polyurethane rubbers resist heat and withstand remarkable stresses and pressures. Polyurethane foams are dense to light. The ingredients of polyurethane rubbers include ethylene, propylene, glycols, adipic acid, and diisocyanates.

They have excellent strength and resistance to abrasion when compared with natural rubber. They tend to permanently distort, following long periods of time in the mouth, and often lose their elastic properties. They are mainly used for elastic ligatures.[1-9]

CLASSIFICATION OF ELASTICS

Elastics can be classified in many ways: According to the material, their availability, their uses, and force.[3,4,10-15]

According to the Material

- *Latex elastics:* These are made up of natural rubber materials, obtained from plants; the chemical structure of natural rubber is 1,4-polyisoprene.
- *Synthetic elastics:* These are polyurethane rubber containing urethane linkage. They are synthesized by extending a polyester or a polyether glycol or polyhydrocarbon with a diisocyanate. These are mainly used for elastic ligatures.

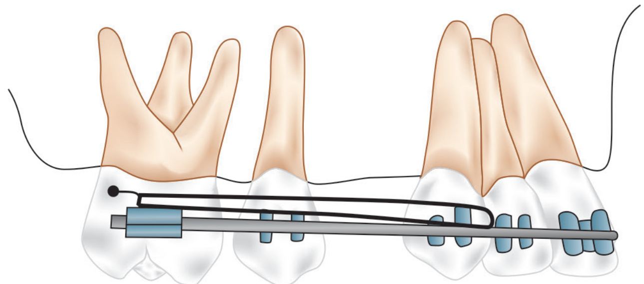
According to the Availability

According to the Uses

- Intraoral
- Extraoral

Intraoral Elastics

- Class I elastics or horizontal elastics or intramaxillary elastics or intra-arch elastics (Fig. 1)
- Class II elastics/intermaxillary elastics/interarch elastics (Fig. 2)
- Class III elastics (Fig. 3)
- Anterior elastics (Fig. 4)
  (Force: 1–2 oz)
- Zigzag elastics



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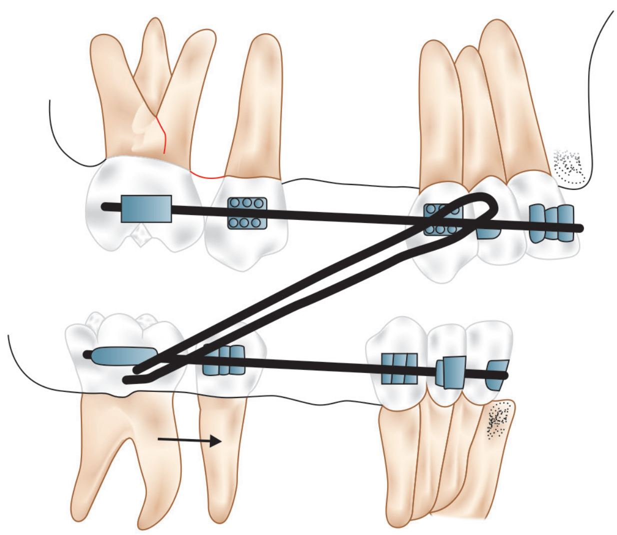

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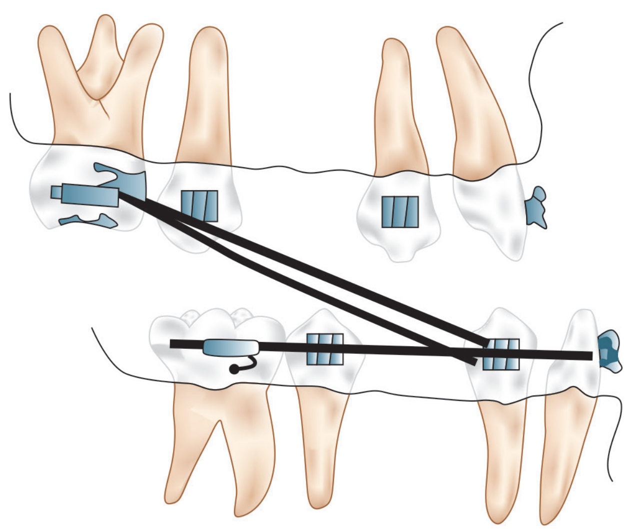

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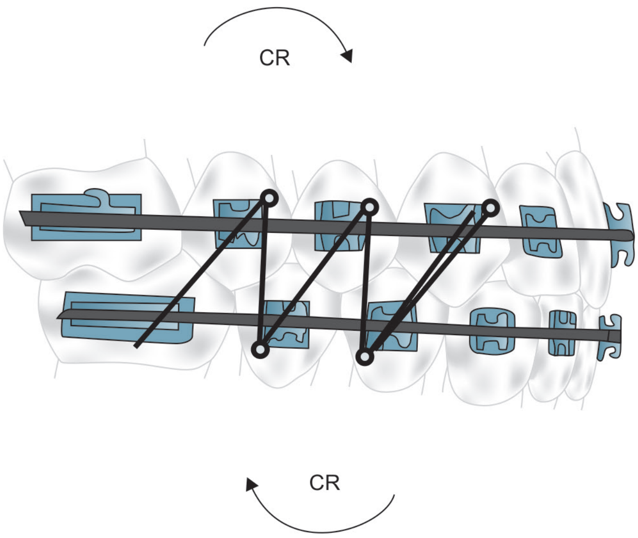

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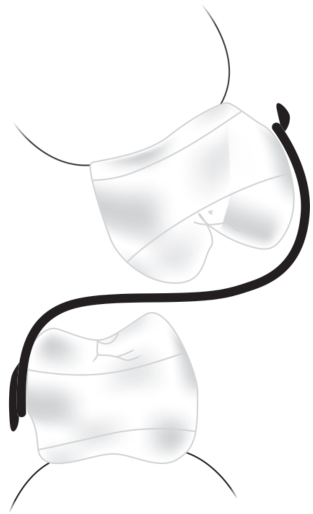

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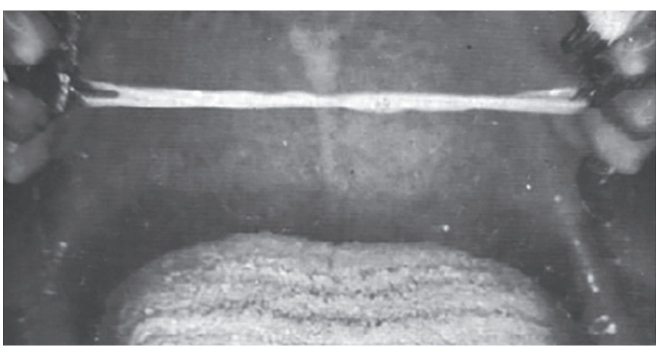

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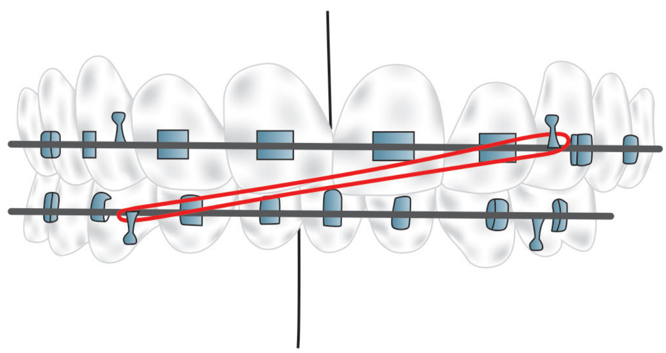


Fig. 8:

Aras et al 2001[16] have done a pilot study of "The effect of zig zag elastics in the treatment of CL II div 1 malocclusion subjects with hypo and hyper divergent growth pattern." The conclusion of this study can be summarized as follows: Zig zag elastics used in the last stage of fixed appliance treatment of class II malocclusion in growing patient were effective in the correction of molar relationship. They established a good intercuspation as well as improved sagittal skeletal relationship (Fig. 5).

- Cross-bite elastics (Fig. 6)
  Force recommended is 5–7 oz.
- Cross-palate elastics (Fig. 7)
- Diagonal elastics (midline elastics) (Fig. 8)
  Force used is 1½–2½ oz.
- Open bite elastics (Fig. 9)
  These are used for the correction of an open bite.

It can be carried out by a vertical, triangular, or box elastic. Vertical elastic runs between the upper and lower brackets of each tooth.

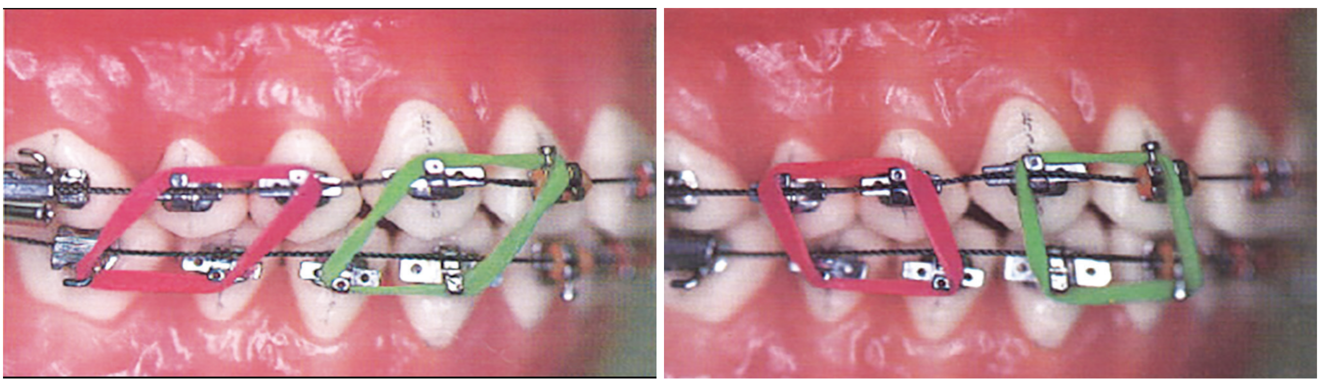
- Box elastics (Fig. 10)
  Force used is ¼″ 6 oz or 3/16″ 6 oz.
- Triangular elastics (Fig. 11)
  Elastics of 1/8″ 3½ oz is used.
- Vertical elastics (spaghetti) (Fig. 12)
  Force used is 3½ oz.
- M and W elastics (Fig. 13)
  Force used is ¾″ 2 oz.
- Lingual elastics (Fig. 14)
  They can be used as a supplement or a counter-balancing agent to buccal elastic force, thereby increasing the efficiency of force distribution.

Fig. 9:

Lingually tipped lower molars can be uprighted by the use of class II elastics attached between t the lingual hook of the lower molar and the intermaxillary hook of upper arch wire on the same side.

Lingual elastics can be used as a substitute for buccal elastics like class I and class II elastics, provided the arch wire should be tied back to the cuspid bracket.

- Check elastics (Fig. 15)
  Check elastics can provide a potent mechanism for overbite reduction, causing extrusion of maxillary and mandibular molars and counteracting the tendency of the anchor bends to tip the molars distally plus aiding incisor intrusion.
- Sling shot elastics (molar distalizing) (Fig. 16)
  Two hooks on buccal and lingual sides of the molar to be incorporated in the acrylic plate to hold the elastic. The elastic is stretched at the mesial aspect of molar to distalize it.
- Elastics in removable appliance (Fig. 17)
  Elastics in conjunction with the removal appliance are used for the movement of single and groups of teeth, and for intermaxillary traction. They can be used to move the impacted canine to a proper place along with the Hawley appliance.



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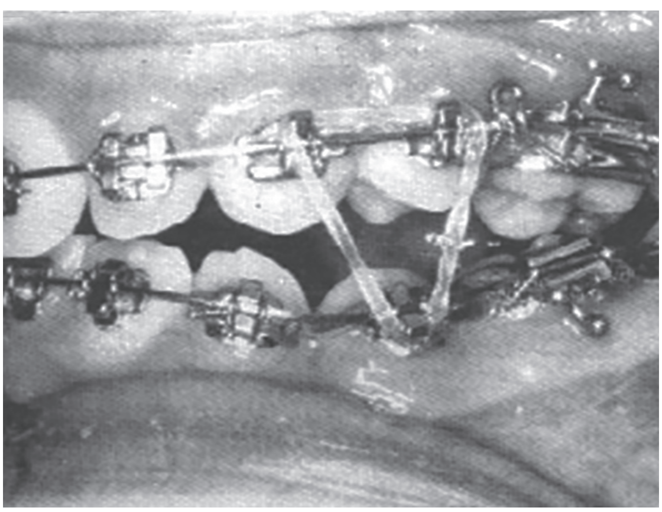

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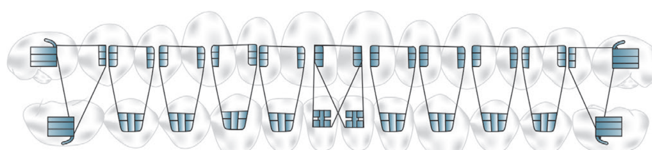
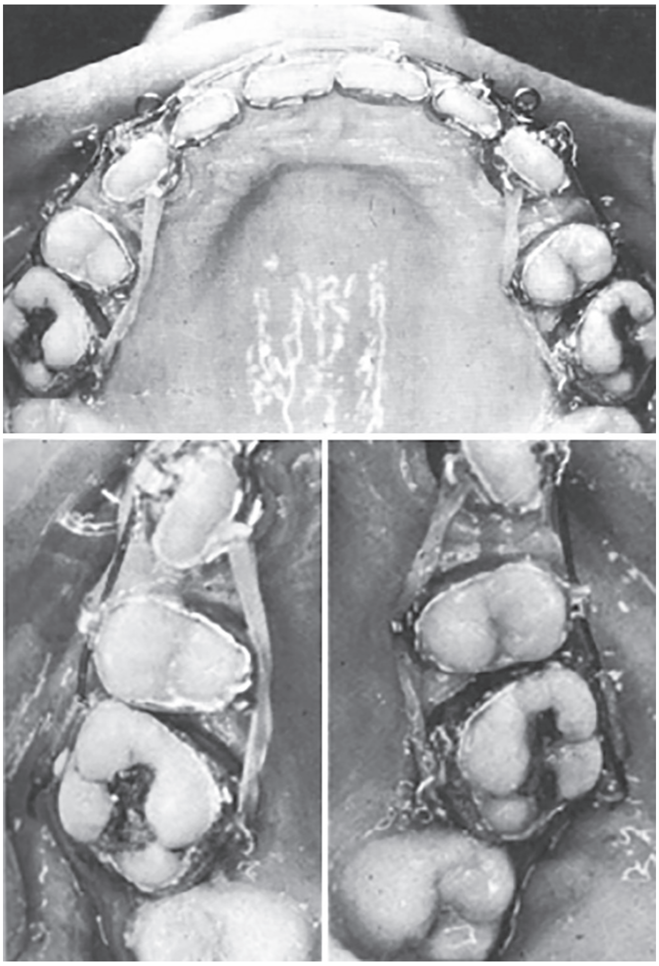


Fig. 12:

Fig. 13:



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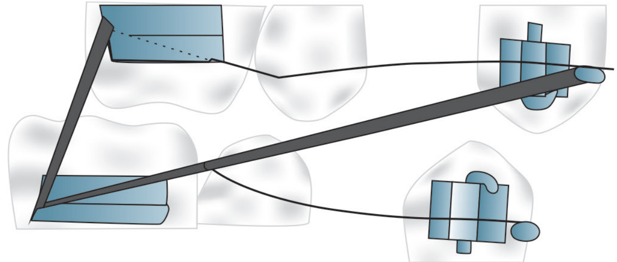

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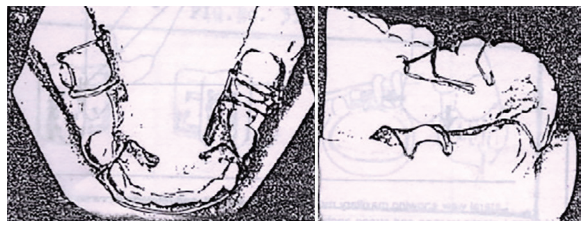

Fig. 16:

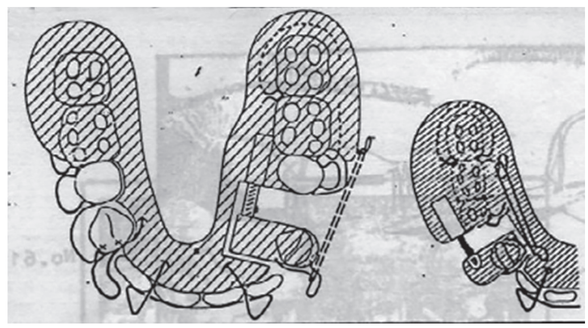

Fig. 17:

They are used in moving the canine distally along with screw appliances.

The acrylic plates cover the premolars and molars and tuberosities for bodily anchorage.

- Other elastics

  Asymmetrical elastics: They are usually class II on one side and class III on the other side. They are used to correct dental asymmetries. If a significant dental midline deviation is present (2 mm or more), an anterior elastic from the upper lateral to the lower contralateral lateral incisor should also be used.

  Finishing elastics: They are used at the end of the treatment for final posterior settling.

  Force recommended ¾″ or 2 oz.

According to the Force

High pull: Ranges from 1/8″ (3.2 mm) to 3/8″ (9.53 mm). It gives 71 gm force (2½ oz)

Medium pull: Ranges from 1/8″ (3.2 mm) to 3/8″ (9.53 mm). It gives 128 gm or 4½ oz force

Heavy pull: Ranges from 1/8″ (3.2 mm) to 3/8″ (9.53 mm). It gives 184 gm or 6½ oz force.

Elastic Separators

Elastic separators and Dumbell separator (Fig. 18)

TYPES OF ELASTICS

Intraoral Elastic

It can be light, medium, or heavy.

Extraoral Elastic

Heavy elastics and plastic chain are used with the head gear.

e-Link: It is used as intermaxillary class II and class III applications. It is available in different lengths.

Lig-A-Ring: It is used for individual ligation of the tooth. It can be used in place of conventional ligature ties in straight wire therapy and for cuspid ties in Begg. It is o 1.5–2 mm in diameter.

Tip Edge Rings

It can control and hold the desired degree of mesiodistal inclination. The cross-bar can give up-righting forces.

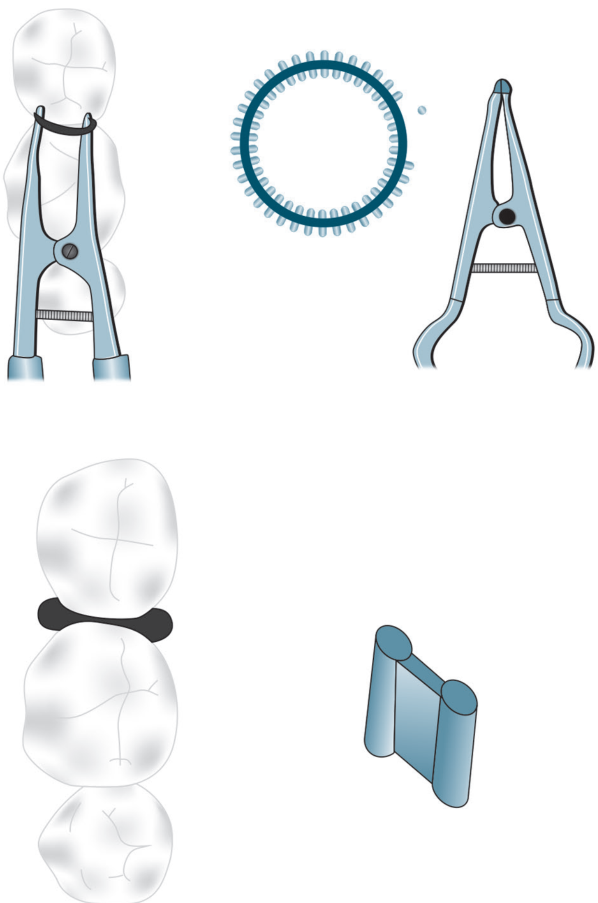

Fig. 18:

e-Chain

It is used for continuous ligation and consolidation etc. It is available as 3 types:

1. Small (continuous)
2. Medium (short)
3. Large (long)

Power Thread (Elastic Ligature)

This is polyurethane thread, used for rotating, extruding, losing minor spacing, and consolidating.

Elast-O Chain

It is used for consolidation of arches. It gives a light continuous traction force.

Elastic Thread

This is an elastic ligature covered with silk or nylon. The nylon fibers resist the unravelling and protect the latex core. It is used for rotation correction, traction, etc., both with fixed and removable appliances. It is available in 3 types:

1. Light
2. Medium
3. Heavy

Separating Rings

It gives a continuous force during contact opening.
Small – used in anterior region
Large – used in posterior region

ROTATION WEDGES

It acts as a fulcrum between wire and bracket to correct the rotation. It is ligated to the tie wing of the bracket.

Plastic Chain

It is used extraorally along with head gear, for the orthopedic correction using heavy forces.

ANALYSIS OF ELASTIC FORCE

Force produced by elastics on a tooth or teeth depends on its magnitude. The stress produced depends on the site of application, distribution through the periodontal ligament and direction, length, diameter and contour of root, alveolar process, tooth rotation and health, age, and above all the cooperation of the patient.

Class I elastic traction is judiciously combined with a strong anchor bend. Deliberate consideration of anchorage conservation is essential, because the resultant of the retractive and intrusive forces that lies distant to the maxillary molars will induce adverse movements or anchorage loss of the maxillary molars.

Intermaxillary elastic force exerts pressure on the incisors in a vertical direction bringing them into supraocclusion or accentuating supraocclusion already present. Tilting of anchor teeth may also occur.

The amount of light force exerted by the elastic is at an optimal level to tip the anterior crowns backward but a minimal level to move the lower molars forward bodily. Elastic force received by the molars and anteriors are equal and opposite; the resistance is not equal. So the crown tipping is relatively rapid and bodily movements are slow.

A continuous force can bring about rapid intrusive movement. Each anterior tooth will intrude by a force as light as 20–30 gm. The light force produces very short hyalinization periods and the anterior teeth will be intruded quite rapidly.

FORCE DEGRADATION

Relaxation is defined as a decrease in force value carried or transmitted over time with the element maintained in a fixed activated state of constant strain.

The force decay under constant force application to latex elastic, polymer chains, and tied loops showed that the greatest amount of force decay occurred during the first 3 hours in water bath. The force remained relatively the same throughout the rest of the period.

Russell et al in 2001 conducted a study on the assessment of mechanical properties of latex and non-latex orthodontic elastics.

So there are a few general conclusions that can be drawn and applied clinically to all elastic types. Although all the elastics met the Australian standard for breaking force, there was trend toward non-latex elastics having lower breaking force than the latex elastics.

After an exhaustive review of the literature regarding elastomeric chain, it can be said that most marketed elastomeric chains generally loses 50–70% of their initial force during the first day of load application. At the end of 3 weeks they retained only 30–40% of the original force.[9,10,13,15]

ELASTIC ERRORS

Latex Allergy

Allergies to the latex proteins are increasing, which has implication for dental practitioners because latex is ubiquitous in dental environment. KA Russel 2001, reaction to the latex materials have become more prevalent and better recognized, since 1988 adoption of universal precautions. Only 3 reports have been cited in the literature relating latex allergies to orthodontic treatment. Two of these studies related the allergic reactions to use of latex gloves, and 3rd report related to the development of stomatitis with acute swellings and erythematous buccal lesions to the use of orthodontic elastics.

Staining of Elastics

Elastomeric materials do stain from certain food such as mustard. The attempt to solve this problem by masking with metallic color inclusions reduces the strength and elasticity. It is because of the difference in the resilient properties. A study regarding staining in 1990 by Kenneth KK Lew divided staining into 3 categories: No staining: With coco cola presumably the most colorless foodstuff; gradual staining: With chocolate drink, red wine, tomato ketchup.; rapid staining: With coffee and tea.

Storage

According to the manufactures, orthodontic elastics should be stored in the refrigerator, because increased atmospheric temperature for a long period will decrease the strength. Keeping in refrigerator (cool and dry) will give a long shelf-life.

Pre-stretching of Elastics

Allen K Wong suggested in 1976 that the elastomeric materials need to be pre-stretched 1/3rd of their length to pre-stress the molecular polymer chain. This procedure will increase the length of a material. If the material is overstretched a slow set will occur but will go back to the original state in time. If the material is overstretched to near breaking point, over and over again, permanent plastic deformation will occur.

This means that the initial force may come to an effect during a pre-stretched process. So when it is in use it will give more stable force.[3,8-10]

FLUORIDE RELEASE FROM ORTHODONTIC ELASTIC CHAIN

Plaque accumulation around the fixed orthodontic appliance will cause dental and periodontal decease.

Decalcification can be avoided by mechanical removal of plaque or by topical fluoride application or with a mechanical sealant layer.

Controlled fluoride release device has been in use since the 1980s. In such device a copolymer membrane allows a reservoir of fluoride ions to migrate into oral environment rate.

The study was designed to a stannous fluoride release from a fluoride impregnated elastic power chain.

The delivery of stannous fluoride by means of power chain would presumably reduce count and inhibit demineralization.

An average of 0.025 mg of fluoride is necessary for remineralization.

But this protection is only temporary and of a continued exposure needs; the elastic should be replaced at weekly intervals. The force degradation property will be higher with the fluorinated elastic chain.[8,11]

ELASTIC LIGATURES *VS* WIRE LIGATURES

Elastic ligature may be a substitute for the wire ligatures in most situations.

Elastic ligatures will give an easy work to the doctor and since they have no sharp ends they will be more acceptable by the patient.

In rotation control, higher force levels than elastomeric materials are required. The brackets in rotation cases the partial engagement of the arch wire will be difficult with elastic ligature, so in these cases wire ligature are advised.

When the sliding of a bracket on the arch wire is needed, it is advisable to use elastic ligature because of its smoothness.

The strength and inflexibility of wire ligatures may also provide more secured ligation. The relatively low strength of the elastic ligature is its major disadvantage.

Ligature wire can transfer elastic force from arch wire to tooth and for holding the engagement of the arch wire in the bracket.[8,9]

COIL SPRINGS *VS* ELASTICS

To overcome the drawbacks of elastomeric material, Andrew L Souis in 1994 conducted a study on nickel–titanium (NiTi) coil springs and elastics.

This study shows the following:

- NiTi coil springs have been shown to produce a constant force over varying length with no decay.
- NiTi coil springs produced nearly twice rapid a rate of tooth movement as conventional elastics.
- No patient cooperation needed.
- Coil springs can stretch as much as 500% without permanent deformation.
- The force delivered is 90–100 gm.[8,11]

ORTHODONTIST'S PART IN PATIENT WEARING ELASTICS

Educate the patient to wear the elastics continuously except while brushing and replacing. Occasionally there may be some exceptions.

Instruct the patient carefully where the elastics are to be attached and have him to do so before you.

Every visit check whether the patient is wearing elastics, properly or not.

Make sure that the patient can place his elastics easily and that they remain in place.

Check whether the hooks, pins, tubes, and cleats are easily accessible and remove all sharp edges that may cause breakage of elastics.

Caution the patient not to allow the lower jaw to come forward in response to the pulling force exerted by class II elastics. Be sure that the patient closes in the proper retruded position.

It is most important to impress upon the patient and the parents that if there is any difficulty in wearing elastics it should be informed to your office immediately.

Dispense sufficient amount of elastics required till the next visit.

Do not increase elastic force for a patient who shows unsatisfactory progress, before making sure that he is actually wearing the elastics already prescribed.

ARMAMENTARIUM

Dontrix Gauge: It is used to determine proper-size elastic for each application by measuring the force. Measuring range is 28–450 gm.

Stress Gauge (Correx Gauge): The measuring range is 25–250 gm or 100–500 gm or 200–1000 gm.

Elastic Separator Placing Pliers: Pliers with the limit for excess expansion. Rounded beak protects patient's soft tissue. It can be used with large and small rings.

Mathieu Forceps: It is used for placing all types of elastomers. It has got a slip-free grasping and quick release ratchets for fast operation.

Fig. 19:

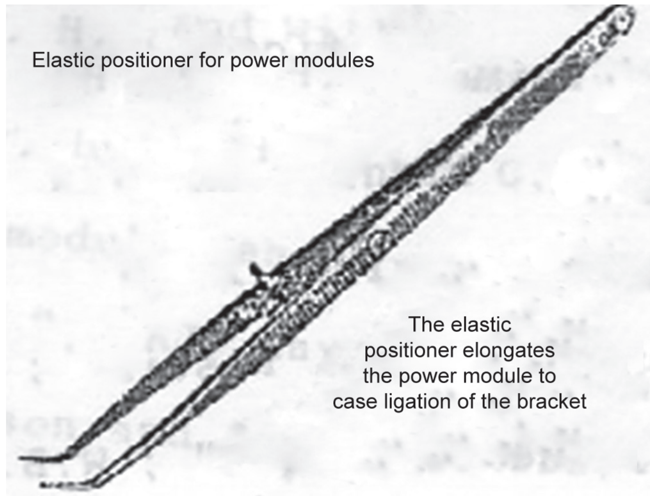

Fig. 20:

Twirl on ligature: It is used for placing elastomeric modules and can be preloaded.

Module Remover: Double-ended instrument for removing modules from the bracket.

Mosquito Forces: Having curved delicate serrated tips for applying modules

Orthodontic Wrench (Fig. 19): It is a double-ended plastic instrument for the use of attaching and elastics by patient himself.

Elastic positioner for power modules (Fig. 20).

CONCLUSION

To put it in a nutshell, elastics are a prime consideration in orthodontics.

Elastics are one of the most versatile materials available to the orthodontist.

It is an invaluable tool of the orthodontist armamentarium.

An orthodontist who does not exploit these materials to the fullest is not doing justice to the patient. As a matter of fact I would think that it is all but not impossible to practice this branch of dentistry without this material.[15]

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