Elastics in Orthodontics: A Comprehensive Review

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Publication Date: 2025/09/24

Abstract: Orthodontic elastics have long been employed as adjuncts in fixed orthodontic therapy to apply inter-arch or intra-arch forces for correcting malocclusions. These small yet potent tools offer clinicians a simple, cost-effective, and patient-manageable means of exerting continuous forces to guide tooth movement . Their use has been particularly pivotal in the correction of Class II and Class III discrepancies, midline deviations, and occlusal settling.

This comprehensive review highlights the classification ,evolution of elastics in orthodontics, emphasizing the transition from natural rubber to synthetic elastomers, clinical uses and biocompatibility. Synthetic materials address limitations such as force degradation and allergic reactions associated with natural rubber. The study also discusses the introduction of fluoride-releasing elastomeric ligatures to reduce plaque retention and the risk of demineralization. However, it notes that elastics, unlike NiTi springs, do not maintain a continuous force over time, which can impact treatment efficacy.

How to Cite: Dr. Sharath kumar Shetty; Dr. Revanth S Soonthodu; Dr. Aashiq Iqbal (2025) Elastics in Orthodontics: A Comprehensive Review. *International Journal of Innovative Science and Research Technology,* 10(9), 1364-1374. https://doi.org/10.38124/ijisrt/25sep882

I. INTRODUCTION AND HISTORICAL CONTEXT

Orthodontic treatment aims to achieve optimal functional occlusion, facial esthetics, and long-term stability through controlled tooth movement. Among the wide array of appliances and biomechanical strategies used to deliver orthodontic forces, **orthodontic elastics**—also known as intermaxillary or interarch elastics—play a pivotal role in managing sagittal, vertical, and transverse discrepancies. These simple yet highly effective auxiliaries have become a cornerstone in fixed orthodontic therapy due to their versatility, cost-effectiveness, and ease of application (Kumar et al., 2012; Ramachandraiah et al., 2018).

Orthodontic elastics are elastic modules made from either **natural rubber (latex)** or **synthetic polymers (non-latex alternatives)**, capable of exerting continuous tensile force across dental arches. They are typically used in conjunction with fixed appliances to enhance or direct tooth movement by generating specific vectors of force. The ability to deliver light, continuous, and physiologic forces makes them invaluable for correcting anteroposterior discrepancies such as Class II and Class III malocclusions, midline deviations, vertical control in open bite or deep bite cases, and crossbites (Rinchuse & Cozzani, 2015).

- *Historical Evolution*

The incorporation of elastics in orthodontics can be traced back to the late 19th century, when Edward H. Angle used rubber tubing cut from surgical supplies to apply interarch forces. However, widespread usage did not begin until the early 20th century when commercially available latex elastics became accessible. The mid-1900s marked a surge in their popularity, particularly after the development of precise force-calibrated elastics, standardized in size and strength by manufacturers (Proffit et al., 2019). Over the decades, improvements in material science led to innovations like color-coded elastics, non-latex alternatives for allergic patients, and force-indicator elastics, making them more adaptable to various clinical needs.

- *Biomechanical Basis*

The primary appeal of orthodontic elastics lies in their simple application and biomechanical predictability. Interarch elastics are typically attached from brackets or hooks on the upper arch to those on the lower arch, creating a vector of force that helps in manipulating the position of teeth and jaws. Depending on how they are placed, these elastics can influence either dentoalveolar movements (like tipping or rotation) or more complex changes in skeletal relationships, especially in growing patients (Burstone & Koenig, 1974).

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25sep882

Despite their simplicity, elastics introduce complex force systems involving moments, anchorage considerations, and side effects such as vertical bite opening or closing, which must be carefully managed. Their effectiveness depends on multiple factors including force magnitude, direction of pull, wear time, and most importantly, patient compliance (Melsen, 2000).

➢ *Clinical Importance*

Orthodontic elastics are particularly vital during the finishing stages of treatment, where precise intercuspation and occlusal detailing are necessary. They are also commonly used during space closure, midline correction, and anchorage reinforcement in both extraction and non-extraction cases. In growing patients, elastics may assist in orthopedic modifications, especially in combination with functional appliances or extraoral traction (e.g., headgear or facemask) (Graber et al., 2016).

Moreover, elastics serve as a powerful adjunct in **non-compliance appliances** when skeletal correction is desired without surgery. However, improper use—either in direction, force magnitude, or wear duration—can result in **undesirable side effects**, such as open bites, posterior crossbites, or TMJ complications, especially when applied without appropriate anchorage control (Weiland et al., 2003).

➢ *Latex vs Non-Latex Debate*

Historically, most orthodontic elastics were made from natural latex rubber, valued for its elasticity and cost-effectiveness. However, latex elastics can provoke allergic reactions in a subset of the population, ranging from mild local irritation to severe hypersensitivity. This has led to the development and increased usage of non-latex elastics made from synthetic polymers like polyurethane. While safer for allergic individuals, non-latex elastics often exhibit greater force decay and less consistent mechanical properties, raising questions about their clinical reliability (Huang et al., 2001).

A significant area of research has thus focused on comparing the performance of latex and non-latex elastics in terms of force delivery, degradation patterns, and clinical outcomes. These studies underscore the need for evidence-based material selection depending on the patient's needs and treatment phase.

II. CLASSIFICATION OF ORTHODONTIC ELASTICS

Orthodontic elastics can be classified based on several parameters including duration of use, material composition, force magnitude, and direction of application. Understanding these classifications is essential for appropriate selection and clinical application, allowing orthodontists to customize treatment strategies for individual malocclusions and biomechanics. This section outlines the most widely accepted classification systems, supported by literature and clinical practice.

➢ *Based on Duration of Use*

- *Interarch Elastics (Removable)*

These elastics are worn by the patient and are typically removed during eating and brushing. They are commonly used to correct anteroposterior and vertical discrepancies and are dependent on **patient compliance** for effectiveness (Nattrass & Sandy, 1995). Common interarch types include:

✓ Class II Elastics: Upper canine to lower molar (mesially directed force on the lower arch)
✓ Class III Elastics: Lower canine to upper molar (distally directed force on the lower arch)
✓ Vertical Elastics: Used to settle occlusion or close open bites
✓ Cross Elastics: Used for buccal-lingual correction in transverse discrepancies

- *Intraoral Elastics (Fixed or Removable)*

These elastics are used within the same arch (intra-arch) to close spaces or align teeth. They may be ligated to brackets and are frequently used during space closure or midline correction (Proffit et al., 2019).

- *Extraoral Elastics*

Used in conjunction with external anchorage appliances such as **headgear** or **facemask**, these elastics help in orthopedic corrections of the maxilla or mandible in growing patients (Graber et al., 2016). They are generally thicker and stronger than intraoral elastics.

➢ *Based on Material Composition*

- *Latex Elastics*

Latex elastics are made from natural rubber, offering superior elasticity, initial force generation, and longer-lasting tensile strength. Due to their hydrophilic nature, however, they undergo degradation when exposed to the oral environment (Huang et al., 2001). Latex remains the most commonly used material due to cost-effectiveness and predictable performance.

- *Non-Latex Elastics*

Also known as latex-free elastics, these are made from synthetic materials like **polyurethane** and are used primarily in patients with **latex allergy** or sensitivity. Although biocompatible, they tend to exhibit **more rapid force decay**, reduced extensibility, and less consistent force over time (Kersey et al., 2003; Dowling et al., 2013).

A study by Hwang et al. (2001) demonstrated that latex elastics retained a significantly higher percentage of their original force than non-latex elastics after 24 hours in artificial saliva, highlighting the limitations of non-latex alternatives in long-term use.

➢ *Based on Force Magnitude*

Manufacturers label elastics according to **force magnitude** (typically measured in ounces or grams) and **internal diameter** (measured in inches or millimeters). Common categories include:

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Table 1 Classification of Elastics Based on Force Magnitude

Category	Internal diameter (inches)	Force magnitude (ounces)
Light	1/8” to 3/16”	2-4
Medium	3/16” to 1/4 “	4-6
Heavy	1/4" to 5/16”	6-8

III. MATERIAL PROPERTIES OF ORTHODONTIC ELASTICS

The clinical efficiency of orthodontic elastics largely depends on their **material properties**, which determine force delivery, biocompatibility, resistance to environmental degradation, and patient comfort. The two most common types of elastics in orthodontics are **latex (natural rubber)** and **non-latex (synthetic polymers)**, each with distinct physical and biological behaviors. Understanding these properties is essential for selecting the appropriate elastic type and predicting their clinical performance in varying intraoral conditions.

➢ *Composition and Manufacturing*

- *Latex Elastics*

Latex elastics are derived from **natural rubber latex (Hevea brasiliensis)**, a polymer composed primarily of cis-1,4-polyisoprene. Latex elastics are characterized by high elasticity, tensile strength, and good force sustainability over short durations. They are formed via **dipping processes**, where metal rods are immersed in a latex solution, then vulcanized to enhance strength and elasticity (Miller et al., 1993).

- *Non-Latex Elastics*

Non-latex elastics are made from synthetic polymers such as **polyurethane or silicone derivatives**. These are preferred for patients with **latex hypersensitivity**, but they exhibit reduced elasticity and faster **force degradation**. Manufacturing involves extrusion or molding of thermoplastic elastomers (Hwang et al., 2001).

➢ *Physical and Mechanical Properties*

The core mechanical properties that affect the clinical use of orthodontic elastics include:

- *Initial Force Delivery*

The force exerted by an elastic upon placement is termed its **initial tensile force**. Latex elastics typically generate higher and more consistent initial forces compared to non-latex elastics. A study by Kersey et al. (2003) revealed that latex elastics produce a more linear force-stretch curve, while synthetic elastics often display a nonlinear response, especially at lower extensions.

- *Elastic Modulus and Stiffness*

The **modulus of elasticity** defines a material's stiffness—how much it resists deformation. Latex elastics usually have a **lower modulus** than synthetic alternatives, allowing greater elongation with smaller increases in force. In contrast, non-latex elastics tend to be stiffer and less forgiving in dynamic movements (Han et al., 2009).

- *Creep and Stress Relaxation*

Orthodontic elastics undergo **creep** (gradual deformation under constant load) and **stress relaxation** (reduction in force under constant elongation). Latex elastics typically exhibit better stress relaxation properties, maintaining force over several hours of wear, which is crucial for consistent tooth movement (Parreira et al., 2015).

➢ *Force Degradation in the Oral Environment*

One of the most studied characteristics of orthodontic elastics is **force degradation**, which refers to the reduction in force over time due to intraoral exposure. Factors influencing degradation include:

- Salivary enzymes and proteins
- pH fluctuations
- Temperature variations
- Mechanical fatigue from mastication and speech
- Absorption of water (hydrolysis)

- *In Vitro vs in Vivo Studies*

While many studies report elastic degradation under controlled in vitro conditions, in vivo degradation is often more rapid and variable. For instance, a study by Weissheimer et al. (2007) found that latex elastics lost 20–30% of their force within the first 3 hours and up to 50% after 24 hours. Non-latex elastics may degrade more rapidly—losing as much as 70% of their initial force within 24 hours (Miller et al., 1993).

- *Comparative Performance: Latex vs Non-Latex*

Table 2 Comparison of Latex and Non Latex Elastics.

Property	Latex Elastics	Non Latex Elasatics
Initial force	Higher and consistent	Lower and variable
Force decay	Moderate (30-50%)	Rapid (50-70%)
Biocompatibility	Allergic in some	Lesser incidence
Elastic recovery	Better	Weaker
Clinical longevity	12-24 hours	8-12 hours

IV. FORCE DELIVERY AND DECAY

Orthodontic elastics function by delivering a **continuous tensile force** to move teeth through the

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periodontal ligament into the desired positions. The magnitude, duration, and stability of this force are critical factors in determining both the **efficiency of tooth movement** and the **risk of unwanted side effects**. A major challenge in clinical orthodontics is **force decay**, the reduction of elastic tension over time, which can compromise treatment outcomes if not properly managed.

➢ *Force Generation and Delivery*

The force produced by an elastic depends primarily on its:

- Initial length and stretch ratio
- Material (latex vs. non-latex)
- Cross-sectional area
- Diameter
- Configuration (single, triangle, box, etc.)

The **amount of stretch** (i.e., how far the elastic is pulled) is the most influential factor. According to Proffit et al. (2019), elastics are typically stretched to **three to four times their resting length** to deliver optimal orthodontic force—ranging from **50 to 250 grams** depending on the desired movement.

A study by Wong (1976) demonstrated that a 1/4-inch latex elastic stretched to 3 times its original length delivered a force of approximately 150 grams. This force increases with further stretch but may reach levels that are biologically undesirable, risking tissue damage, root resorption, or loss of anchorage.

➢ *Ideal Orthodontic Force and Clinical Implications*

The **optimal orthodontic force** is defined as the minimum amount of force that produces **maximum tooth movement with minimal tissue damage**. For continuous forces, this is often:

- **20–150 grams** for tipping
- **100–200 grams** for bodily movement
- **200–300 grams** for intrusion/extrusion or correction of occlusal cant

Elastics ideally deliver **light, continuous forces**, but this goal is complicated by **rapid force degradation**, especially in non-latex varieties. Therefore, force delivery must be **frequently renewed**—typically 3 to 4 times daily—to maintain efficacy (Kersey et al., 2003).

➢ *Force Decay Dynamics*

- *Immediate Force Decay*

Most elastics experience a significant force reduction within the **first hour** of placement. This is known as **initial decay**, and may range from **10% to 30%** of the original force. It is primarily due to:

✓ **Stress relaxation** (loss of internal molecular tension under constant elongation)
✓ **Creep deformation** (gradual elongation over time)

A landmark in vitro study by Hwang et al. (2001) found that **latex elastics** lost about **20–25%** of their force within the first 60 minutes, while **non-latex elastics** lost up to **40%** in the same time frame.

- *Delayed/Intraoral Force Decay*

After the initial phase, elastics continue to lose force due to:

✓ Exposure to **saliva and enzymes**
✓ **pH fluctuations** (especially in acidic environments)
✓ **Mechanical fatigue** from mastication and speech

In vivo studies have shown that latex elastics can lose up to **50–60%** of their force within 24 hours of intraoral use (Weissheimer et al., 2007; Parreira et al., 2015). Non-latex elastics degrade even faster—often losing **60–70%** of their force within the same period (Vieira et al., 2012).

➢ *Factors Affecting Force Decay*

- *Material Type*

✓ **Latex elastics** have better force stability due to their ability to resist deformation.
✓ **Non-latex elastics**, although hypoallergenic, degrade rapidly due to poorer molecular cohesion and sensitivity to hydration.

- *Environmental Conditions*

✓ Temperature: Heat accelerates polymer relaxation and breakdown.
✓ Humidity and Saliva: Latex elastics absorb water, leading to hydrolytic degradation. Enzymes in saliva (e.g., amylase) further break down rubber chains.
✓ Oral pH: Acidic environments (e.g., GERD, high-sugar diets) cause faster decay.

- *Amount of Stretch*

Greater stretch ratios yield higher initial force but also more **rapid decay**. Overstretching elastics beyond 3.5× their original length can increase initial force above safe limits and decrease longevity (Huang et al., 2001).

- *Elastic Configuration*

Force loss is also influenced by how elastics are configured:

✓ **Single elastics** show more uniform force decay.
✓ **Box or triangle elastics** may degrade faster due to multiple vectors and longer effective length.

➢ *Recommendations for Clinical Practice*

Based on current evidence, best practices to optimize force delivery include:

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- Frequent Replacement**:** Elastics should be replaced every **12–24 hours** for latex and every **8–12 hours** for non-latex types.
- Patient Education**:** Patients must be trained to recognize when elastics lose tension and be encouraged to replace them **multiple times daily**.
- Monitoring Wear Patterns**:** Regular check-ups should include assessment of elastic wear, force integrity, and side effects.
- Avoid Overstretching**:** Clinicians should carefully measure stretch to avoid excessive forces that may cause discomfort or damage.

➢ *Side Effects of Inconsistent Force*

Inconsistent or insufficient forces due to decay can result in:

- Delayed or stalled tooth movement
- Anchorage loss
- Asymmetric corrections
- Excessive force peaks if patients use stronger elastics to "compensate," which may cause root resorption or periodontal damage

A balance between **sufficient force duration** and **biological safety** must be maintained to ensure optimal outcomes (Davidovitch, 2003).

V. CLINICAL APPLICATIONS OF ORTHODONTIC ELASTICS

Orthodontic elastics are integral components in fixed and removable appliance systems, widely used to facilitate controlled **tooth movement**, correct **malocclusions**, and manage **skeletal discrepancies**. Their versatility, ease of use, and cost-effectiveness make them indispensable in contemporary orthodontic therapy. Clinical application depends on multiple factors including malocclusion type, treatment phase, patient compliance, and elastic configuration.

➢ *Objectives of Using Elastics*

The main goals of using orthodontic elastics in treatment are:

- Correction of **anteroposterior discrepancies** (Class II and Class III)
- Establishment of **vertical control** (open bite/ deep bite correction)
- Correction of **midline deviations**
- Space closure during **finishing and detailing**
- Assistance in **extrusion or intrusion** of specific teeth
- Achieving proper **interdigitation and intercuspation**

Elastics deliver **interarch or intraarch** forces based on how and where they are placed. Their clinical effectiveness relies heavily on **force vector orientation**, magnitude, and duration of wear (McLaughlin et al., 2001).

➢ *Interarch Elastics*

Interarch elastics are used across the upper and lower arches to correct **jaw relationships** and coordinate occlusion. The three primary types include:

- *Class II Elastics*

Used from the maxillary canine (or premolar) to the mandibular molar, these elastics pull the **maxillary arch backward** and **mandibular arch forward**.

✓ Indications**:** Mild to moderate Class II malocclusions, mandibular retrognathism, space closure.
✓ Effects**:** Retrusion of maxillary anterior teeth, proclination of mandibular incisors, extrusion of molars.
✓ Considerations**:** May worsen vertical dimension in high-angle patients due to molar extrusion (Janson et al., 2005).

- *Class III Elastics*

Attached from the mandibular canine to the maxillary molar, they pull the **lower arch backward** and **upper arch forward**.

✓ Indications**:** Mild Class III cases with dental component, maxillary deficiency.
✓ Effects**:** Proclination of maxillary incisors, retroclination of mandibular incisors, extrusion of maxillary molars.
✓ Limitations**:** Use cautiously in low-angle cases due to bite deepening (Uner et al., 2015).

- *Vertical Elastics*

Connected between corresponding teeth in the maxilla and mandible, they are used to **enhance intercuspation**, especially during finishing.

✓ Indications**:** Open bite cases, improvement of occlusal contacts.
✓ Effects: Extrusion of teeth, improvement of overbite.
✓ Risks**:** May cause incisor flaring or increased vertical dimension if not controlled (Proffit et al., 2019).

➢ *Intraarch Elastics*

These elastics operate within a single arch and are primarily used for space management or alignment.

- *Midline Correction Elastics*

Used diagonally across the arch to correct dental midline deviations. Often attached from a canine on one side to a molar on the opposite arch.

✓ Indications**:** Unilateral Class II or III relationships, dental midline shifts.
✓ Considerations**:** Require careful anchorage planning to avoid iatrogenic effects.

- *Figure-8 or Chain Elastics*

Used for space closure by applying continuous force between brackets. These are not interarch but are considered **elastomeric ligatures** functioning similarly to power chains.

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- *Box Elastics*

Form a rectangular pattern . They help in **occlusal settling** and **open bite closure**.

- *Skeletal Applications and Functional Orthopedics*

In growing patients, elastics may influence **skeletal growth direction** when used with anchorage reinforcement:

- *Class II Correction with Functional Appliances*

Functional appliances such as the Twin Block or Herbst appliance use **incorporated elastics** to enhance mandibular advancement. Elastics support forward mandibular posture and help with **muscular adaptation**.

- *Maxillary Protraction*

In Class III cases, **reverse pull headgears** (facemasks) with elastics are used to **protract the maxilla**, especially in patients with maxillary retrusion.

- ✓ Protocol**:** Elastics from facemask to intraoral hooks near canines; 400–500g per side; 12–14 hours/day.
- ✓ Success Factors**:** Best outcomes before growth peak (age 8–10); improved with expansion appliances (Ngan et al., 1992).

- *Application in Open Bite and Deep Bite Cases*

- *Anterior Open Bite*

Vertical anterior elastics **are used to** extrude anterior teeth **and reduce open bite. However, they must be used cautiously in high-angle patients to avoid excessive molar extrusion.**

- *Deep Bite Cases*

Vertical posterior elastics can promote **posterior extrusion**, flattening the occlusal plane and aiding in **bite opening**. Use is often combined with **bite turbos** or **anterior intrusion mechanics**.

- *Finishing and Detailing*

In the final stages of orthodontic treatment, elastics are frequently used to:

- Improve **occlusal settling**
- Fine-tune **midline discrepancies**
- Achieve **Class I canine and molar relationships**

Light vertical elastics **(1/8 inch, 2–4 oz) are typically employed for 2–4 weeks to ensure stable intercuspation and patient comfort (Burstone & Koenig, 1974).**

- *Patient Compliance and Instructions*

The **success** of elastic use is heavily dependent on **patient compliance**, which requires:

- Wearing elastics **full-time** (20–22 hours/day)
- **Replacing elastics** at least **3–4 times daily**
- Avoiding **"doubling up"** without clinical guidance
- Understanding the purpose of elastics to encourage **motivated behavior**

Studies show that **noncompliance is the leading cause** of prolonged treatment time and suboptimal results when elastics are prescribed (Almog et al., 2008).

VI. COMPLICATIONS AND SIDE EFFECTS

Despite their widespread use and relative simplicity, orthodontic elastics can lead to a number of **unintended consequences** and **adverse effects** if not carefully prescribed and monitored. These complications may arise from **excessive force application**, **poor patient compliance**, or inappropriate elastic selection. Recognizing and managing such side effects is crucial to ensure safe and efficient treatment progression.

- *Uncontrolled Tooth Movement*

- *Anchorage Loss*

One of the most common mechanical complications of interarch elastic use is **anchorage loss**, which refers to the unintended movement of teeth that are expected to remain stationary. For instance:

- ✓ Class II elastics may cause **mesial movement of mandibular molars** and **distal tipping of maxillary incisors**, reducing effective space closure.
- ✓ Class III elastics can induce **mesial migration of maxillary molars**, potentially reopening extraction spaces or altering occlusion.

Studies such as those by Janson et al. (2003) and Al-Nimri & Al-Khatieeb (2005) confirm that elastic forces applied without proper anchorage control can significantly alter tooth positions and compromise planned outcomes.

- *Unwanted Tipping and Torque Effects*

Elastics primarily deliver **tipping forces**, which can cause teeth to lean rather than move bodily. This is particularly problematic when elastics are used for:

- ✓ **Midline corrections**, where lateral forces can flare or tip adjacent teeth.
- ✓ **Class II or III corrections**, where incisors may become **proclined or retroclined** depending on the direction of force application.

Linjawi et al. (2016) reported that excessive use of Class II elastics led to **proclination of lower incisors**, complicating retention and aesthetics in adult patients.

- *Effects on the Periodontium and Supporting Structures*

- *Root Resorption*

Orthodontic tooth movement exerts stress on the periodontal ligament and alveolar bone, which, when excessive, can trigger **external root resorption (ERR)**. Force levels exceeding biologically safe thresholds (typically >150–200g) are associated with increased resorption risk.

While elastics typically generate lighter forces, **misuse or "doubling up"** can raise applied forces to harmful levels.

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25sep882

According to Davidovitch (2003), prolonged excessive forces may activate odontoclastic activity, leading to irreversible apical shortening.

- *Gingival Inflammation and Tissue Trauma*

Elastics that are mispositioned or dislodged can cause:

- ✓ Gingival ulceration
- ✓ Localized inflammation
- ✓ Hyperplasia

When placed incorrectly into the gingival sulcus—especially by untrained patients—elastics may migrate subgingivally, leading to **periodontal breakdown** or even **tooth loss** (Tay et al., 1981).

- *Tooth Mobility*

Temporary **mobility** is expected during tooth movement; however, poorly controlled elastic use can result in **persistent mobility**, particularly in teeth under constant and heavy forces. This is usually reversible but must be closely monitored.

➢ *Skeletal and Vertical Dimension Changes*

Elastics can influence not just dental but also **skeletal and vertical relationships**, particularly when used over extended periods or in growing patients.

- *Vertical Dimension Increase*

Class II elastics tend to cause **extrusion of maxillary incisors and mandibular molars**, leading to:

- ✓ **Increased lower anterior facial height**
- ✓ **Clockwise mandibular rotation**
- ✓ **Open bite tendency** in high-angle patients

This side effect is more pronounced in patients with **hyperdivergent growth patterns** (Graber et al., 2011). Vertical elastics, similarly, may worsen open bites if not carefully controlled.

- *Facial Asymmetry and Occlusal Canting*

Unilateral elastic wear (e.g., for midline correction) can lead to **asymmetric molar extrusion** and **canting of the occlusal plane**, which may affect facial esthetics.

➢ *TMJ Disorders and Muscular Strain*

Improper elastic usage, especially when involving continuous force across asymmetrical vectors, may cause or exacerbate:

- ✓ Temporomandibular joint (TMJ) discomfort
- ✓ Myofascial pain
- ✓ Muscle fatigue or soreness

While the evidence is mixed, some reports (e.g., Conti et al., 2003) suggest that chronic asymmetric elastic wear can alter mandibular function and provoke TMJ symptoms in susceptible individuals.

➢ *Latex Allergy and Hypersensitivity*

One of the few **material-based complications** involves the use of latex elastics, which may cause:

- Contact dermatitis
- Oral mucosal ulceration
- Systemic allergic reactions **(in severe cases)**

While rare, **latex hypersensitivity** requires complete avoidance of latex-based elastics and substitution with **non-latex alternatives**. Non-latex elastics, however, degrade faster and require more frequent replacement (Kersey et al., 2003).

➢ *Elastic Impaction and Tissue Entrapment*

- *Subgingival Migration*

There are documented cases where patients mistakenly place elastics around teeth rather than on brackets or hooks. This can cause the elastic to **migrate subgingivally**, strangulate the periodontal ligament, and lead to **rapid tooth loss**.

Tay et al. (1981) presented a case where a misplaced elastic around a tooth's cervical margin migrated apically, causing **complete periodontal attachment loss and exfoliation** of the tooth within days.

- *Inhalation or Ingestion*

Though rare, elastics may become dislodged and **inhaled or swallowed**, especially during placement. Precautionary advice includes:

- ✓ Instructing patients to insert elastics over a sink or mirror
- ✓ Advising them to wear elastics **only as prescribed** and not during sports or meals (if advised otherwise)

VII. COMPARATIVE STUDIES ON ORTHODONTIC ELASTICS

Orthodontic elastics, though simple in appearance, vary significantly in their **material properties**, **mechanical behavior**, **biocompatibility**, and **clinical performance**. Comparative studies have played a pivotal role in understanding these differences and guiding evidence-based clinical decisions. This section highlights key comparative research on orthodontic elastics, categorized under **material comparisons**, **force decay**, **clinical effectiveness**, and **patient compliance**.

➢ *Material-Based Comparative Studies*

- *Latex vs. Non-Latex Elastics*

One of the most extensively studied comparisons in orthodontics is between **natural latex** and **synthetic (non-latex)** elastics. Natural latex elastics are traditionally favored for their superior elasticity and force retention, but concerns about **allergic reactions** and **inconsistent degradation** have spurred interest in non-latex alternatives.

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25sep882

- ✓ **Kersey et al. (2003)** compared latex and non-latex elastics and found that **non-latex elastics exhibited a significantly faster force decay**, losing up to **50% of initial force within the first hour**, whereas latex elastics showed more **gradual degradation**.
- ✓ **Hernández et al. (2012)** corroborated these findings, reporting that latex elastics maintained clinically useful forces for **24 hours**, while non-latex options required **more frequent replacement** to maintain consistent force levels.
- ✓ **Conclusion**: Latex elastics outperform non-latex in terms of **force retention**, but the latter are safer for patients with latex sensitivity.

- ***Elastomeric Chains vs. Interarch Elastics***

Elastomeric chains (used primarily for **space closure**) differ from interarch elastics in both **composition** and **clinical purpose**. A study by **Miller et al. (2007)** demonstrated that elastomeric chains deliver **higher initial forces**, but also **greater force decay**, making them less predictable for applications requiring long-term sustained force, such as interarch correction.

➢ *Force Decay Comparisons*

- *Dry vs. Wet Environments*

In vitro studies simulate **intraoral conditions** to analyze how elastics perform in **saliva** or **moist environments** compared to dry storage.

- ✓ **Huang et al. (2001)** found that elastics stored in **artificial saliva at 37°C** experienced **faster degradation** than those stored dry, especially within the first 6 hours.
- ✓ **Barwart (1985)** also demonstrated that the presence of moisture accelerates **polymer relaxation**, reducing effective force.

- *Brands and Manufacturers*

Several studies have tested elastics from different commercial brands under standardized conditions.

- ✓ **Baty et al. (1994)** compared three brands of latex elastics and found significant variability in both **initial force** and **rate of degradation**, even when labeled with similar specifications (e.g., ¼-inch, 4 oz).
- ✓ **Li et al. (2017)** tested 10 brands and found that **quality control** and **manufacturing technique** impacted the force consistency and longevity of elastics.

➢ *Clinical Comparative Studies*

- *Class II Correction: Elastics vs. Functional Appliances*

- ✓ **Janson et al. (2005)** conducted a study comparing **Class II elastics** and the **Herbst appliance** for mandibular advancement in adolescents. Results indicated that the **Herbst appliance produced more skeletal effects**, while elastics resulted in **dentoalveolar changes**, especially proclination of lower incisors.
- ✓ **Conclusion**: Elastics are more effective for **dental correction**, while functional appliances are indicated for **skeletal modification**.
- ✓ ***Vertical Elastics vs. Bite Turbos for Deep Bite***
- ✓ **Kalra et al. (2008)** compared **vertical anterior elastics** with **posterior bite turbos** in deep bite correction. The elastic group showed **faster anterior extrusion**, but also increased **incisor flaring**. Bite turbos provided **more stable intrusion** with fewer side effects.
- ✓ **Clinical recommendation**: Use a **combination** of bite turbos and vertical elastics for balanced correction.

➢ *Efficiency of Elastic Configurations*

- *Box vs. Triangle Elastics*

Different configurations (box, triangle, vertical, cross) offer varying biomechanical outcomes:

- ✓ ***Weiland et al. (2001)*** *compared* ***box vs. triangle elastics*** *in finishing stages and found:*

  - ▪ Box elastics were more efficient in **posterior open bite closure**.
  - ▪ Triangle elastics enhanced **anterior settling** and **occlusal contact** formation.

- ✓ **Clinical implication**: Configuration should be matched to **specific occlusal objectives**.
- ✓ ***Unilateral vs. Bilateral Elastics***
- ✓ **Häsler et al. (1997)** assessed **unilateral Class II elastics** and found they can correct **midline discrepancies**, but also lead to **asymmetric molar extrusion** and **canting of the occlusal plane**.
- ✓ Bilateral elastics, though more stable, are **less effective for unilateral corrections**.

➢ *Compliance Comparisons*

- *Self-Reported vs. Sensor-Monitored Wear*

- ✓ **Almog et al. (2008)** studied elastic wear compliance using **electronic sensors** placed in appliances and found a **significant discrepancy** between self-reported and actual wear time. Patients claimed **20+ hours/day**, but sensors recorded an average of **14 hours/day**.
- ✓ **Conclusion**: Overestimation of compliance is common; **reminder systems and monitoring devices** may improve wear time.
- ✓ ***Adolescent vs. Adult Patients***
- ✓ **Mandall et al. (2006)** compared adolescents and adults in terms of elastic wear and discomfort. Adolescents reported **more discomfort**, but **higher compliance**, especially when educated and monitored closely.
- ✓ **Implication**: Adolescents may be more **trainable**, while adults may need **greater motivation and autonomy**.

➢ *Comparative Efficacy in Open Bite and Deep Bite Cases*

- **Iscan and Akkaya (2006)** compared the outcomes of **vertical elastics alone** versus **elastics with skeletal anchorage (TADs)** in open bite cases. The combination

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25sep882

group showed **superior control over molar extrusion** and more **stable results**.

VIII. RECENT ADVANCES AND FUTURE TRENDS IN ORTHODONTIC ELASTICS

Orthodontic elastics have traditionally been seen as passive auxiliaries used for tooth movement and interarch correction. However, recent years have witnessed significant advancements in **material science, force application monitoring, digital integration**, and **customization of orthodontic appliances**. These innovations not only address the limitations of conventional elastics, such as **rapid force decay**, **biocompatibility concerns**, and **patient compliance issues**, but also pave the way for more **efficient**, **predictable**, and **patient-friendly treatments**.

➢ *Advances in Material Science*

- *Nano-Enhanced Elastomeric Materials*

Recent research has explored the incorporation of **nanoparticles** into elastomeric materials to improve their **mechanical properties**, **biocompatibility**, and **force sustainability**.

✓ **Nanofillers**, such as **nano-silica**, **titanium dioxide**, and **carbon nanotubes**, have been shown to **reinforce the polymer matrix**, reducing **stress relaxation** and improving **force delivery consistency**.
✓ **Li et al. (2021)** demonstrated that elastics reinforced with nano-silica showed **30% lower force degradation** after 24 hours compared to conventional latex elastics.

These materials also offer enhanced **antimicrobial properties**, potentially reducing the **plaque-retentive nature** of elastics in the oral cavity.

- *Smart Polymers and Memory Materials*

Research into **shape-memory polymers (SMPs)** and **thermoresponsive elastomers** has opened up possibilities for elastics that can **self-regulate force** in response to temperature changes or time-based activation.

✓ Smart elastics can potentially maintain **constant forces** over longer durations, minimizing the need for frequent replacement.
✓ This feature is particularly useful in **low-compliance patients**, reducing reliance on patient responsibility.

Although still in **experimental phases**, such materials may lead to the development of **programmable orthodontic forces**.

➢ *Biocompatible and Hypoallergenic Innovations*

With the increasing prevalence of **latex allergies**, there has been a global push toward **non-latex**, **hypoallergenic elastics**. New non-latex formulations using **thermoplastic polyurethanes (TPUs)** and **medical-grade silicones** are being tested to mimic the elasticity of natural rubber while offering **superior safety profiles**.

- These newer elastics are undergoing **clinical trials** to assess their long-term **force behavior**, **aging characteristics**, and **tissue compatibility**.
- Manufacturers are also working to **standardize labeling and performance metrics**, which historically varied widely among non-latex options.

➢ *Technological Integration in Force Monitoring*

- *Electronic Sensors and Smart Monitoring Systems*

One of the biggest limitations in elastic therapy is the **inability to verify actual wear time**. Technological innovation has led to the development of **microelectronic sensors** that can be embedded into appliances or brackets to monitor:

✓ Elastic wear duration
✓ Force levels applied
✓ Moisture and temperature exposure

Studies by **Almog et al. (2008)** and more recently **Cunningham et al. (2022)** have evaluated these sensors, showing promising results in improving **compliance and communication** between orthodontists and patients.

These sensors can wirelessly transmit data to apps, allowing real-time tracking and **remote patient monitoring**, which is especially useful in **teleorthodontics** or **aligner-based practices**.

➢ *Customization Through Digital Orthodontics*

- *3D Printed Elastic Hooks and Attachments*

Digital orthodontics has revolutionized how auxiliaries are planned and implemented. With **3D printing**, clinicians can now fabricate **custom elastic hook designs**, **precision jigs**, and **bite corrector auxiliaries** that are digitally designed to suit the patient's **individual malocclusion**.

✓ This allows for better **elastic vector control**, **reduced trauma**, and **improved esthetics**.
✓ Hooks can be incorporated into **clear aligners**, **lingual systems**, or **TADs**, providing innovative anchor points for elastic wear.

- *Simulation Software for Elastic Planning*

Software platforms like **OrthoCAD**, **Dolphin Imaging**, and **ClinCheck Pro** (for Invisalign users) now allow clinicians to simulate **elastic vectors**, **anchorage demands**, and **tooth movement predictions**.

✓ This aids in better **treatment planning**, especially in asymmetric cases or when using **Class II or Class III elastics** in combination with aligners or TADs.
✓ Future versions may incorporate **real-time force modeling** to enhance accuracy.

ISSN No: -2456-2165 https://doi.org/10.38124/ijisrt/25sep882

➢ *Elastic Use in Clear Aligner Therapy*

As clear aligner therapy gains popularity, elastic integration has evolved to complement **aesthetics and biomechanics**.

- **Precision cuts** in aligners allow for elastic wear without compromising esthetics.
- Newer aligner systems (e.g., **Spark**, **Invisalign G8/G9**) have built-in designs to facilitate Class II and Class III elastic attachments.
- Studies by **Weir et al. (2020)** indicate that aligner-based elastic therapy has similar effectiveness in **anteroposterior corrections** compared to fixed appliances, provided **excellent patient compliance** is maintained.

Future aligner systems may have **smart elastic interfaces** that adjust tension dynamically or alert wearers to incorrect usage.

➢ *Biomechanical Modeling and Artificial Intelligence (AI)*

AI and **finite element analysis (FEA)** are being used to study elastic forces in complex treatment scenarios.

- **Machine learning algorithms** can predict force decay patterns based on **patient-specific variables** like **saliva composition**, **temperature**, and **wear behavior**.
- **AI-integrated clinical decision systems** may suggest optimal **elastic size, configuration, and replacement frequency** tailored to each case.

This could eventually lead to **automated prescription systems** that recommend elastic protocols based on input clinical data and projected movement goals.

➢ *Sustainable and Eco-Friendly Elastic Products*

Environmental considerations are beginning to influence orthodontic product development. Researchers are investigating **biodegradable elastics** and **eco-conscious packaging**.

- Products using **plant-based polymers** or **renewable elastomers** may soon replace traditional rubber bands, aligning orthodontics with broader healthcare sustainability goals.

➢ *Challenges and Limitations in Implementation*

Despite these advances, several challenges remain:

- **Cost of smart materials and monitoring systems** may limit widespread adoption.
- **Standardization** of testing protocols for new materials is needed.
- The **regulatory approval** process for electronic and smart devices in orthodontics can delay innovation.

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IX. CONCLUSION

Orthodontic elastics have remained a cornerstone of orthodontic biomechanics for over a century, owing to their versatility, simplicity, and effectiveness in managing interarch and intra-arch discrepancies. This literature review has explored the **historical development**, **classification**, **material properties**, **force delivery patterns**, **clinical applications**, **complications**, **comparative studies**, and **recent innovations** in orthodontic elastic use.

The **mechanical performance** of elastics, particularly their initial force delivery and inevitable force decay, underscores the importance of **frequent replacement**, **patient compliance**, and **strategic application**. The **difference in performance between latex and non-latex elastics** is clinically significant, especially in terms of **force retention** and **hypersensitivity risks**, guiding orthodontists to tailor material choices based on both mechanical needs and patient-specific considerations.

In clinical settings, elastics serve vital roles in **Class II and Class III correction**, **midline shift correction**, **deep bite management**, **open bite closure**, and **finishing and detailing of occlusion**. However, they are not devoid of complications, including **unintended tooth movement**, **anchorage loss**, **vertical discrepancies**, **root resorption**, and **patient discomfort**. As such, **controlled force application** and **good anchorage planning** are essential to minimize adverse effects.

Comparative studies continue to shed light on the **efficacy of different configurations**, **material choices**, and **treatment modalities**, enabling clinicians to make **evidence-based decisions**. Importantly, the orthodontic field is witnessing rapid advances in the development of **nano-reinforced materials**, **smart elastics**, **digital integration**, and **compliance monitoring technologies**. These innovations promise to improve the **consistency**, **predictability**, and **patient experience** associated with elastic use. Despite these advancements, the **clinical success of elastics remains heavily dependent on patient cooperation**. Future developments must therefore not only focus on improving material properties and force behavior but also address **behavioral and motivational factors** that influence patient compliance.

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