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Impact of Ph on Force Degradation of Elastics in Orthodontics: A Systematic Review

Dr M V Durga[1], Dr Suma S[2], Dr Jyothi Kiran H[3]

[1]PG Student, Department of Orthodontics, JSS Dental College and Hospital
[2]Reader, Department of Orthodontics, JSS Dental College and Hospital
[3]Professor and HOD, Department of Orthodontics, JSS Dental College and Hospital

Abstract

Background:

Orthodontic elastics and elastomeric chains are integral to achieving controlled tooth movement in orthodontic treatment. However, these materials are susceptible to force degradation, particularly when exposed to varying intraoral conditions. Among the influencing factors, pH fluctuations in the oral environment—caused by diet, hygiene products, or saliva composition—may significantly affect the mechanical integrity of elastics. Understanding how pH levels impact force degradation is crucial for optimizing clinical outcomes.

Objective

Objective of the review was to comprehensively evaluate the existing literature on the impact of pH variations on the mechanical properties and degradation rates of orthodontic elastics.

Data Source:

Databases such as PubMed, Scopus, Web of Science, and ScienceDirect were searched for studies published between January 1990 and December 2024 with keywords such as force decay, force degradation, e chain, elastics, orthodontics, pH.

Result:

Out of 611 initially identified articles, 5 met the inclusion criteria. These studies investigated the degradation behaviour of orthodontic elastics under pH conditions ranging from 4.0 to 7.5. Two studies focused on latex elastics, while three evaluated elastomeric chains. Results varied, with some studies identifying a significant correlation between pH and force degradation particularly under acidic or alkaline conditions while others reported no statistically significant relationship.

Conclusion:

This review indicates that pH fluctuations especially in acidic or alkaline environments can adversely affect the mechanical properties of orthodontic elastics, contributing to premature force loss. Despite some inconsistencies across studies, the findings underscore the importance of patient education regarding dietary and oral hygiene habits that influence oral pH. Further standardized research is recommended to establish definitive clinical guidelines for material selection and maintenance under variable pH conditions.

Keywords: force decay, force degradation, e chain, elastomeric chain, elastics, orthodontics, pH.

INTRODUCTION

Orthodontic treatments are dependent on the utilization of diverse appliances and materials to attain optimal outcomes in dental alignment and occlusion. Among these materials, elastics and elastomers play an important role in imparting controlled forces to facilitate orthodontic tooth movement and correction of malocclusions [1]. Elastics are characterized as flexible and stretchable substances, commonly employed with both fixed and removable orthodontic and orthopaedic devices. Their function is to exert directional forces that assist in the movement of teeth and the correction of specific malocclusions [2].

A notable limitation of elastics is that their strength diminishes over time. This phenomenon is referred to as "force decay," and it is essential that this decay remain within acceptable parameters to ensure optimal orthodontic tooth movement [3-6]. Prior studies suggest that elastics undergo considerable force loss shortly after being introduced into the oral environment, with the majority of degradation transpiring within the initial six hours of exposure, and studies have documented that the elastomeric chains experience a reduction in strength ranging from 50% to 70% at the 24-hour mark[7-8], followed by a relatively stable phase exhibiting a 10–20% force decay over the subsequent four weeks[9].

Various external factors, including the temperature of the oral cavity, the intraoral environment, the influence of substances present in saliva, food, or beverages, fluctuations in salivary pH, and exposure to ultraviolet light are reported to contribute to the degradation of elastomeric chains [10]. The relationship between pH levels and the force degradation of elastics used in orthodontics is a critical area of investigation, particularly given the increasing use consumables that can alter oral pH. As pH can significantly affect the material properties of elastics, it is imperative to understand how these changes influence their mechanical performance over time. This systematic review aims to explain these dynamics, providing insights for both clinical practice and future research. Understanding the interactions between elastics and varying pH levels will not only enhance treatment outcomes but also guide orthodontists in selecting appropriate materials that can withstand the challenges posed by dietary influences.

Objective of the Review

Objective of the review was to comprehensively evaluate the existing literature on the impact of pH variations on the mechanical properties and degradation rates of orthodontic elastics.

Methodology

Protocol: The review is reported following the PRISMA (Prefererred Reporting Items for Systematic Review and Meta Analysis) Guidelines. The search strategy involved a thorough examination of multiple databases, including PubMed, Scopus, and Web of Science, Sciencedirect to identify relevant studies published till December 2024 Terms used in search included keywords such as force decay, force degradation, e chain, elastomeric chain, elastics, orthodontics, pH. Two investigators sorted out those studies that complied with selection criteria.

The focused PICO research question was: to what extent the pH affects the degradation of the mechanical properties and strength of the elastics used in orthodontic treatments

P: elastics / e chain

I: mechanical properties and strength

C: varying pH levels

O: degradation of elastomeric chains.

Inclusion And Exclusion Criteria

The present study included only those articles that met specific inclusion criteria to ensure relevance and consistency. Eligible studies were required to involve in vitro exposure of either elastomeric chains or elastics to varying pH levels, focusing specifically on the evaluation of force degradation under such conditions. To maintain the scientific validity and contemporaneity of the data, only studies published between January 1990 and 2024 were considered. Additionally, only studies published in the English language were included to ensure accurate interpretation and analysis of findings. Conversely, studies were excluded if they were published in languages other than English, did not specifically assess the impact of pH on force degradation, or were categorized as systematic reviews or meta-analyses, as these do not provide primary experimental data. These criteria were applied to refine the selection process and focus the review on original experimental research directly related to the objective of evaluating the effect of pH on the mechanical properties of orthodontic materials.

Screening Process and Data Collection

Two reviewers independently carried out a systematic screening of the titles and abstracts of all retrieved articles. In instances where there was a disagreement, a third reviewer was involved to resolve the issue. If the abstract did not provide sufficient detail to determine the study's eligibility, the full text was reviewed to make an informed decision. After identifying potentially relevant studies, both reviewers obtained and evaluated the complete articles. Full-text reviews were conducted for included studies,data extracted from the included studies comprised general details such as the publication year, type of elastics, manufacturer, intervals of measurement, distance between pins, the pH of solution tested, and the control conditions used. Full-text reviews were conducted for excluded studies, and the reasons for their exclusion were recorded.

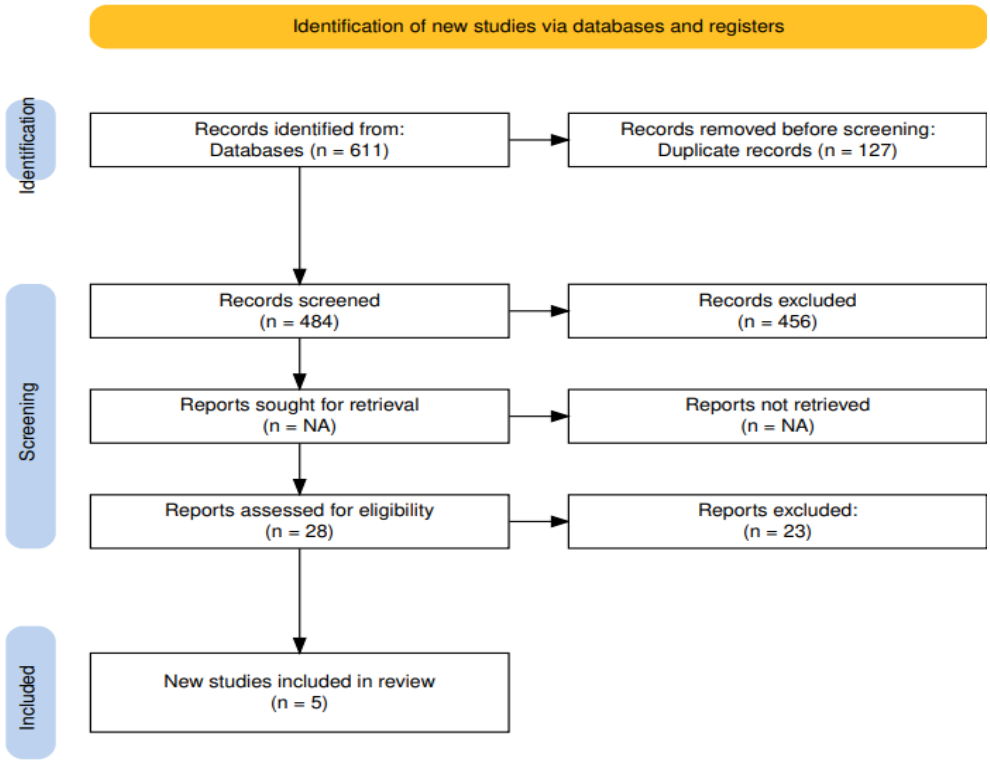

Fig:1 PRISMA 2020 flow diagram for new systematic reviews which included searches of databases, registers and other sources

Results

Out of the 611 articles initially screened, 606 were excluded based on the predefined eligibility criteria. As a result, only 5 studies were included in this systematic review. All included studies were in vitro experiments that investigated the effect of pH on the force degradation of orthodontic elastics. Two of the studies focused on elastics, while the remaining three examined elastomeric chains. The pH levels tested across the studies ranged from 4.0 to 7.5. One study utilized citric acid, a weak acid, but did not specify the exact pH value. Two studies assessed force degradation on a weekly basis over a period of four weeks, whereas the others recorded measurements at specific hourly intervals. In four of the studies, elastics were stretched to 25 mm, while one study did not report the extent of elastic stretch.

Discussion

This systematic review provides a comprehensive evaluation of the influence of pH on the force degradation of orthodontic elastics, with a particular focus on the mechanical behavior of elastics and elastomeric chains in varying pH environments. The findings suggest a complex relationship between pH levels and the performance of these materials, reflecting the potential impact of oral environmental factors on orthodontic treatment outcomes.

The pH scale, ranging from 0 to 14, is a fundamental indicator of acidity and alkalinity in the oral cavity. A neutral pH of 7 represents equilibrium, while values below and above this threshold indicate increasing acidity and alkalinity, respectively. Salivary pH can fluctuate due to diet, oral hygiene, microbial activity, and the use of acidic or basic oral care products—all of which may contribute to variations in the physical properties of orthodontic materials over time.

Among the reviewed studies, James P. et al. observed that the rate of force decay in polyurethane elastomeric chains is inversely proportional to the pH level. Their findings imply that basic (alkaline) environments are particularly detrimental to the mechanical integrity of these chains, accelerating force degradation. This result highlights the potential risk posed by alkaline oral conditions, which may occur due to specific diets, mouth rinses, or individual salivary composition [11].

In contrast, studies by Rogério et al. and Paul S. reported no statistically significant correlation between pH levels and force degradation. These findings suggest that other variables, such as the type of material, duration of exposure, and method of force measurement, might play a more dominant role in determining force loss than pH alone. It is possible that within certain pH ranges, the effect on elastomeric properties may be minimal or that methodological differences masked subtle trends [12-13].

On the other hand, Shabnam Ajami et al. found a significant association between pH fluctuation and force degradation in latex elastic bands, only at the 36-hour mark. This partial correlation indicates that both the duration of exposure and pH variability may influence how elastics behave in the oral environment, emphasizing the dynamic and time-dependent nature of degradation processes [14].

Amin Khaleghi et al. contributed further insights by demonstrating that citric acid, a weak acid, effectively reduced the force of elastomeric chains. Although the study did not specify the exact pH of the citric acid solution used, the observed degradation underscores the role of even mildly acidic conditions in compromising the structural integrity of orthodontic elastics [15].

Overall, while some inconsistencies exist among the studies, the majority of findings support the conclusion that pH fluctuations—particularly in acidic or alkaline extremes—can negatively impact the mechanical stability of orthodontic elastics. These insights are clinically relevant, as they suggest that patient education regarding dietary habits, oral hygiene, and product use may help minimize premature

force loss in elastomeric components, potentially enhancing the effectiveness of orthodontic treatment.

Limitations

This review is limited by the small number of included studies and their methodological heterogeneity, which prevented a meta-analysis. All studies were in vitro, limiting the applicability to real-world oral conditions. Inconsistent reporting of experimental details and a focus on short-term outcomes further restrict the findings. Additionally, language and publication biases may have excluded relevant data.

Conclusion

This systematic review highlights the significant influence that pH levels can have on the force degradation of orthodontic elastics and elastomeric chains. While the included studies demonstrated some variability in their findings, the overall evidence suggests that both acidic and alkaline environments can adversely affect the mechanical properties of these materials, potentially compromising the consistency of orthodontic forces over time.

Although some studies reported no clear correlation between pH and force decay, others identified a significant relationship, particularly in acidic conditions or with the use of agents such as citric acid. These discrepancies may be attributed to differences in study design, material composition, testing intervals, and the pH range examined.

Given the importance of maintaining optimal force levels for effective orthodontic treatment, clinicians should consider the potential impact of oral pH on elastomeric materials. Educating patients on factors that can alter intraoral pH—such as diet, acidic beverages, and oral hygiene products—may help reduce premature force degradation.

Further research with standardized methodologies and broader pH ranges is warranted to establish clearer clinical guidelines and improve the durability of orthodontic materials under varying oral conditions.

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