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Systematic Review

Force decay of orthodontic elastomeric chains: A systematic review

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ABSTRACT

Background: In orthodontic therapy elastics and elastomeric chains are commonly used as an active component. These synthetic elastic materials are not supposed to be ideal, as they are sensitive to prolonged exposure to saliva, water, enzymes, temperature variations and external factors. The main disadvantage of elastomeric auxiliaries is their inability to sustain the delivered force for an extended period of time.
Objective: The objective of this review is to determine the time taken by the elastomeric chains force to degrade after stretching and to assess oral environment and external factors affect the decay force of elastomeric chains.
Data Source: Databases such as PubMed, Medline, and the Cochrane Library are searched electronically. Additional sources (Google Scholar, clinicaltrails.gov) were manually searched for additional trials or protocols until December 2021
Eligibility Criteria: Studies involving in vitro and in vivo exposure of elastomeric chains in various factors like, temperature, saliva, beverages, food, paste, mouthwash, etc were included.
Result: 18 studies included primarily focused on the force decay in E-chains and also the associated external factors. The force decay of the Elastomeric chains was affected by time, temperature and environment.
Conclusion: The force decay of the elastomeric chains was affected by time, temperature, and environment. The greatest effect on the elastomeric chain is shown by temperature. Force loss increased with increasing temperature, as expected of a viscoelastic material.

1. Introduction

Orthodontic therapy frequently includes the use of elastics and elastomeric materials. In orthodontic therapy, both natural rubber and synthetic elastomers are frequently employed. Clinically, elastomeric chains are appealing due to their low cost, simplicity in use, need for little chairside time, and no patient compliance. However, due to their sensitivity to extended contact with water, enzymes, and temperature fluctuations, these synthetic elastic materials cannot be regarded as ideal elastics.[1–5] They frequently harbour plaque, become discoloured, and experience permanent deformation in the oral environment. Main disadvantage of the elastomeric auxiliaries is their inability to maintain the delivered force for a significant duration.[6] The depletion of force reported in the initial 24 hours was between 50% and 70% of the initial value, indicating a very quick decrease in the force levels. Following that, a more stable polymer structure with only minor changes of 10% to 20% up to 4 weeks has been reported. Due to its ability to close diastemas, correct rotations and shifting midlines, and close spaces,

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polyurethane elastomeric chains are frequently utilised as tooth-moving mechanisms. In order to accomplish the maximum rate of orthodontic tooth movement without causing tissue damage or excessive patient discomfort, they use the lightest continuous forces that are safest and most effective.[7,8] Many variables, including design, manufacturing processes, environmental conditions, colour, and others, affect force decays in elastomeric chains. E-chains and their force decay have been the subject of several in vitro experiments evaluating the media and environmental components that affect force decay. One such study conducted by Baratieri et al[9] compared conventionally used and enhanced Echains and reported that the greater force decrease occurred within the first hour. The remaining force of the enhanced chains measured at different time intervals was greater than the conventional one. Buchmann et al[10] demonstrated influence of initial strain on the force decay of different elastic chains over time in vitro and showed that the force levels of chains from different manufacturers vary widely, and that the chains that were identified as having superior characteristics had only 40% loss of force after 3 weeks. Although the manufacturers claim to produce elastomeric chains with improved and superior properties in relation to force degradation, most of the studies that support their claims are performed in an extraoral environment.[11] A few in vivo studies[12,13] was also performed to test the properties of elastomeric chains in an oral environment but elastomeric chains were taken out of the oral cavity in these approaches to check the force decay during subsequent visits. Repeated removal and placement of the same elastomeric chain in the mouth for measurement purposes might alter the force values, leading to erroneous results. Furthermore, there is a need to assess the characteristics of elastomeric chains which have been affected due to force decay in the oral cavity itself and also determine the various factors that are responsible for causing early degradation of E-chains.

Thus, the aim of the present systematic review is to answer the following questions:

1. In what time elastomeric chains force gets degrade after stretching?.
2. Does oral environment and external factors affect the decay force of elastomeric chains?.

2. Objectives

The objective of this study was to determine the time taken by the elastomeric chains force to degrade after stretching and to assess oral environment and external factors affect the decay force of elastomeric Chains.

3. Materials and Methods

Protocol and Registration: The review is reported following the PRISMA (Prefererred Reporting Items for Systematic Review and Meta Analysis) Guidelines. The protocol for this Systematic Review was prospectively registered on PROSPERO. Registration number: CRD42021250175.

A systematic study was performed via electronic querying of several databases (Medline, PubMed, Cochrane library, Google scholar, clinicaltrails.gov) were manually searched for additional trials or protocol till December 2021. Terms used in search included keywords such as “Elastomeric Chains in orthodontics”, “Force decay of Elastomeric Chain”, “E-chain in orthodontics”, “Decay rate of E-chain”. Reference lists of the retrieved articles were also checked. The language was restricted to English in the search. Two investigators sorted out those studies that complied with selection criteria.

3.1. Inclusion criteria

The following criteria were included in the study:

1. Studies involving in vitro exposure of elastomeric chains in various factors like, temperature, saliva, beverages, food, paste, mouthwash, etc.
2. Studies involving in vivo exposure of elastomeric chains in various factors like, temperature, saliva, beverages, food, paste, mouthwash, etc.
3. Studies done on human subjects only are included.
4. Studies from January 1998 to 2021 are included.

4. Results

From the 2067 articles screened, 2049 articles were excluded. Only 18 studies were included in this systematic review. 18 studies included primarily focused on the force decay in E-chains and also the associated external factors. Out of 18 included studies, 16 were in-vitro studies; wherein the E-chains were exposed to different external environment and the force decay was noticed for a time span in each of the different studies. The remaining 2 studies amongst the included were in-vivo comparative interventional studies which included patients. The force decay and other external factors were in E-mechanics of the patients were observed over a period of time. Majority of the studies have shown that the force decay of the E-chains occurs maximally in the initial time duration; i.e., from the very first hour to about 24 hours after the placement. These studies showed almost comparable and similar results due to the fact that the same study setting and parameter was utilised amongst all in-vitro studies with almost concurrent eligibility criteria. Furthermore, almost all the studies which compared different types of E-chains, showed that Memory chains and thermoplastic E-chains showed lower force degradation as compared to the conventional ones. When the external oral environment factors and its effect was assessed on different E-chains, majority of the studies have depicted similar results with one another; showing the maximum force degradation in relation to

time, fluoride mouthwashes, whitening toothpastes and carbonated beverages; whereas lesser force decay was noted in presence of air or regular toothpastes without whitening agents. Force decay behaviour of elastomeric chains is influenced by various factors such as design, manufacturing techniques, environmental conditions, colour and etc.

5. Discussion

Elastomeric chains have long been a popular means of force immersion in orthodontic treatments. It is important that the applying forces should be as much light and continuous as possible. Understanding the behaviour of elastic chains during orthodontic mechanics and their performance with respect to prestretching is essential to adapt their use to clinical orthodontic needs. Thus, a more favourable result can be achieved by decreasing the undesirable aspect of strong decay of the initial force.[12,14] Different types of E-chains are being used in routine orthodontic practice. The addition of various substances in the manufacturing process of the memory type chains is one of the examples of the modifications made in these products. The primary reason for newer modifications is to provide a continuous gentle force with optimum force memory. Each of the different types of E-chains have different impact on the oral cavity and also the force applied varies with the external environmental in the oral cavity.[15] Considering the repeated removal and placement of the same elastomeric chains in the mouth for measurement purposes might alter the force values, leading to erroneous results. Furthermore, there is a need to assess the characteristics of elastomeric chains which have been affected due to force decay in the oral cavity itself and also determine the various factors that are responsible for causing early degradation of E-chains. Thus, the aim of the present systematic review was to assess the time of force decay of elastomeric chains after stretching and further analyse the oral environment and external factors that affect the decay force of elastomeric chains. This systematic review studied 18 included studies for fulfilling its aim and objectives and for reaching its desired conclusion.

5.1. Force decay of e-chains and other external environmental factors reported in in-vitro studies

In this systematic review, force decay of e-chains and other external environmental factors reported in in-vitro studies was determined by analysing 16 included in-vitro studies that were conducted previously. Majority of the studies have shown that the force decay of the E-chains occurs maximally in the initial time duration; i.e., from the very first hour to about 24 hours after the placement. These studies showed almost comparable and similar results due to the fact that the same study setting and parameter was utilised amongst all in vitro studies with almost concurrent eligibility criteria. Furthermore, almost all the studies which compared different types of E-chains, showed that Memory chains and thermoplastic E-chains showed lower force degradation as compared to the conventional ones. When the external oral environment factors and its effect was assessed on different E-chains, majority of the studies have depicted similar results with one another; showing the maximum force degradation in relation to time, fluoride mouthwashes, whitening toothpastes and carbonated beverages; whereas lesser force decay was noted in presence of air or regular toothpastes without whitening agents.

5.2. Force decay of e-chains and other external environmental factors reported in in-vivo comparative interventional studies

In this systematic review, the force decay of e-chains and other external environmental factors reported in in-vivo comparative interventional studies was determined by analysing 2 included in-vivo studies that were conducted previously. Both the studies stated that with increase in the time duration the tensile strength of the E-chains decreased. Furthermore, there was a greatest amount of force decay noted in the initial first hour after placement. Moreover, the patient related habits and factors significantly affect the force degradation of the chains. Such similar results in both the studies may be attributed to the fact that same clinical settings with patients' and other controlling factors were evaluated; with approximately comparable sample size. Thus, it can be derived that both in-vitro as well as in-vivo studies have shown a maximum force degradation during initial time duration after placement. Force decay behaviour of elastomeric chains is influenced by various factors such as design, manufacturing techniques, environmental conditions, colour and etc. As this is essential for clinicians to know the properties of all materials they use, this systematic review was done to publish a comprehensive information about E- chains, their characteristics and various factors affecting them in orthodontic treatments.

6. Limitations

With the present data meta-analysis may not be possible also it can be more of a hindrance than a help.

1. The present studies are diverse making meta-analysis meaningless
2. There is a mix of comparisons of different comparators, each combination of which may need to be considered separately. • Genuine differences in effects may be obscured.
3. Further, the outcomes are too diverse.
4. Meta-analyses of studies that are at risk of bias may be seriously misleading. If bias is present in each (or some) of the individual studies, meta-analysis will simply compound the errors, and produce a

'wrong' result that may be interpreted as having more credibility.

7. Conclusion

The following occlusions can be derived from this present systematic review: -

1. The force decay of the Elastomeric chains was affected by time, temperature and environment.
2. Whilst force decay of elastomeric chain in air was rapid for up to 24 hours, force loss between 1 and 24 hours either remained the same in the case of beverages, fluoride mouthwashes, whitening toothpastes and carbonated beverages; whereas lesser force decay was noted in presence of air or regular toothpastes without whitening agents.
3. Temperature had the greatest effect on elastomeric chain. As is to be expected of a viscoelastic material, force loss increased with increasing temperature.

8. Conflict of Interest

None.

9. Source of Funding

None.

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