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Review Article

Evaluation of force decay rate in orthodontic elastomeric chains in the environment of various mouthwashes: A systematic review

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ABSTRACT

Background: Different studies about the effects of mouthwashes on force reduction by elastomeric chains are reported in the literature. Hence, this review was done for the assessment of force degradation in the elastomeric chains in different mouthwash compositions. This study helps to improve the clinical performance of elastomeric chains used in orthodontics, reducing force degradation, and finally assisting clinicians in choosing better and more efficient methods for their treatments.
Materials and Methods: In this review article, an extensive search was performed in the electronic databases of Cochrane Library, Web of Science, PubMed, and Scopus from the year 1990–2020. No language restriction was considered and manually investigated the reference lists of all articles related to the title. Out of 450 obtained articles, 14 *in vitro* studies were chosen based on the inclusion criteria, and their quality was assessed using modified CONSORT. This systematic review was limited and written based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses protocol.
Results: Based on the results achieved, mouthwashes containing alcohol caused considerable force degradation in the elastomeric chains compared to the alcohol-free ones and mouthwashes with fluoride caused lesser force degradation compared to other types.

Key Words: Degradation, elastomeric, environment, mouthwash

INTRODUCTION

Today, it has generally been accepted that effective and physiologic treatment of malocclusion is possible by using gentle and constant forces in orthodontics. Various methods are available for producing this force in orthodontics, namely coil springs, loop archwires, elastomeric chains, and magnets.[1] First introduced in the 20th century in orthodontics, elastomeric chains are the most popular method for space closure. Low costs, ease of use, and comfort for both patients and clinicians are among the advantages of this method.[2] Due to variations in these elastomeric chains and differences in force degradation in each chain in different environments, coming up with the most efficient chain in orthodontic treatments is of utmost importance.[3,4] Elastomeric chains are employed in a significant number of places, such as diastema closure, midline treatment, canine retraction, and tooth rotation treatments.[2-5] Although the main feature of these chains is retrieving the original length after force application, different *in vivo* and *in vitro* studies have shown that force

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degradation happens to these chains after applying the force.[6-9] Despite their extensive clinical use, elastomeric chains are prone to certain limitations: limited water and saliva absorption, irreversible color change, and breakage of internal links, which leads to permanent deformation. Thus, force degradation in elastomeric chains is affected by several factors, such as design; manufacturing technique; color; and mouth environment conditions.[3,10] Nearly 50%–70% of orthodontic primary force loss happens in the first 24 h, and that is due to oral exposure, enzymes of saliva, oral hygiene, and mastication.[11-13]

The sensitivity to the changes in the oral environment due to various food, beverages, and mouthwashes is one of the major causes of plastic deformation and force loss in elastomeric chains.[14] Under normal circumstances and disease-free conditions, PH alterations, fluoride ions, components of saliva, alterations in temperature, and oxygen level can affect force decay in orthodontic chains.[11,14] Mouthwashes are extensively prescribed for patients undergoing orthodontic treatments. The ones containing fluoride are done to inhibit tooth decay, demineralization of enamel, and reduction of tooth sensitivity. Chlorhexidine (CHX), although prescribed more often, has side effects such as color change and taste confusion. Nowadays, herbal and alcohol-free mouthwashes such as green tea, persica, *Punica granatum*, cinnamon, and *Aloe vera* have become common and they are replacing the ones containing alcohol.[15-17] This research was done to investigate the importance and vast application of elastomeric chains in orthodontics and the effects of mouthwashes on force degradation. No comprehensive and systematic study has elaborated on the impact of various types of mouthwash on the elastomeric chains. The current research aims to improve the clinical function of elastomeric chains in orthodontics, reduce force degradation in them, and help orthodontists choose a precise and efficient method.

MATERIALS AND METHODS

Information sources and search

This study had a systematic review of articles published on primary electronic databases of PubMed, Cochrane Central Register of Controlled Trials, Web of Science, and Scopus. For doing so, specific medical subject headings were used, including elasticity, elastomers, orthodontic appliances, dental materials/chemistry, mouthwashes, tensile strength, time factors, and stress mechanical. The mentioned keywords were combined with "and" and "or" in the time range of January 1, 1990 − December 31, 2020. Furthermore, for a broad search, the reference list of all articles and related reports was analyzed.

Protocol and registration

This review article was then issued the code of ethics. IR.GUMS.REC.1399.442

Data collection and interpretation were modeled on Preferred Reporting Items for Systematic Reviews and Meta-Analyses.[18]

Study selection

After gathering the data, the articles had matching titles and abstracts – and, if necessary, the full text – with the inclusion criteria entered the study.

Based on PICOs.

The inclusion criteria were designed as follows:

- Population: Orthodontic elastomeric chains required for space closure
- Intervention: The effect of different mouthwashes on the force degradation pattern of elastomeric chains
- Comparison:
- Outcomes: The aim of this systematic review was to evaluate the force degradation of elastomeric chains in different mouthwashes.

The exclusion criteria

Based on those mentioned earlier, *in vitro* articles entered the study; abstracts, animal and review articles, case reports, case series, and discussions were excluded. Recurrent papers were omitted using END-NOTE X8 software (Thompson Reuter, CA, USA), and to prevent bias in search protocols, exclusion criteria were applied after the primary analysis. For identifying and detecting all the related articles, even those with only their abstract in English were included.

Search and extraction of data were carried out by two separate researchers. The researchers evaluated the titles and abstracts and in case of approval, the full texts were analyzed.

Data extraction

The extraction of data and assessment of validity were performed by two expert reviewers independently.

As the first step, one of the researchers extracted some data, including title, authors, type and year of study;

sample size; type of mouthwash; kind of elastomeric chain; and results. Moreover, then, the second researcher carried out a second analysis; in case of divergence, the subject was discussed for the final decision.

Moreover, then all information is checked by a third expert reviewer. The process of assessing validity followed a previously established checklist.

Risk of bias assessment

Quality analysis of *in vitro* studies regarding dental material was done based on Faggion[19] using a modified CONSORT checklist, parameters of which are shown in Table 1. Based on being reported or not reported, each one got a "yes" or "no," and finally, the score for each article was calculated, and the final results were reported as a mean percentage of all articles. The authors examined the articles' quality separately, and in case of discrepancy, the final decision was made through negotiation.

RESULTS

Study selection

Altogether, 414 articles were found on electronic databases and also by manual searching [Figure 1]. After omitting duplicate articles and initial review, the full text of 15 surveys entered the final study. In the end, 14 *in vitro* articles had the inclusion criteria for this systematic review [Table 2].

Study characteristics

Out of 14 selected articles, 11 were collected from searching electronic databases and three from the reference list of articles, all of which had investigated the effect of force degradation of elastomers in different mouthwash environments. The mouthwashes used in these studies are as follows: Fluoride;[20,21] sodium fluoride (NaF);[5,6,15,22] alcohol mouthwash;[16,22,23] Listerine;[16,22-26] Persica;[7] Orthokin;[7] Sensikin;[7] CHX;[15,21,23,24,27] Chlorohexidine gluconate;[27] and Whitening mouthwash.[6,20,26] The significant findings of the mentioned articles regarding the effects of various mouthwash environments on chain force decay can be summarized as follows: the type of elastomeric chain is one of the influential factors in their force decay. Significant force degradation was observed in the environment of mouthwashes containing bleach, and a similar outcome was present with the ones containing alcohol compared to alcohol-free ones. However, the extent of this loss did not depend on the

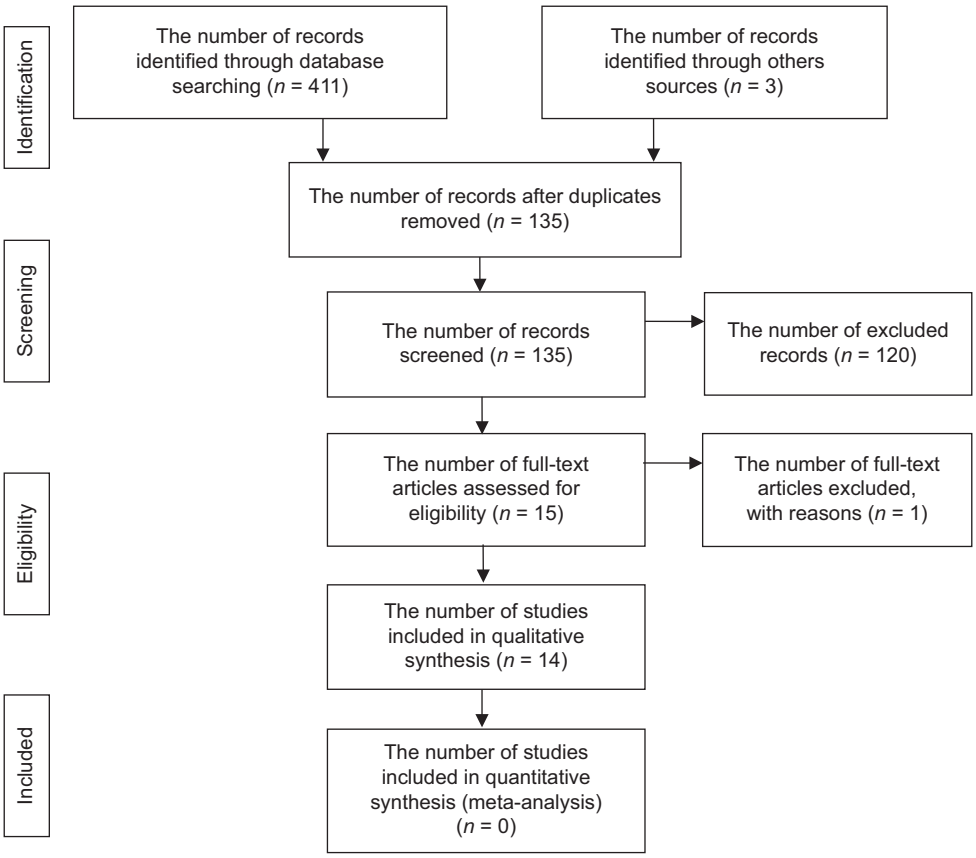

Figure 1: The PRISMA flow diagram. PRISMA: Preferred Reporting Items for Systematic Review and Meta-Analyses.

Table 1: Assessment of studies using the modified Consolidated Standards of Reporting Trials(CONSORT) checklist

Studi's citation	Ramazanzadeh *et al.*, 2009[5]	Behnaz *et al.*, 2018[6]	Javanmardi and Salehi, 2016[7]	Omidkhoda *et al.*, 2015[15]	Larrabee *et al.*, 2012[16]	Dadgar *et al.*, 2020[20]	Oshagh *et al.*, 2015[21]	Ramachandraiah *et al.*, 2017[22]	Santana *et al.*, 2017[23]	Menon *et al.*, 2019[24]	Kumar *et al.*, 2014[25]	Pithon *et al.*, 2013[26]	Pithon *et al.*, 2013[27]	Mahajan *et al.*, 2014[28]
1	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2a	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2b	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5	No	Yes	No	No	No	No	No	No	No	No	No	No	No	No
6	No	No	No	No	No	No	No	No	No	No	No	No	No	No
7	No	No	No	No	No	No	No	No	No	No	No	No	No	No
8	No	No	No	No	No	No	No	No	No	No	No	No	No	No
9	No	No	No	No	No	No	No	No	No	No	No	No	No	No
10	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
11	No	No	No	No	No	Yes	No	No	No	No	No	No	No	No
12	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
13	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
14	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Information regarding the following parameters was judged as reported (yes) or not reported (no): (1) Structured summary of trial design, methods, results, and conclusions; (2a) Scientific background and explanation of rationale; (2b) Specific objectives and/or hypotheses; (3) The intervention for each group, including how and when it was administered, with sufficient details to enable replication; (4) Completely defined, prespecified primary and secondary measures of outcome, including how and when they were assessed; (5) How sample size was determined; (6) Method used to generate the random allocation sequence; (7) Mechanism used to implement the random allocation sequence (for example, sequentially numbered containers), describing any steps taken to conceal the sequence until intervention was assigned; (8) Who generated the random allocation sequence, who enrolled teeth and who assigned teeth to intervention; (9) If done, who was blinded after assignment to intervention (for example, care providers, those assessing outcomes), and how; (10) Statistical methods used to compare the groups for primary and secondary outcomes; (11) For each primary and secondary outcome, results for each group, and the estimated size of the effect and its precision (for example, 95% CI); (12) Trial limitations, addressing sources of potential bias, imprecision, and, if relevant, multiplicity of analyses; (13) Sources of funding and other support (for example, suppliers of drugs), role of funders; (14) Where the full trial protocol can be accessed, if available. CI: Confidence interval

Table 2: Characteristics of studies related to force decay in different enviroment

Study	Title	Design	Elastomeric type	Mouthwash	Setting	Outcome	Recevie time
Dadgar 2020 (20) {Dadgar, 2020 #6}	Effects of six different chemical treatments on force kinetics of memory elastic chains versus conventional chains: An *in vitro* study	*In vitro*	2 type: conventional, memory 132 chain: 11 memory, 11 conventional in each g.p, 6 g.p of chemical treatment	Artificial saliva, fluoride, Oral B mouthrinse, whitening Oral B mouth rinse, toothpaste, whitening toothpaste	Measuring initial force in artificial saliva at 37°C removed from the saliva twice daily	Final residual forces (28th day) above 150 g force decay, with fluoride, whitening toothpaste difference among five intervals of time was not significant when elastic types significant	Days 1st, 7th, 14th, and 28th
Behnaz 2018 (6)	Effect of bleaching mouthwash on force decay of orthodontic elastomeric chains	*In vitro*	160 gray-closed elastomeric chains	Whitening (Listerine® healthy white™) 30 s NaF (Listerine® total care zero) mouthwashes daily	Twice a day for 30 s in the whitening (Listerine® healthy white™) and daily NaF)	Increase force decay NaF in 1 and 28 after activation Bleaching mouthwash more force decay at days 1 and 28 after activation	Initial, 1, 7, 14, 21, 28th
Ramachandraiah, 2017 (22)	Force decay characteristics of commonly used elastomeric chains on exposure to various mouth rinses with different alcohol concentrations: An *in vitro* study	*In vitro*	Specimens 180 3M Unitek, Ortho Plus, Ortho Organizer	Artificial saliva, Listerine, wokadine, alcohol mixture 21.6%, and alcohol mixture 8.38%	Twice a day for 60 s, for the entire 28 days test period	Alcohol-containing mouth rinses cause an increase in force decay Listerine (69.25%) more, wokadine (64.54%) less force decay	Initial, 1, 7, 14, 21, 28th
Santana 2017 (23)	The effect of alcoholic mouthwash, nonalcoholic mouthwash and artificial saliva toward the power chains force decay	*In vitro*	40 power chain - SA; 40 power chain - SB; 40 power chain - LA; 40 power chain - LB, divided into 5 groups	Minosep® 0.1% of CHX gluconate; Listerine® with 0% of alcohol; Hexadol® with 9% of alcohol; Listerine® with 26.9% of alcohol	Twice a day every 12 h	Force decay in alcoholic mouthwash was higher compared to nonalcoholic mouthwash and an artificial saliva	Day: 0, 1, 14, 28
Javanmardi 2016 (7)	Effects of Orthokin, Sensikin, and Persica mouth rinses on the force degradation of elastic chains and NiTi coil springs	*In vitro*	40 specimens (Ortho Technology, USA), 40 NiTi closed coil springs (3M Unitek, Germany	Orthokin, Sensikin Persica	Twice a day	At least force decay in the Orthokin in the coil spring no statistically significant difference in force degradation	1 h, 24 h, 1 week, and 3 weeks
Omidkhoda, 2015 (15)	Evaluation of the effects of three different mouthwashes on the force decay of orthodontic chains	*In vitro*	CG 1: Short-connector chains in artificial saliva CG 2: Closed-connector chains in artificial saliva. EG 1: Short-connector chains in CHX 0.2%	Artificial saliva persica CHX 0.2% NaF 0.05%	Mouth washes 1 min/day rinsed by distilled water returned to artificial saliva	Persica is preferred to CHX	Initial 24 h, 1 weeks, 2 weeks, 3 weeks, 4 weeks

Contd...

Table 2: Contd...

Study	Title	Design	Elastomeric type	Mouthwash	Setting	Outcome	Recevie time
			EG 2: Closed-connector chains in CHX 0. 2% EG 3: Short-connector chains in persica EG 4: Closed-connector chains in persica EG 5: Short-connector chains in 0.05% NaF EG 6: Closed-connector chains in 0.05% NaF				
Oshagh, 2015 (21)	The effect of different environmental factors on force degradation of three common systems of orthodontic space closure	*In vitro*	Elastomeric chains (Maximum™ power chain, Ortho Technology, Tampa, Florida, USA) 9 mm of superelastic NiTi closed coil spring[19] (TruFlex™ NiTi closed coil spring, Ortho Technology, Tampa, Florida, USA) TBs (Powerstick™ elastomeric ligatures, Ortho Technology, Tampa, Florida, USA)	Hot tea hot water (65°), CHX mouthwash, fluoride mouthwash	Hot water, tea: 3 min once a day Mouth wash: 1 min once a day	Tea increases force decay in EC and TB Mouthwashes resulted in rapid force decay than CG EC and Ni-Ti groups not affected in oral mouthwashes	24 h, 1 week, 3 weeks
Kumar 2014 (25)	Effect of commonly used beverage, soft drink, and mouthwash on force delivered by elastomeric chain: A comparative *in vitro* study	*In vitro*	480 specimens, gray closed elastomeric chain (Alastik, 3M Unitek)	Coca-Cola, tea, Listerine mouthwash	For 60 s, twice a day	Tea caused highest force decay followed by Listerine and Coca Cola	1 h, 24 h, 7th, 14th, 21th, 28th
Pithon 2013 (27)	Does CHX in different formulations interfere with the force of orthodontic elastics?	Laboratory study		0.12% CHX (Group 2), 0.2% CHX (group 3), 0.12% CHX gluconate-based oral solution (0.12% Periogard; group 4), 0.2% Cleanform mouthwash (formula and action; group 5)	30 s twice a day and the interval of 12 h between immersions	CHX no significant influence on the force degradation of the chain elastic end 28th CG lower force value than the CHX Two 0.12% CHX the highest force degradation	Initial, 1th, 7th, 14$^{th[1]}$ 21th, 28th
Pithon 2013 (26)	Do mouthwashes with and without bleaching agents degrade the force of elastomeric chains?	Prospective laboratory study	Elastomeric chain 108 specimens were divided into six groups (18 in each group)	Plax Listerine plax whitening Listerine whitening	Twice a day for 60 s	Bleaching agent has no influence on the force degradation of elastomeric chains	Initial, 1th, 7th, 14th, 21th, 28th

Contd...

Table 2: Contd...

Study	Title	Design	Elastomeric type	Mouthwash	Setting	Outcome	Recevie time
BRATU, 2013 (32)	Effect of different artificial saliva on the mechanical properties of orthodontic elastomers Ligatures	*In vitro*	A total number of 160 elastomeric ligatures (GAC, Gac CompanyTM) were divided into four groups (*n*=40 in each group)	Three types of artificial saliva, (unmodified artificial saliva, coca cola topical fluoride agent)	1: Artificial saliva, 2: Artificial saliva with 50% coca cola (Coca Cola, 3: Artificial saliva with 50% topical fluoride agent The test groups were incubated at 37°C The fourth group (control group) stored dry room (22±2°C)	Increase force decay and decrease in tensile load at failure over time of elastomeric ligatures in artificial saliva, coke, and topical fluoride	7, 14, 21, 28 days
Larrabeea 2012 (16)	The effects of varying alcohol concentrations commonly found in mouth rinses on the force decay of elastomeric chain	*In vitro*	450 specimens Energy Chain, Rocky Mountain Orthodontics; Denver, Colo	Ce pacol antibacterial mouthwash 14% (Combe Inc, White Plain, NY) Listerine antiseptic mouthwash (Johnson and Johnson, McNeil-PPC, Skillman, NJ), 26.9% alcohol	Twice a day 60 s	Alcohol causes an increase in force decay concentration dependence was not observed	Initial, 1th, 7th, 14th, 21th, 28th
Ramazanzadeh 2009 (5)	Effect of NaF Mouth rinse on elastic properties of elastomeric chains	*In vitro*	Dentaurum (Dentaurum, Germany) American Orthodontics (American Orthodontics, USA)	0.05% NaF	NaF 0.05% daily 1 min, artificial saliva–NaF mixture for 30 min, in artificial saliva for the rest of the day	Daily use of NaF mouth rinse does not affect force degradation	1 h 24 h 1 week 2 weeks 3 weeks
Maharajan 2014 (28)	Influence of alcohol and alcohol-free mouth rinses on force degradation of different types of space closure auxiliaries used in sliding mechanics	*In vitro*		Alcohol-free mouth rinse (Colgate Plax) alcohol-containing mouth rinse (Listerine		The force degradation in alcohol-containing mouthwash solution (Listerine) is more as compared to alcohol-free mouthwash solution (Colgate Plax)	24 h 1 week 2 weeks 3 weeks 4 weeks
Menon 2019 (24)	Comparative assessment of force decay of the elastomeric chain with the use of various mouth rinses in simulated oral environment: An *in vitro* study	*In vitro*	Total sample size of 840 specimens. A specimen is described as a three-link, short module, clear elastomeric chain (Clear Chain Elastic Short; Ortho Organizers®, Carlsbad, California)	0.2% CHX>Clohex Plus>Colgate Phos-Flur>0.04% NaF>26.9% alcohol, and Listerine	Mouth rinses for 60 s, twice daily	Listerine and 26.9% alcohol solution caused maximum force decay by the end of 28 days. Least force degradation of the elastomeric chain was seen with the use of 0.2% CHX	24 h 1 week 2 weeks 3 weeks 4 weeks

CHX: Chlorhexidine, NaF: Sodium fluoride, NiTi: Nickel-titanium, SA: Short A, SB: Short B, LA: Long A, LB: Long B, CG: control group EG: Experimental group, EC: elastomeric chains, TB: tie back

concentration of alcohol. One study, however, found that bleach in mouthwashes had no such significant effect. NaF and CHX, Orthokin, Sensikin, and Persica were not the fundamental causes of force decay, but

Persica and CHX caused the lowest and highest rates, respectively, which were statistically significant.

Risk of bias assessment

The quality of the 14 articles was evaluated based on a modified CONSORT checklist, the details of which are available in Table 1. The average score of 14 articles based on the checklist was 59.43%. It means all articles scored 60% except Ramachandraiah *et al*. and Santana *et al*.[22,23] which obtained 53%, and Dadgar *et al*.[20] 66%.

DISCUSSION

This systematic review focuses on force degradation in orthodontic elastomeric chains caused by different mouthwashes.

Fourteen RCT articles were covered in this study, all of which measured the effects of mouthwashes on the force loss in elastomeric chains. Among them, three papers were on mouthwashes containing alcohol,[16,22,24] 5 articles investigated the effects of fluoride mouthwash,[5,6,15,20,21] 4 articles used CHX mouthwash,[15,21,23,24,27] 3 studies had mouthwashes with bleaching agents,[6,20,26] and in 5 articles Listerine mouthwashes were studied.[16,22-26]

The measurement of the force degradation in elastomers caused by mouthwashes in all articles was measured in four intervals: the 1st day, the 1st week, the 3rd week, and the 4th week. Orthodontic elastics are the essential sources of force transmission to the teeth, which, ideally speaking, are expected to have minimal force loss on activation and to apply force continuously throughout the treatment. As the results of the reviewed articles revealed, however, the case was not so. Various investigations performed by different authors at different times unanimously showed that force transfer did not proceed according to the ideal assumptions. Because of various mechanical and environmental factors, force loss would occur right from the beginning. One study claimed the maximum rate of force loss in the early hours was 50% to 70%, which would continue in a downward trend for 3–4 weeks.[21] Another research estimated the loss to be 40%−50% in the first 24 h.[29-31]

Ramachandraiah *et al*.,[22] however, claimed that mouthwashes containing alcohol with a concentration of 21.6% showed the highest force dissipation (55.18%) among other mouthwashes after 24 h, but in Menon *et al*.'*s*,[24] mouthwashes had an alcohol concentration of 26.9% and they showed the highest rate of force loss (49.48%) among other types. In the Larrabee *et al*.'*s* study,[16] 24 h after using Listerine mouthwash, 53% of the force was lost. In the clinical conditions, if the rate of force degradation was high in the first 24 h, it would increase the patient's comfort, but on the other hand, it would cause a tissue response to the effect of tooth movement.

A proven factor affecting the initial load force loss is a humid environment compared to a dry one. Most force loss occurs in the early hours, but it has been shown that this degradation rate is higher in humid environments than in dry ones.[8] Therefore, in elastomeric studies, chains are immersed in the artificial saliva throughout the experiment, and it was placed in the mouthwash only at the determined time during the day. It is shown that a higher initial load causes a greater force to be lost. All elastomers used in the reviewed articles for this systematic review were under prestretch conditions except Ramachandraiah *et al*.,[22] which examined elastomeric chains under prestretch and unstretched conditions. Their study showed that force decay in unstretched elastomeric chains was higher than prestretch ones. Another influential factor in force degradation is the ambient temperature, so in all articles studied, the temperature was set at 37 ± 1°C, matching the oral cavity and body temperature. The results of a study by Dadgar *et al*.,[20] who conducted their study on two types, memory chain and conventional chain, showed that in the first 24 h, the latter loses more force than the former, while memory chain had higher force stability during the first few days, but at the end of 4th week, no statistically significant difference was observed between the two regarding the force loss. Mirhashemi *et al*.[4] also confirmed the same results. However, they found a statistically significant difference in the 4th week since the conventional chain retained only 40% of the initial force, but regarding the memory chain, that number was 60%. One of the critical factors in the rate of force loss is the environment of different mouthwashes. The amount and concentration of soluble substances in mouthwashes have secondary effects on the oral mucosa and dental tissues diet, bioflora and its biproducts can influence on elastomeric chains materials.[32] CHX mouthwash, besides its antibacterial and anti-plaque effect, causes the color change of teeth and oral mucosal ulcers.[22] Pithon *et al*., which examined their effects on elastomeric chains, showed

that CHX 0.2% compared to CHX 0.12% caused less force degradation in the chains during 4 weeks, but this amount was not statistically significant. They also observed that the highest rate of force loss in the chains happens in the first 3–5 h.[27] Omidkhoda *et al*. announced that the highest loss occurred in CHX mouthwash, followed by NaF, while the lowest rate was observed in Persica mouthwash. The reason for the highest force degradation in CHX mouthwash can be attributed to its ethanol composition (13.65%).[15] Ramazanzadeh *et al*. and Javanmardi and Salehi showed that the pattern of force decay in elastomers with the presence of mouthwashes would not change compared to the control group.[5,7] Pithon *et al*. had reported a similar result for mouthwashes with bleach.[26] Javanmardi and Salehi and Pithon *et al*. stated that the chains were removed from the pins five times for force measurements and transferred to a dry medium.[7,26] However, this matter would not occur in clinical conditions, so their results can be attributed to the limitations of these articles regarding the environmental changes of elastomeric chains. However, Behnaz *et al*. showed whitening mouthwashes with the active ingredient hydrogen peroxide, which would change the teeth' optical properties and react with organic molecules and increase the rate of force loss compared to NaF mouthwashes.[6]

On the other hand, Oshagh *et al.*, Omidkhoda *et al*., and Dadgar *et al*. reported a tremendous force loss in elastomeric chains in the NaF mouthwash environment.[15,20,21] The difference in the results of these studies could be related to different brands of chains.

Ramachandraiah *et al*., who studied mouthwashes with different concentrations of alcohol, concluded that mouthwashes containing alcohol cause structural and molecular changes in elastomeric chains that can increase the rate of force degradation in them.[22] Larrabe *et al*., who made a similar comparison, showed that alcohol-based mouthwashes increased the rate of force loss in chains and reported the difference to be statistically meaningful.[16] Santana *et al*. and Mahajan *et al*. investigated the effect of alcohol-free mouthwashes and alcohol-based ones on force degradation. They showed that alcohol (ethanol) in mouthwashes with the chemical structure CH3-CH2-OH bonds with polyurethane polymer in the chain structure, and thus alcohol-based mouthwashes cause more force loss than alcohol-free mouthwashes.[23,28] Menon *et al*., who compared the effects of 26.9% alcohol NaF, CHX, and Listerine mouthwashes on the force decay of the chains, observed a statistically significant difference among them. Because of the alcohol it contained, Listerine mouthwash caused the highest force degradation due to hydrolysis of elastomeric chains, and the lowest rate was observed in CHX mouthwash.[24] Ramazanzadeh *et al*., who studied the effects of fluoride mouthwash regarding the mentioned loss, did not find fluoride mouthwashes to cause force degradation in elastomeric chains.[5] Thus, it can be concluded that they can safely be used for reducing the prevalence of caries, especially in patients undergoing orthodontic treatments since they are more prone to primary caries lesions and whitespots around the brackets.

CONCLUSION

Elastomeric chains provide the force needed for the tooth movement in orthodontic treatments. However, this force does not remain constant until the end of the said treatment and is influenced by environmental and mechanical factors. Regardless of other influential factors, mouthwashes are among the most critical contributors to force loss in chains. However, on the other hand, they are influencing the forces in decreasing the prevalence of dental caries and periodontal disease in patients undergoing orthodontic treatment. According to the research results reviewed in this systematic review, it is recommended to use fluoride-containing mouthwashes in orthodontic patients, which cause less force decay in the elastomeric chains than other types. It is also suggested to consider alcohol-free CHX mouthwashes in treating periodontal diseases of patients undergoing orthodontic treatments. However, patients should be aware of the complications of CHX. The results also showed that alcohol mouthwashes cause significant force loss, so the recommendation is to replace them with alcohol-free types as much as possible.

Although based on the explanation in the data extraction part, all of the selected articles have got problem in sampling and randomization. We just tried to review the result of selected articles. According to the results of this review, the development of the feature research is reasonable.

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Conflicts of interest
The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.

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