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Effect of magnetic water mouthwash on force decay of orthodontic elastomeric ligature ties

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ABSTRACT

Objectives. The objective of the present study was to evaluate the effect of magnetic water (MW) as a mouthwash on the force decay of the orthodontic elastomeric ligature ties.

Methods. One hundred twenty elastomeric ties divided into 3 groups (40 ties each) based on mouthwash used: group1: washed with artificial saliva (AS)(control), group 2: washed with Ortho Kin mouthwash (OK), Group 3 washed with prepared magnetic water (MW). Each group was further subdivided into 4 subgroups, 10 ties for each time interval (initially, one day, one week and two weeks). Distilled water had been magnetized using a locally prepared device. 2430 Gauss (Gs) neodymium magnets was used. The force decay for the ties were measured by Instron universal testing machine. The outcomes were detailed as mean force decay changes and was compared with Mann-Whitney and Kruskal-Wallis tests, $P \leq 0.05$.

Results. The highest force decay value was for MW group at two weeks. For OK group, there was significant difference of force decay in comparison between the initial - one day, and one day - one week. For the MW group, there was significant differences between the initial - two weeks. For MW-OK comparison, significant differences were found at one week.

Conclusion. MW caused more force decay in the elastomeric ligature ties than OK mouthwashes especially at two weeks period.

Keywords: elastomeric ligature ties, force decay, mouthwash, magnetic water

INTRODUCTION

The ligation of orthodontic arch wires to the brackets is done using a stainless-steel ligature, elastomeric ties, pins and self-ligating clips. Due to their several advantages, as ease of use, comfort and desire to the patient, low cost and reduced chair time, elastomeric ligature ties are most widely used [1]. Their disadvantage is microbe accumulation on the tooth surfaces adjacent to the brackets, the arch wires may not sit completely during torque or rotation corrections, and associated binding with sliding mechanics [2]. Many brands of elastomeric ties in a variety of colors are available that meet the demand for aesthetic orthodontic appliances. Elastics are mainly used in orthodontics as an active component to correct the different types of malocclusions [3]. Orthodontic elastomeric ligatures are elastomeric polymers and consist of materials that, after substantial physical deformation, quickly return to its original dimensions [4]. Two basic forms of elastomeric ligation ties are produced: cutting and injection molding [2].

Limited studies have assessed the behavior of single elastomeric ligatures. The presence of moisture via water sorption altered the behavior of elastomeric materials through facilitating molecules or polymer chains slippage past one another hastening the process of force decay of such materials [5]. Presence of elastomeric chains in an experimental

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solution of alkaline pH (7.26) produced significantly larger force decay than a solution of acidic pH (4.95) [6]. Other authors have reported rapid force loss and permanent deformation of elastomeric products [5,6]. Huget [5] showed that exposure of ligatures to moisture first results in weakening of non-covalent forces before degradation of the ligature. The percentage of changes were very changing with broad ranges, particularly regarding elastomeric ligature thickness and inside diameter. Up to 50% - 70% of their force was lost during the first 24 hours. Initially, the elastomeric ligatures fastened the strength of stainless-steel ties to the largest twin brackets, however, forces exerted by elastomeric ligatures on fully engaged arch wires were not as high as those for stainless steel ties [7]. In a clinical study of Samuels [8], forces exerted by elastomeric ligatures for closing space dropped to zero after 5 to 8 weeks. Factors like the magnitude of the initial force exerted by an elastomeric ligature, the duration that the force may be applied, and the decay rate of the ligature affect the force generated by these ligatures. Moisture and heat decrease the dimensional stability and force levels of elastomeric materials [9].

Treatment with a fixed orthodontic appliance modifies the oral environment, there is an accumulation of plaque around the orthodontic attachments [10]. Unlimited number of commercial mouthwashes; with their un-favorable side effects; were prescribed across the orthodontic therapy to improve oral health and decrease caries formation that occur throughout the course of therapy, one of them is Orthokin mouthwash that contains fluoride in an optimal concentration of 500 ppm, which helps to prevent dental caries and promotes the remineralization of tooth enamel during orthodontic therapy [11].

Magnetic water (MW) is an avant-garde technology via magnetic instruments that allows an active focusing of the magnetic field (MF) by using the tubular wall to treat the water and its features. A non-chemical method for water softening is by treating it with magnetic forces which is a divisive technique supposed to diminish the effects of hard water by passing it across a MF [12]. Specific changes occurred to the water when flowed through the MF. MF changes the electrical features of hydrogen ions of the water and metals. Southern bio-magnets help decrease tartar buildup. The northern MW is used in the treatment of many illnesses [13]. When there is incessant connection of water with eternal magnet for recognized time, the magnetic flux of the magnet changes the water, and it becomes magnetic, acquiring magnetic properties as well. The best results are reached when using water immediately after treatment [14].

The aim of this study was to evaluate the outcome of MW mouthwash on the force decay value of elastomeric ligature ties.

MATERIAL AND METHODS

The sample consisted of 120 translucent ligature ties (Dentarum, Ispringen, Germany) divided into three groups (40 ties each) based on mouthwash used: group1: washed with artificial saliva (AS) (control), group 2: washed with Ortho Kin ((LABORATORIES KIN S.A., Barcelona, Spain) with 500 ppm NaF mouthwash (OK), Group 3 washed with newly prepared MW(MW). Each group was further subdivided into 4subgroups, 10 ties for each time interval, force levels were recorded at initial (before stretching), one day, one week and two weeks periods.

Ligature ties were placed in AS bath at 37±1°C, pH 7 during the study. Washing was done for 1 minute twice daily for 2 weeks [15]. The samples were kept at 37°C in an incubator (NLF64-320, Ningbo, China). One hundred ml distilled water had been magnetized using a locally prepared device. 2430 Gauss (Gs) neodymium magnets (K&J Magnetics, Ningbo, Chin was used. The magnetic strength and polarity of the magnet were determined by Gaussmeter (Lake Shore, 455 DSP, Westerville, USA). Two magnets were fixed around a glass container filled with 100 ml distilled water in a north-north repulsion manner [16] and maintained for 48 hrs at 37°C. The pH value and electrical conductivity for the MW were checked by pH Meter and electrical conductivity Meter (WTW Inolab, Germany), to ensure water magnetization [17]. Instron universal testing machine (Gester, Dongguan, China) was used to analyze the ligature ties force decay values.

Ligature ties were stretched over 0.022 inch slot stainless steel standard edgewise brackets of maxillary central incisor (Dentarum, Ispringen, Germany) with 0.018 inch round stainless-steel wire (Lancer orthodontics, Carlsbad, California), Figure 1.

After incubation, the ligature ties were separated from their baths to check the stretch when they were secured to the brackets with round stain-

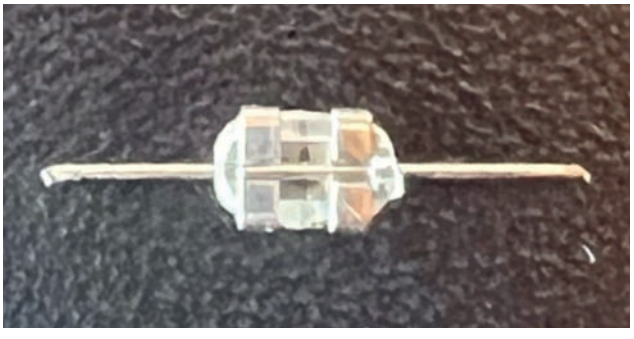

FIGURE 1. Ligatures stretched over 0.022-inch slot stainless steel standard edgewise brackets of maxillary central incisor with 0.018 inch round stainless-steel wire

less-steel wires. The force decay of ligature ties was tested by Instron Universal Testing Machine (Instron Universal Testing Machine). Two acrylic blocks encircling 0.7mm stainless steel wires with a hook for holding elastic ties were made (Figure 2). The wire had been heat treated to enhance its rigidity [18].

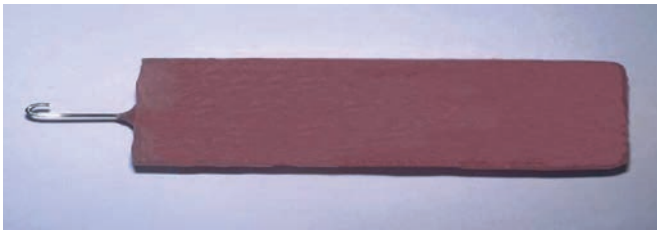

FIGURE 2. Acrylic block encircling 0.7-mm stainless steel wire with hook

Ligature ties were extended at the rate of 5 mm/min to a predetermined length (x) (Figure 3) on a universal testing machine. The initial force scores were expressed in grams at a load of 5 kg the elastomeric ties were stretched at a speed of 5 mm/min [18].

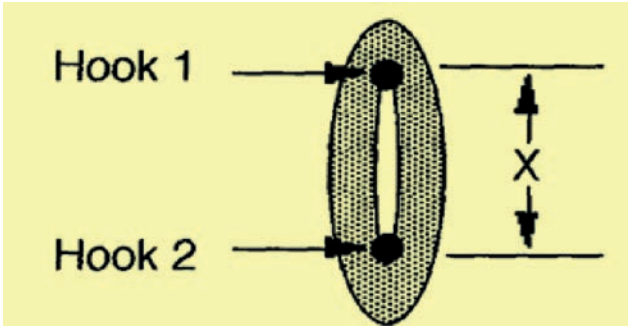

FIGURE 3. Close-up of stretched elastomeric ligature ties with separated hooks and linear spacing (X) mm [9]

The hooks diameter on the force analyzed device is (0.029 inch or 0.7 mm) (D2). Replacement of the variables identified in the equation and explanation for (x) found that the distance needed to stretch the elastomeric ties was (0.063 inch or 1.544 mm) [9].

Statistical Methods

The outcomes were detailed as mean force decay (in newton) changes from primary to final measurements for ligatures ties and were compared between two-points time intervals with Mann-Whitney tests. Kruskal-Wallis tests were applied to compare the mean of force decay of ties among the studied mouthwashes. P ≤0.05.

Pilot Study

A pilot study was conducted to:

1. Determine the required sample size by founding the standard deviation (SD) (0.204) of mean for 10 measurements representing the force decay of ligature tie measured at room temperature and humidity. The sample size calculation was done based on single mean formula [$n = (z\ r/D)^2$]. In which, n is considered as the number of sample subjects, z [constant] = 1.96 for 95% confidence, r [standard deviation] = (0.204), and D [precision] = 0.2 unit. The analyzed number was (3.61). However, 10 elastic ties were used in each subgroup for more accurate statistical results.
2. Determine the time required to achieve maximum water magnetization which is checked at different time intervals (1 hour, 2hours, 3 hours, 6 hours, 12 hours, 1 day, 2 days and 3 days). The maximum magnetization for water was achieved at 2 days.

RESULTS

Table 1 and Figure 4 reveal descriptive statistics of force decay for the AS, OK & MW groups at the studied time intervals. The highest force decay value was for MW group at two weeks, while the lowest was for OK group at one week.

TABLE 1. Descriptive statistics of force decay for the studied mouthwashes at the studied time intervals

Test group	N	Initially	One day	One week	Two weeks
		Mean±SD	Mean±SD	Mean±SD	Mean±SD
AS	10	1.73±0.19	1.64±0.22	1.55±0.25	1.63±0.16
OK	10	1.73±0.19	1.56±0.12	1.38±0.12	1.61±0.12
MW	10	1.73±0.19	1.62±0.13	1.81±0.13	2.10±0.12

N = number of samples, SD = standard deviation, AS = artificial saliva, OK = Ortho Kin, MW = magnetic water, force decay value in newton

Table 2 reveals comparison between two-points time intervals of the study groups. For AS group there was significant difference between the initial -one week and one day -one week. For the OK group there is significant differences between the initial -one day and one day -one week. For the MW group there was significant differences between the initial -two weeks.

TABLE 2. Comparison of force decay value between two-points time intervals for the study groups

Time interval	AS	OK	MW
Initial-One day	1.000	0.011	1.000
Initial-One week	0.011	0.955	1.000
Initial-two weeks	0.599	0.092	0.003
One day-one week	0.015	0.000	1.000
One day-two weeks	0.714	1.000	0.011
One week-two weeks	0.846	0.001	0.092

AS = artificial saliva, OK = Ortho Kin, MW = magnetic water, Sig = significance at P ≤0.05, force decay value in newton

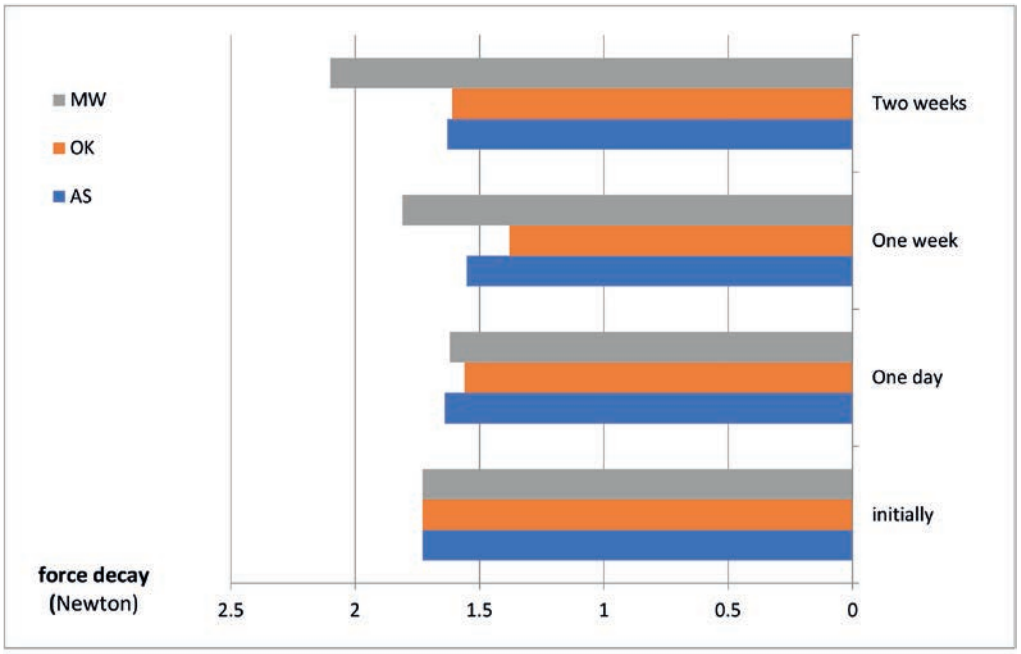

FIGURE 4. Histogram showing comparison of force decay values at different mouthwashes for the studied time intervals. AS = artificial saliva, OK = Ortho Kin, MW = magnetic water, force decay value in newton

Table 3 shows Kruskal wills test of the force decay for the study groups among the tested mouthwashes. For AS-MW, there was significant difference at the two weeks, for AS-OK in the one day, one week and two weeks, and for MW-OK in the one day and one week.

TABLE 3. Kruskal wills test of the force decay for the study groups among the tested mouthwashes

Times	AS_MW	AS_OK	MW_OK
Initial	1.000	1.000	1.000
One day	1.000	0.001	0.001
One week	0.910	0.000	0.012
two weeks	0.000	0.002	1.000

AS = artificial saliva, OK = Ortho Kin, MW = magnetic water, Sig = significance at P ≤0.05, force decay value in newton

DISCUSSION

High incidence of dental and gingival diseases during the orthodontic treatment period makes the use of an adjunctive method for improving the oral health unavoidable. Use of mouth rinses has been presented as the active way for decreasing dental plaque buildup. Limitless number of commonly used antiseptic mouth rinses are presented. Currently, due to some unwanted side effects stated from commercially available rinses, the tendency to use natural mouthwashes has increased [19]. The effect of MW as mouthwash was studied and compared to OK in this research.

More than 70% of the human body is made up of water. Blood circulation, absorption, digestion and excretion relies on the water essential for blood, lymph, skin and muscles. The pH of the human build is acidic when they are sick. MW is alkaline, which elevate the pH of our body, allowing the body to eliminate toxins. Bio-MW stimulates energy, with motivating and cleansing power [13]. Water treatment with the help of MF restores the balance and normal energy provided by nature. MW contains much more hydroxyl ions than tap water, which makes it alkaline and reduces acidity. Tap water has a pH of about 7, while MW is alkaline with pH up to 9.2. One of the advantages of magnetic force is to reduce the surface tension of water, which makes it lighter, wetter, thinner and more absorbent, and can penetrate cell walls and absorb nutrients [20].

An oral irrigator using MW may be a useful device to prevent calculus accumulation in periodontal disease patients, but it has to some extent effect on plaque reduction. In addition, there is a clinical improvement in the gingival index, but the statistical significance is not reached [21]. It is shown that treatment with MW extremely decrease the calculus accompanied or co-existed with dental caries21. MW prevents the progress of the attachment development between the plaque and the teeth by magneto hydrodynamics which prevents the metallic precipitates that normally occur in liquids [22]. Shihab [17] recommended using MW as a good antibacterial irrigate solution for maintenance of good oral hygiene. Also, Qassabbashe and Al-Hamdany [23] proved an antifungal efficacy of MW as a mouthwash against Candida albicans. Meanwhile, Qassabbashe and Al-Hamdany [24] showed advantageous effect of MW as a mouthwash; in comparison with chlorhexidine; on the shear bond strength of bonded orthodontic brackets. Al Zubaidy and Al Hamdany [25,26] found a reduction of nickel and chromium

ion release with less deleterious effects on surface characteristics of stainless steel orthodontic archwires when using MW as a mouthwash in comparison to OrthoKin.

The MF used in this study was static. As the benefit of static MF is that the user clearly notices how the field behaves continuously, while variable MF are extremely questionable in the terms of field's frequency, strength, and the depth of field effects27. Static MF can be used without limitations in continuum and are simple to control. Adversely, other MF such as electrical MF are inappropriate for daily usage, as they are restricted to be used in a laboratory environment [27].

The strong permanent magnet neodymium (Nd Fe B) was the preferred choice to be used in the present study, due to their highest magnetic properties of all permanent magnets and their high magnetic strength [28]. The MF strength used in this study was 2430Gs, this is completely safe for using according to the magnet safety guide of Massachusetts Institute of Technology, Environment, Health and Safety office [29], which submitted that the 4000Gs magnetic exposure is within the general public exposure, which was in accordance to the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and American Conference of Governmental Industrial Hygienists (ACGIH) in 2009.

The northern pole was utilized in the present study, as it is the negative pole and has the responsibility of raising pH values toward alkalinity, which is crucial for disinfection [30].

OK mouthwash was selected in this study because it is widely marketed in country and is easily obtained by patients, also it has active ingredients such as fluoride and chloride, it has optimum solution concentration of 500 ppm fluoride, according to manufacturer, to assist in avoiding dental caries and aiding in teeth enamel remineralization during the orthodontic therapy, and it is one of the mouthwashes that is prescribed by many orthodontists [31].

Comparison of force decay among the studied mouthwashes

The comparison of the force decay for the study groups among the tested mouthwashes reveals different pattern of behavior for each mouthwash. For (AS-MW), no significant difference exists at all-time intervals except at two weeks, meaning that the presence of ties in MW not affect elastic decay initially till one week, but after this time force decay affected significantly. For AS_OK comparison, the results reveals that OK significantly increase elastic decay of ties from one day up to the end of second week. Concerning the comparison of force behavior of ties between MW_OK, the results indicated significant effects of OK in comparison to MW on the ties especially from one day to one week, after which the force decay affected non significantly between the two mouthwashes till the end of the second week.

The current results agreed to some extent with Rafeeq [10] who found there was significant difference of the result of artificial mouthwashes (0.12% Chlorhexidine) on force decay of elastomeric ties. These elastomeric ties (closed type) of 3 colors translucent, pearl lilac, and crystal yellow separated into two group, the first was washed with distilled water as a control group and the second one was regularly washed between distilled water and chlorhexidine mouthwash as a test group. They used elastic chains as an alternative of elastic ties and used chlorhexidine with distal water while our study OK (500 ppm NaF) and MW were used.

Similarly, the study of Pithon [32] was in agreement to the current study. They found significant difference in the force decay between distal water group and other groups (Chlorhexidine in different concentration). This study used distal water as control group and Chlorhexidine in different formulation instead of OK (NaF) of 500 ppm, MW as mouthwash and orthodontic elastic chain instead of elastic ties.

The result of Nahidh [33] was in contrast to our study result as they found non-significant difference in the force decay value when comparing the studied mouthwashes (Listerine green tea, Tebodont, Aloe-dent, Silca herb) in the first week and was in agreement to our study as they found there was no significant difference among the mouthwashes in the two weeks. This study used pieces elastomeric chain instead of elastic ties and used specific mouthwash instead of OK (NaF) of 500 ppm and MW mouthwashes that were used in our study.

Comparison between two-points time intervals for the studied mouthwashes

For AS group, there was significant difference at initial & one week, and one day & one week. For OK group, there was significant difference in the initial & one day, one day & one week.

The study of Pithon [32] came in covenant to the current results. They found statistical difference when the test groups were assessed separately comparing the feature time, the force was statistically higher in the initial period than that of all the other experimental periods ($P < 0.05$) and unlike to our study where test groups were compared with each other over the same time period, there were no statistical differences among the groups were found at the initial, 24-hour, and 7-day time periods ($P > 0.05$). This study used distilled water instead of MW used in our study and used Chlorhexidine in different

formulations (0.12% and 0.2% manipulated Chlorhexidine, 0.12% Chlorhexidine digluconate and 0.2% clean form) mouthwashes and chain elastic instead of OK (NaF) of 500 ppm, and elastic ties used in our study.

The results of Omidkhoda [34] was in an agreement to our result. They found a significant difference of three mouthwashes (persica, chlorhexidine 0.2% and NaF0.05%) and AS, as control in one day, one week, two weeks on the force decay value of orthodontic elastomeric chains. The result of this study used elastic chain instead of elastic ties and use chlorhexidine with 0.2% and NaF0.05% and percika while our study of OK (NaF) of 500 ppm.

The study of losito [35] came in agreement where they found the seven and fourteen days-time periods varied statically among the examined groups (chlorhexidine digluconate solution 0.12% and parasitic acid solution) ($p<0.05$). And in contrast to current study as they found there was no significant difference at the control group (AS) did not vary from the other two test groups at 24 hr and It was found that there was no significant difference for the non-immersed sample in disinfectant solutions between the time period of seven and fourteen days and it was found that there was no significant differenc among the examined groups in most time periods. However, this study used elastomeric chain in place of elastomeric ties and used chlorhexidine digluconate solution 0.12% and parasitic acid solution instead of OK (NaF) of 500 ppm and MW with the time intervals (24 hr, 7, 14 and 21 days) instead of time periods (initial, 1 day, 7, 14 days) used in this study.

The result of Mirhashemi [36] was in contrast to our result. They found there was no significant differences in the force decay among studied mouthwashes (persica, CHX 0.2%, NaF with 0.2% and the combination of CHX and NaF). This study used elastomeric chain instead of elastic ties and used persica, CHX 0.2%, NaF0.2% and the combination of CHX and NaF mouthwashes instead of OK (NaF) 500 ppm.

The study of JavanmardI & Salehi [31] was in agreement to current study. They found that force decay of the elastomeric chain occurred over time. After 3 weeks interval, the elastic chain test group, OK mouthwash showed significantly lesser force decay value compared to other groups ($P<0.05$). This study used OK, Sensikin and Persica, while in present study OK 500 ppm and MW was used and elastomeric chain instead of elastic ties that used in the current study.

The result of Sadeghian [37] was in agreement with our result, who found that there was significant difference of three different mouthwashes on the force decay of two different orthodontic chain brands before testing (initial) and at one week, and in contrast to our study when they found no significant difference at 1 day and found there was significant difference at two weeks. This study used elastic chain, while the current study used elastic ties and used NaF0.05%, listerine mouthwash instead of OK (NaF) of 500 ppm and MW.

Correspondingly, the study of Issa & Kadhum [38] agreed to the existing study. They found that there was significant effect generally. The force level value of elastomeric chains destroys rapidly over time, with the majority of deterioration occurring in the first 24 hours, after which the rate decreases over time. And was in contrast to our study when found that there was no significant effect (no negative impact) of use of NaFand chlorhexidine mouthwash on elastomeric chain force decay. This study used elastic chain instead of ligature ties with salivary enzymes, strong alkaline and acidic pH (<5.4) instead of AS with pH7 that was used in our study.

The study of Mude [39] agreed with our study they found there was significant difference of using various formulation of chlorhexidine mouthwash. This study used [0.1%, 0.12%, 0.2%] chlorhexidine-gluconate, [0.2%] chlorhexidine-gluconate with [0,05%] NaF and [0,09%] zinc chloride, [0.2%] chlorhexidine-gluconate with [0,05%] triclosan and [0.07%] sodium mono-fluoro-phosphate in place of OK (NaF) of 500 ppm.

Our result was in contrast to study of Sufarnap [40] who found that force decay of elastomeric chain was non-significantly differ among the AS, chlorhexidine _NaF, chlorhexidine (0.1%) for one day, one week. However, this study used elastic chain instead of elastic ties, 0.1% chlorhexidine digluconate and 0.1% chlorhexidine digluconate with NaF, while our study used of OK (NaF) of 500 ppm and MW.

For MW, elastic ties showed significant difference in the initial & two weeks, one day & two weeks. Meaning that the ties deteriorate significantly in the presence of MW during the whole study period. This can be clarified as that the surface tension of the water decreased by the magnetic force, making it easier, wetter, cleaner, finer, more absorbable, and more permeation [20].

CONCLUSION

MW caused more force decay in the orthodontic elastic ties than AS and OK mouthwashes especially at two weeks period.

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