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The effect of hydrochloric acid and sodium hypochlorite on fracture resistance of orthodontic self-cure acrylic base

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ABSTRACT

Background: Patient cooperation is necessary for treatment success in removable orthodontics. Every factor has an adverse effect on appliances appearance can impede appliance wearing. This study investigated the effect of immersion in household cleaner and bleach liquids on fracture resistance of self-cure orthodontic acrylic resins.

Materials and Methods: This *in vitro* study two orthodontic acrylic resins (Megadental® and Acropars®) were used. Eighty identical acrylic samples (50 mm × 5 mm × 3 mm) from each acrylic resin were fabricated and divided into four groups (n = 20). For each type of acrylic resin; Group 1: 15 min immersion in household cleaner liquid (hydrochloric acid [HCl], 10%), 1 min rinsing with running water, 15 min immersion in household bleach liquid (sodium hypochlorite [NaOCl], 5.25%) and 1 min rinsing with running water were done. For Group 2, two times and for Group 3, three times immersion just like Group 1, were done. Group 4, as control, had no immersion. Fracture resistance of samples was measured with universal testing machine (Instron) in 3-point bending set-up. Data were analyzed with two-way repeated measurement ANOVA. Significance level was set at 0.05.

Results: Fracture resistance of Acropars groups was greater than counterpart Megadental ones ($P < 0.001$). Immersion factor, alone ($P = 0.375$) and in combination with material ($P = 0.603$), did not make a significant difference among fracture resistance of each acrylic resin groups.

Conclusion: 15 min immersion in household cleaner liquid (HCl acid) followed by 15 min immersion in household bleach liquid (NaOCl 5.25%) and even 3 times repetition of this process had not significant adverse effect on fracture resistance of acrylic resins.

Key Words: Fracture Resistance, orthodontic removable appliances, self-cure acrylic base

INTRODUCTION

Providing and maintaining the cooperation of orthodontic patients are cornerstone of the success of removable orthodontic treatments.[1,2] The esthetic appearance of the appliance is one of the effective means for making and maintaining motivation, especially for children. Color changes, unpleasant smell, sedimentation of calcareous materials, and any other factors which result in an unpleasant appearance for the removable appliance can reduce the patient's tendency to use them. Insufficient knowledge or weak

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cooperation of the patient in cleaning the appliance will further exacerbate these problems.[3,4]

The microorganisms in the oral cavity are capable to attach themselves on any external body and growing on it.[5] Some like Candida can infiltrate the acrylic bases.[6] Colonization of micro-organisms is more frequent on those surfaces of the plate which contact the mucous or dental surfaces.[7] The moist environment of the oral cavity and keeping the appliance in water help the microorganisms to grow on the surface of the orthodontic plates.[6,8]

Cleaning with only water is not an efficient method for cleaning the plate.[9,10] The most frequently recommended method for cleaning an acrylic base is mechanical cleaning using only toothbrush or toothbrush together with detergent.[4,9,11-13] Some experts have reported this method even more efficient than that with using solutions of cleaning tablets.[14,15] Some have demonstrated that using toothbrush only is not as effective as using chemical cleaners in reducing bio-film on acrylic bases.[16,17] Some others do not consider either of the methods more efficient than the others.[18] Some regard a combination of both methods as the most efficient one.[14] Using toothpastes or other abrasive materials is not recommended due to their effect in reducing the surface smoothness.[19] Micro-wave disinfection is also recommended for cleaning acrylic bases, even though it has proved to be most effective when combined with toothbrush and cleaning tablet methods.[20]

Easy application, antimicrobial properties, absence of negative effects on the structure, appearance, and hardness of the acrylic base, along with the ability to remove organic matter, added colors, odors, and minerals from the plates are essential properties of an ideal cleaner.[21-23]

Hydrochloric acid (HCl) is a strong acid. The weakened form of it is used in household cleaners (10%) and for eliminating calcareous sediments from different surfaces. This solution is also used in dentistry for eliminating the color changes of the enamel through micro-abrasion method.[24] Sodium hypochlorite (NaOCl) is an inexpensive oxidizer which is frequently used as a household bleaching liquid (5.25%). This solution also has decolorizing and deodorant properties. Even in low concentrations, it is a strong disinfecting agent for the surfaces, nonmetal objects, and dental casts.[25-29] Due to its antibacterial properties, it is also used as a cleaning solution in root canal treatments.[30,31]

Considering the possibility of using HCl acid for eliminating minerals from the surface of orthodontic removable appliances and subsequently using NaOCl for eliminating unpleasant smell and color, this research aims to assess the effect of immersing in household cleaner solution (with 10% HCl-acid) and subsequently immersing in household bleaching liquid (5.25% NaOCl) on the fracture resistance of two types of orthodontic self-cure acrylic bases.

MATERIALS AND METHODS

This *in vitro* study was approve in research and ethics committee of Isfahan (NO:295094). Two types of orthodontic self-cure acrylic bases were used in this research: (1) Megadental (GmbH, D-63654, Budingen, Germany) and (2) OP Acropars (Marlic, Tehran, Iran).

For preparing acrylic parts with the same dimensions, a computer numerical control machine was used on a steel ingot to create molds with 50, 3, and 5 mm of length, depth, and width [Figure 1]. Eighty acrylic pieces were made out of each type of acryl based on the manufacturers' instructions. After being kept in physiological serums in room temperature for 24 h, samples of each type of acryl were randomly divided into four groups of 20. Then, they entered the immersion process in room temperature separately. Household cleaner solution (Active®, Padideh Shimi Gharn Co., Tehran, Iran) was used as the solution containing 10% HCl acid and household bleaching solution (Active®, Padideh Shimi Gharn Co., Tehran, Iran) containing 5.25% NaOCl.

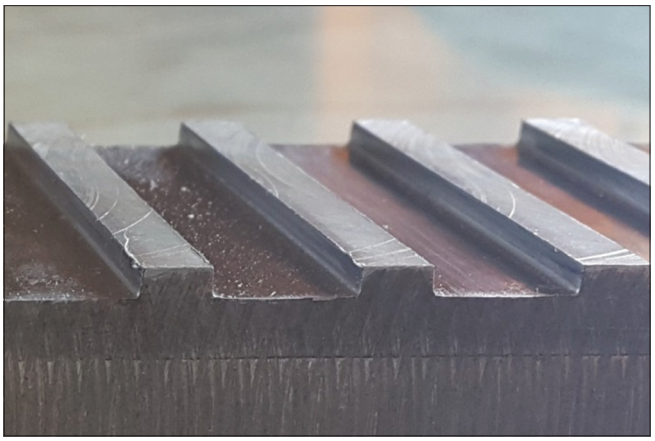

Figure 1: Metal molds to prepare acrylic resin bars with equal dimensions.

For each type of acryl in Group 1, 15 min of immersing in the cleaner liquid, 1 min of washing with flowing water, 15 min of immersing in the bleaching liquid, and then 1 min of washing with flowing water were carried out. The same process was carried out twice for Group 2 and three times for Group 3. Group 4 as the control group did not undergo any immersion. Finally, all of the samples were dried using a cotton towel. For blinding the research, the samples were coded by first author and then measurements were done with second author. The fracture resistance of the samples was measured using the Instron® Universal Testing Machine (MA, USA) in a 3 point bending manner with a 0.5 mm/s speed [Figure 2]. The data were analyzed using SPSS (Version 22, Chicago, USA, IBM Corp) with two-way repeated measured ANOVA test with a 0.05 significance level.

RESULTS

The mean and standard error for fracture resistance of different groups of both materials are listed in Table 1. These results are also shown in Figure 3. The analysis of two-way repeated measured ANOVA showed that the mean fracture resistance in all Acropars acryl groups was significantly higher compared to the corresponding Megadental groups ($P < 0.001$). The immersion times variable, either alone ($P = 0.375$) or combined with the material variable ($P = 0.623$), results in no significant change in the fracture resistance of the groups of each type of acryl.

Table 1: Mean and standard error of fracture resistance (Newton) in different groups (newton)

Groups	Control	Group 1	Group 2	Group 3
Acropars	70.72 (3.1)	73.61 (2.7)	73.69 (3.1)	67.75 (3.6)
Megadental	45.62 (1.7)	47.01 (1.0)	48.73 (1.2)	48.73 (1.2)

Figure 2: Three-point bending setup for fracture test.

DISCUSSION

Orthodontic removable has the potential of food debris retention and help the microbial plaque growth; therefore, cleaning the appliance and maintaining the oral hygiene are important.[4,11,13] Sedimentation of calcareous materials on the removable appliance, not only brings about an unpleasant appearance, but also increases the surface roughness and microbial growth and makes it more difficult to keep it clean. These sediments can also spoil the conformity of appliance in areas which contact the teeth. This brings about the possibility of unwanted movement in dental retainers.[5]

Two types of acryl were used in this research to help to generalize the findings. The results of this research show that immersion in 10%-HCl acid and subsequently in 5.25%-NaOCl, each for 15 min, does not result in significant change of the fracture resistance of acrylic bases, even if carried out for up to three times. Repeating the process for three times showed that the acrylic base will not suffer serious damage even after 45 min of immersion in the mentioned solutions. This confirms the safety of this method of immersion in fewer times and for shorter durations. At the time of this study, no researches had

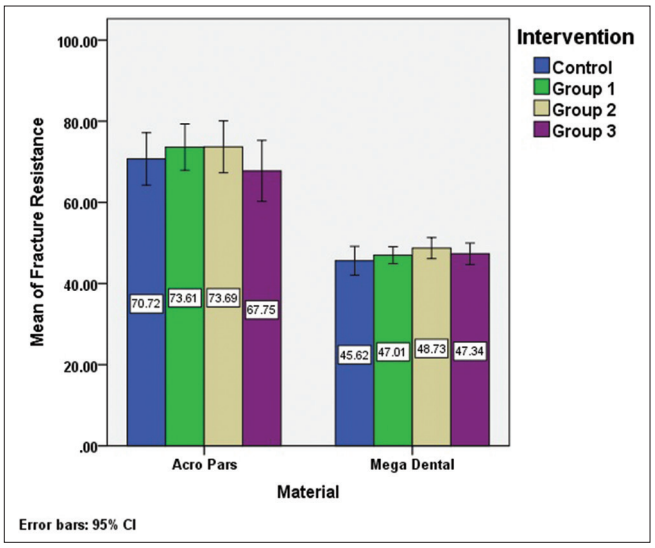

Figure 3: The mean of fracture resistance of different groups of both materials (Control: without Immersion; Group 1: One time immersion; Group 2: Two immersions; Group 3: Three times immersion).

analyzed the effect of HCl on acrylic bases. HCl is not listed as a cleaning solution, but NaOCl is considered an affective one even in low concentrations.[27] Even 0.02% of this solution is effective on Candida.[28] The most effective cleaning solution for preventing the growth of microbial biofilms and colonization of Candida is 0.5% NaOCl.[32] 1% NaOCl can eliminate the common micro-organisms in the oral cavity even in 10 s.[33] In 2017, Pires *et al*. mentioned 1% NaOCl to be a suitable solution for disinfecting acrylic bases.[34] Therefore, the method suggested in the current study can also be applied for disinfecting orthodontic plate and eliminating microbial colonization.

In this regard, sedimentation in solutions such as diluted vinegar, diluted NaOCl, or shaker bathing method with a detergent are also recommended. Moreover, Sodium perborate and 0.2% and 0.12% chlorhexidine are also preferable solutions for sedimentation.[4,5,28,34-37] Microwaving with a power of 450 to 650 wats for 3 min is also recommended for disinfecting acrylic bases, but temperatures above 70° of centigrade will increase the deformation possibility. As a solution for this problem, a combination of microwaving method and cleaners available in market is recommended,[38] though placing orthodontic appliances or tooth sets in the microwave might displease the other members of the family.

NaOCl has little destructive effects on acrylic bases.[39] Also reduction of micro-hardness of acrylic bases as a result of 1% hypochlorite Sodium in 90 cycles of 10 s has been reported.[7] Arruda *et al*. however did not report any significant change in the hardness of the surface after 1 year of daily immersion in 0.5% hypochlorite or 20 min.[40] Some studies reported that 1% and 0.5% NaOCl does not result in the surface roughness changes of acrylic bases.[7,41] according to the study of Sharma *et al*., immersion of heat curing resin samples for 3 months in 1%-NaOCl, increases surface roughness.[42] Other studies have not reported any effect of 0.5% NaOCl (90 days of immersion, 3 min for each day[43] and simulating a 1-year immersion, 20 min or each day[40,44] on the smoothness of significant surfaces. Although, some market cleaners may reduce the smoothness of the surfaces of acrylic bases.[45] Sharma *et al*. reported that, the use of 1% NAOCL for 3 months reduced the flexural strength of denture base resin.[42] Letícia Resende Davi *et al*. demonstrated that the 1% NaOCl during the simulated period of 180 days presented significantly lower flexural strength of polymerized acrylic resin compared with the control group.[46] In short disinfection simulations, NaOCl solutions at 1%, 2.5% and 5.25% concentrations did not change the flexural strength of the acrylic resin.[47] Kurt *et al*. Also showed that the flexural strength of samples kept in 1% hypochlorite for 7 days were comparable with the control group.[48]

According to other studies, NaOCl (1%, 3 times a day, 30 min each time, for 30 days[19]) and (0.5%, simulating 1 year of immersion, 20 min a day[40]) will not result in any changes in the fracture resistance of acrylic bases. This is also confirmed in the current study in which immersion was carried out with 5.25% NaOCl for 15 min for up to 3 times.

Color stability is regarded a desired property for acrylic bases. Insufficient polymerization, surface roughness, consumption of colored foods and beverages such as tea, coffee, or juices can result in color changes of acrylic bases. Although the lower the pH of the foods or drinks is, the more its effects will be on color changes.[49] While In 2015, Shah *et al*. Reported that immersion in basic denture cleaning solutions caused the most base color discoloration, which was time-dependent.[50] Considering the fact that the acrylic base of removable orthodontic appliances is made of self-curing acryl, these bases have less resistance against color changes compared to tooth sets.[51] This is while some have reported the resistance of self-curing acryl against external colors to be more.[52] Another aspect of color stability is the property to maintain the initial color against the process of cleaning. Although market cleaners are affective for eliminating the external colors caused by foods or drinks, some can affect the initial color of the acrylic base in long term.[53] Panariello *et al*. have demonstrated that 1%-NaOCl causes a slight change in the initial color of acrylic bases in 90 cycles of 10 s.[7] Although other studies have not reported any significant change in the initial color of the acrylic bases resulted by use of NaOCl (0.5%, 90 days, 3 min[43] and simulation of 1 year of immersion, 20 min a day[40]). Although we did not systematically analyze the effect of immersion in HCl acid and hypochlorite Sodium in the current study, we did not observe any significant change in the color. Confirming or denying this requires us to design another research.

0.05% NaOCl does not result in significant ions release from metal structures.[54] Although, it can bring about

unpleasant results like stains or corrosion (pitting in the surface) on metal surfaces such as the chrome-cobalt framework or orthodontic wires.[22,27,39] HCl acid has corrosive effect on metals. The average concentration of HCl acid used in household cleaners is 10%.[55] Moreover, household cleaners contain organic materials which act as preventers that reduce the corrosive property of the acid.[56] Analyzing the effect of immersion of orthodontic plate, following the method introduced in the current study, on the metal components of the plate, requires further research.

CONCLUSION

Fifteen minutes of immersion in a household cleaner solution (10% HCl acid) and subsequently 15 min of immersion in a household bleaching liquid (5.25%-NaOCl) and even 3 times repetition of this process does not result in significant reduction of fracture resistance in acrylic bases even up to three times repetitions.

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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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