The Effect of Denture Cleansing Solutions on the Retention of Yellow Hader Clips: An In Vitro Study

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<u>Purpose</u>: To evaluate the retention of yellow Hader clips after exposure to various denture cleansers. <u>Methods</u>: Seven groups of 18 yellow Hader clips each were soaked for the equivalent of 6 months of clinical use in the following denture cleansing solutions: Polident Regular, Polident Overnight, Efferdent, 5.25% Sodium Hypochlorite (NaOCl, 1:10 dilution) 15 min/day, NaOCl (1:10 dilution) 8 hours/day, water and dry (control) group. A Universal Testing Machine, set at a crosshead speed of 2 in/min, pulled each clip once, and the peak load-to-dislodgement was recorded and used as a measure to reflect changes in the retention of the Hader clips. Data were analyzed by a one-way analysis of variance followed by Tukey's HSD test. A p value ≤ 0.05 was considered significant.

<u>Results</u>: Denture cleansing solutions affected the retentive values of yellow Hader clips (F = 6.102, $p \le .0001$). Sodium hypochlorite solution, 15 min/day for 6 months, caused an increase in the retentive values of the clips tested with a mean peak load-to-dislodgement of 22.63 ± 1.29 N. In addition, clips soaked in water showed no difference in retentive values when compared with all other groups. Furthermore, Polident Regular, Polident Overnight, Efferdent, and NaOCl (8 hours/day) had no effect on the retentive values of yellow Hader clips.

<u>Conclusion</u>: This in vitro study demonstrated that the retention of yellow Hader clips used in implant overdentures is unaffected when soaked in commercial effervescent denture cleansers (Polident 5 Minute, Polident Overnight, and Efferdent) for six simulated months. Sodium hypochlorite statistically increased the single-pull retentive values of the clips, an effect that may not be beneficial. Increased retentive values may be associated with reduced durability of clips; further research is needed to address this issue.

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CCORDING TO THE McGill consensus ${f A}$ statement, there is overwhelming evidence that a two-implant-retained overdenture should be the first choice of treatment for the edentulous mandible.¹ Overdentures can be retained by clips, precision attachments, or magnets,²⁻⁵ and the most common method for retaining implant overdentures (IOD) is a combination of adjustable metal clips attached to a bar connecting two or more implants.⁶⁻⁸ As an alternative, a combination of nylon clips attached to a bar is sometimes used to retain IOD, because they are easily replaced and give adequate retention, although they cannot be adjusted.9 Nylon clips are approximately 75% less expensive than their metal counterpart, and do not cause wear on the bar, as is reported for metal clips.¹⁰

Although implant-retained overdentures may be a less expensive alternative to a fixed

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implant-supported prosthesis, problems with retentive clips, such as frequent replacement, have been reported.^{11,12} Many investigators have studied the physical properties of Hader clips and reported that a direct relationship exists between prosthesis retention and patient satisfaction.^{11,13,14} The best predictor of patient satisfaction with denture wearing was the patient's perception of retention and appearance.¹⁵

Many edentulous patients with advanced mandibular bone loss treated with mandibular implant-retained overdentures need professional hygiene care.¹⁶ The most common method of routine denture cleansing is brushing with tap water and either soap or toothpaste.¹⁷⁻²² The dominant approach to denture cleansing in the United States is the use of an effervescent commercial denture cleansing product dissolved in water.²³ Sodium hypochlorites (NaOCI) such as Clorox[®] Bleach are useful as denture cleansers, because they remove stains, dissolve mucus as well as other organic substances, and are bactericidal and fungicidal.^{21,24}

Denture cleansers have been shown to have a detrimental effect on dentures and liners, and a disadvantage of NaOCl is that it bleaches acrylic resin.^{20,25-27} The whitening effect of cleansers on acrylic resin dentures was investigated by Unlu,²⁵ who concluded that oxidation, in combination with a strong alkaline solution, is deleterious to the esthetics of a denture.²⁸ Efferdent and Polident, which produce CO₂ when dissolved in water showed the least whitening effect.²⁹

Nylon clips are made from polyamide³⁰ which has been shown to be affected by NaOCl,³¹ a common household material used to cleanse dentures. To date, no study has evaluated the effect of denture cleansers on overdenture clips. Denture cleansers may cause changes in Hader clips, which may in turn affect their physical properties. More importantly, denture cleansers may affect the retentive capacity of overdenture clips. In this paper, we examine the effect of various denture cleansers on the retention values of yellow Hader bar clips.

Material and Methods

Fabrication of the Hader Bar

Two implant analogs (ILA20, 3i Implant Innovations, Palm Beach Gardens, FL) were embedded 10 mm apart in a $1 \times 1 \times 2$ inch block of Type III stone (Modern Materials, Heraeus Kulzer, Armonk, NY). Parallelism was established by using a surveyor (The JM Ney Co., Hartford, CT). UCLA abutments (3i Implant Innovations) were screwed onto the lab analogs with Lab Screws (3i Implant Innovations). A plastic Hader bar pattern (APM-Sterngold, Attelboro, MA) was used to create a bar connecting the two implant analogs. The pattern was invested with gypsum-bonded investment (Beauty-Cast, Whip Mix, Louisville, KY) and placed into a burnout oven (Accu-Therm III 3000, Jelenko, San Diego, CA). After the burnout procedure was completed, the investment was cast with Type III Gold (Firmilay, Heraeus Kulzer). The investment was divested, and the sprues were cut and lightly finished with a diamond particle-impregnated rubber wheel (Universal Polisher, Brasseler, Savannah, GA).

Fabrication of the Acrylic Block with Implant Lab Analogs and Hader Bar

Base plate wax (Tru Wax, Heraeus Kulzer, South Bend, IN) was shaped into a rectangular box $2 \times 1 \times 1$ inch, invested, boiled out, and packed with heat cured Ortho Jet Acrylic (Lang, Wheeling, IL) at 165°F for 9 hours. Once the cycle was completed, the block was divested, finished, and polished.

The bar was screwed onto two implant analogs and was embedded into the acrylic. The bar was then blocked-out with Type II stone (Kerr Lab, Orange, CA), except for the processing clip and the metal housing (Sterngold) placed onto the center of the bar. Another block of wax was formed on top of the acrylic block with the lab analogs and bar. The assembly was invested, boiled out, packed with clear acrylic resin, heat polymerized, finished, and polished in the same manner described above. In addition, the first acrylic block had four notches on each side. The second acrylic block had raised areas on each edge to complement the notches in the first acrylic block. These notches aided in the verification of complete seating during testing procedures and ensured consistent pulls.

Testing Procedure

Denture cleansing solutions tested were Polident Regular, Polident Overnight, Efferdent, 5.25% NaOCl diluted 1:10 in tap water,²³ and tap water (Table 1). The control group was the dry group in which the clips were not soaked in any denture cleansing solution.

The Hader clips were placed in a small, perforated plastic bag. A second bag containing a small marble was placed within the first bag to prevent the clips from floating to the top of the solution and to ensure that the clips were immersed in the solution during the whole soaking period. The bags were immersed in

Denture Cleanser	Co., City, State
Efferdent	GlaxoSmithKline, Philadelphia, PA
Polident	Pfizer Inc, NY, NY
Polident Overnight Bleach	Pfizer Inc, NY, NY Clorox, Oakland, CA

 Table 1. Denture Cleansers Tested

each solution according to manufacturer's instructions for the time equivalent of 6 months. The solutions were changed on a daily basis. For example, Polident Regular required 5 minutes of soaking per day according to manufacturer's instructions. A timer was set to ring every five minutes and then the solution was changed. At that time, the clips within the mesh bag were rinsed with tap water for 15 seconds, and then immersed in 50 ml of tap water prior to inserting the next tablet into the beaker for the next period representing the second day of soaking (Table 2).

Each Hader clip was tested once on the Universal Testing Machine (Satec Material Testing Equipment, T Series, Scottsdale, AZ). The Satec machine was set at a crosshead speed of 2 in/min to simulate in vivo snap removal.³² The acrylic block with the bar on it (Fig 1) was clamped down and stabilized to the bottom part of the Satec machine. A screw hook was embedded into the top part of the upper acrylic block, which in turn was clamped into a Pneumatic Grip. The grip attached to the Satec machine, which allowed a tensile force to be applied to the specimen until the clip separated from the bar. The peak load-to-dislodgement was recorded and used as a measure to reflect the retentive values of the Hader clips. Each clip was tested once after completion of the immersion period. After testing, each clip was removed from the metal housing in the acrylic block by using a blade to cut the clip into two pieces down the center. A yellow nylon Hader clip holder tool (Sterngold)

Table 2. Experimental Design and Soaking Periods

Denture Cleansing Solution	Solution Change Interval (manufacturer's recommendations)	Immersion Time 6 Months Equivalent
Water Polident Efferdent Sodium hypochlorite Dry (control) Sodium hypochlorite Polident overnight	5 min 15 min 15 min 0 8 hours 8 hours	1440 hours 15 hours 45 hours 45 hours 0 1440 hours 1440 hours

was used to place a new clip into the metal housing within the acrylic block.

The peak load-to-dislodgement was determined for all clips in each group. The data were collected and analyzed by a one-way analysis of variance (ANOVA) followed by Tukey's HSD test. A p value ≤ 0.05 was considered significant.

Results

The behavior of the clips from each group in response to dislodging forces over time is presented in Figure 2. This figure shows the behavior of the clips during the one pull test. The highest point of each line in the graph represents the peak load-todislodgement in Newtons (N). Immediately after that point in time, the clip was dislodged from the Hader bar.

Denture cleansing solutions had significant effects on the retentive values of yellow Hader clips $(F = 6.102, p \le .0001, \text{Table 3})$. The retention of nylon Hader clips soaked in NaOCl solution for 15 minutes per day was significantly higher than the retentive values for all other clips except water (Table 3, Fig 3). Figure 3 represents the mean peak load-to-dislodgement for each denture cleansing solution tested. The retentive values ranged from 18.64 ± 1.08 N for Polident 5 Minute to $22.63 \pm$ 1.29 N for NaOCl 15 min (mean \pm standard deviation). In addition, water showed no difference in retention as compared with all other groups. The retentive value of each group in descending order was: NaOCl (15 minutes), water, Polident Overnight, Dry (control), Efferdent, NaOCl (8 hours), and Polident Regular.

In summary, there was no significant difference between Hader clips soaked in water versus all other groups. There was no difference in the retentive value of the clips whether the clips were kept overnight in a denture cleansing solution or just plain water. There was no significant difference between the retentive value of the Hader clips soaked in Polident Regular and Polident Overnight.

Discussion

As the first choice of treatment for the edentulous mandible,¹ IODs will increase as a treatment option for patients, and maintenance protocols for IODs will need to be evaluated. Detailed





Denture Cleansing Solution

Figure 2. Load-to-dislodgement (N) during a single pull on the tested clips. In each of the test groups, the load was documented in a continuous fashion during the pull until the clip was dislodged. Error bars represent standard deviation (SD).

Figure 3. Mean peak loadto-dislodgement (N) for each denture cleansing solution tested. Error bars represent standard deviation (SD). Groups modified with the same letter are not significantly different.

Group	Ν	Mean (Peak Load, N)	SD	F	þ
Sodium hypochlorite (15 min)	18	22.63ª	1.29	6.102	0.0001
Water	18	$20.66^{\mathrm{a,b}}$	2.17		
Polident (8 hr)	18	20.21 ^b	4.02		
Dry (control)	18	19.73 ^b	1.36		
Efferdent (15 min)	18	19.71 ^b	2.97		
Sodium hypochlorite (8 hr)	18	18.89 ^b	1.42		
Polident (5 min)	18	18.64^{b}	1.08		

Table 3. ANOVA Table

*Groups modified with the same letter are not significantly different.

home care instructions should be provided and emphasized to the patient at the denture placement appointment to maintain a healthy oral mucosa.^{23,33,34} In this study, yellow nylon Hader clips were soaked in various denture cleansing solutions and a one pull test was performed on a universal testing machine. Only one pull was performed, because it has been shown that a significant loss of retention occurs after the first removal of the clip from the cast metal Hader bar.¹³ Further, each additional time the clip was removed from the bar, an additional decrease in retention occurred.¹³ By using a one pull test, this variable was eliminated, enabling us to test changes in retentive value caused only by denture cleansing solutions. A crosshead speed of 2 in/min was used, because it was the speed by which patients remove the implant overdenture from the Hader bar.³⁰ Results showed that load-to-dislodgement increased over time for each group tested and peaked at the point in time that the Hader clip was completely removed from the Hader bar (Fig 2). Results also showed that denture cleansers affect the retentive values of yellow Hader clips, specifically those soaked in diluted NaOCl solution. Surprisingly, these effects were manifested as an increase in the retentive values rather than a reduction. This increase in retentive value may be desirable at first, but the effect on the durability of the clip is still uncertain. The rigidity of the Hader clips may have increased due to NaOCl, thus increasing their retentive value.

Polyamide (nylon) is used to fabricate Hader clips utilized for implant overdentures. The exact chemical composition is not known because the manufacturing company would not disclose this information due to proprietary rights. Polyamides' attribute of low moisture absorbency may explain why the increased duration of soaking per day did not affect its peak load-to-dislodgement.³⁰ In a study by Cornelius, it was shown that NaOCl affects nylon, and changes in surface morphology of the material, such as porosity and cracking, were detected at the SEM level.³¹ Our data demonstrated that the retentive values were higher in clips soaked in NaOCl for 15 minutes, indicating increased rigidity. The possible nature of its rigidity may negatively influence its durability. Further research is needed to evaluate the effect of denture cleansers on clips after multiple pulls. Soaking the clips in NaOCl for 8 hours did not cause a similar increase in the retentive values like that caused by NaOCl for 15 minutes. On the contrary, clips soaked in NaOcl for 8 hours exhibited the lowest peak load-to-dislodgement. This may be because soaking for longer periods resulted in structural changes affecting the integrity of the clips.

The current study has several limitations. It was performed in vitro and may differ from results obtained if performed in vivo. Clinically, the patient may remove the denture containing the Hader clip from the oral cavity several times a day prior to placing the denture with the Hader clip into a cleansing solution. To reduce the variability between clips, the yellow Hader clips used were from the same batch, and were randomly assigned into groups. This study only tested the clip with one pull. Multiple pulls may have produced different results, simulating clinical use of the overdenture in between the soaking periods of the patient's home care. Breeding¹¹ showed there is a decrease in retentive value of Hader clips after each pull until the twelfth pull, in which the retentive value plateaus. In addition, the clips were continuously soaked in each solution for the amount of time equivalent to 6 months without any time spent outside of the solution. In reality, dentures are kept in a solution for some time and then taken out

for several hours. Within those hours, the denture may or may not be used under function in the oral cavity. Clips were not tested under function, and thermocycling was not performed in this study in order to eliminate other factors that would influence the results of this study. Thereby, this study only evaluated the effect of denture cleansers on the retentive value of Hader clips. Although Hader clips were only tested for a maximum simulated time of 6 months, their retentive value may only be affected after exposure to the denture cleansing solution for 12 months or more of soaking as well as use.

Conclusion

The results of this in vitro study indicate that the retention of yellow Hader clips used in implant overdentures is unaffected when soaked in commercial effervescent denture cleansers (Polident 5 Minute, Polident Overnight, and Efferdent) for a simulated 6 months' exposure time. In this study, soaking Hader clips in NaOCl solution for a simulated time of 45 hours statistically increased single-pull retention of clips tested. Clinicians may want to avoid use of these materials for cleaning dentures. These results should be interpreted clinically with caution, realizing that different results may be obtained when fatigue stress during function (in vivo) is combined with the chemical action of denture cleansers.

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