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The Effect of Different Water Temperatures on Retention Loss and Material Degradation of Locator Attachments

Lillian Pui Yuk Chiu, BDS, MClinDent, Nicola Di Vitale, DipDent, Haralampos Petridis, DDS, MSc, PhD, & Ailbhe McDonald, MSc, FDS RCS, PhD

Prosthodontics Unit, Department of Restorative Dentistry, UCL, Eastman Dental Institute, London, UK

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Correspondence
Miss Lillian P. Y. Chiu, Prosthodontics Unit, Department of Restorative Dentistry, UCL, Eastman Dental Institute, 256 Gray's Inn Road, London, UK WC1×8LD.
E-mail: lillianpychiu@gmail.com

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Abstract

Purpose: To examine the changes in Locator attachments after exposure to different water temperatures and cyclic loading.
Materials and Methods: Four groups of pink Locator attachments (3.0 lb. light retention replacement patrix attachments; 10 per group) were soaked for the equivalent of 5 years of use in distilled water at the following temperatures: 20°C, 37°C, 60°C. One group was kept dry to test the effect of water. A universal testing machine was used to measure the retention force of each treated attachment during 5500 insertion and removal cycles, simulating approximately 5 years of use. The results were compared using Kruskal-Wallis one-way ANOVA by ranks. Surface changes of tested attachments were examined using scanning electron microscopy (SEM).
Results: The exposure to 60°C water significantly increased the percentage of retention loss in Locator attachments ($p < 0.05$) compared to the 20°C water group and significantly reduced the final retention force compared to the other groups ($p < 0.05$). SEM examinations revealed severe cracking and material degradation in Locator attachments after exposure to 60°C water and cyclic loading, which were not evident in other groups. Cracking was observed after exposure to 60˚C water before cyclic loading.
Conclusions: Exposure to 60°C water, potentially similar to denture cleansing procedures, could cause cracking in Locator attachments. Cracking is associated with hydrolytic degradation of nylon at 60°C. The change in structure could result in a significant loss of retention.

According to the 2009 UK Adult Dental Health Survey,[1] 6% of the national population were affected by complete edentulism.[1] The majority of edentulous patients were elderly people who required rehabilitative dental treatment. As our population ages, there will be an increasing proportion of people in the older age group, the group most likely to need dentures.[2]

Implant-retained and mucosal-supported removable complete overdentures have been indicated as the first choice of treatment for patients with persisting complaints concerning lack of retention and stability of their mandibular conventional removable complete dentures.[3] In 2009, another consensus statement[4] was released as a support and follow-up to the McGill consensus. Implant-supported mandibular overdentures are associated with significantly higher general satisfaction,[5] oral and general health-related quality of life,[5] and significantly improved masticatory performance compared to conventional dentures[6] regardless of the type of implant and attachment system.[7] Patients who received implant-supported overdentures reported major improvement in their ability to chew, and less social restriction compared to those who received conventional complete dentures.[8] Two-implant-supported mandibular overdentures offer a less complex and expensive option for patients,[9] but with the same masticatory efficacy as fixed prostheses.[6] The total costs of implant overdenture treatment were found to be 1.6 times higher than conventional dentures, taking into account maintenance cost of relining the prosthesis, prosthesis replacement, and check-ups.[10] Indirect costs included patients' time and out of pocket expenses.[10]

Although high cumulative survival and success rates of implants supporting overdentures have been reported,[11] the prosthesis survival or success rates have ranged widely between studies and prosthetic types, as reported in a recent review.[12] This systematic review also demonstrated that prosthodontic complications involving the implant attachment system were the most common technical problem, irrespective of the system used, but could not conclude which required the least maintenance. Overdenture attachment systems can be classified into bar, ball, magnet attachments, and rigid or non-rigid telescopic copings.[13] Various studies[13-19] have tried to compare the maintenance requirements of various implant attachment systems; however, controversies remain due to the variability of study design. There is a lack of long-term follow-up studies providing information on maintenance needs and costs associated with various, more recently introduced implant overdenture attachment systems, which are designed to allow for easy replacement when they are worn.[12] One of these is the Locator attachment system (Zest Anchors, Inc., Escondido, CA), which was reported as an increasingly popular stud type of implant overdenture attachment system among 86% of the prosthodontists in a recent published survey.[20] The reasons for its popularity may be related to the potential versatility, ease of insertion and replacement, and low vertical profile.[20,21] According to the manufacturer, this attachment system is self-aligning, dual-retentive, and tolerant of slight degrees of inter-implant divergence.[22,23] It comprises a titanium-nitride coated titanium abutment (matrix) that connects to the implant, and a replaceable color-coded nylon insert (patrix) housed inside the titanium Denture Cap within the overdenture.

Implant overdentures require meticulous denture and oral hygiene maintenance by patients, to avoid biofilm accumulation and subsequent biologic complications.[24] Regardless of the attachment system employed, homecare hygiene maintenance for implant overdentures, as recommended by the manufacturer, is similar to that of conventional removable dentures, mainly the combination of mechanical brushing with an effective non-abrasive denture cleanser, and the use of chemical denture cleansers on a daily basis, to reduce the levels of adherent denture biofilms and potentially harmful bacteria and fungi.[25]

Nguyen et al[26] and You et al[27] studied the effects of chemicals found in different commercially available denture cleansing solutions on the retention of pink Locator attachments. Their studies showed that denture cleansing solutions, specifically diluted sodium hypochlorite, significantly reduced the retention values of Locator attachments, but the results did not show any detrimental effects on those attachments soaked in alkaline peroxide type denture cleansers for 1440 hours using tap water at room temperature. Temperature may be an important factor for Locator wear behavior because of the low glass transition temperature and strong affinity for water of the nylon used in the replaceable patrix attachment.[28] A questionnaire survey[29] revealed some denture wearers were using the alkaline peroxide type denture cleansers with very hot water at high temperatures in the range of 90 to 100°C in denture cleansing procedures daily.

Most proprietary denture cleansing products available on the market are the alkaline peroxide type cleansers. They exist in tablet forms, which dissolve in warm or hot water to give an effervescent reaction to enhance cleansing effects. The recommended immersion time is either a short-term soak of 30-minute duration or a long-term soak on a daily basis. The chance of using tap water up to 60°C, through domestic water heating, is high, as this is the hot water temperature recommended by the World Health Organization at which most bacteria can be killed.[30] However, the effect of exposure to elevated water temperature in the range of 60°C on the retention and material properties of Locator attachments has not been reported previously.

Table 1 Experimental design and conditions of immersion

Groups	Immersion medium	Temp. (°C)	Immersion time: 5 years equivalent	Simulated denture immersion
1	Distilled water	20	38 days	30 minutes/day
2	Distilled water	37	38 days	30 minutes/day
3	Distilled water	60	38 days	30 minutes/day
4	Distilled water	60	19 days	15 minutes/day
5	Dry air	20	38 days	No immersion

One of the Locator attachment complications commonly reported is the activation and replacement of the plastic components as a result of wear.[14] Kleis et al[31] noticed damage in the patrix parts of the Locator attachments, which led to a 75.5% loss of retention of the prostheses 1 year post-insertion. After 1 year, Locator nylon inserts showed extensive deformation and deterioration, with a substantially higher need for replacement due to loss of retention and damage, compared to ball attachments.[28,31] The performance of the Locator nylon matrices was related to the creep response, while that of the metal patrices was related to hardness.[28,31]

A recent in vitro study[32] compared the change in retention of the resilient ball attachments and pink Locator attachments after 5000 insertion-removal cycles, and they did not find significant differences. The tests were carried out using dry specimens under dry conditions at room temperature. Although not significant, the SEM images of the Locator nylon matrices showed relatively more changes in diameter measurements, compared to the ball attachments; however, retention loss for the Locator attachments after 5500 insertion-removal cycles was less.[32] Two in vitro studies[32,33] reported that the retention loss during insertion-removal cycles and visual dimensional changes using SEM images were not directly correlated.

The aim of this in vitro investigation, therefore, was to examine the changes in retention values and material quality of Locator attachments, after exposure to water at 20°C, 37°C, and 60°C, and cyclic loading for a simulation period equivalent to 5 years of clinical use. The null hypothesis was that the mean retention values provided by pink Locator attachments before, during, and after simulated use would not be influenced by either the varying water temperature or the duration of storage.

Materials and methods

As pink Locator patrix attachments (3.0 lb. Light Retention replacement patrix attachments; Zest Anchors) are the most widely used in practice,[26] they were used as test specimens for this study. A pilot study familiarized the authors with the experimental procedure and was used to calculate sample size. The results of the pilot test showed that 10 specimens/group would be needed for a 2-tailed test, with a significance level ($\alpha = 0.05$) and power equal to 0.8.

A total of 50 pink Locator attachments were equally and randomly divided into five groups (Table 1). Four groups were immersed in distilled water of varying temperatures (20°C, 37°C, 60°C) for the equivalent of 5 years of clinical use. The time

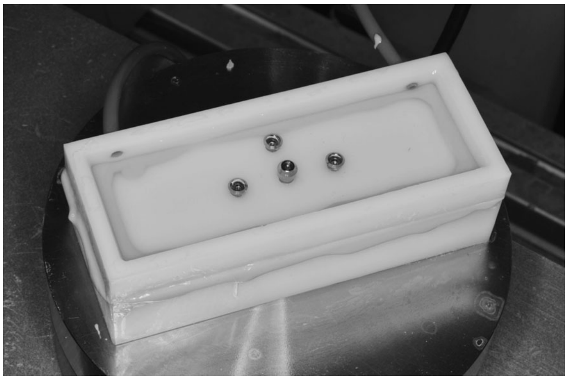

Figure 1 The artificial saliva bath unit controlled at 37 ± 2°C was set up for 5500 insertion-removal cycles.

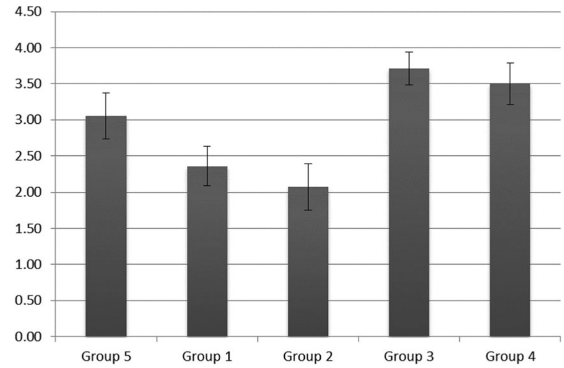

Figure 2 Comparison of 95% confidence intervals of mean rate of retention force loss over the log cycles calculated from linear regression of the 5 groups. The fatigue behavior of groups 3 and 4 are significantly different from that of groups 1 and 2.

Table 2 Comparison of mean initial and final retention, and percentage of retention loss between groups. Groups with the same lowercase letters were not significantly different

Groups	Initial retention (mean ± SD, N)	Final retention (N) (mean ± SD, N)	Loss in retention (mean ± SD, %)
1	21.95 ± 5.82	8.98 ± 1.07a	59.09 ± 10.36a
2	25.29 ± 4.53	8.76 ± 0.76a	65.36 ± 8.53a
3	19.53 ± 5.17	4.29 ± 1.54b	78.03 ± 15.64b
4	21.34 ± 3.55	7.60 ± 0.82a	64.39 ± 6.14a
5	22.94 ± 2.09	8.75 ± 0.62a	61.86 ± 4.02a

simulated was based on 30 minute/day soaking duration in alkaline peroxide type denture cleansing solutions, as recommended by their manufacturers. To study whether the effects of 60°C water were time dependent, the immersion time was reduced by half in group 4. To study the effects of water, group 5 was not exposed to distilled water and acted as a control group. Before the immersion procedure, all specimens were placed in an airtight container with desiccating silica gel and weighed until there were no weight changes for 3 days. They were subsequently placed in a small, perforated plastic bag and immersed in a glass container containing 100 ml of distilled water. Each container was placed inside separate temperature-controlled incubators at the pre-set temperatures. The immersion was continuous to minimize the effects of environmental factors on specimens. Following the immersion, the specimens were stored in dry polyethylene bags.

They were subsequently tested for retention values using a testing apparatus design adopted from a previous study.[23] The testing assembly consisted of two custom-made acrylic resin blocks. The lower block contained four implant analogs (4.1 mm diameter x 10 mm in length, Straumann, Stevenage, Hertfordshire, UK) secured using epoxy resin. It was connected to the horizontal base of the hydraulic universal testing machine (Dartec HC10; Dartec Limited, Stourbridge, West Midlands, UK). Only the central implant analog was used in this study. A Locator abutment of 4 mm in diameter and 2 mm in height (Zest Anchors) was connected to the implant analog at the centre of the lower platform and hand tightened. It was manually tightened to the implant analog with 35 Ncm using a Locator driver and torque ratchet. The upper block of the jig assembly housed the denture caps of the Locator attachment system and the nylon insert to be tested, which could allow replacement after each test. The metal housing (4 mm in depth) was indexed to the implant analog with a "direct" pick-up technique using autopolymerizing poly-methylmethacrylate (Oracryl; Bracon Limited, Etchingham, UK) to ensure proper alignment. The upper block was attached to the universal testing machine using a brass mount and plate connected to the load cell via a threaded steel shaft via a brass plate and locking pins. The top of the implant analogs and of the Locator attachments were positioned in a thermostatically controlled bath of artificial saliva at 37 ± 2°C (Fig 1). The temperature was measured and consistently achieved throughout the tests.

All specimens were subjected to 5500 cycles of seating and unseating equivalent to approximately 5 years of use, based on a minimum of three daily placements and removals of the implant overdenture. The retentive forces were measured 35 times during regular intervals from cycle 1 to cycle 5500. Before each test, the upper block, which housed the nylon insert, was lowered to ensure accurate alignment to the Locator abutment on the lower block by visual assessment, and was subsequently secured in position on the testing machine. Each Locator nylon attachment was inserted onto the metal housing and then removed after each test using a Locator Core Tool. The force experienced by the load cell of the testing machine was recorded during each loading and unloading cycle. Each pink Locator nylon insert was subjected to the same number of cyclic loadings, controlled by the computer software, which was programmed to produce 5500 crosshead movements, with a sine waveform pattern, 1.4 mm vertical range, and 4 Hz frequency.

The data from the experiment were imported into a spreadsheet for analysis. The data were imported into appropriate statistical software (SPSS 20; IBM, Armonk, NY). Box-and-whisker plots were constructed to visually represent the data in terms of the mean, median, upper quartile, lower quartile, and range. A plot of mean retention over 5500 cycles was produced for all groups.

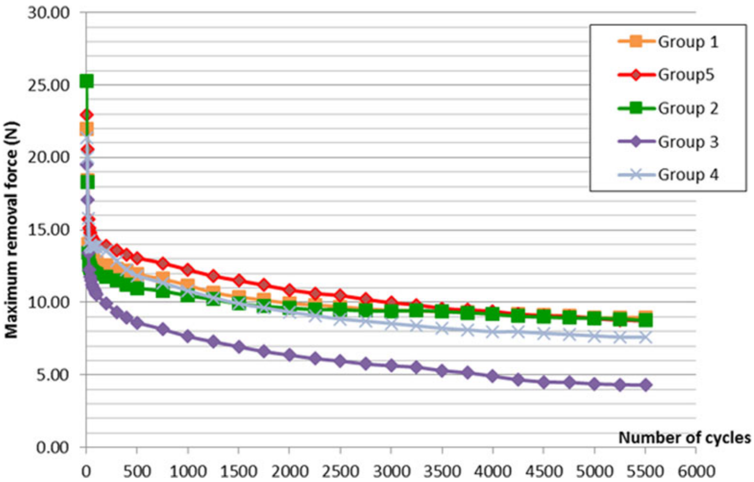

Figure 3 Change of retention force over 5500 of insertion-removal cycles for each group.

Normality of distribution and equality of variance between groups was tested using the Shapiro-Wilk test and Levene's test. If the assumptions were met, one-way ANOVA was used, and then Bonferroni's post hoc test was used to detect which groups exhibited significant difference. If assumptions were not met, Kruskal-Wallis one-way ANOVA by ranks was used.

Surface characteristics of the Locator nylon inserts from groups 1 to 5 were examined using SEM (FEI XL30 FEG SEM; FEI, Eindhoven, Netherlands) after being carefully retrieved from the metal housing in the acrylic resin block. Two specimens that underwent immersion procedure and 5500 insertion-removal cycles were randomly selected from each group for SEM imaging. Five specimens randomly selected from groups 3 and 4 without undergoing 5500 insertion-removal cycles were examined using SEM. All of the specimens were sputter coated with a layer of gold (95%). The SEM images captured were evaluated at 35–100x, 200x, and 500x magnifications.

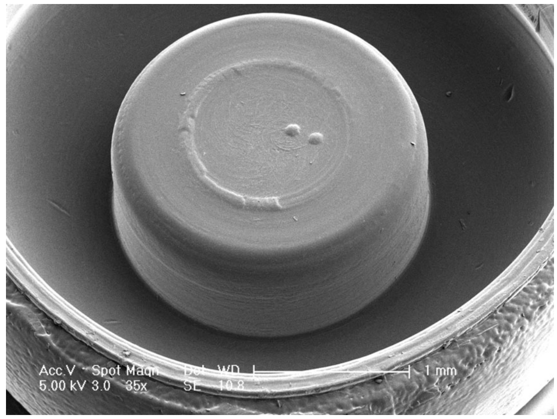

Figure 4 SEM image (35x) of a dry pink Locator attachment without water immersion shows a smooth, finely grained inner surface.

Results

The mean initial, final, and percentage change in retention of those Locator attachments exposed to water at 20°C or human body temperatures (37°C) were not significantly different from the dry specimens and from each other. There were no significant difference in the mean initial, final, and percentage change in retention between groups 1, 2, 4, and 5 (Table 2).

The Shapiro-Wilk and Levene's tests did not confirm normality of distribution and did not confirm homogeneity of variance between the groups. Therefore, Kruskal-Wallis one-way ANOVA by ranks was used and showed significant difference in final retention after 5500 cycles between the 60°C water (4.29 ± 1.54 N) and the 20°C water (8.98 ± 1.07 N) groups ($p < 0.001$), between the 60°C water and the 37°C water (8.76 ± 0.76 N) groups ($p < 0.001$), and between the 60°C water and the dry specimen (8.75 ± 0.62 N) groups ($p < 0.001$) (Table 2). Therefore, the null hypothesis that there would be no difference in final retention between groups was rejected.

Kruskal-Wallis one-way ANOVA by ranks was used and showed significant difference in the percentage of retention loss after 5500 cycles between the 60°C water (78.03 ± 15.64%) and the 20°C water (59.09 ± 10.36%) groups ($p = 0.006$), and between the 60°C water and the dry specimens (61.86 ± 4.02%) groups ($p = 0.025$) (Table 2). Therefore, the null hypothesis that there would be no difference in percentage of change of retention between groups was rejected.

Comparison of 95% confidence intervals of mean rate of retention loss from linear regression of the five groups showed that specimens of both groups 3 and 4 had significantly higher rate of retention loss than groups 1 and 2. There was no significant difference in the mean gradient between groups 3 and 4, but significant difference existed between group 5 and groups 1, 2, and 3 (Fig 2). A plot of mean retention over 5500 cycles for all groups is presented in Figure 3, which shows a significant loss of retention in group 3; however, the pattern of change in retention of other groups is similar.

Visual surface inspection under SEM of selected specimens exposed to 20°C and 37°C water after 5500 insertion-removal cycles showed a similar slight degree of surface condition when compared to dry specimens (Figs 4 and 5), as surface irregularities, scratch lines perpendicular to the path of insertion/removal, and localized deformation were present on the central core of the specimens of groups 1 (Fig 6) and 2 (Fig 7); however, those specimens subjected to 60°C water before or after wear simula-

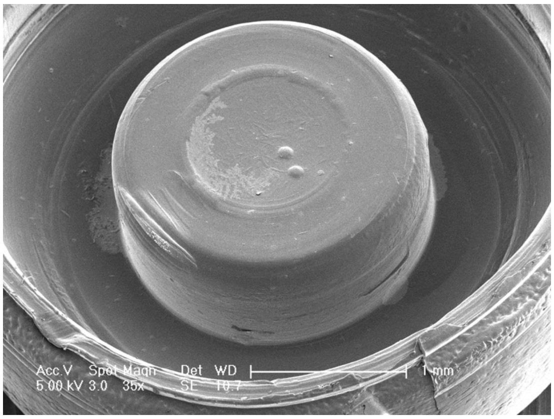

Figure 5 SEM image (35x) of group 5 attachments after 5500 insertion-removal cycles showed minor surface irregularities, scratch lines along the path of insertion/removal, and localized deformation at the central core.

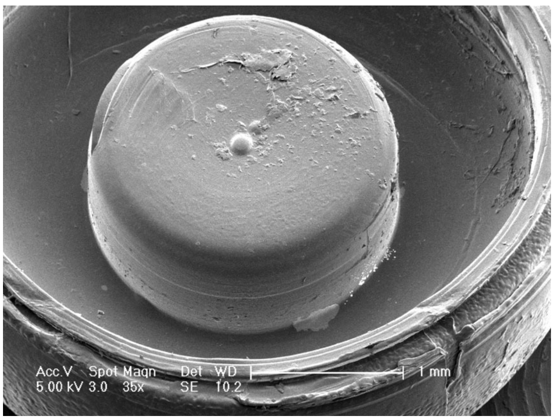

Figure 6 SEM image (35x) of group 1 attachments after 5500 insertion-removal cycles, showed surface irregularities, scratch lines along the path of insertion/removal and localized deformation at the central core.

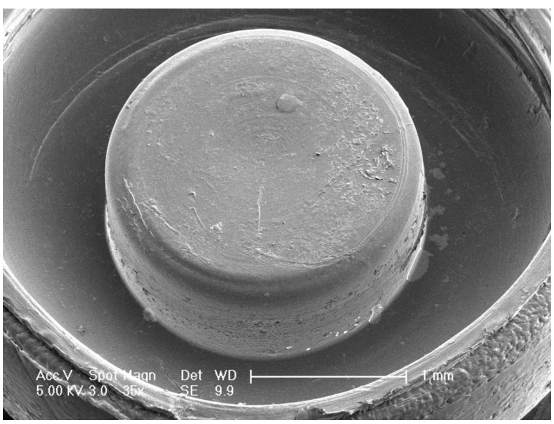

Figure 7 SEM image (35x) of group 2 attachments after 5500 insertion-removal cycles showed surface irregularities, scratch lines, and deformation at the central core.

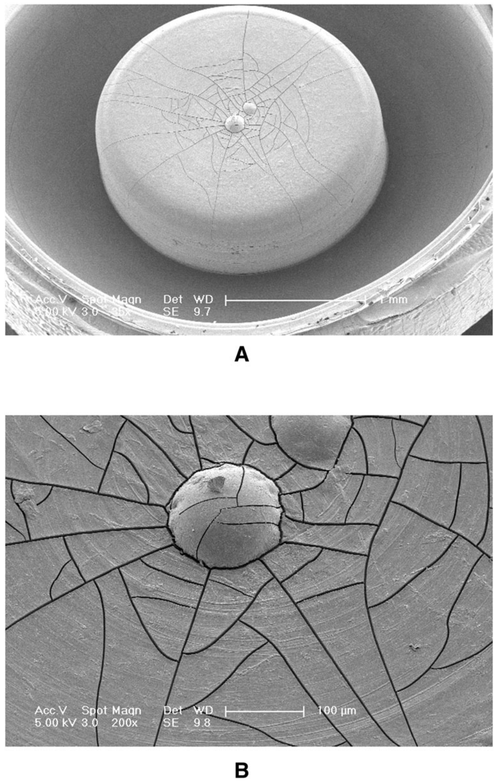

Figure 8 SEM images (35x & 200x) of group 3 attachments (A, B) before 5500 insertion-removal cycles showed extensive areas of cracking and crazing randomly propagated in the central core and outer wall before wear simulation.

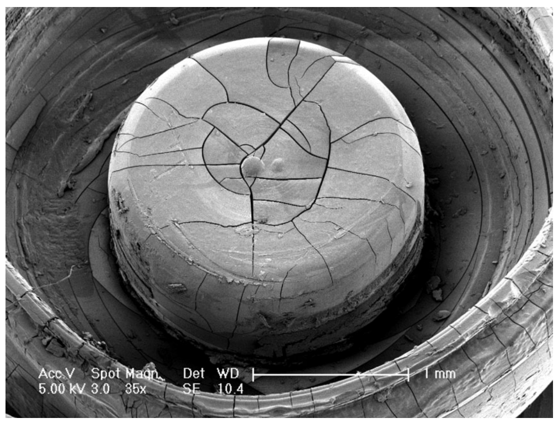

Figure 9 SEM image (35x) of group 3 attachment after 5500 insertion-removal cycles. Group 3 attachments had the most severe cracking, plastic deformation, surface deterioration, micro-voids, and particle loss throughout the pink Locator attachment after 5500 insertion-removal cycles.

tions exhibited marked changes in surface characteristics with extensive area of cracking and crazing randomly propagated throughout the central core and outer wall of the attachments (Figs 8–10).

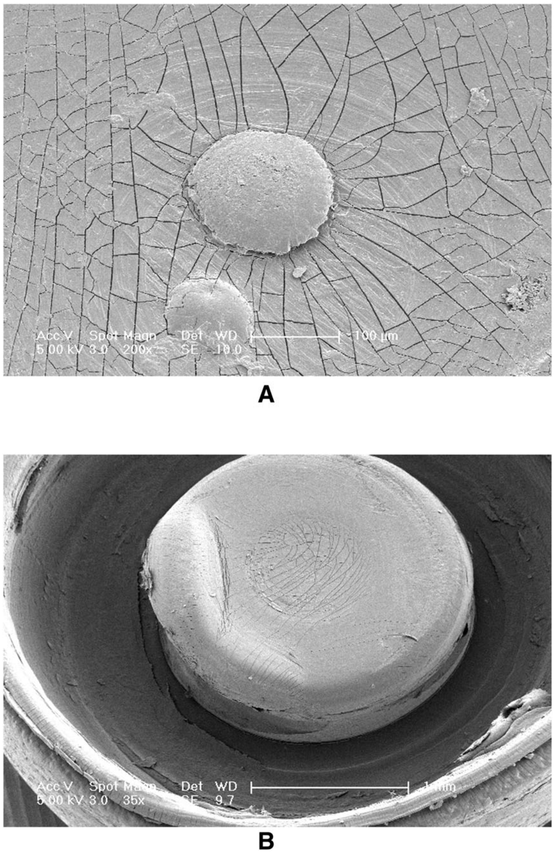

Figure 10 A and B: SEM images (200x & 35x, respectively) of group 4 attachments at a higher magnification showed cracking and crazing, which were randomly propagated in the central core and outer wall before 5500 insertion-removal cycles. Severe deformation and material deterioration were shown after 5500 insertion-removal cycles.

It was clear that cracking initiated during the immersion procedure before cyclic loading in 60°C water. Brittle fracture features were detected at 35x magnification, throughout the internal and external surfaces of the Locator attachments of group 3 (Fig 8A). Cracking initiation was found along the outer wall and on the central portion of the inner core, extending circumferentially around the wall (Fig 8).

After 5500 insertion-removal cycles, group 3 specimens exhibited extensive areas of cracking, deformation, severe surface deterioration, micro-voids, and particle loss on surfaces of the central cores and outer walls (Fig 9). The nylon inserts were difficult to remove from the metal housing due to a loss of stiffness. The reduction in the length of time of exposure to water at 60°C did not appear to reduce the cracking effects on the attachments, as similar features were observed for both groups 3 and 4 (Fig 10).

Discussion

This in vitro study investigated the effects of various water temperatures used during cleansing on the retention and material degradation of Locator attachments. The results of this study rejected the null hypothesis, as temperature seemed to significantly and detrimentally affect the final retention and the percentage of retention loss of pink Locator attachments. The results also showed that exposure to water at room temperature did not have any significant effect on retention values. This is in agreement with the results of a similar previous study[27] where the effects of the use of denture cleansers, at room temperature, and repeated pulls on the retention of pink Locator attachments were studied.

The experimental design of the testing apparatus and insertion-removal cycles was similar to previously published work,[33,34] and similar mean retention values were obtained for dry pink Locator attachments. The overall pattern of change in retention was also similar to one in vitro study.[34] The 4 Hz frequency used in this study was higher than what was previously reported and could have constituted another factor affecting the results, as the glass transition temperature (Tg) is frequency-sensitive.[35] However, the similarity of values compared to other studies[33,34] that used a different frequency demonstrated that the effects were probably minor.

The material characteristics, such as surface irregularities, scratch lines, and localized deformation, of selected specimens without immersion in water (group 5) after the simulated insertion-removal cycles observed in this study agree with SEM images published in three in vitro studies[32,33,36] where the attachments were tested in dry conditions. They are very different from SEM images published by Alsabeeha et al[28] after 1 year of use by patients. The prospective study[28] found plastic deformation, material deterioration, surface rupture, material loss on the central portion and the outer margins of the nylon matrices similar to material characteristics displayed by group 3 and group 4 attachments, after exposure to 60°C water and simulated insertion-removal cycles. Detachment of the nylon matrices from the metal housings with plaque and debris accumulation underneath the deformed areas were also reported.[28] However, the resolution and magnifications of the SEM micrographs published by Alsabeeha et al[28] were not high enough to detect the presence of brittle fracture features such as cracking. Increased creep response after water absorption and low Tg of nylon in the intraoral environment both caused extensive deformation and deterioration observed in Locator nylon attachments. This required high maintenance after 1 year.[28] Limited data are available to compare regarding the effect of water and temperature on the surface properties and retention values of Locator attachments; therefore direct comparison of the findings is not possible.

Possible explanations for the behavior of the Locator attachments in this study may be attributed to their material science. Locator attachments are made of nylon (Dupont Zytel 101L NC-10 Nylon; Zest Anchors Inc). According to the nylon manufacturer, this is an unreinforced polyamide 66 resin for injection molding.[37] The two most influential factors on unreinforced polyamide 66 properties and performance are moisture and temperature.[37,38] This type of nylon absorbs moisture from the atmosphere.[37] Low moisture adsorption lowers its strength and stiffness but increases its toughness and elongation.[37] This phenomenon may provide an explanation regarding the reduction in retention values of Locator attachments after exposure to water at 20°C and 37°C compared to the dry situation. As unreinforced polyamide 66 has great affinity for water molecules, this process allows water molecules to diffuse into the polyamide chains, forcing them apart and weakening the attraction between the chains.[37] The effects of water include increase in dimension, weight, flexibility, creep and stress relaxation, reduction in flexural strength, tensile strength, and stiffness; however, the impact toughness tends to increase slightly.[37]

The premature failure of unreinforced polyamide 66 is related to its ability to absorb moisture, which lowers the glass transition temperature (Tg).[37,38] The Tg is an approximate upper limit of its useful temperature range.[37,38] The plastic is hard and glassy below this temperature, and becomes rubbery above its Tg.[37,38] It is also a measure of the onset of molecular movement within the plastic.[37,38] The published Tg of unreinforced polyamide 66 is in the range of 45 to 78°C when it is dry.[39,40] However, as Locator attachments are used in intraoral environments (100% relative humidity, RH), they become saturated with water, and their Tg will gradually level down. They will gradually lose most of their stiffness, dimensional stability, and mechanical properties. This process is accelerated by increasing conditioning temperatures and/or RH.[37] It is also influenced by the thickness of the material.[37] Locator attachments consist of areas of a mean diameter of 2 mm in the core and wall thickness of 0.75 mm.[33] Therefore, the outer wall reaches full saturation faster than the thicker inner core.

Moisture could lead to physical corrosion and microcracking as well as chemical degradation of the unreinforced polyamide 66.[38] Martin and Gardner[41] mentioned that the unreinforced polyamide 66 is not suitable for 18-month exposure to 100% RH at temperatures of 66°C or above, because of susceptibility to hydrolysis.[41] The rate of hydrolysis increased, while the tensile strength decreased by 80%, and all of the tensile modulus diminished after 2 months in humidity at 66°C.[41]

In this study, the detrimental effects of water at a temperature of 60°C on Locator nylon attachments are shown through SEM images and significantly lower retentive values. The cracking indicates a ductile-brittle transition, called embrittlement, induced by hydrolytic degradation at elevated temperatures in the presence of oxygen.[42] Hydrolytic degradation occurs over the range of 25 to 90°C with significant effects detected at 60°C, published by Gonçalves et al.[43] This may explain why degradation did not occur in groups 1 and 2 in this study; however, the rate of moisture-sorption may also be slower at a lower conditioning temperature. Although the effect on final retention after 19 days in the 60°C water was insignificant after 5500 cycles, the effects of material deterioration would be manifested in the longer term, as hydrolytic degradation is a function of time and temperature.[43]

There were limitations to this study. The Locator attachments were immersed continuously for a simulated period of 5 years to study the effects of different temperature on retention. The 5500 insertion-removal cycles were performed after immersion procedures. This could be different from clinical situations, where periods of immersion are interrupted by periods of use, as patients wear the denture during the day and immerse them during the night.

Clinical performance of Locator attachments may be affected by masticatory loading,[36] parafunctional habits,[33,36] number of denture insertions and removals, presence of saliva,[44,45] use of denture cleansing agents,[26,27] and presence of food particles,[46] which could accentuate wear effects. Wear may be influenced by inter-implant angulations[22,23] and different rates of denture displacement,[27] which would be difficult to simulate in an in vitro study. Therefore, the results of this study may underestimate the true effects.

A few clinical studies[19,28,31] have reported that Locator attachments demanded higher maintenance after the first year due to loss of retention and damage; hence an annual follow-up[31] may be necessary for the Locator attachment system. Instructions should be given to patients when carrying out denture cleansing or immersion procedures for hygiene maintenance of implant overdentures with Locator attachments to avoid using hot water. Further research on the long-term effects of humid aging at lower temperatures is required.

Conclusions

It was the conclusion of the evaluation that within the limitations of this study, cracking of Locator nylon attachments was associated with hydrolytic degradation of nylon at 60°C. Degradation of the nylon used in Locator attachments would lead to a significant loss of retention during repeated insertion-removal of the implant overdenture. Hence, precautions should be taken by patients to avoid using hot water at temperatures near 60°C during denture cleansing or immersion procedures to extend the life of Locator attachments.

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