Preliminary In Vitro Study on O-Ring Wear in Mini-Implant–Retained Overdentures

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This preliminary in vitro study evaluated the simulated retention force of O-rings used for mini-implant overdenture treatment and the effect of mechanical fatigue corresponding to 6 months of wear. A mandibular overdenture analog device was attached to two mini-implants and underwent a tensile strength test before and after the application of insertion-removal and simulated masticatory cycles. Insertion-removal cycles led to a retention loss of 24%, whereas masticatory cycles did not influence retention. Micro-CT scans showed minor deformation following mechanical cycling, but the changes were milder than those observed in similar clinical specimens. Both experimental loading methods led to physical changes in the O-rings, which explains in part the similar clinically observed wear. *Int J Prosthodont 2016;29:357–359. doi: 10.11607/ijp.4677*

O-ring retention is popularly employed for mini-implant-supported overdentures,[1] which have been effectively used for immediate loading protocols. They are less costly than standard implants[2] and are often placed in thin mandibular ridges via a single-stage, flapless surgical technique.[3] However, O-rings demand periodic replacement due to retention loss, which varies considerably among different manufacturers.[4]

This preliminary in vitro study evaluated the retention force of an attachment system for mini-implants after insertion-removal and simulated masticatory cycles corresponding to a 6-month wearing period. Wear pattern was also evaluated using microscopic computed tomography (micro-CT) and compared with specimens obtained from participants in a clinical trial of mini-implant overdentures.

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Materials and Methods

This study evaluated a ball/O-ring attachment system used for mini-implant overdentures as reported in the literature.[3] The retentive strength of 15 pairs of silicone O-rings was tested before and after insertion-removal cycles (n = 10) and mastication simulation (n = 5). Afterward, O-rings underwent micro-CT scans to identify patterns of topographic changes.

A mandibular wax cast was made, and two 2.0 × 10-mm mini-implants (MDL, Intra-Lock International) were inserted with 20 mm between them. This cast was invested in a dental flask, with subsequent wax elimination and pouring of heat-polymerized acrylic resin. Thereafter, a device simulating a mandibular overdenture with two O-ring capsules (4-mm diameter) was fabricated on the cast.

After the capsules and O-rings were inserted, a tensile strength test was performed to check the force needed to separate the device and cast at baseline (T_0). The device-cast set was mounted in a testing machine with a 1-kN load cell (EMIC) and submitted to a 15 mm/minute dislodgment until complete separation was achieved between O-rings and mini-implants. The same test was repeated following fatigue cycles corresponding to a week (T_1), 3 months (T_2), and 6 months (T_3) of use. The insertion-removal cycles were tested at T_1 (21 cycles), T_2 (270 cycles) and T_3 (540 cycles), with an interval of 10 seconds before each re-insertion to allow elastic recovery of the O-rings.[5]

Masticatory cycles were performed by a cycling device (ER 37000, Erios) using a 6.8-kgf compressive force on the first molars bilaterally.[5] This latter assay

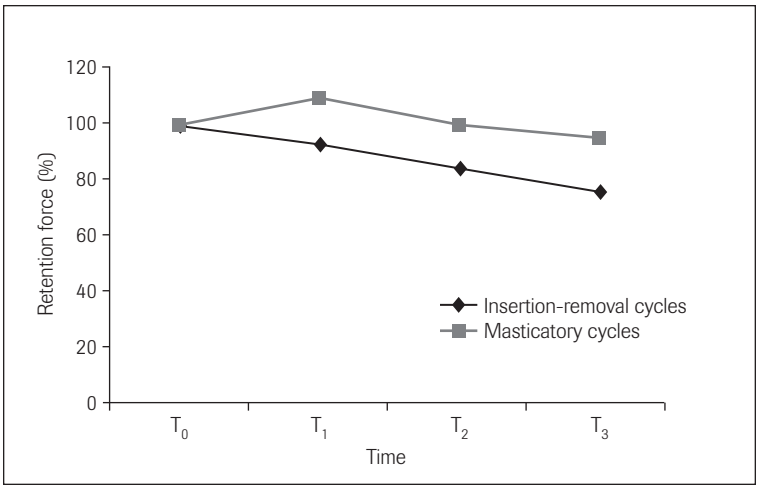

Fig 1 Percentage of the tensile strength retained after insertion-removal and masticatory cycles. T_0 = baseline; T_1 = after 1 week of use; T_2 = after 3 months of use; T_3 = after 6 months of use.

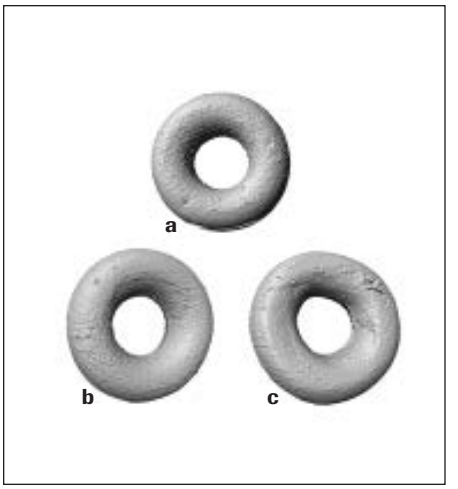

Fig 2 Reconstructed micro-CT images for silicone O-rings **(a)** before and **(b)** following insertion-removal cycles or **(c)** in vitro masticatory forces.

Table 1 Mean Tensile Strength (N) and Standard Deviations of the Tested Attachment System Following Insertion-Removal or Masticatory Cycles

	T_0	T_1	T_2	T_3
Insertion-removal cycles	5.90 ± 1.50[a]	5.52 ± 1.52[a,b]	4.96 ± 1.11[b]	4.49 ± 0.96[b]
Masticatory cycles	3.15 ± 0.39	3.45 ± 0.34	3.16 ± 0.29	3.00 ± 0.35

Distinct superscript letters represent significant differences (Bonferroni test, $P < .05$).
T_0 = baseline; T_1 = after 1 week of use; T_2 = after 3 months of use; T_3 = after 6 months of use.

considered T_1: 7,778; T_2: 100,000; and T_3: 200,000 cycles. Tensile strength values were compared using one-way analysis of variance and Bonferroni test ($\alpha = .05$).

Micro-CT images were obtained for each O-ring after cycling (SkyScan 1176; SkyScan) using 40 kV, 600 mA with 180-degree step rotation and isotropic resolution of 9 µm, without filter. Tridimensional reconstruction of specimen images was done using CTan and CTvox software (SkyScan). Scans were also obtained from O-rings used by six edentulous participants of a randomized controlled trial (Clinicaltrials.gov: NCT01411683) also treated with two mini-implants.[3] These O-rings were removed following 6 months of denture wear, following patient complaints of time-dependent reduction of the original retention.

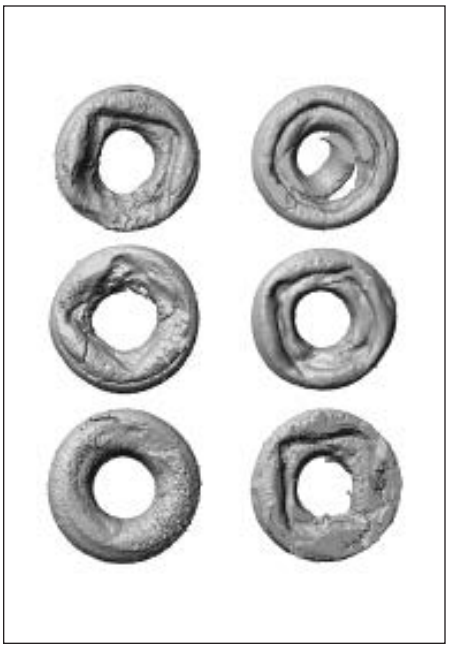

Fig 3 Reconstructed micro-CT images for O-rings from trial participants. Each image corresponds to a trial participant (n = 6).

Results

Insertion-removal cycles significantly reduced retention force over time ($P = .030$), as opposed to compressive forces ($P = .258$) (Table 1). For the insertion-removal cycling, T_0 was higher than T_2 and T_3, which were similar, whereas T_1 presented intermediate values. The relative retention loss after 3 and 6 months corresponded to a 15% and 24% decrease from the baseline values, respectively (Fig 1).

Micro-CT scans revealed a subtle degree of morphologic changes following in vitro protocols. Figure 2 provides representative images of intact and worn O-rings. Insertion-removal cycles caused no noticeable deformation, such as changes in the internal diameter, tearing, or topographic alterations (Fig 2b). Masticatory cycles visibly altered O-rings, by conferring an oval shape and marking the form of the mini-implant's squared neck (Fig 2c).

O-rings from trial participants revealed more evident changes (Fig 3). Specimens presented square-shaped marks as found after compressive cycling, but these were more pronounced.

The wear pattern was characterized by changes in the internal diameter and some roughening of surfaces contacting mini-implants. A few O-rings were torn, which probably resulted from their removal from the denture bases.

Conclusions

Within the limits of the employed in vitro design, this preliminary study suggests that the retention efficacy of the attachment system used with mini-implants may be more affected by insertion-removal cycles than by simulated mastication forces. The testing methodology may account for part of the clinically observed wear, but it may be used to investigate the efficacy of other retention systems. Several factors account for more discreet wear after cycling compared with clinical specimens, such as absence of saliva, stable temperature, and controlled application of bilateral forces.

Acknowledgments

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Literature Abstract

Cigarette Smoking, Tooth Loss, and Chronic Obstructive Pulmonary Disease (COPD): Findings From the Behavioral Risk Factor Surveillance System

Chronic obstructive pulmonary disease (COPD) is a major cause of morbidity and mortality in the United States. The aim of this study was to examine the association of cigarette smoking and tooth loss with COPD among US adults aged ≥ 18 years using population-based survey data (n = 439,637) from the 2012 Behavioral Risk Factor Surveillance System. A log-linear regression estimated prevalence ratios for the interaction of combinations of tooth loss (0, 1–5, 6–31, and all) and cigarette smoking status (never, former, and current smoker) with COPD after adjusting for age, sex, race/ethnicity, marital status, educational attainment, employment, health insurance coverage, dental care utilization, and diabetes. The proportion of persons with COPD increased with number of teeth lost and was highest among current smokers (13.0%) compared with former smokers (9.2%) and never smokers (2.8%) The likelihood of COPD was seven times higher in current smokers with all teeth removed as compared with never smokers with no teeth removed, after adjustment for sociodemographic status. Tooth loss status was found to significantly modify the association between cigarette smoking and COPD. However, this relationship is very complex. An increased understanding of the causal mechanisms that link the three factors together can assist in reducing the burden of COPD. Guidelines for tobacco cessation should be employed by healthcare providers to counsel their patients.

Cunningham TJ, Eke PI, Ford ES, Agaku IT, Wheaton AG, Croft JB. *J Periodontol* 2016;87:385–394. **References:** 50. **Reprints:** Dr Timothy J. Cunningham, Division of Population Health, National Center for Chronic Disease Prevention and Health Promotion, CDC, Atlanta, GA 30341, USA. Fax: 770/488-5965. Email: tjcunningham@cdc.gov —*Sheralyn Quek, Singapore*