# Global Dental Science
## Phase III

**Purpose:** Compare the wear of the experiment denture tooth material to the wear of conventional denture teeth in a simulated environment.

**Executive Summary:** There is no statistical difference in the wear of the two materials ($p > 0.10$) for any of the wear parameters. The total combined wear (upper + lower) measured by volume was small: 300K: 0.018 cubic mm; 600K: 0.027 cubic mm. This is equivalent to the wear found for IPN denture teeth using similar wear parameters in ART 1 (Coffey et al. J Prosthet Dent 1985 54(2):273-79).

# Method

**Materials:**

- Two different plastic materials were used: Experimental and Commercial.
- The experimental material was milled to tooth shapes using CAD/CAM.
- The commercial teeth were standard plastic denture teeth currently available.

**Test Samples:**

- Each test sample consisted of a second premolar and first molar in clinical alignment.
- Upper and lower samples were made using maxillary and mandibular teeth, respectively.
- The upper and lower teeth were aligned to produce the correct occlusion.
- Test samples were opposed by samples of the same material.

**Wear Simulation:**

- A test couple consisting of upper and lower sets of teeth were mounted in the University of Minnesota ART 1 wear simulator.
  - When mounted in the test system there was only one point of contact.
  - No occlusal adjustment was done to increase the number of contact points.

**ART 1 Chewing Parameters:**

| | |
|---|---|
| Maximum force | 30N |
| Lateral slide | 1 mm |
| Cycle rate | 4 Hz |
| Lubricant | Deionized water |
| Temperature | 37 °C |

# Method

**Scanning of Test Samples:**

Each sample except Sample 1 was digitized using a custom contact profiling system.

Accuracy: 0.010 mm at a surface angle of 55 degrees to the horizontal plane.

Precision: 0.001 mm out to a surface angle of 55 degrees to the horizontal plane.

Step Size: X: 0.100 mm; Y: 0.050 mm

Sample 1 was digitized using the Lavascan.

Samples were digitized at baseline (0 cycles) and at 300,000 and 600,000 cycles in ART 1.

**Analysis:**

Wear was analyzed using Cumulus Alpha Build V 0.8 20121023.

Wear was characterized using volume loss, maximum depth, and mean depth.

Total wear was calculated by combining the upper and lower values.

The two materials were statistically compared using EXCEL t-test.

**Accuracy of Measurements** (calculated from test measurements):

Volume: 0.002 ± 0.001 cubic mm – calculated as the average of the projected wear area times the absolute mean distance for all samples.

Maximum Depth and Mean Depth: 0.005 ± 0.001 mm – calculated as the average absolute mean distance for all samples.

# Wear Data

Two of the denture teeth samples (3 and 5) had multiple wear facets. In these cases, the volume of the wear facets were summed to get the total volume removed, the maximum depth is the maximum depth for all the samples, and the mean depth is the weighted average of the mean areas. Volume was used as the weighting factor. Volume is in cubic millimeters, the depths are in millimeters, and the areas are in square millimeters. Area is the projected area into the horizontal plane.

| | Upper | | | | | | | | Lower | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 300K | | | | 600K | | | | 300K | | | | 600K | | | |
| | | Depth (mm) | | | | Depth (mm) | | | | Depth (mm) | | | | Depth (mm) | | |
| Sample | Volume | Max | Mean | Area | Volume | Max | Mean | Area | Volume | Max | Mean | Area | Volume | Max | Mean | Area |
| Denture Tooth | | | | | | | | | | | | | | | | |
| 1 | 0.006 | 0.028 | 0.017 | 0.305 | 0.010 | 0.037 | 0.022 | 0.376 | 0.014 | 0.024 | 0.017 | 0.488 | 0.016 | 0.024 | 0.015 | 0.591 |
| 2 | 0.010 | 0.064 | 0.027 | 0.318 | 0.016 | 0.073 | 0.032 | 0.442 | 0.020 | 0.075 | 0.034 | 0.491 | 0.034 | 0.106 | 0.042 | 0.689 |
| 3 | 0.009 | 0.039 | 0.018 | 0.405 | 0.011 | 0.047 | 0.018 | 0.603 | 0.007 | 0.043 | 0.016 | 0.410 | 0.011 | 0.047 | 0.018 | 0.544 |
| 4 | 0.003 | 0.035 | 0.012 | 0.385 | 0.005 | 0.036 | 0.014 | 0.370 | 0.006 | 0.041 | 0.018 | 0.286 | 0.008 | 0.041 | 0.018 | 0.375 |
| 5 | - | - | - | - | - | - | - | - | 0.009 | 0.058 | 0.025 | 0.314 | 0.014 | 0.078 | 0.033 | 0.358 |
| Experimental Tooth | | | | | | | | | | | | | | | | |
| 1 | 0.011 | 0.044 | 0.021 | 0.465 | 0.012 | 0.048 | 0.025 | 0.446 | 0.006 | 0.026 | 0.017 | 0.320 | 0.006 | 0.029 | 0.015 | 0.397 |
| 2 | 0.007 | 0.055 | 0.024 | 0.283 | 0.011 | 0.078 | 0.026 | 0.366 | 0.008 | 0.052 | 0.020 | 0.371 | 0.011 | 0.056 | 0.021 | 0.453 |
| 3 | 0.004 | 0.050 | 0.017 | 0.267 | 0.008 | 0.067 | 0.022 | 0.354 | 0.004 | 0.038 | 0.018 | 0.178 | 0.009 | 0.047 | 0.020 | 0.399 |
| 4 | 0.014 | 0.085 | 0.029 | 0.409 | 0.019 | 0.092 | 0.036 | 0.453 | 0.012 | 0.070 | 0.030 | 0.348 | 0.016 | 0.068 | 0.031 | 0.437 |
| 5 | 0.016 | 0.077 | 0.030 | 0.465 | 0.022 | 0.085 | 0.033 | 0.600 | 0.010 | 0.053 | 0.023 | 0.401 | 0.015 | 0.056 | 0.025 | 0.523 |
| **Statistics** | | | | | | | | | | | | | | | | |
| T-test comparing Denture teeth wear to Experimental Tooth Wear | | | | | | | | | | | | | | | | |
| T-test | 0.25 | 0.11 | 0.20 | 0.64 | 0.30 | 0.06 | 0.19 | 0.96 | 0.32 | 0.97 | 0.94 | 0.23 | 0.34 | 0.64 | 0.66 | 0.35 |
| T-test comparing Maxillary and Mandibular wear for the same material | | | | | | | | | | | | | | | | |
| Dent | 0.21 | 0.58 | 0.49 | 0.40 | 0.28 | 0.54 | 0.59 | 0.47 | | | | | | | | |
| Exp | 0.39 | 0.22 | 0.46 | 0.38 | 0.38 | 0.05 | 0.15 | 0.97 | | | | | | | | |

**Conclusions:**

There are no significant differences between

1) the denture and experimental teeth for any of the wear parameters.

2) the upper and lower wear of teeth with the same material type

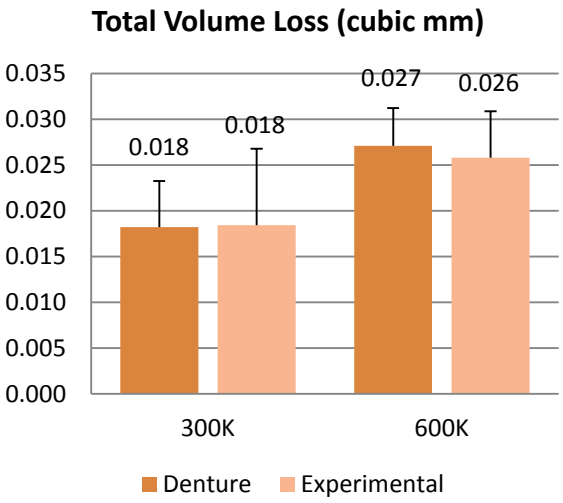
# Summary Results

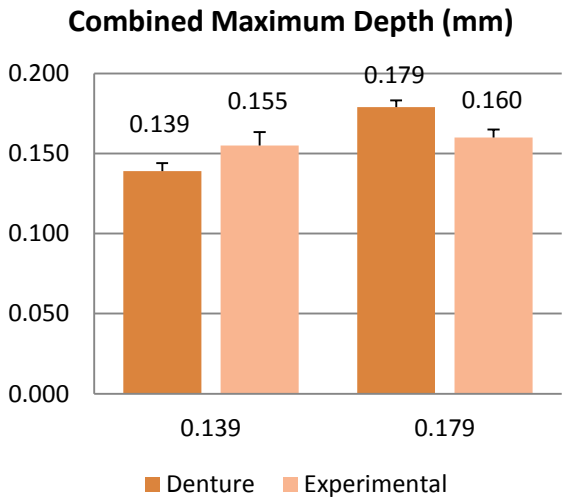
Upper and lower wear values were combined for the different parameters. This is a better representation of the wear. Volume loss was combined by adding the upper and lower volumes. The maximum depths for the upper and lower wear areas were added as were those for the mean depths.

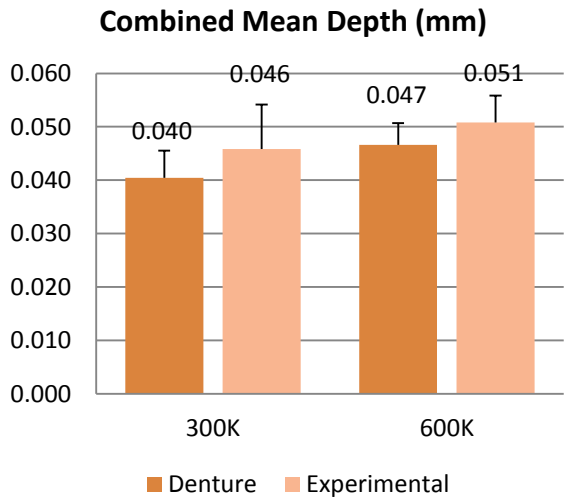
Volume loss is the best parameter for measuring the wear because it does not have a strong dependence on the surface anatomy. Maximum and mean depths depend on the orientation of the measurement. Maximum depth can be influenced by outlier points in the digital models. A second issue with maximum and mean depths is that there are an infinite number of values of both for a given volume value.

A previous study done in ART 1 (Coffey et al. J Prosthet Dent 1985 54(2):273-79) using similar chewing parameters found the total wear on opposing IPN denture teeth to be 0.018 cubic mm, which is similar to the wear found in this study for the experimental and commercial denture teeth.

**Conclusion:** There is no difference in the wear of the two materials.



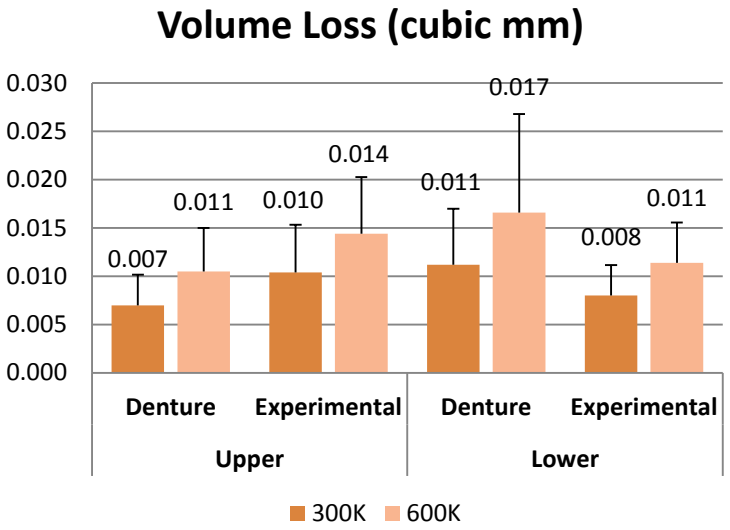



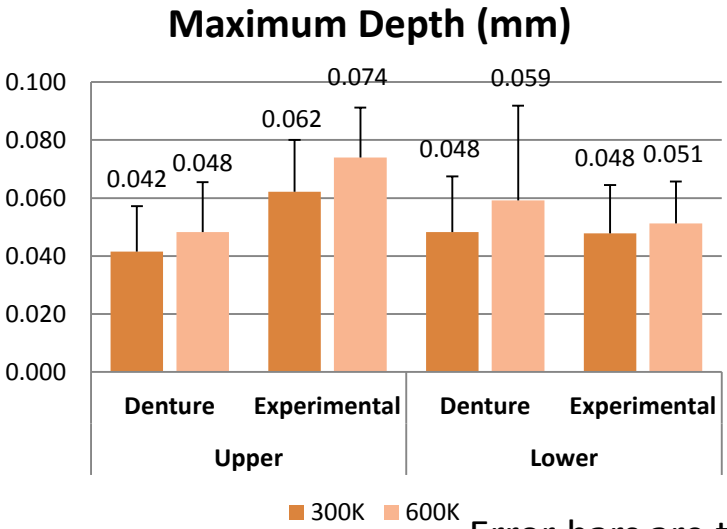



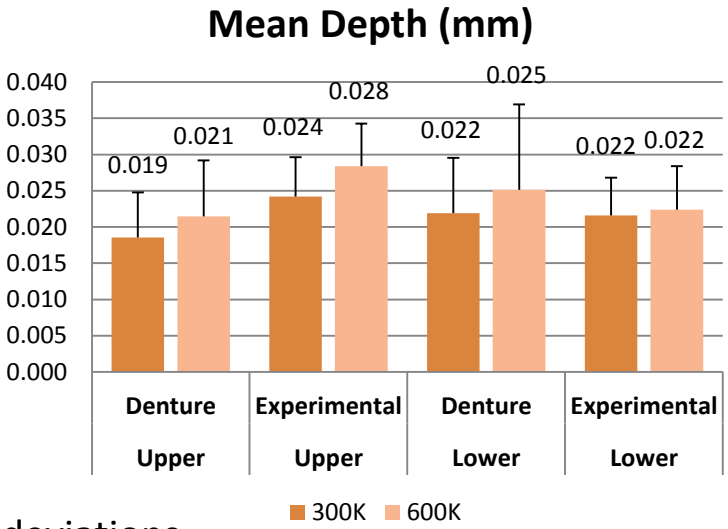

Error bars are the standard deviations

# Summary Results

Comparing upper and lower and Denture and Experimental wear




Error bars are the standard deviations

# Quality of Digital Model Alignment

The first samples for both the denture and experimental teeth were scanned using the LavaScan digitizer. Because of the need to spray the models with powder and the small amount of wear, which could be masked by the powder, it was decided to use the contact profiler for the remaining samples.

**Mean Absolute Distance between Aligned Digital Models**

| | Denture Tooth (mm) | | | | | Experimental (mm) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Lower | | Upper | | | Lower | | Upper | |
| Sample | 300K | 600K | 300K | 600K | Sample | 300K | 600K | 300K | 600K |
| 1 | 0.005 | 0.006 | 0.006 | 0.007 | 1 | 0.008 | 0.006 | 0.003 | 0.003 |
| 2 | 0.007 | 0.008 | 0.005 | 0.005 | 2 | 0.006 | 0.005 | 0.005 | 0.005 |
| 3 | 0.006 | 0.006 | 0.005 | 0.005 | 3 | 0.005 | 0.005 | 0.005 | 0.005 |
| 4 | 0.005 | 0.005 | 0.005 | 0.005 | 4 | 0.005 | 0.005 | 0.006 | 0.006 |
| 5 | 0.005 | 0.005 | 0.005 | 0.005 | 5 | 0.005 | 0.006 | 0.005 | 0.005 |
| Average: | 0.006 | | | | Average: | 0.005 | | | |
| Std Dev: | 0.001 | | | | Std Dev: | 0.001 | | | |

**Statistics**

T-test comparing the quality of the denture and experimental digital model alignments at 300K and 600K

| | | | | |
|---|---|---|---|---|
| 0.94 | 053 | 050 | 028 | |

T-test comparing the quality of denture and experimental digital model alignments: 0.22

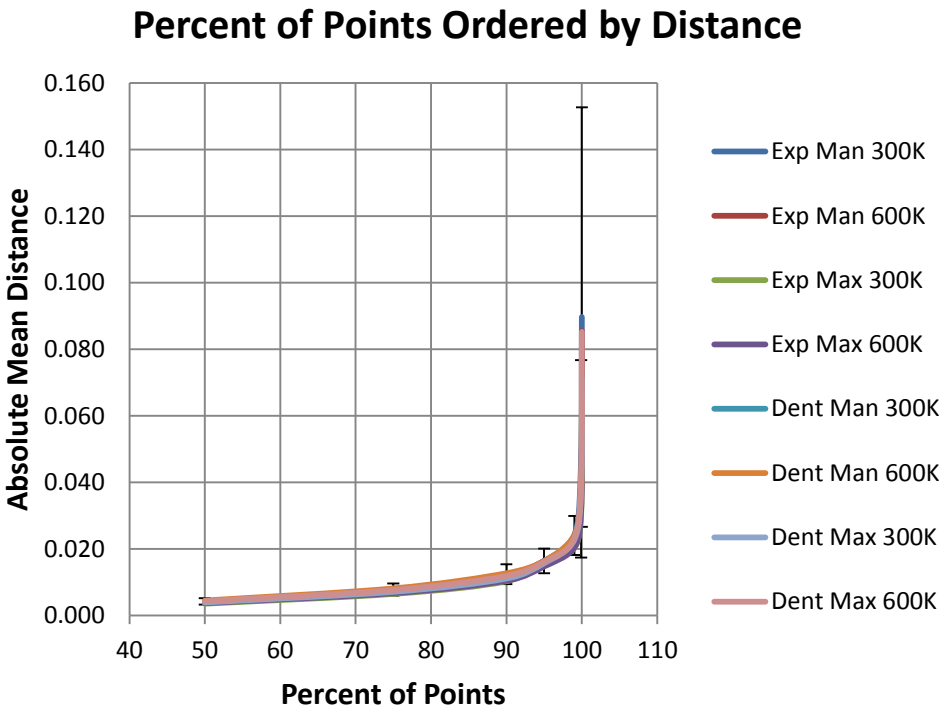
**Conclusion:** There is no difference in the quality of the digital model alignments.

# Quality of Digital Model Alignment

The graph represents all of the absolute distances between the points in the first model to the second model after the alignment. The average number of points used in the alignments was 120,000. Points were ordered from smallest to largest. The percentage of points at or below a defined distance are shown. The error bars are the largest standard deviations for the eight comparisons.

For a perfect alignment, the graph would be a straight line with an absolute mean distance of zero. Normally, however, the graph has a gradual slope with a sharply rising tail approaching 100% of the points. The tail represents outlier points in the digital models.

The accuracy of the contact profiler depends on the surface angle, which is highly variable for dental anatomy. Because the shapes of the eight curves are very consistent, and because more than 80% of the distances are less than the accuracy of the profiler (0.010 mm at 55 degrees of surface angulation), the quality of the alignments is considered excellent.




**Conclusion:** The quality of the alignments is excellent for all comparisons.