

**Appendix I**  
**Preliminary finite element analysis**

A number of Functionally Graded Structured Posts (FGSPs) designs of various compositions were investigated in a pilot study to select the best combinations for the FGSPs. The best results were observed in four layered FGSP where the first layer is either zirconia (model A), alumina (model B) or titanium (model C) and the other three layers are made from xTi-yHA compositions as illustrated in Figures A (1-3).

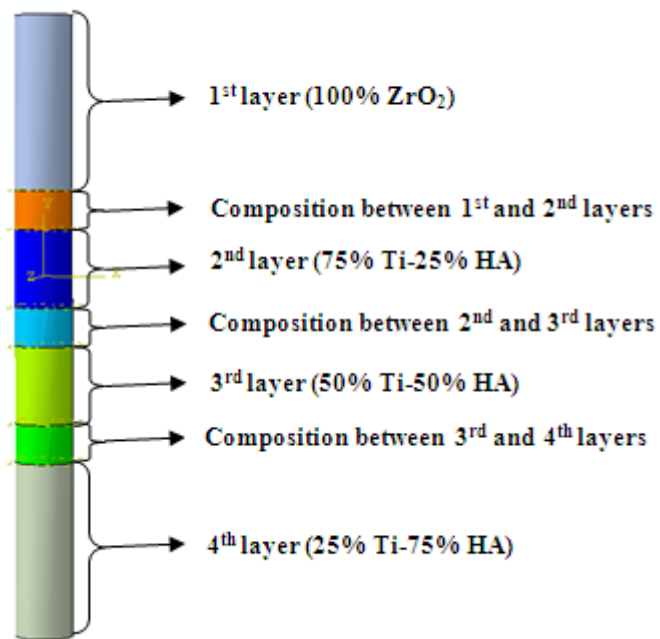


Fig. A1 Functionally graded composite

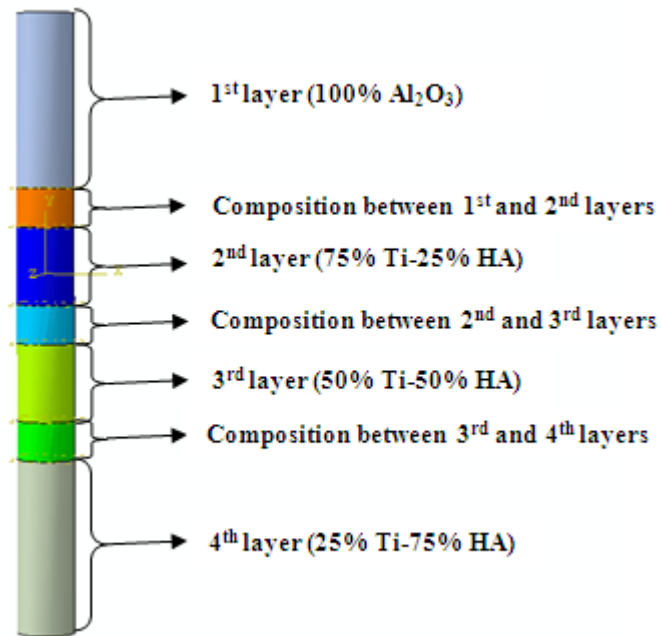


Fig. A2 Functionally graded composite

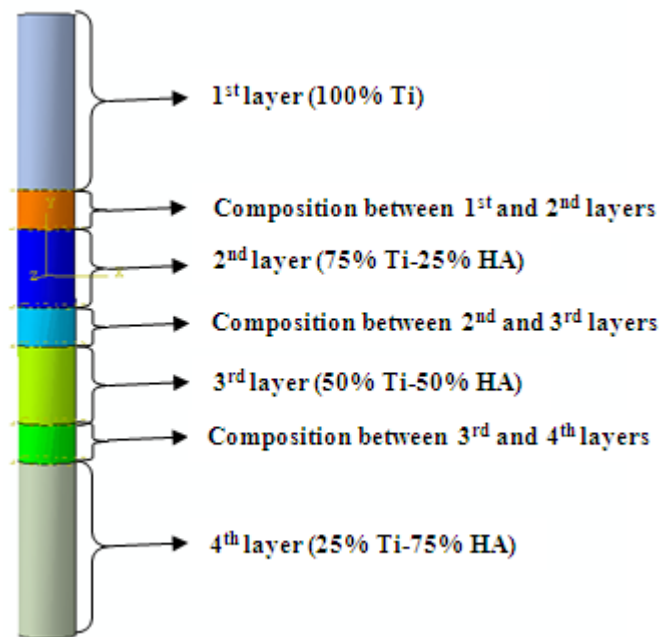
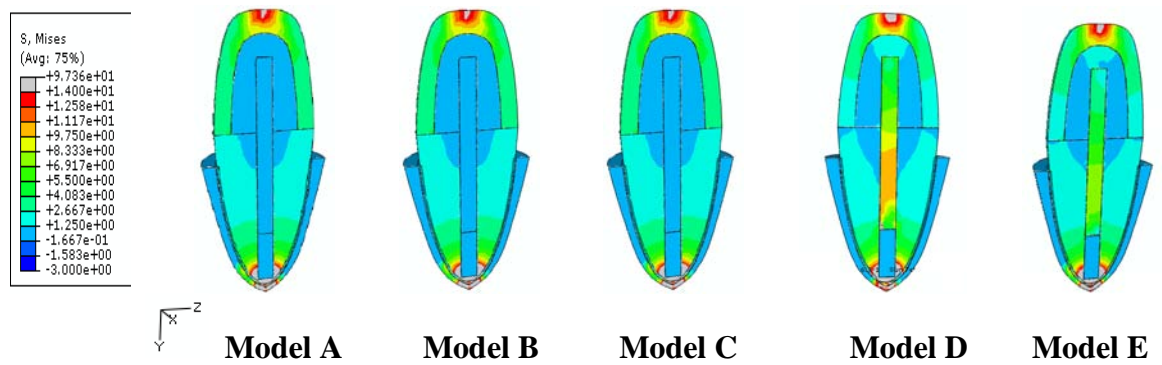
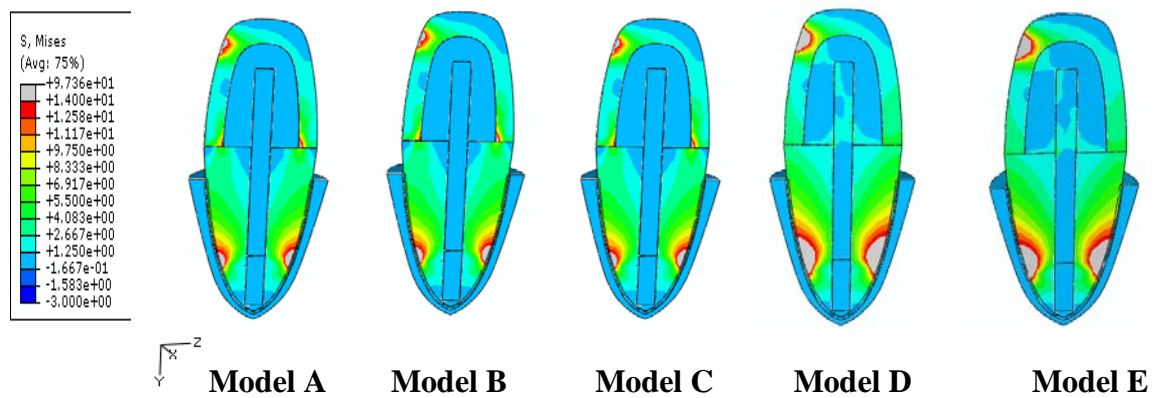


Fig. A3 Functionally graded composite

(a) Vertical loading



(b) Oblique loading



(c) Horizontal loading

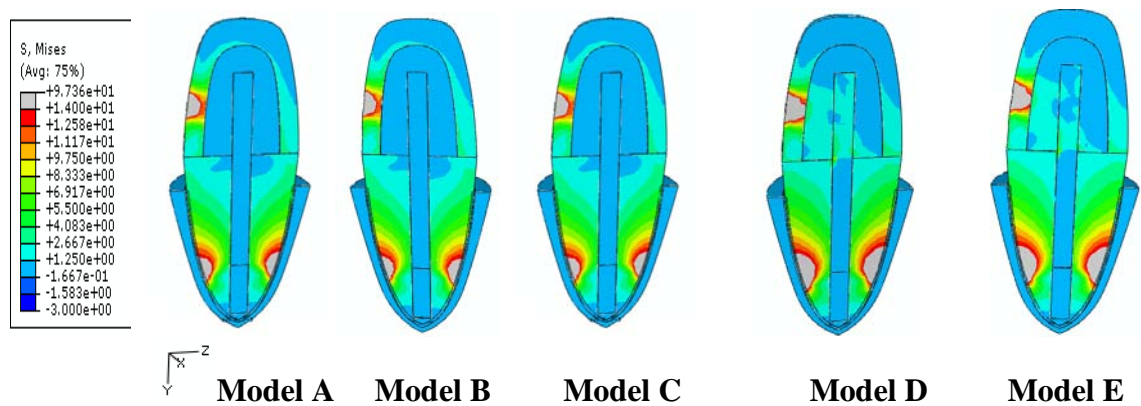
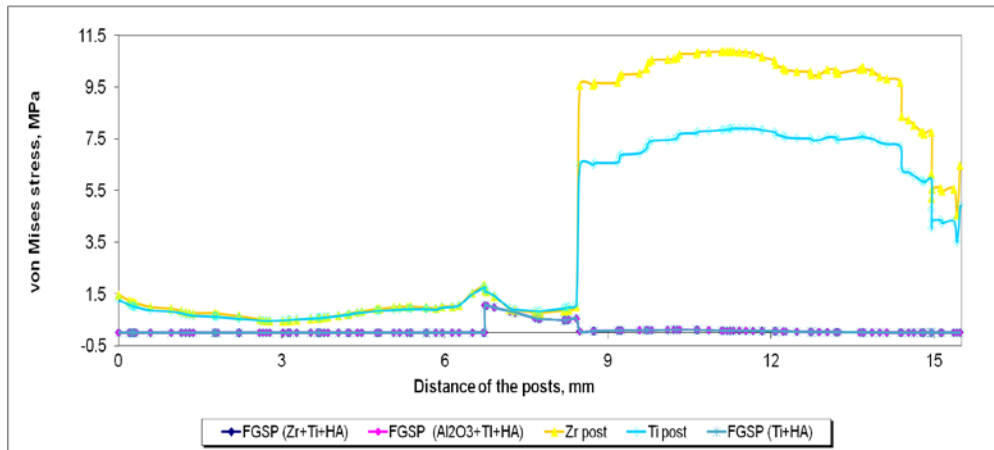
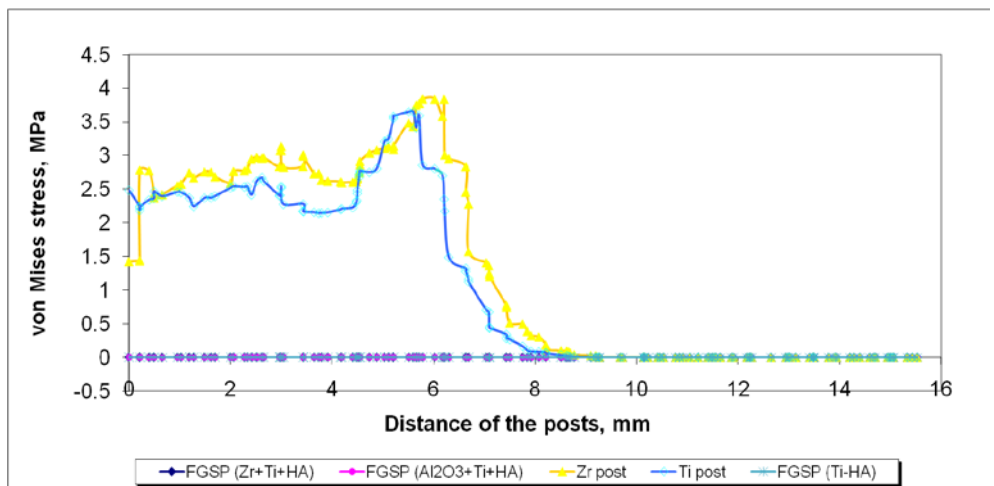


Fig. B Contour plots of the von Mises stress distributions in models A [FGSP: zirconia/(xTi + yHA)]; B [FGSP: alumina/(xTi + yHA)]; C [FGSP: titanium /(xTi + yHA)]; D [zirconia post]; E [titanium post].

(a) Vertical loading



(b) Oblique loading



(c) Horizontal loading

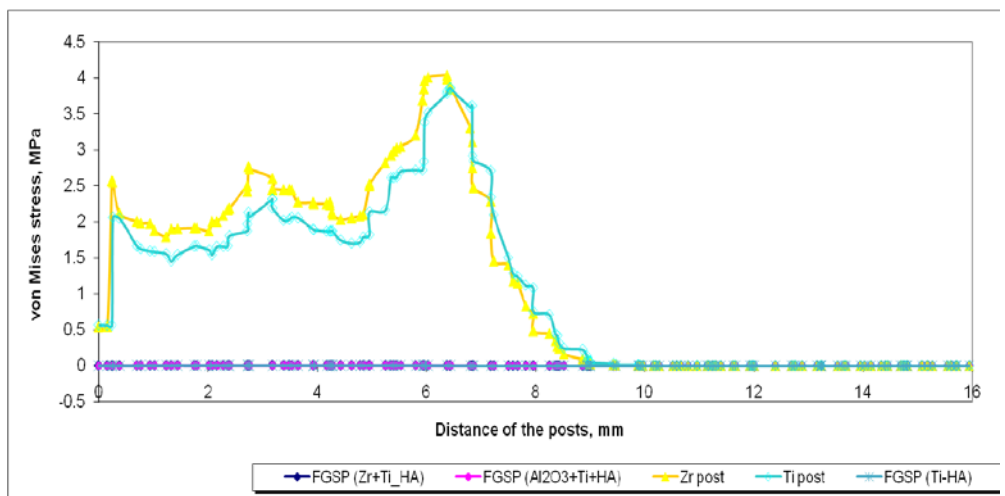
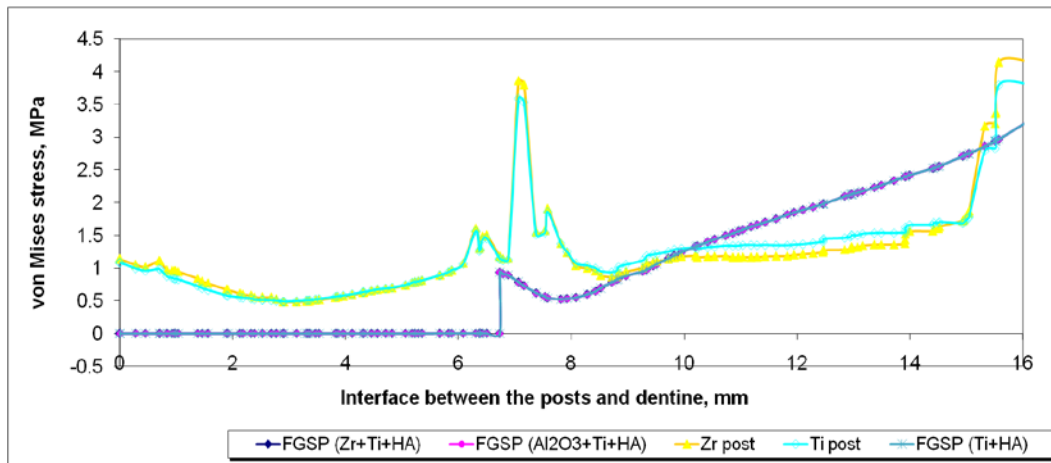
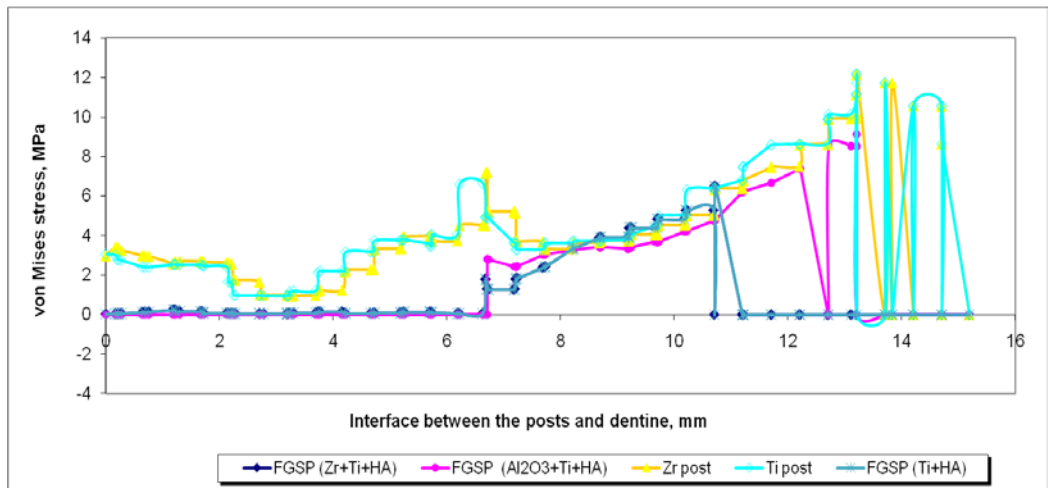


Fig. C Von Mises stress distributions along the center of the post loaded vertically (a), obliquely (b) and horizontally (c).

(a) Vertical loading



(b) Oblique loading



(c) Horizontal loading

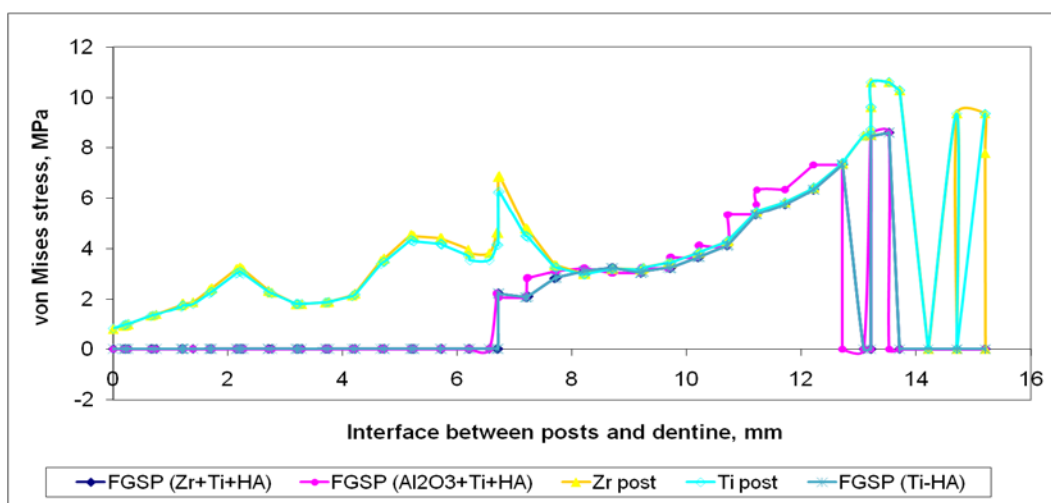


Fig. D Von Mises stress distributions at the dentine-post interface loaded vertically (a), obliquely (b) and horizontally (c).

## **Appendix II**

### **Density of water at different temperature**

Table A Density of water at different temperature

| <b>Temperature (°C)</b> | <b>Density (gcm<sup>-3</sup>)</b> |
|-------------------------|-----------------------------------|
| 30                      | 0.9956502                         |
| 25                      | 0.9970479                         |
| 22                      | 0.9977735                         |
| 20                      | 0.9982071                         |
| 15                      | 0.9991026                         |
| 10                      | 0.9997026                         |
| 14                      | 0.9999720                         |
| 0                       | 0.9998395                         |
| -10                     | 0.998117                          |
| -20                     | 0.993547                          |
| -30                     | 0.983845                          |



## **Appendix III**

### **Data analysis**

Table A Tests of Normality

|                     | Groups                                       | Shapiro-Wilk |    |      |
|---------------------|--|--------------|----|------|
|                     |  | Statistic    | df | Sig. |
| Fracture resistance | FGSP (ZrO <sub>2</sub> -HA-Ti)               | .875         | 10 | .115 |
|                     | FGSP (Al <sub>2</sub> O <sub>3</sub> -HA-Ti) | .974         | 10 | .923 |
|                     | FGSP (Ti-HA-Ti)                              | .931         | 10 | .461 |
|                     | Cast dental post                             | .896         | 10 | .200 |
|                     | Titanium dental post                         | .945         | 10 | .610 |
|                     | Endodontic treated teeth without dental post | .878         | 10 | .125 |
|                     | Extracted sound teeth                        | .891         | 10 | .174 |

\* This is a lower bound of the true significance.

a Lilliefors Significance Correction

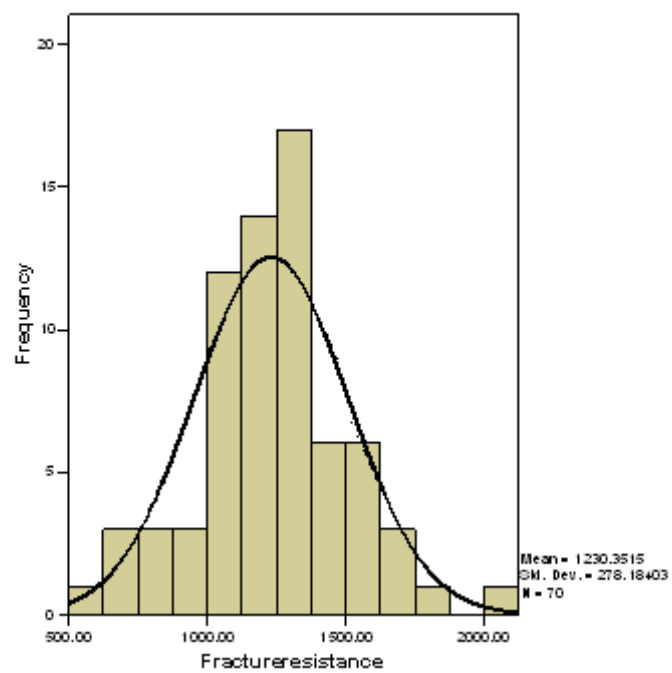


Figure A Histogram

Table B Post Hoc for multiple comparisons for various restoration: Fracture resistance

| (I) Groups                                      | (J) Groups                                   | Mean Difference (I-J) | Std. Error | Sig. |
|---|--|-----------------------|------------|------|
| <b>FGSP (ZrO<sub>2</sub>-HA-Ti)</b>             | FGSP (Al <sub>2</sub> O <sub>3</sub> -HA-Ti) | 56.78770              | 106.04147  | .594 |
|   | FGSP (Ti-HA-Ti)                              | 31.63500              | 106.04147  | .766 |
|   | Cast dental post                             | -99.27400             | 106.04147  | .353 |
|   | Titanium dental post                         | -109.33700            | 106.04147  | .306 |
|   | Endodontic without post                      | 247.90920(*)          | 106.04147  | .023 |
|   | Extracted sound teeth                        | 376.83810(*)          | 106.04147  | .001 |
| <b>FGSP (Al<sub>2</sub>O<sub>3</sub>-HA-Ti)</b> | FGSP (ZrO <sub>2</sub> -HA-Ti)               | -56.78770             | 106.04147  | .594 |
|   | FGSP (Ti-HA-Ti)                              | -25.15270             | 106.04147  | .813 |
|   | Cast dental post                             | -156.06170            | 106.04147  | .146 |
|   | Titanium dental post                         | -166.12470            | 106.04147  | .122 |
|   | Endodontic without post                      | 191.12150             | 106.04147  | .076 |
|   | Extracted sound teeth                        | 320.05040(*)          | 106.04147  | .004 |
| <b>FGSP (Ti-HA-Ti)</b>                          | FGSP (ZrO <sub>2</sub> -HA-Ti)               | -31.63500             | 106.04147  | .766 |
|   | FGSP (Al <sub>2</sub> O <sub>3</sub> -HA-Ti) | 25.15270              | 106.04147  | .813 |
|   | Cast dental post                             | -130.90900            | 106.04147  | .222 |
|   | Titanium dental post                         | -140.97200            | 106.04147  | .189 |
|   | Endodontic without post                      | 216.27420(*)          | 106.04147  | .046 |
|   | Extracted sound teeth                        | 345.20310(*)          | 106.04147  | .002 |
| <b>Cast dental post</b>                         | FGSP (ZrO <sub>2</sub> -HA-Ti)               | 99.27400              | 106.04147  | .353 |
|   | FGSP (Al <sub>2</sub> O <sub>3</sub> -HA-Ti) | 156.06170             | 106.04147  | .146 |
|   | FGSP (Ti-HA-Ti)                              | 130.90900             | 106.04147  | .222 |
|   | Titanium dental post                         | -10.06300             | 106.04147  | .925 |
|   | Endodontic without post                      | 347.18320(*)          | 106.04147  | .002 |
|   | Extracted sound teeth                        | 476.11210(*)          | 106.04147  | .000 |
| <b>Titanium dental post</b>                     | FGSP (ZrO <sub>2</sub> -HA-Ti)               | 109.33700             | 106.04147  | .306 |
|   | FGSP (Al <sub>2</sub> O <sub>3</sub> -HA-Ti) | 166.12470             | 106.04147  | .122 |
|   | FGSP (Ti-HA-Ti)                              | 140.97200             | 106.04147  | .189 |
|   | Cast dental post                             | 10.06300              | 106.04147  | .925 |
|   | Endodontic without post                      | 357.24620(*)          | 106.04147  | .001 |
|   | Extracted sound teeth                        | 486.17510(*)          | 106.04147  | .000 |
| <b>Endodontic without post</b>                  | FGSP (ZrO <sub>2</sub> -HA-Ti)               | -247.90920(*)         | 106.04147  | .023 |
|   | FGSP (Al <sub>2</sub> O <sub>3</sub> -HA-Ti) | -191.12150            | 106.04147  | .076 |
|   | FGSP (Ti-HA-Ti)                              | -216.27420(*)         | 106.04147  | .046 |
|   | Cast dental post                             | -347.18320(*)         | 106.04147  | .002 |
|   | Titanium dental post                         | -357.24620(*)         | 106.04147  | .001 |
|   | Extracted sound teeth                        | 128.92890             | 106.04147  | .229 |
| <b>Extracted sound teeth</b>                    | FGSP (ZrO <sub>2</sub> -HA-Ti)               | -376.83810(*)         | 106.04147  | .001 |
|   | FGSP (Al <sub>2</sub> O <sub>3</sub> -HA-Ti) | -320.05040(*)         | 106.04147  | .004 |
|   | FGSP (Ti-HA-Ti)                              | -345.20310(*)         | 106.04147  | .002 |
|   | Cast dental post                             | -476.11210(*)         | 106.04147  | .000 |
|   | Titanium dental post                         | -486.17510(*)         | 106.04147  | .000 |
|   | Endodontic without post                      | -128.92890            | 106.04147  | .229 |

\*Significantly different from other groups ( $p < 0.01$ ).

**Table C Chi-Square Tests for among all groups  
Chi-Square Tests**

|                                 | Value     | df | Asymp. Sig.<br>(2-sided) |
|---------------------------------|-----------|----|--------------------------|
| Pearson Chi-Square              | 37.974(a) | 6  | .000                     |
| Likelihood Ratio                | 45.245    | 6  | .000                     |
| Linear-by-Linear<br>Association | 18.265    | 1  | .000                     |
| N of Valid Cases                | 70        |    |                          |

a 7 cells (50.0%) have expected count less than 5. The minimum expected count is 4.86.

**Table D Fisher's exact test for FGSP (Al<sub>2</sub>O<sub>3</sub>-HA-Ti and FGSP (ZrO<sub>2</sub>-HA-Ti)**

|                                 | Value   | df | Asymp. Sig.<br>(2-sided) | Exact Sig.<br>(2-sided) | Exact Sig.<br>(1-sided) |
|---------------------------------|---------|----|--------------------------|-------------------------|-------------------------|
| Pearson Chi-Square              | .392(b) | 1  | .531                     |                         |                         |
| Continuity<br>Correction(a)     | .000    | 1  | 1.000                    |                         |                         |
| Likelihood Ratio                | .399    | 1  | .528                     |                         |                         |
| Fisher's Exact Test             |         |    |                          | 1.000                   | .500                    |
| Linear-by-Linear<br>Association | .373    | 1  | .542                     |                         |                         |
| N of Valid Cases                | 20      |    |                          |                         |                         |

a Computed only for a 2x2 table

b 2 cells (50.0%) have expected count less than 5. The minimum expected count is 1.50

**Table E Fisher's exact test for FGSP (FGSP (Ti-HA-Ti) and FGSP (ZrO<sub>2</sub>-HA-Ti)**

|                                 | Value   | df | Asymp. Sig.<br>(2-sided) | Exact Sig.<br>(2-sided) | Exact Sig.<br>(1-sided) |
|---------------------------------|---------|----|--------------------------|-------------------------|-------------------------|
| Pearson Chi-Square              | .392(b) | 1  | .531                     |                         |                         |
| Continuity<br>Correction(a)     | .000    | 1  | 1.000                    |                         |                         |
| Likelihood Ratio                | .399    | 1  | .528                     |                         |                         |
| Fisher's Exact Test             |         |    |                          | 1.000                   | .500                    |
| Linear-by-Linear<br>Association | .373    | 1  | .542                     |                         |                         |
| N of Valid Cases                | 20      |    |                          |                         |                         |

a Computed only for a 2x2 table

b 2 cells (50.0%) have expected count less than 5. The minimum expected count is 1.50.

**Table F Fisher's exact test for cast dental post and FGSP (ZrO<sub>2</sub>-HA-Ti)**

|                                 | Value     | df | Asymp. Sig.<br>(2-sided) | Exact Sig.<br>(2-sided) | Exact Sig.<br>(1-sided) |
|---------------------------------|-----------|----|--------------------------|-------------------------|-------------------------|
| Pearson Chi-Square              | 12.800(b) | 1  | .000                     |                         |                         |
| Continuity<br>Correction(a)     | 9.800     | 1  | .002                     |                         |                         |
| Likelihood Ratio                | 14.723    | 1  | .000                     |                         |                         |
| Fisher's Exact Test             |           |    |                          | .001                    | .001                    |
| Linear-by-Linear<br>Association | 12.160    | 1  | .000                     |                         |                         |
| N of Valid Cases                | 20        |    |                          |                         |                         |

a Computed only for a 2x2 table

b 0 cells (.0%) have expected count less than 5. The minimum expected count is 5.00.

**Table G Fisher's exact test for titanium dental post and FGSP (ZrO<sub>2</sub>-HA-Ti)**

|                                 | Value     | df | Asymp. Sig.<br>(2-sided) | Exact Sig.<br>(2-sided) | Exact Sig.<br>(1-sided) |
|---------------------------------|-----------|----|--------------------------|-------------------------|-------------------------|
| Pearson Chi-Square              | 12.800(b) | 1  | .000                     |                         |                         |
| Continuity<br>Correction(a)     | 9.800     | 1  | .002                     |                         |                         |
| Likelihood Ratio                | 14.723    | 1  | .000                     |                         |                         |
| Fisher's Exact Test             |           |    |                          | .001                    | .001                    |
| Linear-by-Linear<br>Association | 12.160    | 1  | .000                     |                         |                         |
| N of Valid Cases                | 20        |    |                          |                         |                         |

a Computed only for a 2x2 table

b 0 cells (.0%) have expected count less than 5. The minimum expected count is 5.00.

**Table H Fisher's exact test for endodontic treated teeth without dental post and FGSP (ZrO<sub>2</sub>-HA-Ti)**

|                                 | Value    | df | Asymp. Sig.<br>(2-sided) | Exact Sig.<br>(2-sided) | Exact Sig.<br>(1-sided) |
|---------------------------------|----------|----|--------------------------|-------------------------|-------------------------|
| Pearson Chi-Square              | 1.250(b) | 1  | .264                     |                         |                         |
| Continuity<br>Correction(a)     | .313     | 1  | .576                     |                         |                         |
| Likelihood Ratio                | 1.297    | 1  | .255                     |                         |                         |
| Fisher's Exact Test             |          |    |                          | .582                    | .291                    |
| Linear-by-Linear<br>Association | 1.187    | 1  | .276                     |                         |                         |
| N of Valid Cases                | 20       |    |                          |                         |                         |

a Computed only for a 2x2 table

b 2 cells (50.0%) have expected count less than 5. The minimum expected count is 2.00.

**Table I Fisher's exact test for extracted sound teeth and FGSP (ZrO<sub>2</sub>-HA-Ti)**

|                                 | Value     | df | Asymp. Sig.<br>(2-sided) | Exact Sig.<br>(2-sided) | Exact Sig.<br>(1-sided) |
|---------------------------------|-----------|----|--------------------------|-------------------------|-------------------------|
| Pearson Chi-Square              | 16.364(b) | 1  | .000                     |                         |                         |
| Continuity<br>Correction(a)     | 12.929    | 1  | .000                     |                         |                         |
| Likelihood Ratio                | 21.024    | 1  | .000                     |                         |                         |
| Fisher's Exact Test             |           |    |                          | .000                    | .000                    |
| Linear-by-Linear<br>Association | 15.545    | 1  | .000                     |                         |                         |
| N of Valid Cases                | 20        |    |                          |                         |                         |

a Computed only for a 2x2 table

b 2 cells (50.0%) have expected count less than 5. The minimum expected count is 4.50.

**Table J Fisher's exact test for FGSP (Ti-HA-Ti) and FGSP (Al<sub>2</sub>O<sub>3</sub>-HA-Ti)**

|                                 | Value   | df | Asymp. Sig.<br>(2-sided) | Exact Sig.<br>(2-sided) | Exact Sig.<br>(1-sided) |
|---------------------------------|---------|----|--------------------------|-------------------------|-------------------------|
| Pearson Chi-Square              | .000(b) | 1  | 1.000                    |                         |                         |
| Continuity<br>Correction(a)     | .000    | 1  | 1.000                    |                         |                         |
| Likelihood Ratio                | .000    | 1  | 1.000                    |                         |                         |
| Fisher's Exact Test             |         |    |                          | 1.000                   | .709                    |
| Linear-by-Linear<br>Association | .000    | 1  | 1.000                    |                         |                         |
| N of Valid Cases                | 20      |    |                          |                         |                         |

a Computed only for a 2x2 table

b 2 cells (50.0%) have expected count less than 5. The minimum expected count is 2.00.

**Table K Fisher's exact test for cast dental post and FGSP (Al<sub>2</sub>O<sub>3</sub>-HA-Ti)**

|                                 | Value    | df | Asymp. Sig.<br>(2-sided) | Exact Sig.<br>(2-sided) | Exact Sig.<br>(1-sided) |
|---------------------------------|----------|----|--------------------------|-------------------------|-------------------------|
| Pearson Chi-Square              | 9.899(b) | 1  | .002                     |                         |                         |
| Continuity<br>Correction(a)     | 7.273    | 1  | .007                     |                         |                         |
| Likelihood Ratio                | 11.016   | 1  | .001                     |                         |                         |
| Fisher's Exact Test             |          |    |                          | .005                    | .003                    |
| Linear-by-Linear<br>Association | 9.404    | 1  | .002                     |                         |                         |
| N of Valid Cases                | 20       |    |                          |                         |                         |

a Computed only for a 2x2 table

b 2 cells (50.0%) have expected count less than 5. The minimum expected count is 4.50.

**Table L Fisher's exact test for titanium dental post and FGSP (Al<sub>2</sub>O<sub>3</sub>-HA-Ti)**

|                                 | Value    | df | Asymp. Sig.<br>(2-sided) | Exact Sig.<br>(2-sided) | Exact Sig.<br>(1-sided) |
|---------------------------------|----------|----|--------------------------|-------------------------|-------------------------|
| Pearson Chi-Square              | 9.899(b) | 1  | .002                     |                         |                         |
| Continuity<br>Correction(a)     | 7.273    | 1  | .007                     |                         |                         |
| Likelihood Ratio                | 11.016   | 1  | .001                     |                         |                         |
| Fisher's Exact Test             |          |    |                          | .005                    | .003                    |
| Linear-by-Linear<br>Association | 9.404    | 1  | .002                     |                         |                         |
| N of Valid Cases                | 20       |    |                          |                         |                         |

a Computed only for a 2x2 table

b 2 cells (50.0%) have expected count less than 5. The minimum expected count is 4.50.

**Table M Fisher's exact test for endodontic treated teeth without dental post and FGSP (Al<sub>2</sub>O<sub>3</sub>-HA-Ti)**

|                                 | Value   | df | Asymp. Sig.<br>(2-sided) | Exact Sig.<br>(2-sided) | Exact Sig.<br>(1-sided) |
|---------------------------------|---------|----|--------------------------|-------------------------|-------------------------|
| Pearson Chi-Square              | .267(b) | 1  | .606                     |                         |                         |
| Continuity<br>Correction(a)     | .000    | 1  | 1.000                    |                         |                         |
| Likelihood Ratio                | .268    | 1  | .605                     |                         |                         |
| Fisher's Exact Test             |         |    |                          | 1.000                   | .500                    |
| Linear-by-Linear<br>Association | .253    | 1  | .615                     |                         |                         |
| N of Valid Cases                | 20      |    |                          |                         |                         |

a Computed only for a 2x2 table

b 2 cells (50.0%) have expected count less than 5. The minimum expected count is 2.50.

**Table N Fisher's exact test for extracted sound teeth and FGSP (Al<sub>2</sub>O<sub>3</sub>-HA-Ti)**

|                                 | Value     | df | Asymp. Sig.<br>(2-sided) | Exact Sig.<br>(2-sided) | Exact Sig.<br>(1-sided) |
|---------------------------------|-----------|----|--------------------------|-------------------------|-------------------------|
| Pearson Chi-Square              | 13.333(b) | 1  | .000                     |                         |                         |
| Continuity<br>Correction(a)     | 10.208    | 1  | .001                     |                         |                         |
| Likelihood Ratio                | 16.912    | 1  | .000                     |                         |                         |
| Fisher's Exact Test             |           |    |                          | .001                    | .000                    |
| Linear-by-Linear<br>Association | 12.667    | 1  | .000                     |                         |                         |
| N of Valid Cases                | 20        |    |                          |                         |                         |

a Computed only for a 2x2 table

b 2 cells (50.0%) have expected count less than 5. The minimum expected count is 4.00.

**Table O Fisher's exact test for extracted sound teeth and FGSP (Ti-HA-Ti)**

|                                 | Value     | df | Asymp. Sig.<br>(2-sided) | Exact Sig.<br>(2-sided) | Exact Sig.<br>(1-sided) |
|---------------------------------|-----------|----|--------------------------|-------------------------|-------------------------|
| Pearson Chi-Square              | 13.333(b) | 1  | .000                     |                         |                         |
| Continuity<br>Correction(a)     | 10.208    | 1  | .001                     |                         |                         |
| Likelihood Ratio                | 16.912    | 1  | .000                     |                         |                         |
| Fisher's Exact Test             |           |    |                          | .001                    | .000                    |
| Linear-by-Linear<br>Association | 12.667    | 1  | .000                     |                         |                         |
| N of Valid Cases                | 20        |    |                          |                         |                         |

a Computed only for a 2x2 table

b 2 cells (50.0%) have expected count less than 5. The minimum expected count is 4.00.

**Table P Fisher's exact test for cast dental post and FGSP (Ti-HA-Ti)**

|                                 | Value    | df | Asymp. Sig.<br>(2-sided) | Exact Sig.<br>(2-sided) | Exact Sig.<br>(1-sided) |
|---------------------------------|----------|----|--------------------------|-------------------------|-------------------------|
| Pearson Chi-Square              | 9.899(b) | 1  | .002                     |                         |                         |
| Continuity<br>Correction(a)     | 7.273    | 1  | .007                     |                         |                         |
| Likelihood Ratio                | 11.016   | 1  | .001                     |                         |                         |
| Fisher's Exact Test             |          |    |                          | .005                    | .003                    |
| Linear-by-Linear<br>Association | 9.404    | 1  | .002                     |                         |                         |
| N of Valid Cases                | 20       |    |                          |                         |                         |

a Computed only for a 2x2 table

b 2 cells (50.0%) have expected count less than 5. The minimum expected count is 4.50.

**Table Q Fisher's exact test for titanium dental post and FGSP (Ti-HA-Ti)**

|                                 | Value    | df | Asymp. Sig.<br>(2-sided) | Exact Sig.<br>(2-sided) | Exact Sig.<br>(1-sided) |
|---------------------------------|----------|----|--------------------------|-------------------------|-------------------------|
| Pearson Chi-Square              | 9.899(b) | 1  | .002                     |                         |                         |
| Continuity<br>Correction(a)     | 7.273    | 1  | .007                     |                         |                         |
| Likelihood Ratio                | 11.016   | 1  | .001                     |                         |                         |
| Fisher's Exact Test             |          |    |                          | .005                    | .003                    |
| Linear-by-Linear<br>Association | 9.404    | 1  | .002                     |                         |                         |
| N of Valid Cases                | 20       |    |                          |                         |                         |

a Computed only for a 2x2 table

b 2 cells (50.0%) have expected count less than 5. The minimum expected count is 4.50.



**Table R Fisher's exact test for endodontic treated teeth without dental post and FGSP (Ti-HA-Ti)**

|                                 | Value   | df | Asymp. Sig.<br>(2-sided) | Exact Sig.<br>(2-sided) | Exact Sig.<br>(1-sided) |
|---------------------------------|---------|----|--------------------------|-------------------------|-------------------------|
| Pearson Chi-Square              | .267(b) | 1  | .606                     |                         |                         |
| Continuity<br>Correction(a)     | .000    | 1  | 1.000                    |                         |                         |
| Likelihood Ratio                | .268    | 1  | .605                     |                         |                         |
| Fisher's Exact Test             |         |    |                          | 1.000                   | .500                    |
| Linear-by-Linear<br>Association | .253    | 1  | .615                     |                         |                         |
| N of Valid Cases                | 20      |    |                          |                         |                         |

a Computed only for a 2x2 table

b 2 cells (50.0%) have expected count less than 5. The minimum expected count is 2.50.

**Table S Fisher's exact test for extracted sound teeth and cast dental post**

|                                 | Value    | df | Asymp. Sig.<br>(2-sided) | Exact Sig.<br>(2-sided) | Exact Sig.<br>(1-sided) |
|---------------------------------|----------|----|--------------------------|-------------------------|-------------------------|
| Pearson Chi-Square              | 1.053(b) | 1  | .305                     |                         |                         |
| Continuity<br>Correction(a)     | .000     | 1  | 1.000                    |                         |                         |
| Likelihood Ratio                | 1.439    | 1  | .230                     |                         |                         |
| Fisher's Exact Test             |          |    |                          | 1.000                   | .500                    |
| Linear-by-Linear<br>Association | 1.000    | 1  | .317                     |                         |                         |
| N of Valid Cases                | 20       |    |                          |                         |                         |

a Computed only for a 2x2 table

b 2 cells (50.0%) have expected count less than 5. The minimum expected count is .50.

**Table T Fisher's exact test for titanium dental post and cast dental post**

|                                 | Value   | df | Asymp. Sig.<br>(2-sided) | Exact Sig.<br>(2-sided) | Exact Sig.<br>(1-sided) |
|---------------------------------|---------|----|--------------------------|-------------------------|-------------------------|
| Pearson Chi-Square              | .000(b) | 1  | 1.000                    |                         |                         |
| Continuity<br>Correction(a)     | .000    | 1  | 1.000                    |                         |                         |
| Likelihood Ratio                | .000    | 1  | 1.000                    |                         |                         |
| Fisher's Exact Test             |         |    |                          | 1.000                   | .763                    |
| Linear-by-Linear<br>Association | .000    | 1  | 1.000                    |                         |                         |
| N of Valid Cases                | 20      |    |                          |                         |                         |

a Computed only for a 2x2 table

b 2 cells (50.0%) have expected count less than 5. The minimum expected count is 1.00.

**Table U Fisher's exact test for endodontic treated teeth without dental post and cast dental post**

|                                 | Value    | df | Asymp. Sig.<br>(2-sided) | Exact Sig.<br>(2-sided) | Exact Sig.<br>(1-sided) |
|---------------------------------|----------|----|--------------------------|-------------------------|-------------------------|
| Pearson Chi-Square              | 7.500(b) | 1  | .006                     |                         |                         |
| Continuity<br>Correction(a)     | 5.208    | 1  | .022                     |                         |                         |
| Likelihood Ratio                | 8.202    | 1  | .004                     |                         |                         |
| Fisher's Exact Test             |          |    |                          | .020                    | .010                    |
| Linear-by-Linear<br>Association | 7.125    | 1  | .008                     |                         |                         |
| N of Valid Cases                | 20       |    |                          |                         |                         |

a Computed only for a 2x2 table

b 2 cells (50.0%) have expected count less than 5. The minimum expected count is 4.00.

**Table V Fisher's exact test for endodontic treated teeth without dental post and titanium dental post**

|                                 | Value    | df | Asymp. Sig.<br>(2-sided) | Exact Sig.<br>(2-sided) | Exact Sig.<br>(1-sided) |
|---------------------------------|----------|----|--------------------------|-------------------------|-------------------------|
| Pearson Chi-Square              | 7.500(b) | 1  | .006                     |                         |                         |
| Continuity<br>Correction(a)     | 5.208    | 1  | .022                     |                         |                         |
| Likelihood Ratio                | 8.202    | 1  | .004                     |                         |                         |
| Fisher's Exact Test             |          |    |                          | .020                    | .010                    |
| Linear-by-Linear<br>Association | 7.125    | 1  | .008                     |                         |                         |
| N of Valid Cases                | 20       |    |                          |                         |                         |

a Computed only for a 2x2 table

b 2 cells (50.0%) have expected count less than 5. The minimum expected count is 4.00.

**Table W Fisher's exact test for extracted sound teeth and titanium dental post**

|                                 | Value    | df | Asymp. Sig.<br>(2-sided) | Exact Sig.<br>(2-sided) | Exact Sig.<br>(1-sided) |
|---------------------------------|----------|----|--------------------------|-------------------------|-------------------------|
| Pearson Chi-Square              | 1.053(b) | 1  | .305                     |                         |                         |
| Continuity<br>Correction(a)     | .000     | 1  | 1.000                    |                         |                         |
| Likelihood Ratio                | 1.439    | 1  | .230                     |                         |                         |
| Fisher's Exact Test             |          |    |                          | 1.000                   | .500                    |
| Linear-by-Linear<br>Association | 1.000    | 1  | .317                     |                         |                         |
| N of Valid Cases                | 20       |    |                          |                         |                         |

a Computed only for a 2x2 table

b 2 cells (50.0%) have expected count less than 5. The minimum expected count is .50.

**Table X Fisher's exact test for extracted sound teeth and endodontic treated teeth without dental post**

|                                 | Value     | df | Asymp. Sig.<br>(2-sided) | Exact Sig.<br>(2-sided) | Exact Sig.<br>(1-sided) |
|---------------------------------|-----------|----|--------------------------|-------------------------|-------------------------|
| Pearson Chi-Square              | 10.769(b) | 1  | .001                     |                         |                         |
| Continuity<br>Correction(a)     | 7.912     | 1  | .005                     |                         |                         |
| Likelihood Ratio                | 13.681    | 1  | .000                     |                         |                         |
| Fisher's Exact Test             |           |    |                          | .003                    | .002                    |
| Linear-by-Linear<br>Association | 10.231    | 1  | .001                     |                         |                         |
| N of Valid Cases                | 20        |    |                          |                         |                         |

a Computed only for a 2x2 table

b 2 cells (50.0%) have expected count less than 5. The minimum expected count is 3.50.

## **Contributions of this study**

## Patent

Noor H. Abu Kasim, Ahmed A. Madfa, Hamdi M., Rahbari R.G. (2011). Metal-Ceramic Dental Post, Patent Number (PI): **2011004506**.

## Publications

### *ISI/SCOPUS Cited Publications*

1. R. G. Rahbari, N. H. Abu Kasim, A. A. Madfa, M. Hamdi, M. Bayat. (2011). Porosity Reduction Model in Titanium- Hydroxyapatite FGM Composites Using Shrinkage Measurement. *Material Research Innovations*; 15(Suppl 2): S110-S113.
2. N. H. Abu Kasim, A. A. Madfa, M. Hamdi, R. G. Rahbari. (2011). 3D-FE Analysis of Functionally Graded Structured Dental Posts. *Journal of Dental Materials*; 30(6):869-880.
3. A. A. Madfa, N. H. Abu Kasim, M. Hamdi, R. G. Rahbari. Effect of Temperature on the Thermo-Mechanical Stress in Functionally Graded Dental Posts. *Journal of Biomechanics* (Under review).

### **Manuscript in preparation**

4. A. A. Madfa, N. H. Abu Kasim, M. Hamdi, R. G. Rahbari. Investigating the Mechanical Resistance to Fracture of Endodontically Treated Tooth Restored with Prototype Functionally Graded Dental Posts. *Journal of Endodontics* (In progress).
5. Ahmed A. Madfa, Noor H. Abu Kasim, Hamdi M., R. Rahbari G. Tensile, Compressive and Shear Stresses Analysis of a Maxillary Central Incisor Restored with Functionally Graded Dental Posts. *Dental Materials* (In progress).
6. A. A. Madfa, N. H. Abu Kasim, Hamdi M., R. G. Rahbari. Fabrication of functionally graded multilayered composites by using two different sintering techniques. *Biomaterials* (In progress).

### ***Non-ISI/Non-SCOPUS Cited Publications***

1. Noor H. Abu Kasim, Ahmed A. Madfa, Hamdi M., Rahbari, R.G. (2011). New Generation of the Dental Posts for Endodontic Application. *UMCIC Technology Bulletin*; 6:14-15.

### **Conference Papers**

#### ***Extended Abstracts***

1. R. G. Rahbari, N. H. Abu Kasim, A. A. Madfa, M. Hamdi, M. Bayat. (2010). Porosity reduction model in functionally graded metal-ceramic composites using shrinkage measurement. 3<sup>rd</sup> International Conference on Functional Materials and Devices, ICFMD, Terengganu, 14-17 June 2010, Malaysia.
2. A. A. Madfa, N. H. Abu Kasim, M. Hamdi, R. G. Rahbari, M. Bayat. (2010). A new multilayer composite with functionally graded design for endodontic application, 3<sup>rd</sup> International Conference on Functional Materials and Devices, ICFMD, Terengganu, 14-17 June 2010, Malaysia.

#### ***ISI- Cited Abstract***

1. A. A. Madfa, N. H. Abu Kasim, M. Hamdi, R. G. Rahbari, and M. H. Latifi. (2009). A finite element study of the multilayered structured dental post. *Journal of Dental Research*; 88B, Abstr. 182, 2009 (www.dentalresearch.org) (*ISI-Cited Publication*).
2. A. A. Madfa, N. H. Abu Kasim, M. Hamdi, R. G. Rahbari, and M. Bayat. (2010). Thermo-Mechanical Stress in Multilayered Dental Post due to Temperature Gradient. *Journal of Dental Research*; 89C, 2010 (www.dentalresearch.org) (*ISI-Cited Publication*).
3. A. A. Madfa, N. H. Abu Kasim, M. Hamdi, R. G. Rahbari. (2011). Fracture Resistance of Endodontically Teeth Restored with Functionally Graded Posts. *Journal of Dental Research*; 90B, 2011 (www.dentalresearch.org) (*ISI-Cited Publication*).

#### ***Non-ISI/Non-SCOPUS Cited Abstract***

1. A. A. Madfa, N. H. Abu Kasim, M. Hamdi, R. G. Rahbari (2010). Microstructural Characteristics of Functionally Graded Materials Designed as Dental Post. Programme book of 9<sup>th</sup> Scientific Meeting IADR Malaysian Section, 5-6 February 2010, UKM.

## **Exhibitions and Awards**

### **2011**

#### **Gold Medal**

New Generation of Dental Post Based on the Concept of Functionally Graded Materials. Noor H. Abu Kasim, Ahmed A. Madfa, Hamdi M., Rahbari R. G.  
International Exposition of Research and innovation of Institutions of Higher Learning (PECIPTA' 2011), 13-15 September, 2011.

#### **Gold Medal**

New Generation of Dental Post Based on the Concept of Functionally Graded Materials. Noor H. Abu Kasim, Ahmed A. Madfa, Hamdi M., Rahbari R. G.  
22<sup>nd</sup> International Invention, Innovation & Technology Exhibition (ITEX' 2011), 20-22 May, 2011.

#### **Invited Exhibitor**

New Generation of Dental Post Based on the Concept of Functionally Graded Materials. Noor H. Abu Kasim, Ahmed A. Madfa, Hamdi M., Rahbari R. G.  
Business bitching, International Exposition of Research and innovation of Institutions of Higher Learning (PECIPTA' 2011), 13-15 September, 2011.

New Generation of Dental Posts for Endodontic Application  
Noor H. Abu Kasim, Ahmed A. Madfa, Hamdi M., Rahbari R.G.  
SEM Innovation Show Case (SMIDEX' 11), 7-9 June, 2011.

### **2010**

#### **Gold Medal and Special Award (Woman BioInnovator of the year)**

New Generation of Dental Posts for Endodontic Application  
Noor H. Abu Kasim, Ahmed A. Madfa, Hamdi M., Rahbari R.G.  
BioMalaysia 2010 (BioInno'2010), 1-3 November, 2010.

### **Gold Medal**

New Generation of Dental Posts for Rehabilitation of Endodontically Treated Tooth.  
Noor H. Abu Kasim, Ahmed A. Madfa, Hamdi M., Rahbari R.G., M. Bayat.  
21<sup>st</sup> International Invention, Innovation & Technology Exhibition (ITEX' 2010), 14-16 May, 2010.

### **Bronze Medal**

A New Multilayer Composite with Functionally Graded Design for Endodontic Application.  
Noor H. Abu Kasim, Ahmed A. Madfa, Hamdi M., Rahbari R.G., M. Bayat.  
3<sup>rd</sup> International Conference on Functional Materials and Devices (ICFMD' 2010), 14-17 June, 2010.

### **Gold Medal**

Development of the Novel Dental Post with the Functionally Graded Design to Restore Endodontically Treated Teeth.  
Noor H. Abu Kasim, Ahmed A. Madfa, Hamdi M., Rahbari R.G., M. Bayat.  
Creativity & Innovation Expo University of Malaya 2010 (Innovation, Creativity Expo' 10), 1-3 April, 2010.

### **Silver Medal**

Functionally Graded Structured Dental Post (FGSP): A Novel Device to Restore Masticatory Function.  
Noor H. Abu Kasim, Ahmed A. Madfa, Hamdi M., Rahbari R.G., M. Bayat.  
Malaysia Technology Expo (MTE'2010), 4-6 February, 2010.

### **Invited Exhibitor**

Development of the Novel Dental Post with the Functionally Graded Design to Restore Endodontically Treated Teeth.  
Noor H. Abu Kasim, Ahmed A. Madfa, Hamdi M., Rahbari R.G., M. Bayat.  
UM Innovation Day, 16- 17 December, 2010.



**2009**

**Bronze Medal**

Development of the Multilayered Graded Structured Dental Post for Root Canal Therapy.

Noor H. Abu Kasim, Ahmed A. Madfa, Hamdi M., Rahbari R.G.

BioMalaysia 2009 (BioInno'2009), 17-19 November, 2009.

**Silver Medal**

Functionally Graded Structured Post (FGSP): A New Approach to Restore of Endodontically Treated Teeth.

Noor H. Abu Kasim, Ahmed A. Madfa, Hamdi M., Rahbari R.G.

International Exposition of Research and innovation of Institutions of Higher Learning (PECIPTA' 2009), 8-10 October, 2009.