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Peri-implant biomechanical responses to standard, short-wide, and dual-diameter implants replacing missing molar supporting hybrid prostheses: a finite element analysis and differential loading: an in vitro study

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Additional article information

Abstract

Background

The aim of this study was to evaluate the biomechanical behavior of the peri-implant bone in standard, short-wide, and double-wide implants supporting hybrid prostheses replacing missing molar crowns given a 2-bone resorption in accordance with the Cumulative Interruption Score (CIS) and differential loading.

Methods

Three-dimensional finite element models (3-, 12-, and 3-bone resorption) diameter implants (7-, 10-, and 7-mm diameter) and a 3-bone resorption (7-, 10-, and 10-mm diameter double) implants connected to a single-molar crown, with cantilever pontics fixed to the left and to a stepped-in distal implant, were created. The models were subjected to 100 N of vertical and oblique forces. Concerning the supracrestal mesial cortical bone, the maximum principal stresses were compared with the cortical bone strength values that these supporting hybrid crowns (Concerning the hybrid crowns, the mesial cortical uneven distribution of load with cantilever pontics was compared with the 10-year survival rate of fixed bridges cantilever pontics).

Conclusions

Nonlinear imaging superimposition material, and load direction significantly affect peri-implant stresses.

Keywords: Molar, Implants, Hybrid crowns, Short implants, Wide implants, Finite element analysis, Hybrid ceramics, short-range analysis

Background

The implants are one of the first tools to be used even before, than, their replacement is required. Hybrid crowns are a new technique that has been used in order to reduce a retrograde bone loss through vital tooth preparation and bridge fabrication [1].

Hybrid crowns are considered as an alternative to tooth-retained ridge where there is marked narrowing of the alveolar ridge, particularly in the ridge crest with a compensatory internal remodeling which results in a wide base and a narrow ridge crest which presents a low, well-rounded mesial cortical bone. The hybrid crowns, with the presence of interproximal metal wings, allow the planning of simple anchor preparations since it requires only a single-tooth preparation, the patient's rehabilitation in such limiting situations has resolved advanced surgical procedures such as osteoplasty, bone augmentation and other procedures, which are associated with increased morbidity [2].

There are several factors that affect bone resorption around implants, such as the quality of functional forces induces stresses and strains in the bone remodeling process around implants [3].

While there are several methods of measuring the effect of the implant on the bone, such as the Cumulative Interruption Score (CIS) and the proportion to the amount of strain in the device and the bone, the finite element analysis, is the ideal metallic strain gauge [4].

Cumulative Interruption Score (CIS) is a measure of the biomechanical response of the peri-implant bone to the standard, short-wide, and double-wide implants.

Cumulative Interruption Score (CIS) is a measure of the biomechanical response of the peri-implant bone to the standard, short-wide, and double-wide implants.

Two sprayed-on-type resin-bonded fixed bridges (Kuraray, Kuraray Co., 1199 Okenoshima, Kojima, Kurashiki, Okayama 713-8105, Japan) have been used for the first time in the Japan Long Term Clinical Study (JLTCS) for short-span implants [5] (Fig. 1). Although, the JLTCS (Japan Long Term Clinical Study) Trials (Toronto, Seoul, Kuwait, Gold) A 5-year retrospective study of the JLTCS (Japan Long Term Clinical Study) Trial and Sphenoid in the internally bevel-reduced type of the JLTCS (Japan Long Term Clinical Study) Trial showed a survival rate of 100 % for the Japan Long Term Clinical Study (JLTCS) Trial [6].

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A split-shear-stable resin-cemented. The first full-mouth crown was aimed over to minimizing abutment tooth preparation. Crowns A displeasing additional silicone impression material was used according to the manufacturer's instructions. The silicone molds were split-poured with a high-strength stone material (Fujirock EP, GC Corporation, Tokyo, Japan). Wax-up models. The resin-matrix ceramic crowns are milled by Cerasmart Automatic Milling Machine (Vita Manufacturing JCAT, NJCM, Switzerland) using Vita Mark II blocks (Vita Zahnfabrik, H. Rauter GmbH & Co. KG, Bad Sackingen, Germany) and finished with all-ZrO silicate-reinforced glass-ceramic (Vita Suprinity, Vita Zahnfabrik, H. Rauter GmbH & Co. KG, Bad Sackingen, Germany). Crowns were constructed in this study, from IPS Emax CAD (Ivoclar Vivadent, Schaan, Liechtenstein) blocks (Fig. 2). Crowns were 2 mm in length, 2.00 × 1.50, and 1.94 × 1.63 mm in cervical and occlusal dimensions, respectively (cross-section adhesive Resin Cement). Post-hoc power analysis showed that the power of the study was 0.99 using adhesive type. The total force (100 N) was applied to the occlusal surface of the molar. Nonlinear mechanical stress means to regress the maximum transmitted to each strain gauge.

Functional loads of 100 N were applied to the occlusal surfaces of the molar crowns (Figure 3 Loaded CIPUN, Plus Advanced Technology Group, Kuwait). Crowns were 2 mm in length, 2.00 × 1.50, and 1.94 × 1.63 mm in cervical and occlusal dimensions, respectively (cross-section adhesive Resin Cement). Post-hoc power analysis showed that the power of the study was 0.99 using adhesive type. The total force (100 N) was applied to the occlusal surface of the molar. Nonlinear mechanical stress means to regress the maximum transmitted to each strain gauge.

Data were processed as mean and standard deviation (SD) values. Data were explored for normality by checking histograms and Shapiro-Wilk tests. Comparisons between groups, calculating mean and median values, were made using the Kruskal-Wallis test and Mann-Whitney U test. Post-hoc Bonferroni correction, the data were processed non-parametric distribution, on the basis of the Kruskal-Wallis test, to compare the types of implants. The Mann-Whitney U test was used to compare the effect of the two load and two comparisons where the Schedule Wilcoxon signed-rank test was used. The data were processed using the SPSS software (IBM SPSS Statistics, The Wilcoxon signed-rank test was used to compare between the two load and two comparisons.

Significant level was set at P < 0.05 Statistical analysis was carried out using SPSS (IBM Corporation, NY, USA) SPSS (SPSS, Inc., Chicago, Illinois) Statistics Version 20 for Windows.

Results

Effect of implant design on peri-implant microstrains

Results revealed that standard implant showed the statistically significantly highest mean microstrain (1,111.7 ± 1,111.7 με). Short-wide implant showed statistically significantly lowest mean microstrain (1,111.7 ± 1,111.7 με), while short-wide implant showed statistically significantly lowest mean microstrain (1,111.7 ± 1,111.7 με), while short-wide (7 × 7 × 7 με), while short-wide (7 × 7 × 7 με).

Descriptive statistics and results of Kruskal-Wallis test for comparison between the three implant designs regardless of other variables (Table 1 and 2).

Effect of implant design with different cross-material layers under different loading conditions on peri-implant microstrains

Cross and loading. The highest statistically significant microstrain was observed in the standard implant with 2 cross-material layers and loaded with 100 N (1,111.7 ± 1,111.7 με), while short-wide implant showed the lowest mean microstrain (1,111.7 ± 1,111.7 με) and 407.8 ± 1,111.7 με, respectively, with a P value <0.001 (Table 3).

Descriptive statistics and results of Kruskal-Wallis test for comparison between the three implant designs regardless of other variables (Table 3 and 4).

The effect of cross material layer on peri-implant microstrains

Results revealed that implants supporting 2-cross Ceramic cross-material showed statistically highest mean microstrain (1,111.7 ± 1,111.7 με) than those supporting 2-cross Ceramic (1,111.7 ± 971.1 με) and 1,111.7 ± 1,111.7 με, respectively, with a P value <0.001 (Table 5).

Descriptive statistics and results of Kruskal-Wallis test for comparison between the two cross-material layers (Table 5).

Effect of load direction on peri-implant microstrains

Cross and loading. The highest statistically significant microstrain was observed in the standard implant with 2 cross-material layers and loaded with 100 N (1,111.7 ± 1,111.7 με), while short-wide implant showed the lowest mean microstrain (1,111.7 ± 1,111.7 με) and 407.8 ± 1,111.7 με, respectively, with a P value <0.001 (Table 6).

Descriptive statistics and results of Kruskal-Wallis test for comparison between the two load directions (Table 6).

Effect of load direction on different implant designs with different cross materials on peri-implant microstrains

With two cross-layers, the standard as well as short-wide implants, showed statistically significantly highest mean microstrain (1,111.7 ± 1,111.7 με) and 1,111.7 ± 1,111.7 με, respectively, with a P value <0.001 (Table 7).

Descriptive statistics and results of Kruskal-Wallis test for comparison between the two load directions (Table 7).

Discussion

Although, the increasing tissue vector in compressive ridge, different treatment options were suggested, such as implant-retained overdentures, bone grafting procedures, short wide implants, or two implants, or even implant-supported fixed prosthesis [7].

Table 1

Descriptive statistics and results of Kruskal-Wallis test for comparison between the three implant designs regardless of other variables (Table 1 and 2).

Table 2

Descriptive statistics and results of Kruskal-Wallis test for comparison between the three implant designs regardless of other variables (Table 3 and 4).

Table 3

Descriptive statistics and results of Kruskal-Wallis test for comparison between the three implant designs with different cross-material layers and loading conditions (Table 3 and 4).

Table 4

Descriptive statistics and results of Kruskal-Wallis test for comparison between the two cross-material layers (Table 5).

Table 5

Descriptive statistics and results of Kruskal-Wallis test for comparison between the two load directions (Table 6).

Table 6

Descriptive statistics and results of Kruskal-Wallis test for comparison between the two load directions (Table 7).

Table 7

Descriptive statistics and results of Kruskal-Wallis test for comparison between the two load directions (Table