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The use of a masticatory robot to analyze the shock absorption capacity of different restorative materials for implant prosthesis

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Abstract

The aim of the present research was to measure in vitro the chewing load forces transmitted through crowns made of different prosthetic restorative materials onto the dental implant. A masticatory robot that is able to reproduce the mandibular movements and the forces exerted during mastication was used. The forces transmitted to the simulated periimplant bone during the robot mastication were analyzed, using different occlusal materials. Two-way analysis of variance (ANOVA) was used. The zirconia and the ceramic crowns transmitted significantly greater forces (p-value < 0.0001) than the other crowns tested. Dental materials with lower elastic modulus were better able to absorb shock from occlusal forces than more rigid materials.

Introduction

The occlusal load is a critical factor in reaching and maintaining osseointegration, and therefore affecting the long term survival of dental implants. The restorative material used in dental implants may be one of the factors affecting the forces transmitted to the periimplant bone [1-3]. The aim of the present study is to investigate *in vitro* the shock absorption capacity of dental restorative materials currently in use.

Materials and Methods

A masticatory robot was used, which is able to simulate human chewing *in vitro*, reproducing three-dimensionally the masticatory movements and the loads exerted during mastication. The robot, which simulates an implant setup, has been described and validated in a previous paper [1]. The materials tested were: zirconia (Procera), a glass ceramic (Empress 2), a gold alloy (Ney-Oro cb), two composites (Experience, Signum), an acrylic resin (Easytemp 2) (Tab. 1). Each crown was positioned on the implant abutment simulation of the robot and placed under 350 chewing cycles with the sample crown occluding with the chrome-cobalt steel upper arch (Fig. 1).

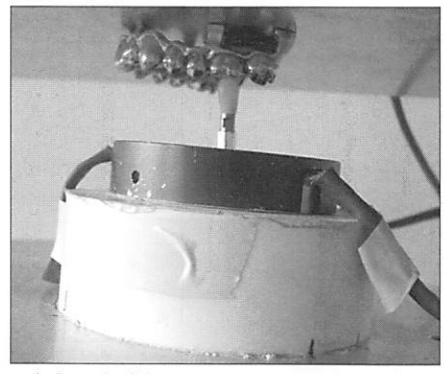

Figure 1. Detail of the sensor-equipped masticatory robot

Vertical loads transmitted at the simulated bone-implant interface were recorded. The maximum values of the forces recorded for each masticatory cycle were highlighted and underwent statistical analysis with SPSS software (Version 13.0, SPSS Inc.). Two-way analysis of variance (ANOVA) was used to compare transmitted stresses between the different occlusal materials tested. Alpha was set at .05.

Results

The ANOVA test found a significant ratio between the variations and so Scheffe's post hoc test was applied: within the materials an internal comparison showed a significant result with p-value <0.0001 (Tab. 1).
The slope of the curve, representing the force transmitted at the periimplant level, showed that materials with greater elastic modulus have steeper peaks than the other materials, that is that the maximum force is reached more rapidly.

Materials tested	Manufacturer	Elastic Modulus (MPa)	Mean (kg)	Dev. Std.	Err. Std	%
Procera Zirconia	Nobel Biocare	210000	39.529	1.378	0.097	-
Empress 2	Ivoclar Vivadent	96000	30.127	0.572	0.031	- 23.79
Ney-Oro cb	Dentsply	77000	20.761	1.207	0.070	- 47.48
Experience	DEI@italia	13000	17.491	1.085	0.058	- 55.75
Signum	Heraeus Kulzer	3500	9.510	0.507	0.027	- 75.94
Easytemp 2	DEI@italia	2300	2.471	0.663	0.035	- 93.75

Table 1. Comparison of mean maximum occlusal force (kg).

Discussion

The use of different restorative materials significantly affected stress transmission at the simulated bone-implant interface. In fact the masticatory robot recorded values of forces transmitted significantly higher when using materials with higher elastic modulus with respect to other materials. Zirconia and ceramic crowns also showed steeper peaks of force than the other materials. This was considered another effect of the different elastic modulus of the materials tested. Acrylic resin was able to reduce the forces transmitted at the simulated bone-implant interface up to -93.75% with respect to zirconia. It is the authors opinion that these findings should be taken into consideration in clinical decision making especially in the clinical situations (such as immediate loading protocols) and in particular unfavourable conditions (such as parafunctions) when implant loading needs to be limited. The use of an acrylic resin provisional prosthesis or a definitive composite resin prosthesis is essential in such situations to reduce the risk of overload in a critical moment for the obtainment or maintenance of osseointegration.

References

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