The Use of a Masticatory Robot to Analyze the Shock Absorption Capacity of Different Restorative Materials for Prosthetic Implants: A Preliminary Report

Enrico Conserva, DDS, PhD[a]/Maria Menini, DDS[b]/Tiziano Tealdo, DDS, PhD[c]/Marco Bevilacqua, DDS[b]/Giambattista Ravera, PhD[d]/Francesco Pera, DDS[b]/Paolo Pera, MD, DDS, PhD[e]

Purpose: This study was conducted to measure, in vitro, the chewing load forces transmitted through crowns made of different prosthetic restorative materials onto dental implants. ***Materials and Methods:*** A masticatory robot capable of reproducing the mandibular movements and the forces exerted during chewing was used. The forces transmitted to the simulated peri-implant bone during the robot mastication were analyzed using four different occlusal materials: three resin composites and one glass ceramic crown. ***Results:*** The ceramic crowns transmitted significantly greater forces (up to +63.06%, $P < .0001$) than the composite crowns tested. ***Conclusion:*** Composite crowns are better able to absorb shock from occlusal forces than crowns made of ceramic material. *Int J Prosthodont 2009;22:53–55.*

Occlusal load is a critical factor in reaching and maintaining osseous integration. The restorative material used in dental implants may be one of the factors affecting the forces transmitted to peri-implant bone.[1–5] The aim of this study was to verify whether the stress transmitted by the prosthetic implant to the surrounding bone is different when using a ceramic restoration rather than one composed of a composite material.

Materials and Methods

A masticatory robot was used to aid in determining the effect restorative materials may have on occlusal loads. This robot 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, is able to record the forces transmitted to the simulated peri-implant bone on the vertical z-axis, the laterolateral x-axis, and the anteroposterior y-axis, as described in a previous paper.[5]

Three different composites (Adoro, Ivoclar Vivadent; Experience, DEI italia; and Signum, Heraeus Kulzer) and a glass ceramic (Empress 2, Ivoclar Vivadent) were tested (Table 1). Two identical metal-free crowns were made for each material tested, as described in a previous paper.[5]

One crown of each material tested was placed under 350 chewing cycles with the sample occluding with the flat fixed upper part of the masticatory robot (test 1). This predominantly measures vertical loads. The other crown of each material was placed under 350 chewing cycles occluding with the chrome-cobalt steel simulation of the maxilla fixed on the upper part of the robot (test 2), thus measuring the transversal stresses produced during mastication. The only variable in the system was the material from which the crowns were made.

Statistical analysis was done using SPSS version 13.0.

Table 1 Elastic Modulus of Tested Materials

Trade name	Material	Manufacturer	Elastic modulus (MPa)
Empress 2	Glass ceramic	Ivoclar Vivadent	96,000
Experience	Composite	DEI italia	13,000
Adoro	Composite	Ivoclar Vivadent	7,000 ± 500
Signum	Composite	Heraeus Kulzer	3,500

[a]*Assistant Professor, Department of Fixed and Implant Prosthodontics, Genoa University, Genova, Italy; Private Practice, Albenga, Italy.*
[b]*Lecturer, Department of Fixed and Implant Prosthodontics, Genoa University, Genova, Italy.*
[c]*Assistant Professor, Department of Fixed and Implant Prosthodontics, Genoa University, Genova, Italy.*
[d]*Professor and Chair, Department of Health Sciences, Section of Biostatistics, Genoa University, Genova, Italy.*
[e]*Professor and Chair, Department of Fixed and Implant Prosthodontics, Genoa University, Genova, Italy.*
Correspondence to: *Dr Enrico Conserva, Via Mazzini 45/4 17031 Albenga (Sv), Italy. Fax: +390-182555144. E-mail: studioconserva@libero.it*

Table 2 Mean Values of Force Peaks Registered on the z-, x-, and y-axes

	z		x		y	
Material	Mean (kg)	95% CI	Mean (kg)	95% CI	Mean (kg)	95% CI
Empress 2	59.784	59.299–60.270	17.782	17.664–17.900	7.438	7.410–7.466
Experience	36.484	36.453–36.515	11.228	11.130–11.325	4.388	4.358–4.417
Adoro	29.130	28.755–29.505	8.499	8.464–8.534	3.606	3.576–3.637
Signum	22.429	22.397–22.461	6.568	6.528–6.608	2.930	2.921–2.938

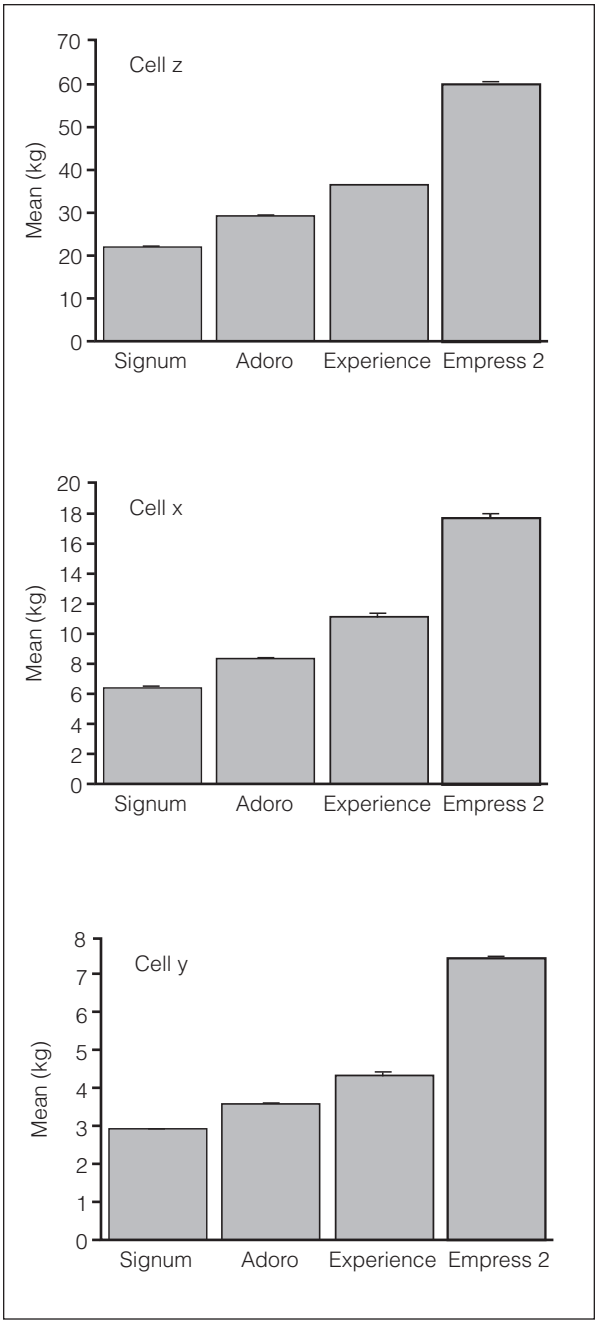

Fig 1 Mean (kg) maximum loads recorded (95% CI, $P < .0001$).

Table 3 One-way ANOVA Comparison between the 4 Occlusal Materials for the z-, x-, and y-axes

Source of variation	*df*	Mean square	F	*P*
z-axis				
Between materials	3	92,589.606	10,829.225	< .0001
Residual	1,396	8.550		
x-axis				
Between materials	3	8,393.267	14,106.999	< .0001
Residual	1,396	0.595		
y-axis				
Between materials	3	1,385.491	22,986.372	< .0001
Residual	1,396	0.060		

Results

In the first test, the statistical evaluation of the force peaks recorded on the vertical z-axis showed mean values of 59.784 kg for the Empress 2 ceramic, 36.484 kg for Experience, 29.130 kg for Adoro, and 22.429 kg for Signum (Table 2, Fig 1).

In the second test, the statistical evaluation of force peaks recorded on the horizontal x- and y-axes showed mean values of 17.782 kg and 7.438 kg, respectively, for the Empress 2 ceramic. The composite materials Experience, Adoro, and Signum showed mean values of 11.228 kg and 4.388 kg, 8.499 kg and 3.606 kg, and 6.568 kg and 2.930 kg, respectively (Table 2, Fig 1).

One-way analysis of variance (ANOVA) testing revealed significant differences between the materials (Table 3). Scheffe post hoc test showed that each comparison within materials for each axis was significant ($P < .0001$). In both tests, the slope of the curve, representing the force transmitted at the peri-implant level, shows that the ceramic has steeper peaks than the other materials, that is, that the maximum force is reached more rapidly.

Discussion

The results of the experiments described in this paper are in agreement with Hooke's law, which states that the strain ϵ of an object is linearly proportional to the stress σ applied to it ($\epsilon = \sigma/E \rightarrow E = \sigma/\epsilon$, where E is the elastic modulus, or Young's modulus). In fact, the

values of transmitted forces for the ceramic were always significantly higher than those for the composite materials.

The ceramic showed steeper force peaks than any of the composite materials. This was also demonstrated by Soumeire and Dejou[4] and was considered to be another effect of the different elastic modulus of the materials.

The composite Signum was able to reduce the force transmitted to the simulated peri-implant bone up to –62.48% on the vertical z-axis, up to –63.06% on the x-axis, and up to –60.61% on the y-axis with respect to the ceramic.

Conclusions

From the data collected, it is possible to draw several conclusions. A ceramic crown placed under a load transmitted higher stress to the abutment below and at the simulated bone-implant interface than crowns made of composite materials. Composite crowns, most likely due to their lower elastic modulus, are better able to absorb shock from occlusal forces.

Acknowledgments

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Literature Abstract

Clinical and radiographic evaluation of one- and two-visit endodontic treatment of asymptomatic necrotic teeth with apical periodontitis: A randomized clinical trial

The aim of this randomized clinical trial was to record the 2-year clinical and radiographic outcome of one- and two-visit endodontics performed on a previously studied group of patients and to study the significance of microbiologic sampling results on the outcome of treatment. Patients with asymptomatic teeth with necrotic pulps and apical periodontitis, as verified radiographically, were consecutively enrolled in the study. Using tooth group and size of periapical lesions as the 2 randomization factors, patients were randomly assigned to one- or two-visit treatment groups using the "minimization method". Ninety-four patients with 101 eligible teeth consented to participate in the study. Each tooth was isolated with rubber dam and disinfected with 30% hydrogen peroxide and 10% iodine tincture. For both treatment groups, the working length was established radiographically after access preparation and apical boxes prepared up to size ISO #40 and #60, depending on the size of the root. Canals were irrigated with 0.5% NaOCl during instrumentation. Post-instrumentation microbiological samples were obtained immediately after completion of the chemomechanical preparations. For the one-visit group, canals were filled with Tubulicid Plus for 20 seconds, dried with paper points, and refilled for another 20 seconds. Subsequently, the canals were filled with 5% iodine-potassium-iodide (IPI) solution for 10 minutes. A post-medication microbiologic sample was obtained prior to gutta percha obturation and rosin chloroform sealer. For the two-visit group, calcium hydroxide (CH) was placed in the root canals and sealed. After one week, the CH was removed and irrigation was done with VMGA I. A post-medication microbiologic sample was obtained before obturation as per the one-visit group. Four endodontists performed treatment. All preoperative and follow-up radiographs were coded blind and randomly organized. Two independent examiners evaluated the radiographs. In case of disagreement, joint reevaluation was done until a consensus was reached. Outcome of treatment was classified using the modified Strindberg criteria. Twelve teeth were lost to follow-up. Thirty-two teeth (65%) in the one-visit group and 30 teeth (75%) in the two-visit group were classified as healed. Thirteen teeth (27%) in the one-visit group were deemed healing uncertain as compared to 5 (13%) in the two-visit group. Four teeth (8%) in the one-visit group and 5 teeth (12.5%) in the two-visit group were unhealed. Forty-nine of 61 teeth (80%) obturated after a negative bacteriological sample were healed while 12 of 27 teeth (44%) that showed positive samples healed. The authors found no statistically significant difference in healing outcomes between the one- and two-visit treatment modalities ($P = .75$). They also reported a tendency toward a more favorable outcome in teeth yielding a negative culture immediately before obturation. Hence, they suggested that postmicrobiologic sampling could replace radiographically based long-term studies and be used as a surrogate end-point.

Molander A, Warfvinge, Reit C, Kvist T. *J Endod* 2007;33:1145–1148. **References:** 33. **Reprints:** Dr Anders Molander, Clinic of Endodontics, Public Health Service, Medicinaregatan 12, SE 413 90, Gothenburg, Sweden. Email: anders.molander@odontologi.gu.se—*Elvin W.J. Leong, Singapore*