Use mouthguard for protecting dental Implants from Impact - Experimental and Finite Element Analysis

Soares Carlos*, Carvalho Valessa, Verissimo Crisnicaw, Pessoa Roberto, Versluis Anthony, Soares Priscilla

Federal University of Uberlândia, MG, Brazil

The University of Tennessee Health Science Center, TN, EUA

Abstract

Background: Rehabilitation with dental implants has been frequent in athletes with extensive activity that involves contact sports. The use of mouthguards can reduce the incidence and severity of sports-related oral injuries.

Aim: The purpose of this study was to evaluate mouthguard shock absorption ability, strain, and stress generation during impact on dental implants placed in the anterior maxilla. The mouthguard material was also characterized.

Materials and Methods: Sixty experimental models were created and divided into six groups (n = 10): implant type, external hexagon (EH) and Morse taper (MT); without and with two mouthguards (MTG), EVA custom-fitted (Ct-MTG) and standard self-adapted (St-MTG). The Shore A hardness, EVA sheet and mouthguard thickness, and elastic modulus were measured to characterize the mouthguard material. A strain gauge was attached to the palatal surface of the implant abutment, which was subjected to an impact test. Distortion of the abutment and implant was determined after impact from centroid displacements in standardized radiographic images. Two-dimensional finite element models were created to represent the six groups and were submitted to nonlinear dynamic impact analysis. The data were statistically analyzed using analysis of variance (ANOVA) and Tukey test (significance = .05).

Results: Ct-MTG resulted in higher Shore A hardness ($P < .001$). After the heat-forming process, the St-MTG maintained the original thickness, but the Ct-MTG thickness had decreased. The elastic modulus of EVA was 18.1 ± 0.5 MPa. The mouthguard presence reduced strain values significantly ($P < .001$), particularly for Ct-MTG. There was no significant difference between implant connection types EH and MT ($P = .547$).

Conclusions and Clinical Implications: The external hexagon abutment resulted in higher stress and micro-displacement values. The mouthguard was able to absorb 40% to 46% of the energy caused by the impact on the dental implant. This study supported the importance of the use of MTG for shock absorption for patient rehabilitated with dental implant. It was evident that the material Ct-MTG thermoforming suffers thickness reduction, being necessary to use 2 sheets for a better result, especially in anterior teeth.

Methods and Materials

1 Sample Preparation

2 Characterization of MTG Material: Thickness, Shore A Hardness, and Elastic Modulus

3 Mouthguard Fabrication

4 Impact Test: Strain Values of Implant and Shock Absorption

5 Implant-Abutment Distortion Test

6 Finite Element Analysis

Results

Material	Elastic modulus (MPa)	Poisson's ratio	Density (g/cm ³)
Polyurethane F16	1.0 ^a	0.25	1.053
Acrylic resin	2.7 ³⁰	0.30	1.247
Titanium	110 ³¹	0.33	4.50
EVA (Bio-art)	18.1 ^b	0.30	0.95
Steel	200 ³²	0.30	7.8

^aData from manufacturer.

^bExperimental data.

Mouthguard	Connection type	
	MT	EH
Ct-MTG	-88.0 ± 26.3 ^{Ab}	-103.0 ± 27.8 ^{Ab}
St-MTG	-147.5 ± 21.4 ^{Ab}	-145.8 ± 38.1 ^{Ab}
Without MTG	-175.4 ± 46.3 ^{Ac}	-180.1 ± 29.4 ^{Ac}

Mouthguard	Connection type	
	MT	EH
Ct-MTG	-47.2	-191.6
St-MTG	-47.7	-186.7
Without MTG	-80.0	-347.4

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Conclusion

This in vitro and computational study concluded that:

- The use of mouthguard has significant effectiveness in shock absorption in patients rehabilitated with dental implants;
- A micro-displacement in the implant-abutment was significantly higher without the mouthguard;
- Despite the satisfactory results of St-MTG, the Ct-MTG is better indicated;
- The Ct-MTG shore A hardness values were higher than the St-MTG values;
- EH and MT implant stress during the impact analysis were very close; however, the EH abutment had the highest stresses;
- The MT connection presented better stability and had less shock effect when associated with the use of a mouthguard.

References

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