Mechanical and Microstructural Properties of Monolithic Zirconia:
Crown Fracture Resistance and Impact of Low-Temperature Degradation

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av

Keisuke Nakamura

Fakultetsopponent: Docent Per Vult von Steyern
Odontologiska fakulteten, Malmö högskola

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I. Nakamura, K., Adolfsson, E., Milleding, P., Kanno, T., Örtengren, U. (2012) Influence of grain size and veneer firing process on the flexural strength of zirconia ceramics. *Eur J Oral Sci* 120: 249-254
II. Nakamura, K., Harada, A., Ono, M., Shibasaki, H., Kanno, T., Niwano, Y., Adolfsson, E., Milleding, P., Örtengren, U. (2015) Effect of low-temperature degradation on the mechanical and microstructural properties of tooth-colored 3Y-TZP ceramics. Submitted for publication.
III. Nakamura, K., Harada, A., Inagaki, R., Kanno, T., Niwano, Y., Milleding, P., Örtengren, U. (2015) Fracture resistance of monolithic zirconia molar crowns with reduced thickness. *Acta Odont Scand*, E-pub ahead of print
IV. Nakamura, K., Mouhat, M., Nergård J.M., Lægreid, S.J., Kanno, T., Milleding, P., Örtengren, U. (2015) Effect of cements on fracture resistance of monolithic zirconia crowns. Submitted for publication.
V. Nakamura, K., Harada, A., Kanno, T., Inagaki, R., Niwano, Y., Milleding, P., Örtengren, U. (2015) The influence of low-temperature degradation and cyclic loading on the fracture resistance of monolithic zirconia molar crowns. Submitted for publication.

UNIVERSITY OF GOTHENBURG

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Keisuke Nakamura
Department of Prosthetic Dentistry/Dental Materials Science, Institute of Odontology, Sahlgrenska Academy at University of Gothenburg, Göteborg, Sweden

Zirconia has been widely used in dentistry to improve the strength of ceramic restorations maintaining aesthetics. In addition, zirconia is increasingly being used for monolithic crowns without veneering porcelain. However, there is a lack of scientific information regarding whether or not monolithic zirconia crowns can function with sufficient durability, especially in the molar regions. The overall aim of this thesis was to analyze factors that would affect mechanical and microstructural properties of monolithic zirconia crowns.

Material testing was performed to evaluate the influence of sintering temperature, additional heat treatment, coloring procedure and autoclaving-induced low-temperature degradation (LTD) on the biaxial flexural strength of zirconia. Additional heat treatment did not reduce the strength, but the strength was found to decrease as the sintering temperature increased. The tooth-colored zirconia possessed equivalent strength to the non-colored zirconia. In addition, X-ray diffraction analysis and scanning electron microscopy showed that the tooth-colored zirconia had higher resistance to LTD.

Crown fracture testing showed that the fracture resistance of the monolithic zirconia crowns with an occlusal thickness of 0.5 mm was significantly higher than that of lithium disilicate crowns with an occlusal thickness of 1.5 mm. The types of cements did not significantly affect the fracture resistance of monolithic zirconia crowns. When subjected to autoclaving-induced LTD, the fracture resistance of the monolithic zirconia crowns significantly decreased. By contrast, cyclic loading with a load of 300 N for 240,000 cycles did not significantly affect the fracture resistance of the crowns.

The knowledge obtained by the laboratory studies performed suggests that monolithic zirconia crowns with a minimal thickness of 0.5 mm will have the capability of being applied to the molar region with sufficient durability, providing there is a properly controlled fabrication process to avoid unexpected degradation of the material.

Keywords: zirconia, flexural strength, microstructure, fracture resistance, monolithic crown, low-temperature degradation, phase transformation
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