Fractographic Analysis of Different Commercially Available Zirconia Blocks for CAD/CAM Technology

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Abstract

Purpose: The purpose of this study was to perform fractographic analysis to evaluate crack behavior of commercially available zirconia for CAD/CAM technology. **Methods:** Four different commercially available zirconia blocks (IPS e.max ZirCAD, 3M™ Chairside Zirconia, CEREC® Zirconia & KATANA™ Zirconia) sliced into discs. Specimens were sintered and polished. Specimens were then indented under a 98N load, thermally etched, ultrasonically cleaned and gold coated prior to SEM examination. Crack patterns were analyzed on digital images. **Results:** Crack patterns analyses showed that the ratio of trans-granular to intergranular fracture was affected by the sintering temperature and the different phase composition of the different blocks. **Conclusion:** Crack patterns are strongly influenced by the crystalline phase composition of the material. Following the recommended manufacturer's sintering temperature is crucial for predictable outcomes and therefore better clinical performance.

Introduction

Zirconia ceramics for dental restorations are commonly machined by grinding of pre-sintered blocks and then sintered at temperatures ranging from 1350 and 1650˚C for durations between 1 and 5 hours depending on the manufacturer. The most predictable outcomes are achieved when sintering is performed from 1500-1550˚C[1].

One key factor that determines the clinical performance of restorations made of dental zirconia is the presence of processing flaws created either at the fabrication stage or during chair side adjustments. The presence of flaws and microcracks is likely to be detrimental to their short and/or long-term performance[2,3,4].

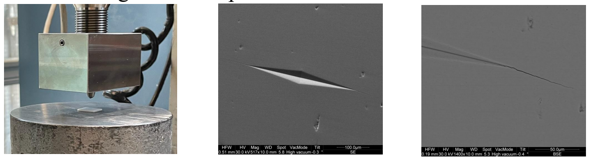
Fractographic analysis of two-phase zirconia ceramics showed that regions with high tetragonal phase fracture inter-granularly, while regions with high amount of cubic phase fracture trans-granularly. High amounts of tetragonal phase, which fracture inter-granularly, is indicative of improved mechanical properties and therefore better clinical performance[5].

Methods

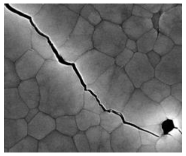
- Four different commercially available zirconia blocks (IPS e.max ZirCAD, 3M™ Chairside Zirconia, CEREC® Zirconia & KATANA™ Zirconia) were sliced into discs 1.25 mm thick using a low-speed diamond saw.

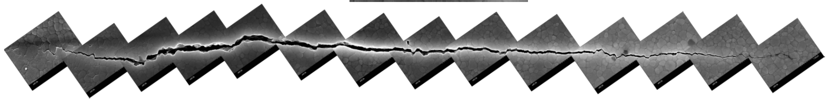
- Specimens (*n*=5 per group) were sintered following manufactures' recommendation. Specimens were polished to a mirror polish using a series of abrasives ending with a diamond polishing suspension.

- Polished specimens were indented using Knoop indenter under a 98N load. Specimens were thermally etched, ultrasonically cleaned and gold coated prior to SEM examination.



- Crack patterns were analyzed on digital images. The length ratio of trans-granular to intergranular fracture were determined.





Results

Crack patterns analyses showed that the ratio of trans-granular to intergranular fracture was affected by the sintering temperature and the different phase composition of the different blocks.

Sintering Temperature (℃)	% Intergranular fracture	% Transgranular fracture
3M™Zirconia 1500	22.4 ± 1.1	77.6 ± 1.1
CEREC® Zirconia 1510	21.6 ± 1.4	78.4 ± 1.4
IPS e.max ZirCAD 1520	20.5 ± 1.3	79.5 ± 1.3
KATANA™ Zirconia 1550	17.9 ± 1.2	82.1 ± 1.2

Discussion

Results showed that the proportion trans-granular fracture increased with sintering temperature. This can be explained by the larger amount of cubic phase, which has been shown to lead to trans-granular indentation crack patterns. In addition, the cubic phase exhibits lower fracture toughness and is therefore more likely to fracture trans-granularly

Conclusions

Crack patterns are strongly influenced by the crystalline phase composition of the material. Following the recommended manufacturer's sintering temperature is crucial for predictable outcomes and therefore better clinical performance.

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