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Biomaterials Research Report

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Machinability of n!ce® Block on a Cerec® inLab MC XL Mill

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Introduction:

The machinability of new ceramic materials on current milling hardware is a hot topic for the ever-changing digital dental materials landscape. Swiss-based Straumann recently introduced ***Straumann® n!ce***, a high-strength lithium aluminosilicate CAD-CAM block which claimed to be compatible with current milling programs while requiring no additional post-processing other than polishing. We tested these claims by milling this new material on a ***Cerec® inLab MC XL*** and compared the machinability to ***IPS e.max CAD*** using the same milling parameters and 12S step bur and 12S cylinder pointed burs. We looked at important properties for milling restorations like machining accuracy, machining damage, minimum thickness, surface roughness and polishing time.

Conclusions:

Machining the ***n!ce*** block on the ***inLab MC XL*** mill ***showed equivalent results*** to ***IPS e.max CAD*** in its ability to be milled with similar minimum wall thickness, surface roughness, machining damage and accuracy. Combined, these results suggest that the ***n!ce*** block could be used with a similar restoration design and workflow as ***IPS e.max CAD*** with the ***inLab MC XL, but without an additional crystallization step.***

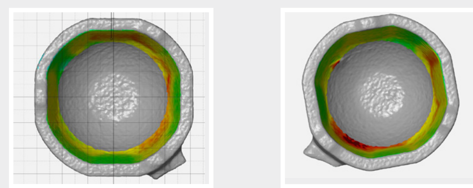
Machining Accuracy:

Being able to machine a material to high accuracy is an important consideration for material and mill combinations. We applied the ISO TR 18845 method to evaluate the machining accuracy of ***n!ce*** and ***IPS e.max CAD*** by milling standardized crown specimens with a diameter of approximately 12 mm and a height of 10 mm, with flat sections 1 mm thick and a 6° wall angle. Milled crowns were scanned and compared to the original design file in FOM-Inspect software to measure any discrepancy with 5 different surface measurements.

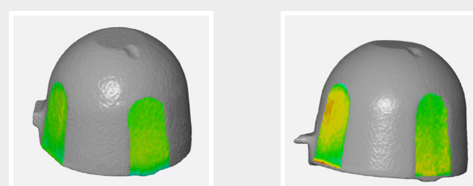
Machining Accuracy Discrepancy					
Material	Intaglio Lateral, µm	External Lateral, µm	Intaglio Z-Direction, µm	External Z-Direction, µm	Prep-line, µm
n!ce	47 (42)	3 (37)	25 (53)	9 (31)	-34 (40)
IPS e.max CAD	34 (31)	14 (28)	21 (48)	8 (24)	-28 (36)

Comparable mean accuracy results were found with both milled materials, and both were below 50 µm. The large standard deviations are a result of the calculation taking in account local minimums and maximums which varied +/- ~100 µm in some areas. Similar accuracy should be expected when milling each material using the ***inLab MC XL*** mill.

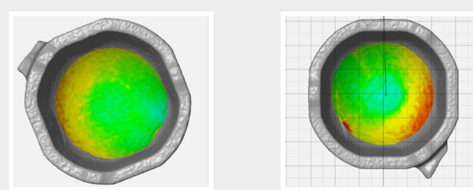
n!ce | IPS e.max CAD



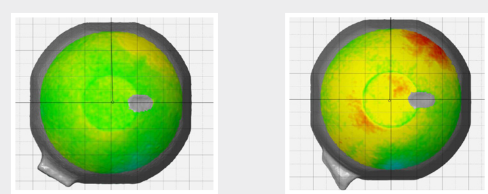
Specimen intaglio surface plane in the lateral direction.



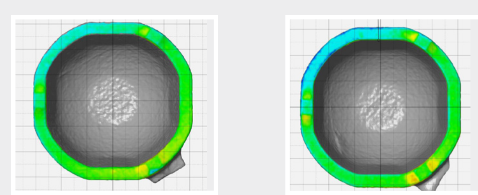
Specimen external surface plane in the lateral direction.



Specimen intaglio surface plane in the Z-direction.



Specimen external surface plane in the Z-direction.

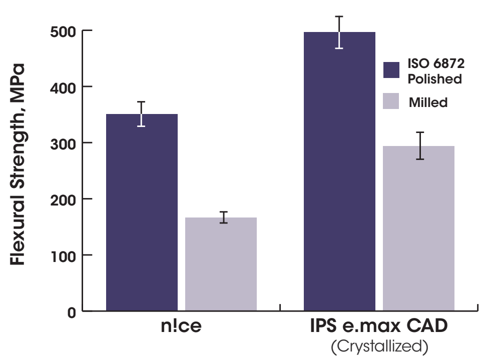


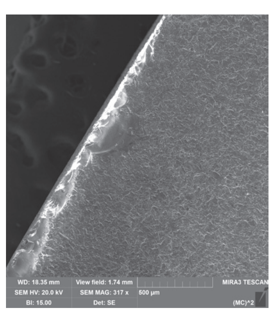
Specimen prep-line surface in the Z-direction.

Flexural Strength:

Machining any ceramic will introduce flaws and microfractures, which can reduce the overall strength of the resulting restoration. Polishing the restoration can minimize the critical flaws where fractures initiate, leading to a higher strength. To test the effect the machining damage has on these materials, we measured the 3-pt bend flexural strength of milled ***n!ce*** bars (2 x 4 x 16 mm) and milled, crystallized ***IPS e.max CAD*** bars without any polishing as the worst-case scenario, and compared this to standard ISO 6872 wafer cut and polished bars under ideal conditions as a positive control. It should be noted that, unlike crowns, flexural strength bars have four right angles which can increase the chipping factor of milled bars (see below). This results in a lower strength than might be expected clinically.

Both materials showed a drop in flexural strength as expected, with ***IPS e.max CAD*** dropping about 40% and ***n!ce*** block dropping 50%. In both materials, the ISO 6872 tested values are very close to the manufacturer stated values, thus confirming those results.





Edge damage of an ***IPS e.max CAD*** flexual strength bar after milling.

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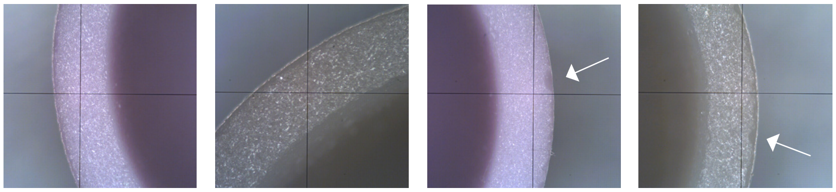
Machinability:

An important factor for the compatibility of milling a material is whether the material will withstand the forces of milling without fracturing or chipping. This can result in wasting materials with excessive remakes, or force-changing restoration designs to have a higher minimum wall thickness. Excessive chipping can require more extensive polishing of the margins, which can affect the restoration's fit. We tested how well the ***n!ce*** block mills with an ***IPS e.max CAD*** profile using methods proposed in a new ISO/TS 18675 test method to measure the chipping factor and minimum wall thickness.

Chipping factor is determined by milling standardized crown shapes with 1 mm thickness and examining the margin surface under a microscope to detect any chips or flakes greater than 0.1 mm in size. The total length (L) of the chipped areas is divided by the perimeter length (P) to give a chipping factor (CF = L/P).

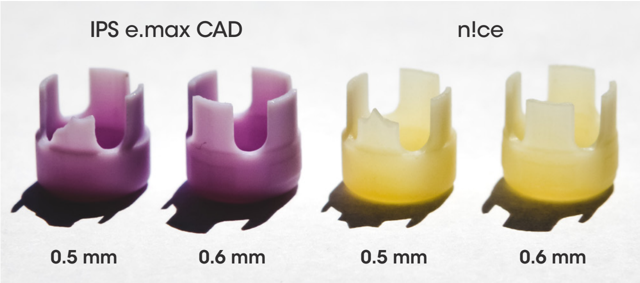
After examining five crowns of each material, we measured a nearly identical number and length of chips for both the ***n!ce*** and ***IPS e.max CAD*** blocks. The shallow chips were found over approximately 1% of the circumference and were difficult to see without magnification.



No chips - ***IPS e.max CAD*** No chips - ***n!ce*** One chip - ***IPS e.max CAD*** One chip - ***n!ce***

Merlon Fracture Test: Minimum wall thickness is measured by machining hollow cylinders with four distinct free-standing walls called merlons, and another wall at the base of the cylinder to determine at what thickness the material can survive the machining process. Specimens were machined per 0.1 mm wall thickness until a 100% success rate was determined.

The ***n!ce*** and ***IPS e.max CAD*** materials showed identical success rates with 73% (11/15) walls surviving at 0.5 mm and 100% of walls surviving at 0.6 mm. This demonstrates that both materials should survive machining with the same wall thickness without fracturing. Although the materials may survive machining at this thickness, it is suggested to design restorations according to the manufacturer's specifications for successful clinical use and added strength.



Representative samples of failed merlon wall fractures at 0.5 mm and successful merlon specimens at 0.6 mm.

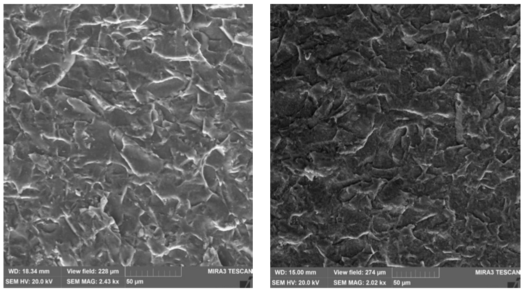
Surface Roughness and Polishing:

When considering whether a material can be machined, an important factor is the amount of surface roughness the resulting restoration will have, which can impact the time required to polish it to a tooth-like luster for stain resistance and esthetics. To test this, we measured the initial surface roughness and topography of both materials over an 80 x 80 µm area with a nano-sized contact probe using an atomic force microscope (Bruker Dimension Icon). Both materials were polished with the Meisinger ***Luster Polishing System*** for 15 and 30 seconds per step to establish the time to polish, and for 120 seconds to determine the maximum expected polishing level.

Surface Roughness and Polishing

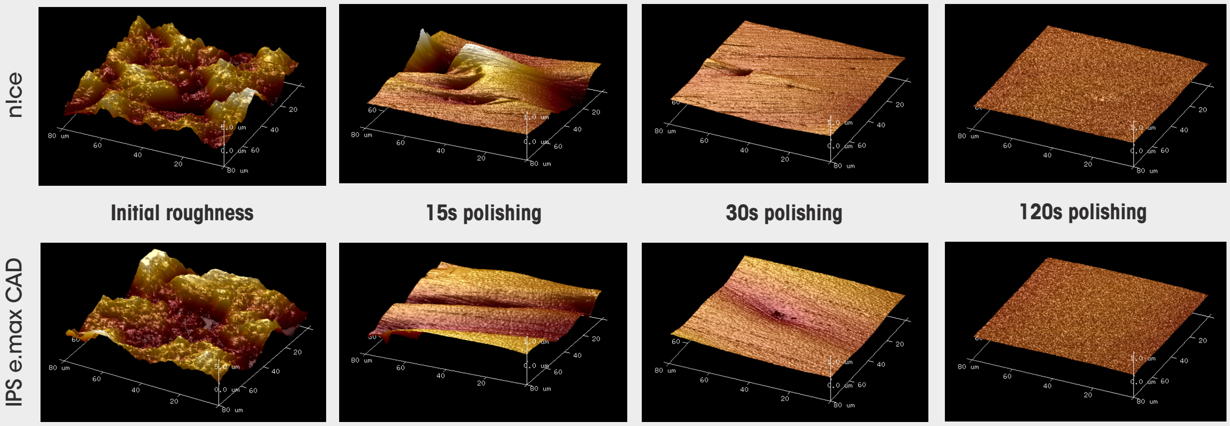
Product	Test	Initial	15s	30s	120s
n!ce	Gloss, gu	3.0 (0.3)	65.2 (4.1)	89.2 (2.8)	97.7 (1.0)
	Roughness Ra, nm	1161 (57)	194 (47)	39 (5)	14 (5)
IPS e.max CAD	Gloss	2.7 (0.2)	68.0 (4.0)	84.0 (5.0)	96.6 (1.2)
	Roughness Ra, nm	1100 (170)	178 (47)	35 (6)	12 (3)

IPS e.max CAD and ***n!ce*** showed similiar polishing characteristics and initial surface roughness after milling. Only marginal improvement was noted with polishing over 30 seconds using *Meisinger Luster Twist Polishers,* which achieved an average roughness of less than 40 nm with both materials.

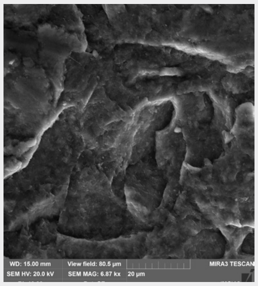


Surface Appearance of ***IPS e.max CAD*** (left) and ***n!ce*** block (right) after milling

Topographic maps of surface roughness



SEM image of the representative appearance of an 80 x 80 µm area of initial surface evaluated by AFM



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