Influence of veneering treatment on the storage modulus of zirconia

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Objective:

The aim of this investigation was to evaluate whether heat treatment during glass-ceramic veneering, the application of glass-ceramic for veneering or long term storage have an influence on the storage modulus of zirconia.

Material and Methods:

Rectangular zirconia bars (Cercon base, DeguDent, G; 0.5x2x20mm) were fabricated and treated according to veneering conditions. Heating regimes between 680°C and 1000°C (liner bake and annealing), sandblasting (Al_2O_3 110µm, 0.25MPa) and steam cleaning were used. The bars were investigated after 90 days of storage (37°C) in distilled water and acetic acid (25%). To investigate the influence of veneering, the bars were veneered by press (Cercon X Press, DeguDent, G) or layer technique (Cercon Kiss, DeguDent, G) according to manufacturers conditions. Dynamic mechanical analysis (DMA 242, Netzsch, G; F=1.66Hz, 20µm, 6N) was performed in a three point bending design to determine the storage modulus E`. All specimens were loaded on top and bottom (treatment on pressure or tensile stress side). Scanning electron microscopy (SEM Quanta, FEI Philipps, NL) was used for evaluating the zirconia surface.

Statistics: Mean 25%/75%; Mann Whitney U-test; α=0.05.

Group	Temp °C / Time min	C	LT(layering)	PT(press)	C_{anneal}	C_{acid}	C_{water}
Material		Core	Core+veneering		Core		
Bar thickness (mm)		0.5	0.5 und 0.5 + veneering		0.5		
After treatment:							
Sintering		X	X	X	X	X	X
Al_2O_3(110µm/0.25MPa)		X	X	X	X	X	X
Steam cleaned		X	X	X			
Liner 1	970/1	X	X				
Liner 2	960/1	X					
Shoulder bake	950/1	X					
Dentin first bake	830/1.5	X	X	X			
Dentin second bake	820/1.5	X					
Glaze/Stain	800/1	X	X	X			
Correction	680/1	X					
Final Shoulder	680/1	X					
Annealing	1000/60				X		
90 days water							X
90 days acid						X	

Tab 1: Study overview and classification of the different treatments (x indicates the performed treatments)

Fig 1: Dynamic mechanical analyzer (DMA 242, Netzsch, G)

Fig 2: Scanning electron microscop (SEM Quanta, FEI Philipps, NL)

Results:

Sintered zirconia provided a storage modulus E` of 215 (203/219) GPa. Sandblasting reduced E` to 213GPa, while heating modulated E` between 205GPa (liner) and 222GPa (dentin). Steam cleaning, annealing and storage changed E` by values between 4GPa and 22GPa, depending on the side of loading. After veneering, a significant E` reduction was found down to 84 (press) -125 (layer) GPa.

Fig. 6: SEM figures of the zirconia surface (magnification 30.000x)

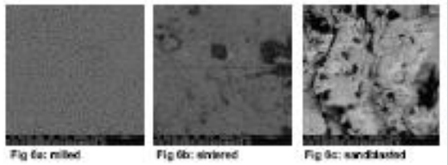

Fig 6a: milled | Fig 6b: sintered | Fig 6c: sandblasted

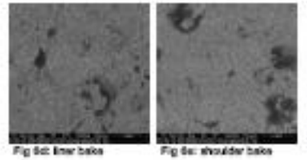

Fig 6d: liner bake | Fig 6e: shoulder bake

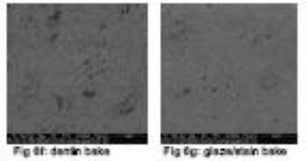

Fig 6f: dentin bake | Fig 6g: glaze/stain bake

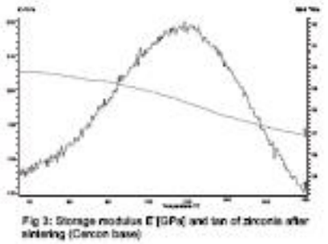

Fig 3: Storage modulus E`[GPa] and tan of zirconia after sintering (Cercon base)

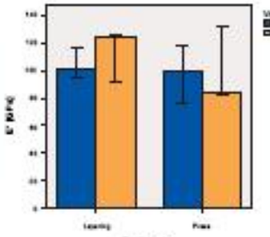

Fig 4: E`after veneering in layer- or press technique (median, 25%/75%)

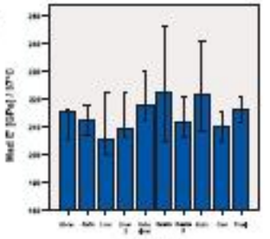

Fig 5: Change of E`in relation to E`after sintering; influence of the surface or heat treatment (median, 25%/75%)

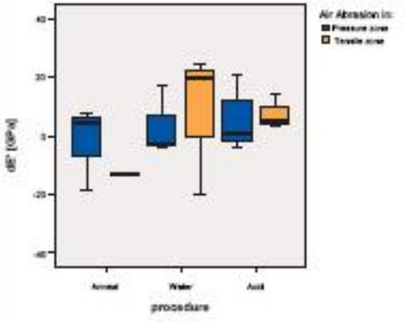

Fig 7: Change of storage modulus (dE`[GPa]) in relation to E`after sintering; influence of aging conditions

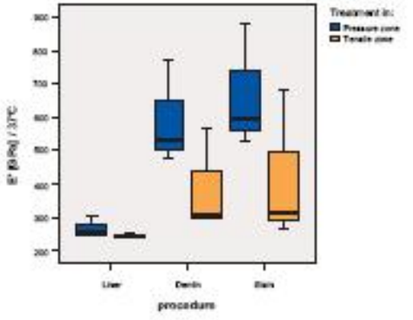

Fig 8: Storage modulus (E`[GPa]): influence of applied liner, dentin or stain masses; related to core thickness

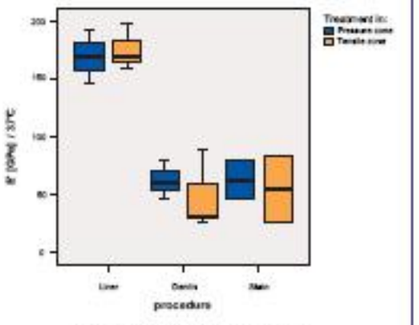

Fig 9: Storage modulus (E`[GPa]): influence of applied liner, dentin or stain masses; related to core thickness + veneering

Conclusion:

The veneering of zirconia with glass-ceramic, in contrast to heat treating during the veneering procedure, had a strong influence on the storage modulus.

IADR Miami 2009