Influence of sandblasting before sintering on flexural strength of zirconia

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Introduction

Surface roughness of zirconia implants is an essential requirement for osseointegration. E.g. sandblasting may induce surface damage and phase transformation from tetragonal to monoclinic. To avoid these negative effects one strategy to generate a rough zirconia surface is sandblasting prior to sintering. Zicari et al could show that the surface roughness of sandblasted zirconia before and after sintering decrease after sintering [1]. However, with grinded zirconia abutments before/after sintering, an increase of surface roughness after sintering was found [2].

Aim of the study

The aim of the study was to investigate the effect of sandblasting before sintering on the flexural strength.

Materials and Methods

Ninty zirconia discs (Zenotec, Wieland) were investigated which were cut from zirconia rods into samples with a thickness of 1 mm using a saw (Accutom 50, Struers, Willich, Fig. 1). Prior to sintering 30 samples were used in the as machined condition, 30 sandblasted with 120 µm Al_2O_3 and 250 µm respectively (distance 10 mm, 2 bar). The as machined samples were polished with SiC 4000. For sandblasting a special holder was used (Fig. 2). Sintering was done according to manufacturer`s instruction using the Vita Zyrcomat (Fig. 3). The mechanical properties of the resulting sintered zirconia discs were then analyzed by biaxial test (Fig. 5a-c) with additional Weibull statistics according to ISO 6872. From 10 discs of each group the Ra values were measured before and after sintering process (surface topography with 121 profiles over an area of 3x3 mm; Perthometer S6P, Mahr, Göttingen). From each topography the profile No. 60 was taken and a D-profile was performed depending on the surface treatment. Additionally SEM pictures were taken with different magnification (LEO 1453, Oberkochen).

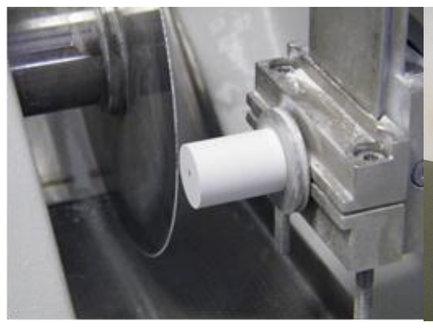

Fig.1: Cutting the samples from a Zirconia rod with a saw.

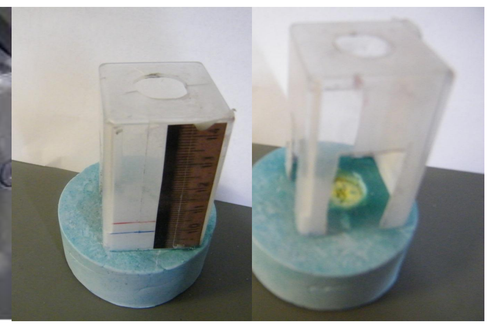

Fig.2: Sample holder for sandblasting the samples

Fig.3: Prepared samples ready to sinter.

Fig.4: Sintering the samples using Zyrcomat

Fig. 5a-c: Biaxial test

Results

Biaxial Flexural Strength and Weibull Statistics according to ISO 6872

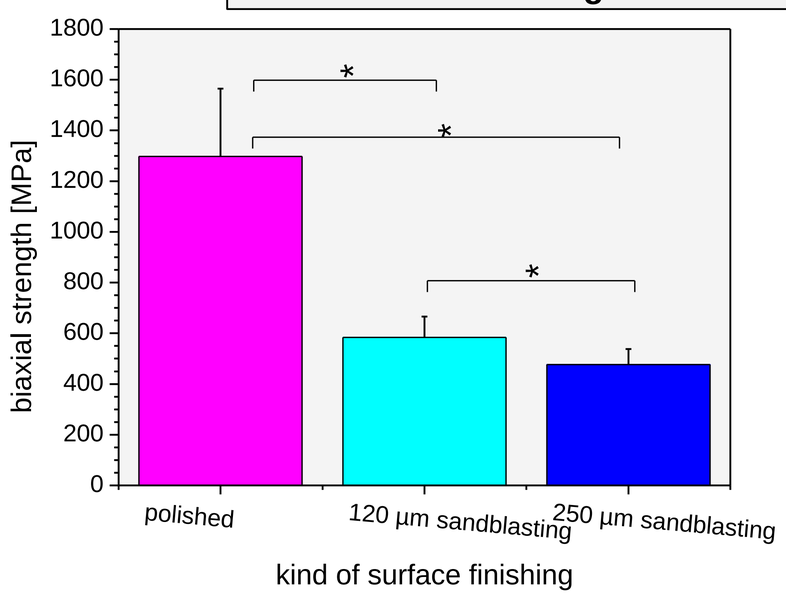

Fig.6: Calculated biaxial strength depending on surface finishing

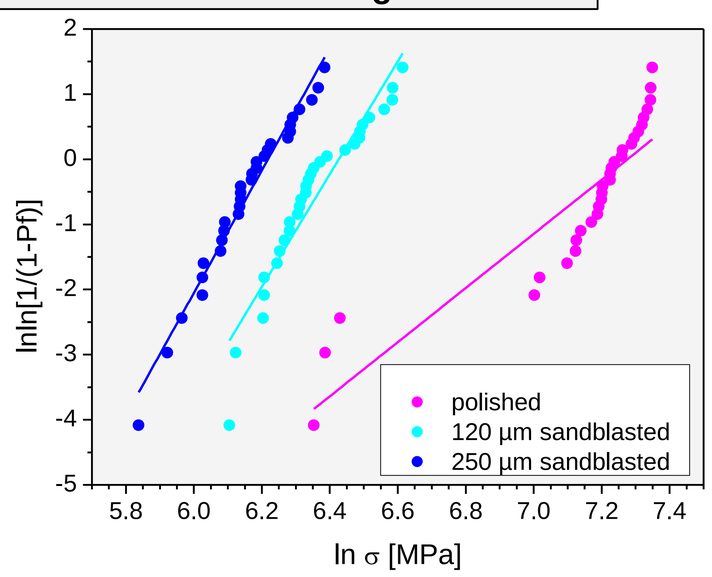

Fig. 7: Weibull plots depending on surface finishing

Surface treatment	Weibull strength [MPa]
polished	1444.83
120 µm sandlasted	617.90
250 µm sandblasted	501.79

Surface treatment	Weibull modulos m
polished	7.28
120 µm sandlasted	6.43
250 µm sandblasted	6.22

Tab.1: Calculated Weibull strength and Weibull modulos from the results of Fig.6

Surface roughness

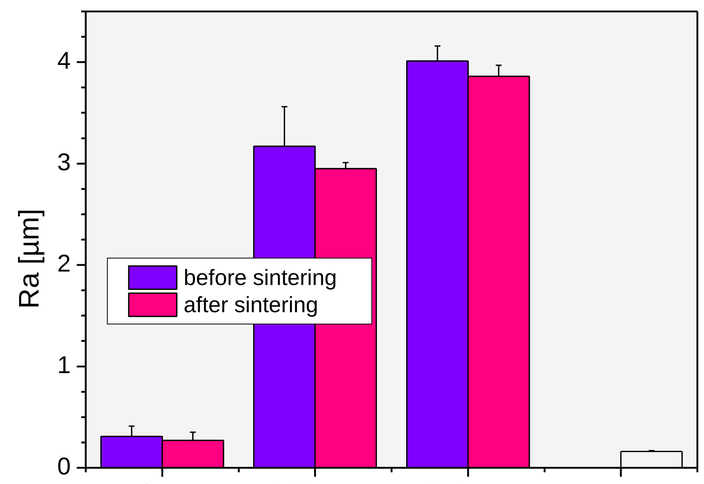

Fig.8: Calculated Ra values before and after sintering for each surface treatment

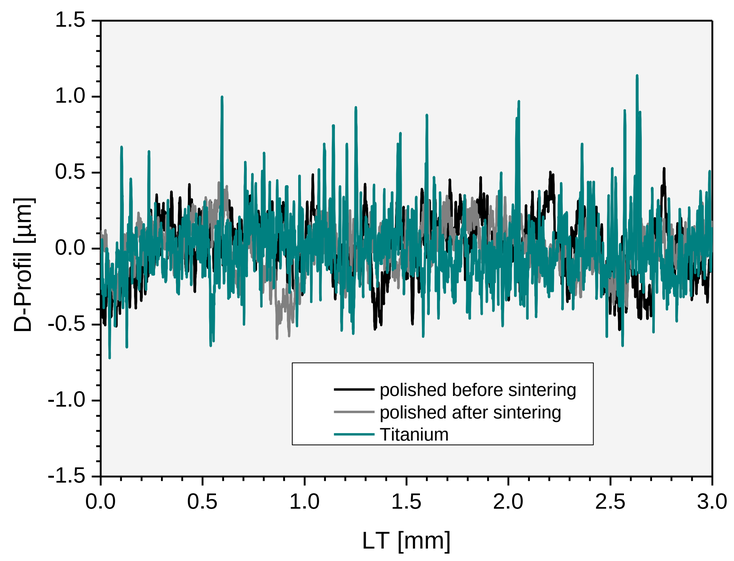

Fig. 9a: D-Profil of the polished Zirconia sample before and after sintering and Titanium as reference material

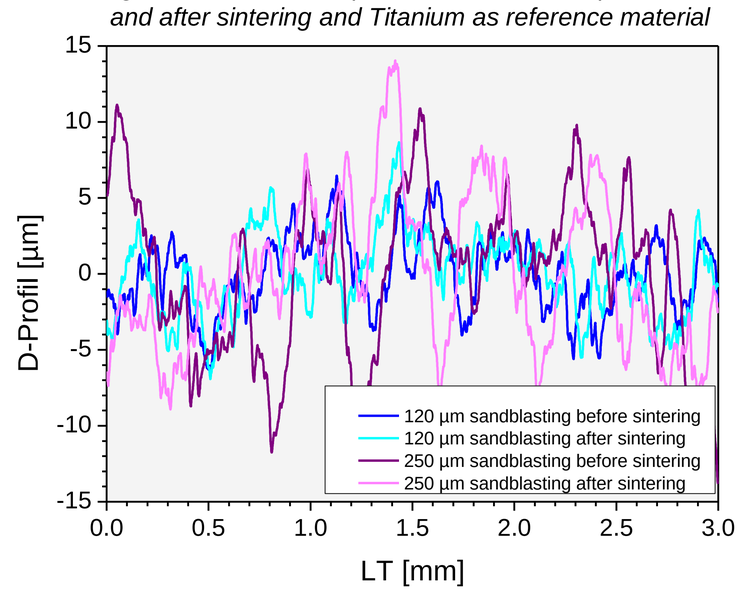

Fig. 9b: D-Profil of the sandblasted Zirconia sample before and after sintering (mean curves of 10 samples)

SEM

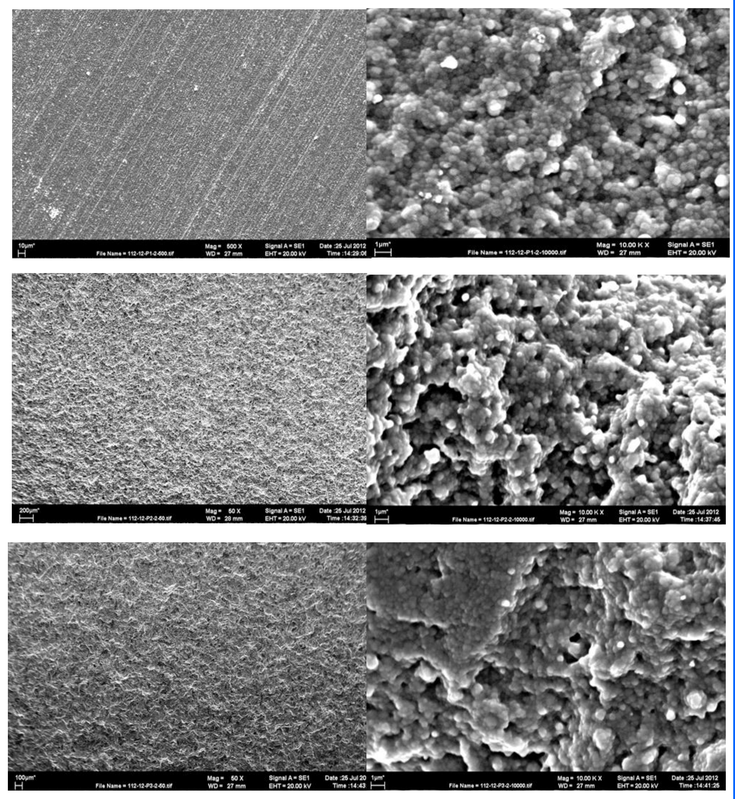

Fig.10a-c: SEM pictures of polished and sandblasted samples after sintering at a magnification of 500 and 5000.

Summary

- Compared to polishing, sandblasting of zirconia decrease the strength significantly.
- Compared to the reference material and the polished samples the D-Profiles of the sandblasted samples range in an order 10 times higher (Fig. 9a, 9b).
- With exception of the polished samples and the reference material, the Ra value of the sandblasting samples were significantly different before and after sintering (Fig.8).

Conclusion

Similar to sandblasting after sintering sandblasting prior to sintering revealed decreased biaxial flexural strength to 45% (250 µm) and 37% (120 µm).

References

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[2] T. Kanno, P. Milleding, A. Wennerberg: Topography, microhardness and precision of fit on ready-made zirconia abutment before/after sintering process. Clinical Implant Dentistry and Related Research, Vol. 9, 3, 2000, p. 156-165.

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Contact

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