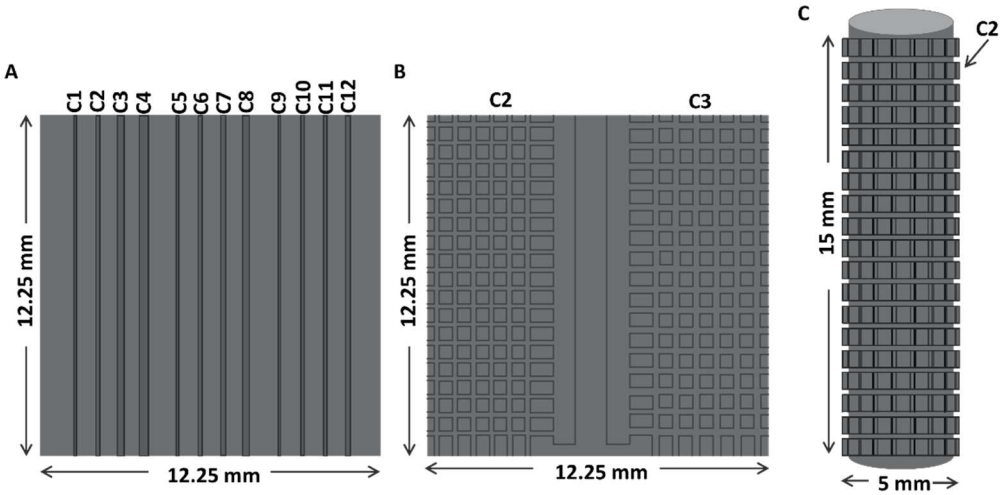
How contact angle measurements can help to improve the biocompatibility of dental implants

Dental implants have become the best alternatives for natural teeth, restoring the function and aesthetics of missing teeth perfectly. In general, modern dental implants make use of two biological processes:

1. Osseointegration, where the living bone is tightly connected with the surface of a specific artificial implant by growing on the implant material
2. Vascularization, which describes the process of tissue growth on the implant surface that guarantees for a proper blood and nutrients supply

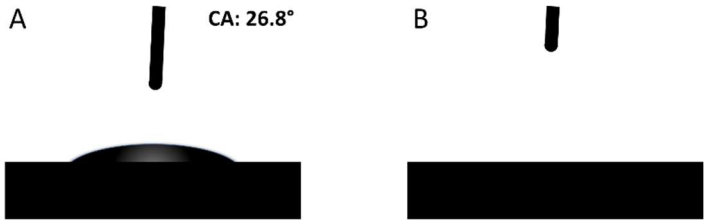
Amongst the possible materials for dental implants, Zirconia has shown promising characteristics for due to its excellent biocompatibility, stability, mechanical and aesthetical properties. Most studies on zirconia as a dental implant material focus on avoiding the tetragonal-monoclinic phase transformation of zirconia which normally leads to instability. Further studies aimed at improving implant osseointegration rather than an effective vascularization. The wettability of dental implant surfaces is of great significance for their application in a biological environment, influencing the blood and nutrients supply by affecting osseointegration and vascularization. One of the biggest challenges in the application of zirconia-based implant materials is controlling the osseointegration and vascularization processes around the implant immediately after the insertion and during the function period. Dantas et al. have recently designed zirconia surfaces with micro-channels aiming at promoting the vascularization and osseointegration at the surface of the zirconia implant, and have found that a higher hydrophilicity and capillarity of the implant surface facilitates the vascularization and further osseointegration.

In this work, the authors endowed zirconia implants with multiple micro-channels which helped improve the infiltration and supply of nutrients around the implants, enhancing the vascularization at the surface of the implant. They fabricate three zirconia specimens with different micro-channel dimensions (**Picture 1**). C1-12 corresponds to different depths and widths of the micro-channels.



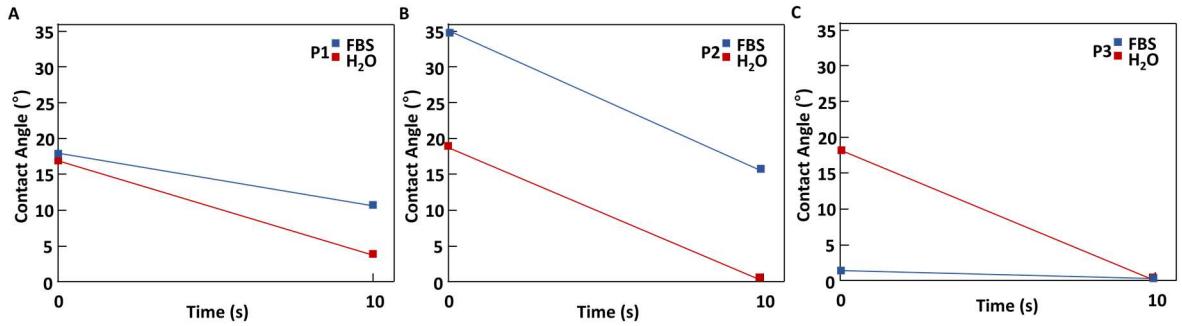
Picture 1. *Three different zirconia implant specimens: (A) P1; (B) P2; (C) P3.*

Previous studies showed that hydrophilic implant surfaces play an important role in the biological response after dental implant insertion. Accordingly, they first evaluated the wettability behavior of their zirconia dental implant surfaces by conducting contact angles measurements with both water and fetal bovine serum (FBS). They captured the representative images after the water droplet reached the implant surface, and 10 s later (**Picture 2**).



Picture 2. *The images of a water droplet immediately after reaching the surface (A), and after 10 s (B).*

All specimens presented good hydrophilicity with the contact angles much below 90° (**Picture 3**). The P3 specimen displayed the lowest contact angles both with water and FBS—which correlates well to is lower surface roughness compared to the other specimen. The contact angles all considerably decreased in the first 10 s on the dental implant surface going close to 0° in case of P2 (water) and P3 (water and FBS) indicating superhydrophilicity.



Picture 3. *Water and FBS contact angles of P1 (A), P2 (B) and P3 (C) for 0 s and 10 s.*

They also assessed the capillarity of three specimens and found out that P3 with the cylindrical geometry and C2 channels on the surface presented the strongest capillary effect. Both the hydrophilicity and the channel dimensions strongly influenced the capillarity. Additionally, the adhesion of the fluid to the implant surface and the coherence of the fluid contribute to the magnitude of capillary effects.

Overall, the authors successfully produced zirconia implants with different micro-channels on surfaces for dental implant applications. Three specimen with different surface morphology all showed good hydrophilicity and capillarity with both water and FBS fluids. In particular, specimen P3 with cylindrical geometry and C2 (100 µm deep and 200 µm wide) micro-channel dimension exhibited the best performance. Good hydrophilicity and capillarity are beneficial to both vascularization and osseointegration in dental implants applications. Therefore, these zirconia implants hold considerable potential for inducing the vascularization and further improving the long-term implant osseointegration.

An optical contour analysis system OCA (DataPhysics Instruments GmbH, Germany) was used in this research.

For more information, please refer to the following article:

Design and optimization of zirconia functional surfaces for dental implants applications; T. A. Dantas, P. Pinto, P. C. S. Vaz, F. S. Silva, *Ceramics International* ***2020***; DOI: 10.1016/j.ceramint.2020.03.190