“Transition to ceramic materials in implant dentistry is inevitable”

An interview with Dr Alessandro Alan Porporati

Dr Alessandro Alan Porporati is a distinguished expert in zirconia-based materials and has extensive expertise in hip arthroplasty. Based on more than 20 years of research experience, Dr Porporati specialises in the development and clinical application of advanced high-performance ceramics for orthopaedic and dental implants. He is the director of medical and scientific affairs at the Medical Products Division of the CeramTec Group in Plochingen in Germany. At the German Society for Environmental Dentistry’s 2025 annual meeting in Leipzig in May, he gave a lecture titled “Materials for dental implants: Hip arthroplasty teaches us that it is matter of time”. He discusses this topic in the following interview.

In your lecture at the German Society for Environmental Dentistry’s annual meeting, you pointed out that the transition to ceramic materials in implant dentistry is inevitable given the trend towards the use of ceramics in hip arthroplasty over the last two decades. Could you elaborate?

Indeed, I believe that the transition to ceramics is just a matter of time—mainly because we’ve already seen this shift in hip arthroplasty. At the beginning of total hip arthroplasty surgery in the early 2000s, cobalt–chromium and stainless steel were the materials of choice for implants, but in the last two decades, there has been a clear and steady move towards ceramic materials. This shift to ceramics is clearly reflected in the registry data. In Germany, according to the German Arthroplasty Registry, over 90% of femoral heads used in primary total hip replacements in 2023 were ceramic, making ceramic by far the dominant material.[1] In the UK, the National Joint Registry reported that about 59% of femoral heads in 2023 were ceramic, making them the clear majority choice.[2] In the US, recent registry data shows that more than 80% of femoral heads in primary hip replacements are now ceramic, a significant and consistent preference.[3]

Not only is the registry data convincing, but long-term clinical and scientific evidence also shows that orthopaedic surgeons are increasingly choosing ceramic components because they are more wear-resistant and biocompatible and because they reduce metal-related complications such as adverse local tissue reactions. Moreover, over the last decade, a growing body of evidence has shown that ceramic bearings reduce the risk of revision due to infection. These same advantages can also be applied to dental implants. In implant dentistry, we’re following the path that orthopaedic surgery has already forged. The materials have matured, the clinical results are convincing, and as more data comes in, confidence in ceramics is growing. So, yes, as in hip arthroplasty, I think it’s only a matter of time before ceramics share the dental implant market with titanium.



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What are the key requirements for materials used for dental implants compared with those used in hip replacements?

That’s an important question, because while hip and dental implants might seem very different, the materials used share a lot of performance requirements, albeit with different emphases, and differ in some key areas. Both applications demand materials with excellent biocompatibility, fracture strength and toughness, and chemical stability. These are essential properties for long-term performance under load and in contact with living tissue. In implant dentistry, however, the challenges go even further. The oral cavity is a much more hostile environment: it’s constantly exposed to saliva, fluctuating pH levels and temperature changes, and it’s subject to bacterial

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colonisation. Corrosion resistance is therefore the most important prerequisite for success of a dental material, whereas for hip implants wear resistance of the material is the most important property for articulating surfaces. Another consideration is aesthetics. This is a requirement where zirconia outperforms titanium. For dental implants, the material colour and translucency really matter, especially in

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visible areas such as the anterior teeth. That's not something we need think about with hip implants. In contrast to hip implants, dental implants are in direct contact with the bone and therefore require integration.

In summary, while both applications rely on high-performance materials, dental implants place even greater demands on corrosion resistance, immunological profile and appearance. For these reasons, advanced ceramics such as monolithic zirconia and alumina-toughened zirconia (ATZ) are becoming increasingly important in this field.

In your presentation, you said that ceramics in implant dentistry are now considered mature. What exactly do you mean by that?
What I meant is that ceramics have gone through the full innovation cycle. If you look at the evolution of ceramic materials in implant dentistry—especially zirconia and its composites such as ATZ—they've moved beyond the early hype and uncertainty. In the beginning, there were very high expectations but also scepticism owing to issues with earlier materials that hadn't performed well enough in dental applications. This was followed by a period of disillusionment, during which adoption slowed as limitations became clearer. But, over time, with better manufacturing processes and clinical validation, we've reached what we might call a "plateau of productivity". Today, dental implants made of high-performance ceramics are no longer experimental; they're supported, for instance, by ten-year clinical evidence showing over 95% survival rates. We now

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know how to work with these materials, and they meet both functional and biological requirements. In short, ceramics in implant dentistry are a reliable and mature option for clinical use. However, one should always bear in mind that the production of advanced ceramics requires a high level of expertise, and this means that zirconia composites that appear identical can exhibit completely different performance characteristics.

Are there other factors that have been significant in the evolution of dental implant systems and contributed to wider usage of ceramic implants?

Several key milestones have shaped the evolution of dental implants. In 1962, Prof. Sami Sandhaus introduced the CBS system—an alumina-based ceramic implant produced by Rosenthal Technik AG, linked to CeramTec. In 1965, Prof. Per-Ingvar Brånemark placed the first titanium implant, establishing osseointegration as a clinical standard. By 1972, Japanese oral surgeons began using synthetic sapphire, and by 1977, Brånemark's titanium implants had shown proven clinical success. In 1985, Prof. Sandhaus introduced the zirconia-based SIGMA implant. Research in the early 1990s by Miani and Akagawa confirmed zirconia's osseointegration potential, reinforcing its viability as a metal alternative.[4] Over time, implant materials have gradually shifted toward more biocompatible and aesthetic ceramics, alongside continuous improvements in design and manufacturing.

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Given the growing interest in ceramic implant materials, particularly zirconia composites, how do they compare with titanium in terms of biological performance?

Titanium is a widely accepted material in implant dentistry. However, zirconia composites such as ATZ and zirconia are slowly proving to perform equally or better in all three areas: cytocompatibility, bone regeneration and bacterial resistance. Preliminary scientific data shows that zirconia and ATZ surfaces support osteoblast adhesion and metabolic activity just as well as Grade IV titanium does. That means that bone-forming cells interact with and adhere to zirconia and ATZ surfaces, an indication of their cytocompatibility and a key factor in successful osseointegration. Furthermore, zirconia and ATZ show lower cytotoxicity in comparison with Grade IV titanium, providing a safe and stable environment for surrounding tissue. Another crucial factor is their osteogenic potential. Preliminary data from an ongoing study shows significantly increased expression of key osteogenic differentiation markers—alkaline phosphatase, COL1A1 and osteocalcin—on zirconia and ATZ surfaces compared with titanium, confirming the osteogenic potential of zirconia and ATZ. Finally, perhaps most importantly in clinical practice, zirconia and ATZ have a strong bacteriostatic effect. Ongoing *in vitro* studies show reduced bacterial activity and viability of periodontal pathogens such as *Porphyromonas gingivalis* and *Aggregatibacter actinomycetemcomitans* on ATZ and zirconia surfaces. These are two of the main periodontal bacterial species involved in peri-implantitis, which can lead to implant failure. Titanium, however, shows higher levels of bacterial colonisation. When you put it all together—better cell compatibility, higher osteogenic differentiation and better bacterial resistance—zirconia and ATZ aren't just alternatives to titanium. In many ways, they offer a clinically more advanced solution for modern implant dentistry.

You stated that hip arthroplasty teaches us that transition to ceramic implants is a matter of time. How does that relate to the future of ceramics in implant dentistry?

That statement reflects the pattern we've seen in both fields. In hip arthroplasty, alumina ceramics were the first to gain acceptance. Over time, alumina-based composites such as zirconia-toughened alumina matured and became standard because of their superior performance. It didn't happen overnight; it took decades of development, data collection and clinical refinement. Now, if we look at implant dentistry, it's almost a mirror image, just offset in time. Zirconia and ATZ are now where zirconia-toughened alumina was in orthopaedics about 15–20 years ago, clinically proven, safe and ready for broader adoption. It's the material evolution repeating itself in a different field. Ceramics are successful when the technology and clinical understanding catch up. However, it should be emphasised that the real-world data provided by arthroplasty registries has contributed significantly to improving medical decision-making and to demonstrating the superior long-term performance of ceramic bearings compared with metal bearings. In implant dentistry, that time is now.

So exciting. Thank you very much for this conversation, Dr Porporati.

References

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