Peri-implantitis: the ongoing challenge in implant care

The topic of peri-implantitis is far from new in dental care. From its definition and prevalence statistics to ongoing discussions about prevention and treatment strategies, the debate continues to evolve.

Dr Mariane Sordi, DDS, MSc, PhD

What stands out is the substantial volume of publications on the subject. A quick search for "peri-implantitis" in PubMed, as of April 2025, reveals an impressive 4,858 articles, a number that continues to grow exponentially, particularly in the last 15 years. Besides, these numbers only reflect the articles indexed in PubMed, not even considering the vast range of other scientific databases or grey literature sources. In total, we are likely looking at thousands of research papers addressing every aspect of peri-implantitis.

But with such an overwhelming amount of literature, one must ask: What conclusions can be drawn from all these studies? Is the prevalence of peri-implantitis still on the rise, or are we seeing signs of stabilisation? What are the most effective strategies for preventing this disease? What are the underlying causes of the inflammatory breakdown that leads to implant failure? And perhaps most crucially, have researchers and practitioners come to a consensus on the best treatment options available? These critical questions remain at the forefront of ongoing research as we attempt for more effective solutions for managing peri-implantitis.

There is no doubt that the topic of peri-implantitis is a constant concern for every clinician, particularly those involved in implant care. In fact, peri-implantitis is one of the most challenging conditions to treat. Moreover, studies show that between 20 and 47 per cent of implants placed in patients will eventually develop some form of peri-implantitis.[1] This alarming statistic means that, at the very least, two out of every ten patients will return to their dental practices complaining of a problematic implant, leading to not only dissatisfaction from the patient but also significant frustration for the dentist. Such occurrences can be particularly distressing, as they represent a collapse in the expected success of what is considered a state-of-the-art dental treatment.

Zirconia implants were initially introduced to the market with the primary goal of achieving improved aesthetics in clinical practice. Indeed, white zirconia implants offer a more aesthetically pleasing option compared to traditional grey titanium implants, particularly in visible areas where the colour contrast might be noticeable. However, titanium implants, when placed with a proper approach, deliver excellent aesthetic results, achieving high patient satisfaction.

More recently, there has been a growing shift toward biocompatible and metal-free treatment options. Therefore, zirconia has gained popularity due to its perceived its perceived biological benefits for the peri-implant tissues. But once again, the question arises: **how much does a material change truly impact the overall health and well-being of the patient?** While zirconia implants may be a promising option for some, it is crucial to assess whether the shift to metal-free materials offers significant long-term health benefits or if it is more of an aesthetic and philosophical preference.

There is growing evidence highlighting the release of metallic particles from titanium implants into peri-implant tissues and its impact on both the biological response and the long-term stability of dental implants.[2] Throughout the entire implant treatment process, titanium devices continuously release metallic particles into the surrounding tissues due to several factors, including drill wear, friction between the implant and bone surface, wear caused by biomechanical load, and the biological corrosion effect.[3] These titanium particles can accumulate in the peri-implant tissues over time, and the role of these particles in the progression of peri-implantitis may be significantly underestimated.[3] Animal experiments based on a murine implant model have shown that the titanium implant itself promoted peri-implant inflammation and dysregulated mucosal homeostasis. Titanium ions that were released from the implant acted as a mediator in this process.[4] Therefore, it is already known that the

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presence of titanium particles in the peri-implant area triggers an immune response that exacerbates inflammation, thus accelerating the breakdown of bone and soft tissues surrounding the implant.

As a researcher, I studied an inflammatory process known as pyroptosis. The term is derived from the Greek "pyro," relating to fire or fever, and "ptosis," denoting a falling, which together describe the remarkable pro-inflammatory process of cell death in pyroptosis. This intense inflammatory response overwhelms the host's immune system, leading to irreversible tissue damage.[5] Initially described in the context of rheumatoid arthritis, pyroptosis has more recently been linked to periodontitis and, by extension, peri-implantitis.[5] In my research, I concluded that pyroptosis is a caspase-dependent catabolic process that plays a significant role in periodontal disorders, where inflammation is central to the disease's pathophysiology. Furthermore, I suggested that preventing pyroptosis by removing periopathogen virulence factors—those that trigger pyroptosis—may serve as a potential strategy to combat periodontal disease and restore tissue homeostasis.[5,6] Transferring this knowledge to the context of peri-implantitis, it seems plausible that reducing the presence of peri-implant metallic particles could diminish the activation of inflammasomes, the protein complexes responsible for initiating inflammatory responses. This would likely lead to reduced inflammatory reaction and tissue destruction.

Likewise, findings from various research groups consistently point to a connection between microbial dysbiosis, titanium particle release, and peri-implantitis. Although it remains unclear whether biomaterial breakdown and titanium release precede, coincide with, or follow the dysbiotic shift in the peri-implant microbiota, one conclusion is evident: **titanium particles are omnipresent in peri-implantitis**.[7] Hence, restricting the release of metallic particles in the peri-implant environment is likely to reduce the inflammatory load and tissue breakdown.

There is growing interest in exploring alternative materials, such as zirconia, which is known for its superior biocompatibility, reduced biofilm formation, and lower corrosion rates in challenging environments such as the mouth.[8,9] Zirconia implants, due to their ceramic, stable composition, are unlikely to release particles into the surrounding tissues, consequently leading to a reduced incidence of peri-implant inflammatory reaction. In fact, zirconia implants trigger less inflammation and result in reduced marginal bone loss.[10] This suggests that zirconia implants could offer a promising alternative to reduce the incidence of peri-implantitis in the near future.

However, claiming that zirconia implants will completely eliminate peri-implant inflammatory reactions is an overstatement. After all, even a natural tooth, with its perfect anatomy, can fail when exposed to certain virulence factors. Likewise, an implant may fail, regardless of its material quality. Moreover, it is important to consider the technical complications that are inevitably associated with any type of dental treatment.

Moving forward, if zirconia implants will lead to cases of peri-implantitis, clinicians will need to learn how to manage it, as there are currently no established guidelines or protocols for treating peri-implant inflammation around zirconia implants. While some knowledge from the management of periodontitis or peri-implantitis associated with titanium implants can certainly be applied, the unique properties of zirconia may necessitate specific adjustments in treatment approaches.

To conclude, and returning to my previous question "How much does a material change truly impact the overall health and well-being of the patient?"—It appears that zirconia implants can indeed offer improved well-being, primarely due to their biological benefits. With excellent tissue acceptance, low biofilm formation, and a reduced prospect of inflammatory and biological complications, zirconia implants contribute to enhanced patient satisfaction and long-term oral health.

Literature

Dr Mariane Sordi, DDS, MSc, PhD
Periodontics & Implant Dentistry
Solothurn, Switzerland
Liverpool, United Kingdom
marianebsordi@gmail.com