Carbon fibre—established in implant dentistry

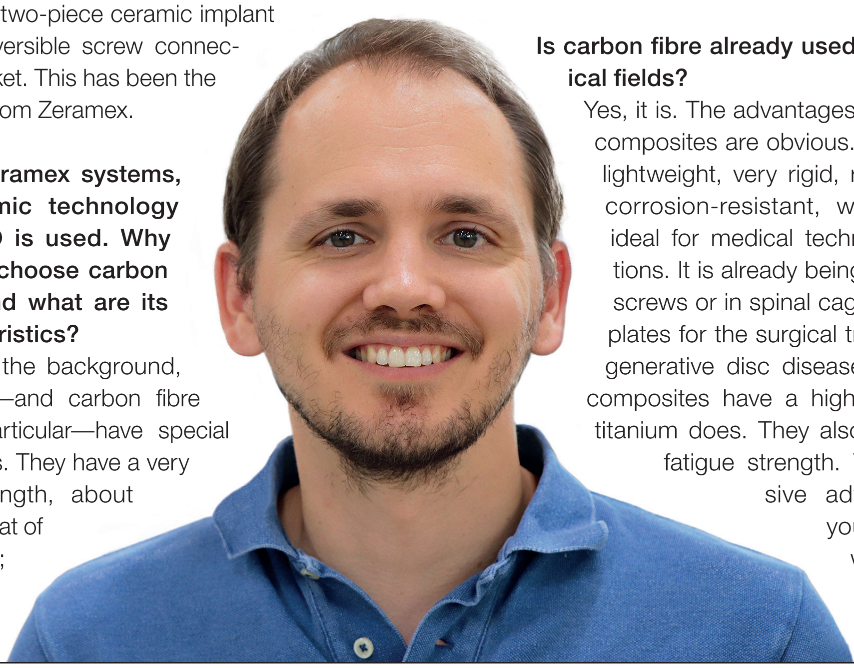
Digitalisation in combination with ceramic implantology is one of the fastest-growing and most innovative areas in dentistry. With its Zeramex brand, Dentalpoint is considered a pioneer of "white implants". The screw connection of its metal-free two-piece ceramic implant system Zeramex P6 is unique worldwide. Carbon–ceramic technology provides the connection strength required for such a system. The centrepiece is the VICARBO screw, made of carbon fibre-reinforced high-performance PEEK. In this interview, Pascal Wettstein, Head of Research and Development at Dentalpoint, shares some insight on implant–abutment connections and what the future holds in this field.

Mr Wettstein, it is predicted that ceramic implant systems will have a market share of up to 25 per cent by 2022. Which innovations from Zeramex have contributed to this development?

Traditionally, there was a choice between a one-piece or two-piece cemented implant system and this is where Zeramex first began. But we quickly realised that, for reasons of prosthetic flexibility, a two-piece reversible solution was required. One-piece systems are not easy to use in prosthetic treatments and are practically no longer used in titanium implantology. So it was clear to us that, even in metal-free implantology, a system with reversible screw connections was required. And we were the first to bring a metal-free two-piece ceramic implant system with a reversible screw connection on to the market. This has been the major innovation from Zeramex.

In relation to Zeramex systems, a carbon–ceramic technology called VICARBO is used. Why did Dentalpoint choose carbon fibre for this, and what are its special characteristics?

To briefly sketch the background, fibre composites—and carbon fibre composites in particular—have special material properties. They have a very high tensile strength, about twice as high as that of Grade V titanium; they have a high rigidity; they are chemically resistant; and because of the fibres, they are anisotropic. This means that the properties along the fibre axis differ from those across it. This can be utilised by controlling the fibre direction or ensuring that it is parallel to the main loading direction or directions. A classic example is a bicycle fork made of a carbon fibre composite: this is designed to react elastically to longitudinal loads so that it can optimally absorb bumps etc. In relation to transverse or torsional loads, it is very rigid, which greatly improves the handling of the bicycle. With an aluminium fork, it is not possible to control the properties to the same extent, since aluminium is an isotropic material (the properties are generally the same in all directions). These excellent mechanical properties, in combination with the low weight, have led to carbon fibre becoming established in various high-tech industries, such as aviation (Airbus A380 and Boeing 787), space travel and racing. We also exploit the mentioned properties. As a result, we design the process so that the main fibre flow in the screw is such that it can withstand high levels of mechanical stress in the form of torsion and tension. The combination of a relatively soft screw and the very hard ceramic also allows us to produce the screw so that it is slightly over-dimensioned. The screw then fits snugly into the ceramic inner thread. This provides the sealing effect. The matrix material in our case is PEEK, which has a long tradition in medical technology.



Is carbon fibre already used in other medical fields?

Yes, it is. The advantages of carbon fibre composites are obvious. The material is lightweight, very rigid, radiolucent and corrosion-resistant, which makes it ideal for medical technology applications. It is already being used for bone screws or in spinal cages and cervical plates for the surgical treatment of degenerative disc disease. Carbon fibre composites have a higher rigidity than titanium does. They also have a better fatigue strength. This is a decisive advantage when you are dealing with high cyclical alternating loads, which occur continuously in the spinal column, for instance. Naturally, the same applies to an abutment screw, which is constantly exposed to alternating loads due to chewing.

We often hear of stability problems with screws in two-piece implant systems. What about the VICARBO screw's long-term stability?

Although no clinical studies are yet available on the VICARBO screw, our five-year data gives a very clear message. Of course, even with a composite material such as VICARBO, material failures such as fibre pull-outs or matrix delamination can occur. These are not fractures in the conventional sense, but each one starts with failure at the interface of the PEEK matrix and the carbon fibres, which ultimately leads to failure of the composite. As with any screw, care should be taken to ensure that the torque is maintained. In addition, the prosthetic wrench must be squarely seated in the screw drive to ensure optimum force transmission. This is generally true for all screws, not just the VICARBO screw. However, based on our market feedback, we can say that, since the introduction of our VICARBO technology, the screw has been extremely reliable.

Studies are always a much-discussed topic in medicine and can also provide information on whether a product is ready for the market. Are studies available on the VICARBO screw?

As I said, there are no long-term studies available, but we have well-documented five-year data from our market feedback and it looks very good. We have had very few problems with the VICARBO screw and that makes us feel very positive about the future. We will have to wait for another five to 15 years for the ten- to 20-year data. But this is generally true for any new development, regardless of the system. However, enough data has been generated to allow us to conclude that the materials used or the system as a whole is stable in the long-term. The data was obtained from, among others, artificial ageing tests, alternating tests in various media and maximum stress tests. All these tests have shown that the VICARBO material is highly suitable for this application because of its unique properties. The values in cyclical loading tests in particular are comparatively very high. Also, all Zeramex systems currently available on the market have been approved by the U.S. Food and Drug Administration.

Are there any special points to consider in comparison with titanium screws?

Basically no. Our VICARBO screw is also a simple screw that is inserted using a prosthetic wrench. Because a relatively soft screw is screwed into a very hard ceramic thread, the haptic feedback is somewhat different to when two ductile materials, such as titanium on titanium, are used. Owing to the specific properties of the two materials, our screw connection is also in the form of a round thread, which is not the case with titanium implants.

Zeramex XT implant system with abutment and VICARBO screw connection.

Other manufacturers have also now introduced reversible two-piece ceramic implants. Which system do you think will become the market standard?

Quite simply, the system that is easiest to use and gives the best results will ultimately prevail. Time will tell which system that will be. What I can say is that we have been working with VICARBO for five years. We are very satisfied with the market feedback and are therefore on the right track to playing a decisive role in the industry. Well-known companies are including our products in their portfolio, underlining the confidence in our developments—something which we can be proud of. We as a company have been dealing with ceramics for more than 12 years, with a corresponding pool of experience, setbacks and successes. We have invested heavily in experiments, tests and groundwork, testing various compounds and materials to establish a rigorous and experimentally validated basis. In our industry, anything else would be negligent. The decision to use VICARBO was finally made because, based on the data, we came to the conclusion that this is the best solution that optimally complements the very specific properties of ceramics. But let's not forget that there are always new products coming on to the market and that many very talented people are working on new solutions. It is impossible to say which developments, improvements or (r)evolutions are in the pipeline and whether these will displace existing products. In any event, it is always interesting for us to observe the dynamic developments in this field.

contact

Dentalpoint AG
Bodenäckerstr. 5
8957 Spreitenbach, Switzerland
www.Zeramex.com