

Zirconia implant: Close to the natural root?

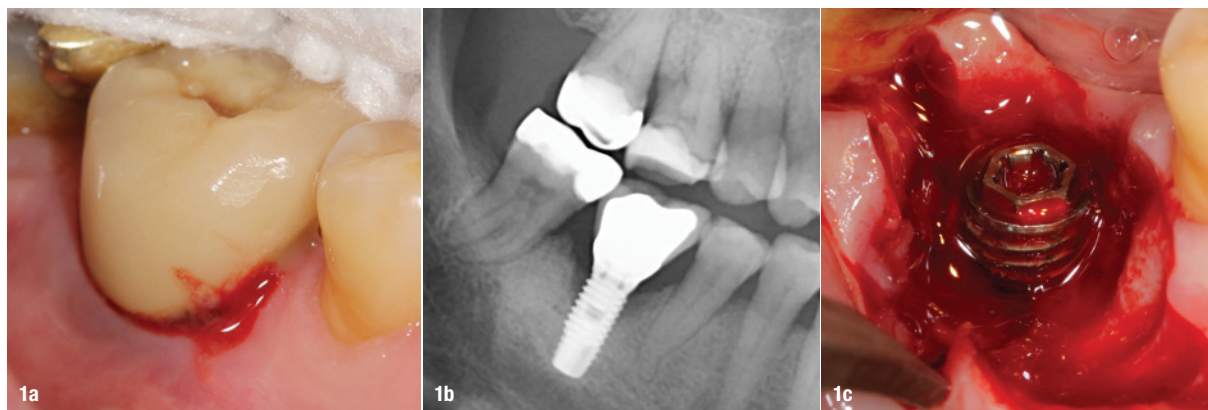
Dr Fabrice Baudot & Dr Giancarlo Bianca, France; Dr Pascal Eppe, Belgium

Titanium (Ti) implants are generally used to restore function and aesthetics following tooth loss.¹ Numerous studies have demonstrated their excellent biocompatibility and high success rates.^{2,3} However, the prevalence of peri-implantitis (PI) around Ti implants, should be a daily clinical concern due to their high incidence (Figs. 1a–c; resolution of the case shown in Figs. 8a & b).⁴ Recent studies have reported the presence of Ti particles around implants with PI compared to a healthy peri-implant environment.^{5,6} Galvanic corrosion phenomena in the oral cavity could be related to the physiopathogenesis of PI.⁷ This issue takes up a large part in most of our conferences, and questions the reliability of our long-term implant treatments.⁸ The qualities of zirconia (ZrO_2) ceramics as a prosthetic restorative material show us in daily use an extremely low bacterial colonisation, and allow soft tissues to act as a barrier to the underlying infection.⁹ This material is not a thermal nor an electric conductor,

consider the current trend in dentistry towards metal-free restorations, and the long-term aesthetic outcome of our restorations.

Osseointegration of zirconia compared to titanium

Successful integration of implants is based on osseointegration (in the hard tissue), and the formation of a peri-implant mucosal seal (in the soft tissues).¹⁴ As for the hard-tissue level, the key parameters to evaluate osseointegration include the measurements of the bone-to-implant contact (BIC) and the implant removal torque values (Fig. 2).¹⁵ Most of the studies show no significant differences between Ti and ZrO_2 implants.^{16,17} Several reviews of the literature mention the osseointegration capacity of ZrO_2 ,¹⁸ including a 2016 review, which selected 14 articles out of 1,519 publications, with a cu-



Figs. 1a–c: Peri-implantitis around an implant in position 46 and the metal-ceramic crown (a), panoramic radiograph showing the type of bone defect (b), bone destruction with granulation tissue around the Ti implant; after attempting periodontal debridement and GBR, it was decided to remove the implant (c).

and, thanks to its high inertia, it has excellent chemical stability with almost no ionic release;¹⁰ this greatly contributes to its biocompatibility observed with periodontal cells, and could explain the absence of allergy or hypersensitivity to ceramics.¹¹ ZrO_2 implants may be considered as a real alternative to Ti for our patients, especially those with allergies, autoimmune diseases, periodontal risk factors and metal intolerances.^{12,13} We must also

consider the current trend in dentistry towards metal-free restorations, and the long-term aesthetic outcome of our restorations. In all these reviews, the authors concluded that ZrO_2 implants do represent an alternative to Ti, but that further long-term studies are needed to confirm this.¹⁹ Different surface treatments have been proposed. For example, a laser-machined surface allows to achieve an increase of the BIC surface due to an increased micro- and macro-roughness. This technique considerably reduces the time

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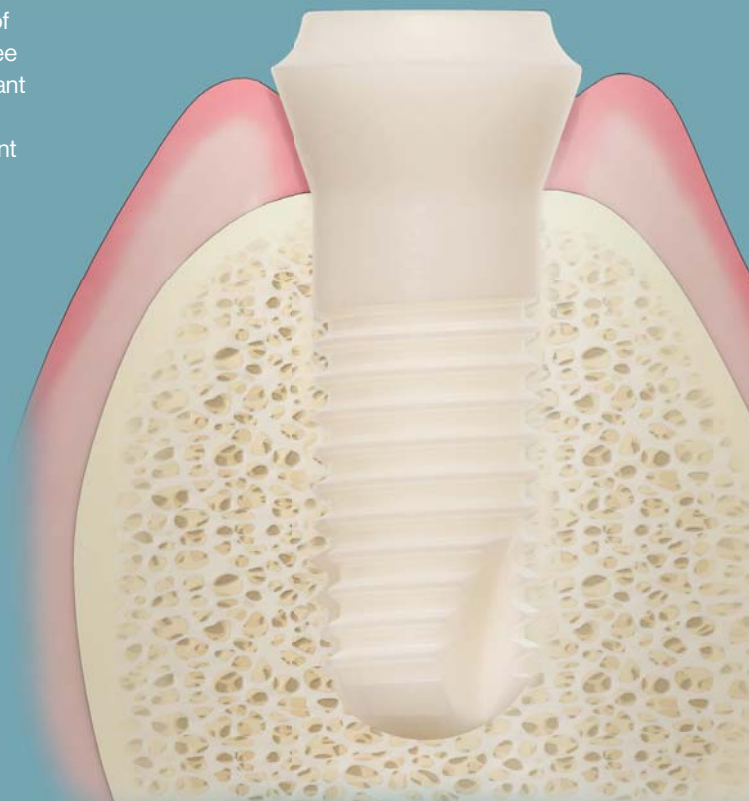
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¹ Becker J, John G, Becker K, Mainusch S, Diedrichs G, Schwarz F. Clinical performance of two-piece zirconium implants in the posterior mandible and maxilla: a prospective cohort study over 2 years. Clin. Oral Impl. Res. 28, 2017;29 – 35 doi: 10.1111/clri.12610



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Bone-to-implant contact

Weeks	Titanium (%)	Zirconia (%)
4	23.5 ± 7.5	27.1 ± 3.5
8	55.3 ± 27.6	51.9 ± 14
12	58.5 ± 11.4	57.1 ± 12.4

Fig. 2: Evidence of ZrO₂ osseointegration.

for osseointegration. The survival rate currently exceeds 98%, and is comparable to that of new generation Ti implants. In regard to the soft-tissue level, the qualitative and quantitative dimensions of the peri-implant mucosa around ZrO₂ implants are similar to those of Ti implants (Fig. 3).^{20, 21} Under these conditions, immediate implantation protocols can also be implemented as for Ti implantology (Figs. 4a–h).

Soft-tissue behaviour towards zirconia

A protective anti-microbial, anti-inflammatory barrier

Our implant restorations are inserted on the long-term, in a very septic and aggressive environment. The interface between this environment and the underlying structures (bone, vascular network) is provided by the peri-implant soft tissues. There is a real difference in terms of quality of this interface between a tooth and an implant. In 1991 and 1994, researchers described a fibre-free epithelial junction attachment around transmucosal Ti compared to the Sharpey's fibres present around teeth, and concluded that the peri-implant soft tissues are more fragile.^{22, 23} They offer less mechanical strength, but are also less vascularised and more immune-sensitive.^{24–26} The long-term stability of peri-implant soft tissues is a key issue both in the fight against PI, and in the aesthetic and functional outcome of implant-supported prosthetic restorations. The quality of the mucosal seal around the transmucosal part of the implant restoration is crucial. In 2006, a list of the important and influential soft tissue factors for implant integration was published.²⁷ This study revealed, among other things, that tissue-level implants behave better than bone-level implants; Ti and ZrO₂ are preferable to gold or feldspathic ceramics for the transmucosal components; smooth surfaces are preferable to rough surfaces; in the case of bone-level implants, disconnection and reconnection of the prosthetic abutments should be avoided. It therefore appears logically that tissue-level implantology is better with respect to soft-tissue integration of implants (Fig. 5) in that issues such as gap problems, hermeticity of the subgingival prosthetic parts, the platform switching concept to reinforce the soft tissue seal no longer exist. Ti and ZrO₂ seem to be the best materials for the transmucosal in-

Days	Titanium (%)	Zirconia (%)
14	36	45
28	45	59

tegration of our restorations. Integrating biological and aesthetic parameters, what is the best material to choose between ZrO₂ and Ti at the soft-tissue level? This is a legitimate issue to question. The peri-implant mucosal seal

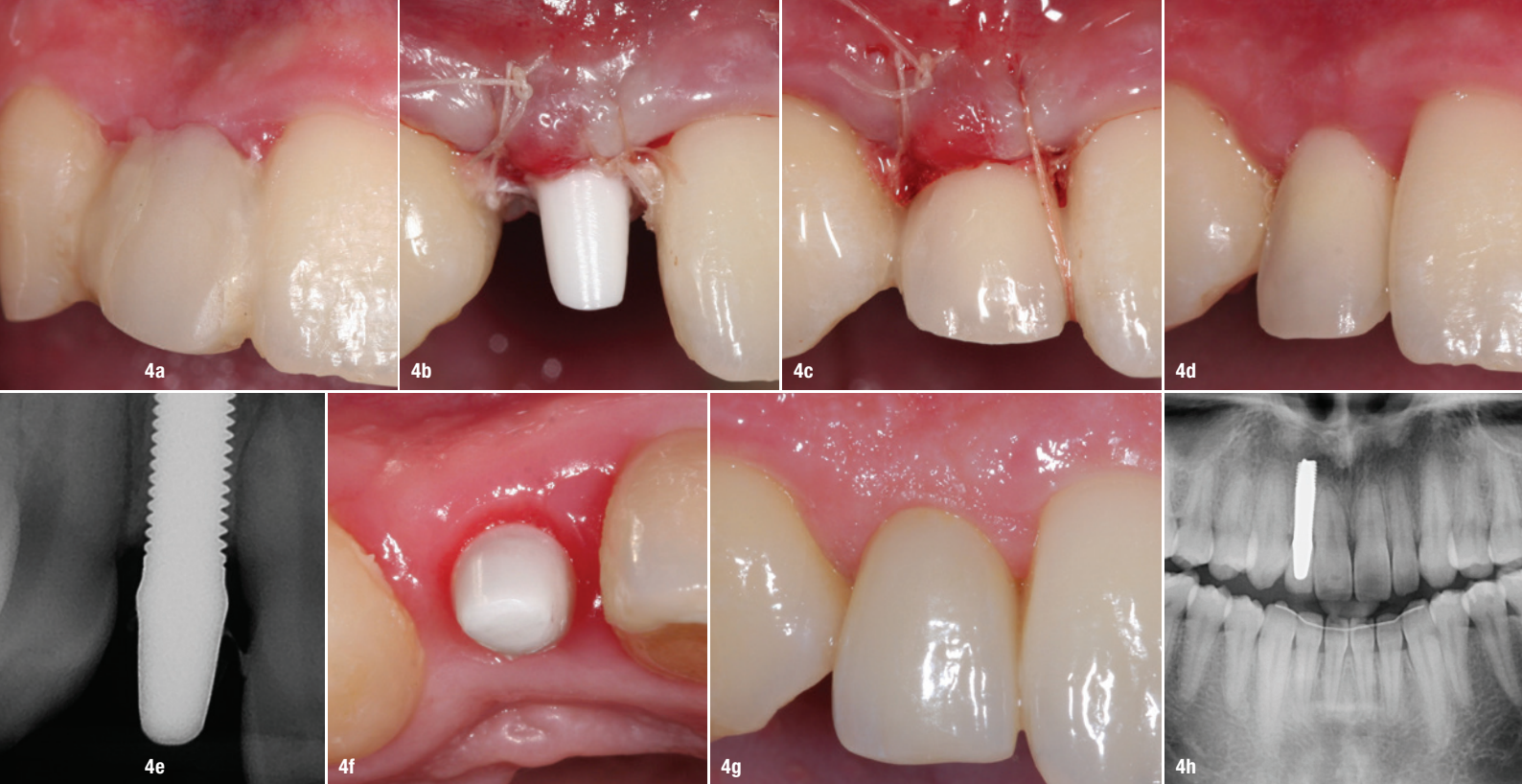


Fig. 3: On the day of impression taking: clinical case of a one-piece implant (Z-SYSTEMS) in site 11 showing perfect soft-tissue integration.

acts as a protective barrier towards the underlying structures. There are three fundamental aspects to be considered: the microbiological aspect, the biomechanical aspect related to cell adhesion and proliferation around transmucosal implant structures, as well as the potential release of metal ions that disrupt local immunity.²⁸

Microbiological behaviour of zirconia

In a 2002 *in vitro* and *in vivo* comparative study on Ti, researchers described the transmucosal ZrO₂ interface as an anti-microbial shield.²⁹ This observation was confirmed by further studies. In 2014, researchers conducted an *in vivo* study based on the use of split casts worn for 24 hours, comparing ZrO₂, smooth Ti and rough Ti.³⁰ Analyses of the pathogenic and non-pathogenic flora revealed less microbial adhesion on ZrO₂ than on the other two Ti surfaces. Consequently, bacterial colonisation is lower on ZrO₂ than on Ti. This was confirmed again in 2016 by the same author, and later on by another researcher in 2018 in a 6-month follow-up study comparing transmu-



Figs. 4a–h: An 18-year-old patient with agenesis of an upper right lateral incisor (**a**), a 3.6 mm diameter one-piece implant is placed with an abutment correction using a red ring diamond bur; a pedicled soft-tissue graft is performed using a roll technique (**b**), placement of an immediate provisional crown out of occlusion; sling sutures for the coronally advanced flap (**c**), tissue healing around the immediate provisional crown (**d**), periapical radiograph showing implant osseointegration at three months following immediate temporisation (**e**), occlusal view of soft-tissue healing with preparation of the one-piece implant prosthetic abutment (15° axis adjustment) (**f**), aesthetic result at ten years (in this 28-year-old patient) (**g**), panoramic radiograph at ten years (**h**).

cosal ZrO₂ and Ti abutments they observed more pathogenic bacteria on Ti.^{31, 32} This difference in microbial behaviour towards Ti compared to ZrO₂ exposes Ti to an increased risk of PI, as was pointed out in a review article in 2014.³³ Microbial colonisation causes an inflammatory infiltrate within the tissues in response to this microbial presence. The tissue defence barriers are weakened and more permeable to biofilms. A chronic inflammatory wound then develops within the peri-implant soft tissues which disturbs bone metabolism, thus constituting a risk factor for PI: a phenomenon very similar to periodontitis. Around transmucosal ZrO₂, researchers showed in 2015 that inflammation level decreased compared to Ti.³⁴ The risk of alteration of the soft tissue barrier effect therefore lower with ZrO₂ than with Ti.

A recent study from 2017 confirms the positive influence of transmucosal ZrO₂ on the level of pro-inflammatory cytokines present in the peri-implant sulcus.³⁵ In this publication, the authors compared the behaviour of the transmucosal ZrO₂ and Ti abutments using split-mouth *in vivo* study. They showed that the pro-inflammatory cytokine levels were significantly higher around Ti compared to ZrO₂. As often reported in the medical literature, some controversies exist. In 2015 researchers published, in the very serious *Journal of Clinical Oral Implant Research*, a meta-analysis comparing the effect of Ti and ZrO₂ on the soft tissues.³⁶ The inclusion criteria were strict: 11 studies were selected including only prospective randomised controlled studies on the same patient. They concluded that Ti and ZrO₂ behaved similarly. The only difference in

favour of ZrO₂ was aesthetics. However, very recently in 2018, in the same Journal a review article and meta-analysis on the effect of transmucosal abutment characteristics on peri-implant soft tissue health was published: the authors concluded that the risk of PI is increased with Ti compared to ZrO₂.³⁷

Tissue and cell behaviour towards zirconia

In addition to the “antimicrobial” effect of ZrO₂ mentioned earlier, the literature describes a favourable behaviour of ZrO₂ on the peri-implant soft tissues. The interaction with soft tissues and transgingival ZrO₂ generates a mechanical antimicrobial barrier effect that protects the underlying structures (Fig. 6). In a 2004 study on the cell behaviour around transmucosal ZrO₂ implant necks compared to Ti, the authors observed better fibroblast adhesion and cell proliferation around ZrO₂.³⁸ In another study from 2009 on animal histological sections, the authors showed collagen fibres orientated perpendicular to the ZrO₂ surface as opposed to Ti where they were parallel.²⁰ This fibre orientation reinforces the peri-implant mucosal joint and may partly explain the “creeping attachment” phenomenon which is clinically observed around ZrO₂ necks. In 2019, a Korean team carried out a comparative *in vivo* and *in vitro* animal study on the behaviour of peri-implant tissues with respect to ZrO₂, Ti and hydroxyapatite.³⁹ In particular, they evaluated the quality of the mucosal joints around these three implant surfaces. ZrO₂ obtains the best results on the histological sections and *in vitro* cell levels; ZrO₂ also promotes better prolif-

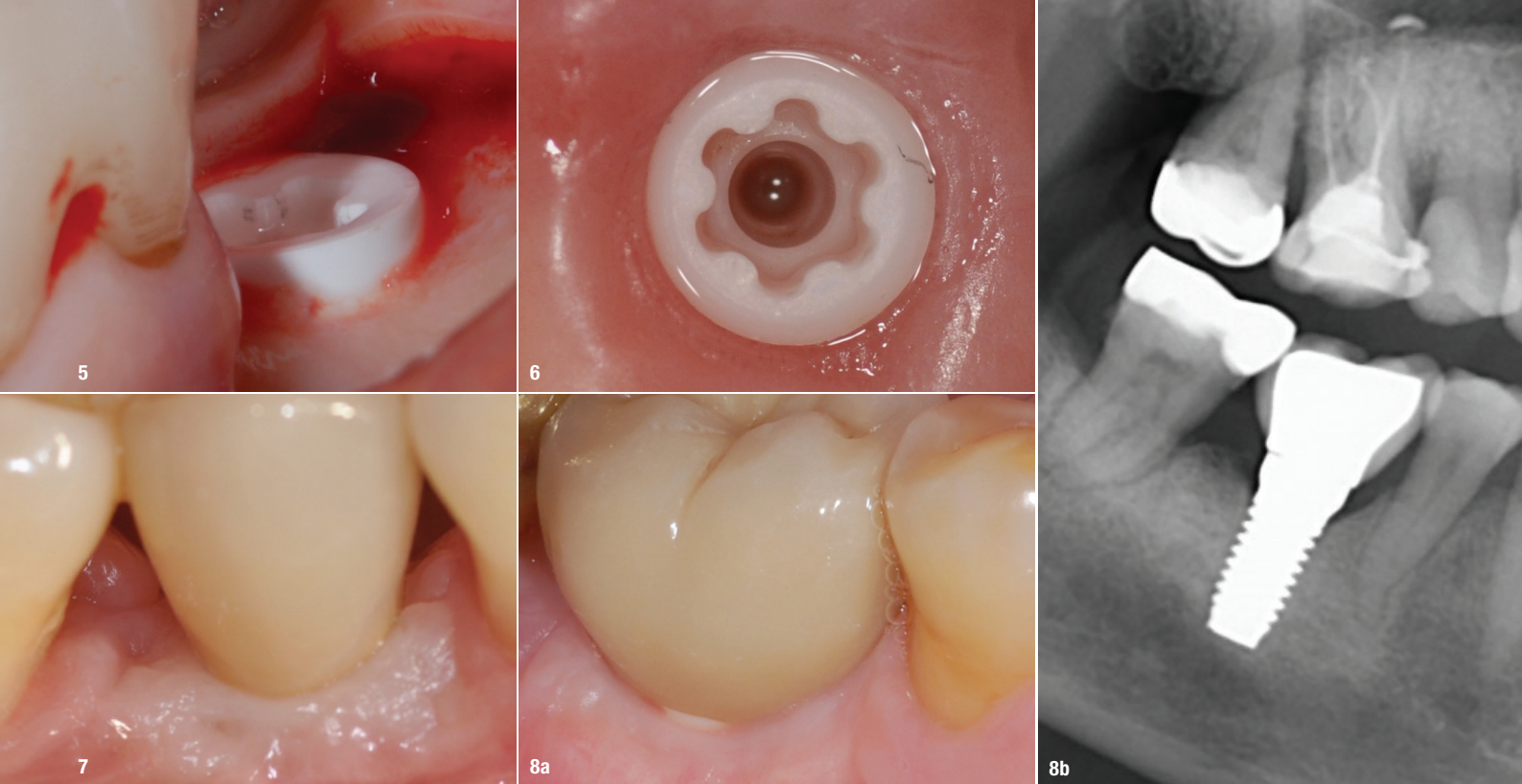


Fig. 5: A 5.5 mm diameter implant, placed “supracrestally” 1.6 mm above the bone crest (NobelPearl, Nobel Biocare). **Fig. 6:** The quality of peri-implant soft tissue achieved with transmucosal ZrO₂ provides an antimicrobial barrier effect (CERALOG, BioHorizons Camlog). **Fig. 7:** Tissue integration of a ceramic-to-ceramic restoration on a ZrO₂ tissue-level implant. The stability of the soft tissues favours papillae preservation. **Figs. 8a & b:** Soft-tissue quality and quantity around a one-piece implant Z-SYSTEMS zirconia crown **(a)**, peri-implant bone level stability at five years **(b)**.

eration of human fibroblasts (HPLF and HGF) and extracellular matrix cells (lhCEM) compared to Ti and hydroxyapatite. Due to its properties, transmucosal ZrO₂ appears to behave more like natural teeth with respect to soft tissues. This can be illustrated by a 2015 study which shows that blood flows around transmucosal ZrO₂ abutments are similar to those around natural teeth (Fig. 7).⁴⁰ ZrO₂ appears to be a biomimetic material around which the quality of the peri-implant mucosal joint is better than around Ti. The reduction to biofilm proliferation and the quality of soft tissue integrity which have been demonstrated around ZrO₂ provide a double protective barrier for the underlying tissues to chronic inflammatory infiltration and microbial invasion which is probably the main risk factor for PI. Thus, the use of the ZrO₂ implant to establish a high quality peri-implant mucosal seal can be considered a preventive approach in the strategy to control PI.

Conclusions

ZrO₂ implants have been around for 20 years, and if at first glance their interest may seem limited to pure aesthetics due to their colour. Today we realise that, thanks to their exceptional mechanical properties and optimal biocompatibility and immuno-compatibility, they certainly represent the future of implantology. Placing ZrO₂ implants in our patients is part of a preventive approach to peri-implantitis, because the quality of the peri-implant tissues achieved around these implants is an anti-microbial barrier which protects the underlying structures. The absence of oxidation reactions around the ZrO₂ implants

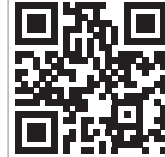
and the reduction of bacterial plaque are real assets for their long-term stability in the particularly aggressive environment of the oral cavity. The latest currently available generations of ZrO₂ implants offer mechanical, biological and aesthetic qualities close to those of natural teeth.



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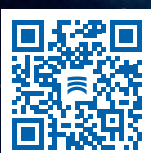
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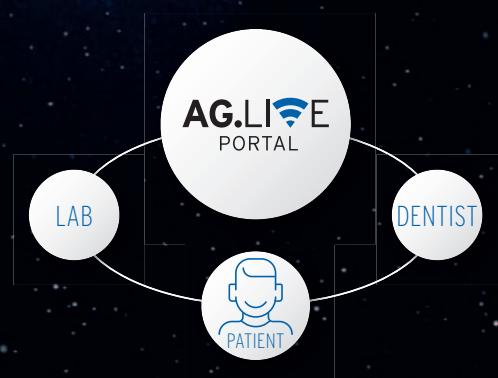


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