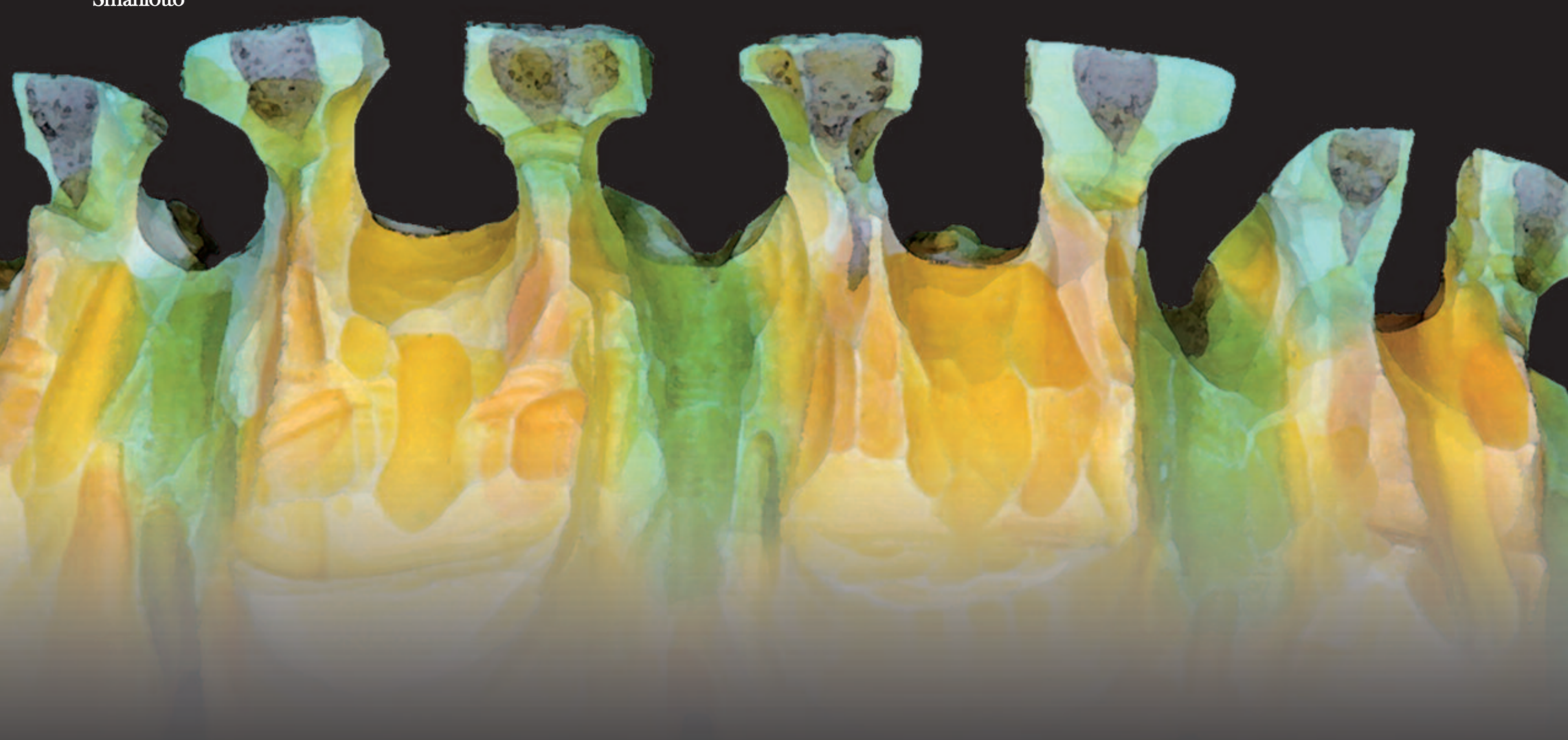
A New Design for Devices in Zirconia - Ceramic Partially Stratified, Part 2

Paolo
Smaniotto

Part II: P.S.Z. or the physical characteristics of zirconia and aesthetics of ceramic



In the first part of the article published in Spectrum dialogue March Issue 2014, I attempted to provide a brief summary of the motives which have, over many years of creating structures in zirconia, driven me to experiment with and propose an alternative design for the creation of partially stratified monolithic structures (Figs. 1 and 2). In this second part, I will, as I mentioned in the previous article, attempt to provide encouragement with scientific discussion based on a review of specific articles (see the literature), participation in courses and conferences held by leading researchers (e.g.: A.I.O.P. Closed Meeting, 2011-2012-2013) and a wealth of verified information obtained as part of daily laboratory practice, which has enabled me to test their merits and seek out new methods to improve the ways of satisfying the ever-increasing clinical demand for function and aesthetics [1-2-3]. Ceramic materials can be divided into two groups:


Fig. 1


Fig. 2

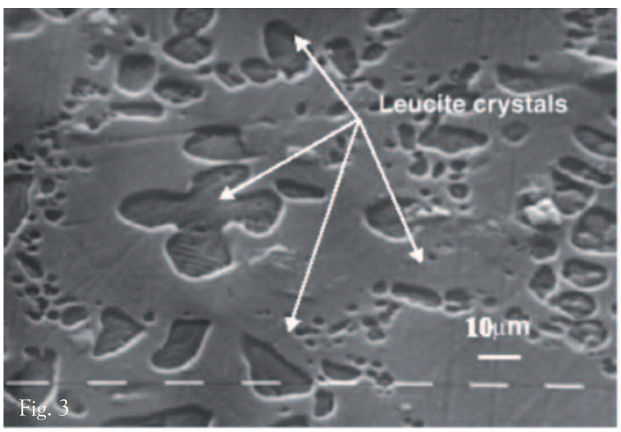


Fig. 3


Fig. 4


Fig. 5


Fig. 6

Figs. 1 and 2: Different materials in different situations; nature offers up countless combinations

Fig. 3: Leucite in a feldspathic glass matrix

Figs. 4 to 6: Structures in pre-sintered zirconia

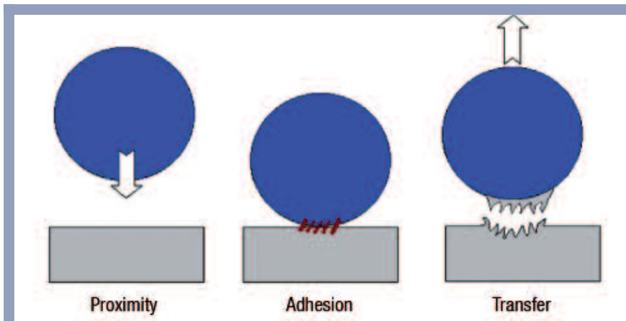


Fig. 7

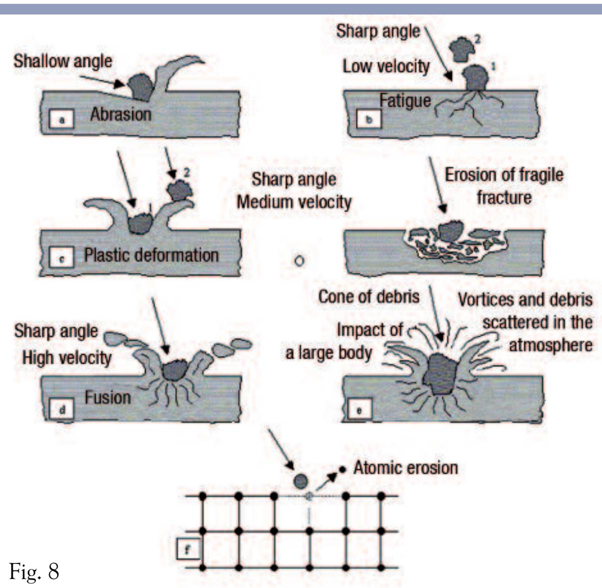


Fig. 8

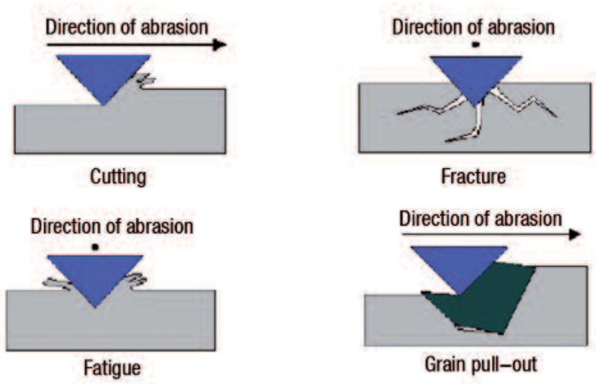


Fig. 9

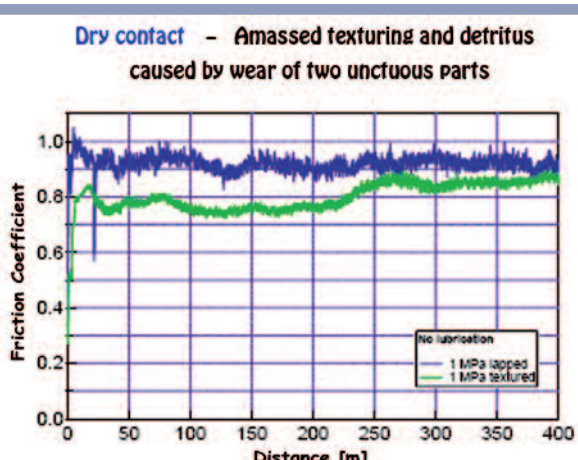


Fig. 10

- Traditional (ceramics providing an aesthetic-functional covering for metals) (Fig. 3)
- Advanced (for the construction of self-supporting biomedical structures), for example alumina, lithium disilicate, zirconia (Figs. 4 to 6), whose main advantages include:
- Low impact on the immune system
- Chemical inert to fluids
- Extremely low resistance to compression
- Low friction coefficient.

It is well-known that dental-prosthetic devices in the oral cavity are prone to wear during the masticatory process.

One branch of the science of materials which studies such phenomena is known as tribology, which has applications in the field of dentistry.

The wear and tear that affects our materials causes a gradual deterioration in their performance, causing the dissipation of energy due to friction, with the negative consequences that this entails (Figs. 7 to 9).

Wear is defined as the gradual removal of material from the surfaces of our prosthetics and is expressed in various ways, such as:

A) Adhesive wear
B) Erosive wear
C) Abrasive wear.

An analysis of wear is performed with reference to

Figs. 7 to 9: Diagram of the various abrasion typologies

Figs. 10 to 13: Tribology of prosthetic materials: graphics, design and images under the microscope showing the constant and gradual wear and tear process in the absence of a correct occlusal function

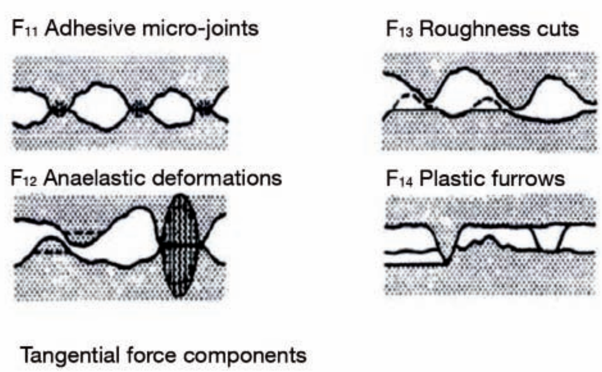
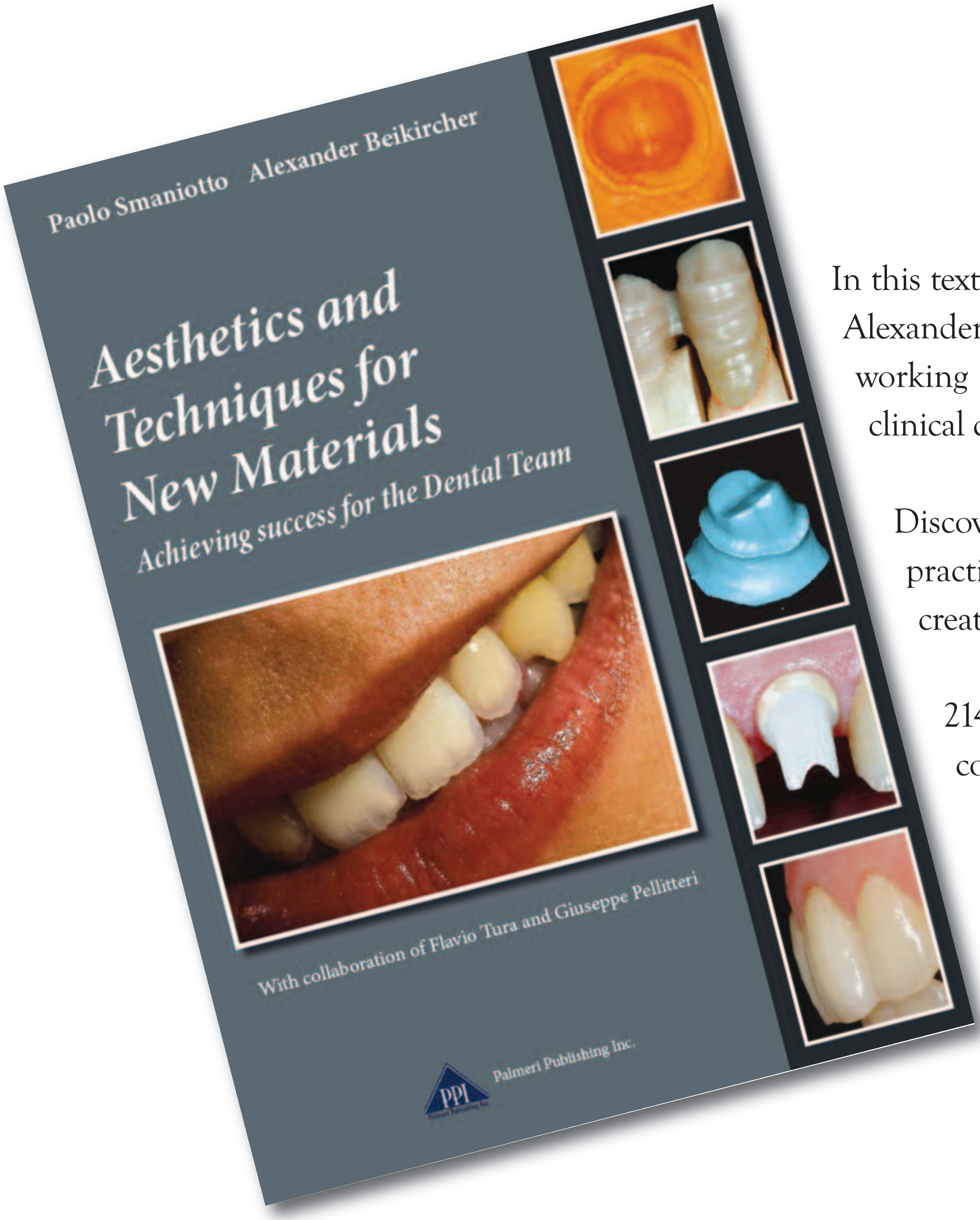


Fig. 11

Paolo Smaniotto, MDT and Dr. Alexander Beikircher show the way to a beautiful aesthetic smile.



In this text, Paolo Smaniotto, MDT and Dr. Alexander Beikircher describe in detail the working methods, they use to solve every clinical case in an aesthetic way.

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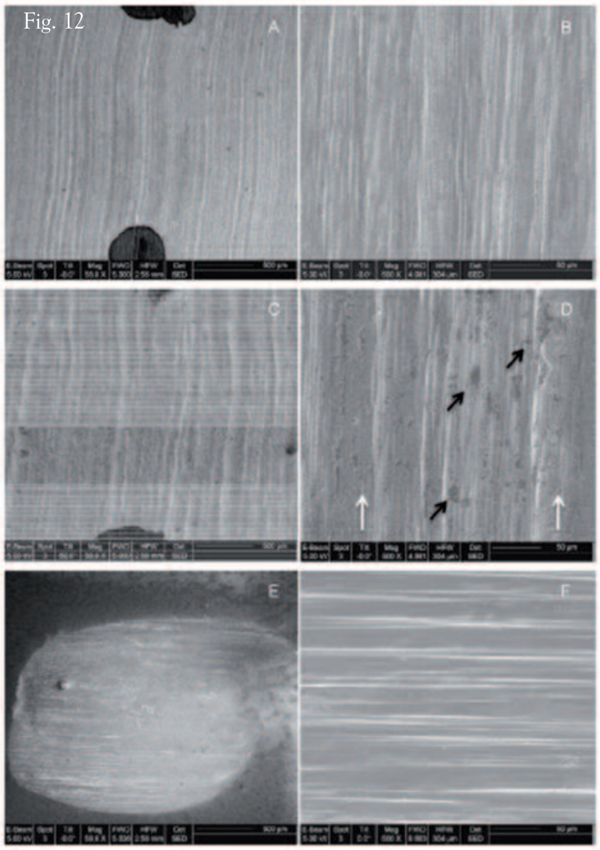
Fig. 12


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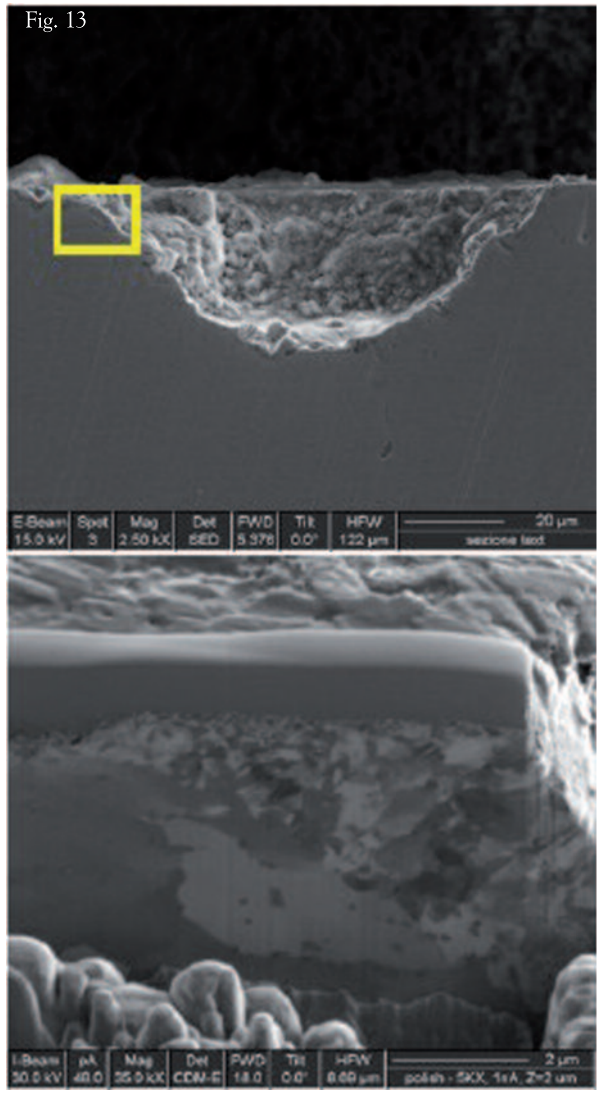

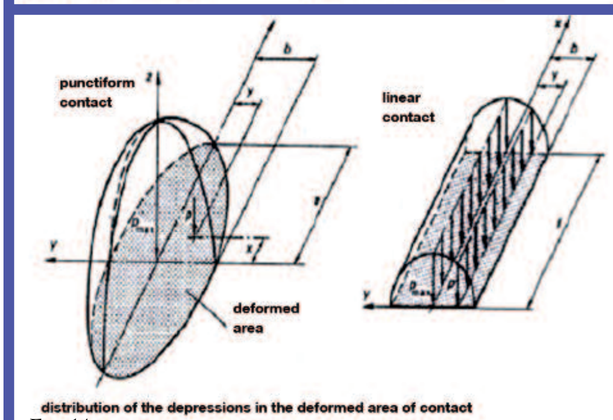

Fig. 14

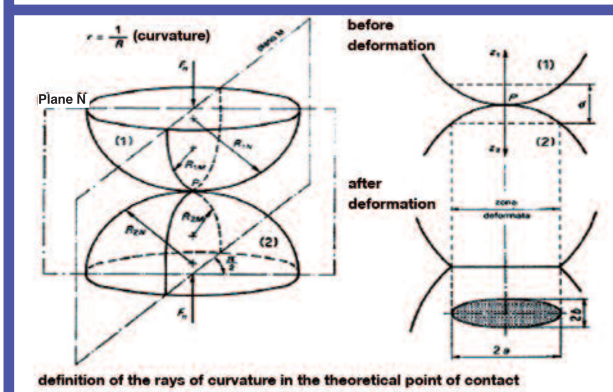

Fig. 15

Figs. 14 and 15: Punctiform contacts are always preferable in order to more effectively dissipate the functional loads which act on our prosthetics

the masticatory and functional cycles, but the complexity of the phenomenon requires more subtle analysis focusing on the macroscopic mechanism, on the appearance of the worn surfaces and on the nature of the antagonist materials (Figs. 10 to 15).

The title of this article refers to a new "Project" design for the construction of prosthetic structures which make precise use of advanced ceramics in Partially Stratified Zirconia, which for the sake of brevity I will refer to as P.S.Z.

In this kind of structure, it is useful to remember the presence of two materials, i.e. zirconia and dental ceramic, which differ for the following reasons:

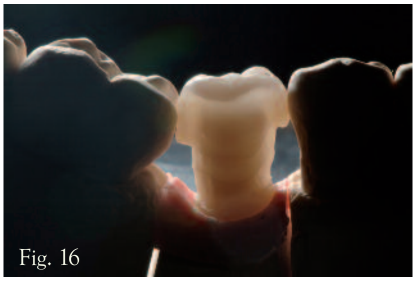
Fig. 16


Fig. 17


Fig. 18


Fig. 19


Fig. 20

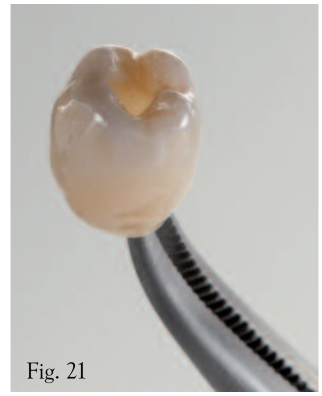
Fig. 21


Fig. 22


Fig. 23


Fig. 24


Fig. 25

Fig. 16: Screwed posterior element for implant constructed using the P.S.Z. technique in Partially Stratified Zirconia with functional and proximal area in monolithic zirconia

Figs. 17 and 18: Partially ceramic posterior element of the lingual and vestibular portion. The view with transmitted light shows the excellent integration of the materials

Figs. 19 to 21: The posterior elements of the implants, which are ankylosed, are more heavily subjected to functional loads compared to element of natural teeth. For this reason, the crowns are constructed partially stratified. Completed device, various views

Figs. 22 to 25: I always prefer modelling in traditional wax, which enables an assessment of aesthetics and function, after which I move on to the dual scan

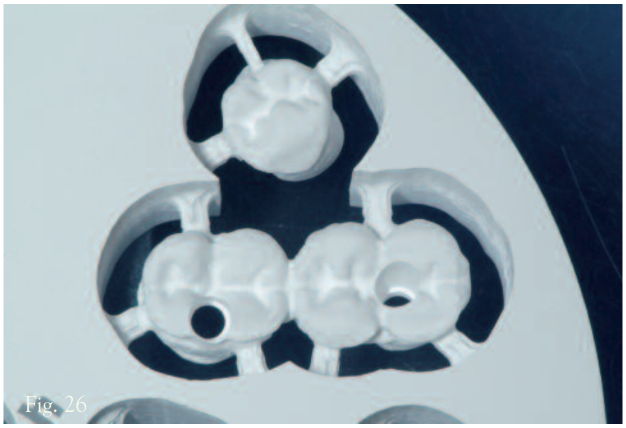
Fig. 26

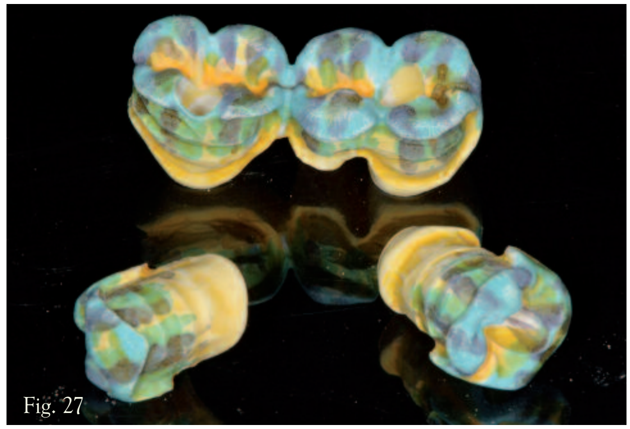
Fig. 27


Fig. 28


Fig. 29


Fig. 30


Fig. 31


Fig. 32

Figs. 26 and 27: Elements in pre-sintered zirconia. At this point I perform all refinishing manually before proceeding with sintering; this vastly reduces the use of the cutter on the sintered zirconia structure

Figs. 28 and 29: P.S.Z. structure of sintered zirconia with diffuse, transmitted light

Figs. 30 to 32: Finished prosthetic device. The physical characteristics of the zirconia and the aesthetic effect of the ceramic guarantee long-term success

- Resistance to loading and wear
- Resistance to thermal stress
- Resistance to stresses typical in "border" areas during functional contacts

Because mono-crystalline zirconia has "Metallic" functional characteristics and poly-crystalline dental ceramic has aesthetic characteristics which are typical of a "vitrous phase" (Figs. 16 to 18). The zirconia and ceramic are bonded to each other using weak chemical bonds, unlike metal-ceramics which favour the interposition of oxides. I remember that in the initial experiments in dental prosthetics performed by Dr. Horn, with the application of vitrous ceramic on metal, the material used was leucite KAISi2O6, containing feldspathic glass.

Subsequently, modifications to this material have enabled improved chemical adhesion to the metal. The combination of metal and ceramic has undergone further study, and today, the leucite used is a modified version of Dr. Horn's which differs in terms of its composition and microstructure, as well as in terms of the distribution of the crystalline phase if this is adjusted for resistance values ranging from 30-40 MPa to 120 MPa.

The main disadvantage of dental ceramics is that

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the magnitude of the stress generated within the vitrous matrix reaches high levels which can lead to damage due to the formation of internal cracks, creating gaps and acting as force concentrators.

Until a few years ago, we had no alternative to metal-ceramic, but then we began to study alternative methods, materials and equipment which have brought us to this metal-free phase of technology.

Research into biomaterials has over the years taken on an increasingly important role, also due to the increasing average age of the population [4-5-6]. In fact, it is expected that by 2050, 35% of the population will be more than 70 years of age, meaning that it will be increasingly necessary to offer dental-prosthetic treatments which are efficacious in terms of biological, economic cost as well as in terms of aesthetic and functional yield; these reasons have led research along new, now very more computerized Metal-free routes. Currently, Zirconia Ceramics comprise two materials which from a chemical point of view "do not talk" to each other, with all of the problems which putting them together entails:

- Different elastic modulus
- Different flex strength behaviour; in zirconia, this parameter is ten times higher than that for Dental Ceramic,

thus the major worry that we have to take into account is the different behaviour of the two materials when subjected to cyclical loads (Figs. 19 to 21). The purpose of this publication is not to support the reasons proposed for protecting the functional area subjected to wear while at the same time encouraging an optimal aesthetic yield by means of the targeted use of Dental Ceramic, but rather to consider what can happen when loads "inevitably" affect the zirconia - ceramic interface, a problem which many authors have described as the main cause of peeling and chipping. It is also intuitive, as described above, to understand the importance of providing zirco-ceramic composite structures with a suitable, adequate design for the support structure (Figs. 22 to 29).

Finishing the structure

Recent studies performed in vitro on the basis of "resistance to fatique" tests with samples of various types of zirconia subjected to cyclical loads typical of the masticatory phases, show that, after undergoing surface finishing treatments with rotating cutters and when compared with counterparts with no surface treatment, better results in terms of the controlled integration of the zirconia structure are obtained by using diamond cutters with a grain size of 40 micron at 100,000 rpm, with constant irrigation of 40 millilitres of water per minute, applying a cutter pressure on the zirconia structure of 2 Newton (equivalent to 200 g, corresponding to the weight of two decilitre cups of water). The following instruments were used for the test:

- Diamond cutter with fine 40 micron grain size
- Diamond cutter with medium 80 micron grain size
- Diamond cutter with large 150 micron grain size
- Speed controlled at 10,000 to 150,000 rpm
- Irrigation or less with water flow
- Variable cutter pressure on the structure.

This type of finishing does not mechanically weaken the finished structure and the test values are identical to structure which are not surface-treated.

Great care must be taken with the issue of surface roughness; finishing with large grain cutters must be avoided, as tests have shown that these cause "subcritical" cracks which, with cyclical loads, lead to fractures.

We must always consider the system from the point of view of the cyclical load as any cracks which are present in the structure are so small that they are not easily seen, but with the passage of time in the oral cavity, this progresses until a fracture occurs. It is therefore recommended to follow the procedure of using 40 micron rotary cutters as described above for making corrections to the zirconia, both on the external and internal surfaces.

After treating the surfaces with a suitable diamond cutter, I proceed with polishing using dedicated rubber polishers with decreasing grain sizes in order to bring out the "glossy" surfaces of the zirconia. At this point, I apply a light coat of glaze colours and, after low temperature firing, at 700°C, I apply a second neutral opaque glaze at 780°C, in order to finish the gloss firing and to protect the underlying colours (Figs. 30 to 34).

The reasons given above have resulted in

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Fig. 33

Fig. 34

Fig. 35

Fig. 36

Fig. 37

Fig. 38

Figs. 33 and 34: The correct polishing of the occlusal surfaces in Monolithic Zirconia provides the basis for controlling potential abrasion and thus wears. Research has shown that zirconia is much less abrasive compared to ceramic materials with vitrous matrices

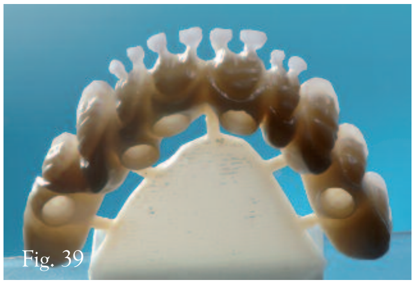
Figs. 35 to 38: I re-iterate the importance of traditional modelling in wax, as only in this way am I in a position to be able to assess aesthetics and function, in order to be able to properly show the boundaries between areas which I will keep in monolithic zirconia and others on which I will apply Dental Ceramic

companies producing dental materials (such as Komet, Bredent, Renfert) embarking on the study, construction, testing and launch on the market of cutters and polishers of various types which are suitable for obtaining what is required.

Conclusion of part two

As announced previously in this magazine, Spectrum dialogue March Issue 2014, I have addressed a number of issues which affect the use of methods combining the implementation of IT and a number of recent techniques which encourage the use of Metal-free structures which are increasingly focused on the use of zirconia [8-9].

In laboratory practice, I combine the A.R.D. technique [7] with CAD/CAM processing to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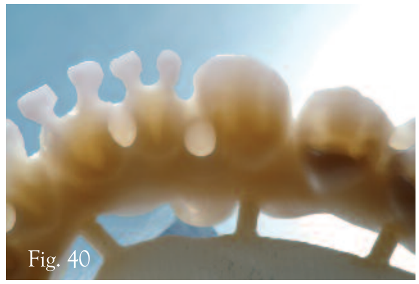
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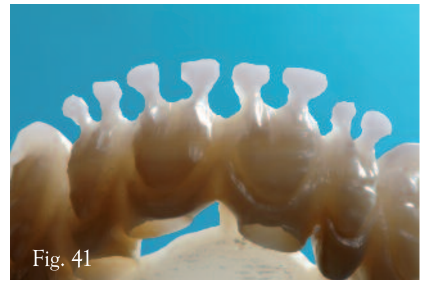
Fig. 41

Figs. 39 to 41: Full-Arch structure constructed in P.S.Z. using the new proposed design. Function obtained from the contribution provided by the physical characteristics of the zirconia, and the aesthetics enabled by being able to apply Dental Ceramic on a structure which through its design allows goods optical light effects

construct structures in partially stratified monolithic ZrO_2 in order to be able to combine materials such as Zirconia and Dental Ceramic (Figs. 35 to 41).

I have expanded upon some of the questions brought up in the previous issue with the intention of laying the groundwork for the next, final article covering topics such as: Multidimensional Uncertainty, Volumetric Calibration and New P.S.Z. Design. Until next time... Sd

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