From dream to reality

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For a long time we technicians had been longing for metal restoration coming out of the sinter furnace perfectly fitting the model. This desire, however, is unlikely to come true after consecutive firings especially in case of implants. Nevertheless, the dream can come true if zirconia is used.

Zirconium was discovered in 1789 by the German Martin Klaproth and isolated by the Swedish J.J. Berzelius in 1824. Zirconia is a silicate whose composition is Zr(SiO4). It is obtained from a mineral and is one of the most abundant elements in the terrestrial crust. Chemically very reactive it is mainly found combined with oxygen forming zirconium dioxide (ZrO2). Zirconium is used as coating on nuclear fuel parts, for photographic flashes and for the protective slabs of space shuttles.

In the last decades zirconium has been successfully used for artificial limbs and joints in the medical field. The material is considered biologically and chemically inert. Due to the small diameter of its grains a very polished surface is obtained which explains the reduced accumulation of plaque and the excellent tissue tolerance. Like any other metal zirconium is radiopaque and thus allows us by means of x-ray to check its marginal adjustment. It has better mechanical properties than aluminium, especially as far torsion and traction is concerned.

Is zirconium a metal?

Yes, zirconium is a metal like most of the elements on the periodic table, but it differs fundamentally from the rest by the type of connection between its atoms. It is a metallic compound whose electrons form a cloud that moves around the nuclei.

Zirconium or zirconia?

Zirconium or zirconia refer to the same material, much of the confusion arises because a commercial house labels a product with zirconia which in fact is made up by a 67% of alumina and a 33% of zirconium. Observe that the ceramics that we must use for its coating are those of alumina.

Typology

All zirconia available on the market is very similar and can only be differentiate by its physical state:

Green Zirconia: elaborated by means of metal milling burs in dry.

Partially sintered zirconia, elaborated with tungsten burs cooled by water.

Totally sintered zirconia, elaborated with tungsten burs cooled by water.

Structural characteristics

Although we are always talking of zirconium, what we are really speaking of is zirconia dioxide (ZrO2). Its thermal characteristics are the following:

- Point of fusion 2715ºC
- cubical Structure to 2370ºC
- tetragonal Structure over 1163ºC
- monoclinical Structure below 1163ºC

Stabilization with yttrium (Y-TZP)

The English scientist Ron-Garvie, obtained the tetragonal state of the zirconium by adding approx. 5% of yttrium oxide to the zirconium. It is its state of utmost stability, with no need to reach 1163ª simply at ambient temperature.

Addition of aluminium (Y-TZP-A).

In order to increase its resistance to corrosion and to increase its durability, aluminium is added to zirconia in a maximum proportion of 0,5% , adding more would be considered as an impurity.

Transformation toughening

The so called phase transformation or airbag effect can cause the tetragonal phase to convert to monoclinic, with the associated volume expansion (4.7%).

This phase transformation can then put the crack into compression, retarding its growth, and enhancing the fracture toughness. Zirconium is a bad heat conductor. Heat produced in one point, is not propagated, and results in changes in its structure that's why it is not advisable revising it by blasting it either with oxide or with steam.

Clinical case

Patient, 49 years old, 8 implants were placed in the upper maxilar. We decided to make a splinted zirconia structure with individually prepared zirconium-ceramic crowns and gum made of pressed resin. Furthermore we made a temporary lower circular bridge.

Fig. 1 and 2: Starting Point: the patient with his old prosthesis

Fig. 3: Mount of teeth in wax

We detected a significant support deficiency in upper lip as well as an aesthetic deficiency in the individual proportions of the teeth and in their three-dimensional alignment. First of all we made an assembly in wax with resin teeth which served us as a basis to decide on the final volume, size and position of the teeth. This was the crucial moment of the treatment and as Dr William Pagan put it "Everything we say before starting the treatment is part of the diagnosis but everything we say afterwards are mere excuses". This was the point where we had to define the most ideal final outcome in accordance with the patient, the dental surgeon and the dental technician. By following this process can avoid undesired surprises, the patient will be well informed about what he can expect and we will obtain better results at lower costs.

We started with the making of a model in light curing composite rigid for easy milling. The composite of the plates is a good and economic choice but if we want a more pleasant appearance, composite for provisional of Tryad-dentsply type are better. Afterwards we had to carve the teeth out of the splint like individual stumps.

4 and 5: resin model of the restoration

We checked the model in mouth to make sure that the measurement was exact and had a correct passive adjustment. Once the control was made, we passed on to the milling of the structure by duplicating it onto zirconia in the following way:

We fixed the model in a resin made template that was put into the right table insert of the milling machine. The corresponding zirconia block was glued in the left insert. The system offers a great variety of zirconia blanks of different sizes and diameters. Without moving the horizontal tray, we began to mill the general volume of the frame structure, including attachments to the piece that connect it to the transephitelial of implants. The Zirkonzahn System offers us the possibility to reproduce the connection to implants as well as rendering possible its cementation to zirconium.

At this point we put some positioning elements on both sides (model and zirconia blank) which we glued two by two in three strategic points, this allowed us to relate the model to the zirconia blank which we were milling - at any time.

Fig. 6: Restoration positioned, general volume milled

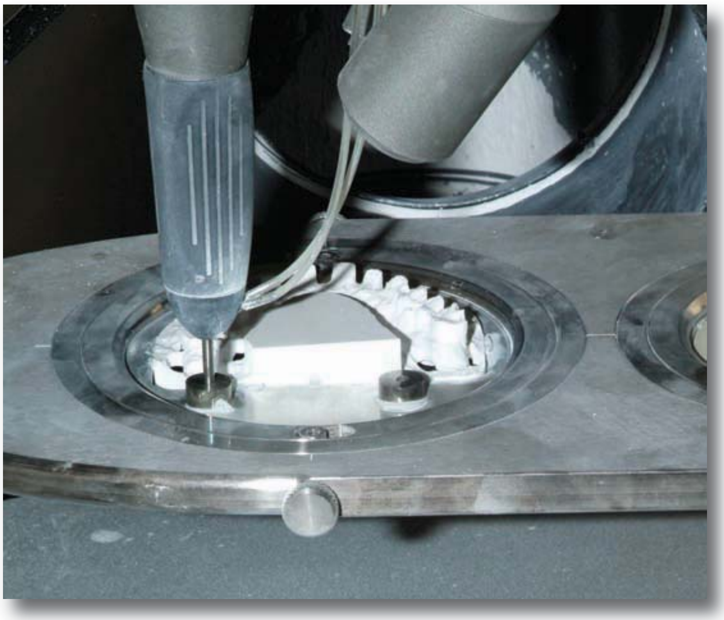

Fig. 7 Positioning elements

Fig. 8: Looking for parallelism

In order to be able to mill the chimneys of the screws as well as the attachment to the implant, we had to place them totally parallel to the milling bur. This position differs from implant to implant. To check parallelism, we inserted a copy of the implant and a large screw of the laboratory. Then we turned the model to the left and to the right until we reached the exact parallel position. Afterwards we inserted the horizontal working plate and by means of the positioning elements we brought the zirconia blank into the same position as the model.

Presently the system is provided with a mechanism that unites the two metal table inserts of the milling machine allowing greater agility. Nevertheless, it is not sufficient for all implants as in complex works the 45° rotation to the left and the right of the centre of the model does not allow us to complete the process and makes the use of positioning elements necessary.

After having completed the milling process we removed the frame structure from the insert and we elaborated it with tungsten burs (6-8 mil. turns max.)

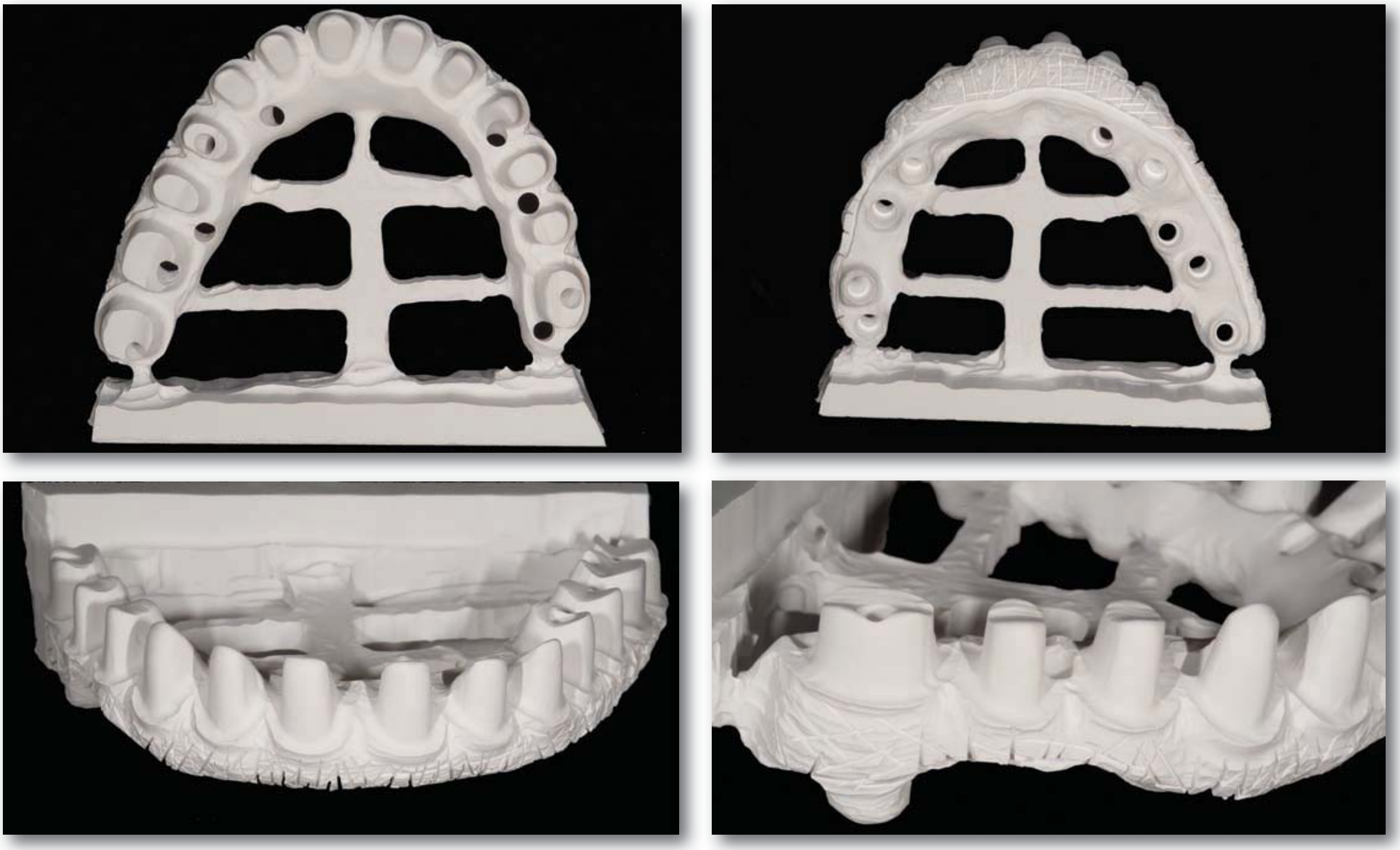

Fig. 9 – 12 Milled frame work structure in green state

We went on with the colorization of the structure by dipping it into acid for 1-2 seconds. The system is delivered with 16 liquid colours which correspond to the VITA colour scale and a reddish colour for gums will be available soon. It is necessary to put the dyed zirconia structures under a drying lamp for 45 minutes.

Afterwards the furnace can be loaded for sinterization. During this firing process the frame structure shrinks to the original size of the model (20%) and gets the characteristics of sintered zirconia, i.e. hardness of 1200- 1400 vikers and bending strength of 1000 Mpa.

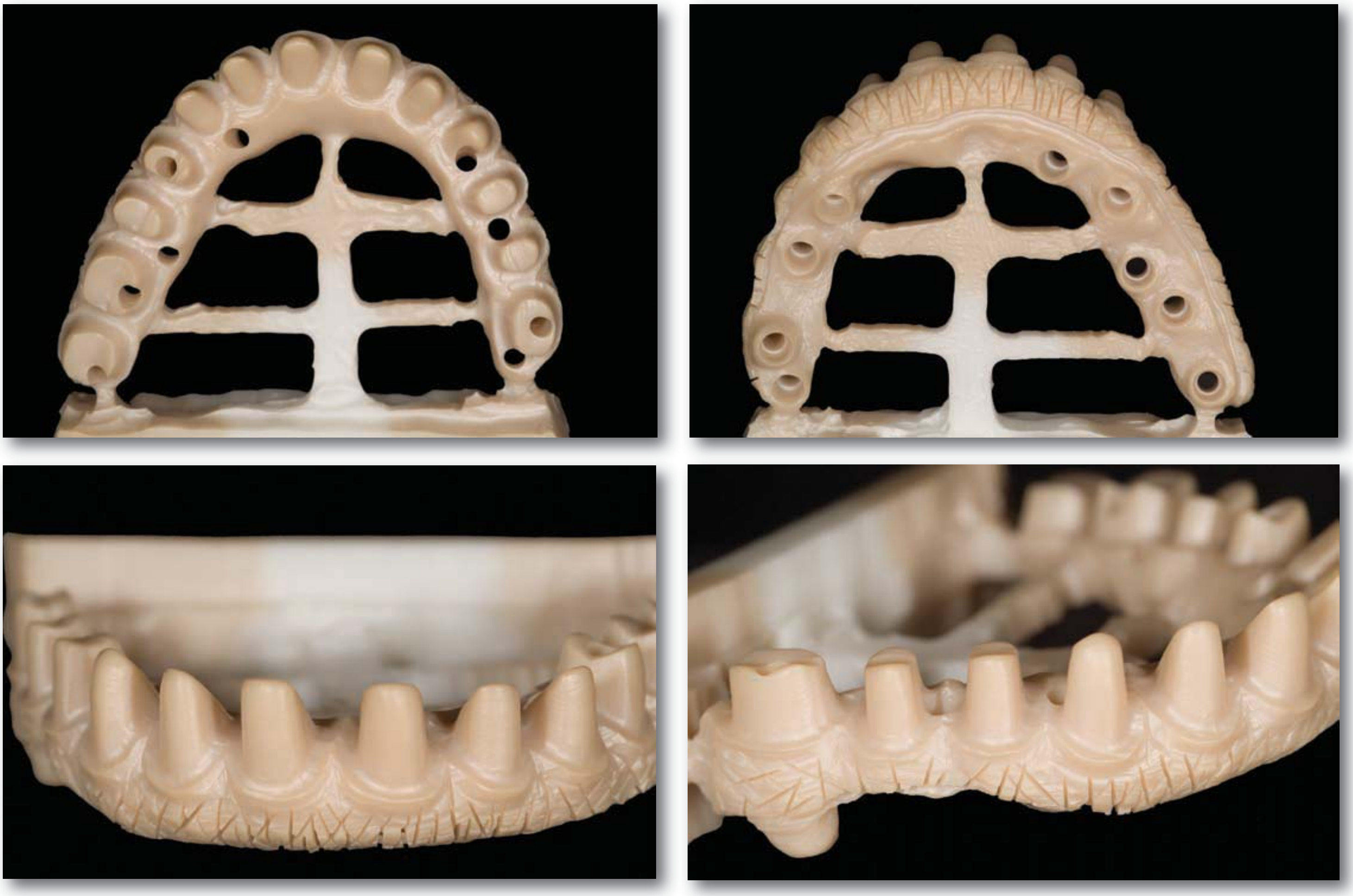

Fig. 13 – 16 Dyed and sintered frame work structure

We then separated the frame structure from its basis with sintered diamond discs at 6000/min and checked the bridge on the model. In this case we had to insert the metallic pieces which later were cemented to the zirconium, in other cases the system allows the milling of the attachment to implants directly in zirconium.

We continued with the realization of the single zirconia copings. Once again we made a model with the easily manageable light curing resin and we repeated the process described above.

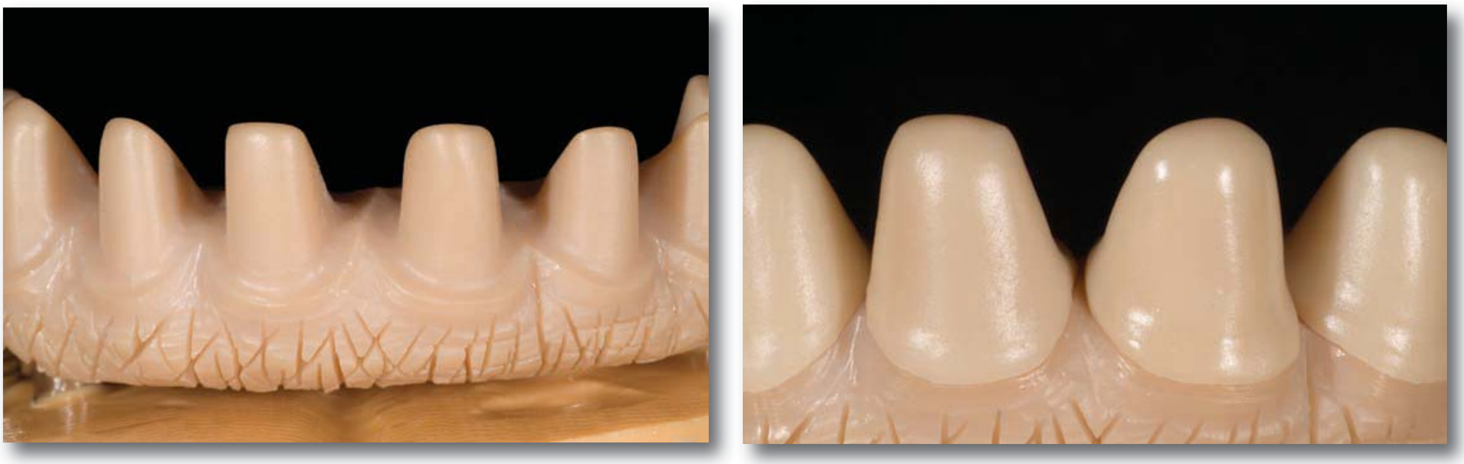

Fig. 17 and 18 Copings

Then we started with the application of ceramics on the copings applying a thin coat of transparent ceramics which we fired 30-40° C higher than dentin. In this way we got a good connection between the frame structure and the rest of the ceramic layer.

Thus we avoided loosening of material and marginal and occlusal rises. We were using transparent material as it is the purest material.

Fig. 19 and 20: Stratification of dentine

Especially with complex works, when we are talking about ceramics on zirconia we have the problem of low luminosity values and the belief that the solution to the problem is having white nuclei, or lighter colorization of nuclei we produced or using opaques, liners, bonders, etc on the basis of metallic oxides to resist the loss of this final value, but the question is: If what we want is an opaque nucleus, why should we use zirconium if the metal already perfectly fulfils this aim?

The answer is to my understanding that the luminosity error lies not in what is underneath but in what we are doing above, in the last layers. We do not have to use other material than dentine in the medial cervical area since if we cover it with incisal or transparent material - materials necessary when we are working with metal in order to simulate depth - lowers too much the luminosity or the final value of the restoration in zirconia. It is there in the medial cervical part where we must demonstrate all our abilities. We have to apply incisal, transparent and opalescent material and, first of all, we have to create contrasts which should be a little bit more intense than on metal as less light is reflected and therefore, contrasts are less evident.

We cannot use any kind of zirconia or ceramic if what we want to obtain is a restoration that behaves just like the natural tooth under different types of light, the zirconia material we have to use has to be translucent, dyed with acids and not with metal oxides as they render the material more opaque. Furthermore, the ceramics we use must have the translucency inherent to the natural dentine in order to provide a certain profundity. In this way we can make the best use of the potential of zirconia.

When we finally finished the teeth structure, we realized the frame of the gums and checked the fit in the patient's mouth to evaluate the marginal adjustment, the aesthetics and occlusion. As everything was correct we could go on and finish the restoration by adding glaze and enmuffle the gums.

Fig. 21: We can make a firing of dentine

Fig. 22: individual layering of the pieces

Fig 23: Application of incisal and transparent

Fig. 24: Finished teeth material

Fig. 25 – 26: “In-situ” Try in

Fig. 27- 28: photographs of the finished case

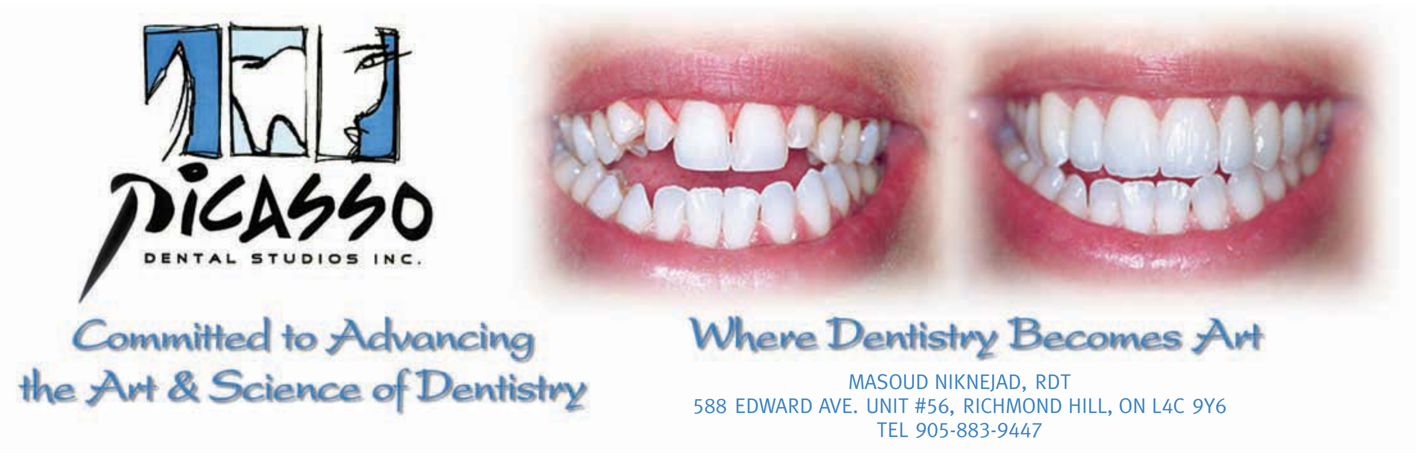

Fig. 29- 32: photographs of the finished case

Fig. 33-35 In situ

Fig. 36-37 In situ

Fig. 38 -39. Profile of the patient with the new prosthesis

About the author

Xavier Balmes graduate of the Ramon y Cajal School for dental technicians in Barcelona (1991), Worked in the laboratory of Mr. August Bruguera y José Luis Ayuso. Own laboratory since 1996 in Sabadell (Barcelona), completed his professional training with William Pagan, Anibal Alonso, Giovanni Furmo, Oliver Brix, Aldo Zilio....

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References

1- Steger,E.: Zirkon-Zahn para el procesamiento de piezas en verde de material para armazones de dióxido de zirconio. Quintessence técnica; 1/2006
2- Hegenbarth,E.A.: Estética y dióxido de zirconio ¿dos conceptos opuestos? Quintessence técnica; 9/2005
3- Propiedades y características de los materiales empleados en la confección de puentes totalmente cerámicos. Premio Gaceta dental 2005
4- Schenk,H.; Estética con zirconio. Dental Dialoge; 1/2006
5- Estudio del desgaste de la zirconia. Departamento de cristalografia. Universidad de Barcelona. Bio mecánica, 2005