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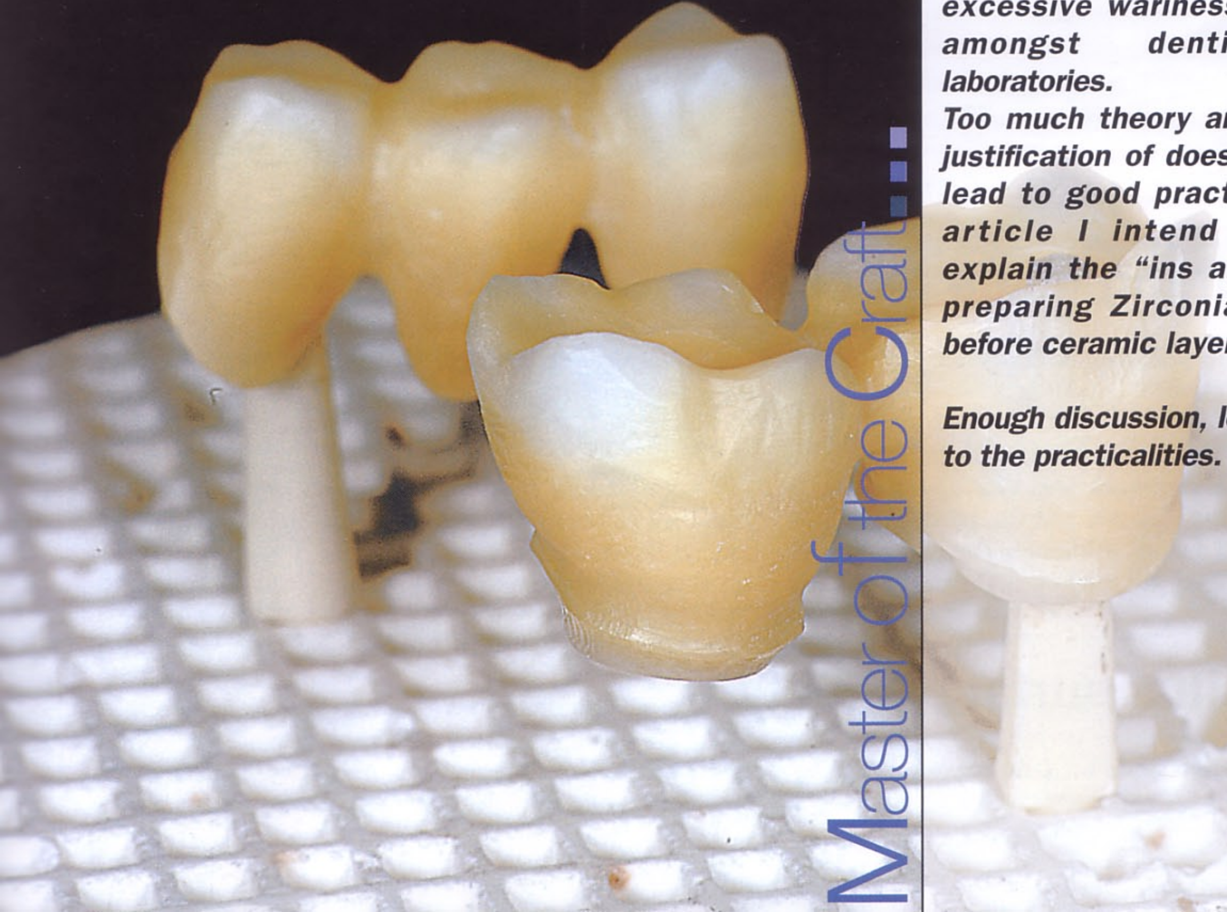
ZIRCONIA how do I bond with it?

Avoid distressing accidents

***A** frequent criticism of Zirconia highlights the bonding of "Zirconia and Porcelain", the separation of which is so unheard of that it is considered to be dramatic.*

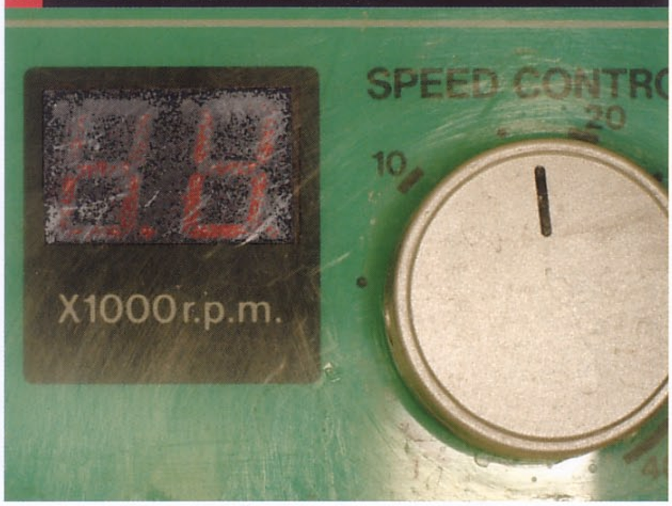
Zirconia is a material, which has not only earned its place in dental prosthetics of the future, but is already being used in day-to-day practice. However, Zirconia must be used in the right way so that it does not lose its credibility and provoke an excessive wariness of its use amongst dentists and laboratories.
Too much theory and scientific justification of does not always lead to good practice. In this article I intend to simply explain the "ins and outs" of preparing Zirconia's surface before ceramic layering.

Enough discussion, let's move on to the practicalities.



1 *Surface between Zirconia and Ceramic*

2 *Microtour with digital rotational speed*



3 *The initial surface state after sinterisation*

"a faulty interface between the Zirconia and the porcelain will be the major cause of failure."

Everything takes place on the surface

Before applying the porcelain to Zirconia, the surface must be in its best possible condition.

The adherence of the ceramic to the coping remains a critical problem, it can work well (fig 1) but a faulty interface between the Zirconia and the porcelain will be the major cause of failure. Although the two materials may appear to be similar, they are not physically comparable and because of this Zirconia requires a specific working protocol. The processes used when grinding are fundamental to a successful bonding.

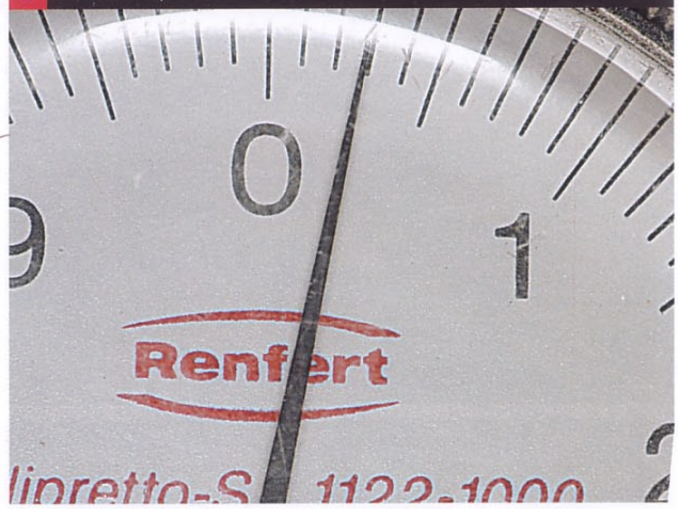
To begin with, it is essential to have a micro motor with the right ball bearings, in good condition and with a good digital display for the rotational speed. It is absolutely vital to keep a strict eye on the speed (fig 2).

The initial surface situation

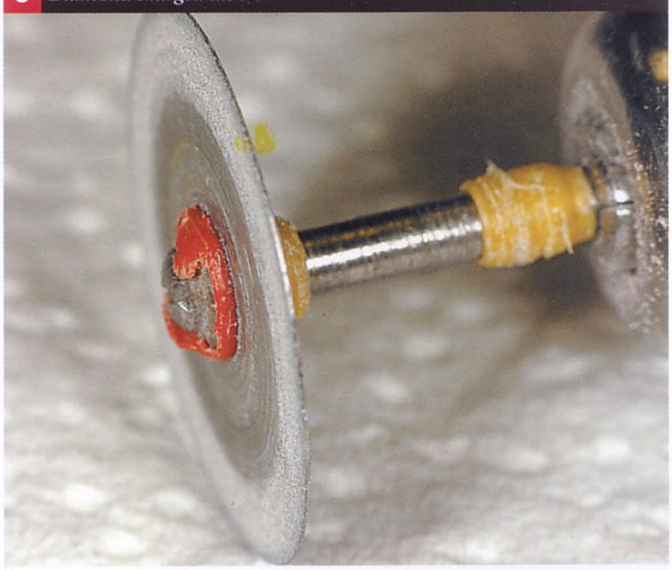
After the thermal treatment used during the sintering-process, the piece of Zirconia appears semi-shiny with a satin finish. This appearance is caused by light reflecting off the delicate crystallites. The roughness of the surface

4 *Finely cut*

5 *Thickness of the cut*



6 *Diamond-charged disk*



7 *Diamond-charged disk*

COMMENTARY

White Zirconia can appear more pearly and shiny; its surface structure is more homogenous and tensio-active.

Coloured Zirconia presents a partial alteration of the impregnated section.
A greater resistance to mechanical stress at the surface is due to a certain amount of dysmorphy found among the crystallites. This change occurs during the colouring process and in this case the ceramic bonding is often much better.

Too much colouring, on the other hand, will alter the structure too much and will thus render the mass less resistant to strain. It would therefore be better to carry out a colouring of the localised surface structure rather than dipping it or dousing it.

does not change its appearance (fig 3). However, the cohesion of the surface crystals is far from perfect, particularly in pre-coloured Zirconia.

A standard sandblasting is not sufficient enough to remove the excess surface crystals. Having said this, extended sandblasting would be over-doing it and would consequently be fatal for the Zirconia. Therefore, the surface should only be grinded in order to remove crystals with no cohesion.

The cut

Links and extensions are severed and elements are easily separated with the help of an extra thin fine-grit diamond disk, using a reduced speed of 3000 to 5000 t/min and a little water for important and extended cuts (figs 4,5,6 and 7).

8 *Figs 8&9: Fine-grit diamond burs*

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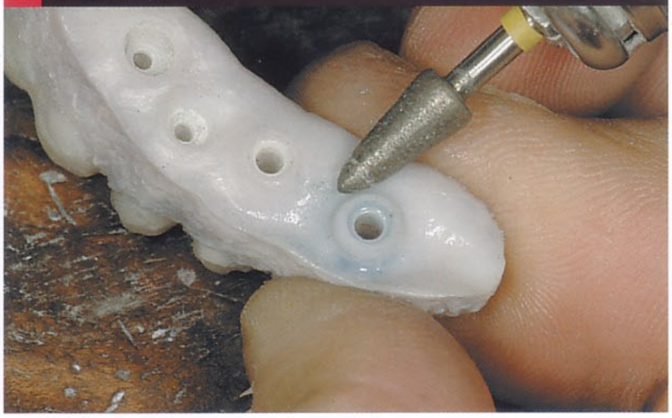
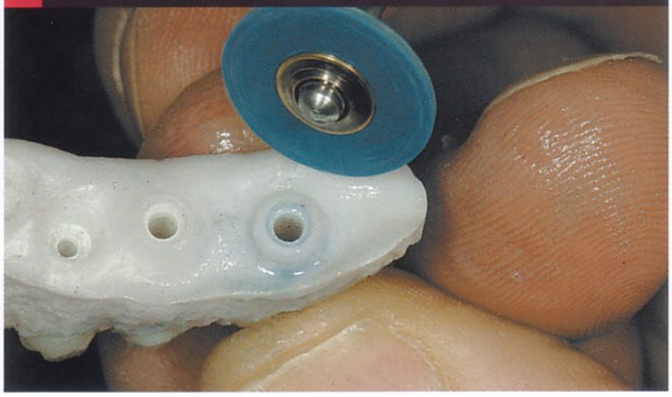
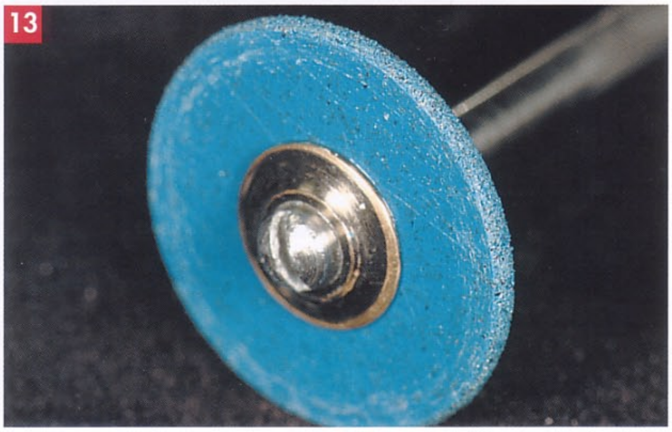


10 *Grinding of free surfaces*

11 *The pontic's surface is ready to be polished.*



12 *Figs 12 & 13: diamond-charged rubber disk.*



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Polishing the free surfaces

The Pre-Polishing

The surfaces to be polished will firstly be treated with a fine-grit diamond bur, without water, at a speed of 6000 to 10,000 t/min depending on the appearance and size of the piece to be reduced.

The larger the mass, the more energy it can absorb (in joules) and since this also avoids rapidly heating-up, higher speeds can be used (figs 8 and 9).

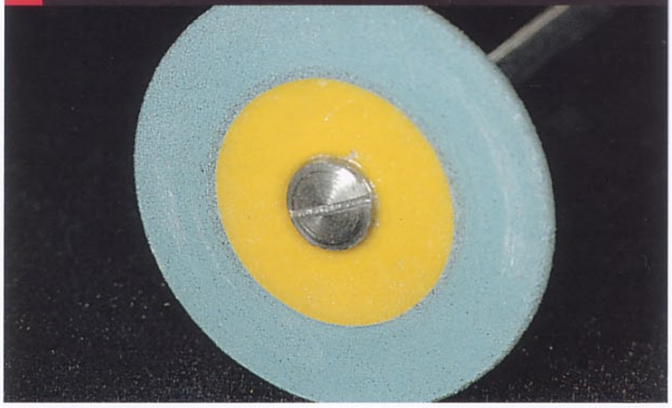
Ploishing and surface shining

Having passed the fine-grit diamond bur, polishing can begin.
For this purpose, a blue rubber rotary disk charged with diamonds or silica (less expensive but just as effective) is used in the preliminary stages (figs 12 and 13).

An initial surface state is easily obtained with a speed of 6000 to 8000 t/min without water (fig 14).

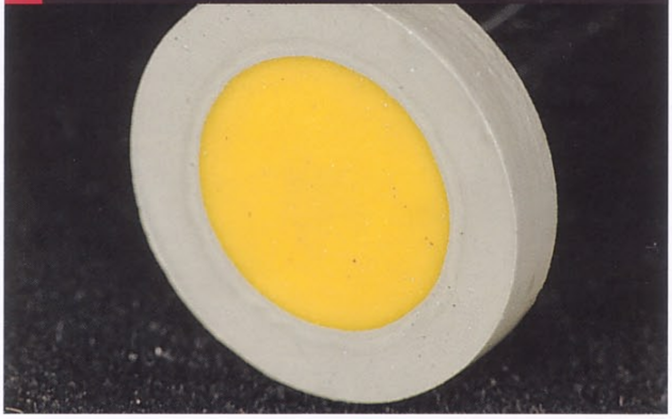
14 *Surface state after first polish.*

15 *Blue polishing disk.*



16 *Wait for the heat to subside.*

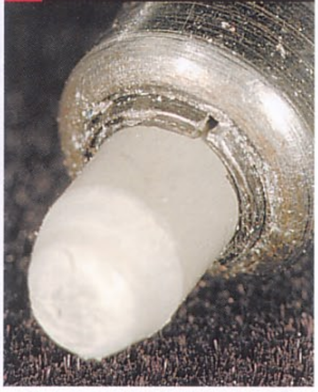
17 *Silicon polishing grinder to finish*



18 *Results after silicon grinder.*

19 *Conventional rubber polisher.*

20 *Fine silicon point.*



21 *High gloss polish.*

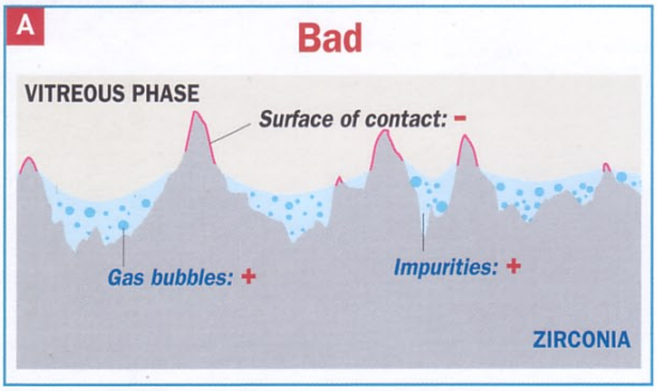
Next, a primary blue disk (fig 15) is used to polish at speeds of 8-12000 t/min without water. Cooling with compressed air or taking short pauses is necessary in order to allow the heat to dissipate (fig 16).

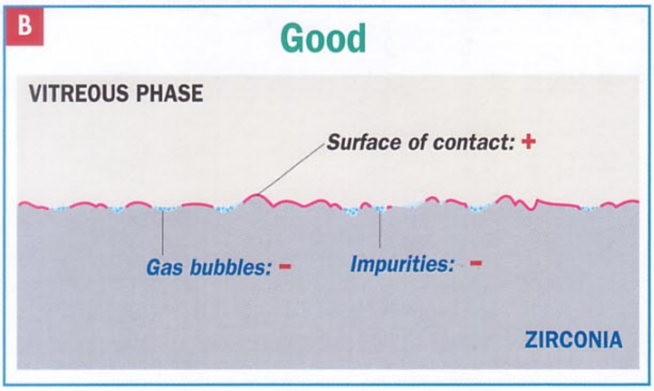
Alternatively, a silicon grinder used for the finishing polish (fig 17) is immediately very effective (fig 18) at the same speeds, or even at 4000-10000 t/min without water.

A conventional rubber polisher (fig 19) or fine silicon points (fig 20) can be used for accessing places which are narrow or difficult to reach and leave a highly sought after surface result. High speeds (between 8000 and 16000 t/min) are necessary.

Indeed, since these tools are so small, the working speed at its circumference is lower than with a larger tool and the speed of rotation can therefore be increased without taking unnecessary risks.

The pearly state obtained will be perfected by casting (oh yes!) and finished with a high-gloss polish, applied with a brush during the final stage (fig 21).






22 *Heatless grinder.*


23 *Roughly polished surface.*

Preparing the surfaces for bonding

The surface roughness resulting from trimming the Zirconia must be sufficient enough to increase the surface contact with the porcelain. However, be aware that too much ruggedness can leave grooves that are too deep and out of reach. These will imprison gasses, air and impurities, which could then pollute or pass through the mass during the next firing (diagrams A and B).

Furthermore, any grooves which are too deep can prevent direct contact in certain areas therefore reducing the bonding surface and in turn weaken the link, not to mention the absence of closeness preventing Foucault's Currents. From this stems a double problem: bad retention and little "surprises" in the porcelain.

Rough Polish

As surprising as it may be, I use tools that in principle may appear too aggressive. It's not the instrument used that carries out the work and creates the desired effect, it is the way in which it is used and the movement that obtains the results. It is possible to work with "dangerous" instruments on the condition that they are manipulated with the required delicacy.

Large bumps or grooves, undesirable depth and irregularities in positioning should be removed with silica or heatless mineral grinders without applying pressure and at a speed of around 6000-8000 t/min. The piece should be submerged in water from time to time and more frequently when heavy grinding is carried out (fig 22). The obtained surface is regular and yet still satiny (fig 23).

Grinding clean with stone

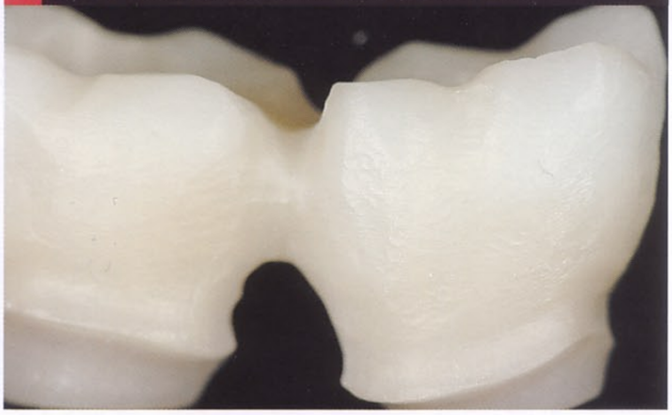
At this stage I use stones, in mounted points, as the specific binding of this material does not pollute the Zirconia and will not heat up during the grinding process when grains of stone are torn off (photos 24 and 25).

These stones are essential to the process and expensive. Their specific characteristics, along with their abrasive nature, make the price of this tools higher than normal and it is moreover their high price tag that clearly distinguishes these as zirconia products - cheaper tools lead to a bad treatment of the zirconia.
Above all, there must be no cheating or short cuts taken at this stage of the work where the surface begins to loose its

24 *Semi-coarse blue stone point.*

25 *Fine-green stone point.*

26 *Figs 6 & 27: the surface becomes more and more dull.*



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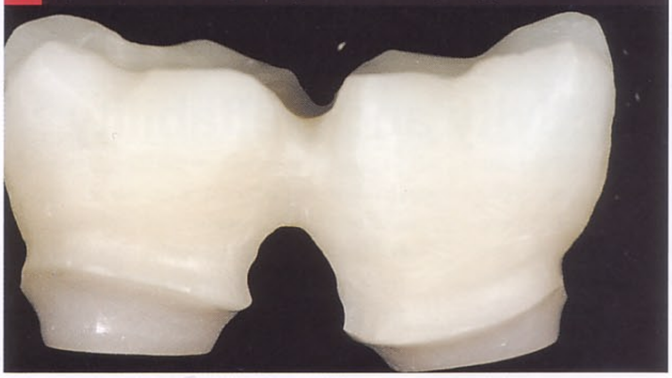
28 *Figs 28 & 29: it is a good sign when the surface appears 'matte'.*



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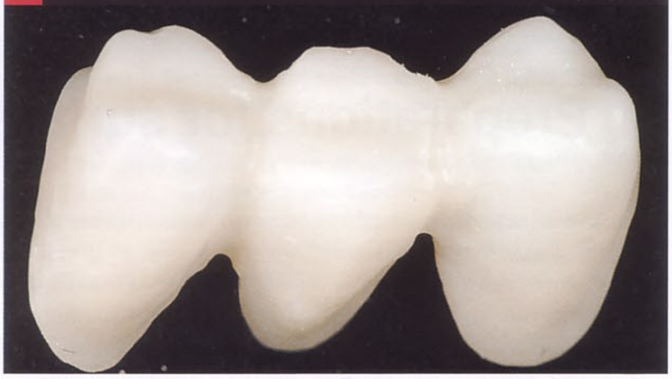


COMMENTARY

The mounted point must only be used moderately (it's more economical) otherwise the pressure of the grinding is too strong. A stone like this can be used on a dozen or more single surfaces. It is clear that by applying even less pressure we can economise with the instrument, but as a result we would only caress the surface and would not obtain a significant result.

shine and gain a tensio-passivity (figs 26 and 27). The grinding pressure must be moderate with a rotational speed of 8 to 12000 t/min. In my own practice I use only coarse and semi-coarse points (large grit and medium grit).

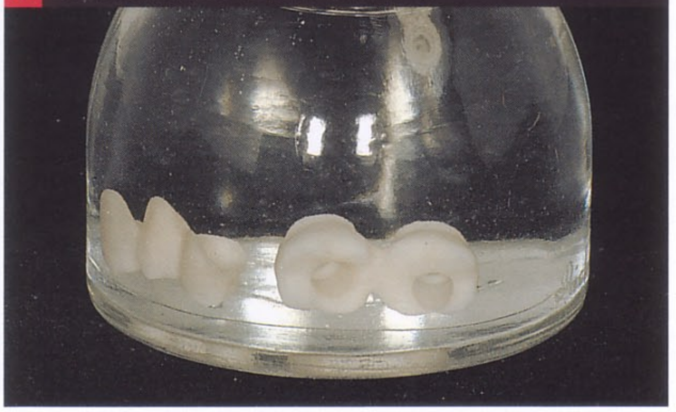
Sanding Clean

A sanding becomes necessary for surfaces undergoing cosmetic treatment that have been grinded by blue or green stones. It is carried out using refined aluminium oxide (50 microns of Al_2O_3, pressure 2 to 2,4 bars, 1cm from the nozzle). No steam cleaning should be carried out, nor cleaning with water and no "sticky fingers" over the surfaces! Only air should be blown, from small bellows (at a distance of 20cm), to avoid grease and possible humidity from the air compressor.

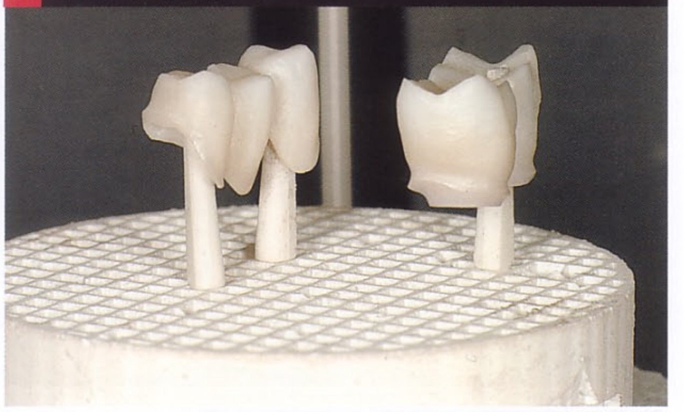
ULTRASONIC CLEANER MUST NEVER BE USED!
(Ref. See previous article in CAD/CAM dossier, Jan 2009)

It is a good sign when the surface is dull! (figs 28 and 29)

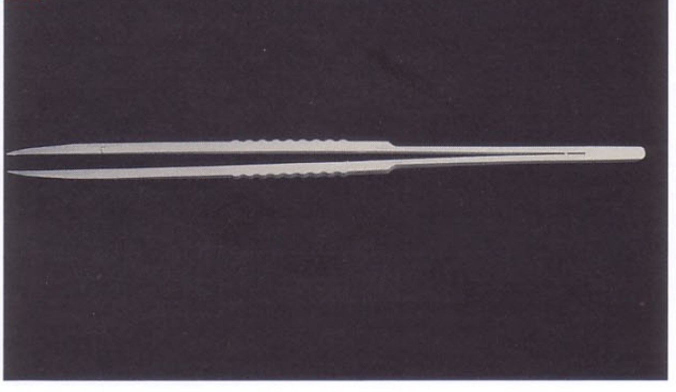
30 *The elements are submerged in Chloroform.*



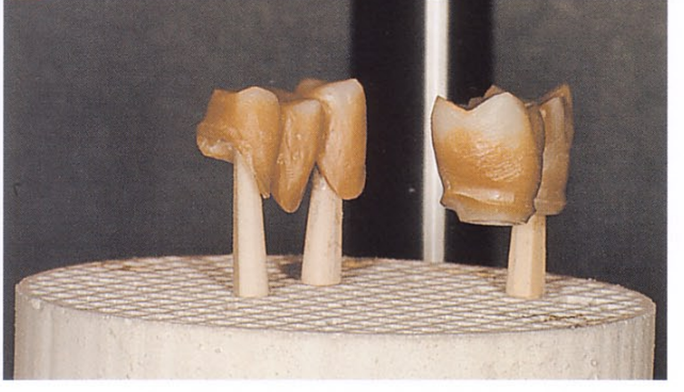
31 *Zirconia firing supports.*



32 *Zirconia tweezers.*



33 *800° is hot!*



Preparations for surface passivity and wettability

All the elements are plunged into chloroform (him again!) for 15 minutes (fig 30).
This immersion not only completely degreases the Zirconia, but above all it increases the electronic activity of the surface (Foucault's Currents). During the thermal cleaning treatment, this electronic activity allows a reorganisation of the surface structure by solidifying certain particles and eliminating others.

Next they are positioned onto supports specifically made for technical-ceramics or zirconia (no metallics or carbon graphite) (fig 31). The elements are passed through the kiln for a final thermal cleaning treatment, which will not alter their chemical structure.

Program used:

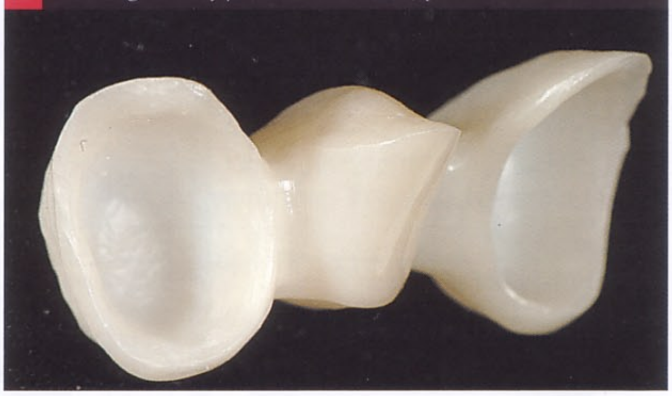
Pre-drying time -	6,8 min
Start -	400 atmosphere
Gradient -	35 to 40 °/m
Stop -	600 atmosphere
Duration/ Hold time -	2 minutes
Temperature Rise -	920° in vacuum
Vacuum -	-720 mm/hG
Support -	0'30" under atmosphere (or 0'0" to 930°) + atmosphere
Slow cooling -	from 850° to 300° = 6 to 8 minutes

The whole working environment must be specific to zirconia. **NB:** Zirconia tweezers exist so that nothing is dirtied or contaminated (fig 32).
The colour of the elements is intensified and takes time to recover its normal nuances (figs 33 to 37). Wait before moving the pieces, nothing must be rushed. Zirconia always requires time to be worked with. Forgive the repetition but never try to alter the working protocol when using Zirconia. Having correctly followed this protocol, applying an ineffective liner would be pointless, Zirconia is better suited to a fine pre-layer of dentine (or opaque dentine) to activate adherence. This should be fired at 50° above the temperatures recommended by the manufacturer (except when using high infusions) as explained in the CAD/CAM dossier (published Jan 2009).

34 *Take out of the furnace at 600°.*

35 *100° - 80°*

36 *Room temperature.*



37 *The bridge is ready for the ceramic build-up.*

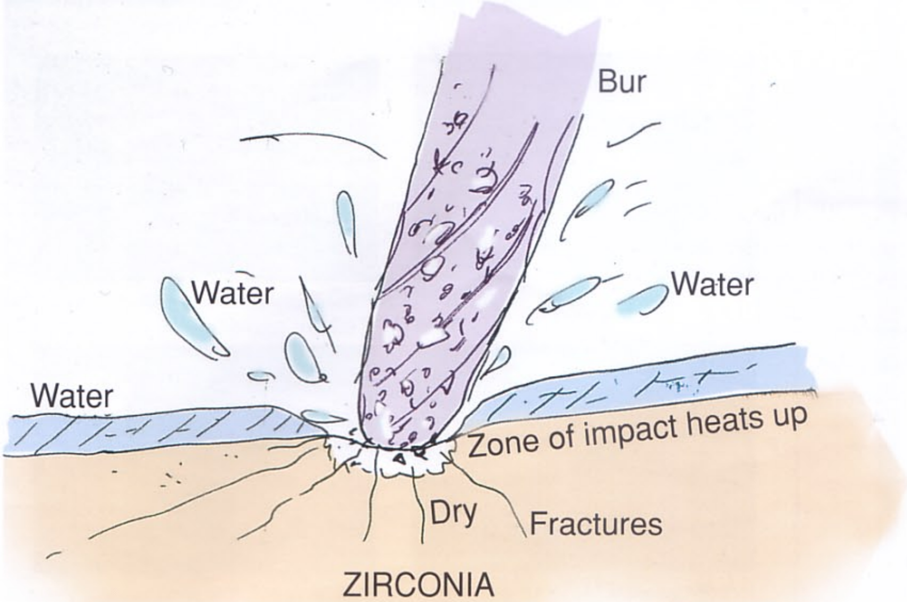
Grinding: slow down and avoid the puddles!

RECOMMENDATIONS

Zirconia requires grinding at a slow speed in order to avoid additional energy being created by the impact of the bur's deep grooves. High speeds bounce the instrument against the heavily concentrated surface, rotating without actually grinding down the Zirconia.

Diamond-tipped machining with a little water in the turbine is possible but this method mustn't be abused. Water is used not only to lessen the thermal effect of grinding, but also to avoid the spread of surface cracks caused by the impact of the bur. The use of water does not, however, affect the cracks that spread into the internal structure of the piece. What's more, unlike when using milling machines under powerful jets, with lab hand pieces there is no water at the surface where the burr is used. This therefore leads to a build up of heat and an outbreak of fractures. Although these factures are minor, it is better to avoid them.

When using this method much less dust is produced (only a little residual pulp) but the resulting quality of the grinding is just as poor as without water. To conclude, we should be asking ourselves if water is really necessary at all when grinding?



THE ESSENTIALS

Slow speeds lead to a greater efficiency when grinding Zirconia since the material is torn off little by little rather than destroyed in entire areas. Less aggressive grinding uses less energy, thus less heating-up takes place, shock waves on impact with the bur are reduced and the spreading of micro-cracks is negligible.

In my own lab I do not use a turbine hand-piece, even with water, although it can be effective and useful at certain stages. With reasonable use this could be a good method, but to base the entire grinding process on this practice alone is an error. Indeed, the smoothing and warping of the crystallites provoked by the speed of the turbine is a real problem and contributes to failure during bonding by reducing the surface passivity.

Master of the Craft ... SUMMARY ...

Surface states of Zirconia – step by step

Zirconia after sinterisation.

Rough polish.

Diamond-charged grinding.

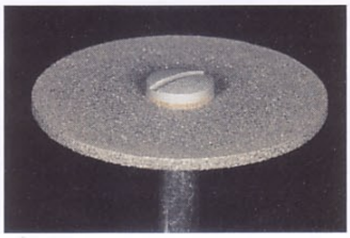
Blue Stone.

Sanding.

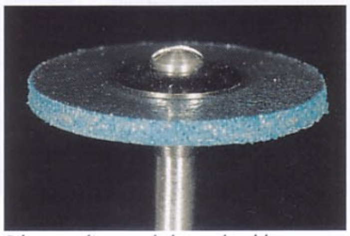
TOOLS

Separation disks.

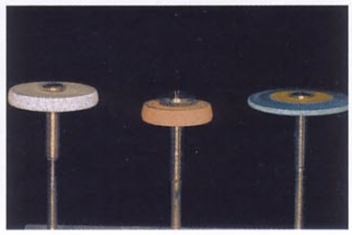
Extra-fine stones.



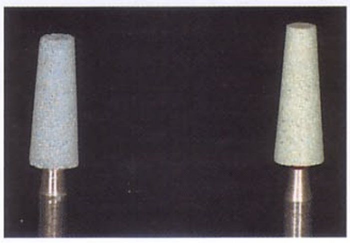
Diamond-charged grinder for rough grinding, 5,000 - 10,000 t/min.



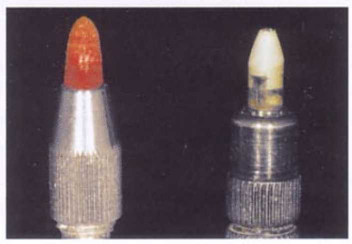
Silica or diamond-charged rubber grinder.



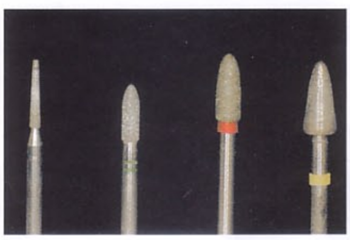
Rubber grinders for pre-shine.



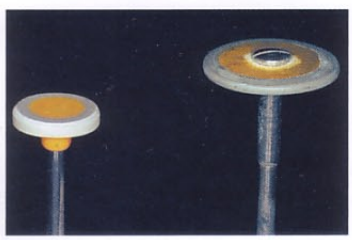
Blue or Green stones, coarse and fine.



Fine access polishers.



Diamond-charged burs.



Primary shine silicon grinders.

Heatless grinders.

High gloss polish or wax.

SUMMARY OF GRINDING PROCEDURES

WHAT?	WHICH TOOL?	HOW? Using low speeds
Cut	Extra fine diamond-charged disk	3000-5000 t/min
Rough polish for reduction	Silicon heatless grinder dipped in water	4000-8000 t/min
Rough polish for smoothing	Diamond-charged bur (with a weakly bonded mass)	6000-10000 t/min
Milling of small or fragile parts	Fine diamond-charged bur, small size with oil	4000-10000 t/min
Smooth and friction grinding	Extra fine, turbine and water hand-pieces with oil	6000-15000 t/min
Cleaning of crystallite debris	Stones or special mounted points for zirconia dipped in water	5000-12000 t/min (according to pressure applied)
Polishing	Blue rubber, Green mineral-charged or diamond-charged grinder with compressed air to cool.	8000-12000 t/min
Shine	Dry silicon grinder with compressed air	8000-16000 t/min
High Gloss	Fine diamond-charged paste or wax with a brush Paste – coarse	10000-18000 t/min 3000-12000 t/min
Final sanding	Aluminium Oxide (50 microns, 1cm from the nozzle)	Pressure – 2 to 2,4 bars

About the Author:

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Richard Fouquier was born on the 29th of April, 1956 near Paris. After completing his high school diploma in science, he began a Diploma of General University Studies in chemical physics and became interested in dental technology. In 1978 he obtained his Professional Certificate and has continued to deepen his knowledge, earning a Masters in Dental Technology in 1982, a Degree in Dental Technologies in 1997 and a Maxillofacial University Diploma in 1997.
He divides his time between training courses and conferences, was a final candidate for the "Best French Worker" competition in 2000 and is also the vice-president of the French Club of Dental Ceramics.
Richard Fouquier directed various laboratories in France before moving to the United States to work for a prosthodontic office in Portland, Maine from 2000 to 2003. There he had the opportunity to be in direct contact with his patients.
Since then, Richard has returned to France where, in 2004, he created the RVF Laboratory.

Bonding with ceramic

It is not easy to judge Zirconia's surface state with the naked eye, but by correctly following these stages of preparation, the shiny surface assures optimal bonding, not only to the porcelain, but also with resin (in this case an extra procedure is necessary, however that is whole other story...).
Next month we will tackle the mounting of ceramics onto zirconia. ◆

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Dental Technician