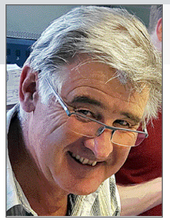
Anatomical Multi-layered Zirconia

Part two: practical applications



By Remy Desprez
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The same bridge has been done using two techniques: the bridge at the back has been glazed and polished. The bridge at the front has been infiltrated and stained.

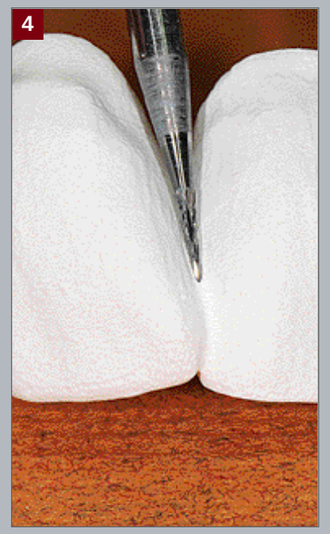
In my first article on anatomical, multi-layered zirconia (Dental Technologies, issue 130), I discussed how zirconia materials had evolved over the past few years, offering better flexural strength and greater translucency.
However, we still do not have a reliable standard to gauge the translucency of a material, and I suggested that an indicator of light transmission could be the solution for this.

I have tested various new zirconia materials, partially constituted of cubic crystals. However, we found them to be lacking in translucency. Precise sintering is of course the basis for validating any kind of test you may undertake with new materials, and as promised, I will discuss this further on. We have been very pleased with the results obtained using high-translucency multi-layered zirconia, which is the main focus of both this and the previous article in issue 130.

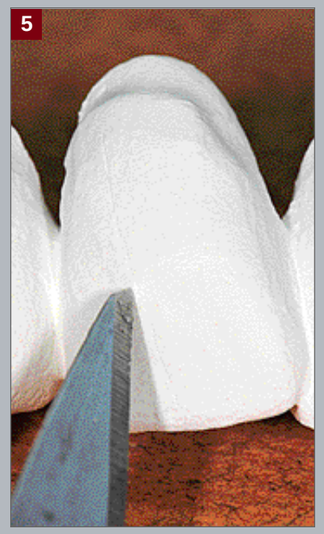
Having discussed various factors for optimising results, such as managing light diffraction, and having summarized some basic notions which I thought would be useful, I would now like to discuss some practical applications for Zirlux Anterior Multi, via several cases. I will also discuss some of my techniques for optimising the results when working with this material.

Figs. 1 and 2: Zirlux Anterior Multi, result after sintering

The disk must be positioned correctly

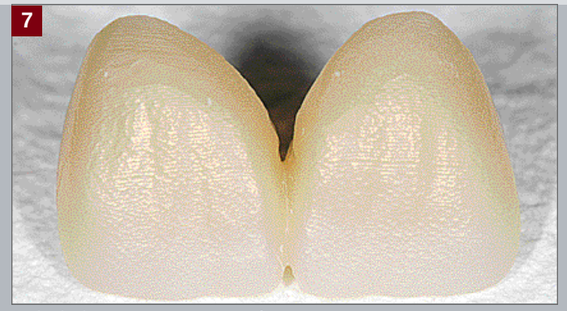


Adding inter-dental definition

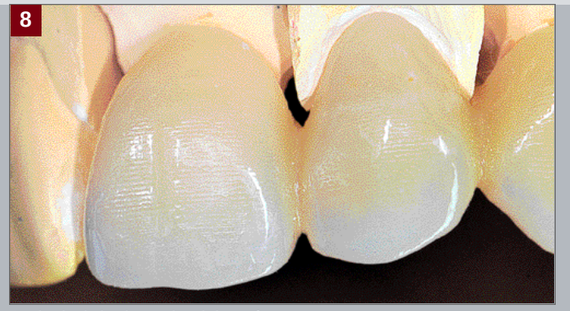


Crack simulation using a scalpel

Occlusal surface: the grooves and cusps have been stained

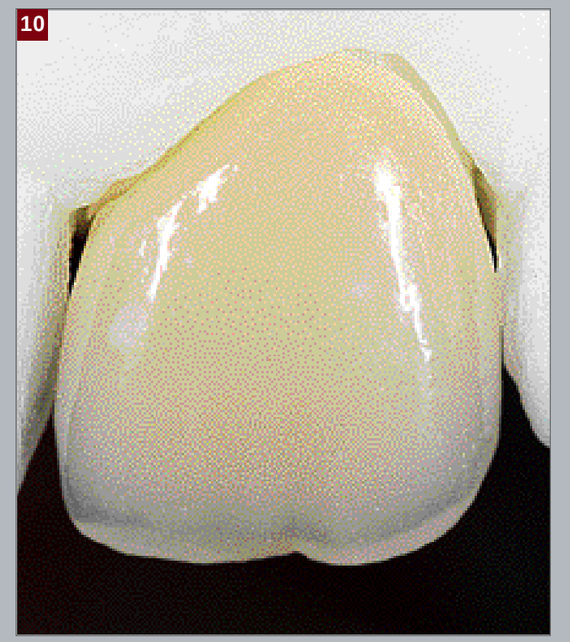


Light-shade zirconia copings just after sintering



Light-shade bridge with subtle surface stains

Layered porcelain on zirconia: there is high contrast, with high saturation on the cervical half



Abraded incisal edge, highly transparent, three-powder build-up

Depth, colour contrast and translucency
Three examples that would be difficult to create in anatomical zirconia.
Avante Z Porcelain / Pentron Ceramics / Henry Schein

Making crowns and bridges: simple and highly efficient

As discussed in part one, the thickness required for posteriors is a determining factor. If this factor is correctly taken into account, a highly satisfactory result can be obtained fairly easily, as the mulit-layered Zirlux Anterior Multi zirconia offers excellent aesthetic results (figs. 1 and 2).

The procedure is simple: the restoration is first designed as required and then the file can be transferred to the milling machine. It is important to choose a disk with the appropriate thickness – as close as possible to the required thickness, in order to maximise the effects of the internal layering. Be sure to position the disk correctly in the milling machine, following the incisal direction indicator - the most saturated colour needs to be at the cervical contour! (fig. 3). Once you have removed the restoration from the zirconia disk, if corrections or morphological details are required, it is possible to adjust it with a small bur or scalpel (figs. 4 and 5). Ensure that all dust from the milling is removed. The procedure is the same for both posteriors and anteriors, however, I'll discuss various techniques for optimising the integration of anterior restorations further on.

The restorations can then be put directly into the sintering furnace.

The material and technique are highly efficient: the time spent in relation to the final result and the solidity of the restoration would be difficult to top.

We will discuss the sintering process later in the article. For posterior restorations, once the sintering is completed, the results are already excellent. If the restoration is going to be glazed, a little bit of brown stain can be applied to the cusps to imitate infiltrations, and / or some whitish areas on the crest lines or the cusps (fig. 6).

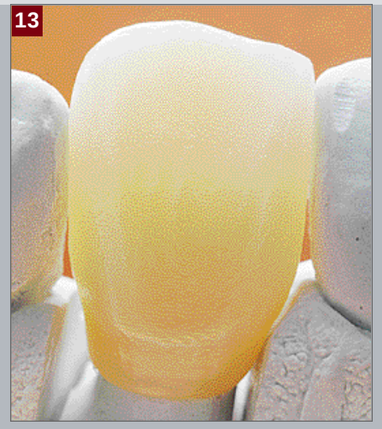
The surface aspect can be prepared before applying the glaze – we will discuss this later. It is possible, if you have the time, to improve or adapt the restoration according to the tooth shade, the patient's age, anterior restorations... and this is also possible with a few touches for posterior restorations.

Subtle colour infiltration on anteriors

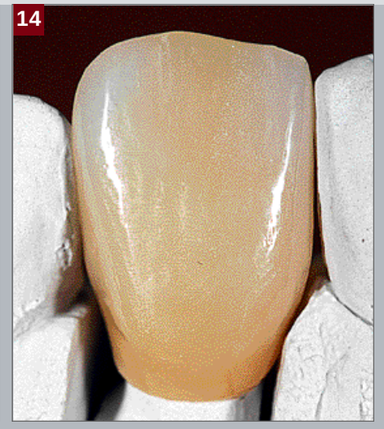
The results obtained with this material in the anterior sector are satisfactory without stains, particularly for lighter shades (figs. 7 and 8). If stains are not going to be used, a harmonious effect can be created with a less contrasted gradation of colours, from a not-too saturated dentine to the incisal. However, results can be optimised, particularly for medium to saturated shades. If the aim is to reproduce the natural tooth structure according to age, and therefore to characterise it, it is useful to work on the tooth colouring. It would be illusory to imagine that the correct reproduction of tooth morphologies, which vary greatly with age, can be obtained with colour gradation. With time and skill and by using colour infiltration techniques and slight surface stains at the glazing stage, it is possible to design anatomical zirconia restorations that are perfectly integrated in the mouth.

For this type of restoration, the time taken corresponds, more or less, to the time required for a high-end zirconia crown with porcelain build-up. However, mastering the technique for characterising high-quality, multi-layered zirconia requires less experience. This type of restoration can create an excellent illusion, but it will not create the same effect as layered porcelain. This is because three-dimensional layering adds depth to the restoration. Layering creates variations in light reflection and diffraction, resulting from the oppositions and layering of translucent, transparent, opaque and coloured effects (figs. 9, 10 and 11).

Slight infiltration on the cervical and incisal edges

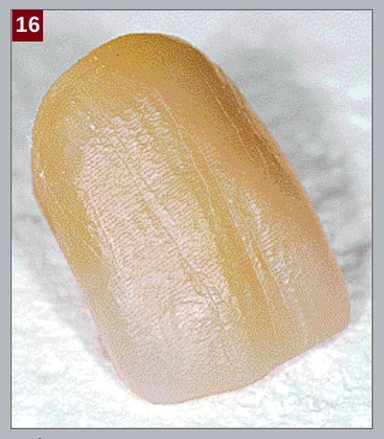


After sintering, note the quantity of light

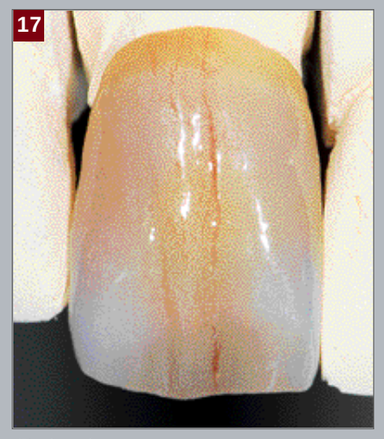


Result after glaze

Infiltrations: orange at the neck, purple for the emergence, grey heart for the incisal edge, blue for the proximals...



... after sintering



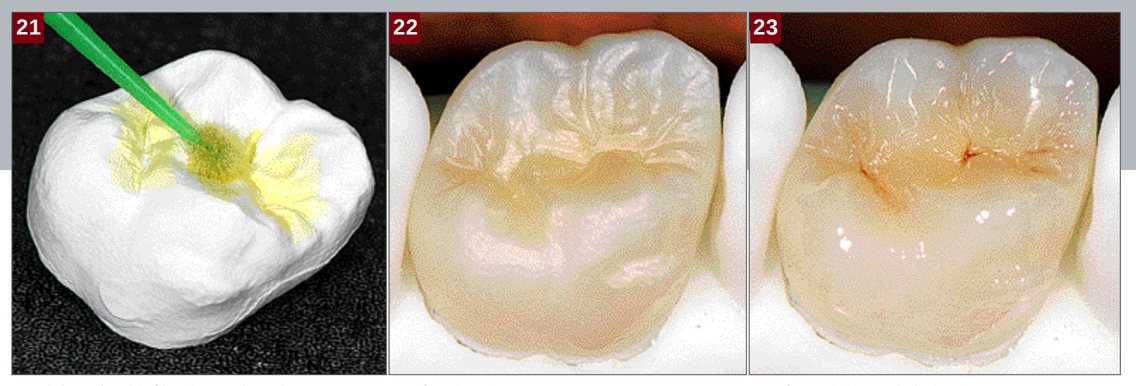
Final result

Colouring by infiltration

This technique involves adding slight touches of colour to add to the aesthetic qualities of the multi-layered zirconia and enhance the restoration. I won't go into long descriptions about how tooth appearance varies over a lifetime, as this is not the subject of this article.
The simplest technique is to apply a slight colouring using a brush or a stamp, from the medial area of the crown to the incisal edge, avoiding the proximal edges, which should remain neutral. The more saturated the required shade, the bigger the crown, or the older the patient, the more you can spread out the colouring to the incisal edge. Creating this effect is fast and easy, and adds realism, especially for larger teeth (figs. 12 to 14). It is important to keep a light hand, so as not to exaggerate the colour. The brush should be very lightly imbibed with the stain solution. For restorations with little coronal height, it is better to avoid this technique, or only apply a tiny amount.

This technique can also be used with different colours, such as grey, to darken the incisal area, orange or other colours in the occlusal, medial or proximal zones; yellow, purple etc... As you know, there are numerous possibilities for characterisation, a few of which are presented in this article. This will allow for the personalisation of your work, and the restorations gain a lot from it, whilst the technique is both fast and accessible (fig. 15 to 17).

Figs. 18, 19 and 20: Bridge infiltration and results after sintering



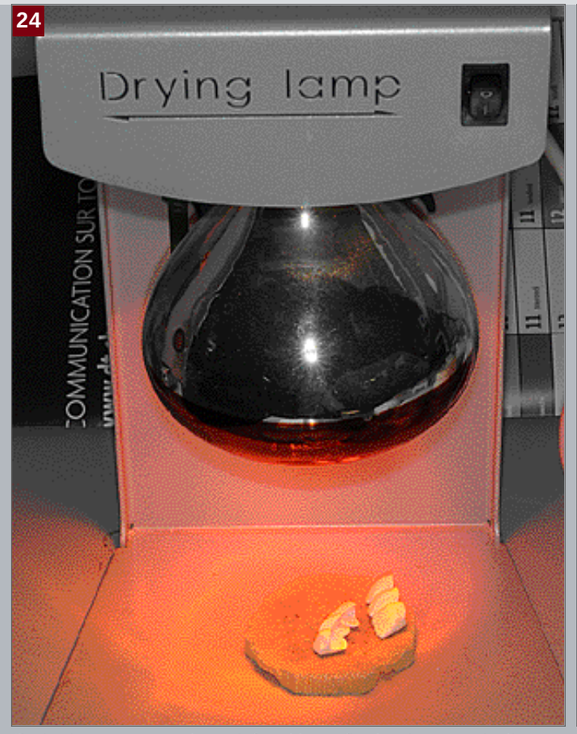
A subtle occlusal infiltration and results... *... after sintering* *... after staining and glazing*

For anterior bridges

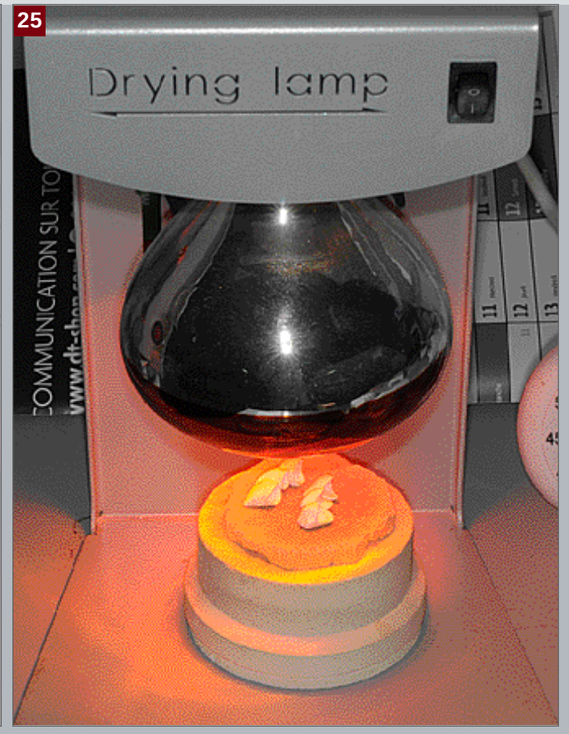
The technique and possibilities are the same. Creating a dynamic effect such as a higher value or warmer colour infiltration in the inter-dental areas will improve the visual separation of each tooth and give overall depth to the bridge (figs. 18 to 20).

For the posterior occlusal surfaces

A slight colour infiltration of yellow, orange, or brown deep inside the occlusal surface will bring out the relief (figs. 21 and 22).
After sintering, other characterisations will be added subtly using stains (fig. 23).



Drying in two stages under an infrared lamp: first keeping a certain distance ...



... then closer, to prevent evaporation happening too fast, which could cause cracks

The sintering has been managed well: note the central (21) has the same translucency as the abutments

Procedure for drying infiltrated restorations prior to sintering

An infrared lamp is generally sufficient to dry the restorations, as they are not very damp, since the infiltrations are generally minor. Half an hour under the lamp is generally required, or even better, two drying phases of 20 minutes each under a lamp at different heights, so as to dry the restoration gently (figs. 24 and 25).

Tip:

If the restoration is exposed to more moisture, after you have dried it under the lamp, it is recommended to continue drying in a furnace. Ideally, start drying in a cold furnace and allow it to heat to around 150°C, hold for 20 minutes, then heat to 250°C and again stabilise for 20 minutes. A slow and gentle moisture elimination prevents cracks from appearing, which can be caused by sudden moisture evacuation. Another advantage to a slow drying technique is that the translucency will be improved.

If drying in a sintering furnace, the heating elements do not generally appreciate the vapours and gasses caused by the release of moisture from the restorations. If using the furnace for drying out restorations regularly, it is a good idea to clean the furnace and heating elements regularly.

Sintering multi-layered zirconia

This is the essential stage. In the same way that a well-managed porcelain bake will look good, be saturated in colour with good translucency, depth and optimal mechanical properties, so a well-sintered zirconia framework that is translucent, with saturated colours and a silky surface, will be at its best (fig. 26).
There is no hope of obtaining a good level of translucency and optimal mechanical properties if the zirconia is badly sintered.

The right method

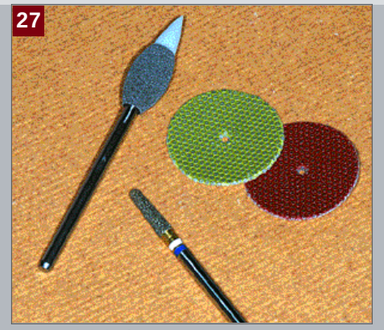
Heating times (temperature rise) are virtually identical whatever the volume of the parts to be sintered. For larger restorations, it is important to leave a very long cool down phase.
This stage is essential to preserve the intrinsic qualities of the zirconia.

“ Fast sintering is not advised in any case. A quality sintering will generally last between ten and twelve hours. ”

When programming the sinter cycle, it is preferable to start with a temperature rise of around 5°C / minute up to 400°C. The aim is to evacuate residual moisture slowly, in order to prevent micro-cracks that could be caused if steam is evacuated too fast.
Following this, the temperature can be increased faster: a rise of between 8°C and 12°C per minute up to 1150°C. Personally, I find 1150°C a bit too hot. A temperature of 1000°C or even 900°C (our choice) gives very good results. Once you have reached this temperature, the temperature rise needs to continue more slowly: a 2°C or 3°C rise per minute up to the final temperature of 1450°C (give or take 30°C). It is during this phase – indeed up to around 1350°C, that the successfulness of the sinter process will determined – the densifying of the material and its translucency.
Choosing the hottest possible final temperature does not necessarily mean optimal translucency. We obtain the best results at a temperature of 1433°C for all multi-layered and high translucency zirconias in our furnaces (Ivoclar and Mihm Vogt). These figures are only for indication, and need to be adapted to each furnace: it is advisable to do tests using your furnace to ensure reliable results.
The hold time is two hours.
The cool phase should be at 10°C per minute to 700°C. Following this it can be a bit faster: 25°C per minute. At the end of the sinter cycle, the furnace must not be opened before it has cooled to 250°C – ideally, leaving it to cool to 150°C is better. If you are sintering large restorations, it is better to wait until the furnace has cooled to 100°C.

Definition of a large restoration

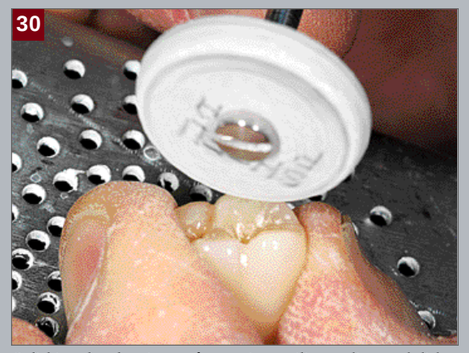
An implant-borne three-unit bridge can be considered a large restoration if the teeth are large. The volume of each unit will influence the size more than the number of units.
In all cases, I would advise against fast sintering. A quality sinter should last between ten and twelve hours. It is possible to shorten the sintering time for smaller restorations that have not been infiltrated. There will be some loss in quality, but the quality will still be acceptable.



Burs and disks for use with zirconia

Adjustment using a diamond bur

Surface state after using a silicone diamond grinder



Polishing the abrasive surfaces using a silicone diamond disk

Surface adjusted before glaze...

Figs. 32 and 33: Polished crown, this since can be obtained through mechanical polishing without glazing

BOX 1

Comparative shade results

Zirlux Anterior Multi allows for a highly satisfactory shade reproduction.
I think it is useful to recall one simple, yet essential condition for obtaining the right colour and saturation. All internally shaded translucent materials must have an appropriate thickness so that the colour and the correct level of saturation become apparent. As you can see in fig. A, the canine shade is at the right level of saturation (A3.5): its thickness is larger than 2mm.
In photo B, on the same bridge, the central shows a weakness in the corresponding shade: this crown is a maximum thickness of 1mm, which is too thin. For good shade correspondence, a minimum thickness of 1.5mm is required. This is simply because there needs to be enough pigment to transmit the right colour, and this is impossible to contain in a smaller volume, because otherwise the restoration would be opaque rather than translucent. It is necessary to strike a balance between the desired translucency and the amount of pigment used.
If the required thickness is not respected, it can be useful to increase the saturation of the restoration with infiltration.

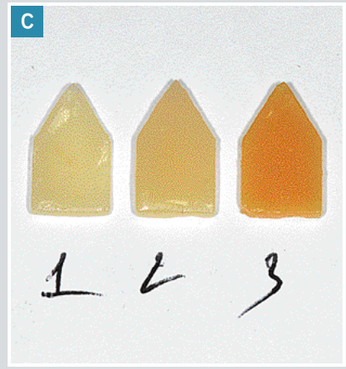


Fig. C: Samples 1 and 2 have been made using the same ceramic. Sample 1 has a thickness of 1mm, the colour is less saturated than for sample 2, which has a thickness of 1.7mm. It is not possible to cumulate translucency and colour saturation if the material is not thick enough. If more pigment is added to the same translucent base material, the result is that it becomes opaque (see sample 3).

“ Using diamond burs in the main body of the restoration causes heat due to friction and will permanently damage the zirconia ”

Post-sinter prep before glazing

It is useful to prepare the surface of the zirconia before the application of the glaze. For greater efficiency, use a special zirconia diamond bur, soft disks with diamond pastilles and a silicone diamond polisher (figs. 27 to 29). Only the surface should be prepped. The use of diamond burs in the main body of the restoration must be avoided at all costs. The heat caused by the friction from these burs will permanently damage the zirconia.
This is equally true for all other ceramic materials.
The buccal and anterior surfaces can be reworked to remove any minor faults or to highlight the relief. This will compensate for the reduction of these effects by the glaze.
Occlusal modifications and fine adjustments to the contacts are done on the surface using a silicone diamond grinder (fig. 30). The surface either needs to be completely polished (increasing the saturation value) or have a satiny aspect. If a surface has both polished and satiny areas, for example on a buccal surface, this will create a marked or smeared effect. Sandblasting the restoration gently (15 cm, 50 microns at 2/3 Kg) can create a uniform surface state prior to glazing.

Mechanical polishing techniques

The crown is now ready for glazing (fig. 31). It is possible to choose a mechanical polish (figs. 32 and 33).
This technique is more fussy, but offers several advantages:
- The first, which goes without saying, is that the glaze can wear down over time. The poor surface aspect of a glazed zirconia restoration can be observed under a microscope, or even by magnifying a photo. As explained earlier, polished zirconia is not abrasive. However, it becomes so when the glaze is applied.
- The second advantage is that the colour saturation is preserved. The glaze acts as a mask, desaturating the colour and significantly reduces light transmission: the crown loses vitality.
- The third advantage, and perhaps the most important one, is that mechanical polishing offers better hygiene and infection prevention (prophylaxis). The integration and tissue compatibility, both advantages presented by zirconia, are degraded by the imperfect surface aspect of glazed restorations.

However, the pearly aspect that is obtained through mechanical polishing can be displeasing for some. There exists a plethora of polishing instruments on the dental market for the polishing of zirconia.

Staining after stabilising in the furnace

Zirlux stains and glaze

Result after glaze

Stain bake

First glaze bake

BOX 2

Why glaze and bake temperatures should not be above 800°C

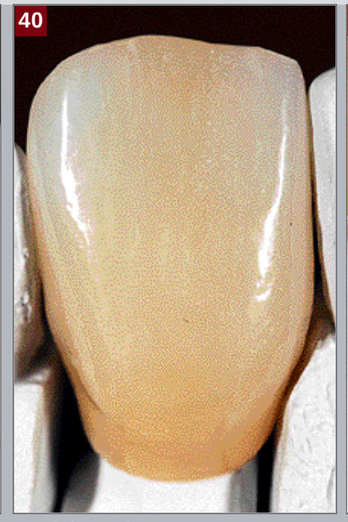
Zirconia (ZRO2) is an unstable material, comprised of three types of crystal phases: monoclinical, quadratic and cubic. At ambient temperature, non-stabilised zirconia has a mononclinical crystal structure. A majority of monoclinical phase crystals means the zirconia will be stable. Transition from the monoclinical phase to the quadratic phase happens if energy is added, and causes a loss in volume of 3%. This causes internal tensions in the material, creating micro-cracks. These micro-cracks actually reinforce the material, as they prevent critical cracks from propagating.

Adding yttrium oxide to the zirconia stabilises it (Y TZP or ZRO2/Y2O3).

When the temperature of the YTZP is increased, there is a transition from the monoclinical phase to the quadratic phase, which occurs at 1163°C. However, when cooling the phase modification occurs at 1063°C (100°C lower than during the temperature rise). Most importantly, this phase ends at a lower temperature: 800°C.

Having spoken to several engineers, who are specialists in this domain, when firing our zirconia, we aim to keep the temperature much lower than 1063°C, and aim not to go above 800°C. Our aim is to prevent a crystal phase modification which we do not control, which could weaken the zirconia over time.

Result after second glaze bake



Result for another case

Mechanical polishing under the pontic

BOX 3

Aesthetically, what are the differences between lithium disilicate and and high-translucency zirconia?

Although the indicator of translucency of these two materials is now the same, there are notable differences in the results obtained.

Zirconia does not undergo a glass phase, because it is monophasic. Lithium disilicate is biphasic, as it has both a glass phase and a crystalline phase.

Zirconia is a refractive material, which means it refracts (sends back) light strongly. Because it is so dense and does not undergo a glass phase, light is less diffracted, and the diffusion is not as good as with a ceramic. However, this has improved with the introduction of high-translucency zirconia, because the more translucent a material the less it throws back light, and the more light is transmitted. Even so, glass ceramics offer a better perception of translucency, with a structure that redirects light internally, because it has better diffraction.

In comparison, the aspect will be slightly more luminous with high-translucency zirconias, which doesn't mean it will be out of place or exaggerated.

The disilicate will be darker (perhaps too much so?) When choosing a shade, this can make things easier for the latter: it is easier to mimic with too little luminosity rather than too much.

If you wish to reduce the luminosity for a particular case when using high-translucency zirconia, you can infiltrate the surface of the crown with a very slight grey shade.

This is the last real advantage that glass-ceramics have to offer.

In all other areas, comparisons between the materials are in favour of high-translucency zirconia: abrasiveness, mechanical properties and chemical performances (solubility, natural tissue compatibility, for example).

These advantages mean that zirconia can be indicated for a far wider range of applications, from veneers to long-span bridges, with a wide range of options now available on the market.

Glazing and surface characterisation

Despite these arguments, the glaze technique is generally preferred by most labs. It is much faster, and offers the possibility of adding in a few characterisations and surface effects. Characterising the restoration in this way increases the realism and facilitates integration in the mouth. There are two cays of doing this. The first is to start with the application of stains and characterisation effects such as cracks, bluish incisal effects and other minute details which are then fixed with a bake in the furnace (figs. 34 and 35). Next, a fine layer of glaze is applied and glaze bake is done. The second possibility is to do both the characterisations and the glaze in a single bake. A fine layer of glaze is applied. The characterisations are then delicately applied to this layer; whitish surface effects etc. With this technique, the effects blend into the glaze, appearing softer and more natural (fig. 36).

Use surface stains, but do not abuse them! They must be barely perceptible prior to the bake. This case demonstrates the maximum effects possible, on an old tooth requiring a lot of characterisation (figs. 37 and 38).

Personally I dilute certain stains, such as blue, 50 / 50 with the glaze. In this way the colour is desaturated and is perfectly diffused, creating a visual illusion of internal positioning which is particularly successful! The aim is to avoid an exaggerated effect – we are aiming for softness and realism.

It is better to do two glaze bakes with a very fine, well applied layer of glaze each time, rather than one single bake for a thick layer which could collect in the interdental spaces, pool in the occlusal grooves and whiten the restoration with a mask-like effect.

If doing two glaze bakes, the second layer can be applied specifically to the emergence profiles in order to increase the lustre.

The quality of the result is undeniable (figs. 39 to 40).

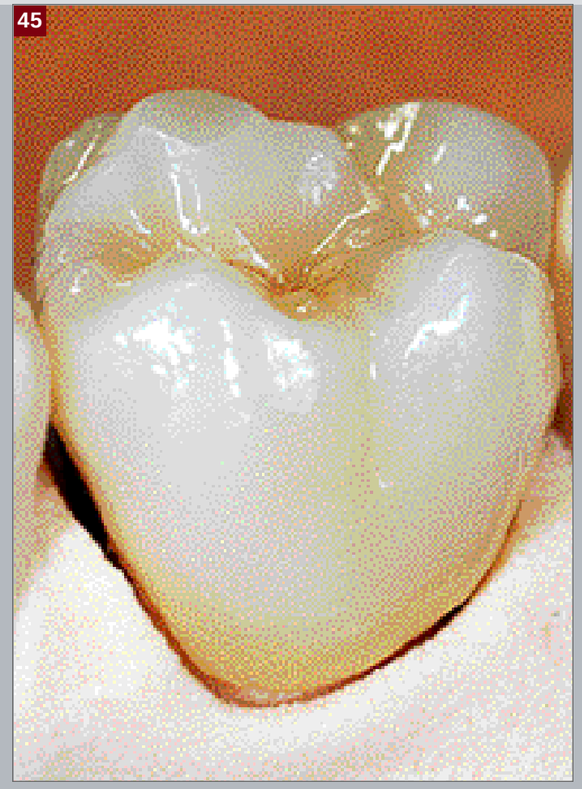
For bridges, pontic fit surfaces should be glaze-free and carefully polished (fig. 41).

The glaze programme in the porcelain furnace must respect essential rules, such as the drying time, a long enough cool down phase and a maximum temperature of 800°C (see box 2).

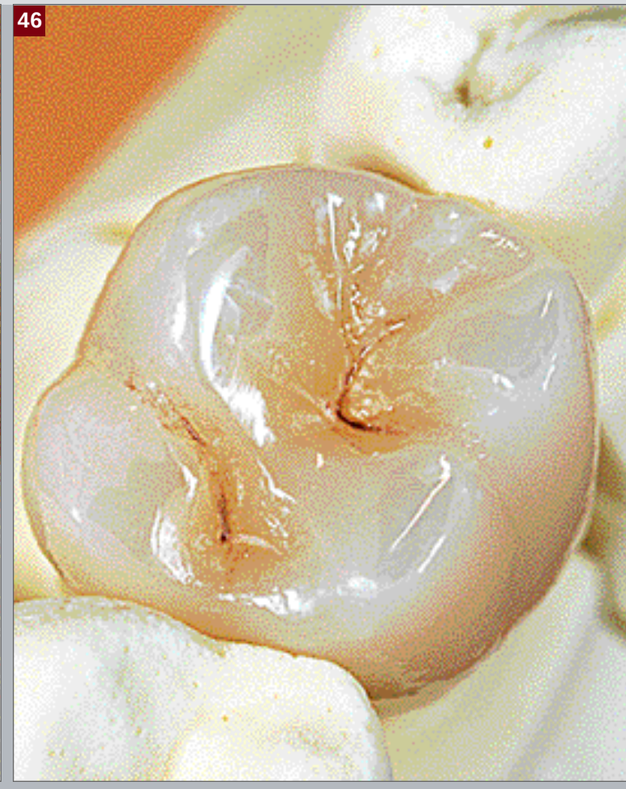
Polishing the neck

Excessive polishing after the glaze bake has deteriorated the quality of the surface aspect

Finished crown



Another case...



...And yet another

Finishing

If a glaze has been used on the restoration, it is extremely important to remove it from the abrasive surfaces, occlusal contacts and incisal edges.
Areas of zirconia likely to come into contact must be free from this 'pollution'. The reasons for this were discussed earlier in the article: glaze is abrasive, so any area likely to be in contact should be free of it. It reduces the biocompatibility of the zirconia material in contact with the gingiva: these areas require a perfect surface state.
After removing the glaze, these areas will be worked using a felt grinder and diamond paste in order to obtain a perfect surface state with a mirror shine (fig. 42). I must highlight the importance of this stage, because badly polished zirconia will have an abrasive hardness, like sandpaper.
This stage required discipline. In my opinion, if a crown has to be adjusted at the chairside, be it full-contour zirconia, all-ceramic with a cosmetic layer, or PFM, it should systematically be returned to the lab for polishing again, and, in the case of a cosmetic layer, should be baked again.
Often, crowns are adjusted at the chairside and not polished prior to fitting. In addition to increasing their abrasiveness, these rough surfaces weaken the restoration by putting it under increased effort. They are also destructured due to micro-cracks caused by the heat generated by grinding. This can, in some cases, cause breakage, and the lab is asked to do a free remake. Which manufacturer guarantees parts that have been modified by its customers? This generally makes up one of the basic clauses of non-guarantee.
The glazed areas should also be given a quick polish using a felt diamond polisher, without insisting too much. This little stage vastly improves the overall surface aspect of the restoration. However, you need to be careful not to remove the glaze from certain areas due to excess polishing, since these areas will be more saturated, creating an uneven aspect (fig. 43).
After finishing, the restoration should be perfectly shiny, and the surface perfectly smooth. Reflecting the pureness of the material (figs. 44 to 46).

Conclusion

High-translucency multi-layered zirconias, such as Zirlux Anterior Multi, offer us the possibility of creating quality crowns, both from an aesthetic and mechanical perspective, without being a master ceramist. Using this product to its full potential takes time if you are respecting protocols and aiming for aesthetic realism. As always in our profession, it is a far call from the quick fix you might expect from this type of product.

Is it simple? Yes, but this is relative, because it still requires time and careful application if you wish to respect the procedure.

You might wonder what is left for layered porcelain. It is difficult to reproduce the effects created with a 3D build-up, such as dentine cut backs, internal shading, various other internal effects and the play of translucent layers - whether coloured or not. These fascinating techniques are currently the exclusive domain of porcelain build-up, which is concerned with layering depth to offer the most realistic results. I say currently, because I am certain that in a few years time, technology will allow us to model the three dimensional layers of a crown using CAD programmes.
The multi-layered 3D printing of zirconia, or another technology, will produce the finished restoration. This is currently the Holy Grail for engineers working on dental CAD. When this happens, perhaps we will final put down out brushes and take up our mice - with regret for some of us, and with pleasure for others...
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