Monolithic restorations made of zirconium oxide

Surface matters

Modern zirconium oxide materials incorporate a wide range of light-optical properties that impart an inherent natural appearance to restorations. In spite of these high-performing material characteristics, it is in the hands of the technician to use these materials to their best advantage. Results that are virtually indistinguishable from the original, the natural dentition, can be achieved by creating suitable textural and morphological features and, in some cases, by adding external shade effects. Aiham Farah uses a monolithic anterior restoration to introduce his technique. The state-of-the-art zirconium oxide IPS e.max ZirCAD Prime, skilled craftsmanship and the well-rounded range of IPS Ivocolor stains and glazes help him achieve highly esthetic restorations.

Nature's perfection is reflected in intricate details, such as the pattern of incident light on the surfaces of natural teeth. The typical appearance of "naturalness" arises from their richly faceted surfaces on which even the smallest rays of light create specific patterns. However, nature does not produce perfectly straight lines, but CAD/CAM milling machines do. So, is the CAD/CAM fabrication of monolithic restorations incompatible with natural esthetics? No, this is not the case, because there is a remedy: If CAD/CAM technology and monolithic materials are used to generate as perfect a copy of the natural tooth as possible, the resulting restoration should be finalized by hand. This gives the dental technician an opportunity to refine the secondary anatomy with craftsmanship and skill. Think surface texture! Morphological details can be created with the aid of fine diamonds that have a geometrical configuration that is amenable to surface contouring. And while the morphological details are being created, the tooth is gradually "springing to life" (Fig. 1).

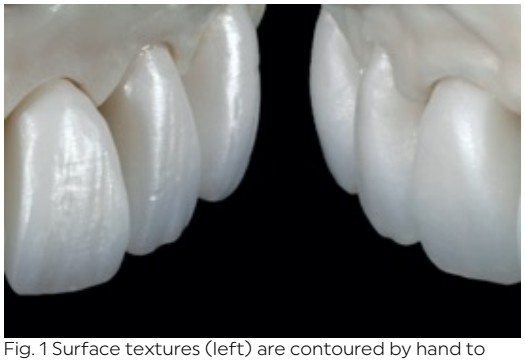

Fig. 1 Surface textures (left) are contoured by hand to impart a natural appearance to the restoration.

Monolithic CAD/CAM zirconia restorations can be given an additional touch of individuality and natural beauty by applying external shade effects to refine the surface texture (secondary anatomy). When the staining technique was introduced in the 1980s, it revolutionized the manufacture of ceramic restorations. Its success was based on its user-friendly technique and re-liability. In recent years, the layering technique has experienced a revival in response to the in-crease in esthetic expectations. At the same time, polychromatic ceramic materials have begun to compete successfully with conventional layering methods due to their efficiency. Innovative restorative materials have outperformed the layering ceramics in a number of aeras. So, what could be more tempting than creating monolithic restorations and customizing them with the staining technique?

Ivoclar is a company that has been aware of this change in expectations from an early stage. The company's product developers realized that a skilful combination of framework material with a matching staining system had the potential to achieve enhanced results in terms of esthetics, reliability and economic efficiency. Today, this combination of materials is available to dental laboratories: it consists of the high-strength IPS e.max ZirCAD Prime and the versatile IPS Ivocolor range of stains and glazes.

Looking at the materials science of a contemporary innovative zirconium oxide material

Fig. 2 IPS e.max ZirCAD features a continuous and smooth progression of shade and translucency.

The zirconium oxide material IPS e.max ZirCAD Prime is based on a unique manufacturing technology which, among other things, produces discs that offer a seamless internal progression of shade and translucency (Fig. 2). Unlike conventional blocks that are built up in multiple layers, this zirconium oxide features a continuous seamless progression of shade and translucency and combines two zirconium raw materials into one product: In the dentin zone, the high-strength zirconium oxide 3Y-TZP (flexural strength of around 1,200 MPa) endows the material with stability. This attribute enables the fabrication of restorations with a reduced wall thickness and a minimally invasive preparation technique. Given its high strength, IPS e.max ZirCAD Prime is suitable for bridges with up to 14 units. In the incisal area, the disc contains the highly translucent zirconium oxide 5Y-TZP. This zirconium oxide compound features a lower flexural strength, which has no limiting effect in the incisal area and in areas away from the connectors. Its high translucency is a major advantage, as it is optimally coordinated with the incisal area. The excellent optical properties give monolithic restorations a naturally vibrant appearance, even without additional characterization work. IPS e.max ZirCAD Prime delivers an accurate shade match. And yet, it leaves all options open. If desired, the restorations can be customized using the infiltration, staining or layering technique. This is especially advantageous in the anterior region, where the already high potential can be maxed out.

Processing the restoration after CAD/CAM milling and sintering

This report focuses on the process to finalize a monolithic zirconium oxide restorations, create the restoration's secondary anatomy and apply external shade effects. Full-contour anterior crowns milled from IPS e.max ZirCAD Prime are used to demonstrate a proven approach. Once the crowns are sintered, fitted on the working model and their contact points adjusted, the attention is turned to the restoration's surface texture.

Applying secondary anatomical features to the monolithic framework

In the first step, a long diamond bur (usually coded with a red ring) is used to grind over the entire restoration lightly, without applying pressure (Fig. 3). By slightly roughening the surface, the actual shade of the zirconium material can be seen more accurately. After sintering, zirconium oxide surfaces tend to have a mirror-like reflective appearance. Because of this, their shade tends to be slightly distorted. By removing the reflective layer, the proper shade comes to the fore. If this step is performed correctly, the real base shade of the zirconium oxide is revealed. Additionally, the subtle natural progression of shade and translucency incorporated into IPS e.max ZirCAD Prime can be observed, without having to illuminate the restoration with a light source from any particular angle (Fig. 4).

Fig. 3 Grinding over the entire surface with a long diamond bur


Fig. 4 Polychromic zirconium oxide with subtle progression of shade and translucency

In the next step, the tooth shape is checked to make sure that the milling machine has faithfully translated all the details of the technician's design to the restoration. A diamond rubber is a good choice for applying any necessary corrections and for surface contouring (Fig. 5). When fine-tuning the shape of anterior crowns, it is essential to bear in mind that the gradation in translucency (from cervical to incisal) is more visible if there is a vestibular curvature. This makes the translucency of the incisal third appear more clearly.


Fig. 5 Contouring the surface using a diamond rubber


Fig. 6 Creating natural textural features using stone burs

In the third step, the transition lines are accentuated and then the surfaces are checked to see if they are symmetrical. This check can be carried out with the help of a pencil or a direct light source. Attention is now turned to creating the macrotexture. This step is essential to reproduce the three-dimensional features typical of natural teeth. Eroded green stone burs, applied at low rpm, have been shown to provide good results here. The natural texture of the teeth can be emulated in a targeted fashion using the tip of the stone (Fig. 6).

Now the vertical microstructure is applied. Diamond burs are again very useful here. In the case shown here, a bur that looks a bit like an American football (Fig. 7) produces a delicate texture without leaving aggressive grooves. The tip of the bur creates a fine pattern of micro grooves that gradually and softly open out, resembling very closely the natural tooth structure. A direct light source is ideal for visualizing these fine details. In the absence of an adequate light source, the intensity of the texture can be visualized with an auxiliary

method, such as dusting the surface with silver powder or passing over the surface with articulating paper. Visualizing the textures assists in observing the differences between highly reflective zones (e.g. prominent areas such as angle lines or strong contours) and shaded zones (e.g. depressions or fine grooves).

Lens- or ball-shaped diamond burs are used for creating the horizontal microtexture (Fig. 8). Important rule for creating a natural surface texture: when creating perikymata and grooves, make sure that vertical lines run parallel to the long axis of the tooth and horizontal lines run perpendicular to the long axis.. After that, any sharp angles created while texturing the surface are softened using a rubber wheel (small diameter). Excessively textured areas are slightly smoothed over. Subsequently, the restoration is blasted with aluminium oxide (50 µm, 1.5 bar) to remove any contamination or deposits left by the diamond-coated burs or rubber wheels.

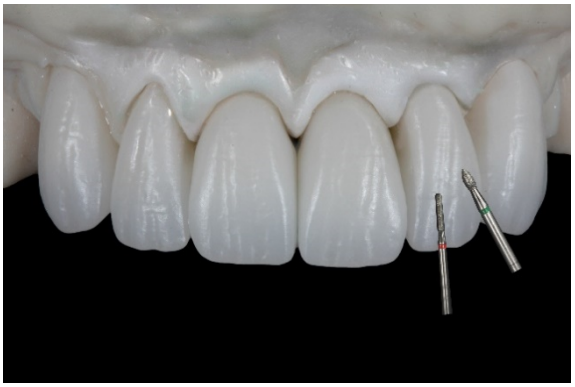

Fig. 7 Applying vertical microtextures using a diamond bur with a tip in the shape of an American Football

Fig. 8 Creating the horizontal microtexture

Ideally, the incisal third of the crown is not too heavily textured. This is because the more textured the surface, the more reflective it is. Figure 9 shows a selection of differently textured surfaces next to each other. To take the picture, the restorations were illuminated from behind to better visualize their textures. One set of crowns have been textured as described in the procedure above, and the others have not been. Clearly noticeable: The more pronounced the texture, the more light is reflected. This has also an effect on translucency. For this reason, surface textures should be kept light; especially in the incisal third, where a high degree of translucency is essential for the monolithic crown to look natural.

Figs 9a and b Comparison of various differently textured teeth. Note: The more texture, the more reflection.

Precise Shade matching

The shade is checked one more time before proceeding to applying the external shade effects. However, there is a problem when evaluating the shade using a conventional shade guide and this problem needs addressing: To start with, shade guides and zirconia restorations are made from different materials with a different surface behaviour (light reflection, etc.). What is more, the tabs of the shade guide have a high gloss finish while the zirconia crowns have a matte finish after having been blasted. To create a level playing field, the shade guide is first sandblasted and then, together with the crowns, moistened with glazing material (Fig. 10). This enables an accurate evaluation of the shade match. In the clinical case shown here, the shade of the crowns (IPS e.max ZirCAD Prime) harmonizes beautifully with the target shade on the shade guide (BL2 Bleach). Additional shade adaptations are not a must. In principle, the crowns could now be simply glazed and finished. In the mouth, their shade would look beautiful and natural. However, additional customizations – such as a youthful opalescence and mamelons – can be created at this stage by applying external shade effects using the staining technique.

External shading and characterization using IPS Ivocolor and IPS e.max Ceram for 3D effects

The middle area of the monolithic crowns shows a shade that matches the IPS Ivocolor Shade Incisal 2 (SI2). In principle, this would be the shade that is used to create the desired translucency according to the shade guide to achieve a progression of shade. However, the crowns have been made from a polychromatic material, with the translucency incorporated into the incisal edge. So, there is no need for painting a translucent effect onto the restoration and the focus can be placed straight away on creating the opalescent effect. For this purpose, Shade Incisal 3 (SI3) is used. The bluish hue of this ceramic material provides incredibly natural-looking illusions of opalescence, which can hardly be attained with other stains, especially not in Bleach areas. The mesial and incisal edges are characterized using SI3. The technician should not be shy to move the brush slightly down (toward the dentin) to achieve a soft transition. After that, a small line of interrupted dashes is applied horizontally under the incisal edge with the tip of the brush using Shade Incisal 1 (SI1). The shades applied to the restoration are now fired at a low temperature (e.g. 700 °C) to fix them in place (Fig. 11a). Subsequently, the mamelon and halo effects can be applied.

Fig. 10a-c The shade match is assessed after the shade tabs (shade guide) have been given a matte finish (by sandblasting) and both the restorations and shade tabs have been moistened with glaze paste.

Mamelon effects can be produced by applying one of the light-reflecting bright stains of the Essence kit. To create an additional "true-to-life", three-dimensional effect, the shade is mixed with 10% layering material, such as IPS e.max Ceram Opal Effect 4 (OE4). As a Bleach shade is used in the case shown here, this "thin veneering layer" is applied. The blend consists of IPS e.max Ceram OE4 and IPS Ivocolor Essence white, mixed together with IPS e.max ZirCAD Zirliner liquid. In my opinion, the IPS e.max ZirCAD Zirliner features a better consistency for mixing the materials than the Build-up Liquid. When applied to the surface, the mixture stays in place and can be placed exactly where wanted (Fig. 11b).

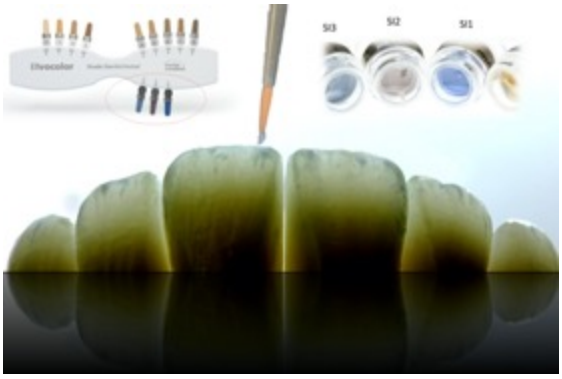

Fig. 11a Characterizing the incisal area using IPS Ivocolor Shade Incisal

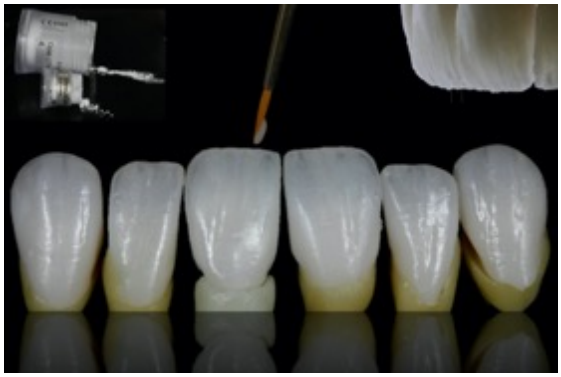

Fig. 11b Applying a thin veneering layer using the materials of the IPS e.max Ceram range

The opacity of the monolithic crown is optimally coordinated, especially in the cervical third, and makes for an impressive result (Fig. 12). In spite of the dark shade of the preparation, the restoration accurately matches the shade of the BL2 shade guide. Finally, glaze material is applied to smooth out any uneven areas created between the layered 3D mamelon structures. This is done with a fluorescent glaze material (IPS Ivocolor Glaze FLUO). Fluorescent glazes are generally recommended for monolithic zirconia surfaces. The restoration is fired using the standard glaze firing program. After that, the entire surface is coated with a second, extremely thin layer of fluorescent glaze material. This time, the material is applied in a slightly thinner consistency to make sure that the textural features are retained (Fig. 13).

Fig. 12 Optimally coordinated opacity of monolithic CAD/CAM crowns

Conclusion

Monolithic zirconia restorations can be "brought to life" by manually creating surface textures and, as an option, by applying external shade effects. To do so successfully, the skilled craftsmanship and creativity of the dental technician are required in addition to a coordinated range of materials. The procedure presented in this report involves clearly less work than the conventional layering method; the result, however, comes very close to the high benchmark set by layered restorations. Even in the anterior region, it is possible to create monolithic restorations that are a near perfect representation of the natural tooth. (Fig. 14a and b)

Fig. 13 Completed zirconia restorations on the model

Fig. 14a and b Inserted restorations offering natural-looking shade effects and a natural surface texture

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Aiham Farah is a certified dental technician. He focused his work on esthetic dentistry. In 2003-2006 and 2009-2012 he specialized in the field of esthetic-restorative dentistry. From 2010 to 2011 he was a teacher lecturer at the Department of Dental Technology at the University of Kalamoon. Since 2009, he has been a materials consultant for Ivoclar Vivadent in the Near East and Orient. He is a member of the National Association of Dental Laboratories (NADL) and an ICDE Ivoclar (Switzerland) certified Master Trainer.