**Fixed aesthetic restorations**

Combining implantology with dental CAD/CAM technology

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Full-arch implant-supported superstructures can be achieved by various methods. Depending on the bone quality and number of implants, the patient may either receive a fixed or removable implant restoration. If a fixed prosthesis is indicated, the superstructure may either be cemented or, alternatively, screwed directly to the implant fixture, depending on the clinical situation.

In the case described here, we opted for a cemented zirconium oxide bridge. Monolithic crowns were used in the posterior region. For the anterior region, the crowns were cut back and veneered. Translucent zirconium oxide (Zenostar T, Wieland Dental) was used for the framework and IPS e.max Ceram for the veneering of the anteriors. These materials allowed us to achieve the desired strength and aesthetics.

When the patient came to our dental lab, she wore a classic full-arch denture in her upper jaw. She was unhappy about the aesthetic appearance, functional qualities and the loose fit of the denture. Her oral condition was assessed with digital volume tomography (DVT) to confirm that adequate bone quantity was available to facilitate the anchorage of the implants.

Although the placement of four implants would have provided adequate stability for a removable denture, the patient asked for a fixed all-ceramic reconstruction. Having discussed the treatment options with her, we abandoned the idea of providing an implant-supported denture based on the “All-on-4” concept and instead chose to manufacture a fixed, implant-retained bridge. The framework would be made of zirconium oxide and the anterior teeth would be individually veneered.

Based on the DVT examination, seven implants (Replace CC, Nobel Biocare) were planned and placed. An adequate primary stability of 30 to 35 Ncm was achieved. During the healing phase,
the patient wore the existing denture that had been relined with soft silicone.

After a six-month healing period, a satisfactory level of osseointegration was achieved, without any signs of bone resorption or inflammation. The implants were uncovered and gingiva formers inserted. Two weeks later, an impression was taken to transfer the position of the implants to the dental lab. After model fabrication, appropriate abutments were selected and adapted to achieve a common insert direction for the bridge (Fig. 1).

Digital technology was used to manufacture the temporary bridge. The model was scanned with a Zenotec D800 lab scanner (Wieland Dental) and the temporary bridge was designed with the 3Shape dental design software. Milling was carried out in a Zenotec select S2 milling unit (Wieland Dental) using a PMMA material (Telio CAD).

Framework fabrication

Since the patient was satisfied with the shape and function of the temporary restoration, we used it as the base for the final restoration design. The natural wear facets that formed during the temporisation period should be reflected in the final restoration. A conventional impression of the oral situation was taken in the practice. In the lab, a model and a gingival mask were prepared and scanned. First, the working model together with the temporary bridge was digitalised. Then we scanned the model together with the abutments, the opposing jaw model and the bite registration. Finally, the abutments were scanned individually one after the other because the abutment shoulders were located subgingivally and could therefore not be captured accurately enough with the model scan alone (Figs. 2a & b).

CAD construction

First, the position of the digitised model was defined in the design software according to the common insert direction of the abutments. In a second step, the shoulder lines of the abutments were marked and the thickness of the cement gap was defined. The shoulder line represents the "preparation margin" of the restoration. In this case, we set the cement gap to 0.2 mm and the cement space to 0.4 mm. The thickness of the cement gap at the marginal border was set to 0.1 mm. From our experience, these settings result in an excellent accuracy of fit of the restoration on the model and in the patient’s mouth, eliminating the need for later adjustments. At the end, the design of the restoration was checked once more against the individual design parameters. If the wall thickness is lower than the minimum acceptable, the software will issue a warning and enable an automated remediation step.

The final restoration was designed using the full-contour long-term temporary as a basis. The full contours of teeth 13 to 23 were reduced by 0.9 mm on the vestibular aspect to make space for the partial veneers (Figs. 3a & b).

The incisal border was left fully contoured as a large number of functional movements occur in this area. The fully contoured shapes of the posterior teeth and the palatal surfaces of the anterior teeth were left unaltered to ensure a maximum level of

Figs. 3a & b: First, the restoration was designed in full contour and then cut back in the visible aesthetic region.

Fig. 4: Nesting of the bridge framework in the CAM software.
strength in the final restoration. There was a risk that the abutments might shimmer through. For this reason, we decided to use translucent zirconium oxide. The layer thickness appeared to be adequate to mask the abutments.

Milling

The completed CAD design divides a basic crown framework into 18,000 to 20,000 coordinates and generates a harmonious surface texture and perfect marginal seal. The completed design was transferred to the CAM unit.

We use the V3 CAM version, which gives us the option to choose between various output formats. The Zenocam 3.2 format is our preferred output option because, in contrast to the open STL format, it provides information on the specified cement gap, implant axes and restoration margins. The CAM software uses this information to calculate milling parameters that distinguish between the different areas of the restoration. For instance, when milling the restoration margins, the unit reduces the speed, infeed and feed rate to prevent thin crown margins from breaking or fracturing. As a result, even wafer-thin cervical margins having a thickness of as little as 0.1 mm can be reliably milled and require only very little reworking after the sintering process. In less sensitive areas, the unit uses a higher milling speed.

After the output format has been entered, a milling strategy using 2.5 mm, 1.0 mm and 0.7 mm burs was selected for the production of the bridge. The option of using a 0.3 mm bur was not taken as it was not needed for the restoration in question. Next, the job was placed in a virtual Zenostar blank (Fig. 4). We decided to use a translucent, pre-shaded Zenostar T zirconium oxide disc in the shade T sun, because the posterior teeth from 14 to 16 and 24 to 26 were planned to be restored with monolithic zirconium oxide. The warm, reddish shade of this disc closely matches the selected tooth shade and allows the A–D shades to be recreated efficiently and reproducibly.

A sinter support structure was designed to allow the restoration to be sintered in an upright position in the Programat S1 sintering furnace. The sinter frame minimises distortion during sintering and is instrumental in achieving a high accuracy of fit in long-span objects. Finally, the program calculated the milling data in a process that took less than three minutes to finish.

Then, the milling operation was started. This process was achieved in a Zenotec select S2 milling unit that features 5-axis operation and an 8-disc material changer (Wieland Dental). The absolute precision with which this unit works was evident in the excellent milling results obtained on the occlusal and palatal surfaces and at the incisal edge (Fig. 5).

Customising the framework

Once the milling was completed, the framework and the sinter support structure were separated from
the disc. In the next step, the unsintered bridge was customised with colouring liquids using the infiltration technique. The range of Zenostar Color Zr liquids is perfectly suited for this purpose, as they are supplied in the standard shades of the A–D shade guide. Five Effect shades are available for further customisations. We used Zenostar Color Zr in shades A2 and A3 as well as the grey-violet Effect shade.

In order to render the infiltration of the individual liquids visible, the virtually colourless liquids were mixed with a visualizer (Zenostar VisualiZr). First, the interior surfaces of the crowns and the basal surface were infiltrated; followed by approx. 1 mm of the cervical margin, the fissures and the central areas of the palatal surfaces. Infiltration of all these aspects was achieved with Zenostar Color Zr A3 mixed with yellow Zenostar VisualiZr (Fig. 6). After that, the dentin area up to the incisal third was infiltrated with shade A2 mixed with red VisualiZr liquid.

The incisal area of the anterior teeth and the cusps of the posteriors were customized with a diluted version of grey-violet Effect shade and Zonentec Color Optimizer mixed with blue VisualiZr liquid (Fig. 7). It is essential to use a separate brush for each shade. After having been allowed to dry for two hours, the framework was sintered in the Programat S1.

After the sintering process, the restoration exhibited an excellent accuracy of fit, without the need for any adjustments by grinding, e.g. on the insides of the crowns. The advantages of the translucent zirconium oxide became obvious at this stage. Owing to the colouring liquids, the cervical and dentin areas were beautifully accentuated. The incisal areas exhibited a slight greyish-translucent sheen, which should facilitate the subsequent layering procedure (Figure 8 shows the smooth transition of the shades).

The simulation in Figure 9 demonstrates how difficult it would have been for us to achieve the desired tooth shade if we had used opaque white zirconium oxide for the framework. Despite the high translucency of the zirconium oxide, the titanium abutments did not show through the framework.

### Individual framework refinements

An optimum aesthetic outcome is only achieved if the restoration exhibits ideal optical properties. A controlled brightness value, adequate saturation and translucency and minimised light reflection are essential to achieve a pleasing aesthetic outcome. If these parameters are not met, the result will never be satisfactory, even if the restoration is veneered with ceramics. The result would simply be a restoration that looks good on the model but appears too bright in the mouth.

Staining the zirconium oxide prior to sintering is the first measure to control the light reflection effects. Application of a liner is the second measure. The bridge was veneered with IPS e.max Ceram. As the framework already exhibited a pleasing basic shade, we applied a mixture of IPS e.max Ceram ZirLiner Clear and Incisal (70:30). ZirLiner Incisal reduces the light reflection of zirconium oxide; alternatively Liner 4 may be used. In order to mix the liners, IPS e.max ZirLiner BuildUp Liquid was added. The result was a mixture with a pleasing consistency that would ensure an even coating. After the firing process, the restoration exhibited a homogeneous surface and an adequate level of fluorescence.

For the foundation firing of large restorations, we prefer the layering technique rather than the sprinkle technique. The layering technique provides...
better adhesion and optical effects (wash firing: Deep Dentin A2, A1, DA2, A1 and T–Neutral) (Fig. 10). The individual vestibular surfaces can be easily veneered.

The tooth shape was given and the framework was used as the basic shade (veneering: Dentin A2, A1, T–Neutral, OE1, OE2, I1) (Fig. 11). After the firing process was completed, the value, saturation and light reflection effects looked as desired. The shade effect of the restoration is identical in intensive light, in normal light and in the shade and matches the chosen A–D tooth shade.

Shade characterisations (Shades, Stains) are applied to the monolithic portions before dentin firing. We continued to apply thin "soft" coatings of colour and used IPS e.max Glaze Fluo for the glaze firing process.

After the final firing, the restoration exhibited harmonious shade effects. The bridge satisfied all functional and aesthetic criteria. The monolithic portions did not appear brighter than the veneered parts (Fig. 12). Finally, we polished the bridge and ensured that the conditions for optimum oral hygiene were in place. Smooth surfaces are essential to prevent the excellent biocompatibility of zirconium oxide from being diminished and undesirable wear from occurring in the opposing jaw. After a final check, the restoration was forwarded to the dental practice (Fig. 13).

Conclusion

After the preparations were completed, the bridge was cemented in place. The ceramic restoration looks three-dimensional. Even without layering, the posterior teeth demonstrated a natural colour depth. With their vibrant internal shade effects and lifelike warm translucency, the anterior teeth demonstrated impressive aesthetic properties (Fig. 14).

“\textit{The combination of cutting-edge milling technology and high-quality veneering ceramics provides an efficient route to achieving aesthetically pleasing, reliable and long-lasting treatment results.}”

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