In the short-wave spectral band, with part of this energy being emitted in the range of visible light. In UV light a natural tooth emits a weak whitish-blue fluorescence. This should be taken into account when selecting restoratives. If restorative materials do not offer this property of fluorescence, they will look dark in UV light, and the restored tooth (Figure 1) will stand out against the other teeth in the mouth (Figure 2). The fluorescence spectrum of a composite may be violet or blue-green in colour. In addition, the fluorescence intensity of the restorative materials may differ from that of the dental hard tissue (Figures 3 and 4). To ensure a high-quality aesthetic result, the selected restorative should therefore have fluorescence properties resembling those of a natural tooth.

**Abstract**

The fluorescence properties of dental tissue vary between different age groups of patients, as was discovered by the authors of this article, for example during one of their own studies. This observation must be taken into account above all when creating aesthetic restorations, as there is also wide variation in the fluorescence behaviour of restorative materials. A case study shows that dentists are well advised to pay sufficient attention to this aspect.

Dentists nowadays use modern dental materials to construct restorations that match the visual properties of the natural teeth while simultaneously ensuring the required high level of stability. The most stringent demands in terms of visual parameters are made by young patients. They commonly take having a set of perfectly white teeth and a brilliant smile for granted, even at venues where black light is used to create special effects: at discotheques and nightclubs. The ultraviolet rays of black light make natural teeth look especially fluorescent. In terms of the fluorescence properties of restoratives black light, however, also represents the ultimate test of quality.

**The effect of fluorescence**

The short wavelengths ($\lambda < 400$ nm) of UV rays and the long wavelengths ($\lambda > 700$ nm) of infra-red radiation are invisible to the human eye. The effect of fluorescence may, however, occur when objects are exposed to UV radiation. The phenomenon of fluorescence depends on the capacity of certain substances to absorb radiation energy from the short-wave spectral band, with part of this energy being emitted in the range of visible light. In UV light a natural tooth emits a weak whitish-blue fluorescence. This should be taken into account when selecting restoratives. If restorative materials do not offer this property of fluorescence, they will look dark in UV light, and the restored tooth (Figure 1) will stand out against the other teeth in the mouth (Figure 2). The fluorescence spectrum of a composite may be violet or blue-green in colour. In addition, the fluorescence intensity of the restorative materials may differ from that of the dental hard tissue (Figures 3 and 4). To ensure a high-quality aesthetic result, the selected restorative should therefore have fluorescence properties resembling those of a natural tooth.

**Authors’ study: Optimisation of treatment using a composite with fluorescence properties**

The aim of this study was to optimise the quality of dental treatment at the clinic by using a composite with fluorescence properties matching those of natural tooth substance. To this end, the visual properties of dental tissues and restoratives were first of all investigated in the laboratory, with special attention being given to their fluorescence parameters. The aesthetic restorations produced under clinical conditions were then evaluated according to corresponding criteria.
Materials and methods
The following materials were investigated in terms of their fluorescence properties: 40 intact teeth extracted according to clinical indications from patients in the younger age group (up to 25 years of age) and the older age group (45 to 60 years of age); 30 structure micrographs of intact teeth; 24 samples of restorative materials (including Grandio and Amaris, both manufactured by VOCO/Cuxhaven). 60 aesthetic restorations produced under clinical conditions using the composites Grandio and Amaris were also examined. The fluorescence properties were measured at the Institute of Physics of the National Academy of Sciences of the Republic of Belarus using an automated spectrofluorometer, which consists of an excitation monochromator and a recording monochromator. A xenon lamp served as the excitation source here. After passing through the monochromator, the light signal was recorded with a cooled photomultiplier in photon counting mode at 230–800 nm.

Results and discussion
Figure 5 shows the properties of the fluorescence spectra of the enamel and dentine grinding patterns and those of the extracted intact teeth of patients from the different age groups. It can be seen that the highest intensities of fluorescence emissions were registered for the dentino-enamel junction (DEJ) (curves 1 and 2). It is apparent here that in the case of the teeth belonging to the younger age group of patients, a peak of 16,400 ± 162 was measured with a wavelength of 450 nm (curve 1). For the teeth of the older age group an intensity peak of 12,500 ± 152 was measured with a wavelength of 465 nm (curve 2). These high values for the DEJ fluorescence intensity can be attributed to excitation and the resulting fluorescence of the collagen fibre crosslinking proteins that are present in great numbers in this part of the tooth.

Examination of the dentine fluorescence activity revealed that the average level of dentine fluorescence activity for the teeth of the younger age group was 2,500 ± 130 higher than for the highly mineralised teeth of the older patients (curves 3 and 4). The highest fluorescence intensity measured at the surface of the poorly mineralised dentine was a peak of 10,500 ± 149 at 460 nm (curve 3). The highly mineralised dentine, on the other hand, showed a fluorescence peak of 8,000 ± 141 at 460–500 nm (curve 4). In the case of poorly mineralised enamel, analysis of the fluorescence amplitudes of the enamel surface (curves 7 and 8) revealed a low fluorescence intensity of 2,750 ± 130 at 450–480 nm (curve 7). Highly mineralised enamel showed a fluorescence peak of 2,200 ± 130 at 500 nm (curve 8). Together, these different spectral curves could be seen as evidence for fundamentally different enamel fluorescence spectra of the teeth in younger and older patients. The examination of dentine and enamel fluorescence proved that there is no significant variation in the overall fluorescence activity of intact teeth in patients of different age groups (curves 5 and 6). The fluorescence peaks of intact teeth were
simulate the dentino-enamel junction, while curves 4 to 6 represent the fluorescence spectral curves of glass ionomer cements. To ensure that fluorescence properties are as natural as possible when performing restorations, we therefore suggest using composites with average emission intensity, such as displayed by Grandio and Amaris.

Clinical case
The shade of the restoration performed on tooth 11 did not match the neighbouring tooth 21 in daylight (Figures 7 and 8). In UV light this variation was even more apparent (Figure 9). Composite facing work was required on tooth 11 to rectify this aesthetic shortcoming. Tooth 11 and tooth 21 were first cleaned with a fluoride-free paste. The shade of the restorative (Amaris, VO CO) for tooth 11 was matched to tooth 21 in daylight, with attention being paid here to the special physiological and psychological aspects of visual perception.

A tooth is normally divided into nine segments by three vertical and three horizontal lines. In the vertical direction this results in the occlusal, median and cervical segments, and horizontally, in the mesial, medial and distal segments.
The requirements on the restoration are determined accordingly, i.e. separately in each case for the cervical and central segments, the proximal edge and the incisal edge. In this case two opaque shades were required to create a build-up for the central maxillary incisor: a yellowy shade for the cervical area and a lighter shade for the central region. An opaque white allowed for the tooth pigmentation to be covered up here. Three enamel/translucent shades were also required: one for the cervical area, one for the main region of the facing work and one for the incisal edge.

**Measurement and preparation**

The next step was planning the restoration including measurement of the teeth and odontoscopy. Measurement of the teeth revealed that there was major variation in the cross-sectional dimensions of the middle incisors. The mesial surface of tooth 11 projected 0.2 mm beyond the mesial surface of tooth 21. The shape planned for the vestibular surface resembles a rectangle: The proximal contacts between the teeth should extend from the apex of the interdental papilla to the edge of the facing work. Planning was then completed with the selection of a straight incisal edge. Following removal of the old restoration, tooth 11 underwent minimally invasive preparation with a handpiece using diamond burs with an increasingly fine grain in conjunction with the obligatory water cooling. A No. 1 round bur was used to create the contour of the facing work. The preparation margin of the cervical area was situated level with the free gingiva due to the colour impairment. The lateral surfaces were prepared, extending to the vicinity of the contact point to ensure that the junction between the facing work and the tooth would subsequently be invisible. A fine-grain diamond bur was used to finish the enamel margins. The prepared vestibular surface was then slightly convex in shape in both a vertical and mesio-distal direction. The thickness of the facing work needed to be 0.7 mm in the cervical area, 1.0 mm in the centre and 1.5 mm at the incisal edge. Following preparation the tooth underwent thorough cleaning with a water spray and was then dried with an air spray for 15 to 20 seconds (Figure 10). The change in shade and fluorescence of the devitalised tooth was visually inspected with UV light (Figure 11).

**Preparation and restoration**

The next step was adhesive treatment with a self-etching dentine-enamel bond (Futurabond NR, VOCO). The adhesive was spread evenly over the prepared enamel and dentine surfaces using a disposable brush. After an exposure time of
It was necessary to protect the inhibition layer forming on the surface of the adhesive from contamination as this is the only way to ensure stable bonding with the composite. The subsequent restoration work included contouring of the dentine and reproduction of the lateral properties of the tooth. To this end, the initial layer of opaque material, Amaris Opaque O1, was first of all applied to the cervical area with a flat spatula (Figure 12). The composite was then spread onto the pigmented vestibular surface, working from the centre to the edges (Figure 13). In conjunction with strong light-scattering properties, the opacity hinders selective reflection and brings about the so-called “white-sheet” effect. The next layer of opaque, Amaris Opaque O3, was spread over the previously applied layer (Figure 14) and distributed in different directions using a broad spatula. This process also involved reproducing the edges and shaping the geometry. The layers of opaquer were the main component of the build-up with composite, but it was nevertheless essential that the applied layers did not touch the contours of the proposed facing work (Figure 15). In this specific case this meant that the opaque layer was to be applied up to 1.0 mm from the incisal edge, 0.3 to 0.5 mm below the level of the vestibular surface and 0.3 to 0.5 mm from the proximal edges. The next stage of the treatment was the application of the enamel shades to the most recently applied layer of opaque restorative on tooth 11, thereby completing the contouring process. A fine layer of translucent enamel material, Amaris Flow HT (High Translucent), that matched the translucency of tooth 12 was then applied to the vestibular surface and the incisal edge (Figure 16). The same shade was used for the reproduction of the incisal edge and for coating the edges of the facing work.

### Finishing

The restoration was then finished using diamond burs and microfine diamond finishing burs. The palatal surface was finished with a pear-shaped, fine-grain bur. The proximal and
cervical areas were smoothed with a “sting-of-mosquito” bur and the lateral surfaces with strips. The facing work was then completed by polishing the vestibular surface. The final step was to apply a fluoride varnish to the peripheral surface of the facing work. Figure 17 shows the finished restoration by daylight, and Figure 18 in UV light.

**Conclusion**

The fluorescence properties of tooth tissue vary between different age groups of patients. This circumstance must be taken into account above all when performing aesthetic restorations and selecting suitable restoratives. There is also wide variation in the fluorescence behaviour of restorative materials. Dentists are well advised to pay sufficient attention to this aspect to ensure that their restorations will be as aesthetic as possible, customised to the patient and in line with the relevant age group: their work will then also be guaranteed to impress in terms of its fluorescence properties.