Lighting in dental surgeries—frequently neglected requirements of the standard on illumination

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Proper illumination plays an important role in most of our activities, as we acquire more than 80 per cent of information by sight. Precious values such as health and well-being are intrinsic in healthcare.

Lighting in dental surgeries is governed by EN 12464-1:2011 standard specifying minimum lighting requirements for workplaces. National versions of this harmonised standard are made mandatory by country regulations in EC countries. The current standard is effective as of 2011. Some of the illumination systems designed according to the previous edition (2002) are therefore no longer compliant. The requirements of the standard should be understood as the absolute hygienic minimum, as they are a compromise between average physiological needs and average economic potential.

According to ergonomic research, most people prefer their workplaces to be illuminated to 1,000 lx or more, while the standard-prescribed minimum is 500 lx. The standard prescribes the maintained illumination $E_m$. When the real average illumination $E$ falls under $E_m$, maintenance is to be performed: luminaires to be cleaned up, lamps to be replaced, walls to be repainted, etc.

Adequate illumination of the operating area is vital to perform surgical tasks. The standard for dental operating lights requires the operating field illumination to be in the range of 8,000 to 20,000 lx in ellipsis of size 50 × 25 mm (visual task area); but only 60 mm up from the centre of the ellipsis, a maximum of 1,200 lx is allowed to prevent the patient from being dazzled.

Constant re-adaptation of the eye between very bright and dark areas leads to eye fatigue, and finally to overall fatigue for the dentist. A powerful luminaire above the chair meets or exceeds the minimum prescribed illumination of the patient, which is 1,000 lx (co-responds to immediate surrounding area of the visual task: a stripe at least 0.5 m around visual task area). Lower contrast means better visual comfort for the dentist.

Cold tones of light are preferred as peripheral vision is more sensitive to the blue component of light. This leads to a decrease of perceived contrast. The standard requires light with high colour rendering index $R_c \geq 90$. Patients looking directly into the luminaire prefer matt luminous surfaces.

Fig. 1a: Typical situation in dental surgeries in Eastern Europe: lighting is designed using requirements for office workplaces. Most of the requirements are not met, see Table 1.

Fig. 1b: Balanced illumination of dental surgery employing a directional/indirectional panel luminaire above the chair and using additional ceiling and furniture luminaires, see Table 2.

Note: Numbers show the maintained illumination in lx.
The model surgery has dimensions 5 x 6 m and ceiling height of 2.8 m. The luminaire above the chair is suspended in the height of 2.2 m above the floor. Positions of the additional luminaires are a compromise between functionality and aesthetics.

Besides the visual task in the mouth cavity, many other facets exist in the dental surgery that need to be illuminated in order to carry out tasks: instrument trays, controls and displays of diagnostic instruments, material preparation areas, PC table, filing cabinet, etc. Illumination requirements have to be fulfilled at all these places, too. A minimum overall room illumination of 500 lx has to be maintained as well.

One of the principal items in the updated standard is the background surrounding the dentist’s workspace, which is a stripe aligned to the surrounding area of the dentist’s workspace, at least 3 m wide, within the size of the room. According to the standard, this has to be illuminated 1/3 of the illumination of the surrounding area. Installations according to the older standard rarely meet this requirement. A luminance of 5,000 lx directed at the patient can be measured under a powerful luminaire. The background lighting in this case would be 1,670 lx, which is quite expensive to achieve. This requirement has not been met in any of tens of surgeries measured where a powerful directional pendant luminaire was placed above the chair. The updated standard helps us to understand the room as a whole, not just a set of task areas. Not only the illumination of the patient, but also the uniformity and acceptable contrast in the whole space is important.

The focused beam of the operating light provides illumination of about 15,000 lx that is necessary for the dentist’s task in the mouth cavity. The high-output directional/indirectional panel luminaire above the chair provides illumination of the task background area of about 3,000 lx, providing a 1 : 5 contrast, which is already an acceptable level. Colder tones of light further improve the perceived contrast to about 1 : 4. Besides illuminating the patient, the high-output directional/indirectional panel luminaire serves as an ergonomic aid to ease the visually demanding task of the dentist.

Measurements carried out in dental surgeries across some Eastern European countries clearly show that

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning</th>
<th>Overall illumination</th>
<th>Patient illumination</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\mathcal{E}_\text{m}$</td>
<td>Maintained Illuminance Adequate level of light</td>
<td>500 lx</td>
<td>1,000 lx</td>
</tr>
<tr>
<td>UGR$_\text{L}$</td>
<td>Limit of Glare index UGR Glare limitation, acceptable contrast</td>
<td>19</td>
<td>–</td>
</tr>
<tr>
<td>$U_o$</td>
<td>Minimum illuminance uniformity Acceptable distribution of light</td>
<td>0.6</td>
<td>0.7</td>
</tr>
<tr>
<td>$R_a$</td>
<td>Minimum general colour rendering index Required colour discrimination</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>–</td>
<td>Special requirements According to selected task or area</td>
<td>Light should not dazzle the patient</td>
<td>–</td>
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</tbody>
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Table 1: Comparison and evaluation of very basic parameters of illumination.

Table 2: Requirements on lighting in dental surgeries, according to table 5.48 of the standard.
even the very basic requirement of task illumination is often neglected. Also task background and overall illumination are often far too low, which has both eye and overall fatigue implications. As little as 30 lx have been repeatedly measured on the material preparation areas and computer desks. Many surgeries installed in existing buildings kept the original (office) luminaires, not quite following the lighting project. These systems were often projected according to an old standard that required as little as 300 lx for office work. Savings on lighting tend to generate much larger expenses later. The need for light grows with age.

Other parameters of lighting like uniformity, glare, colour rendering or non-visual effects of light and lighting control will be discussed later in a dedicated article.

Lighting the surgery with office luminaires only is not sufficient to fulfil basic requirements. Lighting using a single, powerful central luminaire provides enough light in the visual task area, but may easily fail to meet additional requirements. That is why additional luminaires are needed to provide background area illumination and uniformity.

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References

about
Antonín Fuksa graduated (MSc) in 2000 at the Czech Technical University in Prague, Faculty of Electrical Engineering in the field of study Measurement and instrumentation. He currently works as a developer of intelligent luminaires, smart lighting systems and chronobiological phototherapy devices in NASLI.