Fundamentals of
Shade Matching and Communication in Esthetic Dentistry | Second Edition

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FOREWORD TO THE SECOND EDITION

I have always believed that why we do what we do is just as important as how we do what we do. Knowing why helps one understand a multitude of hows with regard to color and esthetics. When this method of education is coupled with a progressive approach to learning, a powerful tool for understanding is created. Although some may believe that including physics, chemistry, psychology, and psychosocial information in a book on color science and esthetics is superfluous, the authors clearly do not, and I absolutely agree with them. I want to emphasize the importance of this basic tenet in learning a subject in depth. Taking this approach makes something good even better.

The addition of Dr Rade Paravina’s expertise in both the basics of color as well as the future of color education makes this edition more effective in color teaching and in the use of color for creating highly esthetic dental restorations. The staged and step-by-step approach is a proven method for teaching a subject that is simultaneously fun, exciting, and yet highly complex. Much like learning a piece of music requires hearing the music rather than just seeing the notes on paper, color requires as many sensory cues as are necessary for one to learn the subject. The updated electronic approach to learning, matching, and seeing color adds an extra dimension to this edition.

This second edition delves more deeply into digital photography and material selection. As the dental profession advances, it is necessary that educators and clinicians follow suit and provide additional materials to help others use that technology. The authors have taken the necessary steps to include such information in this edition.

When asked by students, “What’s new in dentistry?” and “Why should I become a dentist?” I answer that dentistry is a dynamic profession, developing exciting new materials and methods for treating patients with ever-improving technology that has the clear ability to change people’s lives. Stephen J. Chu, Alessandro Devigus, Rade D. Paravina, and Adam J. Mieleszko have shown that they can provide just that motivation and excitement.

This is a welcome and stimulating addition to color education in dentistry. It encompasses a variety of esthetic dentistry procedures and is a clear guide to integrating additional dental technology, whether digital photography or spectrophotometry, into everyday dental practice.

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PREFACE TO THE SECOND EDITION

Since the first edition of Fundamentals of Color was published, many of the tools and materials used in color dentistry have undergone significant improvements, and a number of new products have been introduced. As technology continues to evolve, so too does the range of digital shade-matching systems available. Technological advances in other industries, such as photography and lighting, and in other subsets of dentistry—e.g., intraoral imaging (CAD/CAM) and teeth whitening—have helped to make the protocols of color dentistry more accurate. The prominence of color dentistry in the general dental community has been raised by the formation of the Society for Color and Appearance in Dentistry (SCAD) and the Journal for Color and Appearance Dentistry; accordingly, the amount of clinical research has also increased, which is extremely important for the expansion of any field.

Fundamentals of Color, Second Edition strives to consider and reflect these new changes. It opens with a critical new chapter on color education and training, which is appropriately followed by sound discussions of color theory and factors that influence perception of color. The book pragmatically reviews the standard recommended protocols for conventional and technology-based shade matching; these chapters culminate in a straightforward, step-by-step protocol that incorporates both the most current and most respected techniques for successful color reproduction. New chapters on digital photography and material selection supplement these protocols and are valuable resources on two topics that strongly influence in shade matching and color communication. The book concludes with 12 in-depth clinical case presentations covering a variety of situations commonly encountered in daily practice. Like the previous edition, this textbook is written in a logical, succinct manner that simplifies the study of color and helps readers understand, qualify, and quantify shade so they can more easily and accurately communicate with colleagues and lab technicians alike.

Acknowledgments

We would like to thank X-Rite, Inc, Olympus, and MHT Optic Research for their outstanding collaboration on dental color-measuring devices. We are grateful to Vita Zahnfabrik and Vident for information on several of their new products and for the support we received for SCAD. We acknowledge SCAD for advancing multidisciplinary collaboration and discovery among industrial and institutional researchers, clinicians, lab technicians, and others, and for creating and implementing research, educational, and training programs on color and appearance for dental professionals and students. We would also like to thank the Heraeus Kulzer Company for providing the high translucency, synthetic feldspathic ceramic material used in the case restorations and give a special thanks to the staff of Quintessence Publishing Co, who made this book a reality.

Additionally we would like to thank Dr Shigemi Ishikawa-Nagai and Dr John Da Silva at Harvard University for their contributions to the clinical cases and Dr Wolfgang Bengel, whose contribution not only to this book but to the specialty of dental photography is an inspiration to practitioners globally. We are indebted to Dr Didier Dietschi, whose research in direct restorative composite materials has set the standard in composite resin color science, and his colleagues Dr Stephano Ardu and Dr Ivo Krejci for the direct restorative case report they contributed to this book.

Thanks also to Kendall Beachman, Assistant Dean at New York University College of Dentistry, Dr Dennis Tarnow at Columbia University, and Dr John M. Powers at Dental Consultants, Inc for their motivation, inspiration, and ongoing support in dental education. Finally, our appreciation goes to Jason Kim, CDT, for imparting his knowledge and skill in the fields of color and translucency.
In this chapter:

- Cultivating the skill of shade matching
- Currently available shade-matching publications and programs
Restorative Materials Selection

The choice of restorative material is extremely important for achieving an accurate shade. The relative translucency of the tooth to be matched and the material selected must coincide (Figs 3-46 to 3-48). Bleached teeth can be especially problematic to match (Fig 3-49). This is because their color is achromatic: hue is white; chroma is low (ie, there is little saturation of hue); and value is high (ie, light). Value is the only tangible parameter that can be addressed; however, it is related to opacity/translucency. Certain materials are higher in translucency (eg, synthetic ceramics), while others are higher in opacity (eg, zirconia and alumina); therefore, identification of the material’s inherent qualities is imperative when quantifying shade (Table 3-3).

It is important to note that although the correct restorative material and shade may be selected, there is still the possibility for error due to inconsistencies and variations in the materials, for which it is difficult to control. 16–22 Moreover, improperly prepared teeth, eg, preparations with incorrect reduction, may contribute to an inaccurate shade match. However, if the protocol recommended in chapter 8 is followed, mistakes resulting from these issues should be discovered in the laboratory during shade verification and corrected before the restoration is returned for clinical try-in.
Restorative Materials Selection

The optical triad: Fluorescence, opalescence, and translucency

For clinicians who practice esthetic restorative dentistry, particularly in the field of ceramics, fluorescence is an important physical property. By their very nature, teeth (more specifically, dentin) are fluorescent because they emit visible light when exposed to ultraviolet light (Figs 3-50 to 3-52). Porcelain consists of agents that cause the restoration to become fluorescent. Fluorescence adds to the natural look of a restoration and minimizes the metameric effect.

### TABLE 3-3
Fracture toughness and relative optical properties of materials for ceramic laminate veneer restorations

<table>
<thead>
<tr>
<th>Material</th>
<th>Brand names</th>
<th>Flexural strength (MPa)</th>
<th>Translucency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slip-cast alumina ceramics</td>
<td>In-Ceram (Vita)</td>
<td>630</td>
<td>Low</td>
</tr>
<tr>
<td>High-alumina-reinforced (sintered)</td>
<td>Procera (Nobel Biocare)</td>
<td>600</td>
<td>Low</td>
</tr>
<tr>
<td>ceramics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leucite-reinforced ceramics</td>
<td>Empress I (Ivoclar-Vivadent)</td>
<td>180</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>Cerpress SL (Leach &amp; Dillon)</td>
<td>180</td>
<td>Variable</td>
</tr>
<tr>
<td>Feldspathic ceramics</td>
<td>Creation (Jensen Industries)</td>
<td>90</td>
<td>High</td>
</tr>
<tr>
<td>ceramics</td>
<td>HeraCeram (Heraeus-Kulzer)</td>
<td>120</td>
<td>High</td>
</tr>
<tr>
<td>Synthetic low-fusing quartz ceramics</td>
<td></td>
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</tbody>
</table>

**Fig 3-50** Natural extracted teeth under natural daylight conditions.

**Fig 3-51** Illustration showing how ultraviolet light interacts with the cells of the dentinal layer, which emit reflected light. This phenomenon is known as fluorescence.

**Fig 3-52** The teeth shown in Fig 3-50 under ultraviolet light. Note the greater fluorescence of the dentinal layer compared with the enamel layer.
MATERIAL SELECTION

Shade selection protocol

According to the natural layering concept, the following four steps should be involved in shade selection for direct composite restorations:

1. Cleaning of the teeth using a nonfluoridated prophylaxis paste (Fig 7-13a)
2. Selection of dentinal chroma in the cervical area (where enamel is thinnest) using samples of the composite material (Figs 7-13b to 7-13d)
3. Selection of enamel tint and translucency by simple visual observation (Fig 7-13e)
4. Combination of both samples to demonstrate the final restorative effect and confirm an esthetic match (Figs 7-13f to 7-13h)

Figure 7-14 presents the shade selection for a case in which the trendy layering concept was used in the direct composite buildup of a peg-shaped lateral incisor.
Fig 7-13e Miris shade guide for enamel. The enamel shade tab is selected by visual observation. No attempt is made to select enamel by comparing the composite sample with the tooth.

Fig 7-13f A thin layer of glycerin gel is placed in the selected enamel shade tab before the dentin tab is inserted.

Fig 7-13g The combined enamel and dentin shade tabs are compared to the teeth to determine whether there is an accurate shade match.

Fig 7-13h Result after 2 years.

Fig 7-14a Preoperative view of a peg-shaped maxillary right lateral incisor with a discolored mesial restoration.

Fig 7-14b Dentin shade selection.

Fig 7-14c The enamel shade with the dentin tab inserted (using glycerin gel) is compared to the tooth to be matched.
4. Interpretation

The laboratory must interpret all of the pieces of shade information provided. The reference photographs help the lab technician to better understand the shade tab selection and the variance in value and chroma, while the digital color map provides a detailed depiction of the shade reading. The technician translates this information into the language of the ceramic system to be used, creating maps of where the ceramic system’s special effects powders should be used to achieve the desired nuances in shade (Figs 8-4l to 8-4n).

Most technicians are familiar with the various nomenclatures and effects of different porcelain systems. This knowledge allows them to select the best ceramic system for the esthetic restorative needs of each clinical case.
Fig 8-4l An 18% reflectance gray card is also used in the dental laboratory by the technician to assess the value differences in shade tabs seen in the reference photographs.

Fig 8-4m Shade tab information is interpreted and converted into the language and nomenclature of the ceramic system used.

Fig 8-4n The language of the ceramic system is transposed onto a printout of a clinical photograph to create a special effects color location and distribution map.