Introduction to Metal-Ceramic Technology

Second Edition

W. Patrick Naylor, DDS, MPH, MS

Associate Dean for Advanced Education
Professor of Restorative Dentistry
School of Dentistry
Loma Linda University
Loma Linda, California

With contributions by

Arlo H. King, CDT
Lumberton, New Jersey

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In Memoriam

Ralph W. Phillips, MS, DSc
Research Professor Emeritus of Dental Materials
Indiana University School of Dentistry
Indianapolis, Indiana
January 12, 1918–May 17, 1991

This book is dedicated to the memory of my mentor, teacher, and friend, Dr Ralph W. Phillips, who passed away unexpectedly in May, 1991, before he was able to see this book in final form. Ralph Phillips was an expert of international renown whose contributions to dental materials science and to dentistry in general are immeasurable. His death was a tragic loss for those of us who turned to him for guidance and insight.

This dedication is a small tribute to a man who left an indelible mark on the dental profession.

Preface

For this second edition, every chapter was revised and updated to include relevant topics not included in the first edition and to expand the chapter content in a meaningful way. Mr Arlo King (Dentsply Prosthetics) contributed immensely to this edition with the industry perspective.

Readers will note that much of the technical data on dental porcelains and metal-ceramic alloys published in the first edition was retained and enhanced with detailed information on more contemporary products. This level of detail will aid readers of older published scientific literature where it was less common for authors to provide actual chemical makeup and percentage composition on the products that were evaluated. The importance of being aware of the elements in materials was highlighted in reports in 2008 of lead contamination of dental restorations outsourced to offshore laboratories in China.[1] It is vital that clinicians and dental laboratories purchase recognized products of known origin from reputable manufacturers.

Among the other major changes is the inclusion of relevant references at the close of each chapter with synopses of selected journal articles and textbooks. Also, key statements in each chapter appear in text boxes to emphasize salient points throughout the book. The nature and extent of the revisions appearing in this second edition are as follows:

- Chapter 1. The history of the metal-ceramic restoration is expanded to offer a richer and clearer perspective on how this technology evolved.
- Chapter 2. The chemistry of dental porcelain and the contributions of several leading pioneers in the development of metal-ceramic technology are expanded substantially. Subjects such as fluorescence, metamerism, and opalescence are explained. Classification of dental porcelains has been updated to reflect contemporary usage and clarify designations not found in many leading dental materials textbooks. The compositions of the components in several modern-day dental porcelain systems are presented in tables.
- Chapter 3. Contemporary classification is suggested along with a modification to the 1984 American Dental Association classification system. The composition of various alloys is included along with expanded lists of important physical properties. Some older articles in the literature refer to alloys by name but fail to identify their classification or major elements; these tables will help readers gain a broader appreciation of the alloys being discussed or evaluated. The section on biocompatibility is expanded with emphasis on the intraoral and extraoral indications of an allergic response to constituent elements such as nickel and beryllium. The occupational risks posed to dental laboratory technicians are also explored.
- Chapter 4. Expanded to provide more details, reference specific statements, and broaden the explanation of the rationale for the steps in substructure design. The ovate pontic is mentioned as an alternative to the modified ridge lap design.
- Chapter 5. Spruing, investing, and casting have not changed since the first edition, but the content is better referenced and the terminology better defined.
- Chapter 6. The theories that explain the nature of the porcelain-metal interface remain the same today, but more statements have been referenced to reflect the evidence-based rationale for the subjects covered in this chapter.
- Chapter 7. More references and improved formatting of the technical steps associated with presoldering and postsoldering.
- Chapter 8. Content is better correlated to contemporary dental porcelain systems. Firing schedules of a few representative products appear in appendix A. The use of visual indicators for assessing the accuracy and appropriateness of temperature settings is explained.
- Chapter 9. Reproducing the variation in natural teeth is explained through an emphasis on outline form, surface texture, and level of glaze. New photographs illustrate how differences in appearance can be identified and captured in porcelain.
- Glossary. Expanded to reflect chapter revisions
- Appendices. Revised and updated in support of the changes made in the text.

1. Furlong A. Lead in dental lab work? ADA urges scrutiny. Am Dent Assoc News 2008;39 (5):1, 22.

Acknowledgments

Many of the historical articles reviewed for this second edition were graciously loaned to me from the personal library of Dr Charles J. Goodacre, Dean of the Loma Linda University School of Dentistry and Professor of Restorative Dentistry. I offer my sincere thanks to Dr Goodacre for his willingness to share this information for the benefit of the dental community at large.

Special thanks are extended to the following individuals: Ms Anita Bobich, Program Director of the dental laboratory technology program at Pasadena City College (Pasadena, CA), who provided welcomed comments and recommendations to improve each chapter, as well as Dr Veeraraghavan Sundar (Dentsply Prosthetics) and Mr Tridib "TD" Dasgupta (Ivoclar Vivadent) for their technical reviews.

I would also like to recognize the following companies for providing products for photographing: Dentsply Prosthetics, Ivoclar Vivadent, Vident, and Whip Mix. Corporate contacts who kindly provided assistance were Ms Jill Piechota (Ivoclar Vivadent), Mr Patrick Boche (Creation International), and Ms Tony Testa (Dentsply Prosthetics).

In addition, I wish to recognize Ms Jennifer Osborne for her administrative role and thank Ms Rebecca Mintz for her help in gathering the research materials used for the updating. A particular note of gratitude is extended to Mr Ryan Becker for the added photographs and transformation of the artwork into a more realistic and contemporary appearance.

Last, I would be remiss if I did not acknowledge the leadership and staff of Quintessence Publishing for allowing me to update this book and for providing editorial and graphic support throughout the publication process.

Preface to the First Edition

The metal-ceramic restoration is one of the most widely used restorative combinations in dentistry today. Unfortunately, there are few publications available that provide introductory level, skill-oriented technical information on the processes involved in fabricating this very popular prosthesis. *Introduction to Metal-Ceramic Technology* was written specifically for dental technology students, dental students, and graduate classes.

Following a brief historical review of the evolution of porcelain in dentistry, chapter 1 introduces the reader to the technical language of metal-ceramic technology. Each of the subsequent eight chapters adds new information to this foundation and literally builds on the preceding material. By the end of the text (chapter 9), the reader will have learned the basic techniques of porcelain application.

A concerted effort has been made to include sufficient information of a theoretical nature to permit the reader to understand why certain procedures, techniques, or equipment are used. The skill of physically constructing an esthetic metal-ceramic restoration is an *art*: however, understanding the rationale for the processes involved requires a knowledge of the true *science* of dental technology.

It is hoped that this text has successfully merged art with science in such a way that the reader is able to meet the challenges of this exciting aspect of dental technology with confidence.

Fig 8-23 Use a mixing instrument to add buildup liquid (or distilled water) to the powder and stir gently. Generally, the enamel mix is slightly wetter than the dentin mix to facilitate its addition to a previously applied and condensed dentin layer. Ideally, mixed enamel porcelain should have a consistency that permits ready pick up by a pointed porcelain brush.

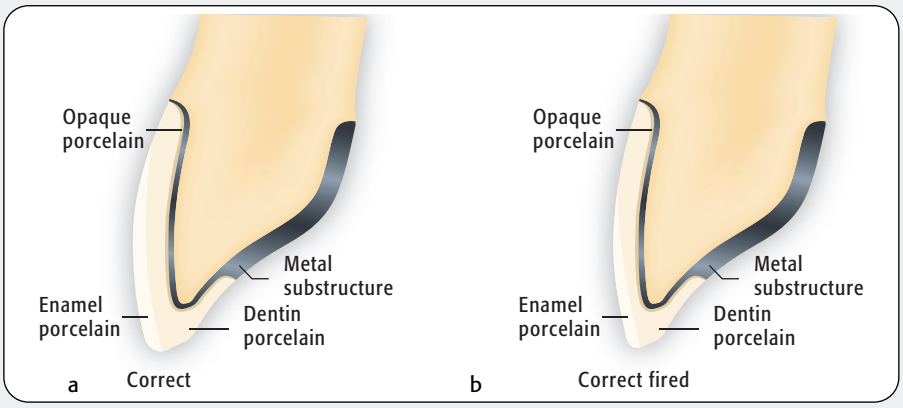

Fig 8-24 The goal is to create a crown with an enamel porcelain veneer placed over a correct thickness of dentin porcelain *(a),* so the fired restoration has the proper final contour and enamel coverage *(b).* Translucent porcelain can be applied over this buildup.

Mixing the enamel porcelain

The same recommendations for mixing opaque and dentin porcelain apply for the mixing of enamel porcelain. Use a mixing instrument to add buildup liquid (or distilled water) to the powder and stir gently (Fig 8-23).

Applying enamel porcelain

When applying the enamel porcelain layer (Figs 8-24 and 8-25), be careful in the placement of each increment to avoid trapping air between additions. Also, avoid "working" the new layer of porcelain into the initial dentin buildup; maintain the delineation between the two materials. By layering the enamel, you have a better opportunity of creating a well-defined junction between dentin and enamel porcelain. The combined dentin and enamel layers should be overbuilt by at least 10% (and no more than 15%) to approximate the estimated shrinkage that occurs during the firing cycle.

The esthetics of each case will vary such that in some instances the enamel porcelain is backed by dentin porcelain; or, you may have to extend enamel porcelain over the incisal edge and slightly onto the lingual surface. With a clean brush, remove any porcelain beyond the porcelain-metal junction with the brush tip. The restoration should be neat, clean, and slightly overbuilt to accommodate the firing shrinkage of the porcelain.

You can condense the porcelain buildup via the vibration method followed by capillary action with blotting (eg, a small mallet for tapping the cast) or the whipping technique followed by capillary action with blotting. However, when using the latter technique, avoid excess whipping because there is a tendency to pull particles of enamel porcelain down over the dentin layer and vice versa with each brush stroke. Such action can dilute the dentin color, diminish translucency, or lower of the value of the overall restoration as enamel particles are incorporated into the dentin layer. Whether for purposes of condensation or not, lightly moving the whipping brush over the buildup helps to smooth the surface and blend the enamel porcelain into the dentin layer (see Fig 8-25e).


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Fig 8-25a With a pointed brush, apply enamel porcelain to one corner of the cutback (mesial aspect shown).

Fig 8-25b Add more enamel porcelain and move it across the facial surface in the incisal third. Push the wet mix toward the middle third of the crown, and work it into the opposite (distal) interproximal line angle.

Fig 8-25c Blend the enamel porcelain at the junction of the middle and gingival thirds, and begin to establish the incisal edge. Condense the porcelain by blotting periodically.

Fig 8-25d With additional enamel porcelain, complete the incisal edge and the mesial-incisal line angle. Work your way along the incisal edge to create more of a distal-incisal line angle.

Fig 8-25e Blend the enamel porcelain into the gingival third on the facial surface. Re-create the interproximal contours and line angles.

Fig 8-25f Shape the mesial-incisal corner as required for each case. Examine the buildup from an incisal view and evaluate the overall shape. Make certain the restoration is slightly overbuilt.

Fig 8-25g Tap the cast lightly to condense the buildup and bring fluid to the surface for blotting.

Fig 8-25h Use a thin razor knife to cut and shape the mesial and distal interproximal areas. This procedure also removes any unwanted porcelain below the interproximal contact areas.


25j

Fig 8-25i Carefully remove the crown from the master cast. Add enamel porcelain to the small dimples in each interproximal contact area. Using either enamel or translucent porcelain, overbuild these areas by about 0.5 mm to compensate for the porcelain shrinkage.

Fig 8-25j Remove excess porcelain beyond the porcelain-metal junction, and clean the facial metal collar (if present) of any porcelain with a small brush or a pointed porcelain buildup brush. Smooth the entire buildup with the whipping brush. Finally, inspect and clean the inside of the casting before firing the porcelain.


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Fig 9-29r Facial view of the fixed partial denture after smoothing with a polishing wheel. Airborne-particle abrade with 50-µm aluminum oxide, and steam clean the prosthesis in preparation for characterizing and glazing. Create the desired surface roughness using preferred instruments (eg, carbide burs, diamond instruments, ceramic stones). Repeat the steam cleaning to remove surface debris.

Fig 9-29s Add a small amount of dark brown or gray stain to the connector areas to individualize the teeth. Lightly characterize the lateral and central incisors (shown).

Fig 9-29t Darken the canine more than the incisors. Add more chroma to the cervical and interproximal areas as the case requires to highlight the facial aspect of the restoration.

Fig 9-29u Continue the characterization onto the lingual surface and tissue side of the pontic. Dry the stains and overglaze at a porcelain furnace muffle entrance using the radiant heat.

Fig 9-29v Glaze and stain that have flowed onto the metal substructure are easy to identify because of their white appearance. Use a pointed brush to remove dried stain or glaze from metal surfaces.

Fig 9-29w Labial view of fixed partial denture after glazing with characterization in the cervical regions and interproximal areas.

Fig 9-29x Remember, the level of sheen and surface smoothness can be adjusted by additional mechanical polishing with a mixture of flour of pumice and Brasso. If the characterization is too pronounced, try mechanical polishing the affected areas to reduce or eliminate the amount of surface stains. If unsuccessful, remove both the stains and glaze and repeat the entire characterization process.

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Fig 9-30a Maxillary left central incisor with a textured surface (horizontally), depressions (vertically), and an apparent groove running from the cervical to the incisal third (vertically).

Fig 9-30b Despite two vertical concavities, the more elevated areas on this maxillary central incisor are relatively smooth with a moderate gloss.

Fig 9-30c Maxillary left central incisor with surface irregularities, a prominent depression, and a low gloss.

Fig 9-30d Maxillary left central incisor with a relatively smooth surface and low gloss. Note the differences between the mesial- and distal-incisal line angles.

Reproducing Variations of Natural Teeth

The natural variability of teeth must be captured whether fabricating one or two teeth or an entire quadrant, arch, or dentition. Digital photographs greatly aid in the transmission of information other than shade alone and can be provided to support cases that pose esthetic challenges. Adolfi[28] has written one of the most outstanding textbooks devoted to a photographic depiction of teeth, particularly maxillary anterior teeth. The large, vivid photographs capture the characteristics found in teeth for patients of various ages. Differences in outline form, surface texture, and gloss are showcased throughout the book.

However, there are limitations to relying on a single view; it is highly recommended that ceramists request images from several angles.

The maxillary central incisors presented in Fig 9-30 vary substantially in appearance. Carefully examine each photograph to determine their similarities and differences. Note that natural teeth are not monochromatic but contain gradations of color. Study interproximal and cervical shading, and look for subtle gradations in color. Even a small amount of surface characterization in the interproximal embrasures and the area of the restoration at and just above the free gingival margin individualizes teeth and avoids the appearance of blocks of porcelain. This is true even for light, high-value restorations.