DENTAL MATERIALS IN CLINICAL DENTISTRY

Edited by

M. H. Reisbick

Postgraduate Dental Handbook

DENTAL MATERIALS IN CLINICAL DENTISTRY

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Volume Editor

M. H. Reisbick, BS, DMD, MS
University of Southern California
School of Dentistry
Los Angeles, California

Series Editor

Alvin F. Gardner, DDS, MS, PhD, FICD
Washington, DC

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CONTRIBUTORS

Neal D. Bellanti, DDS, MA
Associate Professor
Department of Restorative Dentistry
University of Kentucky College of Dentistry
Lexington, Kentucky

Robert P. Berger, CDT
Belle de St Claire Laboratory
Van Nuys, California

Martin Brännström, Odont Dr
Professor
Department of Oral Pathology
Karolinska Institutet
Stockholm, Sweden

Wayne V. Campagni, BS, DMD
Assistant Professor
Department of Restorative Dentistry
Director
Graduate School of Prosthodontics
University of Southern California School of Dentistry
Los Angeles, California

I. Leon Dogon, LDS, RCS, DMD
Professor and Chairman
Departments of Operative Dentistry and Dental Materials
Harvard School of Dental Medicine
Boston, Massachusetts

A. John Gwinnett, PhD, BDS, LDS, RCS
Associate Professor
Department of Oral Biology and Pathology
School of Dental Medicine
State University of New York at Stony Brook
Stony Brook, New York

Howard M. Landesman, DDS, MEd
Associate Professor and Associate Dean
University of Southern California School of Dentistry
Los Angeles, California

Harold R. Laswell, DDS, MSD
Professor and Chairman
Department of Restorative Dentistry
University of Kentucky College of Dentistry
Lexington, Kentucky

Karl F. Leinfelder, DDS, MS
Professor
Department of Operative Dentistry
University of North Carolina School of Dentistry
Chapel Hill, North Carolina

John C. Mitchem, DMD, MS
Professor
Department of Dental Materials Science
University of Oregon Health Sciences Center
Portland, Oregon

Stephen M. Parel, DDS
Associate Professor and Chairman
Department of Maxillofacial Prosthetics
University of Texas Health Science Center at San Antonio
San Antonio, Texas

Jack D. Preston, DDS
Professor
Department of Restorative Dentistry
University of Southern California School of Dentistry
Los Angeles, California

M. H. Reisbick, BS, DMD, MS
Professor
Department of Restorative Dentistry
University of Southern California School of Dentistry
Los Angeles, California

Wm. Ralph Sellers, DDS, MS
Colonel
United States Air Force
Dental Investigation Service
Brooks Air Force Base, Texas

Mark R. Spector, DDS
Assistant Professor
Department of Graduate
Prosthodontics
University of Southern California
School of Dentistry
Los Angeles, California

Patrick M. Walker, DDS, MEd
Assistant Professor and Chairman of
Fixed Prosthodontics
Department of Restorative Dentistry
University of Southern California
School of Dentistry
Los Angeles, California

FOREWORD

During the past decade there has been a gratifying increase in demand for new knowledge in the art and science of dentistry, on the part of practitioners of dentistry and dental specialists. The biological and dental sciences are currently in a period of rather explosive growth. Stimulated by the diversification of experimental methods and dental procedures, the basic dental sciences with clinical applications and clinical dentistry are growing particularly fast.

Dental sciences are currently considered as multidimensional, and individual differences are rather great. Dental scientists and practitioners know that the adaptation of techniques from other fields of science is not simple, usually indirect, and unusable unless radically revised, extended or reformulated for use in dentistry. The basic experimental method originating in the clinical dental sciences may now be joined by the methods of the biological and physical sciences and made technically feasible by the introduction of modern electronics and computers.

It is the goal of the Postgraduate Dental Handbook Series to present critical analyses based on impressive clinical and research experience. This dental series provides basic dental sciences with clinical applications and clinical dental sciences in a correlated fashion. This dental series likewise describes current concepts in clinical dentistry that are of direct value to dental practitioners, dental specialists, dental students and dental hygienists throughout the world. By bringing together all of our knowledge, the volumes in the Postgraduate Dental Handbook Series will fill a critical need felt by dental clinicians and dental investigators alike.

Dr. Morris H. Reisbick, Professor of Restorative Dentistry, Chairman of Dental Materials Science, the University of Southern California School of Dentistry, presents the book *Dental Materials in Clinical Dentistry*, which includes material of major concern to the dentist in clinical practice. The author and his contributors deal with their subjects on a highly practical level so that the book will be useful to general practitioners. Examples of the application of dental materials science to clinical dentistry are numerous and varied, and all of them are described in terms of realistic dental situations so that the dental practitioner should acquire very useful information on dental materials in clinical practice.

The remarkable scientific advances which have occurred in the dental materials laboratory have been well integrated into clinical dentistry by the author and his contributors. Dental materials science is a comprehensive field of dentistry. Its effectiveness in dental practice depends on the level of skill the dentist develops in applying it to patient treatment.

This book is well organized, clear and enjoyable. It should be a welcome guide for general practitioners who seek to understand the conceptual foundations of dental materials science.

To the author and contributors who devoted so much of their time and effort to this monograph on dental materials science, I wish to express my gratitude.

Alvin F. Gardner, Series Editor

PREFACE

The topics dealt with in this book are of specific concern to the dental clinician; topics more explicitly concerned with general laboratory materials and procedures have been omitted. The intention of this book is to give the reader practical and useful knowledge that can be directly applied for the patient's immediate benefit.

All contributors have outstanding backgrounds in scientific and clinically-applied dentistry. I wish to acknowledge their efforts in compiling the respective chapters; they have generously given of their time to this project. I wish to express my sincere gratitude and appreciation to each contributor for making this publication possible.

Colonel Sellers is a dental scholar presently conducting full-time research in in restorative dentistry for the United States Air Force. He is a graduate of USAF's General Dentistry Program and is well qualified to write the chapter on direct gold restorations.

John Gwinnett is one of the world's foremost authorities on the acid etch phenomenon. He has written an interesting chapter on this subject and included an exceptional series of scanning electron micrographs. This chapter is an excellent review of Dr. Gwinnett's research.

Leon Dogon has lectured throughout the world on composite resin restorations. He has done extensive clinical research with these filling materials and his comments have immediate clinical application. He has also written prolifically in this area and is a co-author of a monograph on acid etch technique.

Neal Bellanti and Harold Laswell have compiled an informative chapter on pins in restorative dentistry. Cast gold pins as well as threaded stainless steel pins are discussed in detail. Both men have contributed immensely to The University of Kentucky's restorative program, where Dr. Laswell is the department chairman.

Howard Landesman contributed to the chapters on impressions, casts and dies, and provisional restorations. Dr. Landesman is a former chairman of restorative dentistry and, among other things, is associated with the graduate prosthodontic training program at the University of Southern California (USC). Dr. Landesman holds a degree in education and has lectured extensively in the US and abroad. The chapter on provisional restorations is co-authored by Mark Spector who holds a certificate in prosthodontics. This chapter is a superior contribution.

The chapter on interocclusal records is very unusual. Pat Walker has dealt with this subject in a most informative manner. Dr. Walker's knowledge of gnathology and occlusion is well known. He is a former chairman of the Department of Occlusion at USC, a former study club director and a lecturer with worldwide recognition. He is presently Chairman of Fixed Prosthodontics at USC.

Karl Leinfelder, author of the chapter on dental gold alloys, has earned recognition in metallurgy as well as in dentistry. His contributions to dental metallurgy are numerous, his publications are frequently quoted. Although Dr. Leinfelder deals only with gold alloys in this textbook, he has interests and expertise in many areas of dental materials investigation.

Jack Preston, a fixed prosthodontist, and Robert Berger, a laboratory technician, have teamed to present the porcelain-fused-to-metal restoration chapter. Dr. Preston is a leading authority on dental porcelain and Mr. Berger is an excellent technician with superb color knowledge. The clinician and do-it-yourself technician should enjoy reading this chapter.

John Mitchem is well-known for his clinical research with cements. Dr. Mitchem has contributed greatly to this and other fields, and presents an exciting and useful summary of the currently available cements, bases and cavity liners.

Dr. Brännström has brought together several of his research reports to present enlightening information on pulpal reactions to preparation and materials. Dr. Brännström is a worldwide and much-quoted authority on this subject. Information presented here will certainly make clinicians more aware of the pupal response.

Dr. Campagni, the author of the chapter on polymers in prosthodontics, is a prosthodontist with outstanding clinical expertise. He has written an excellent chapter on denture base polymers. Designations of brand names and material types offer the reader a condensed overview of the clinical application of research in this area.

The last chapter, on materials in maxillo-facial prosthetics, while not having direct application for the general dentist, provides good general knowledge. Many forms of oral-facial cancer are successfully treated using techniques described here. Also defects resulting from treatment or from trauma can now be restored. While at the University of Texas I was able to witness Dr. Parel's artistry firsthand. He trained at M.D. Anderson Cancer Center in Houston, and has since established a busy referral practice at the Health Science Center in San Antonio, Texas.

M.H. Reisbick

CONTENTS

1 Amalgam and the Amalgam Restoration

M.H. Reisbick

Silver amalgam has been one of dentistry's most useful materials. Recent metallurgical improvements and additional information concerning preparation design further increase the likelihood of clinical success when using this incredible alloy.

Since early-day amalgam was produced by mixing mercury with shavings of various elements and alloys, often from coins, there is little wonder early advocates fell into disrepute with their colleagues. Yet even today some clinicians have little regard for amalgam. Alternatively, others support the view that a conservative amalgam restoration is preferable to a cemented casting. Obviously this debate will never be resolved and the patient's financial situation often rules out the cast restoration. In addition to the conservative amalgam, the large pin-retained amalgam can provide an outstanding service alone or as the foundation for full-cast crowns.

Well-designed, properly condensed and carved and smoothly polished amalgams provide the patient with lasting functional restorations, and the clinician with great pride of accomplishment.

The next few pages are devoted to a discussion of amalgam. The format follows a typical clinical sequence; that is, it goes from preparation to polish.

PREPARATIONS

Long-standing evidence shows improper cavity preparation to be the principal cause of failure of amalgam restorations.[1] Manifestations of improper preparation are recurrent decay, fracture of the amalgam, and periodontal and pulpal involvement. Improper manipulation of the amalgam is the second-most-common cause of failure. With the improved preparation techniques in use today, principally more precise cutting, and the new alloys, the amalgam failure rate would probably be found, by a current statistical survey, to have improved.

At one time, preparations of extreme occlusal width were thought to increase a restoration's longevity. For example, preparations in primary molars were made to be at least the width of a 39 inverted cone bur. The rationale for this procedure was that, since the primary preparation is of necessity less deep pulpally, a certain volume of amalgam was essential for bulk strength. Recent stress analysis studies support the concept that reduced occlusal area means less fracture potential. This is reasonable because, if a cavosurface can be made to avoid an opposing cusp's excursion, the margin will have a better chance to remain intact. From a practical standpoint, the clinician can use marking paper to register occlusal paths prior to cavity preparation and then slightly alter the occlusal outline to avoid excessive contact over these vulnerable cavosurfaces. A narrower occlusal width, not a wider one, would be used. An extreme approach is to limit the occlusal outline to less than 1.0 mm.[2] Again, discretion must be used by the operator since other factors also dictate outline form.

Stress analysis studies show that internal angles should be round, not sharp. Stress concentrates in and around sharp line and point angles.[3] Slightly rounded internal angles, made with the innovative 330 pear-shaped bur and similar burs, are currently advocated by some dental schools. This concept is by no means universally accepted, but there is absolutely no justification for a sharp internal angle at the cost of undermined tooth structure. For example, many clinicians still advocate a sharp proximo-gingival angle in extensively involved teeth. This procedure invariably undermines one or more cusps. Diametrically, sharp internal angles are of little consequence in a minimally involved tooth. We can demonstrate our manual skills on minimally involved teeth, but care and planning are needed to successfully restore and preserve a severely damaged tooth. One major difficulty in teaching rounded angles is answering the question, "what is round?" "As sharp as you can make it," is much easier to convey than "a gentle curve." Additionally, the instrumentation for rounded angles is more difficult. Care must be exercised not to disturb the curve during wall smoothing.

Laboratory studies using metal and other simulated teeth have shown that proximal grooves play a role in the retention of amalgam.[4] One would expect that a greater force would be required to fracture an amalgam from a proximal box when grooves are present. While this is true in the laboratory, it has not been corroborated clinically. Two recent clinical studies have revealed no differences regarding fracture whether or not proximal grooves are present.[5,6] At least one dental school (Baylor University, Dallas, Tex) has taught that proximal grooves are not necessary for the retention of amalgam. The rationale is that the grooves are not needed and only interfere with subsequent preparation if a cast restoration is needed. Also, it is better for the alloy to become dislodged, should fracture occur, than for recurrent decay to go undetected under a fractured and leaky restoration.

Two reasons given for the necessity of retentive grooves are 1) to eliminate proximal displacement and 2) to minimize creep. Creep manifests itself in slow extrusion from the cavity. The amalgam becomes raised out of the cavity, where once a smooth transition interface existed. An occlusal dovetail should eliminate proximal displacement; this is the reason often given for its use. Today's low-creep amalgam counters the second argument.[6]

Discontinuation of the lingual dovetail in disto-lingual canine preparations is another concept which has become popular recently. Many schools have changed to this newer preparation, and, since it is more conservative, they also favor the use of proximal retention grooves. At any rate, investigation into the necessity of proximal grooves continues. Practically, it probably doesn't matter if grooves are placed in minimally-involved proximals because very little weakening of tooth structure results. The walls of larger preparations possess enough surface area and minute undercuts from bur flutes to render other retentive factors unnecessary, especially with a long gingival undercut. More clinical work and clinical work of longer duration need to be done in this area.

Consideration of the cavo-surface angle is important. An angle approaching 90° is desirable. Fig 1-1 and 1-2 show two different angles. In Fig 1-1 the cavo-surface angle approaches the ideal. There is little wonder that the margin in Fig 1-2 failed. Beveled occlusal margins fracture readily, even if the material contains appropriate copper. There is little doubt that a butt joint is stronger, but steep inclined planes often make a butt joint virtually unattainable. Nonetheless, care

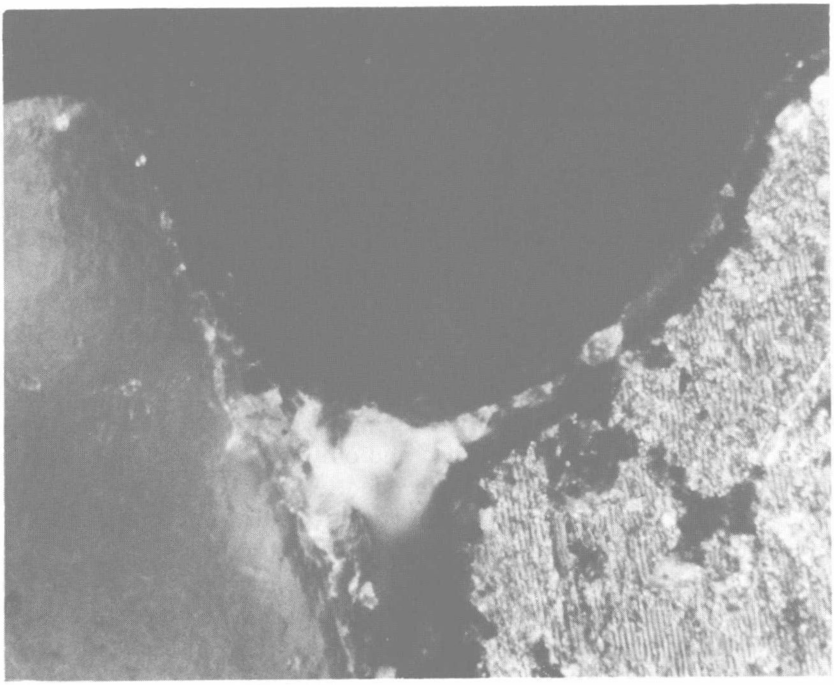

Figure 1-1 Cross section showing 90-degree cavo-surface approximation (tooth on left—amalgam on right). Fracture and corrosion of alloy is evident. Original magnification 300×.

must be taken to maximize this internal angle; otherwise marginal fractures will inevitably occur, and early.

The notion of placing margins into the gingival sulcus has no scientific basis. No investigation has shown the sulcus to be caries-free. In fact, caries are often found in these areas. A more realistic approach, interproximally, is to make certain good separation is obtained between adjacent teeth. Margins placed at, and preferably above, the free margin, are superior, from the standpoint of periodontal health, to margins placed into the sulcus. These areas can be successfully polished with abrasive strips, and then maintained by the patient.

PARTICLES AND CHEMISTRY

The particles to be triturated are either lathe-cut (filings), spherical (or spheroid), or a mixture of the two. Up to about ten years ago all particles were predominantly lathe-cut. Fig 1-3 shows the irregular

Figure 1-2 Cross section showing cavo-surface angle of approximately 30 degrees (tooth on right—amalgam on left). Even a non-gamma-2 containing alloy would soon fracture under such conditions. Original magnification 300×.

nature of these particles. They are essentially Ag_3Sn; that is, 60%–68% silver, 25%–27% tin, 4%–6% copper and 1%–2% zinc.

An understanding of the amalgam reaction is important in making a prudent alloy selection. During amalgamation, the surface of the particles reacts with mercury to form a binding or cementing matrix (Fig 1-4 and 1-5). Newly-formed alloys surround and hold in place the powdered alloy. The most predominant matrix phase is the Ag_2Hg_3 (or gamma-1) phase (Fig 1-4). All amalgams contain this component. The older type alloys do not possess reactive copper. Consequently, one of the matrix alloys (or phases) is tin-mercury (Sn_7Hg). This alloy is named gamma-2 (Fig 1-5). The gamma-2 phase is responsible for the

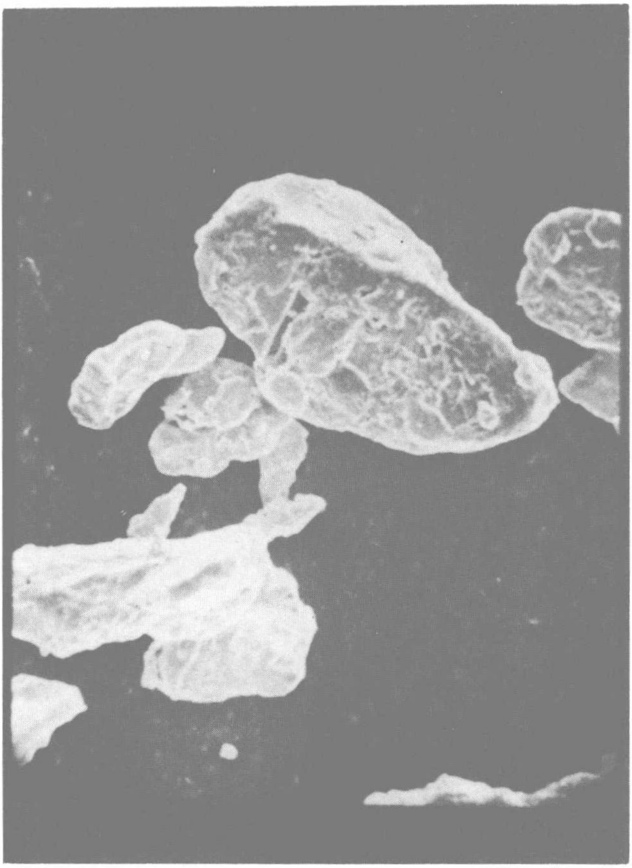

Figure 1-3 Scanning electron micrograph of lathe-cut particles. Original magnification 2000×.

early fracture and failure of the older type alloys. Modern efforts directed toward eliminating this phase have been successful. Amalgam devoid of the detrimental gamma-2 phase contains tin in the form of copper-tin (Cu_6Sn_5).Tin is less prone to corrosion in this form. It is corrosion that weakens amalgam and renders the margins susceptible to fracture secondarily through occlusal forces.

Since tin is the component that must be eliminated, the reader might question its initial inclusion. Very early in research, G.V. Black discovered precise quantities of tin were necessary. Tin controls the normal tendency of silver to expand after amalgamation. Too much tin causes shrinkage. No wonder the early dentists found themselves in a dilemma. At any rate, lathe-cut particles, or filings, must contain tin to