A Century of Innovations
That Transformed the Practice of Dentistry

No one doubts that the past century gave rise to major advances in dentistry. To evoke the triumphs of the recent past, experts in various areas have provided a retrospective glance – and in some cases, personal reminiscences – that take us "back to the future," a time not so very far away that set the stage for the dental technologies we now take for granted.

Fluoride

<By **Dr. Gustavo Cruz**

At the dawn of the twentieth century, the dentist's armamentarium for treating dental caries consisted basically of one approach: tooth extraction. Effective caries prevention techniques were nonexistent and, not surprisingly, dental decay was rampant in the United States and in most Western nations.

Then, in 1945, Dr. H. Trendley Dean, the first director of the National Institute for Dental Research, now the National Institute for Dental and Craniofacial Research (NIDCR), introduced the concept of water fluoridation. Since that time, water fluoridation and the widespread use of fluoride-containing dentifrices have radically reduced the prevalence and severity of dental caries – especially among children. Cities in the United States first started fluoridating their water in 1945. Today over 62 percent of the population, and approximately 300 million people worldwide, drink fluoridated water. In recent years, the benefits of fluoridation have been expanded further through the use of fluoride-containing mouthrinses, supplements and tablets, topically-applied gels, varnishes, and other products such as fluoride-releasing restorative materials. Importantly, the benefits are shared by both children and adults and continue over a lifetime if consumption continues.

Fluoridation is the least expensive, most fundamental, and most socially equitable method for reducing tooth decay, tooth loss, pain and suffering, and subsequent absences from school and work. Thanks to the benefits of fluoridation, tooth loss is no longer considered inevitable, more and more adults are retaining their teeth throughout life, and the quality of life has improved for many Americans. Indeed, the Centers for Disease Control (CDC) recently cited water fluoridation as one of the great public health achievements of the past 100 years.

Yet despite these strides, dental caries continues to afflict more than 90 percent of the U.S. population and its distribution is uneven, resulting in profound oral health disparities. The profession has it within its power to address this problem using fluoride and other methods of caries prevention to virtually eliminate dental caries in children and to significantly control the disease in adults. Most of these methods have in common the use of various forms of fluoride delivery. Thanks to this expanded array of caries-prevention methods, the emphasis has shifted from the restoration and repair of damaged hard tissues to the control, remineralization, and regeneration of lost tissues.

By 2010, the first wave of baby boomers will reach age 65, making this the first generation to reach that age with relatively intact dentition. As a result, more teeth will be at continued risk for dental caries and dentists will be called on in greater numbers than ever before to utilize fluoride in its many delivery forms.

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Anesthesia

<By **Dr. Saul Bahn**

In the 1900s, the majority of dentists embraced the profession's ability to block transmission of peripheral pain and reduce patient distress using a variety of local anesthetics.

Drs. Drummond-Jackson, Hubbell, Jorgensen, Wyckoff, Bullard, Davidau, O'Neil, Verrill and others promoted intravenous anesthesia for ambulatory dental patients using a variety of agents that have proven to be effective and relatively safe anxiolytics, including opioids, barbiturates, benzodiazepines, and propofol. However, patient management problems sometimes occurred. From the 1940s through the 1970s, Drs. Harry Seldin and Harry Langer encouraged dentists to utilize inhalation conscious sedation and developed quality courses and textbooks on "relative analgesia."

Today's dentists and physicians have further refined anesthesia's ability to control fear, anxiety, and pain, and to perform invasive procedures without significant patient distress. Moreover, improved monitoring of patient status now utilizes self-activating or continuous vital sign monitors, pulse oximetry, end-tidal carbon dioxide monitors, and bispectral analysis.

The future is even more promising. Based on discoveries of the genetic and hormonal implications of drug receptor activities, there is growing belief among scientists that analgesia, sedation, and general anesthesia can be precision-tailored for each individual. Bispectral analysis of the level of sedation, using modified electroencephalography, can help to individualize each patient's depth of consciousness and further enhance safety and efficacy. As it has done for the past century, anesthesia continues to light up the darkness.

Dr. Bahn is a professor of oral and maxillofacial surgery and Director of the Pain and Anxiety Control Program.

Bonding Materials

<By **Dr. John R. Calamia**

By 1925, basically three types of cement were used in dentistry to mechanically attach orthodontic appliances, ceramic and metal inlays, posts, crowns and bridges to tooth structure. They were silicate cement, zinc phosphate cement, and zinc oxide eugenol cement. Also used as bases or liners under metal restorations, these materials did not bond to the restoration or to the tooth structure. The situation remained essentially unchanged until 1963, when a British researcher developed zinc polycarboxylate cements, which were set by a reaction between metal oxides and water soluble polymers. This advance was followed in the 1970s by the introduction of glass ionomers, which created the first chemical bonds to tooth enamel and dentin. However, the bond remained fairly weak despite attempts at preconditioning the tooth surfaces with acids.

A major turning point in restorative dentistry occurred in 1955, when Michael Buonocore introduced the acid etch technique. This innovation, which created a physical seal at the tooth enamel-restoration interface, along with the development of composite resins by Rafael Bowen, made possible the longterm adhesion of tooth-colored materials to the enamel tooth structure, and fostered the rapid development of clinical techniques such as pit and fissure sealants, bonded composite restorations, and modern cosmetic bonding.

The next major breakthroughs came with the mechanical and chemical bonding of dental materials to tooth structure, such as electrolytic etching of non-precious alloys (Thompson and Livedits), and etching and silanation of porcelain (Calamia and Simonsen). These innovations introduced a new generation of bonded restorations held to the enamel of teeth with resin cements. The former led to the placement of bonded bridgework with little preparation (reduction) of otherwise healthy abutment teeth. The latter allowed for a predictable repair of porcelain surfaces as well as a veneering technique which has revolutionized cosmetic dentistry.

Subsequently, resin cements were refined to the point that they were able to bond to metals without electrolytic etching (C&B Metabond and Panavia). This also allowed for the direct placement of orthodontic brackets without the need for unsightly bands. The etched porcelain techniques could be applied to posterior restorations if only good bonds to dentin could be created.

In the last quarter of the 20th century, acceptable bonds to dentin finally became a reality and dramatically boosted the popularity of cosmetic dental services. Products of the mid-1960s, like Cervident, produced microleakage at the restoration/dentin interface. The second generation materials of the early 1980s used primarily polymerizable phosphates added to Bis-GMA (hydrophobic resins). These

bonds, though improved, were still very weak and clinically unsuccessful. A third generation of materials, developed in the mid-1980s, utilized a combination of hydrophylic resins and conditioners that removed the smear layer and showed much better bond strengths.

The latest generations of dentin bonding materials have enabled the successful bonding of ceramic and ceromer (ceramic optimized polymer) inlays and onlays, crowns, posts, and bridges, as well as successfully bonded amalgam restorations and posterior direct addition composites of both the traditional and condensable types. These advances have increased the speed, efficiency, and longterm placement prospects of bonded restorations to both enamel and dentin. In so doing, they have set new parameters for the practice of restorative dentistry and have paved the way for even more revolutionary advances in the century now unfolding.

Dr. Calamia is a professor of cariology and operative dentistry and Director of Esthetics and High Technology.

High-Speed Hand Pieces

<By **Mr. George Rhodes**

During the mid-1950s, an air-powered turbine-operated dental handpiece patented by Dr. John Borden of Washington, D.C., transformed the practice of dentistry for both practitioners and patients. "People dreaded dentistry because it was a horrible experience from a sound and vibration standpoint. It was medieval," said Dr. Borden years later.

Dr. Borden knew that more speed was the key to improving on the standard pulley-driven dental drill of the time. However, when increased speeds were used, pulley drills burned the patient's cheek. Dr. Borden's innovation involved using air rather than pulleys to spin a drill bit or other tools in the dental handpiece. But his ideas were way ahead of the technology of his time: ball bearings, a key component of the handpiece, were not small enough or would disintegrate under the intense speed generated by the unit. Still, Dr. Borden persevered in his quest for a better dental handpiece.

By 1954, Dr. Borden had 10 different design concepts, many turbine variations, and repeated ball bearing failures. In 1956, however, he perfected one design with the help of a machinist. Dr. Borden resolved the ball bearing problem by using small, low-speed ball bearings. These were more durable than the high-speed version, which disintegrated within two minutes. He also reduced friction by pushing air between the balls, making 16 ball bearings float in a quarter inch of space.

Whereas conventional drills of the time and earlier rotated the tools used in them – primarily burs for drilling out cavities – at a maximum speed of 6,000 rpm, Dr. Borden's air-powered handpiece, known as the Borden Airotor, could rotate tools at speeds of 250,000 rpm, over 40 times faster than conventional, pulley-driven drills.

The Borden Airotor reduced by 90 percent the time dentists required to repair cavities for fillings, make crown preparations, and perform other functions. A cavity preparation that could take as long as 20 minutes with the old handpiece could now be completed in a minute or two. Patients especially benefited from less time consuming, noisy, and painful procedures. As a result, they were motivated to make more visits to the dentist, the amount of dentistry being done became more productive, and dentists' incomes increased.

One year after Dr. Borden introduced his air-powered handpiece at the 1956 District Dental Society Meeting in Washington, D.C., DENTSPLY, then known as The Dentists' Supply Company of New York, negotiated an exclusive agreement for its manufacture and distribution. The end result was a revolutionary dental tool now used in virtually every dental office around the world.

Mr. Rhodes is vice president for corporate communications for DENTSPLY International.

Composite Resins

<By **Dr. James Kaim**

The development of composite resins (cements, direct and indirect intra-coronal materials, dentin bonding systems, crowns), making it possible to bond a filling to tooth structure, has had a revolutionary impact on the practice of dentistry. Consider the following: The concept of extension for prevention, the classic G.V. Black preparation, has been replaced with a dramatically more conservative "contemporary" preparation. The philosophy of the more you cut a tooth, the more you weaken a tooth, has led to the teaching of minimally invasive procedures. The ability to bond and seal restorative tooth interfaces has provided the

potential for more caries-resistant margins. Recent refinements in the type and percentage of fillers have created flowable and packable materials. Incorporation of adjunct materials – in particular polyacid modified resins – has led to the development of "Componers," or low-fluoride releasing composites. Componers not only have the potential to improve the margins of a restoration but, in addition, the fluoride release potentiates the caries-resistant properties.The success of the original formulation of composite resins can be traced to research done in the 1950s by Dr. Michael Buonocore. Dr. Buonocore's work in the area now known as "etching" enabled dentists to bond and seal the margins of restorations. By the time of the amalgam scare of the 1970s, consumers were demanding not only less controversial treatment options but also more esthetic ones, and the popularity of composite resins soared.

Composite resins permit dentists to cultivate and utilize their skills not only as surgeons but also as artists. And continually improving composite resin systems permit dentists to perform relatively low-cost, esthetic dental makeovers in as little as 45 minutes. By profoundly changing physical appearance, resins thus have impacted not only the dental health but also the mental health and self-esteem of many patients.

With dentistry headed more and more in the direction of prevention and remineralization, composite resins will be the single substance used to treat the next generation of patients throughout their lives, from infants and children requiring preventive procedures to a growing geriatric population with special needs. Even surgical intervention, when required, will take place with improved composite resins.

Dr. Kaim, Class of 1970, is a professor and the chairman of the Department of Cariology and Operative Dentistry.

Dental Implants

<By **Dr. Dennis P. Tarnow**

Today, if a patient loses a tooth, the adjacent teeth do not have to be prepared to support a fixed bridge. A single implant can be placed instead. This saves healthy teeth from ever having to be crowned, which is especially fortunate since the success rate of a single implant is better than that of a three-unit bridge. The reason for this success is that a crown on an implant cannot decay; it's all metal to metal. This means that patients who have a high decay rate can be treated without fear of problems developing under the crowns.

But just as implants have dramatically transformed dental practice, so too have they been transformed from an unpredictable technique when introduced at the beginning of the last century to one of the most scientifically predictable and clinically documented treatment modalities.

In the early 1900s, implant pioneers experimented with various metals to identify one that would be accepted by the alveolar bone in order to support artificial crowns after a tooth was extracted. Most of these attempts were unsuccessful and occasionally caused additional problems for the patient. In the 1940s and 1950s, the subperiosteal implant – which rests on bone rather than going into it – was introduced. Over the years, this implant proved fairly successful in supporting bridges, especially on severely atrophied mandibles.

The 1960s brought new shapes and designs of implants that could be placed into the bone successfully. However, many of these new implants lasted only five-to-10 years before having to be replaced. Then, in the 1970s, the concept of osseointegration of implants to bone took hold. For the first time, the profession could offer predictable, implant-supported restorations for full arch cases. As a bonus, implants were shown to stop the loss of alveolar bone resorption that occurs after years of denture wearing.

In the 1980s and 1990s, the predictability of full arch cases was extended to include partially edentulous jaws, even those involving single tooth replacement situations. Today there is a 95 percent success rate for most implants. In fact, implants have become so safe and predictable that practitioners who in the past were concerned exclusively with getting the implants to function are more concerned today about the esthetics surrounding the implants. Does the buccal height of tissue look normal, and are the papillae reformed adjacent to the implant?

Another indication of how far implants have come is that patients today can be treated with great predictability even if they are prone to periodontal disease or decay since certain types of machined and polished coatings, when placed near the top of implants, make them extremely resistant to peri-implantitis. Now that's a transformation!

Dr. Tarnow, Class of 1972, is a professor and the chairman of the Ashman Department of Implant Dentistry.

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