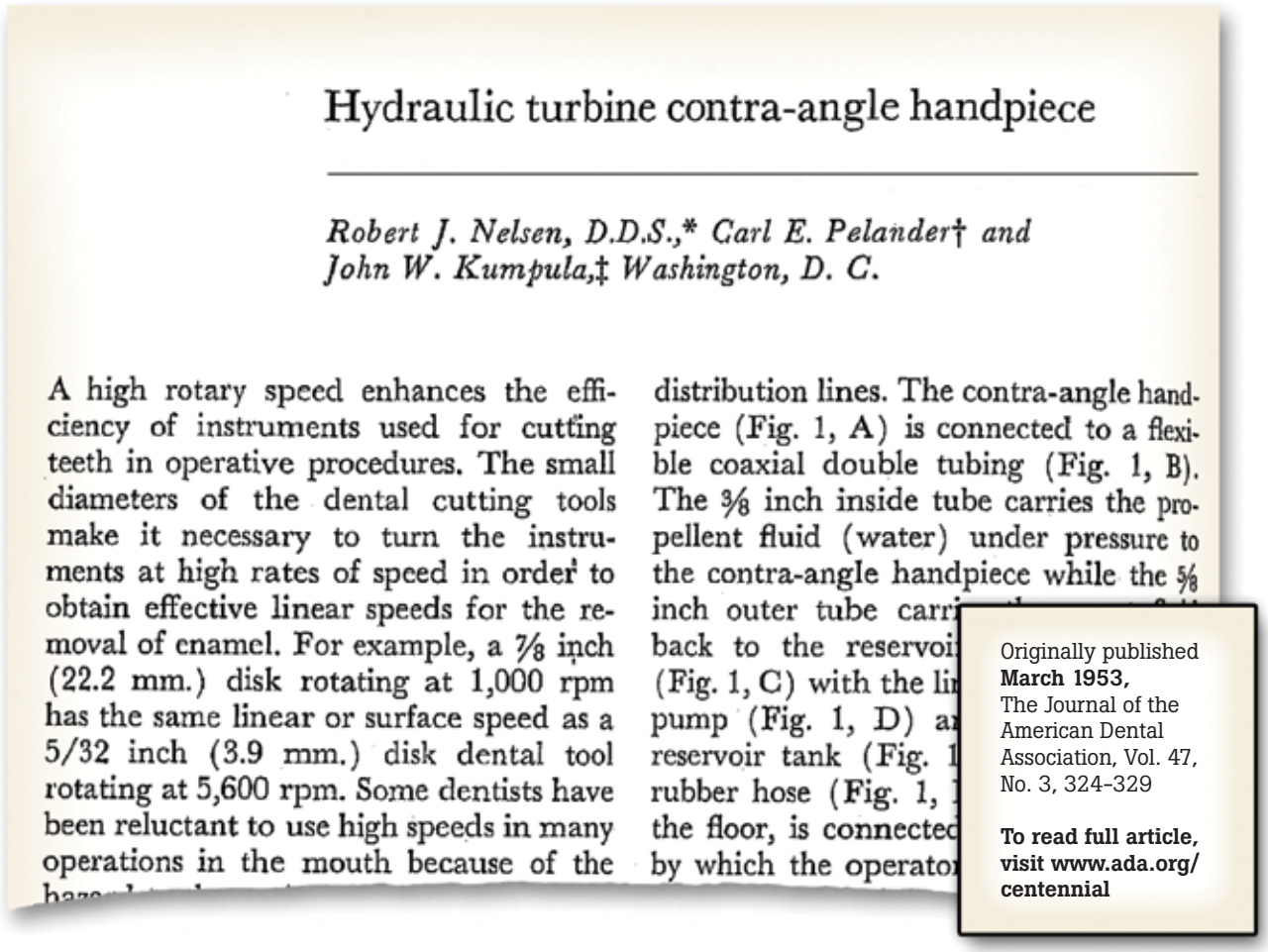
JADA LANDMARK SERIES

Spotlighting articles from past ADA Journals that have achieved landmark status thanks to their lasting impact on dental care and the dental profession



Hydraulic turbine contra-angle handpiece

Robert J. Nelsen, D.D.S., Carl E. Pelander† and John W. Kumpula,‡ Washington, D. C.*

A high rotary speed enhances the efficiency of instruments used for cutting teeth in operative procedures. The small diameters of the dental cutting tools make it necessary to turn the instruments at high rates of speed in order to obtain effective linear speeds for the removal of enamel. For example, a 7/8 inch (22.2 mm.) disk rotating at 1,000 rpm has the same linear or surface speed as a 5/32 inch (3.9 mm.) disk dental tool rotating at 5,600 rpm. Some dentists have been reluctant to use high speeds in many operations in the mouth because of the

distribution lines. The contra-angle handpiece (Fig. 1, A) is connected to a flexible coaxial double tubing (Fig. 1, B). The 3/8 inch inside tube carries the propellent fluid (water) under pressure to the contra-angle handpiece while the 5/8 inch outer tube carri
back to the reservoi
(Fig. 1, C) with the li
pump (Fig. 1, D) a
reservoir tank (Fig. 1
rubber hose (Fig. 1,
the floor, is connected
by which the operato

Originally published **March 1953,** The Journal of the American Dental Association, Vol. 47, No. 3, 324–329

To read full article, visit www.ada.org/centennial

How the development of the high-speed turbine handpiece changed the practice of dentistry

J. Robert Eshleman, DDS; David C. Sarrett, DMD, MS

The development of the high-speed air turbine handpiece changed the practice of dentistry dramatically for both dentists and patients and created a practice transformation that perhaps was more rapid than any the profession has seen. The decade of the 1950s was the period in which a few investigators worked on developing handpieces that could drive tooth cutting instruments at higher and higher speeds. The early 1960s is when the high-speed air turbine handpiece changed dentistry.

The 1953 article by Nelsen, Pelander and Kumpula[1] in The Journal of the American Dental Association describes the development of a water-driven turbine handpiece with the turbine

positioned in the head of the handpiece (Figure 1). They reported this handpiece could achieve a rotational speed of 61,000 revolutions per minute. Although the air-driven turbine handpiece became the standard instrument used by dentists, the work of Nelsen and colleagues[1] provided the prototype for the first commercially produced dental handpiece with the turbine placed in the head of the handpiece.[1-6] The Kern Turbojet, based on the work of Nelsen and colleagues,[1] could operate at a speed of 100,000 rpm, but the introduction of the Borden Airotor (Figure 2) in 1957 never allowed the water-turbine handpiece to gain popularity.[5]

Other authors have provided reviews of development of the high-speed turbine handpiece, and we would refer readers who seek more detailed information to these publications. We will provide only a brief historical recap from the work of these reviews.[2-6] Norlen developed the first air-powered turbine motor with a gear-driven head and bur in 1948, and this design was sold as the Dentalair in 1957.[5] The handpiece could achieve a speed of 50,000 rpm. It appears that two groups of investigators worked independently, without knowledge of each other's work, to develop handpieces without gears and to place the turbine in the handpiece head. Nelsen and colleagues[1] were one group, and the other group included John Walsh working at the Dominion Physical Laboratory in Wellington, New Zealand.[2,4,5] According to Schulein[5] and Stephens,[2] the first air-driven turbine handpiece without gears is credited to Walsh. The device Walsh developed could not function for extended periods of time owing to seizing of the bearings, and further work on this handpiece was abandoned in 1952 owing to lack of support from the New Zealand government. A patent for this work was granted in 1952 to Francis R. Callaghan. What is interesting is that John Walsh was researching hearing loss in New Zealand airmen and found that higher frequencies were not perceived as vibrations, and this suggested a higher-speed handpiece would be less noxious for patients.

Belt- or cord-driven handpieces were the standard in dental practice in the 1950s, and work to increase the rotational speed of this equipment took place at the same time investigators were developing turbine-driven handpieces. Richard Page designed a belt-driven handpiece that became commercially available in 1955 and was able to drive burs at 100,000 rpm owing to the elimination of gears. An improved model of the Page-Cheyes handpiece that could achieve 180,000 rpm was introduced in 1960. Kerr Manufacturing Company made a similar handpiece known as the Kerr Superspeed based on the Page-Cheyes system.[6]

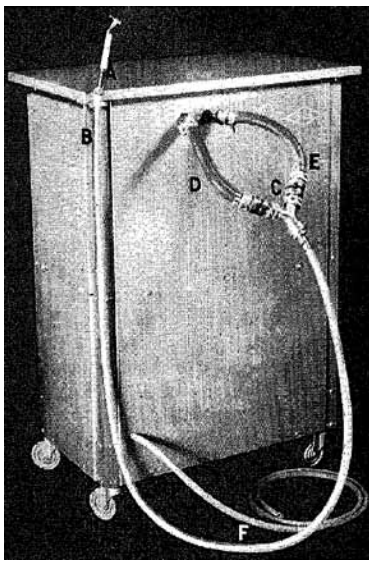


Figure 1. Water-driven turbine handpiece reported on by Nelsen, Pelander and Kumpula[1] in their 1953 JADA article.

Other changes in instrumentation to improve cutting efficiency took place in parallel to the increase in speed. S.S. White Company introduced the tungsten-carbide bur in the late 1940s, but its true benefit in cutting enamel was limited by the slower speeds of cord-driven handpieces.[4,5] As higher-speed equipment became available, the bur shank size was reduced to 1.6 millimeters to accommodate the new systems.[6] Today, the 1.6 mm–shank tungsten carbide bur remains the workhorse for cutting sound tooth structure.

The breakthrough for dental practice came with the marketing of the Borden Airotor,[5,6] which was developed by John Borden and introduced in 1957 (Figure 2). This handpiece, with the air turbine in the handpiece head, could achieve speeds of 150,000 to 300,000 rpm and was lubricated by oil mist in the compressed air. Later, the oil mist was replaced by lubrication at specified intervals because of concerns that inhalation of the oil mist could cause lipoid pneumonia. Borden was eventually awarded a patent in 1967 following a legal battle, and three manufacturing companies agreed to a joint marketing venture (Dentsply International, S.S. White and Ritter).[5] Herschfeld and Robert[3] mentioned a survey by the American Dental Trade Association that showed 94 to 96 percent of dentists were using a turbine contra-angle handpiece in 1962, indicating the rapid adoption of the high-speed technology.

HOW A HANDPIECE CHANGED DENTISTRY

How did the air-turbine high-speed handpiece change the practice of dentistry? To explore this question, we assembled a group of five dentists, all of whom were dental students at

the Medical College of Virginia (MCV) School of Dentistry (now Virginia Commonwealth University School of Dentistry), Richmond, when the Borden Airotor became commercially available. We believe that MCV was one of the earlier schools to adopt the use of the air-turbine high-speed handpiece. The panel of dentists, whose years of dental school graduation are noted in parentheses, consisted of Drs. Madison Price (1959), Robert Eshleman (1960), Joseph Morgan (1961), William Covington (1962) and Maury Hubbard (1962) (oral communication, Oct. 12, 2012). These dentists attended dental school in the late 1950s and early 1960s and originally were trained extensively in tooth preparations with the use of belt-driven handpieces. As soon as the Borden Airotor handpieces were in place in the school, all students were permitted to use them after passing a practical examination using a block holding extracted teeth. The following is a question-and-answer session regarding their personal experiences involving the air-turbine handpiece. Dr. David Sarrett served as the session moderator.

Figure 2. Borden Airotor high-speed air-turbine handpiece. Photograph reproduced with permission of Dentsply International, York, Pa.

Dr. Sarrett: How did the larger dental community view the introduction of the air-turbine handpiece at the MCV School of Dentistry?

Dr. Price: Members of the Virginia Dental Association thought it was very dangerous to allow students to use the air turbines. They feared that teeth would be overprepared. Most of the people who objected had no personal experience with the air turbines themselves.

Dr. Morgan: When you consider the cut cheeks and tongues [that] we had to treat as a result of the large diamond disks and wheels we used with belt-driven handpieces to prepare teeth for crowns, I believe the air-turbine handpiece with small diamond burs [was] safer.

Dr. Sarrett: Did all the students at the school have access to the air-turbine handpiece for clinical work?

Dr. Eshleman: No. We had 10 air turbines, which were checked out to students who had passed the proficiency examination. The handpieces were attached to a box mounted on the bracket arm of the dental unit. Not all students used the air turbines; however, one of my classmates became proficient very early in his clinical years and said, "I did a ton of crown-and-bridge cases." In those days, our requirements were 20 units to include at least three bridges. I suspect Bernie's "ton" was twice the requirement. Since the fee for crowns was $15, it was easy to find patients who wanted and could afford this treatment.

Dr. Sarrett: It was mentioned earlier in our discussion that there was less soft-tissue damage with the high-speed handpiece instrumentation. Were there other significant advantages with the use of air turbines we should know about?

Dr. Price: Belt-driven handpieces had very high torque, and the disks used for making proximal slices during crown preparation would jam and then "walk" away from the tooth, causing soft-tissue damage. The high speed and low torque of the air-turbine handpiece [were] much safer, enabling the operator to make more precise cuts with small-diameter instruments.

Dr. Sarrett: How did patients respond to this new instrumentation?

Dr. Hubbard: The word soon got out around our community that there was a new "drill" in some offices, and they would ask if it was available in a particular office before making an appointment. Some patients referred to it as a "water drill" because of the mist produced by the air-and-water coolant.

Dr. Morgan: Patients did not object to the high-pitched whine of the air turbines, and they also remarked that they liked the reduced vibration. The slow-speed handpieces produced heat, which on occasion was uncomfortable to both the patient and the operator. More than anything else, the patients appreciated the reduced time they spent in the dental chair.

Dr. Hubbard: Patient acceptance was excellent, and for young dentists who more quickly embraced the new technology, it was a practice builder.

Dr. Sarrett: How did the air turbine change the practice of dentistry?

Dr. Price: With slow-speed instrumenta-

tion, a rule of thumb was that 65 percent of the appointment time was used for tooth preparation and 35 percent for tooth restoration. Using the air turbine, this ratio was reversed. We had to guard against the tendency to prepare more teeth than we could restore in a given appointment time. More time and attention to detail enabled the operator to fabricate better-quality restorations.

Dr. Eshleman: Prior to the advent of the air-turbine handpieces, all dental schools trained their students extensively in preparing teeth for inlays, onlays and partial-veneer crowns. This was done for two reasons. First, it was difficult to remove intact enamel, and second, we did not have good esthetic veneering materials. Acrylic was widely used to veneer full crowns; however, it lost its esthetic qualities within a short period of time. The all-porcelain crowns of this era were quite prone to fracture. The partial-veneer crown required much less removal of intact enamel and, if skillfully prepared, would provide an esthetic and long-lasting restoration. The anterior tooth three-quarter crown preparation required a great deal of skill to both hide most of the metal margins and at the same time provide adequate retention and resistance form. As the air-turbine handpiece was becoming almost universally accepted in the 1960s, porcelain-to-metal restoration technology was rapidly developing. By the latter part of this decade and early 1970s, porcelain-fused-to-metal [PFM] technology was sufficiently developed to produce reliable crowns. The marriage of these two technologies had a profound impact on how fixed prosthodontics was taught in dental schools and how it was practiced in most dental offices. Within a span of three decades, the practice of preparing and restoring teeth with partial gold restorations became a lost art.

Dr. Covington: In my office, and in the school dental clinic, I occasionally see gold partial-veneer crowns and onlays, but these are almost exclusively in elderly patients who received them before 1980. In general, the soft tissue is healthier around these restorations than what I see in tissues surrounding PFM crowns. I believe this is due to the fact that it is difficult to accurately contour a PFM margin within the gingival sulcus.

Dr. Sarrett: Do the air turbines of today differ significantly from the original Borden Airotor of 1957?

Dr. Covington: The rotational speed is greater and they are somewhat quieter.

Dr. Hubbard: Today the handpieces have built-in fiber-optic lighting.

Dr. Morgan: The new units can be autoclaved.

Dr. Covington: A bur-changing tool is no longer required.

At the conclusion of the discussion, the panelists were asked whether, in light of the many positive comments they had made about air-turbine handpieces, there was anything negative they had to say about the equipment. Unanimously, they agreed that after more than 50 years of using the handpieces, each of them had significant hearing loss. They noted that younger dentists would be well advised to protect themselves against this occupational hazard.

CONCLUSION

The advent of the high-speed dental air-turbine handpiece revolutionized and forever changed the way dentistry is practiced. All dentists and their patients owe a debt of gratitude to the original pioneers and dental manufacturers who developed and produced the high-speed handpiece for use in the everyday practice of dentistry. ■

Dr. Eshleman is a professor, Department of General Practice, School of Dentistry, Virginia Commonwealth University, Richmond.

Dr. Sarrett is the dean, School of Dentistry, Virginia Commonwealth University, 520 N. 12th St., Lyons Building 450, Richmond, Va. 23298-0566, e-mail dcsarrett@vcu.edu. Address reprint requests to Dr. Sarrett.

Disclosure. Drs. Eshleman and Sarrett did not report any disclosures.

1. Nelsen RJ, Pelander CE, Kumpula JW. Hydraulic turbine contra-angle handpiece. JADA 1953;47(3):324-329.

2. Stephens RR. Dental handpiece history. Aust Dent J 1987; 32(1):58-62.

3. Herschfeld JJ, Robert J. Nelsen and the development of the high speed handpiece. Bull Hist Dent 1987;35(1):37-42.

4. Dyson JE, Darvell BW. The development of the dental high-speed air turbine handpiece, part 1. Aust Dent J 1993;38(1):49-58.

5. Schulein TM. The era of high speed development in dentistry. J Hist Dent 2002;50(3):131-137.

6. Dyson JE, Darvell BW. The development of the dental high-speed air turbine handpiece, part 2. Aust Dent J 1993;38(2):131-143.