This is the second of a three-part series. Part 3 of this Historical Perspective will appear in next month's Journal.

A historic review of endodontics, 1689-1963, part 2

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Dr. G. O. Rogers suggested in an article published in *Dental Cosmos* in 1878 that pathogenic organisms might be the most common causes of diseases of the pulp. He concluded that successful treatment required the total destruction of these organisms.

This conclusion based on the recognition of the pathogenicity of bacteria, led to the eventual demise of the theory of vitalism and consequently opened the door to the new septic theory.[1]

One of the most interesting articles on diseases and treatment of the pulp during the transition from belief in the vitalistic theory to belief in the septic theory, was written by Charles S. Tomes in 1879. In his work, Tomes attempted to incorporate the recent discoveries in pulpal bacterial pathology with the older theory that the etiologic factor of pulp sequelae was a lack of vitality in the tooth.

According to Tomes, the rejection of a pulpless tooth was not accounted for by a septic process that originated in the apical foramen but rather was the result of contamination of one tissue by another. In this case, dentin, the least vital tissue, lost its vitality under septic or arsenical influence and affected cementum, a more vital tissue, which also became infected and involved the periodontal membrane.[1]

The old "dead tooth" theory was supplanted by the septic theory.

In 1882, Arthur Underwood offered a more satisfactory alternative to the dead tooth theory by further developing the septic theory. He proposed that suppuration of the pulp, with its resultant alveolar abscess, depends on the toxic effects of the pathogens. Underwood theorized that, if the pathogens were successfully excluded with the use of powerful and penetrating antiseptic agents, the disease could be prevented.

Underwood believed that whether the pulp was vital made no difference as long as the contents of the pulp chamber and canal were sterilized with antiseptics.

This concept provided clinicians with a new justification for pulp therapy and obturation and clinicians began using caustic germicides to eliminate bacteria. These agents would be widely accepted for more than 30 years[1] (Neaverth, E.J., unpublished material).

Dr. G. A. Mills, Brooklyn, in 1883, described in *Dental Cosmos* a procedure in which dental pulps were extirpated by driving a hickory or orangewood stick into the root canal. The wooden stick first was tapered to allow it to reach the apex; then it was dipped in creosote or in carbolic acid. A quick blow with a mallet drove the tapered wedge to the apex, where it was left for a few seconds before being withdrawn with the pulp firmly attached.[2,3] Others reported performing this procedure as early as 1863.[3]

The obvious brutality of Mills' procedure did not deter acceptance of it by dentists of his time. Curson,[4] for example, gave Mills credit for attempting to do without arsenic in pulpal extirpation. (By that time, arsenic was known to seep beyond the pulp chamber and to damage the vital supporting structures of the periodontium). By 1895, wooden points for "knocking out the pulps" were available commercially.[2]

The same year, Dr. Bowman, Missouri, introduced a solution of chloroform and gutta-percha, aptly termed, chloropercha. This solution was used with gutta-percha cones to obturate root canals. Dentists quickly accepted use of this material; its greatest advocate was Dr. M. L. Rhein, New York, who further developed and described the technique ten years later.[2]

In 1884, Dr. Cassius M. Richmond, originator of the Richmond crown, taught a method of filling root canals based on the following:

—The root canal (and apical area when infected) were sterilized as much as possible with Phenol and iodine.

—The foramen was sealed with a sterile, solid material that did not protrude from the apex.

—The remaining canal and chamber were filled with an antiseptic cement.

Richmond also was the first to use carbolized orangewood as a root canal filling material, and was an advocate and early practitioner of

knocking out pulps with orangewood.[5,6]

During the same year, Koller introduced cocaine as a topical anesthetic. Although it was quite effective, it did not gain wide acceptance because of its extreme toxicity.[7]

During the mid-1880s, nonvital coronal pulps were amputated at the floor of the pulp chamber leaving a nonvital pulp stump in the root canal. These stumps were covered with a drying agent to prevent decompositional changes from taking place. Since 1836, arsenic usually was used for this procedure.

However, in 1885, Lepkowski introduced Formalin as a drying agent, which assured better fixation of the pulp stump without the caustic side effects of arsenic.[8]

In an article published in 1886 in *Dental Cosmos*, Dr. Evans, New York, explained a method of disinfecting devitalized teeth with heat. He used a thick silver bulb attached to a broachlike appendage to expel moisture from the root canal before applying disinfectants and filling material. This instrument became known as the Evans root drier.[3]

In the same year, G. V. Black advocated the total amputation of individual roots of molars that were severely periodontally involved. Root canal fillings which were placed in the remaining healthy roots preserved these structures.[9]

Shortly before the end of the last century, crown and bridge restorations such as the Richmond crown, Davis crown, and Peeso split pin and tube had become increasingly popular. All these procedures required the use of a dowel in the root canal, which in turn created a need for more and more endodontic therapy. These root canal procedures usually were performed under contaminated conditions, with little or no regard for aseptic technique.[10]

In 1888, W. D. Miller, an American dentist practicing in Berlin, formulated the bacteriological basis for endodontic treatment. In a paper that discussed gangrenous tooth pulps as centers of infection, he correctly described the formation of dental alveolar abscesses as a continuation of pulpal infection.[11]

The work initiated by Miller and carried on by others helped to revolutionize the thinking of those interested in the conservation of pulpally involved teeth.

Also in Germany that year, Otto Walkoff invented his famous "thermometric." Using a water bath of variable temperature, he claimed to be able to diagnose the condition of the dental pulp according to the patient's reaction to the changing thermal stimuli.[12]

Although Freud had recognized the value of cocaine as a topical anesthetic in 1884, it was not until 1890 that E. C. Briggs, Boston, used it topically to anesthetize the pulp.[2,4]

Funk improve the procedure the same year by forcing a solution of cocaine directly into the coronal portion of the pulp. To do this, he placed the anesthetic over the exposed pulp and covered it with a piece of unvulcanized rubber. He then used a plunger-like instrument to apply pressure to the rubber to force the anesthetic into the pulp.[13]

In 1890, C. T. Gramm, Chicago, began using copper points for root canal fillings. Later, he improved the points by goldplating them to prevent oxidation and subsequent discoloration.[2]

In 1891, 24 years after Magitot had suggested its use, J. S. Marshall, Chicago, advocated and popularized the electric pulp tester.[2]

W. D. Miller, one of the foremost proponents of the septic theory, described the human mouth as a focus of infection. After studying the use of antiseptics for sterilizing dentin, he concluded that more time should be spent sterilizing the carious dentin. He advocated sealing antiseptic in the cavity preparation and protecting it from saliva for a half hour.

Miller stressed that any organ inhabited by bacteria could produce a metastatic abscess wherever a point of decreased resistance existed.[14,15]

In 1891, Otto Walkoff recommended using chlorophenol to sterilize root canals. In 1899, Hermann Prinz introduced the medicament to American dentists.[8]

In 1892, E. C. Kirk, Philadelphia, suggested the use of sodium dioxide as a root canal cleaning agent for bleaching discolored pulpless teeth.[2] A year later, Emil Schreier, Vienna, introduced a mixture of metallic sodium and potassium for cleaning and disinfecting root canals. When the two alkali metals were inserted into the root canal, they contacted the moisture there and produced an explosive, exothermic reaction. Despite its drawbacks, the method had the effervescent effect of expelling the contents and debris from within the canal.[7,8]

In 1894, Dr. J. R. Callahan, Cincinnati, suggested the use of 20% to 40% sulphuric acid to enlarge and to clean root canals. He sealed a small cotton pellet soaked in sulphuric acid within the canal for 24 to 48 hours. The acid also helped sterilize the pulp chamber and canal. Callahan

showed little concern about possible seepage of the caustic agent through the apical foramen and into the supporting structure. In fact, Callahan believed that, if an abscess existed, some acid should be forced through the foramen and into the periapical lesion.[2,3,16]

During the same year, John Wessler contributed to the list of pulp-capping remedies at the annual meeting of the Swedish Dental Society. His "Pulpol" contained oil of cloves which consisted of 80% to 90% eugenol and zinc oxide.[12]

Breuer, Vienna, is credited with first using electromedication to sterilize root canals.[5] In 1895, Dr M. L. Rhein, New York, began to popularize this technique in America. Although it was initially referred to as electrolization, it later became known as ionization. This was an important step in root canal therapy because it helped to steer the profession away from the use of caustic and sometimes damaging sterilizing agents.[2,8,17]

Dr. Hermann Prinz, Philadelphia, perfected these techniques by 1917. He advocated the use of a 1% sodium chloride solution during electrolization.[17]

In the same year, William C. Roentgen accidentally discovered X rays. His discovery was a major event in the development of endodontics. For the first time, dentists were able to visualize the results of their root canal procedures.

Although this discovery was not adopted by the American dental profession on a wide scale until after 1910, it slowly became accepted as a diagnostic tool that disclosed previously unknown pathologic conditions in the oral cavity.[7,15,18]

A physician, W. J. Morton, took the first dental radiograph in America, shortly after Roentgen's discovery. About the same time, Dr. C. Edmund Kells began to use the X ray in his New Orleans dental practice. In July 1896, Dr. Kells gave the first dental X-ray clinic at Charlotte, NC.

Kells published more than 200 articles and completed many inventions, more than 30 of which were patented. He also was the first dentist to use X rays to study root canals filled with lead wires. He died in 1928 of cancer caused by his early experimentation with X rays.

In 1898, America's greatest inventor, Thomas Alva Edison, discovered that calcium tungstate could be used to manufacture fluorescent dental mirrors. Dentists used these mirrors to observe pathologic conditions and endodontic results. However, the danger of excessive radiation discouraged their use in the 1930s.[19]

At the Zurich Dental Institute, in 1899, Gysi published his work on the famous "triopaste." The main ingredient of this cresol-Formalin mixture was paraformaldehyde. It soon replaced many of the more irritating mummifying agents and remained popular in Europe until the 1960s.

Dr. John P. Buckley first introduced formocresol to the American dental profession. This mixture of tricresol and Formalin was popularized in 1904 and remained in use for over 50 years.[1,8,17]

In 1900, Dr. A. W. Harlan, Chicago, recommended the use of papain (made from paw paw leaves) for digesting dead pulp tissue. The papain was mixed with glycerol and hydrochloric acid to form a thick paste. The paste purportedly had no ill effects on vital pulp tissue and was sealed in the chamber and canals for five to eight days.

Papain had been suggested for this purpose as early as 1893, when it was used in the treatment of diphtheria, lupus, and tuberculosis.[2,3]

In the same year, Zierler and Lehmann from the University of Wurzburg, provided a detailed account of the action of galvanic current on bacterial infection of root canals. Their findings were considered the most complete work on dental electrolization of that time. In addition, Zierler suggested the term electrosterilization, meaning sterilization by electrolysis.[17]

Price did additional work with X rays in 1900 and coined the term blind abscess to describe a radiolucent area in the periapical region with no clinical evidence of drainage. He later advocated the use of radiographs to diagnose pulpless teeth.[11]

T. W. Onderdonk, New York, in 1901, advocated examining the root canal for bacteria before filling the canal. He listed absence of pain under temporary restoration and absence of bacteriologic culture after disinfection as the two conditions necessary before root canal filling.

Initially, his ideas gained acceptance slowly. However, when root canal therapy was criticized by proponents of the "focal infection" theory (about 1919), LaRoche, Appleton, Coolidge, and others began to reemphasize the procedure about 1919.[2,8,11]

By the turn of the last century, trends in dental thought and teaching began to change. Although greater emphasis was placed on sterilization of instruments and on maintaining aseptic technique during root canal procedures, the caustic agents remained in use in the absence of more effective antibacterial agents.

A definite sign of the forthcoming change occurred in 1904 when

Billings directed the attention of dentistry and medicine to the apparent relationship between oral sepsis and bacterial endocarditis.[6]

Although cocaine was used as an effective anesthetic agent for 20 years, many dentists used it sparingly or not at all because of its high toxicity. But, in 1905, Einhorn developed procaine (Novocaine). However, this new anesthetic was cumbersome to use. For mucosal injections, a tablet had to be dissolved in solution, boiled, cooled, and aspirated into a syringe. Nearly a quarter century later, block anesthesia techniques were perfected.[7,8,13]

H. S. Vaughn, New York, was the first to use infiltration anesthesia before pulpal extirpation.[20]

Although Kells, Price, and others have been given credit for pioneering the use of early X rays for root canal treatment, in 1908, Dr Meyer L. Rhein, a physician and dentist from New York, devised a technique to determine canal length and degree of obturation. He used a diagnostic wire in conjunction with radiographs to determine whether the apex had been reached.[2,11,21]

G. V. Black also suggested a measurement control to determine the length of the canal and the size of the apical foramen so that overfilling, a procedure commonly encountered by many at that time,[8] could be prevented.

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