This is the last of a three-part series.

A historic review of endodontics, 1689-1963, part 3

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The focal infection era (1909-1937)

In 1909, an additional study was done concerning the bacteriologic aspect of root canal therapy. E. C. Rosenow, a student of Frank Billings, developed the theory of focal infection. He showed that streptococci were present in many diseased organs and that they were capable of spreading through the bloodstream to establish yet another infection at some distant site.[1]

In the same year, Mayrhofer published a work linking the nature of pulpal infection with specific microorganisms. He found that streptococci were involved in approximately 96% of the cases studied.[2]

By 1910, after safe and effective local anesthetics were developed, and the X ray became available as a diagnostic tool, one would have expected to see giant strides being taken to develop a reliable system of root canal therapy. That might have been the case, were it not for a certain Englishman who nearly sounded the death knell for American dentistry in general and for root canal treatment in particular.

In October of that year, William Hunter, an English physician and pathologist, gave a lecture on focal infection to the faculty of McGill University in Montreal. His lecture, "The Role of Sepsis and Antisepsis in Medicine," also was published a year later in a respected medical journal of the time, the *Lancet.*

In his lecture he unleashed a scathing attack on American dentistry. He termed the gold crown, "a mausoleum of gold over a mass of sepsis." Although Hunter's concern was actually directed more toward the septic conditions found around poorly constructed prosthetic restorations, it was widely interpreted as an indictment of the pulpless tooth.[3,4] Surely, if Hunter would have known the disastrous results of most root canal therapy of the time, as disclosed by the dental radiograph, he would have had a more positive argument for his theory of focal infection.

Even so, the focal infection theory reigned for approximately 25 years and spawned a large following in the American dental profession. These men, who condemned all pulpless teeth to extraction, were known as the "one hundred percenters." They followed the whims and directives of the medical profession; some feared the effects of focal infection, and others were tired of the arduous, meticulous tasks and poor remuneration involved in root canal treatment.

Fortunately, there were a few who instead chose to improve their current procedures by using aseptic techniques, bacteriological and histological methods, and diagnostic X rays. This group included men like Coolidge, Johnson, Rhein, Callahan, Grove, Prinz, and others. Mainly through their efforts, the principle of preserving the pulpless tooth survived.[5,6]

A year after Hunter's lecture, Frank Billings replaced the term "oral sepsis" with "focal infection." At the same time, Charles Rosenow defined "focus" as a well-circumscribed tissue containing pathogenic organisms. Together they identified two types of foci: primary ones in skin and mucous membranes and secondary ones which developed by metastasis from the primary foci.

By 1913, Rosenow was associated with the Mayo Clinic, where he developed the theory of elective affinity of organisms to tissue. He believed that organisms could pass from an apical granuloma to reach organs in the periphery of the body via the process of elective affinity. This work provided additional fuel

for the one hundred percenters as they continued to extract all pulpless teeth.[3]

Callahan presented his rosin-chloroform technique for filling root canals in 1911. He advocated this technique as a means to penetrate and to seal the dentinal tubules which provided a better hermetic boundary.[7]

Callahan later advocated the use of rosin for pulp capping as well.[8] This technique, however, never became as popular as his rosin-chloroform obturation method.

In 1912, Rhein was one of the first to provide a rebuttal to Hunter and his followers. Although he admitted that defective root canal treatment was partially to blame for the "oral sepsis," he also related it to the low fee schedule that forced dentists to use easier and quicker means, such as the use of arsenic paste.

He tried to get the dental profession to adopt better root canal procedures including aseptic methods consisting of the use of the rubber dam and adequate access preparation.

The first dental X-ray unit was available in 1913. It was adopted from a medical unit. In 1919, a year after the advent of the Coolidge tube, a conventional dental X-ray machine became commercially available.[9]

In 1914, Dr. Grove, St. Paul, Minn, performed experimental studies in root canal therapy using various mild and strong antiseptics. He found that Formalin or formocresol produced severe inflammatory changes in the periodontal ligament and that sodium-potassium caused necrosis of the periodontal ligament, whereas the mild antiseptics produced no change.[10] His study, however, would be considered severely deficient by today's standards.

All controversies in dentistry in the post-Hunter period were not related to the focal infection theory, as evidenced by the concept of how to obturate root canals. Whereas Rhein and others contended that all putrescent canals should be filled past the foramen, others warned against protrusion of materials beyond the apex. G. V. Black and Noyes declared that deposition of cementum about the root end was physiologic, whereas Rhein believed it was pathologic.[11]

As a result of the focal infection theory, all radiolucent areas located in the periapical region became synonymous with infection or abscess. In 1916, however, Grove proved through experimentation with animals that chemical injury could produce a radiolucent area in the periapical region.

In 1917, Percy Howe, Boston, recommended the use of silver nitrate and ammonia in a 25% Formalin solution to sterilize root canals. However, the combination caused silver to precipitate, which discolored the tooth structure. It also was highly irritating and caustic to the soft tissues[5] Yet with all these disadvantages, silver nitrate was used for more than 30 years.

In 1917, dental researchers added to the turmoil created by the focal infection theory by questioning the relative efficiency of medicaments for sterilizing tooth structure. They advised that no medicament sealed in an infected tooth would sterilize the tooth. In fact, it would become septic itself within a few hours.

However, this also was the turning point in the type of study and investigation being performed in the name of dental research. Root canal therapy began to turn from heroic instrumentation and medication, to a more careful examination of the biologic principles.[12]

Hermann began using a calcium hydroxide mixture, called Calxyl, for filling root canals in 1920. He condemned the use of substances such as phenol, tricresol-formol, paraformaldehyde, camphor, and other medications that are considered foreign to the body. He believed that these nonbiological medicaments were cytotoxic and would precipitate the formation of various lesions.

Later, in 1930, Hermann also advocated using Calxyl for pulp capping, pulpotomy, pulpectomy, and for treatment of infected canals.[13] He showed that an amputated, viable pulp, when covered with Calxyl, could form a bridge of secondary dentin over the severed pulp.

In 1921, Rosenow and Meisser, using results of animal studies as a basis for their contention, proved that the apexes of healthy teeth can be infected through external contaminants. Rosenow and his sponsoring institution, the Mayo Clinic, both maintained that once a tooth became infected, it always remained infected.[11]

U. G. Rickert, in 1925, proposed the use of a cementing medium, or sealer, in conjunction with the gutta-percha cone. For this method, a prefitted gutta-percha cone which passed to the dentinocemental junction was coated with the sealer. The cone then was inserted and pressed into place, which forced the sealer laterally and apically, so as to obturate and void an accessory foramen.

The technique later was improved by using an instrument designed to facilitate lateral condensation, which, when used, provided space for additional cones to be inserted.[1]

Before 1925, dentists used syringes with a small nozzle, Donaldson smooth broaches, or Gates-type drills

to insert paste fillings into root canals. The same year, Lentulo introduced his rotary paste inserter. It was made from a length of flexible steel wire in the form of a spiral and was mounted on a mandrel. When rotated in a counterclockwise direction, the soft paste was carried apically through the root canal. Later this instrument was used by some to carry the root canal sealer advocated by Rickert.[13]

Walkoff, who, in 1928, was already using a solution of chlorophenolcamphormenthol, added iodoform, creating a resorbable root canal filling paste. He reported that this iodoformized paste would not irritate the tissues, was resorbable, stopped secretions, and was a long-lasting antiseptic. It proved to be a mild and nonirritating filling material; four cases were reported in which the paste was inadvertently carried beyond the apex and into the sinus without any demonstrable clinical reaction.[13]

Until 1929, human pulp was thought to have little capacity for healing. Then, Balint Orban, using histologic studies of pulpal tissue, was able to bring forth a new theory advocating the healing power of the dental pulp. Using the most advanced methods of microscopy, he found that the same tissue and blood cells of defense and repair that are in the pulp also are contained in other connective tissue.

This theory challenged the American clinicians, few of whom were advocates of pulp capping at the time. For, although amputation of pulps was popular in Europe, it did not gain wide acceptance in America.[1,14]

During the same year, Dr. Carl Grove,[15] St. Paul, Minn, called for the standardization of sizes of root canal filling materials and instruments. Many years passed, however, before the manufacturers of dental supplies and equipment acted on this petition.

Since Hunter's denouncement of American dentistry in 1910, the one hundred percenters had, for the most part, reigned supreme. However, about 1930, the pendulum began to swing toward a more conservative approach to root canal therapy with improved and more universally used radiographic practices, bacteriological culturing, and a more pronounced emphasis on definitive diagnosis and aseptic techniques.[16]

An editorial appeared in *Dental Cosmos*[17] in 1930 that emphasized this point. To quote from the editorial, "The policy of indiscriminate extraction of all teeth in which the pulps are involved has been practiced sufficiently long to convince the most rabid hundred percenter that it is irrational and does not meet the demands of either medical or dental requirements, and much less those of the patient. Now let us turn from the destructive policy, the path of least resistance, to the constructive; even though it be beset with more difficulties, it certainly offers more possibilities of making the masticatory apparatus a useful and helpful organ rather than a crippled and constant menace to the welfare of the patient."

Although a change was occurring, it took approximately a decade before a more conservative approach to the pulpless tooth would be generally accepted in practice and widely taught in dental schools.

Rickert and Dixon began a series of experiments in 1931 that were the main support for the hypothesis of the "hollow tube effect." This postulates that if a void is left in a root canal filling, the space may fill with tissue fluids which undergo enzymatic breakdown in the absence of microorganisms. These products were believed to have the capability of reaching the periapical tissues and to precipitate an inflammatory reaction.[10,18]

In 1933, Dr. E. A. Jasper, St. Louis, introduced silver points to dentistry. These points were standardized and had the same diameter and taper as root canal reamers and files.[5] In addition, they were used with a special cement, Neo-balsam.

The scientific era (1937-1963)

One of the major contributions toward placing the focal infection theory in its proper perspective was the work done by Logan in 1937. He believed that the presence of microorganisms did not necessarily imply the presence of infection, that is, bacteria are often present in normal tissues without having pathological significance.[18,19]

In the same year, Tunnicliff and Hammond found that microorganisms were present in the pulps of extracted teeth without any evidence of inflammatory tissue changes.[1,18]

Also in 1937, Cecil at Cornell Medical College, reported 200 cases of arthritis in which treatment consisted of removing suspected foci. He found little benefit from surgical intervention. Burket concluded that any clinical improvement after removal of foci suggested a mere casual relationship between the foci and disease process.[20]

By providing scientific evidence based on sound histological, biological, and pathological findings, these men and others like them were able to usher in a new era in root canal

therapy and to stop the wholesale extraction of nonvital teeth.

Zander concluded his reports on vital pulp capping, initiated in 1938, by showing evidence of complete healing of the vital amputated pulp covered with calcium hydroxide. By showing a continuous row of odontoblasts below the recently deposited bridge of secondary dentin, he was able to confirm Orban's concept of the pulp's potential to heal.[1]

In 1931, a dental radiography textbook by Ennis described different types of periapical lesions as seen on radiographs and attempted to associate them with various causative microorganisms. However, in 1940, Sommer and Crowley compared the radiographic appearance of periapical lesions with the bacteriological status of the pulp cavity. In finding no correlation between the two, they helped to establish the principle that a radiolucent area is not synonymous with infection and that a type of microorganism should not be diagnosed from an X ray.[10]

More recent investigations by Wais in 1958 and others have shown that there is no correlation between the type of radiographic lesion and histopathologic findings.[10]

New concepts in chemotherapeutic treatment of root canals and periapical infections became prevalent near the end of World War I. At that time, chloramine-T solutions, which had proved useful in treating wound infections, were adapted for use as root canal medicaments.

In 1941, Fred Adams helped usher in the use of antibiotics in root canal therapy by reporting his experience with sulfanilamide in treating periapical infections. He also is credited with being the first to use penicillin in pulp canal therapy in 1944.[1]

Grossman also was instrumental in the early application of penicillin for root canal treatment. In 1944, he suggested that, if penicillin were used in endodontic procedures, a nonaqueous solution would be more stable and economical. Dr. Grossman later used absorbent points impregnated with penicillin to sterilize root canals.[21]

Organized endodontics began in 1943 when a group of 20 men met in Chicago and formed the American Association of Endodontists.[6] The name of the organization is significant, in that the term endodontia was virtually unknown before that time. Harry B. Johnston, Atlanta, has been given credit for coining the term, which is a combination of the Greek words: "endon" (within) and "ho dontas" (a tooth). He was also one of the first dentists to have limited his practice to endodontics[4] (V. B. Milas, unpublished material).

The first dental journal devoted entirely to the subject of endodontics, *The Journal of Endodontia,* was published in 1946. The late Balint Orban was its first editor. Although the publication was discontinued in 1948, arrangements were made at that time with the C. V. Mosby Company to establish a section limited to endodontics in their *Journal of Oral Surgery, Oral Medicine and Oral Pathology* (V. B. Milas, unpublished material).

Although the early work with penicillin in root canal treatment by Adams and Grossman appeared hopeful, limitations in the antibiotic later surfaced. Resistant strains of microorganisms necessitated the use of other antibiotics in conjunction with penicillin.

By 1953, many new antibiotics and combinations of various antibiotics had been rushed into use as fast as technology could produce them. It was found, however, that chemotherapeutic means did not completely eliminate all bacteria within the root canal. In 1953, Auerbach helped stem the antibiotic tide by reemphasizing the importance of thorough cleaning of the pulp chamber rather than sole dependence on drug therapy. This led to the acceptance of the principle of combining instrumentation with medication to render a canal aseptic and ready to be filled.[14]

By 1949, the American Association of Endodontists had formed a committee to study the possibility of establishing a specialty board in endodontics. After conferring with the American Dental Association's Council on Dental Education for several years, the American Board of Endodontics was organized in 1956 and incorporated in the state of Illinois.[4]

Sargenti and Richter introduced N_2 to the American dental profession in 1959, and, in so doing, presented a controversy to the practitioners of endodontics that still exists today. N_2 is a medicament and sealer that contains paraformaldehyde and other questionable agents. The proponents of N_2 claim that: it would neutralize connective tissue-remnants within the pulp cavity, a granuloma cannot form on a root filled with N_2, a root filled beyond its apex with N_2 will not present a long-term inflammatory response, and vital teeth can be completely treated in one appointment using N_2.

However, many authors have cited evidence that N_2 is highly irritating to the remaining pulpal and periapical tissue. In addition, the Council

on Dental Therapeutics of the American Dental Association has refuted the claims that N_2 has unusual antiseptic properties.[22]

It is interesting to turn back about 60 years to coincidentally discover a similar situation. One can recall the period just before Hunter's famous speech that precipitated a reign of terror on the pulpless tooth. At that time, a majority of the dentists in North American were tired of the long and involved treatment of root canals and its poor remuneration. An editorial from *Dental Cosmos* (1899) is representative of the thinking of the most able practitioners of the era.

"An important feature in relation to the general introduction of mummifying methods of pulp-treatment should not be lost sight of,—viz, the tendency to their careless and indiscriminate use and to encourage slovenly and imperfect operations.

"It is far less difficult to seal a pellet of mummifying paste into a cavity, complete the operation in a short single sitting, and collect the fee upon its completion than it is to do a thorough canal operation, and the very ease which this short cut through an essentially difficult operation to the fee for it confers is a dangerous temptation to degrade the high standard of dental work which should always be maintained.[23]

In view of the current controversy regarding the N_2 material and its proponents, the article from 1899 could easily be inserted into a contemporary dental journal without losing its relevancy.

By 1963, more than 200 American dentists were limiting their practice to endodontics.[6] Because of the remarkable growth and development of endodontics during the previous 25 years, and because of the untiring efforts of leaders in the American Association of Endodontists, the American Dental Association recognized endodontics as a special area of dentistry in 1963. The first examination and certification of Diplomates occurred two years later, in 1965.[4]

We are presently entering a new era, one so new and boundless that we cannot define its expanding dimensions. The advances of modern technology will allow us to take giant steps in understanding our present concepts of practice.

The immunologic basis of pulpal and periapical pathology will no doubt have an impact on our future concepts of pulpally involved teeth and may well influence the ideas, materials, and medicaments presently in vogue.

The future of endodontics is exciting and limitless. As we move forward we must always remember all those who preceded us. Without their efforts we would have not had the future. An old Italian proverb summarizes the basic theme of this series. "Chi lascia la via vecchia per al nuova, sa quel che perde e non sa quel che trova." (Whoever forsakes the old ways for the new knows what he is losing but not what he will find.)

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