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THE PATHOGENESIS OF FOCAL INFECTION.

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IN ACCEPTING the honor of this invitation to present the results of my work before the National Dental Association I did so in recognition of the Research Institute of the National Dental Association, endowed wholly by the members of this Association. Every member, it seems to me, should feel proud of thus fostering a great idea, for it is true today, as heretofore, that the greatest advances in medical science come from experimental investigation, especially if closely correlated with accurate clinical observation.

Much of the experimental work I have done has a direct bearing on the problems which confront the members of this association in every-day practice. I have been engaged for some years in an intensive study of the streptococcus-

pneumococcus group of microorganisms. Under varying conditions of environment profound changes in form, in growth-characters, and in infecting-powers were noted. The changes in localizing power of these microorganisms under various conditions appeared to me to be especially significant, and this led to a study of the bacteriology and etiology of various diseases with particular reference to the relation which chronic localized infections, especially those in and about the teeth, the tonsils and the sinuses, might have to various systemic diseases. The idea that localized infections in and about the teeth at times give rise to systemic infections is not new. For years clinical observations suggesting this casual relationship have been made by a few observers, but that these

foci are frequently responsible for more insidious diseases, or others never thought possible to be related to them as shown especially by the experimental studies, is relatively new.

The following selected from a large series of cases will serve to illustrate results obtained in elective localization studies.* For further details, reference may be made to the original publications.

Case 205.—Acute appendicitis in a man, 27 years old. There was no history of a sore throat. Nov. 25, 1914, fifty hours after the attack began, a markedly hyperemic and edematous appendix was removed. A deposit of thick fibrin was found along the base and the mesentery, the lumen was free from fecal material and contained a small amount of bloody, odorless pus; the mucous membrane was hemorrhagic and in areas necrotic, but there was no perforation. Smears from the pus in the appendix showed a large number of gram-negative bacilli while those of the fibrin showed streptococci only. The patient had fever for a number of days following the operation but made a good recovery. Cultures from the pus showed 5,400 colonies of colon bacilli; the emulsion of the wall showed 680 colonies of a distinctly green-producing streptococcus and 14 colonies of colon bacilli; the peritoneal coat showed 2,200 colonies of streptococci and 9 colonies of colon bacilli, and the fibrin, countless numbers of streptococci and 65 colonies of colon bacilli.

November 28, cultures which were made (November 27) from the pus expressed from the pockets in the tonsils, and from the reddened, infected gums around a badly decayed loose tooth, yielded chiefly short-chained streptococci in ascites dextrose broth; on blood agar, there was a great preponderance of green-producing colonies of streptococci.

*A summary of the percentage incidence of localization of streptococci from numerous diseases is given in tabular form in *The Dental Cosmos*, May, 1917.

Sections of the appendix showed marked hemorrhage, particularly just outside the circular muscle fibers. The mucous membrane and peritoneal coat were infiltrated with red blood corpuscles and leukocytes. Gram-Weigert stains for bacteria showed diplococci and streptococci which were most numerous in the peritoneal coat and adjacent to the zone of hemorrhage. In the mucous membrane, a few bacilli were found.

In the animal experiments the intravenous injection of the streptococcus in ascites dextrose broth from the tonsils and tooth, and from the peritoneal coat, as well as the mixture of the colon bacillus and streptococcus from the wall of the appendix, produced hemorrhages in the appendix in all but one of seven rabbits. The colon bacillus alone produced hemorrhages in the intestine but not in the appendix.

Case 52.—Ulcer of the stomach and duodenum in a woman 62 years of age. For years the patient had had severe attacks of migraine. Three years previously she had had a severe attack of herpes zoster, involving the surface of the left thorax, and two years previously there had been a recurrence of severe pain in the zoster area, but no blistering. One year later she had had two severe hemorrhages from the stomach, but had made a good recovery under medical management, and was again quite free from gastric symptoms. At this time marked tartar deposit was found about the teeth, and marked gingivitis, especially at the outer aspect of the second right lower molar. The patient was advised to have her teeth put in order, but this was not done. August 19, 1914, several weeks after an attack of so-called grippe, she vomited large quantities of blood. Three days later the temperature rose. Altho there were no physical indications of pneumonia or other demonstrable cause, high fever continued until death occurred.

Only a partial postmortem examination was made. The heart showed

chronic mitral endocarditis. The lungs were edematous, but there was no evidence of pneumonia. The wall of the duodenum just beyond the pylorus showed two thickened, puckered areas, which produced a marked sacculaton on the anterior wall, approximately 2.5 cm. in diameter. On opening the stomach, approximately 100 cc. of mucopurulent material, free from food were found. The puckered areas in the duodenum were scars of healed ulcers. Just outside of the pyloric ring on the posterior wall, there was an indurated, partially healed ulcer with a hemorrhagic base, 0.4 by 1 cm. In the pyloric third of the stomach, there was an entirely healed ulcer, and one acute ulcer with a hemorrhagic base, which was not thickened. The mucous membrane of the entire stomach was hyperemic, in places edematous, and studded with numerous punctate hemorrhages, the membrane over some of the hemorrhagic areas being eroded. The mucous membrane adjacent to the ulcer was no more hyperemic than the rest. The lymph-glands in the gastro-colic omentum were enlarged and hemorrhagic on the cut surface. No thrombosed blood vessels could be found in the stomach. The gall bladder was distended with a dark bile, the ducts were patent and there were no gallstones. The liver showed marked granular and fatty degeneration. The contents of the stomach did not have an acid odor, and were only slightly acid to litmus. There was no peritonitis.

Cultures were made from the blood, lymph-gland, liver, duodenal contents, duodenal and gastric ulcers, and from pus obtained from the depths of the inflamed gum covering the deposit of tar on the right lower molar.

August 31, cultures from the gum in ascites dextrose broth gave a pure culture of a short-chained streptococcus; those from the duodenal contents, the emulsion of the ulcers, the blood, the lymph-gland, and the liver, gave strep-

tococci and colon bacilli. Ascites-dextrose-agar shake cultures from the ulcer emulsion yielded approximately 6,000 colonies of streptococci, and approximately 150 colonies of colon bacilli. The material withdrawn with a pipet from the margin of the duodenal ulcer—the surface having first been seared—showed mostly streptococci, but also a few colon bacilli.

Sections of the ulcer in the duodenum and of that in the stomach disclosed hemorrhage and leukocytic infiltration of the margin and base which extended thru the entire thickness of the mucosa and submucosa. The muscular coat was largely replaced by connective tissue in the case of the duodenal ulcer, but not in the case of the gastric ulcer; in the latter was marked leukocytic infiltration of the peritoneal coat, but no perforation. Sections thru one of the edematous and hemorrhagic areas revealed marked dilation of the intraglandular blood vessels, hemorrhage, and leukocytic infiltration. Gram-Weigert stains of sections of the ulcers disclosed numerous streptococci in the margins and bases of the ulcers, and in the peritoneal coat. Those of the edematous areas also showed a number of streptococci. On the surface of the ulcers, as of the hemorrhagic areas, scattered bacilli were found.

In the first culture the streptococcus from the tooth was injected into four animals and all but one showed hemorrhage or ulcer of the stomach. The results in the case of the dog are as follows:

Dog 120 was injected intravenously Sept. 1, 1914, with the growth from 150 c. c. of ascites dextrose broth of the streptococcus from the tooth.

September 3 the dog seemed well. It was chloroformed and the mucous membrane of the pyloric end of the stomach was found studded with numerous small punctate hemorrhages. There were present a number of larger hemorrhages and four ulcers, from 2 to 4 mm. in

diameter, near the juncture of the middle and lower thirds of the stomach. The intervening mucous membrane was normal. The gastric contents had a typical odor and were highly acid in reaction. The gall bladder, appendix, pancreas, and other organs, appeared normal.

September 4 the cultures from the blood, bile, liver, and the joint fluid were sterile. Cultures from the larger ulcer yielded 150 colonies of streptococci, those from the small ulcer 80 colonies, while those from a hemorrhagic area of corresponding size, without ulceration, gave approximately 2,400 colonies of the injected streptococcus.

In the second culture the streptococcus from the ulcer was injected into 12 animals; 8 developed lesions in the stomach and 4 lesions in the gall bladder. After one and two animal passages, the streptococcus was injected into 6 more animals, giving rise to lesions in the stomach in 1, and to lesions in the gall bladder in 3.

Case 236.—Recurring ulcer of the stomach in a young man. The patient had developed typical symptoms of ulcer of the stomach six months before, following the ulceration of a tooth. He had completely recovered under medical management, but he had had a discharging sinus, as a result of trouble with the tooth, which alternately healed, formed a blister, and again discharged pus. There had been a sudden recurrence of the ulcer of the stomach, associated with hemorrhage, five weeks prior to the examination.

January 22, 1915, two days previous to the extraction of the tooth, a culture was made from pus withdrawn from the sinus after the sterilization of the surface, and insertion of a pipet for a depth of 1 cm. A blood-agar-plate culture gave an almost pure culture of *Streptococcus viridans*, with a few colonies of hemolytic streptococci. Ascites-dextrose-broth cultures yielded a pure growth of a short-chained streptococcus. The cultures from the tooth pulp after extrac-

tion, two days later yielded exactly the same results.

Injection of this strain into guinea-pigs, rabbits, and dogs, showed a most pronounced tendency on the part of the organism to lodge in the mucous membrane of the stomach and to produce hemorrhages and ulceration. Intravenous injection of the strain from the sinus was made into 2 rabbits and 1 dog. The dog developed ulcer in the duodenum; one rabbit had hemorrhage and ulcer of the cardiac end of the stomach, and the other rabbit had arthritis but no lesions of the stomach.

The cultures from one of the ulcers in the dog gave streptococcus in pure growth in broth, and in ascites-dextrose-agar (17 colonies). The broth culture, injected intravenously into one rabbit and 1 guinea-pig, produced hemorrhage or ulcer in both. Injected intraperitoneally into 1 rabbit and 1 guinea-pig, it produced in the rabbit an acute ulcer (2 by 3 mm.) in the lesser curvature of the stomach, but no lesions in the guinea-pig. Injected intrapleurally into 1 guinea-pig, it caused two small ulcers in the pyloric end of the stomach. Injected subcutaneously into 1 guinea-pig, it did not give rise to lesions in the stomach. The streptococcus culture from the tooth was injected intravenously into 1 rabbit and 1 dog, and intraperitoneally into 1 guinea-pig. All developed hemorrhage and ulcer of the stomach or of the duodenum. Cultures from one ulcer from each of 7 animals yielded from 5 to 40 colonies of streptococci, irrespective of whether the injection had been made intravenously, intraperitoneally, or intrapleurally.

Case 227.—An ulcer of the stomach in a physician of middle age. There was a history of severe recurring attacks of tonsillitis and rhinitis for years. April 21, 1914, during an attack of acute rhinitis and acute indigestion, resembling ulcer, a pure culture of a green-producing streptococcus was isolated from the mucopurulent discharge

from the nose. This was injected into 5 animals. Two developed ulcer of the stomach, 1 hemorrhages of the stomach, and 2 cholecystitis. No particular importance was attached to these findings at that time.

December 19, the symptoms of gastric ulcer were typical. The tonsils showed marked infection and tonsillectomy was done. Salt-solution suspensions of the extirpated and washed tonsils caused hemorrhage or ulcer of the stomach in 2 rabbits. Cultures from the tonsils, injected into 6 animals, produced hemorrhages or ulcer of the stomach in 4. After the removal of the tonsils, while the patient was being treated with an autogenous vaccine prepared from the streptococcus isolated from the ulcer in one of the animals, the symptoms of ulcer were reduced for a short time, but they returned, and persisted in spite of strict medical management.

February 27, 1915, the teeth showed the presence of a number of pyorrheal pockets. Cultures from the pus from these pockets injected into 1 dog produced hemorrhage and ulcer of the stomach. On the basis of these findings, the involved teeth were extracted August 15, 1915, the symptoms of ulcer having persisted during the interval. The patient was then placed on strict medical treatment for ulcer. He has since been free from symptoms and has regained his former weight.

Case 276.—Severe unilateral herpes zoster of four days' duration, involving the left thoracic region in a laborer 49 years of age. The blistering was marked and the pain intense. The patient thought he had had high fever at the onset of the disease, but with the appearance of the eruption it had disappeared. There had not been a similar attack. The man was poorly nourished, seemed ill, coughed, and raised small amounts of sputum, but the lung-findings were negative.

Feb. 22, 1915, the tonsils were found cryptic and the teeth surrounded by

marked gingivitis. Cultures were made from the pus expressed from the tonsils, from the material drawn into a pipet from the inflamed gums, and from sputum, spinal fluid, blister fluid, and blood. The spinal fluid was clear, but smears from the sediment showed a moderate number of mononuclear cells in which were a few diplococci.

February 23, cultures from the blood were sterile; the spinal fluid gave a pure culture of a short-chained streptococcus and a few colonies of streptococci in ascites-dextrose-agar. Cultures from the tonsils, the teeth, and the sputum revealed chiefly green-producing colonies of streptococci, *Micrococcus catarrhalis*, and staphylococci. Cultures from the clear blister fluid remained sterile; those from the bloody blister fluid gave a few chains of diplococci, a spore-forming bacillus, and staphylococci.

The original cultures from the tonsils, from pus pockets about the teeth, and from sputum in ascites-dextrose broth were each injected intraperitoneally into a guinea-pig; all 3 developed herpes. Intravenous injections of cultures of the streptococcus from each of these foci into 3 dogs, 3 rabbits and 3 guinea-pigs, were followed by herpes in all but 1 dog and 1 rabbit. The pure culture of the streptococcus from the spinal fluid of these animals caused herpes in 2 rabbits and 1 dog. After cultivation from one to two weeks, this streptococcus, when injected into 5 rabbits and 2 dogs, failed to produce herpes. The streptococcus from the spinal fluid (second culture) produced herpes of the eye and the lip and hemorrhage in the corresponding ganglion in a dog.

Rabbit 46.—February 23 the rabbit was injected intravenously with the growth of a pure culture of streptococcus viridans from the infected gums in 60 c. c. of ascites dextrose-tissue broth.

February 24, it was chloroformed. Marked herpes of the tongue, marked areas of localized edema in the lung,

and the mucous membrane of the trachea suggestive of herpes were found. There were a moderate number of localized hemorrhages and edema of the mucous membrane of the stomach with one ulcer near the lesser curvature and one in the fundus. There was moderate turbidity of the joint fluid from both knees. The spinal fluid was slightly blood-tinged. The gasserian ganglia appeared edematous, but no distinct hemorrhages could be made out.

February 26, the blood, the spinal fluid, the gasserian ganglia, and the joint fluid yielded a large number of green-producing streptococci, and plate cultures from the ulcer in the cardiac end of the stomach gave 500 colonies of streptococci. Sections of the ganglia of the vagus nerve showed one rather large hemorrhage between the cell-groups, and Gram-Weigert stains showed a few diplococci in the hemorrhagic area. Sections thru the ulcerated area at the tip of the tongue showed desquamation, infiltration and necrosis of the epithelium, slight hound-celled infiltration of the underlying muscle, and an aggregation of leukocytes in a small adjacent blood vessel. Stains for bacteria revealed a large number of gram-staining diplococci covering the ulcerated area.

Case 567.—Recurring attacks of neuralgia of the face and neck due to dental pulpitis, neuritis and myositis. The patient, a neurotic woman 35 years of age, had been subject to severe migraine for many years. For the past five or six years she had suffered from recurring attacks of neuralgia of the face, which began with severe pain and distinct swelling over the left upper jaw, spreading to the opposite side, with soreness in the teeth, especially in the upper jaw, followed by intense pain in the left side of the head, neck and shoulders. During the last two or three years the attacks had occurred oftener and had grown so severe as to necessitate the frequent use of hypodermics of morphine; the attacks ended with spasm of

the muscles, and tenderness and swelling of the neck on the left side. The tonsils were removed four years previously, but this did not relieve the condition. One year previously the second left upper molar was extracted, showing a blind abscess at the root. The left maxillary sinus was drained and a piece of the left turbinate was removed, but without relief. The patient became extremely nervous, at times hysterical, during the paroxysmal pain, and had had one or two short periods of mental confusion suggesting *petit mal*. For years previous to tonsillectomy, she had had one or more attacks of tonsillitis, followed by rheumatic pains, during the winter months.

Examination revealed a poor vasomotor tone, moderately firm muscles, fair nutrition, and the general appearance of a nervous woman. January 13, 1916, the hemoglobin was 85 per cent and the leukocytes 9,800. A Wassermann test of the blood was negative. February 17, the hemoglobin was 80 per cent, the erythrocytes 4,210,000 and the leukocytes 5,400. There were no signs of organic disease of the central nervous system. The examination of the heart, lungs, abdomen, reflexes, urine, the blood pressure, and roentgenograms of the jaws and roots of teeth, were all negative. There was tenderness over the left infraorbital foramen and mental foramen, but no superficial tenderness of the overlying skin. There were tender nodules, which appeared to be enlarged glands in the posterior triangle of the left side of the neck. There was a clean tonsillectomy scar, the nose was normal, except for a moderate hypertrophic rhinitis, and the gums and teeth were normal except for a tender dead first upper left molar which had been crowned, and from which the crown had been removed on account of the irritation to the gums. The maxillary sinuses were clear. Owing to the fact that each attack began with swelling of the left upper jaw opposite the dead tooth and in

the region of the left infraorbital foramen, the tooth was extracted January 18. A semilunar eroded area 2mm. in diameter was found near the apex of the largest and inner fang. The surface of this was sterilized with a searing blade, and the root-canal drilled into from the apex with a dental bur.

Figure 1.

Photograph of mouse chloroformed twenty-four hours after intraperitoneal injection of streptococcus from foul pulp in Case 567. Note complete absence of lesions except hemorrhagic edematous areas of lower jaw opposite roots of lower incisors. There was no peritonitis.

The pulp cavity was found full of a foul smelling pus. The erosion was situated so that it was impossible to show it by the roentgen ray. The pulp-cavities of the other two fangs were filled and obliterated and there were no erosions at the apices. There was a large cement filling directly opposite the dead pulp. Smears of the pus from the root showed a few Gram-positive diplococci, diphtheroid bacilli and a few Gram-nega-

tive bacilli. The primary cultures in ascites-dextrose-agar and broth gave a pure culture of a slightly hemolyzing streptococcus. The anaerobic cultures on blood agar slants, and in tall columns of ascites fluid containing sterile tissue covered with paraffin oil, had a foul odor, and there were many short chains of streptococci and numerous bacilli resembling *Bacillus fusiformis*.

Immediately after the extraction of the tooth, the patient developed an unusually severe attack but after several exacerbations she gradually recovered. February 17, after having been free from pain for ten days, and gaining rapidly in weight and strength, a definite tenderness was found in the muscles of the posterior triangle on the left side of the neck and two distant tender nodules appeared just behind the posterior margin of the sternomastoid muscle. One of these nodules, thought to be a lymph-gland, and a portion of the deeper layers of the muscle, were excised. One-half of these tissues was immediately emulsified for cultures and the other half was fixed in formalin-Zenker for sections. The excision of the fascia and muscle precipitated another violent attack of pain and spasm of the muscles of the left side of the neck. The cultures in tall columns of ascites-plain-broth of the emulsion of muscle showed a pure culture of a short-chained streptococcus, and those from the thickened fascia, streptococci and staphylococci.

Blood-agar plates from the culture in ascites-plain-broth from the tooth pulp, and from the muscle (injected into animals) showed pure cultures of streptococci producing a narrow hazy zone of hemolysis. Elective localization in pulps of teeth, dental nerves, and muscles occurred in a large percentage of numerous animals, even when injections were made intraperitoneally. (Figures 1 and 2.) It was thought that this streptococcus might be present quite generally on the mucous membrane in this

patient. Cultures from the nose and pharynx, and three out of six cultures from the stool, proved this actually to be the case.

Sections of the excised muscle showed marked increase in the interstitial tissue, poorly staining nuclei of adjacent muscle fibers, and slight round-celled infiltration. Sections of the fibrous nodule and fascia showed old and young connective tissue, an absence of lymphoid tissue, small nests of round cells, plasma cells, and erythrocytes, chiefly around blood vessels. Gram-Weigert and methy-

extreme exhaustion, and slight fever. The subsequent injections were at first diminished and then gradually increased, aiming to produce a distinct but not severe reaction following the injection. Three months after the extraction of the tooth the attacks were milder and of shorter duration, the intervals between attacks longer, there was marked improvement in the general nervous tone and there was a gain of thirty pounds in weight. The vaccine was then discontinued for four weeks, while the patient was on a vacation. When she re-

Figure 2.

Photograph of lower jaw, pulps of teeth, and dental nerves of rabbit (713) chloroformed two days after intravenous injection of the streptococcus isolated from the excised muscle in case 564. Note the hemorrhagic areas opposite root of lower incisor and second molar at a, the hemorrhagic areas in sheath of dental nerves and hyperemia of dental pulps.

lene blue stains for bacteria revealed a moderate number of diplococci in or adjacent to the fibrous tissue between the muscle-fibers and nests of cellular infiltration, and a large number within and surrounding a small-sized blood vessel in the center of the fibrous nodule.

A vaccine was prepared by heating the streptococci suspended in salt solution from the primary cultures of the pulp of the tooth and muscle, and by treating it with equal parts of the patient's serum for two hours at 37° F. It was then placed over night in the ice chest. This vaccine was used in the treatment of the patient. The first dose consisted of 25,000,000 and was followed by marked muscle-pains, especially at the left side of the neck, by nausea,

turned the same sized dose of vaccine was administered. After this injection a marked swelling appeared at the point of injection followed by the precipitation of a severe attack similar to those she had previously had. These attacks were repeated. In March, 1917, roentgenograms of the jaw showed rarefaction of bone at the apex of another molar on the same side which was not present at the former examination. This tooth was extracted. Cultures gave the same organism as that isolated previously. Injections into rabbits were followed by similar localizations. Cultures were again made from the stool and from the pharynx. Both gave the organism as before and the one from the stool injected intravenously into two

rabbits was followed by the characteristic localization.

The elective localizing powers of streptococci in various types of dental infection have thus been demonstrated. The types of infection studied included pus pockets surrounding badly decayed loose teeth, pus pockets associated with marked tartar deposit under the gum in otherwise sound teeth, ulcerated teeth with a sinus discharging pus intermittently, pyorrhea, severe gingivitis with little tartar deposit, infected dental pulps, and blind abscesses. The results of these studies, and similar experimental studies by others, should be sufficient to convince the most skeptical of the etiologic relation of focal infection to systemic disease.

The enormous clinical material now available of the many patients partly or completely relieved of various diseases following the removal of infected root abscesses, extractions of pulpless teeth without abscess, and of teeth the seat of advanced pyorrhea, leaves no doubt of the direct detrimental effect of these foci to the general health. A blind abscess at the root of a tooth infected pulpless teeth without rarefaction of bone at the apex, pyorrheal pockets about teeth and infected tonsils, constitute a menace to the continued health of the individual. These walled-off areas of infection with little or no chance for bacteria and their products to escape except into the lymph channels and blood stream, are veritable experiments which sooner or later yield results. These foci not only afford excellent entrance ways for the bacteria and their products, but they afford also the favorable conditions for bacteria to acquire peculiar infecting powers. It is this latter fact more than any other one factor which determines the localization in a given case. The conception, therefore, of the relationship of local foci to systemic disease must not be too mechanical. The infecting or invading power of the bacteria is of fundamental

importance. However, the importance of other accompanying factors—such as general or local lowered resistance, from exposure, fatigue, improper food and bad hygiene, severe or frequently repeated slight injuries, strain and sensitization of tissues, should not be lost sight of.

The intensive efforts which have been made in the dental profession for some years, to save defective teeth quite without regard to the general health of the patient have resulted in much harm. The era of the wholesale devitalization of teeth, for example, is happily coming to an end.

On the surface this whole problem of focal infection in relation to systemic disease seems simple. But in the final analysis it involves almost the whole field of bacteriology and pathology and the art and science of both medicine and dentistry. In actual practice it is often exceedingly difficult to know what is best to do in a given case. The case cited above of facial neuralgia and myositis illustrates well some of the difficulties involved. The X-ray findings were negative. The tooth had been crowned for some years; two root canals were properly filled. Both of these were found sterile, while the third contained foul-smelling pus from which the micro-organism responsible for the attacks was isolated. The same organism was isolated from the throat, the nose and the stool. The patient had had one abscessed tooth removed previously, the tonsils had been enucleated, and an infected antrum properly drained, but without relief. After the removal of the tooth combined with the administration of an autogenous vaccine, she had gained thirty pounds in weight, and the attacks had almost entirely disappeared after a period of six months, only to recur following the administration of too large a dose of vaccine. The pulp of an additional tooth had become infected and the same organism was again isolated.

Infections of the mouth and teeth in a given case should, as a rule, be rectified first. Tonsillectomy, as now so commonly practiced before the condition of the teeth has been corrected, is illogical. The lymphatics of the mouth and jaws drain into the tonsils. Some infections in tonsils, if mechanical conditions permit, improve or even disappear fol-

lowing the extraction of infected teeth. This does not mean that microorganisms do not frequently gain entrance thru the tonsils. Indeed, by virtue of the anatomy of these organs, particularly after repeated attacks of tonsillitis, and the degree of infection which they harbor quite constantly, they are probably the most important point of entrance. A pulpitis in an otherwise sound tooth surrounded by normal gums must be looked on as a hematogenous infection, the bacteria being carried there frequently from a focus not situated in the teeth. A pulpitis supposedly from irritation of a deep filling and apical infections, provided the fillings were placed in an aseptic manner, mechanically and improperly filled root canals, if sterile at the time the canals were filled, may also be the result of a bloodborne infection. Both the deep filling and the improperly filled canals favor lowered resistance to infections. The occurrence of pulpitis in an ulcerated tooth should be considered as presumptive evidence of the existence of a focus either in the teeth or elsewhere and should lead to a painstaking search for it and its removal if possible.

The experimental studies I have made show that when bacteria live and grow in a given tissue they acquire a great affinity for that particular tissue. This fact may explain why, as has been observed repeatedly, some persons are particularly prone to recurrences of the same type of infection. This is well illustrated in the patient with "neuralgia" of the face and myositis of the muscles of the neck. The streptococcus infected both the pulp and excised muscle showing affinity for pulps of teeth, dental nerves and muscle respectively. An infected pulp, even tho secondary to a non-dental focus in the first instance, might lead to infection of pulps of other teeth (Figure 3, R820, R815, R814 and Figure 4). An infected joint might act as a secondary focus and be responsible for the involvement of other joints. Indeed the recovery of patients

Figure 3.

Photograph of pulps of teeth of rabbits.

N. Rabbit—Dental pulps of normal rabbit killed with chloroform. Note the absence of lesions.

R823—Dental pulps of rabbit chloroformed two days after intravenous injection of streptococcus from the tonsil in Case 621, a patient with chronic deforming arthritis. Note the absence of lesions.

R820—Dental pulps of rabbit chloroformed one day after intravenous injection of streptococcus viridans from a calcifying pulp of tooth of Case 621. Note hyperemia and small hemorrhages.

R815—Dental pulps of rabbit found dead twenty-four hours after intravenous injection of streptococcus from pus in abscess of tooth in a man. Note marked hyperemia and hemorrhages.

R814—Dental pulps of rabbit chloroformed twenty-four hours after intravenous injection of streptococcus viridans from infected pulp of tooth of Case 621. Note hyperemia and hemorrhages.

with chronic arthritis, aside from the sensitization of tissues which undoubtedly occurs, may be difficult for this reason. Not too much reliance should be placed on the X-ray findings. A shadow surrounding the apex of a tooth does not necessarily mean that there is an infection acting as a focus at that particular time, and the absence of demonstrable rarefaction of bone does not exclude the

interested primarily in curing the patient of systemic disease believed to be of focal origin, the focus for which he cannot find or does not believe exists elsewhere, has at times, no doubt, shown poor judgment in being too insistent on the removal of comparatively sound teeth. The dentist, on the other hand, whose chief interest is centered in the saving of teeth without due regard to the gen-

Figure 4.

Photomicrograph of streptococci in leukocytic area of hemorrhage in dental pulp. Rabbit 815—Diplococci could be found only in and adjacent to areas of hemorrhage.

presence of an infected pulp-cavity which alone is sufficient to act as a focus. The difficulties to demonstrate bacteria in these chronic conditions are necessarily great, but may be overcome by the method used in the demonstration of streptococci in the small granuloma as shown in the description of Figures 5 and 6.

I am aware that the recent studies on focal infection have, in some instances, led to the unnecessary sacrifice of teeth and to differences of opinion between physicians and dentists. This should be expected. The physician who is in-

eral health, has no doubt erred in the opposite direction. A greater degree of cooperation of the two professions is vitally needed in dealing with this problem. Team work and group diagnoses should be the watch-word. However, a patient who is suffering from a serious disease known to be of focal origin should, after due consideration of other factors in the matter of the extraction or non-extraction of one or more teeth, be given the benefit of the doubt, even when the evidence is not conclusive that the responsible focus is contained therein. Extraction will do no harm even

tho inconvenient at the time, while not extracting may result seriously.

In ridding the mouth of infection, particularly in extracting abscessed teeth, removing teeth for pyorrhea, or cleaning and polishing the roots of teeth in patients suffering from systemic disease, especially chronic arthritis, but little should be done at a time, allowing

these dangers, and how to prevent them. And further, that when such conditions have developed that the profession, thru cooperation and individual effort, should do all in its power to eliminate the diseases produced. The opportunity to prevent and cure disease along these lines presents itself as never before to the dental and medical professions.

Figure 5.

Photomicrograph of small granuloma near the apex of extracted tooth whose root canal was improperly filled five years previously. Gram-Weigert stain x50. The specimen was obtained in as sterile a manner as possible incubated at 35° C for ten hours in the bottom of a tall tube of dextrose broth and then placed in 10 per cent formalin. The broth showed slight turbidity at the bottom due to streptococci. Note the dark area at a, near the apex of the granuloma.

an interval of from four days to a week between operations. The exacerbations prone to follow such procedures are frequently in proportion to the amount of work done. If slight, good results may be expected; if too great, disastrous consequences may ensue.

Finally, I would emphasize the real and potential dangers which lie in such conditions, and the necessity for intensive effort on the part of the profession to advise the public of and educate it to

Figure 6.

Photomicrograph showing mass of streptococci in dark area shown at a in Figure 5. Gram-Weigert x500. Painstaking search in serial sections showed this mass to be the only one thruout the tissue and hence may be taken to indicate the point where the infection existed before the tooth was extracted.

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