DENTAL SEPSIS, ITS NATURE AND SYSTEMIC EFFECTS.

By Captain S. H. Woods.
The Army Dental Corps.

(Continued from p. 184.)

SECTION I.—SUBDIVISION (c).

BACTERIOLOGY.

The mouth presents ideal conditions for the growth of bacteria. It is moist, has the optimum temperature for growth, and contains an abundant and suitable food supply. Unlike other cavities lined by mucous membrane, it lacks any definitely known bactericidal substance. While saliva constantly flushes the mouth, carrying away large numbers of its normal inhabitants and adventitious germs taken in with food, and while phagocytes are incessantly passing up between the epithelial cells to ingest them, reinfection is constantly taking place from the numerous mucous crypts and ducts opening into it.

"That there are so few suppurative lesions after operative interference in the mouth is due to the great vascularity of the mucous membrane, which forms lines of communication for the light infantry of the body—the polymorphs—to advance and attack any organisms that may be present, and later for the heavy artillery—the macrophages—which remove the grosser damaged portions of tissue and cells." 1

One hundred to one hundred and fifty different kinds of bacteria may be isolated from an average mouth. Such organisms include cocci, bacilli, spirochetes, leptothrix and amœbæ. There is a constant balance between the bacteria and the lining mucous membrane of the mouth. In the healthy individual the bacteria, though constantly present, are unable to overcome the resistance of the tissues. If, however, this resistance is lowered, as it can be by a variety of causes, then the micro-organisms exert their pathogenic effects and infection results. This upset of balance, by lowering the tissue resistance, may be caused:

(a) Mechanically, as by tartar, the edge of filling or crown, and impaction of food.
(b) By exogenous toxins, as in metallic gingivitis.
(c) By endogenous toxins, as in fevers, in which there is a marked decrease in oral secretion and stagnation at the gum margin.
(d) By the lack of vitamins, as in scurvy, where there is softening and bleeding of gums with resultant infection.
(e) By pressure from dentures which are not kept clean.

1 "Some Bacteriological Problems involved in Dental Practice." By J. W. S. Blacklock. Dental Record, April, 1924.
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"The organisms on healthy teeth have been carefully enumerated, and it was found that under ordinary conditions one milligramme of surface deposit contains about 25 million organisms, of which one million can be cultivated. Cocci formed 60 per cent of the total flora, and streptococci 40 per cent. These numbers increased at night and after meals; they were about four times as great on unbrushed as on brushed teeth. In dirty mouths the bacilli increased more than the cocci, and anaerobes predominated."

The subject of dental bacteriology is still in its infancy, and as no uniform technique or nomenclature is adopted by investigators, textbooks present a bewildering series of classifications and names. It has been shown that the mouth is sterile at birth. Organisms appear ten hours after birth, especially the Streptococcus salivarius, which becomes the predominant species from the twelfth day.

With the appearance of teeth in the infant mouth it was observed that leptothrix, spirochaetes and certain anaerobes, such as fusiform bacilli, appeared, because the accumulation of food in the gingival crevices is favourable to their growth.

It has also been shown by various investigators that an examination of the saliva gives a good index of the bacteria present in the mouth, and it may be of interest to indicate the usual flora present:

<table>
<thead>
<tr>
<th>Organism</th>
<th>Percentage incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pneumococci (by culture)</td>
<td>3</td>
</tr>
<tr>
<td>do. (by mouse) Group IV</td>
<td>40</td>
</tr>
<tr>
<td>Streptococci</td>
<td>100</td>
</tr>
<tr>
<td>M. catarrhalis and meningococcus</td>
<td>3</td>
</tr>
<tr>
<td>M. chromogenicus I and II</td>
<td>73</td>
</tr>
<tr>
<td>M. pharyngis siccus and unidentified strains</td>
<td></td>
</tr>
<tr>
<td>Staph. aureus</td>
<td>2</td>
</tr>
<tr>
<td>Staph. albus; M. candidus group and unidentified strains</td>
<td>23</td>
</tr>
<tr>
<td>Lactose fermenting bacilli; B. coli</td>
<td>2</td>
</tr>
</tbody>
</table>

It will be noted that the streptococci occur in every case. Under pathology we have seen that infection of the periodontal membrane is caused by the access of saliva. It is therefore a mixed infection, but the present trend of investigation goes to show that the greatest importance is to be attached to the streptococci on account of their invariable occurrence, their predominating numbers and their pathogenicity.

The classification of the streptococci is still imperfect, and the one used here is that of Holman (1916), in which they are divided, firstly into haemolytic and non-haemolytic, and secondly into species according to their fermentation reaction in lactose, mannite and salicin.

1 "Organisms found in Periodontal Infections." Prof. E. E. Glynn. 1923. Lectures by Dental Board of United Kingdom.
2 Taken from a graph by Prof. Glynn (Dental Board of U.K. Lectures).
HOLMAN'S CLASSIFICATION OF STREPTOCOCCI.

<table>
<thead>
<tr>
<th>Reaction to</th>
<th>Lactose</th>
<th>Mannite</th>
<th>Salcin</th>
<th>Non-hemolytic</th>
</tr>
</thead>
<tbody>
<tr>
<td>S. infrequens</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>S. fecalis</td>
</tr>
<tr>
<td>S. hemolyticus I</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>S. non-hemolytic I</td>
</tr>
<tr>
<td>S. pyogenes</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>S. mitis</td>
</tr>
<tr>
<td>S. anginosus</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>S. salivarius</td>
</tr>
<tr>
<td>S. hemolyticus II</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>S. non-hemolytic II</td>
</tr>
<tr>
<td>S. hemolyticus III</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>S. non-hemolytic III</td>
</tr>
<tr>
<td>S. equi</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>S. equinus</td>
</tr>
<tr>
<td>S. subacidus</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>S. ignavus</td>
</tr>
</tbody>
</table>

The non-hemolytic type is subdivided into two groups:

(a) *Viridans*, which produces greenish coloration when grown on blood agar, owing to the formation of methaemoglobin. They comprise the first four species of the above table, and are regarded as being definitely toxic. The *S. salivarius* is the predominating species found in all chronic dental lesions.

(b) *Indifferent group*, comprising the last four of the table. These are not considered of such importance as the viridans group, and are non-toxic to guinea-pigs.

The following percentage incidence of the various species of streptococci in the twenty-five normal salivas mentioned before is taken from a graph by Prof. Glynn.

<table>
<thead>
<tr>
<th>Differentiation of Streptococci in Twenty-five Normal Salivas.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemolytic</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>S. pyogenes</td>
</tr>
<tr>
<td>S. anginosus</td>
</tr>
<tr>
<td>Other varieties absent</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

In order to investigate the types of streptococci present in the periodontal membrane and root-canal of infected teeth, thirty-five were investigated in the Research Laboratory of the R.A.M. College, and the following technique was adopted throughout.

As far as possible contamination during extraction was limited by the following means. Upper teeth were chiefly selected, and only a small number of lower teeth, because of the difficulty in keeping saliva from them. The interdental spaces were cleansed of tartar and food debris, and after the usual hypodermic injection of local anaesthetic had been carried out, the interdental spaces were atomized with hot 5-vol. hydrogen peroxide. The site of operation was then kept free from saliva by the use of sterile wool-rolls and the saliva ejector.

The tooth to be extracted and its neighbours were swabbed several times with absolute alcohol, which was allowed to run over gum margin and interdental space. Between each swabbing the alcohol was evaporated by hot air to dehydrate the area, until it was considered as sterile as possible.

The blades of sterile forceps were kept in absolute alcohol; the fingers
were rendered surgically clean and immediately before the extraction were dipped in alcohol; the forceps were then picked up and the blades passed over a flame to burn off the alcohol; the tooth was extracted slowly and carefully to avoid any unnecessary damage to the investing tissues, and placed at once in the centre of a sterile piece of lint two inches in diameter, which was rapidly folded round it and dropped into a special sterile test tube 1½ inches in diameter, which accommodated it easily, and at once dispatched to the laboratory. Here the following technique was adopted:

Cultures were first taken from the apical region of the periodontal membrane by means of a platinum loop moistened with a drop of glucose broth. The periodontal membrane was then burnt off, the tooth cracked open with sterile bone forceps, and a further culture made in the same way from pulp, root-canal or root filling. At first only glucose broth was used, but later in the series cultures were made in both ordinary and glucose broth.

These cultures were incubated overnight, and then plated: (a) on Fildes' medium from glucose broth; (b) on ordinary agar from ordinary broth. The plates were examined after twenty-four hours under low-power, various colonies picked off, cultured in glucose broth and put through the sugar media and plated on blood-agar for the haemolysis test, in order to identify the organism.

Appropriate steps were taken to identify organisms other than streptococci, which grew. They occurred very rarely. The teeth examined are divisible into two groups:

1. Those involved in pyorrhoea but showing no caries of the enamel, i.e., infected via the gingival trough.
2. Those which were not involved in pyorrhoea but which had received root-canal treatment (followed by crowning in some cases), i.e., infected via pulp.

The results were as follows:

**Group I.—Open Sepsis.**

**Teeth involved in Pyorrhoea (External Infection of Periodontal Membrane).**

Number examined, twenty-one.

Fourteen gave growth from membrane only, the pulp-canal being sterile.

Seven gave growth from both membrane and pulp chamber.

<table>
<thead>
<tr>
<th>Organisms in periodontal membrane</th>
<th>Percentage incidence in 21 cases</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>S. salivarius</em></td>
<td><em>S. mitis</em></td>
</tr>
<tr>
<td>Present in 12</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1</td>
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<tr>
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<td>1</td>
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<td>1</td>
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<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

The last two organisms were present in a tooth with a chronic abscess following trauma.
Group II.—Latent Sepsis.

Teeth, not involved in Pyorrhoea, which had received Root Treatment.

Number examined, fourteen.

Growths were obtained from both periodontal membrane and canal or root filling in each case.

Organisms from root-canal

<table>
<thead>
<tr>
<th>Organisms</th>
<th>Percentage incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>S. salivarius</td>
<td>Present in 3</td>
</tr>
<tr>
<td>S. mitis</td>
<td>Present in 8</td>
</tr>
<tr>
<td>S. equinus</td>
<td>Present in 1</td>
</tr>
<tr>
<td>S. faecalis</td>
<td>Present in 1</td>
</tr>
<tr>
<td>S. ignavus</td>
<td>Present in 1</td>
</tr>
<tr>
<td>Coliform bacilli</td>
<td>Present in 1</td>
</tr>
<tr>
<td>B. Hoffmann</td>
<td>Present in 1</td>
</tr>
</tbody>
</table>

Organisms from membrane

<table>
<thead>
<tr>
<th>Organisms</th>
<th>Percentage incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>S. salivarius</td>
<td>Present in 10</td>
</tr>
<tr>
<td>S. mitis</td>
<td>Present in 4</td>
</tr>
<tr>
<td>Other varieties absent</td>
<td>Present</td>
</tr>
</tbody>
</table>

Comparison of Groups I and II brings out the following points:

1. The predominance of the viridans group.
2. The high frequency of S. salivarius, the average percentage incidence being fifty-three, while S. mitis comes next with thirty-five.
3. The mixed nature of the infection in Group I, where there is free access of saliva.
4. The markedly reduced flora in Group II, where there was no free access of saliva.
5. The fact that every tooth investigated in Group II gave growth from both root-canal and membrane, thus corroborating the previously quoted statement of Price and Mouldenhauer.
6. The significance of the absence of the hæmolytic group.

It was difficult to obtain material for control, but I managed to extract, with every possible precaution, three upper first bicuspids from children aged 11. These teeth were absolutely intact as regards crown and gingival trough. They were erupting into an overcrowded arch and their removal was essential for regulation purposes. In each case the apical portion of root was still incompletely formed and the large patent foramen afforded wide contact with periodontal membrane.

The results were as follows:

No growth from periodontal membrane in any case.

Growth from pulp in each case; S. salivarius occurring twice and S. faecalis once. No other organisms were obtained despite every attempt to grow them.

The significance of these control results is as follows:

1. As the periodontal membranes gave no growth, it is presumed that they were sterile, and as similar precautions were taken to avoid contamination throughout the investigations, it may be presumed that it was, at any rate, of small importance as regards the results.
(2) The pulp may be infected early in life via the blood-stream, and this infection may be considered as "normal."

In this connexion it may be of interest to record the results of Kelsey1 on a careful research into the bacteriology of the pulp.

In fifty sound teeth with intact crowns and normal pulps, he found only four were sterile.

In seventy-five teeth which had been filled or had untreated carious cavities, he found only five were sterile.

Total pulps examined, 125; sterile, 9.

Streptococci gave a percentage occurrence of 48.8.

Vaccines.—Fifteen teeth were sent to the Vaccine Department of the R.A.M. College for the preparation of autogenous vaccine, and though the organisms were not identified in every case, the following list, showing the results of the investigation, may be of interest because the teeth were from hospital cases with well-defined systemic disease.

Organisms (from which Autogenous Vaccines were made).

<table>
<thead>
<tr>
<th>Case</th>
<th>Organisms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>S. salivarius; S. ignavus</td>
</tr>
<tr>
<td>2</td>
<td>S. mitis; S. salivarius; S. pyogenes (hæmolytic)</td>
</tr>
<tr>
<td>3</td>
<td>S. mitis; S. salivarius; S. ignavus</td>
</tr>
<tr>
<td>4</td>
<td>S. non-hæmolytic species, not identified</td>
</tr>
<tr>
<td>5</td>
<td>&quot;</td>
</tr>
<tr>
<td>6</td>
<td>S. mitis, practically pure culture.</td>
</tr>
<tr>
<td>7</td>
<td>S. non-hæmolytic species, not identified</td>
</tr>
<tr>
<td>8</td>
<td>S. subacidus (hæmolytic).</td>
</tr>
<tr>
<td></td>
<td>S. salivarius; S. ignavus</td>
</tr>
<tr>
<td>9</td>
<td>S. non-hæmolytic species, not identified</td>
</tr>
<tr>
<td>10</td>
<td>&quot;</td>
</tr>
<tr>
<td>11</td>
<td>&quot;</td>
</tr>
<tr>
<td>12</td>
<td>S. salivarius; staphylococci</td>
</tr>
<tr>
<td>13</td>
<td>S. hæmolytic species, not identified</td>
</tr>
<tr>
<td></td>
<td>Staphylococci, S. mitis</td>
</tr>
<tr>
<td>14</td>
<td>S. hæmolytic and non-hæmolytic species, not identified</td>
</tr>
<tr>
<td>15</td>
<td>S. salivarius; S. mitis</td>
</tr>
</tbody>
</table>

Here it will be noted that hæmolytic organisms were obtained in four cases and that, whenever identified, the S. salivarius predominated.

We have now completed Section I, and can summarize the main points as follows:—

(1) The term "dental sepsis" implies infection of the periodontal membrane, either externally via the gingival trough, or internally via the apical foramen.

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(2) The organisms are mainly the viridans group of non-hæmolytic streptococci, the predominating species being *S. salivarius*.

(3) In every tooth affected, the infection involves both periodontal membrane and alveolus, because of the anatomical relationship.

(4) The infected tissues are invisible, and the condition may be present for long periods without necessarily causing any local symptom.

(5) Dental sepsis is either *open*, as in pyorrhoea alveolaris, where there is an obvious free discharge of pus from the surface, or *latent*, as in all periapical conditions, where there is direct absorption of toxins generally via the lymphatics and often without any external sign.

(6) Pyorrhoea starts as a marginal gingivitis involving many teeth; it is a slow progressive destruction of the tooth socket and involves four tissues, viz., gum, bone, periodontal membrane and tooth, from each of which there is discharge of septic products.

(7) Though there is a free discharge of pus from the gum margin, it must be borne in mind that there is an extensive volume of infected bone, many times larger than that of the affected roots, from which there is active absorption of toxic products.

(8) As regards the *latent* sepsis, the *most potent* is that following the conservation of putrid teeth, many of which are crowned, after root treatment.

**SECTION II.—SUBDIVISION (A).**

**WHAT ARE THE FACTORS GOVERNING THE SYSTEMIC EFFECTS?**

These will be considered under the following headings:

1. Virulence of the organisms, i.e., the intensity of attack.
2. Volume of toxins absorbed, i.e., the extent of attack.
3. The "time factor," i.e., the duration of attack.
4. The patient’s resistance, i.e., the defence.

(1) **Virulence of the Organisms.**

Just as in other pathological infections, diphtheria for example, a small lesion may produce very severe effects if the organism is virulent, an extensive lesion with an organism of low virulence may give rise to little constitutional disturbance.

As an example, a fatal infective endocarditis following periapical infection of a lower central incisor has been recorded. This tooth is the smallest in the mouth, and its periodontal membrane has an area about two-thirds that of the incisor shown in fig. 4 (p. 171). The radiogram indicated that only the apical portion of membrane and alveolus was infected. On culture this tooth gave streptococci identical in character with those found in blood-culture.

It is possible that streptococci gaining access to damaged tissue acquire an increased virulence.
Rosenow's observations (1915, 1919, 1921) must here be mentioned. The older theory of focal infection was that the factor which determined the systemic localization of circulating bacteria was essentially a lowering of resistance in the focal tissues by previous injury. An example often quoted is the acute osteomyelitis of a child's tibia following slight injury.

Rosenow's remarkable researches and experiments, though by no means generally accepted, throw a flood of new light on the question. Briefly, he maintains that streptococci and also other organisms have a "most striking affinity or tropism for the organs or tissues from which they are isolated." He claims to have discovered that it is in the focus of infection that changes occur and the different affinities for various structures are acquired. The focus of infection is both the place of entrance and the place where organisms acquire peculiar properties to infect other areas throughout the body. In typhoid fever the blood is invaded by the typhoid bacillus which, however, shows greatest affinity for intestinal lymphoid tissue. Pneumococci enter the blood in all cases of lobar pneumonia, yet lesions are usually limited to lungs and pleura.

In chronic septic endocarditis streptococci have been isolated from the blood daily for weeks and months, but localization remains limited to the endocardium. In infectious diseases the properties of specific microorganisms determine their localization.

Rosenow's demonstrations go to show that the streptococci of low virulence found in dental lesions have this elective localizing power. If he is correct, it follows that dental sepsis must be given a place of supreme importance as the most widespread source of haematogenous infection of the present day.

It is generally thought that the main organisms in the great majority of dental lesions belong to the viridans group, and have low virulence. The haemolytic group is rare and its presence is of great significance.

(2) The Volume of Toxins absorbed.

Dental sepsis involves three main structures, viz., gingival trough, periodontal membrane, bone. Their surface areas have been indicated, and it must again be emphasized that the terms "dental sepsis" and "oral sepsis" give a totally wrong impression of the pathological picture. They concentrate attention on the external and superficial. The term "jaw-infection" has been suggested as a better one, which would at once imply deep and hidden pathological changes in the structures surrounding the tooth.

The greater the number of teeth involved, the greater the volume of toxic products absorbed. In this connexion it must be remembered that the molars present a much greater root surface than the anterior teeth, and

a reference to fig. 4 will indicate that the periodontal membrane area of a three-rooted upper molar is roughly three times that of an incisor, and a two-rooted lower molar is twice as large as an incisor. The estimation of the volume of infected bone is one of the most important and difficult tasks of the dental surgeon. Here we may indicate the clinical examination required for this estimation.

The patient should be examined in the dental chair before a good light. It is impossible to examine the mouth of a bed patient in the wards with any degree of accuracy. Every tooth must be examined separately by every possible test to determine the presence or absence of any pathological change in its gum, gingival trough, periodontal membrane, pulp, alveolus and bone of jaw. The condition of each tooth is noted on a chart and special attention paid to those which have received any conservative treatment whatsoever. Every crowned tooth—collar or flush—is condemned at once (remember, our patient has definite systemic disease, and we are eliminating actual and potential foci of infection). We are not looking for superficial caries but for internal sepsis. If a tooth is carious and the pulp infected, or still alive but the crown so greatly destroyed as to render it beyond conservation as carried out in Army practice, it is condemned at once.

It is not intended to describe the clinical examination of the teeth in greater detail, but the mouth as a whole must be examined also, and the condition of the following noted: area of palate, mucous membrane of cheek, lips, tongue, floor of mouth, tonsils, preauricular, submaxillary, submental and cervical lymphatic glands. If a denture is worn, the area of palate and gum covered must be examined. In short, a thorough clinical examination, carried out in this manner by the dental officer who is fortunate enough to have an X-ray department available, should not miss a single point of importance.

The odontogram is of immense importance, and its supreme value does not lie in the detection of those obvious periapical bone changes which the clinical examination has presupposed, but essentially in the estimation of their depth and lateral extent. We must suppose a zone of definitely infected bone which will be obvious in the film, surrounded by a zone of partially infected bone in which some attempt is made to limit the infection. This zone will not be so obvious, and indeed may escape detection. Lastly, there is a gradual shading off from the periphery of this zone into what may be regarded as normal tissue. It is the definition of this junction of sound, and more or less unsound, bone which is the most important and most difficult task of the radiologist, and at the same time one of supreme value to the dental surgeon. If he knows the depth of infected bone, his knowledge of the anatomy of the parts will enable him to gauge with some accuracy the extent in three dimensions of the tissue involved in any given lesion.

While the exact definition between sound and infected tissue is difficult
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enough in these localized conditions due to periapical infection, the
difficulty in extensive pyorrhoea is much greater, for here the whole alveolus
and bone of jaw are involved. While the interpretation of odontograms
and the conditions they indicate are beyond the scope of this paper, it must
be stressed that the ideal dental examination presupposes odontograms
of all the teeth in the mouth.

With all the data before him (chart, radiograms, radiologist’s report and
patient), the dental officer should be in a position to estimate the surface
area and volume of the various tissues affected.

(3) The Time-Factor.

The importance of this must be stressed, for obviously the longer the
toxin dosage is kept up the greater will be its effects.

Dental sepsis causing any constitutional symptom must be present for
at least a period sufficiently long to allow the absorbed toxic products to
circulate, elect their site of location, and produce those pathological changes
in the focus selected in sufficient quantity to bring about that impairment
of function of which the constitutional symptom is an expression.

Pyorrhoea is essentially a chronic disease, starting in early adult life, and
many years may elapse before its classical symptoms are obvious. While
the virulence of the organisms is low, the great extent of infected tissue
caused by it and its marked chronicity produce the most widespread con­
stitutional symptoms by virtue of the volume and duration of the toxin
dosage.

Again, in latent dental sepsis, one frequently sees crowned and root­
filled teeth which were conserved fifteen or twenty and more years previ­
ously and which, to the medical officer and patient, are “all right,” though
clinically and radiologically there is ample evidence of long-standing patho­
logical changes. Here we must suppose a much reduced toxin dosage, but
it is of greater concentration because there is no dilution by saliva, as in
pyorrhoea, but direct lymphatic absorption.

The limited bacteriological results previously reported in Group II
(latent sepsis) indicate infection by a limited variety of streptococci, and
recent research tends to show that they are of greater virulence than in
open sepsis. This increased toxicity, together with higher concentration of
the toxin dosage over a long period, produces the most severe constitutional
symptoms. While only one such infected tooth may be present, it is
usual to find three or four and sometimes a large number in the sick
patient, and when it is remembered that they frequently cause no apparent
local sign or symptom, their great significance cannot be exaggerated.

(4) The Patient’s Resistance.

The importance of this factor will be readily appreciated.

“In a person in apparent health in whom slight dental sepsis is present
the toxic substances produced by the streptococci must be neutralized by
the body fluids, and the organisms must be ingested and destroyed by the leucocytes. It is the unneutralized toxic substance and possibly also the organisms themselves which cause by absorption the effects of dental sepsis in the sick person."

We are dealing in the Army with patients who are presumably physically fit in every sense and whose resistance is at a maximum. Dental sepsis may be present and the toxic substances neutralized, but any lowering of the body defences by diseases will adversely affect the balance and a "vicious circle" may be induced in which the effects of the dental sepsis will increase the constitutional symptoms. In such vicious circles it is frequently noted that the systemic disease does not disappear entirely on treatment, but only reaches a certain stage of recovery, and the subsequent removal of the dental condition often brings about a rapid, and sometimes a surprisingly dramatic, complete recovery.

Some cases illustrating this point will be given in the next section.

It is the varying inter-relations of these four factors which determine the resulting systemic lesion, and they may be expressed in the following disease equation:

\[
\text{Virulence} + \frac{\text{toxin dosage} + \text{time factor}}{\text{resistance}} = \text{systemic effects.}
\]

SECTION II.—SUBDIVISION (b).

WHAT ARE THE SYSTEMIC EFFECTS PRODUCED?

The conditions associated with or influenced by dental sepsis may be tabulated as follows:

1. **Mouth and associated parts**: Pharyngitis; laryngitis; squamous-celled carcinoma; chronic superficial glossitis; progressive enlargement of jaws, myeloma; lymphadenitis.
2. **Gastro-intestinal**: Chronic gastritis; gastric ulcer; gastric carcinoma; duodenitis; pancreatitis; sprue.
3. **General malnutrition**: "General debility."
4. **Gland secretions**: Deficient lactation; deficient secretion of the ductless glands.
5. **Chronic rheumatism.**
6. **Chronic arthritis**: (a) Rheumatoid; (b) osteo arthritis.
7. **Anæmia**: Chlorosis; septic anaemia (Hunter); pernicious anaemia.
8. **Skin**: Purpura; erythema multiforme; lupus erythematosus; eczematous dermatitis; acne rosacea; boils; alopecia areata.
9. **Nervous system**: Neurasthenia; mental affections.
10. **Cardio-vascular system**: Dry pericarditis; aortic regurgitation; arterio-sclerosis; infective endocarditis; cardiac irregularity.

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1 Sir W. Willecox, Dental Board of the United Kingdom Lectures, "Systemic Effects," 1923.
2 Condensed from J. F. Colyer's "Dental Surgery and Pathology," pp. 684-706.
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(11) The eye: Inflammatory conditions of iris; ciliary body and choroid.
(12) The ear: Deafness and tinnitus (the membranes being normal).
(13) General infection: Toxæmia.
(14) Intermittent fever: Subacute septicæmia.
(15) Cancer.
(16) Affections of nose and accessory sinuses; antrum, etc.
(17) Neuralgias.

It is a formidable list, but in the main the various lesions with which dental sepsis is associated may be differentiated into three chief groups, according to the paths of infection from the jaws, and I propose here to consider them from this standpoint and to illustrate each group by cases I have treated.

Differentiation of Systemic Effects according to Path of Infection.

(1) Those resulting from lymphatic absorption.
(2) Those resulting from alimentary absorption.
(3) Those resulting from direct extension.

Group I.—Cases Illustrating the Lymphatic Absorption.

In all cases of latent dental sepsis the toxic products are absorbed directly by the lymphatics of the periodontal membrane and the medullary spaces of alveolus and bone of jaw. This absorption of toxins into the circulation brings about those remote conditions which to the physician are so difficult to correlate with dental conditions producing no apparent sign or symptom in the mouth.

At the International Dental Congress in 1914, Sir Rickman Godlee, speaking on toxæmia of oral origin, said, “Of the two ways the system may be poisoned (the other was pyorrhœa), I believe that the absorption of septic products by abscesses and sinus walls is out and away the more important.”

The following cases are selected as illustrating the connexion between systemic lesion and dental condition and are essentially cases of latent dental sepsis.

To shorten the description, the thirty-two teeth are designated by the following notation:

\[
\begin{align*}
\text{Right} & & 87654321 & 12345678 \\
\text{Left} & & 87654321 & 12345678 \\
1 & = \text{central incisors} & 2 & = \text{lateral incisors} & 3 & = \text{canines} \\
4 & = \text{first bicuspids} & 5 & = \text{second bicuspids} \\
6, 7, 8 & = \text{first, second and third molars respectively} & \text{Thus} & 6 & = \text{lower right first molar} & 5 & = \text{upper left second bicuspid}. \\
\end{align*}
\]

Case I.—Major B., aged 46.

Condition.—Lupus erythematosus; extensive.

History.—September, 1918, was bitten in the face while serving in Bulgaria by mosquitoes and sandflies. Much swelling resulted; the skin broke down in parts; scabs formed and healing was only partial. This
condition continued and ultimately spread to the whole area from the lower border of mandible to forehead, the worst spots being the sides of the nose, temples and eyebrows. Boarded in England, 1921, and given seven months' sick leave, during which various treatments were tried without result, and he returned to duty with B.A.O.R., Cologne. In March, 1924, an acute inflammatory condition developed with considerable discharge. Scrapings gave *Staphylococcus albus*, and an autogenous vaccine was prepared and administered, resulting in cure of this superimposed condition only.

He was transferred to Millbank on April 19, 1924, presenting a typical and extensive butterfly distribution.

Examined by Captain Doble, Dermatologist, on 20th, brought in for dental examination at once, and the dental condition was as follows:—

Teeth standing:

<table>
<thead>
<tr>
<th>1</th>
<th>12345</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>87</td>
<td>4921</td>
<td>128</td>
</tr>
</tbody>
</table>

Of these 1274 had gold crowns with marked local pathological changes; 12 had received root treatment and were discoloured; and the lower incisors, though not exhibiting well-marked pyorrhoea, were involved in a marginal gingivitis.

The clinical condition suggested long-standing latent sepsis, four of the gold crowns having been in position for twelve years.

Radiograms showed extensive bone infection under all teeth which had received treatment, and especially a marked osteoporosis under 874. The gaps were replaced by dentures. All the teeth were at once condemned, and a vaccine being considered advisable, due precautions were taken to limit contamination. The sixteen teeth were removed under local anaesthetic in four successive days, and at once the patient was conscious of a change in his condition. This change was most rapid and was maintained without remission. Indeed, to the patient, whose condition for six years had been most distressing and causing him to shun society, it was astonishing. So rapid was the clearance that Captain Doble discharged him to duty on May 17, 1924, the total days in hospital being twenty-eight.

The vaccine was prepared (the organisms being *S. salivarius*, *S. mitis* and *S. ignavus*) but never used. On October 2, 1924, the Dermatologist, Cologne, wrote that improvement was maintained and that his skin was clear except over nose and eyebrows. On examination in August, 1925, the whole condition had disappeared.

This case is recorded in detail as it brings out many points:—

(a) During the six years’ duration of the case the dental condition was never examined or suspected.

(b) Complete removal of dental sepsis produced rapid improvement and complete cure.

(c) That the elimination of the dental sepsis in the earliest stages of the disease would probably have profoundly affected its course.
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(d) No other treatment whatever was given during the twenty-eight days in hospital.

Case 2.—Gunner C., aged 23.
Condition.—Lupus erythematosus, four months' duration, extensive but not nearly so marked as in Case 1.

Dental Condition.—Teeth standing: Right | Left

No caries; no fillings; no crowns.
Marked pyorrhoea of "dry variety," i.e., very little or no pus on pressure, involving nearly all the teeth and most marked round the incisors and bicuspids.
Extensive extractions were done, and four teeth selected from different regions sent for preparation of vaccine. In each case the S. mitis was found in almost pure culture, and the teeth, instead of showing translucency of apices, showed absorption.

Result.—Slow but continued improvement, starting round lower border of mandible and working upwards, leaving clear new skin. After two months, considerably cleared except round nose, temples and eyebrows, and the vaccine was then administered, which hastened clearance. Patient returned to duty and later transferred to another Command. Last report, eight months later, was that the lupus had almost entirely cleared from the face, small patches being localized over the eyebrows.

As an indication of family predisposition, it is interesting to note that this patient's twin brother, who was not a soldier, also developed a similar condition two years previously.

Note.—(1) Great extent of pyorrhoea, even at age 23.
(2) Practically pure culture of organism (S. mitis).
(3) Practically no free pus, but marked absorption of toxins from infected periodontal membranes in apical region.

Case 3.—Sergeant —, wearing upper denture of seven teeth, reported to have it repaired. It was noticed that the whole area of the palate covered by the plate was markedly inflamed, due to the patient never taking it out at night and not keeping it scrupulously clean. At the same time an early lupus erythematosus was noticed, confined to an area the size of a postage stamp, on each side of the nose, and a small patch on each temple. Dermatologist attributed the lupus to the palate condition and the denture was purposely not replaced to test this, and the patient instructed to keep his mouth scrupulously clean.

Result.—In two weeks the patches were smaller and in five weeks had disappeared entirely. No other treatment meanwhile.

Note.—Causal relationship is probably explained by the passage of streptococci from the saliva under the denture through the inflamed and weakened mucous membrane; their location in the submucous tissue and bone; and the toxin absorption from them.

Case 4.—Captain H., aged 30. Admitted September 24, 1923.
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Condition.—Chronic dermatitis, lower lip, about one square inch in area.

No evidence of leishmaniasis in scrapings; no malarial parasites in blood.

Treated by arc light (two exposures) with considerable improvement, but the dermatitis did not clear. Scrapings gave S. aureus; vaccine prepared and administered first on October 29, 1923. Slow improvement but some dermatitis still present. Passed for dental report.

Dental Condition.—All teeth sound except 21 which were somewhat discoloured and had large porcelain fillings suggesting root treatment. No external evidence of abnormality. Radiograms showed 21 with a root filling pushed through its apex and much periapical bone necrosis; and 11 with marked absorption of root and similar periapical condition.

The teeth were extracted on November 5, 1923, and there was a striking change in the lip condition, which healed up entirely within two weeks, the patient being discharged on November 23, 1923.

Note.—(a) A clear illustration of a "vicious circle."
(b) The small area of infected dental tissue.
(c) The necessity of dental examination when there is any cessation in the recovery of a lesion, which may be due to a superadded dental infection.
(d) The extreme importance of the odontogram.

Case 5.—Colonel C., aged 50. Admitted March 25, 1924.

Condition.—Phlebitis in right leg; left leg oedematous and popliteal and external saphenous veins thrombosed.

X-ray report, no abnormality in thorax. No discoverable cause.

Sent for dental report on April 4, 1924.

Dental Condition.—Teeth extracted: 54 21 12 5

125 7 were crowned and the rest had root fillings. In view of the condition, extractions were done singly and completed on April 30, 1924. All teeth, especially crowns, were obviously chronically infected.

General Treatment.—Rest and subsequent massage.

Result.—Slow improvement at first and then more rapid. May 25, 1924, walked across room for first time; no ill effects. Improvement maintained and patient was able to walk a fair distance, and discharged for convalescence on June 13, 1924. Returned four months later physically fit.

Note.—(a) Most of the crowns had been in the mouth over fifteen years.
(b) While all above teeth were obviously pathological to the dental officer, the patient had never experienced any discomfort.

Case 6.—Lieutenant Y. Admitted November 15, 1923.

Condition.—(a) Chronic rheumatism both knees, following rheumatic fever. (b) Subacute iritis left eye; right eye normal.
Left eye first affected 1916, and again August, 1923.

Had received private dental treatment in 1923, eliminating sepsis in upper jaw but lower jaw not treated.

No trace of gonorrhoea.

**Dental Condition.**—Few upper teeth left and these quite sound.

Lower teeth standing: 6754321 12345 78

No crowns. 5|5 were septic under root filling and 6|6 were septic as a result of caries and showed marked bone infection. These teeth were extracted and three specimens sent for preparation of vaccine. Not identified haemolytic and non-haemolytic streptococci were found.

First injection of 0·1 c.c. of vaccine on December 21, 1923, followed by marked reaction in eye and knees.

General treatment was carried out for knees and eye, and he was discharged on April 15, 1924, on sick leave with eye and right knee cured; left knee very much better.

It was considered that elimination of dental sepsis and vaccine therapy helped considerably in the treatment.

**Note.**—(a) Presence of haemolytic streptococcus.

(b) Reaction to vaccine.

(c) The vicious circle.

(d) On return for medical board after sick leave, found fit in every respect.

Case 7.—Sister, Miss A.

**Condition.**—Chronic arthritis of cervical vertebrae, many years standing. Lateral movements painful and increasing difficulty in flexion and extension of neck.

Of teeth standing 21 12 were flush-crowned fifteen years ago, and there was no sinus on gum, no pus on pressure, no loosening. Gum (over apices) showed marked congestion and the finger could feel that marked absorption of roots had taken place. 4|4 was loose as a result of overstrain in biting and obviously infected.

Radiograms showed no dark shadows above crowns, the bone filling up the space originally occupied by absorbed root.

All five extracted and showed extensive changes. No vaccine was prepared.

**Results,** in order of sequence: (a) Gradual decrease in pain. (b) Gradual increase in freedom of lateral movements. (c) Gradual increase in freedom of up and down movements.

Condition three months afterwards, no pain and only slight limitation of movement in each direction.

Case 8.—Staff Nurse, Miss B.

**Condition.**—Neuritis, right shoulder, commencing 1915 and gradually becoming worse.

**Dental Condition.**—Mouth particularly clean and all teeth sound except two, which had received root treatment, and though broken down to gum...
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level had been restored by flush crowns fitted to a cast gold base, ensuring
great accuracy of adjustment. A conscientious attempt had been made to
avoid any ledge or injury to gingival trough.

These teeth [6 and 5] were strongly suspected, radiographed, and
proved to be definitely infected, the [6] specially showing bone infection
round each root. Both were extracted and an abscess sac was attached to
each of the three roots of [6].

Result.—Decrease in pain noticed five days after and maintained till
shoulder was normal. Reports that occasionally there is a slight “twinge”
in winter.

Case 9.—Captain W., Indian Army.

Condition.—Neuritis, right arm, starting in India and first noticed
when drawing sword from scabbard. Increased in severity. During leave
patient came to Millbank and had three weeks’ massage and electrical
treatment, with no marked improvement.

Sent for dental report.

Condition.—All teeth sound except [4], which was collar-crowned and
obviously septic and loose. This was extracted at once and patient left
hospital following day.

Result.—Reported on his own accord four months later that though he
had no further treatment the arm had recovered absolutely. He could play
tennis and wind up his car, and there was no decrease in muscular tone.

Note.—This somewhat unexpected result may have been due to increased
virulence of organisms. The tooth was not examined bacteriologically,
but was very foul both externally and internally and showed marked
absorption.

Case 10.—Major S., aged 42.

Condition.—“Toxic heart,” following severe pneumonia. No organic
change in heart muscle.

Dental Condition.—Many crowns; several root-filled teeth showing
periapical infection and remainder (about seven) involved in pyorrhoea.
Extraction of all teeth in the mouth was necessary and, in view of condi-
tion, three were extracted singly, a vaccine was prepared and administered
as a desensitizing measure and, because of pressure of time, the remainder
were extracted in one sweep under ether.

Result.—Eight weeks later examined and found free of heart symptoms.

Note.—Another case of “vicious circle,” the dental sepsis having
been of long duration before the attack of pneumonia.


Condition.—(a) Marked tachycardia, 132 per minute, and myocardial
irritability. A soft systolic murmur audible over whole precordial area.
(b) Adenitis, right side of neck swollen, red and tender. (c) Low irregular
pyrexia.

Dental Treatment.—Strict rest in bed, etc., and as soon as his condition
allowed he was carried to dental centre, where it was found that [664]
were
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broken-down septic roots, responsible for adenitis, if nothing else. All teeth extracted on two consecutive days.

Result.—Heart rapidly settled down; exercises were gradually increased till exercise tolerance was almost normal, and he was discharged as cured on October 4, 1923.

Case 12.—Colonel J., aged 52. Admitted May 1, 1923.
Condition.—Early arthritis, left hip, with pain on movement, gradually increasing. Otherwise perfectly fit.

Dental Report.—Teeth standing: All uppers except \(3, 7, 6, 4, 2, 1, 12, 35, 6, 8\)

No crowns; no fillings; gums normal; no caries; teeth yellow and hard. Teeth show marked attrition due to grinding movements in mastication. Clinical examination revealed slight tenderness on \(56\) on percussion, probably due to excessive biting strain, which caused a chronic periodontitis, and it was presumed that they would show either productive or rarefactive changes. Radiograms revealed considerable cementosis, each root showing a smooth and very bulbous outline, suggesting a long-standing condition. There was no apparent bone infection, as suggested by the usual dark areas, but a general sclerosis round these teeth. Extraction presented great difficulties in view of deposit on apex, and as it was desirable to obtain a vaccine \(56\) were isolated and kept sterile, as previously described. After local injection, gum was raised from bone in one large flap, external alveolar plate and bone between teeth removed by burring; the slight hæmorrhage stopped by adrenalin, and both teeth shelled out cleanly and at once forwarded to laboratory for preparation of vaccine. Aseptic measures were adopted throughout. Both teeth revealed the same organisms, \(S. salivarius, S. fecalis\) and \(S. mitis\) from which a vaccine was prepared. Probably during the surgical removal each contaminated the other.

Result.—General reaction to first injection of 0.1 cubic centimetre of vaccine; with exacerbation of pain in left hip. Slighter reactions to second; none to remainder. Diminution of pain in joint and increased mobility.

End Result.—Complete disappearance of pain and no further apparent increase in joint lesion, cure of which was not possible owing to permanent pathological changes in it.

Note.—(1) A typical case of the "gouty type" in which the rule is hard, yellow teeth showing marked attrition due to good grinding, with cementosis of a smooth and regular character and sclerosis of bone instead of porosis.

(2) Small number of teeth involved, the only apparent pathological change being the cementosis.

(3) Exacerbation, followed by improvement by vaccine therapy.

(4) Such a condition may involve all or a large number of teeth without causing any external evidence in the mouth, and is intimately connected with extensive and severe arthritic changes,
Case 13.—Lieutenant E., Indian Army, aged 28. Admitted January 10, 1924.

Condition.—Invalided from India with marked neurasthenia and neuritis, both arms. No discoverable cause.

Dental Report.—All teeth sound except 41112 which were filled and showed obvious external and radiographic evidence of extensive periapical infection with imperfect root fillings, particularly 111.

General Treatment.—Routine for neurasthenia, which improved slowly, and massage and electric treatment for arms. Latter was discontinued after extractions to note improvement, if any.

Result, as reported by medical officer, “Rapid and maintained improvement in neuritis and a marked reduction in neurasthenic symptoms.” General treatment was confined to tonics, and eight weeks after last extraction all neuritis had disappeared. Patient sent on sick leave (three months), and on medical board found fit.

Note.—(a) Neurasthenia is quite a common symptom of the “dental sepsis complex,” and is frequently and rapidly benefited by removal of infected teeth.

(b) 11 had been severely injured by blow at age 15; received prolonged treatment and eventually was root-filled and conserved. It was markedly discoloured, showed marked absorption of root and extensive infection of surrounding bone. It is becoming increasingly recognized that such teeth subjected to trauma frequently have extensive periapical bone infection without external evidence, and it is presumed that, as many instances have occurred in which such teeth are intimately connected with severe systemic lesions such as infective endocarditis (as in the case recorded under “virulence”), the organisms have a high virulence, and Rosenow’s “elective localization” theory may account for this.

(c) Such teeth subjected to trauma are usually found among incisors and canines, because of their exposed positions.

(d) The most dangerous variety is the slightly discoloured tooth which has not received any filling and may easily escape detection in clinical examination, though odontograms at once show extensive infection.

Case 14.—Corporal H., aged 27.

Condition.—Abscess, right groin. Opened, drained, but did not close entirely. Chronic discharge.

Reopened, drained and again did not close up.

Patient complained of “sore gums,” was sent for dental report.

Dental Report.—(a) Acute ulcerative gingivitis of Vincent type (specific infection by symbiotic Bacillus fusiformis + Vincent’s spirillum) round erupting $\delta 1$, with large ulcer on cheek. (b) $65$ with putrid or necrotic pulps as a result of caries.

Treatment.—Gun condition first treated and brought under control in four days; $65$ removed on fifth day. Medical officer dressing the groin.
sinus noticed diminution in discharge. Removed on sixth day. Medical officer reported on eighth day considerable reduction in discharge and also decrease in opening of sinus; maintained till fourteenth day when no discharge whatever and much smaller sinus, which eventually closed on sixteenth day. No recurrence.

Note.—(a) A clear case of "vicious circle."
(b) This case is one of many such, in which elimination of such a focus of streptococcal infection in the mouth results in rapid healing of a wound, either operative or gun-shot. It was frequently noticed during the war in fractures and gun-shot wounds of jaws that union of fragments was delayed until all roots, infected or injured teeth, minute sequestra and particles of shrapnel were removed from the site of injury.

(To be continued.)