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PASSAGE OF TISSUE FLUID INTO HUMAN GINGIVAL POCKETS

by

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INTRODUCTION

Some physiological properties of various epithelia were studied experimentally in dogs by *Brill & Krasse* (1958). They reported that tissue fluid permeates the epithelial lining of clinically healthy gingival pockets. Unless damaged other oral epithelia do not allow such passage. If, however, a tooth is about to erupt into the oral cavity, the still intact covering mucosa may also permit tissue fluid to permeate.

The present investigation was carried out in order to reveal if similar results could be demonstrated when human epithelia were studied. A particular object was to test if the epithelium in gingival pockets is permeable to fluorescein molecules, and if so, to study if this feature differentiates pocket epithelium from other oral epithelia and nasal epithelium. A further object was to compare the fluorescein content of products from pocket epithelium and products from various glands, e.g. sudoriferous glands, mucinous glands and salivary glands.

In this paper the term pocket is used to designate the space limited on the one side by epithelium and on the other side by

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tooth substance and often ending at the cemento-enamel junction. The term will be used regardless of whether the contents of this space are physiological or pathological products.

MATERIAL

After exclusion of one person, 12 persons (8 females and 4 males) aged 20—51 (mean age 30.4 yrs.) were studied. Their general health was good except that two persons suffered from acute rhinitis.

Oral conditions varied from person to person. The gingival health ranged from clinically healthy marginal gingivae and papillae through localized inflammation of interdental papillae to generalized chronic gingivitis. Inflammatory reactions, however, were low grade and limited to the gingival margin in all cases. Even in one person, for whom multiple restorations had been made, comprising fillings, crowns and bridges, the inflammation was restricted to local marginal reaction.

METHODS

Each person was given 2—4 grammes of fluorescein sodium in capsules soluble in gastric juices. Fluorescein sodium consists of small molecules, its molecular weight being 376.27 (*Merck* 1952). According to *Sollman* (1948) this substance is used by ophthalmologists in locating intra-ocular inflammation and foreign bodies. For this purpose the safe single dose given per mouth will usually be 3—6 grammes. In the present investigation, however, somewhat smaller doses were used and proved sufficient.

Instructions were given to each person to rinse his or her mouth thoroughly after swallowing the capsules. This precaution was taken in order to eliminate traces of fluorescein which might adhere to the mucous membranes. In cases of doubt the mouth was inspected under ultraviolet light, which discloses fluorescein. As mentioned above one person was excluded from the investigation; the mucous membranes of his tongue and hard palate were found to be contaminated.

The possible occurrence of fluorescein in gingival pockets and on other mucous membranes was tested 2—3 hours later. At that time, all traces of fluorescein deposited on the oral mucous

membranes during the swallowing of the capsules had disappeared in the 12 persons included in the investigation. In pilot studies it was found that generally after this interval, the fluorescein level of blood and urine would be at its peak and remain there for at least another 2 hours. In each person the testing procedure did not exceed 45 minutes.

Before the collection of samples began, the mouth was prepared in the following manner: Cotton rolls were inserted sublingually and into the oral vestibule. Facial and lingual surfaces of teeth and gingivae were carefully dried with special cellulose sponges described by *Björn* (1951). Excess saliva was removed by a saliva ejector. When required, cotton rolls were renewed to prevent the gingivae from becoming contaminated by saliva.

Samples were taken by means of strips of filter paper, 4 mm wide and 15 mm long including a 2 mm long tapering end. The tapering end of the strip was gently inserted into the pocket and allowed to stay there for 3 minutes in order to collect a suitable amount of fluid if present. Tweezers were used in handling the strips in order to avoid their contamination with fluorescent material from extraneous sources.

Strips of filter paper were placed on various other epithelial surfaces such as the attached gingiva, the dorsum and the inferior surface of the tongue, the floor of the mouth, the hard palate, and the buccal mucous membrane. In the case of the last four sites care was taken not to place the strips in the vicinity of glandular orifices. It was, however, impossible to avoid contact with orifices of the minor glands situated in the buccal mucosa and on the inferior surface of the tongue.

A special study was made of the secretion from various glands by placing strips directly over their orifices. Glands studied in this way were the mucinous glands of the hard palate, the parotid gland, and the sudoriferous glands of the skin of the nose, upper lip and forehead. The sudoriferous glands were tested in 2 persons, the mucinous and parotid glands in 11 persons. Samples of mixed saliva were taken from 7 persons. Finally, 10 samples of secretion from nasal mucous membranes were taken by inserting filter paper into the depth of both nostrils of 5 persons, including the 2 individuals suffering from rhinitis.

The presence of fluorescein on the strips was disclosed by

examining them under ultraviolet light of a wavelength of 3,000—4,000 Å furnished by a wood-light lamp, similar to that advocated by *Schaffer & Seymour* (1953). When material containing fluorescein is put under ultraviolet rays, it exhibits a yellowish green fluorescence, not seen in other artificial or in natural light.

RESULTS

The total number of pockets investigated was 317. Fluorescein was detected on strips from 305 pockets, while 12 strips from the remaining pockets carried questionable traces of fluorescent material or none at all. That is to say that 96.2 per cent of the pockets yielded positive results and 3.8 per cent negative results.

The methods used and precautions taken should ensure that fluorescein molecules had entered the pockets along internal routes. To be recovered from a pocket, fluorescein must have passed, first the epithelium somewhere along the gastrointestinal tract, and last the epithelial lining of the gingival pocket.

It was apparent that a correlation existed between the degree of inflammation and the amount of fluorescein occurring on the strips. This is demonstrated in Figures 1 and 2. Fig. 1 shows samples collected from a person with clinically healthy marginal gingivae, and Fig. 2 samples from a person with extensive restorations and suffering from marginal gingivitis at the sites of the restorations.

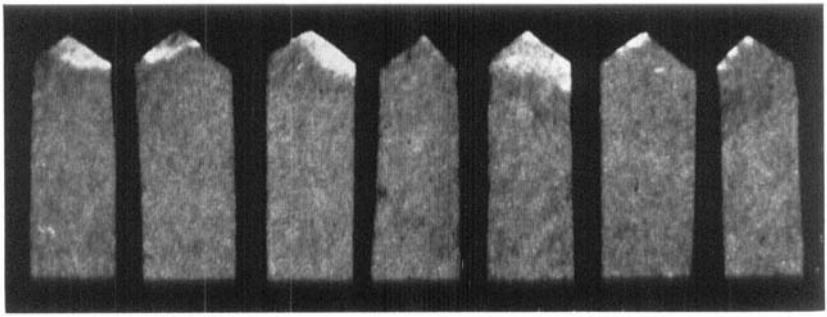

Fig. 1. Samples containing fluorescent fluid recovered from clinically healthy pockets.

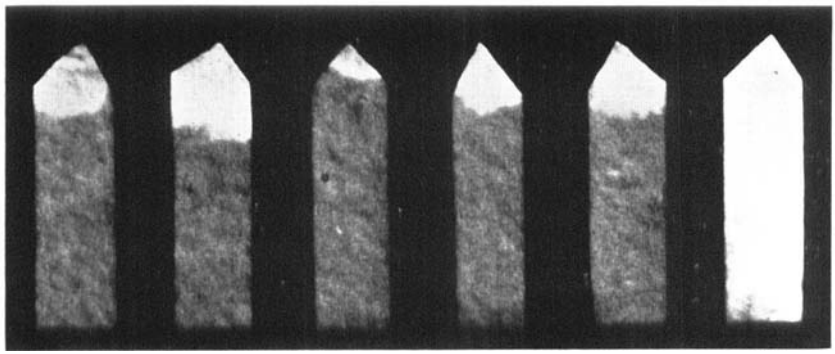

Fig. 2. Samples containing fluorescent fluid from inflamed pockets.

In contrast to these results no fluorescein could be detected on strips which had been placed on the attached gingiva, the dorsum and inferior surface of the tongue, the floor of the mouth, the hard palate and the buccal mucosa.

Nine of the ten samples from nasal mucous membranes were positive and one was questionable. The four samples from the two persons, who had contracted rhinitis, were heavily soaked with fluorescent material (Fig. 3). Samples from two persons without symptoms of rhinitis are shown in Fig. 4.

Strips taken from salivary, mucinous and sudoriferous glandular orifices were all negative as were all of the saliva samples.

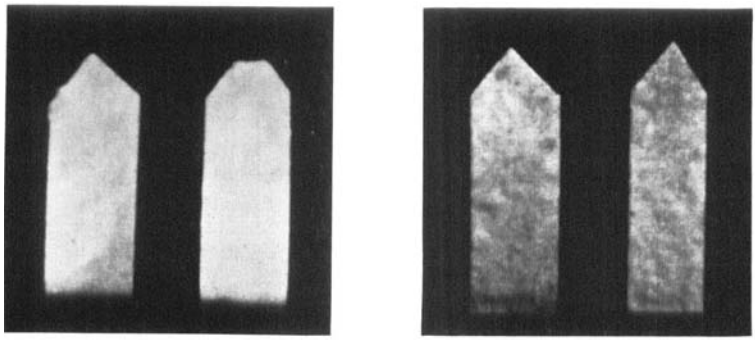

Fig. 3. Samples containing fluorescent fluid from nasal epithelium in a person with rhinitis.

Fig. 4. Samples containing fluorescent fluid from nasal epithelium in a clinically healthy state.

DISCUSSION

The findings demonstrate that the epithelial lining of gingival pockets are generally permeable to the molecules of fluorescein sodium. This is the case whether pocket tissues are healthy, in a clinical sense, or are inflamed.

Thus the present study confirms the results of earlier investigations on dogs by *Brill & Krasse* (1958) though these authors did not study pockets, which could be diagnosed as inflamed. In their animal experiments they found that nasal epithelium is not permeable to fluorescein. This is in contrast to the present findings, which show that human nasal epithelium is permeable.

Since other oral epithelia than pocket epithelium do not allow the passage of fluorescent material, some difference must exist between these epithelia and gingival pocket epithelium.

Some speculations may be ventured to explain this. Two possibilities are suggested: (1) the passage of fluid into pockets is the result of inflammation in surrounding tissues; (2) it is the result of a normal property inherent in pocket epithelium, permitting it to act as a permeable membrane like some other epithelial membranes in the body.

Concerning the first point, it has been made evident by the work of *Wærhaug* (1952, 1953, 1955, 1956), *Wærhaug & Steen* (1952), *Wærhaug & Zander* (1957) and *Zander* (1957) that dental restorations of various kinds will often provoke inflammatory reactions in contacted gingival tissues and very likely the surplus fluid accumulated in such edematous tissues will discharge into pockets. This may be one explanation for the difference between pocket epithelium and other oral epithelia.

Concerning the clinically healthy pockets it might be pertinent to discuss the second point.

Epithelium has two major functions: (1) it constitutes a layer of cells covering internal and external surfaces protecting underlying structures. Epithelia of this type are usually keratinized, e.g. the epidermis. Moreover, epithelium has the not less important function of (2) shifting fluids from one compartment to another. Generally, epithelia of this type are not keratinized. Several mechanisms with this effect will be discussed in some detail below. It will be found that different mechanisms exist

in different epithelia; moreover, the mechanisms vary in regard to the more or less complicated manner in which their products are formed; six examples will be given.

(1) Tears are produced by epithelium organized in multicellular glands, and (2) nasal secretion is formed by unicellular glands — the mucin cells — distributed along the nasal mucous membranes. Both kinds of secretion are produced in an elaborate way, that is to say, the glands concerned have to perform work in producing their secretions, in addition to that which is expended in maintaining cellular integrity (*Maximow & Bloom,* 1957).

(3) The passage of fluid from one compartment to another can also be performed in a simpler manner, e.g. by filtration. This is the case in renal function (*Maximow & Bloom,* 1957). Filtration does not require expenditure of cellular energy, and is often called excretion.

(4) According to *Junqueira & Hirsch* (1956) both mechanisms may be active at the same time in the same cells. This is probably the explanation of the findings made by *Henning* (1932). He demonstrated that intravenously injected fluorescein passes the epithelial lining of the stomach in frogs only when glands of the gastric mucous membrane are in an active phase.

(5) Much discussion has centered around the formation of fluid at other sites in the body. Thus the passage of fluorescein from blood into the aqueous humour of the eye was described by *Yoshida* (1929) as an ultrafiltration, whereas *Fischer* (1929) believed the action to be a dialysis. Finally, *Palm* (1956) states that satisfactory evidence supports the idea that the aqueous humour is formed by secretion in the ciliary body, although other phenomena must also be taken into account.

(6) *Fischer* (1929) found the barrier between blood and cerebrospinal fluid passable to small molecules like fluorescein. *Franceschetti & Hallauer* (1929) and *Hallauer & Franceschetti* (1929) found it passable to larger molecules such as antibodies. The source of the cerebrospinal fluid is generally believed to be the chorioid plexus; but according to *Ranson & Clark* (1953) it can also accumulate through other regions of the barrier between blood and the fluid. Whether the fluid is formed by dialysis or secretion is not fully known.

All epithelia mentioned above act as more or less specialized membranes, and they have one thing in common with gingival pocket epithelium, viz. the lack of keratinization. It should be added that the shifting of fluid from the internal to the external environment sometimes has a protective effect. When the cornea is irritated, its surface is flushed by a stream of fluid coming from the lacrimal glands. In the same manner, when nasal epithelium is irritated physically or chemically, the production of fluids is increased. In both instances the irritant may be either washed away or diluted, and thus a protecting effect is achieved.

In summary it might be stated that the transportation of fluid through epithelium can be brought about by several mechanisms inherent in the epithelia. The hypothesis that one such mechanism might be found in the epithelial barrier constituted by gingival pocket epithelium is worth considering.

However, the main point of this discussion is: should the shifting of fluid from subepithelial compartments through epithelium into the gingival pocket be interpreted as a physiological or pathological event? This problem is not solved in this study, but requires further investigation.

Regardless of whether the outgoing stream of fluid coming from pocket epithelium is formed by a physiological or pathological process, it acts as a defense mechanism in so far as it has a cleansing effect upon the pocket. *Wærhaug* (1952) has shown that minute particles are eliminated from inflamed pockets and *Hagermann & Arnim* (1955) hold the same view. Moreover, by streaming out of the pocket the impact of the fluids blocks the entrance to the pocket, *Wærhaug* (1955).

For a further discussion of the significance of the findings the reader is referred to *Brill & Krasse* (1958).

SUMMARY

12 persons received 2—4 grammes of fluorescein sodium per mouth. 2 hours later is was possible to recover fluorescent fluid from most gingival pockets. In 5 persons fluorescent material was recovered from the depth of nostrils. Exudate containing fluorescein was found regardless of whether these epithelia were inflamed or not. However, it was apparent that inflamed nasal

and pocket epithelium yielded greater amounts of fluorescent fluid than did healthy epithelia. With the exception of pocket epithelium it could not be demonstrated that oral epithelia allow fluorescein to pass. Secretory products from salivary glands, mucinous glands of the hard palate and sudoriferous glands of the upper lip, nose and forehead did not contain detectable amounts of fluorescein.

It is pointed out that the outgoing stream of fluid coming from gingival pockets may have a cleansing effect in that it may carry minute particles out of the pockets and by streaming out the impact of the fluid may block the entrance to the pockets.

RESUME

L'ÉCOULEMENT DE FLUIDE TISSULAIRE DANS LES CULS-DE-SAC GINGIVAUX CHEZ L'HOMME

Deux heures après l'administration per os de 2—4 grammes de fluorescéine de sodium à 12 personnes, on a constaté chez ces sujets la présence de liquide fluorescent dans la plupart des culs-de-sac gingivaux.

Chez 5 des sujets, on a constaté la fluorescence des secrétions de la muqueuse des narines. L'exsudat contenant la fluorescéine a été décelé, que l'épithélium en question fût enflammé ou non. Il est cependant apparu d'une manière évidente que la muqueuse nasale et celle du cul-de-sac gingival produisaient de beaucoup plus grandes quantités de liquide fluorescent dans les cas où elles étaient enflammées que lorsqu'elles étaient saines. Il a éte impossible de mettre en évidence la perméabilité à la fluorescéine d'autre épithelium buccal que l'épithélium des culs-de-sac gingivaux. Les secrétions des glandes salivaires, des glandes muqueuses du palais dur, et des glandes sudoripares de la lèvre supérieure, du nez et du front, ne contenaient pas de quantités décelables de fluorescéine.

Les auteurs soulignent que l'écoulement de fluides provenant des culs-de-sac gingivaux a un effet détergent: il peut vraisemblablement chasser des débris de petites dimensions de l'intérieur du cul-de-sac; et, en s'écoulant avec une certaine force, le liquide peut bloquer l'entrée du cul-de-sac.

ZUSAMMENFASSUNG

ÜBER DAS DURCHSTRÖMEN VON ZAHNFLEISCHTASCHEN MIT GEWEBSFLÜSSIGKEIT BEIM MENSCHEN

12 Personen wurde zwei bis vier Gramm Fluoreszeinnatrium per Os gegeben. Zwei Stunden später wurde in den meisten Zahnfleischtaschen dieser Personen fluoreszierende Flüssigkeit konstatiert. In neun Proben von Sekret aus Nasenlöchern wurde Fluoreszein festgestellt. Es wurde Fluoreszein sowohl in Exsudat aus inflammiertem als auch aus normalem Epithel gefunden. Es war jedoch auffallend, dass die Produktion von fluoreszierender Gewebsflüssigkeit aus inflammiertem Nasen- und Taschenepithel weitaus grösser war als aus gesundem.

Mit Ausnahme von Taschenepithel war es nicht möglich, andere orale für Fluoreszein permeable Epithelien zu konstatieren. Sekret von Speicheldrüsen, von muzinproduzierenden Drüsen im harten Gaumen und von Schweissdrüsen in der Haut von Oberlippe, Nase und Stirn enthielten keine nachweisbaren Mengen Fluoreszein.

Es wird die reinigende Wirkung des nach aussen gerichteten Flüssigkeitsstroms aus den Zahnfleischtaschen hervorgehoben; dieser kann wahrscheinlich kleinere Partikel aus den Taschen entfernen und, da der Flüssigkeitsstrom einen gewissen Druck hat, den Eingang zu jenen blockieren.

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