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EFFECT OF MECHANICAL STIMULATION ON FLOW OF TISSUE FLUID THROUGH GINGIVAL POCKET EPITHELIUM

by

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Intravenously injected fluorescein sodium can be recovered from clinically healthy gingival pockets in dog (*Brill* and *Krasse,* 1958). *Brill* and *Björn* (1959) demonstrated that fluorescein sodium taken per mouth appears in clinically healthy gingival pockets in man. In both studies it was found that no other normal oral epithelium permits the passage from the internal to the external environment of fluids containing fluorescein. Thus it was demonstrated that the permeability of pocket epithelium differs from that of other clinically healthy epithelia of the oral cavity.

Brill and *Björn* (1959) also found that this epithelial barrier is passed by greater amounts of tissue fluid, when the marginal gingiva is subjected to long term irritation causing chronic inflammation. It would therefore be of interest to know if brief irritation of healthy marginal gingiva also increases the rate of flow of tissue fluid into gingival pockets. The present investigation was conducted to throw light on this problem.

As in previous papers the term pocket is used to designate the space limited on the one side by clinically healthy epithelium and on the other by tooth substance and often ending at the cemento-enamel junction. The term will be used regardless of whether the contents of this space are fibrous or fluid in nature.

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MATERIAL AND METHODS

A dog about 8 months old and weighing 18 kg was used. The permanent teeth were fully erupted and gingival health was good. Clinical signs of inflammation could only be detected in two or three minor areas. In these cases the localisation varied, when observed at intervals of one week. These reactions were ascribed to trauma during mastication, as the dog was fed a hard diet requiring vigorous chewing. In pilot studies such a diet was found to prevent widespread gingivitis.

Anaesthesia. — The animal received an initial dose of 8 ml of "Pentothal" ® (Thiopentone Sodium B.P., or Thiopental Sodium, U.S.P.) intravenously and 1½ ml every thirty minutes afterwards during the experiment.

Seven experiments were conducted, one or two experiments being performed at each session. In some instances the investigational methods were applied to the same pockets more than once. In those cases the experiments were conducted after one or two weeks' interval, the reason being that a possible irritation of the tissues caused by the experimental procedure should be allowed to subside. It should be remembered that this investigation was planned to explore the reaction of non-irritated clinically healthy pockets to various stimuli. When pockets were used for experiments more than once, it was clinically checked that the pockets subjected to the experimental procedures one week earlier were now in good health.

The gingival pockets of the following teeth were used for the studies: the first molars, the third, second and first premolars and the canines of the upper jaw; the first molars, the fourth, third and second premolars and the canines of the lower jaw.

The soft tissues surrounding the teeth were stimulated by the following methods:

(1) by chewing;

(2) by mechanical stimulation of

  (a) pocket epithelium,

  (b) the crest of the marginal gingiva,

  (c) the vestibular surface of the marginal gingiva,

(3) by gingival massage, i.e. by brushing according to
   (a) the Stillman method,
   (b) the Charters method,
   (c) a modified method.

The effect of the various kinds of stimulation was judged from the amount of fluorescein sodium recovered from gingival pockets on strips of filter paper after intravenous injection of the test substance. This method has been described in earlier papers (*Brill* and *Krasse,* 1958, *Brill* and *Björn,* 1959). Previous to and immediately after each kind of stimulation strips were inserted into the gingival pockets and left there for three minutes to collect fluid from the pockets. If any difference between a series of recordings before and after stimulation could be registered, it was believed to be a result of the stimulation in question.

Any fluorescent material on the strips was determined by examination under ultraviolet light (wavelength 3,000—4,000 Å) from a Wood-Light lamp similar to that advocated by *Schaffer* and *Seymour* (1953). When material containing fluorescein sodium is examined under ultraviolet rays, it exhibits yellowish green fluorescence not seen in other artificial or natural light.

When method number 1 was applied the experiment was performed in the following manner: a toy rubber bone was placed between the jaws. With their hands the investigators moved the upper and lower jaw of the dog passively against the rubber bone in order to imitate chewing movements; also in order to imitate at the same time the rough handling of food, which dogs usually exhibit when chewing hard and tough substances, the rubber bone was turned and twisted between canines, premolars and molars. Now and then the gums were hit by these movements. This procedure was applied for ten minutes. The effect was recorded for pockets in the upper as well as in the lower jaw.

When using the other methods the effect was studied on gingival pockets either in the upper or in the lower jaw. In the series comprising the methods 2 a, b and c of mechanical stimulation a blunted straight elevator was used. In 2 a the elevator was gently inserted into each pocket, consecutively, the convex surface of the blade facing the epithelium. With a very loose grip

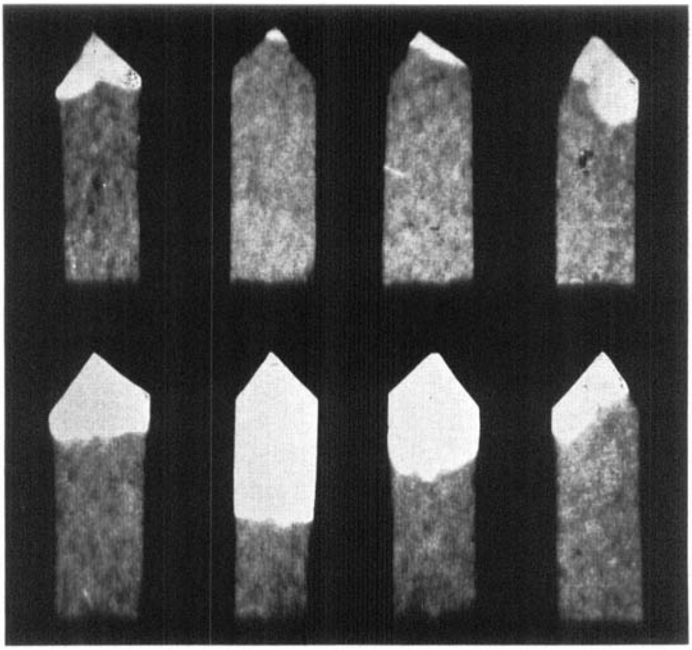

Fig. 1. Strips of filter paper containing fluorescent material from gingival pockets. The white parts represent the uptake of fluorescein sodium.

Upper row: Samples from unstimulated pockets in the upper jaw.

Lower row: Samples from the same pockets after "chewing".

on the handle the instrument was moved from the distal end of the pocket to the mesial end and then removed. This procedure was performed twenty-five times in each pocket as were other kinds of stimulation described below. The time required to perform this stimulation and those described below varied from thirty to forty seconds.

When applying method 2 b the instrument was placed at right angles to the tooth, the tip of the instrument touching the enamel and the convex surface of the blade contacting the gingival margin. With a loose grip the elevator was moved from the distal end of the tooth to the mesial end.

In method 2 c the instrument was placed with the convex surface of the blade against the vestibular surface of the marginal

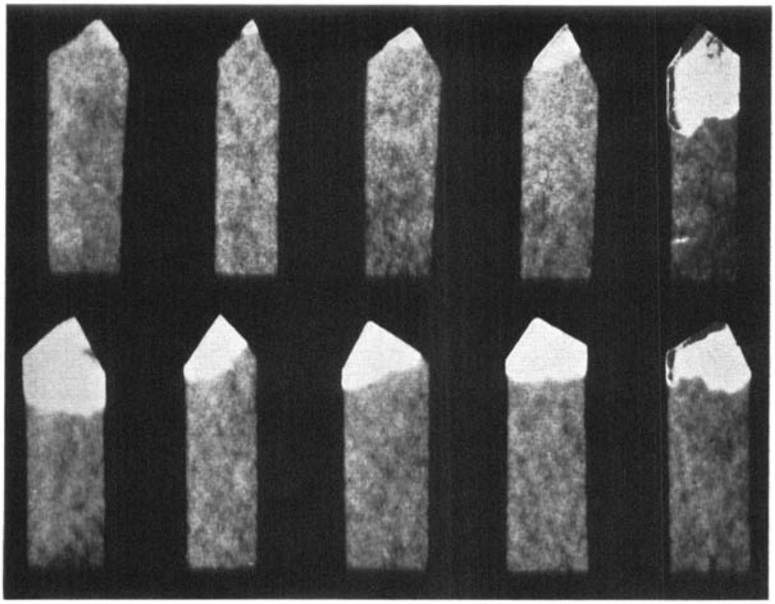

Fig. 2. *Upper row:* Samples from unstimulated pockets in the lower jaw. *Lower row:* Samples from the same pockets after "chewing".

gingiva. With a slightly firmer grip the instrument was moved along the marginal gingiva from the distal end of each tooth to the mesial end. Neither in this method nor in the others was the epithelium stimulated to such a degree that fluid was observed seeping out through the crestal or the vestibular surface of the marginal gingiva.

In the last series of experiments the effect of toothbrushing on gum margins was studied by applying methods 3 a, b and c. The bristles of the toothbrush used were of nylon and had rounded ends. In method 3 a, which is advocated by *Stillman* (1932), the brush was placed with the bristle ends resting partly on the gingiva and partly on the cervical portion of the teeth. The bristles were placed obliquely to the long axis of the teeth, the bristle ends pointing apically, and some of the ends were allowed to slip into the pockets. Sufficient pressure was applied to make the bristles bend and in this position slight rotatory movements were performed. These movements did not cause the

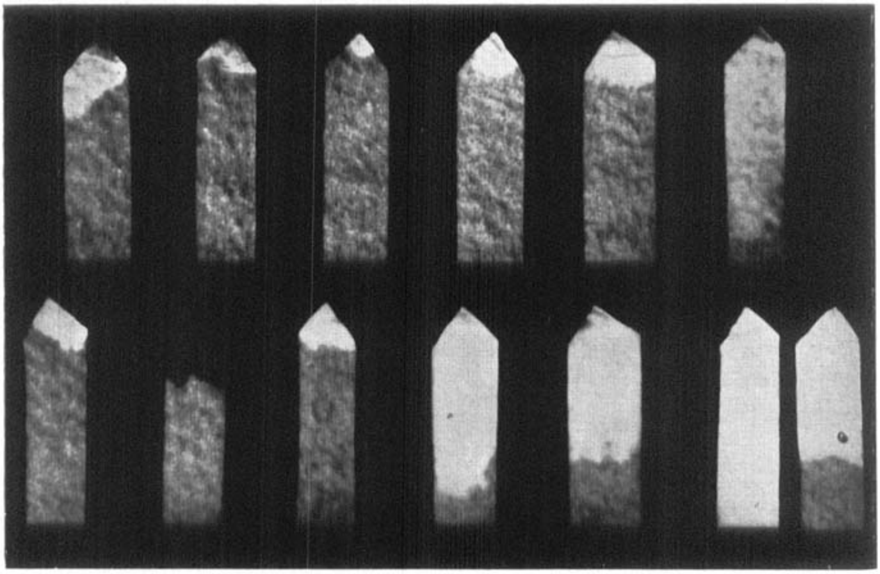

Fig. 3. *Upper row:* Samples from unstimulated pockets.
Lower row: Samples from the same pockets after mechanical stimulation of pocket epithelium (method 2 a).

Note: A bleeding is recorded on the second strip from the left in the lower row. Both of the last two strips to the right in the lower row were required to record the abundant flow of fluid from one pocket after stimulation. Fluid from the same pocket before stimulation is recorded on the last strip to the right in the upper row.

bristle ends to move from the position in which they were originally placed.

In the experimental method 3 b the toothbrushing method advocated by *Charters* (1932) was applied. This method is similar to Stillman's, the main difference being that Stillman recommends that the bristles should point apically, while Charters recommends that they should point occlusally.

In the last series, i.e. 3 c, a third tooth brushing technique was applied. The brush was placed flat on the attached gingiva. The sides of the bristles were contacting the epithelium and the bristles were parallel to the long axis of the teeth. The bristles were pressed against the gingiva and with a sliding movement were drawn towards the gingival margins. Simultaneously the

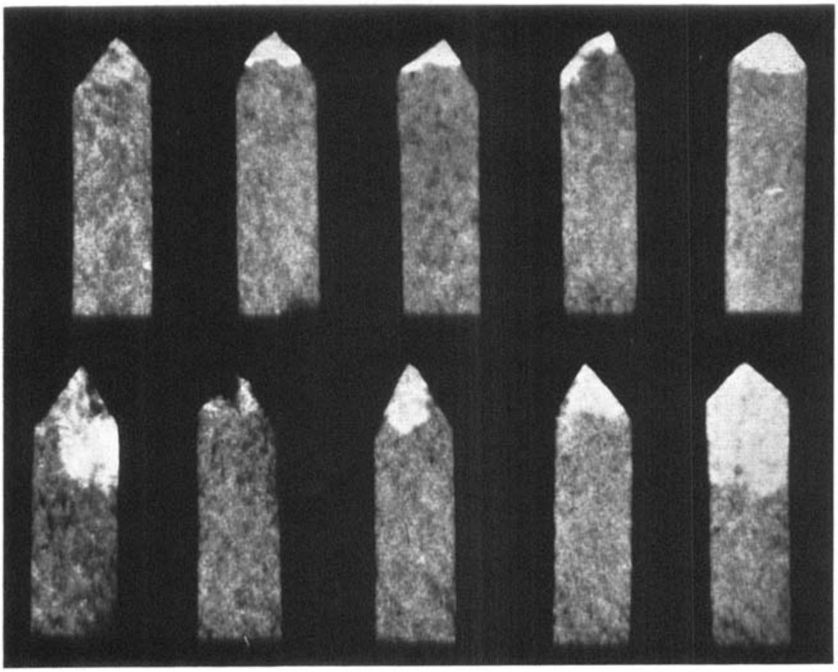

Fig. 4. *Upper row:* Samples from unstimulated pockets. *Lower row:* Samples from the same pockets after mechanical stimulation of the vestibular surface of marginal gingiva (method 2 c).

handle of the brush was rotated in such a way that the bristle ends traversed the attached gingiva and the marginal gingiva but without touching the crest of the margins. The brush was removed and the procedure repeated twenty-five times.

RESULTS

Samples of fluid recovered from pockets in the upper and lower jaw previous to and immediately after "chewing" are photographically reproduced in Figs. 1 and 2. In these figures as well as in those which follow, the upper row of strips represent recordings from the unstimulated pockets and the lower recordings from the same pockets after stimulation. Figures 1 and 2 demonstrate that chewing in the way it was performed stimulated a flow of tissue fluid into the gingival pockets.

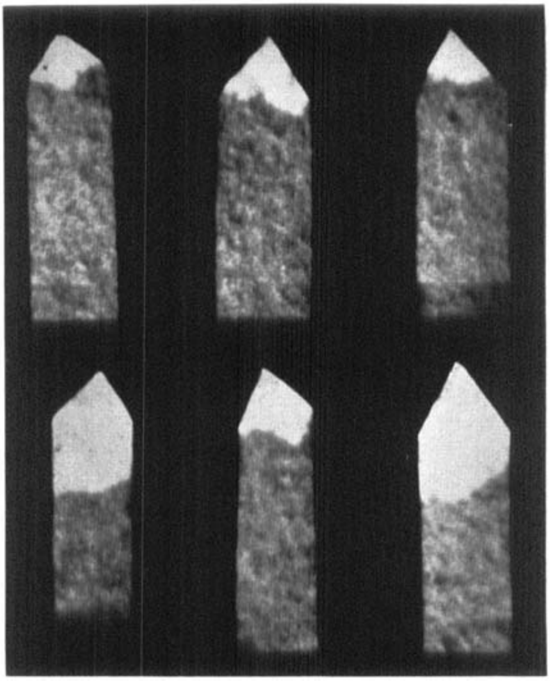

Fig. 5. Samples from the same pockets as those shown in fig. 3 taken 10 minutes after discontinuing mechanical stimulation.

Samples from the series in which stimulation was performed twenty-five times with the straight elevator show similar results. An increased flow of fluid was provoked regardless of whether the stimulation was applied internally or externally to the pocket or on the crest of the marginal gingiva. Fig. 3 shows the effect of internal stimulation and Fig. 4 the effect of external stimulation. The internal stimulation seems to be the more effective. In Fig. 3 in the lower row the last two strips were required to record the fluid coming from the pocket of the right upper first molar after stimulation. These two strips should be compared with the last strip to the right in the upper row (same pocket before stimulation).

Fig. 5 shows samples taken ten minutes after discontinuation of stimulation and should be compared with the upper row in

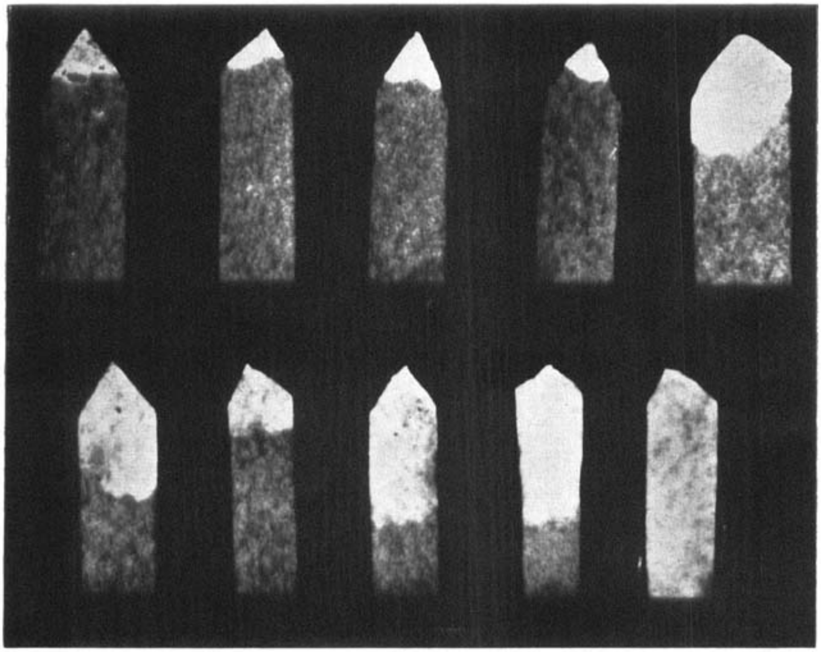

Fig. 6. *Upper row:* Samples from unstimulated pockets. *Lower row:* Samples from the same pockets stimulated by toothbrushing according to the Stillman method.

Fig. 3. After ten minutes the rate of flow has returned almost to normal.

The effect of toothbrushing is recorded in Figs. 6, 7, and 8. Fig. 6 illustrates samples registering the results of the Stillman method, Fig. 7 similar recordings with Charters' method and Fig. 8 recordings of the modified method. The figures show that all three methods stimulate a production of fluid. The Stillman method seems to be the more effective in this respect.

DISCUSSION

The results clearly show that brief mechanical stimulation of clinically healthy pockets provokes an increased flow of tissue fluid through pocket epithelium, even when the stimulation is

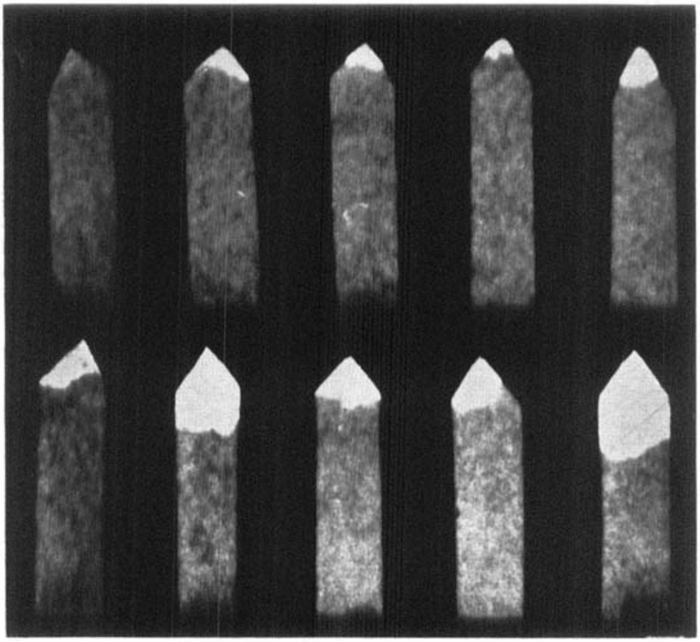

Fig. 7. *Upper row:* Samples from unstimulated pockets. *Lower row:* Samples from the same pockets stimulated by toothbrushing according to the Charters method.

applied externally to the pockets. Another interesting finding is that this increased flow seems to return to the original rate within ten minutes. These effects cannot be readily accounted for, but different explanations may be suggested:

When a vascular bed is mechanically stimulated one reaction of arterioles is a dilatation accompanied by an increased pressure. At the same time an increased permeability of the vessels may occur allowing plasma to escape more freely. Such vascular reactions are ordinarily seen during the initial stages of inflammation. The net result is an increased amount of interstitial fluid. For a review of these problems see *Payling Wright* (1950) and *Florey* (1958).

The connective tissue interposed between vessels and epithelium may also undergo changes caused by mechanical stimula-

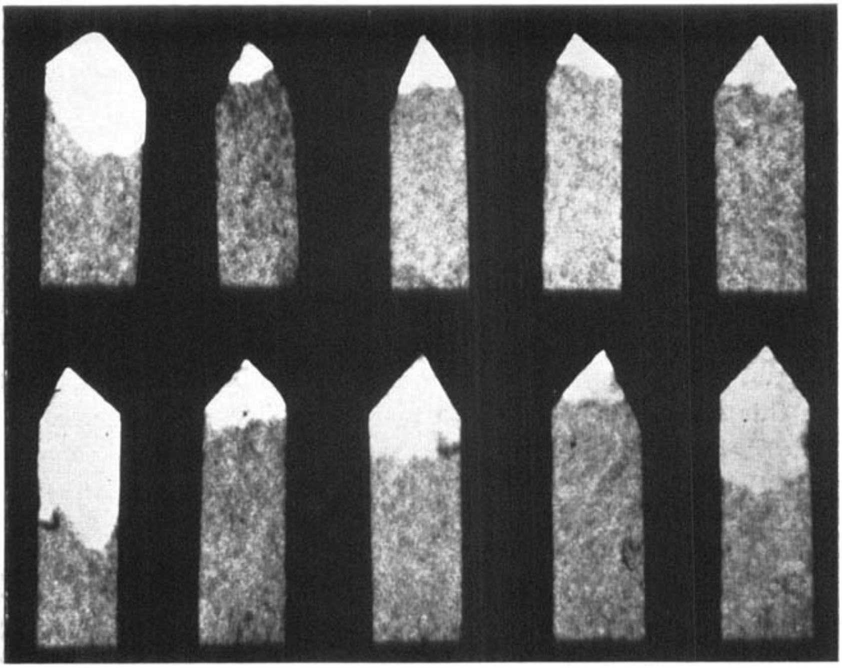

Fig. 8. *Upper row:* Samples from unstimulated pockets.
Lower row: Samples from the same pockets stimulated by toothbrushing according to a modified method.

tion. The ground substance does not ordinarily contain free water but has a gel-like structure because of its large content of highly polymerised acid mucopolysaccharides. This gel, however, is not stable. Tissue manipulation for instance may cause oedema, which is capable of dissolving the ground substance (*Wegelius & Asboe-Hansen,* 1956). In this way the gel may be liquefied and turned into a sol. The matrix, which formerly as a gel acted as a mechanical barrier, is now as a sol with a highly increased permeability turned into a conductor (*Duran-Reynals & Mc Crea,* 1953). The sol condition, however, tends to revert to the former gel structure (*Asboe-Hansen,* 1951). Thus the fluid matrix may be described as a sol $\leftrightarrows$ gel system, which shifts to the left, when connective tissue responds to a stimulus, and to the right, when the tissue returns to a resting state. Such changes in the ground substance may be effected even by mechanical micro-traumata applied directly to connective tissue (*Zweifach,* 1953) or chemical irritation applied to skin (*Rigdon,* 1953).

A stimulation may also influence an epithelial barrier. *Ussing* (1949) reports that microinjuries induce a violent but transient permeability in such a barrier.

Although reactions in the vessels, the connective tissue, and the epithelium have been mentioned separately they are not mutually exclusive. On the contrary they seem to be intimately bound up with one another and it is highly probable that they should occur together under the experimental conditions applied in this study. Thus, when the marginal gingiva is subjected to mechanical stimulation by toothbrushing, vessel walls, connective tissue and pocket epithelium may all react by an increased permeability. This may explain the increased amounts of tissue fluid flowing into gingival pockets.

Turning from theoretical considerations to clinical aspects of the findings these will be discussed at some length because of their general significance.

Modern diets in a civilised community are soft and lack the stimulating and cleansing effect of the hard diets of primitive man (*Fish* 1948, *Mc Call,* 1948). This lack of natural mechanical action must therefore be substituted by artificial measures, if gingival health is to be preserved (*Stillman* 1928, *Leonard* 1929). Authors of text-books on treatment and prevention of periodontal disease agree on this point (*Miller* 1948, *Goldman* 1949, *Glickman* 1953). It is generally accepted that removing food debris and accumulated bacteria by toothbrushing serves the maintenance of good marginal health. But it is a matter of discussion whether gum massage is of benefit also.

The main beneficial effect attributed to massage is that it restores circulation in inflamed structures, with the effect that acids and injurious end-products of inflammation are drained off and fresh oxygen and cell nutrients are brought in (*Leonard* 1948). Thus tissue metabolism is improved (*O'Rourke* 1947).

As yet this effect is not substantiated experimentally and is therefore questioned by *Hart* (1948) and *Ziskin* (1948). It is moreover poor therapy to apply massage to inflamed structures (*Loeb* 1948, *Lyons* 1948).

Concerning an activation of keratinization processes of gingival epithelium *Orban* (1930), *Robinson & Kitchin* (1948) from histological studies, and *Pelzer* (1940), *Beube* (1948) and others from clinical observations believe that tooth brushing promotes hornification of the gums. Their opinions are disputed by *Castenfeldt* (1952), who conducted an experimental study including a histological investigation of the effect of tooth brushing on marginal gingiva. He did not find any tendency to a higher intensity of keratinization, when massage was applied.

These conflicting statements cannot be assessed until further research is carried out. The present investigation, however, suggest one possible explanation of a beneficial effect of toothbrushing. *Waerhaug* (1952) states that if a pocket is irritated to such a degree that an exudate with a large content of polymorphonuclear leukocytes is formed, this exudate removes particles from the pocket. It is highly probable that a stream of fluid provoked by tooth brushing can also remove particles from pockets and if so a fundamental rationale for gum massage is established.

SUMMARY

Short term mechanical stimulation of the clinically healthy marginal gingiva in dog causes an increased flow of tissue fluid into the gingival pocket.

The underlying mechanism of this effect is discussed and its importance in maintaining gingival health is pointed out.

RESUME

L'EFFET DE LA STIMULATION MÉCANIQUE SUR LE TAUX D'ÉCOULEMENT DES FLUIDES TISSULAIRES À TRAVERS L'ÉPITHÉLIUM DU CUL-DE-SAC GINGIVAL

L'excitation mécanique de courte durée de la gencive marginale cliniquement saine chez le chien provoque une augmentation de l'écoulement des fluides tissulaires dans le cul-de-sac gingival.

Les auteurs discutent l'explication possible du mécanisme en cause et soulignent l'importance de ce phénomène pour le maintien d'une gencive saine.

ZUSAMMENFASSUNG

DIE WIRKUNG MECHANISCHER STIMULIERUNG AUF DEN STROM VON GEWEBSFLÜSSIGKEIT DURCH DAS EPITHEL DER ZAHNFLEISCHTASCHE

Eine kurze bestimmte mechanische Stimulierung der klinisch gesunden marginalen Gingiva bei Hunden bewirkt einen ansteigenden Strom von Gewebsflüssigkeit in der gingivalen Tasche.

Die mögliche Erklärung des zu Grunde liegenden Mechanismus dieses Vorganges wird erörtert und dessen Wichtigkeit für Erhaltung einer gesunden Gingiva hervorgehoben.

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