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THE VASCULAR SUPPLY OF THE GINGIVA AND THE ALVEOLAR MUCOSA IN THE RAT

I. DESCRIPTION OF THE METHOD AND THE MORPHOLOGY

by

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INTRODUCTION

The frontal region of the gingiva of lower incisors in rodents is easily accessible for direct observation without any surgical intervention. This area is, therefore, suitable for *in vivo* observations, which at this particular site can be carried out in accordance with the general principles involved in microcirculation research. *Staple* and *Copley* (1959) studied this region and found that the gingival vessels of the neighboring incisors form two morphologically similar systems. Each was supplied by two arterioles that course from the labial vestibule up to the marginal gingiva where they branched to form a vascular bed with a pattern typical for the animal studied (guinea pig, rat, mouse, and rabbit). The large venous trunks that drain this area were the most conspicuous formation seen and these authors found that the regulation of the blood flow is controlled by several factors, the most important of which were changes in the calibre of arterioles, by opening and closing of the main capillary channels, and by the action of arteriovenous anastomoses. When the blood flow was slow, single erythrocytes, leukocytes and platelets and their agglutination could be observed. In larger trunks the blood flow divided into axial and peripheral parts. Occasionally the formation of gravitation strata in the flow could be seen.

The present investigation is a methodological study of several basic biological problems concerning the blood supply of the gingiva and of the alveolar

mucosa surrounding the lower incisors of the rat as well as a test of the technique involved. It is based on the experience obtained whilst studying the vessels of the dental pulp and other oral tissues (*Taylor*, 1950; *Pohto & Scheinin*, 1958; *Kozam & Burnett*, 1959; *Staple & Copley*, 1959; *Mutschelknauss & Schumann*, 1965; *Scheinin*, 1966) as well as of the bone marrow (*Brånemark*, 1959), and is extended into more detail on the dental aspect.

This study is divided into two parts. The first contains the description of the method and of the vascular morphology of the region. The second deals with spontaneously and experimentally induced effects on the gingival and alveolar microcirculation.

MATERIAL AND METHODS

The principal method used was the direct examination of vessels in a live animal with the aid of a microscope. In areas where the direct examination of the vascular bed was not possible, latex casts of the vessels which were exact reproductions of the vascular architecture, were used. Since the pattern of the blood supply varied in individual areas, the microscopic structure was examined by means of celloidin embedded tissue, cut sections from this being stained with hematoxylin and eosin.

The experimental animals were male rats of the Wistar strain. Their weight ranged between 160 and 200 g. They were anaesthetized with Nembutal and premedicated with atropine sulphate (0.05 mg/100 gm. body weight) in order to decrease bronchial secretion.

Direct observations of vessels in the live animal were carried out with an Ortholux microscope (E. Leitz, Wetzlar, Germany) adapted for this investigation. The microscope stage supplied was replaced by a specially constructed stage held at 37°C. This stage also incorporated a micromanipulator to control movement in the horizontal plane. A detailed description of this equipment was published by *Scheinin* (1966).

The animals were fixed to the stage in a supine position (Fig. 1). The upper and lower incisors were joined together by means of warmed dental impression composition placed in a copper ring that was held by an »Ivory 8» pattern matrix holder attached to the microscope stage using a double ball joint.

The lower lip of the experimental animal was retracted using a fine wire retractor that was fixed to the opposite side of the microscope stage also by a double ball joint. The animal was thus immobilized, though the double ball joints permitted a change of position of the animal in an effortless and gentle manner, when necessary, during selection of the area to be investigated. A fine layer of immersion oil was spread over the examined area to clear the tissue

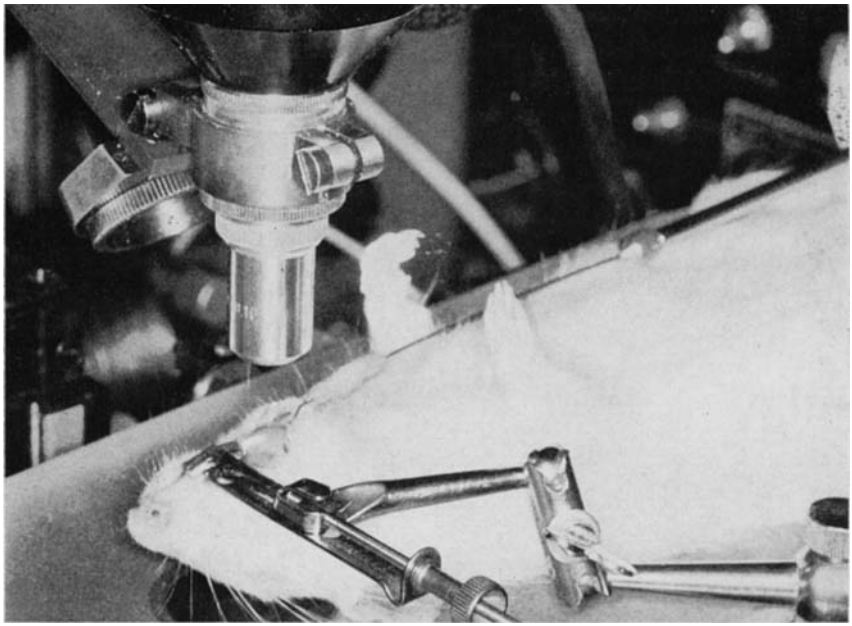

Fig. 1. Positioning of rat for vital microscopy of the vasculature in the gingiva and the alveolar mucosa. Screening illumination.

and to prevent it from drying. A Xenon lamp (XBO 150) was used as the light source. In order to suppress the undesirable heating effect of the light, a heat filter consisting of a cuvette filled with a 15 % solution of copper sulphate was placed in the light path.

After fixing the animal in position a simple objective and an inclined mirror were employed to direct the incidental light and focus the general field of investigation. For detailed observation an Ultrapak Illuminator (E. Leitz) with an 11× objective and an immersion cap was then used. This immersion cap eliminated undesired reflections that otherwise made observations very difficult. However, contact with the tissue had to be very gentle or it easily compressed the capillaries.

Other specimens were prepared by injecting the external carotid artery with latex, which set in the vessels, after which all the tissues, including the vessel wall, were dissolved and the casts of the vessels were placed in water and examined. For a detailed description of the method see (*Kindlová & Matěna*, 1959). These animals were premedicated with heparin /0.1 ml of a 5 % solution per 100 g of body weight/ to prevent blood from clotting.

The vital observations were performed on 90 animals and observations on latex casts from 15 rats were made. Histological preparations were evaluated in the material from 5 rats.

RESULTS

The structure of the vascular bed of the alveolar mucosa and the gingiva in the anterior part of the rat mandible was seen to differ in pattern in these two areas. The differences found are shown in Fig. 2.

The oral mucosa continued from the oral vestibulum and converged conically into the high interdental papilla between the incisors. The papilla formed a conspicuous boundary between the right and left strips of gingiva. The interdental papilla was situated above the connective tissue junction between both halves of the mandible and any movement of one or both of its halves caused its compression. The mucosa covering the alveolus, including the interdental papilla, could be freely moved, such movement producing a series of shallow folds. In contrast to the mucosa, the gingiva was tough and

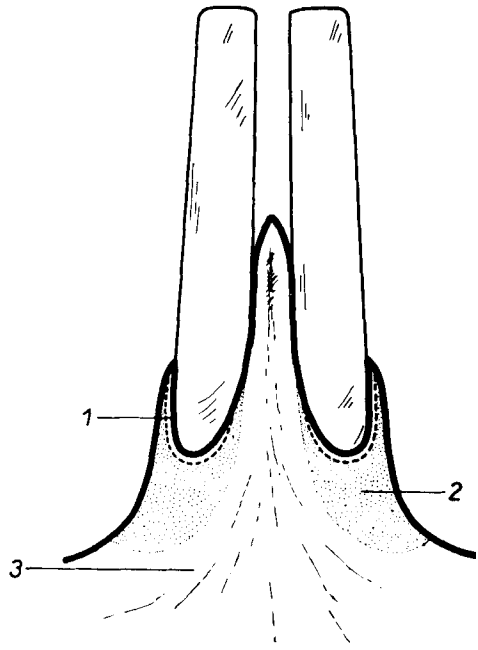

Fig. 2. Scheme denoting the avascular area (1), the gingiva (2), and the alveolar mucosa (3) associated with the lower incisor.

attached firmly to the alveolus and to the tooth wall. Its width narrowed towards the interdental papilla and in the interdental space it formed only a narrow strip in close approximation to the tooth. The mobility of the alveolar mucosa and the different pattern of its vascular architecture constituted the main differences between the two tissues. Histological study did not show these differences so markedly. The alveolar mucosa, in contrast to the gingiva, was covered by a slightly thicker layer of epithelium with a wavy keratinized layer.

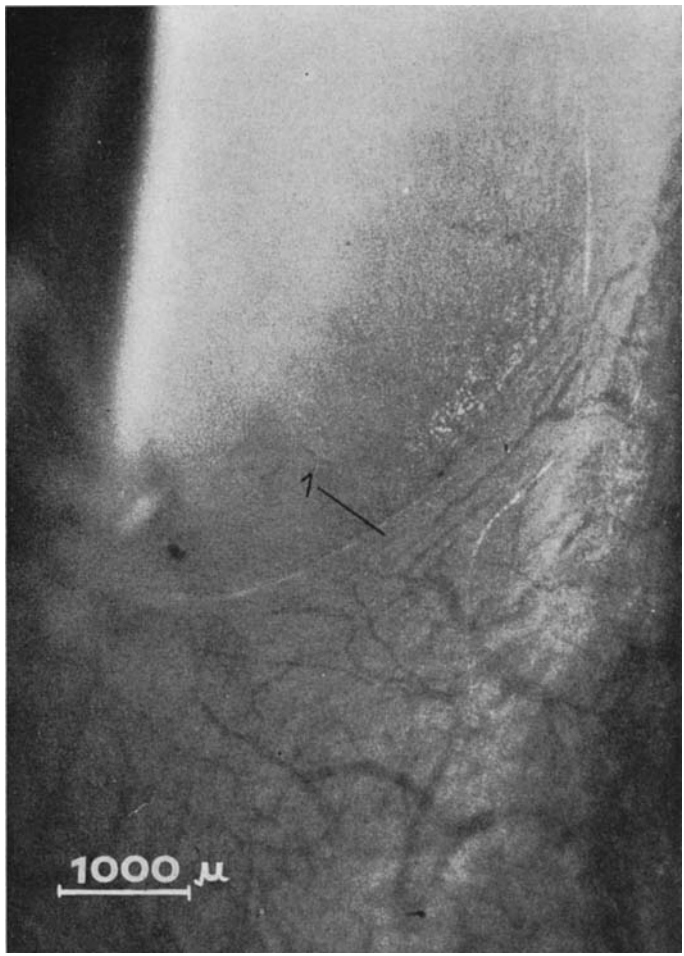

Fig. 3. Microcirculation in the gingiva associated with the lower incisor. Note the avascular area (1) at the gingival margin. Exposure with electronic flash, duration 1/1000 sec.

The architecture of the vascular bed in the gingiva was similar in both incisors. Both the arterial and venous part of the bed was situated at almost the same level of the tissue and was easily visible (Fig. 3). The main arteriole ran across towards the gingival margin where it branched into a capillary net with branches of various density. The entire capillary bed was always open without any area of resting capillaries such as could be seen in the alveolar mucosa. The blood from the capillaries drained into venules that ran in a similar fashion to the arterioles, towards the alveolar mucosa, there to enter

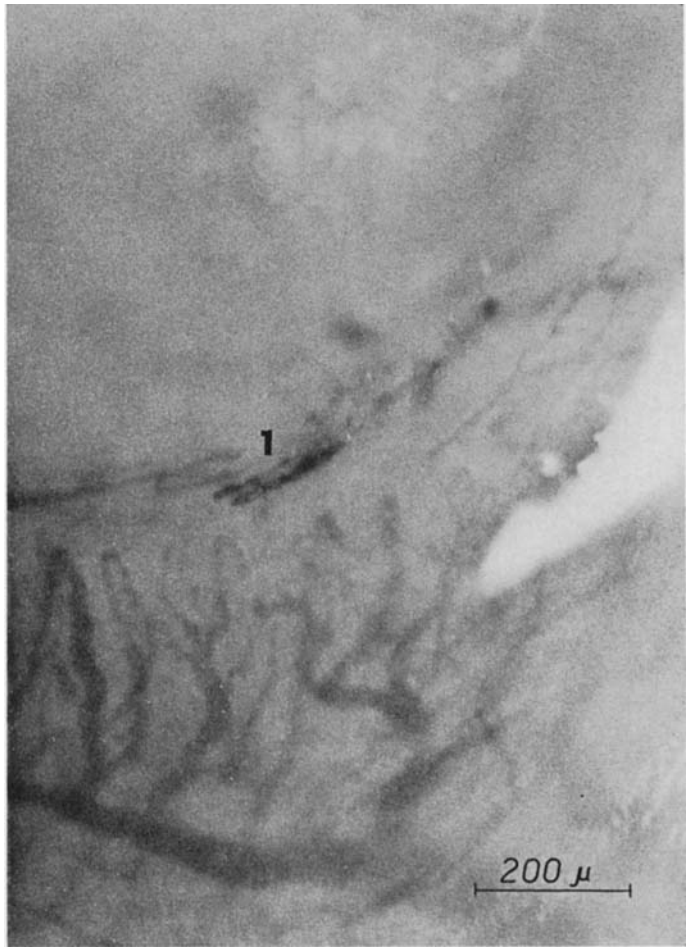

Fig. 4. Thrombosed capillaries (1) belonging to the vascular net supplying the enamel organ. These capillaries run parallel to the gingival margin. Exposure as in Fig. 3.

the massive venous network on the periphery of the alveolus. It was difficult to follow the course of vessels in the area of this venous network in the live animal because the thick venous trunks obscured the field.

The capillary net did not extend up to the margin of the gingival ridge but left a narrow band of avascular tissue near the periphery. Hence, the real margin of the gingiva became less visible than the corresponding line formed by the capillaries of the vascular bed. Between the margin of the gingiva and the tooth wall, sometimes even in the gingival sulcus, fragments of

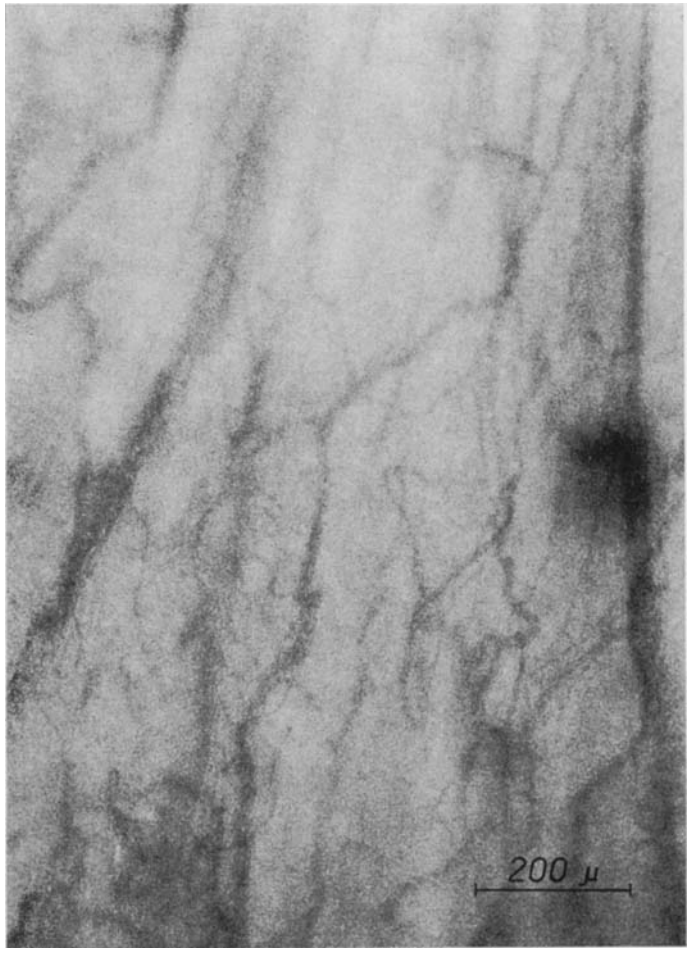

Fig. 5. Vasculature of the alveolar mucosa associated with the lower incisor. Exposure as in Fig. 3.

capillaries were observed that were filled with coagulated blood and ran parallel to the gingival margin (Fig. 4). When focusing on the deeper level of the tissue close to the tooth, capillaries running parallel with the fragments were seen. A comparison with the injected specimens confirmed that the capillaries belonged to the vascular net supplying the enamel organ.

Arterioles of the alveolar mucosa near its surface arose from deeper parts of the tissue and could be followed only for a short distance before they branched into the capillary net that formed a fine network just below the

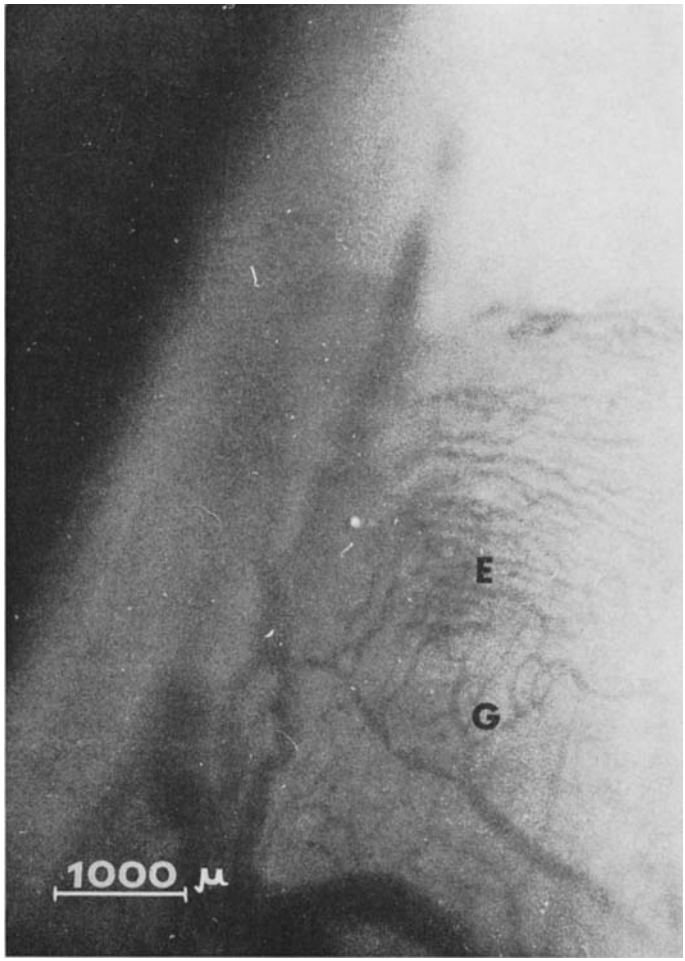

Fig. 6. Injected latex cast of the vascular supply of the interdental papilla.

surface. The venules coursed parallel to the mucosal folds slightly closer to the surface and could be followed for a longer distance. These vessels had to be investigated more gently than those in the gingiva because they were subject to compression more easily due to the shifting of the mucosa (Fig. 5).

The microcirculation in all parts of the interdental papilla was markedly poorer than in the alveolar mucosa and in the gingiva. Injected specimens showed, however, that the vascular bed of the interdental papilla was formed by a massive network situated centrally and corresponding in its shape to the interdental papilla. The venules drained the blood from a fine capillary net (Fig. 6) supplying the epithelium and continuing into the capillaries of the alveolar mucosa. Blood was conveyed to this net by several arterioles penetrating towards the surface between the venules.

DISCUSSION

The vascular supply of the gingiva and of the alveolar mucosa was investigated using vital microscopy and injected latex specimens. The two methods complemented each other and their combination proved to be of advantage. The vital microscopy method was considered superior for the investigation of the function of the vascular supply, though it produced insufficiently complete results for total reconstruction of the vascular bed. The vessels were superimposed so that it was impossible to penetrate into the deep layers of the tissue. In turn, the injected specimens exactly reconstructed the entire vascular supply and permitted the following of individual vessels in their entire course. They were, however, not suitable for following changes in the function of the vascular supply.

The interdental papilla of the rat incisor in the mandible was not analogous to that of the human dentition. Its main part was formed by the alveolar mucosa with the vascular supply being analogous to the latter. The gingiva formed symmetric bands on both sides of the interdental papilla and its blood supply was of a different type.

The poor microcirculation in the interdental papilla was an unexpected finding, especially as the injected specimens showed a rich vascular supply in in this region. The observed differences may be partly due to reduced visibility of the vessels in the interdental papilla, and partly real differences, due to an increased number of resting blood vessels in this area.

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SUMMARY

The vascular supply of the gingiva and of the alveolar mucosa surrounding the mandible incisor in the rat was studied *in vivo* and in injected latex specimens. Vital microscopic observations were performed on 90 animals, 15 specimens were injected and histological material evaluated additionally in 5 rats.

The vascular supply in the gingiva differed clearly from the pattern observed in the alveolar mucosa. The vascular bed in the gingival tissue, in contrast to the alveolar mucosa, contained no resting capillaries, and the arterioles and venules were situated approximately at the same level. Close to the margin of the gingiva the remains of the vascular bed of the now non-existent enamel organ were observed.

The combination of vital microscopy and the use of injected latex specimens was of advantage, and the methods complemented each other.

RÉSUMÉ

VASCULARISATION DE LA GENCIVE ET DE LA MUQUEUSE ALVÉOLAIRE CHEZ LE RAT

I. DESCRIPTION DE LA MÉTHODE ET DE LA MORPHOLOGIE

La vascularisation de la gencive et de la muqueuse alvéolaire autour de l'incisive inférieure du rat a été étudiée *in vivo* et sur des spécimens obtenus par injection de latex. Des observations microscopique vitales ont été exécutées sur 90 animaux, des injections ont été effectuées sur 15 spécimens et une évaluation histologique a de plus été faite sur 5 rats.

La vascularisation présentait dans la gencive en disposition nettement différente de la disposition observée dans la muqueuse alvéolaire. Dans le tissu gingival, le lit vasculaire, contrairement à ce qui se passait dans la muqueuse alvéolaire, ne contenait pas de capillaires all repos, et les artérioles et veinules étaient situées à peu près au même niveau. Près du rebord gingival, on observait les restes du lit vasculaire de l'ancien organe adamantin.

C'était un avantage de combiner la microscopie vitale et l'utilisation de spécimens obtenus par injection de latex, ces deux méthodes se complétant mutuellement.

ZUSAMMENFASSUNG

DIE BLUTVERSORGUNG DER GINGIVA UND DER ALVEOLARSCHLEIMHAUT IN DER RATTE

I. UNTERSUCHUNGSTECHNIK UND BESCHREIBUNG DER MORPHOLOGIE DES GEFÄSSBETTES

Die Blutversorgung der Gingiva und der alveolären Schleimhaut in der Umgebung des Unterkieferschneidezahnes wurde bei der Ratte an *in vivo* und mit Latex injizierten Präparaten untersucht. An 90 Tieren wurden vitalmikroskopische Beobachtungen ausgeführt. 15 Versuchstiere wurden mit der Injektionstechnik verarbeitet und das histologische Material in weiteren 5 Ratten bewertet.

Die Blutversorgung der Gingiva unterschied sich deutlich von dem Bild, das in der alveolären Schleimhaut beobachtet wurde. Im Gegensatz zur alveolären Mukosa enthielt das Blutbett im Gingivagewebe keine Ruhekapillaren, und die Arteriolen und Venolen befanden sich ungefähr in gleicher Höhe In der Nähe des Gingivalsaums wurden die Reste des Gefässbettes. des jetzt nicht mehr existierenden Schmelzorgans beobachtet.

Die Verbindung der Vitalmikroskopie mit der Anwendung von Latexpräparaten erwies sich als vorteilhaft und die Methoden ergänzten sich gegenseitig.

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