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THE DEVELOPMENTAL WEAKNESS OF THE INTERDENTAL EPITHELIUM[1]

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ABSTRACT

Ten *Cynemolgus* monkeys of mixed dentition were studied in this investigation in order to evaluate, in various developmental stages, the structural characteristics of the interdental epithelium. Histological study revealed that the interdental epithelium develops from the juxtaposition of the reduced enemel epithelium of two erupted neighbouring teeth. This vestigial structure of a highly specified tissue explains the evidences of nonkeratinization, the low cellular activity and the low ability of repair. These evidences are in harmony with the conclusions of the morphological and histochemical studies on the same structure by many investigators. The result is convincing that these developmental weaknesses play important role in the initiation of periodontal disease because of their failure in protecting the underlying connective tissues from the external irritants which always exist in oral cavity.

Under the suspicion of being the primary site of the interdental initial lesion of periodontal disease, the interdental epithelium has been studied by many investigators in recent years (1-7). The author also performed morphological and histochemical studies (8, 9) on the same structure in 1963 and 1964 respectively. The results proved that the interdental epithelium is structurally weak to protect itself from external irritants which always exist in the surrounding about the teeth and their supporting tissues and are regarded as the etiologic factors of periodontal disease in many textbooks.

In order to check the plausibility of the hypothesis, a series of studies on the interdental epithelium was planned to be carried out. The first study of this series was to make microscopic examination of the interdental epithelium in different developmental stages to find out the origin of the structural characteristics which represent its weakness biologically.

MATERIALS AND METHODS

The experimental animals of choice were ten *Cynemolgus irus* monkeys of mixed dentition. Since their dental pattern is morphologically resemble closely to that of human being (10, 11), they afford materials representative of the consecutive periods of the development of human teeth.

The monkeys were sacrificed successively by means of intraperitoneal injections of over doses of sodium pentobarbital. For the purpose of examination, "in situ" blocks of tissues incorporating dental, interdental and periodontal tissues in biologic relationship,

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both jaws of each animal were dissected immediately after sacrifice and the pertinent tissues cut into small blocks. The minimal amount of tissues desired for studies consisted of two teeth, in situ, in each block.

All the blocks were immediately fixed in 10% buffered neutral formalin for two weeks. After decalcification in buffered sodium citrate-citric acid solution, the blocks were embedded in paraffin, cut into either buccolingual or mesio-distal sections of 8 microns, and then stained by hematoxylin and eosin.

The interdental epithelium between two erupted teeth, two unerupted teeth, and an erupted and an unerupted teeth were examined microscopically to trace the developmental source of the matured interdental epithelium and of its vestigal type of structure.

Microphotographs were made for analysis and interpretation.

RESULTS

In the bell stage of tooth development, the enamel organ consists of four layers of cells (*Fig. 1*), namely, inner enamel epithelium or the ameloblastic layer, stratum intermedium, stellate reticulum and outer enamel epithelium.[1] The ameloblastic layer is a single layer of tall columnar cells (*Fig. 2*) which are the formative cells of enamel. The next several layers of squamous cells external to the ameloblastic layer are the cells of stratum intermedium. The stellate reticulum layer consists of many star-shaped cells with their processes connected with each other to form a network. The outermost layer is the outer enamel epithelium which in the earlier stages of tooth development is a single layer of cuboid cells. In the bell stage, this layer of cells develops numerous small folds which enlarge the surface to get more blood supply from the surrounding connective tissue for the developing tooth germ (*Figs. 1, 2*).

After formation of enamel the four layers of cells reduce their volume to form a stratified epithelium known as reduced enamel epithelium (*Figs. 2, 3, 4*). The ameloblasts also shorten gradually to the degree that they can no longer be distinguished from the other cells of the reduced enamel epithelium (*Figs. 4, 5, 6*).

As the tooth erupts, its reduced enamel epithelium also approaches the covering oral epithelium and the reduced enamel epithelium of the neighbouring tooth (*Figs. 3, 4*) at the same time. The reduced enamel epithelium on the proximal surfaces of the two neighbouring teeth thus juxtaposed at their contact area. When an unerupted tooth moves occlusally, the connective tissues between the reduced enamel epithelium and the covering oral epithelium gradually disappears and finally, the two epithelia fuse together. After the crown of the tooth emerges into the oral cavity, only a narrow strand of the fused epithelia can be found between this tooth and its trupted neighbour above their contact area (*Fig. 5*). Since the teeth are continuously erupting, this epithelial strand ultimately breaks at its center, and its buccal and lingual halves soon shrink to cover the corresponding interdental embrassures. They are known as interdental papillae. A young interdental col is thus formed by the reduced enamel epithelial portions of the buccal and lingual interdental papillae (as its buccal and lingual slopes) and the juxtaposed enamel epithelium below the contact area of two neighbouring teeth (as its central portion) (*Fig. 6*). Both the bucco-lingual (*Fig. 6*) and the mesio-distal (*Fig. 7*) sections of an interdental col show this vestigial tissue developed from highly specialized enamel epithelium. It is a thin, nonkeratinized stratified epithelium with low cellular activity (8, 9), and inflammatory infiltration can be found right below this interdental epithelium shortly after the eruption of the teeth. A diagram (*Fig. 8*) shows the structure of an interdental col with one tooth in position.

DISCUSSION

The development of the interdental gingival septum has been discussed by a number of investigators (2-5, 12-29). As found in this experiment (*Figs. 1-4*), it is almost

generally agreed that during the late stage of tooth development the stellate reticulum layer of the tooth germ reduces its thickness to a degree that the cells are no longer star-shaped but become compact with other cells of the tooth to appear as a syncytium of cells. This is known as "reduced enamel epithelium". As soon as the enamel matrix is fully formed, there occurs another involutionary process in the ameloblasts, which, originally in high columnar shape (*Figs. 1-3*), gradually shorten and degenerate, then morphologically lose their identity among other cells of the reduced enamel epithelium (*Figs. 4-7*). When the tooth grows and erupts to secure its contact with neighbouring tooth, the connective tissue between these two teeth and that between the erupting tooth and its covering oral epithelium will show atrophy followed by desmolysis (12, 30-35). This destruction of connective tissue permits the approach of the erupting tooth to its neighbour and to the covering oral epithelium. This process of contact may be seen in *Fig. 3* and *Fig. 4*. When these two teeth come into contact, and, as their interproximal surfaces are juxtaposed, their reduced enamel epithelium will be correspondingly joined to cover the soft tissues in the entire interdental area, thus forming the interdental col (*Fig. 7*). The reduced enamel epithelium above the contact area will fuse with its oral epithelium (*Fig. 5*), and will then break at a central point above the contact area, separating to form the buccal and lingual interdental papillae and the buccal and lingual sloping contours of the interdental col as in *Fig. 6* and *Fig. 8*. The interdental gingival tissue between two teeth without contact relation will not separate at its center because there is neither desmolysis of the connective tissue nor fusion of oral epithelium with enamel epithelium in the area between these two teeth. Therefore it is a pyramidal elongation of the mucous membrane of the jaw extending from the buccal to the lingual side between these two teeth and covered by oral epithelium (1) which is identical with the gingival epithelium and will not be brought into specific consideration here.

The interdental epithelium between two contacted teeth derived, as has been described above, from a degenerated highly specialized epithelium named reduced enamel epithelium. As such the cells of a highly specialized tissue do no longer have the ability to proliferate or repair. According to Noyes (36) and Orban (12), the specific functions of the odontogenic epithelium are: to determine the size and the shape of the future crown, to produce enamel matrix, to stimulate the underlying connective tissue to form the dentin, to give rise to Hertwig's epithelial sheath which guides the shape of the forming root, to promote tooth eruption by its desmolytic action, and to produce enamel cuticles and reduced enamel epithelium. After a tooth has erupted, the reduced enamel epithelium becomes a thin stratified epithelium consisting of several layers of squamous cells. This degenerated tissue, after completed its specific functions, can simply cover the crevicular as well as the interdental portions of gingiva without any other functions of the oral epithelium, i.e. keratinization, repair, active mitosis etc. Unfortunately, these functions are of vital importance in protecting the underlying tissue from the irritants which may cause periodontal disease (2, 5, 37-45). The thin nonkeratinized interdental epithelium without high cellular activity and the consistantly existance of chronic inflammatory infiltration in its underlying connective tissue (*Figs. 6, 7*) clearly demonstrate these developmental weaknesses of the interdental epithelium. The evidences are positive confirmations of the results found in the morphological and the histochemical studies of the same structure (1-9).

LITERATURE CITED

1. COHEN, B. 1963. Initiation of periodontal disease; a review of research; 1958-1962. *Acad. Rev. Calif. Acad. Periodont.* **11:** 85-90.
2. COHEN, B. 1959. Pathology of the interdental tissues. *Dent. Pract. and Dent. Rec.* **9:** 167-173.
3. COHEN, B. 1960. Epithelial reactions in periodontal disease. *Abstr. J. Dent. Res.* **39:** 1088-1089.
4. FISH, E. W. 1961. Etiology and prevention of

periodontal breakdown. *Acad. Rev. Calif. Acad. Periodont.* **9:** 45-55.
5. KOHL, J. T., and H. A. ZANDER. 1861. Morphology of interdental tissues. *Oral Surg., Oral Med. and Oral Path.* **14:** 287-295.
6. STAHL, S. S. 1963. Morphology and healing pattern of human interdental gingivae. *Amer. Dent. A. J.* **67:** 48-53.
7. BAUME, L. J. 1963. La keratinization de epithelium. *Parodontologie.* **17:** 4-13.
8. SHYU, K. W. 1964. Morphological studies on interdental epithelium in the etiology of periodontal disease. *Chinese Med. J.* **11:** 137-152.
9. SHYU, K. W. 1965. Histochemical study on the interdental epithelium in the etiology of periodontal disease. *Bull. Inst. Zool., Acad. Sinica* **4:** 1-9.
10. SANDERSON, I. T. 1957. *The Monkey Kingobm* Hamith Hamilton, London, pp 120-137.
11. BAUME, L. J., and H. BECKS. 1950. The development of the dentition of *Macaca mulatta. Amer. J. Orthodont.* **36:** 723-748.
12. ORBAN, B. 1957. *Oral Histology and Embryology,* 4th ed. Mosby, St. Louis. p 238.
13. COHEN, B. 1959. Morphological factors in the pathogenesis of periodontal disease. *Brit. Dent. J.* **107:** 31-39.
14. COHEN, B. 1960. Comparative studies in periodontal diseases. *Roy. Soc. Med. Proc.* **53:** 275-280.
15. FISH, E. W. 1958. An enterprise in dental research. *Ann. Roy. Col. Surg. England.* **22:** 287-310.
16. KRONFELD, R. 1933. *Histopathology of the Teeth and their Surrounding Structures.* Lea and Febiger, Philadelphia. pp 260-262.
17. BAUME, L. J. 1952. Observations concerning the histogenesis of the epithelial attachment. *J. Periodont.* **23:** 71-84.
18. MILLER, S. C. 1943. *Textbbok of Periodontia.* 2nd ed., Blakiston, Philadephia. pp 28-30.
19. BECKS, H. 1929. Normal and pathologic pocket formation. *Amer. Dent. A. J.* **16:** 2179-2195.
20. MARSLAND, E. A. 1951. A histologic investigation of amelogenesis in rats. *Brit. Dent. J.* **88:** 251-266.
21. WELLINGS, A. W. 1940. A critical review of recent histological and other researches on Nasmyth's membrance, etc. *Proc. Roy. Soc. Med.,* **33:** 563-579.
22. COHEN, B. 1959. Studies of the interdental epithelial integument. *Abstr. J. Dent. Res.* **38:** 1219.
23. COHEN, B. 1962. Further studies of the periodontal epithelium. *Abstr. J. Dent. Res.* **41:** 1263.
24. TONGE, C. H. 1962. Cell patterns in the differentiating human tooth bud. *Abstr. J. Dent. Res.* **41:** 1261.
25. HUNT, A. M., and K. J. PAYNTER. 1963. The role of cells of the stratum intermedium in the development of the guinea pig molars. *Arch. Oral Biol.* **8:** 65-78.
26. ORBAN, B., H. BHATIN, J. A. KOLLER, and F. M. WENTZ. 1956. The epithelial attachment. *J. Periodont.* **27:** 167-180.
27. USSING, M. J. 1955. The development of the epithelial attachment. *Acta Odont. Scand.* **13:** 123-154.
28. WAERHAUG, J. 1952. The gingival pocket. *Odont. Tidskr. 60, Suppl.* **1:** 1-186.
29. CHASE, S. 1926. The origin, structure and duration of Nasmyth's membrane. *Anat. Rec.,* **33:** 357-365.
30. AISENBERG, M. and A. AISENBERG, 1951. Hyaluronidase in periodontal disease. *Oral Surg., Oral Med. and Oral Path.* **4:** 317-326.
31. ENGEL, M. B. 1951. Some changes in the connective tissue ground substance associated with the eruption of the teeth. *J. Dent Res.* **30:** 322-333.
32. GERSH, I. and H. R. CATCHPOLE. 1940. The organization of ground substance and basal membrane and its significance in tissue injury, disease and growth. *Amer. J. Anat.* **85:** 457-470.
33. RAY, H. and R. ORBAN. 1950. The gingival structure in diabetic mellitus. *J. Periodot.* **21:** 85-98.
34. WEIMANN, J., SVOBDA, and R. WOODS. 1945. Hereditary disturbances of enamel formation and calcification. *Amer. Dent. A. J.* **32:** 397-406.
35. GERSH, I. 1951. The ground substance of connective tissue and its transformation in normal and pathologic conditions. *Oral Surg., Oral Med. and Oral Path.* **4:** 157-173.
36. NOYES, F. B. ED. 1960. *Oral Histology and Embryology.* 8th ed. Lea and Febiger. Philadelphia. p 62.
37. FISH, E. W., and I. MACLEAN. 1936. The distribution of oral streptococci in the tissue. *Brit. Dent. J.* **61:** 336-362.
38. FISH, E. W. 1936. Bone infection. *Amer. Dent. A. J.* **26:** 691-712.
39. COHEN, B. 1963. An approach to the problem of parodontal disease. *Parodontalgie.* **17:** 13-19.
40. SKILLEN, W. G. 1930. The morphology of the gingivae of the rat molars. *Amer. Dent. A. J.* **17:** 645-668.
41. SCHULTZ-HAUDT, S. D., and S. FROM. 1961. Dynamics of periodontal tissue, I the epithelium. *Odontolgisk Tidskrift,* **69:** 431-460.
42. DEWAR, M. R. 1955. Observations on the composition and metabolism of normal and inflammed gingivae. *J. Periodont.* **26:** 29-39.
43. THEONARD, J. C. and H. W. SCHERP. 1962.

Histochemical demonstration of acid mucopolysaccharides in human gingival epithelial intercellular spaces. *Arch. Oral Biol.* **7**: 128-136.
44. NUCKOLLS, J. 1952. Development of the periodontal lession. *J. Periodont.* **23**: 149-155.
45. POWELL, R. N., and A. G. ALEXANDER. 1965. The treatment of periodontal disease. *Brit. Dent. J.* **119**: 522-524.

LEGEND OF FIGURES

Fig. 1. A portion of an enamel organ in late bell stage showing its four layers of cells. P. predentin. I. inner enamel epithelium or ameloblastic layer. S. I. stratum intermedium. S. R. stellate reticulum. O. outer enamel epithelium. × 100

Fig. 2. Early reduced enamel epithelium. The four layers of cells, except the inner enamel epithelium, have reduced their height to form a stratified epithelium consists of serveral layers of cells. × 320

Fig. 3. The erupting teeth. The second molar is unerupted. Note the reduced enamel epithelium of both teeth. The ameloblasts of the second molar are still in tall columnar shape, but not those of the first molar. The entire reduced enamel epithelium consists of only a few layers of cells like that in *Fig. 2.* × 20.5

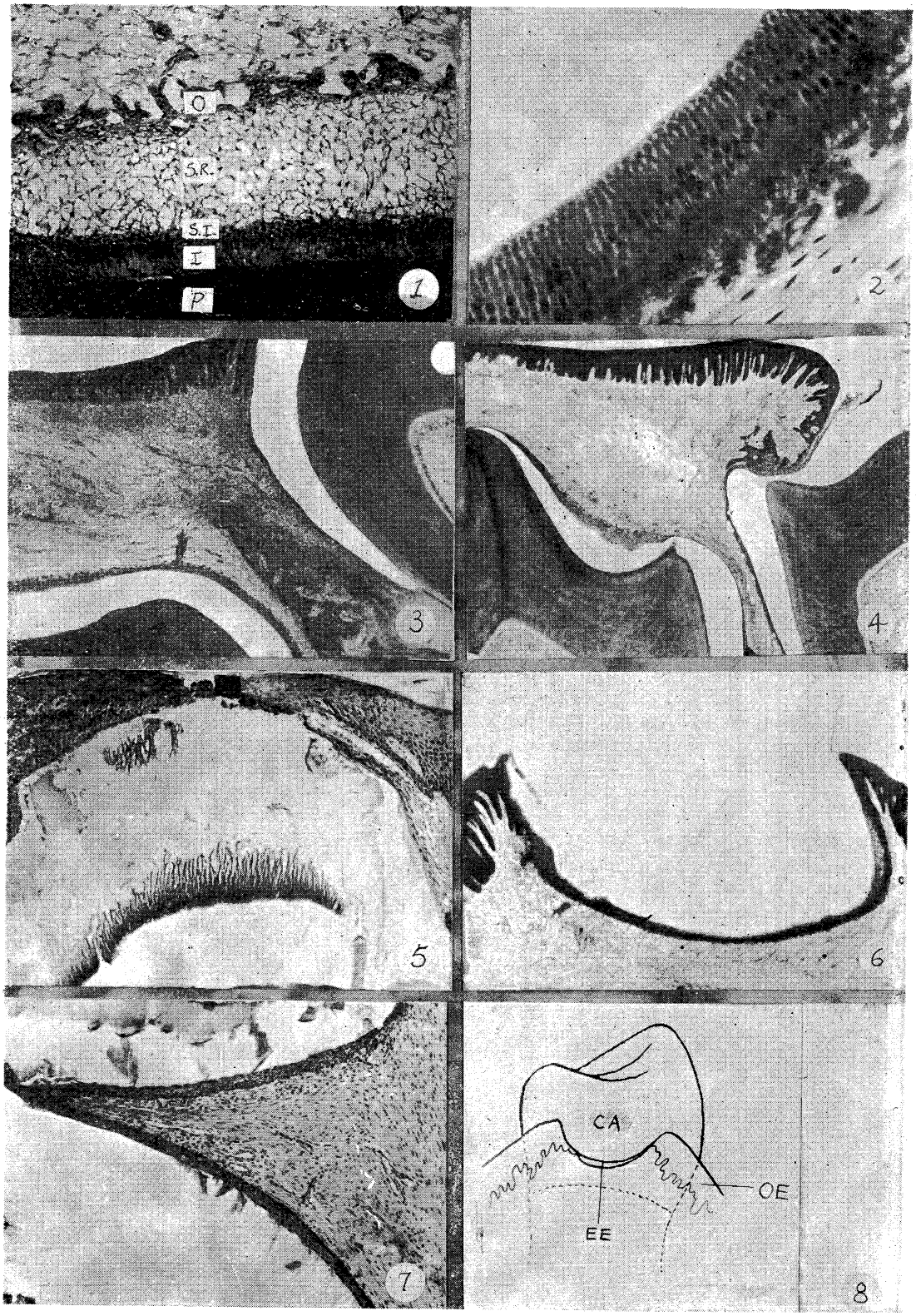
Fig. 4. In the eruption stage later than *Fig. 3*, further eruption brings the reduced enamel epithelium of the interproximal surfaces of both molars into juxtaposition. The ameloblasts have already reduced to be flat cells. × 20.5

Fig. 5. The bucco-lingual section of the epithelial strand above the contact area between mandibular. left deciduous cuspid and first molar. Note the fusion of oral epithelium and reduced enamel epitheliume The central portion of this strand is about to break to form the buccal and lingual interdental papillae and the two end slopes of the interdental col. The central portion of the col will be formed by the juxtaposition of the enamel epithelium of both teeth below their contact area as *Fig. 4* has shown. × 69.5.

Fig. 6. After the breakdown of the central portion of the epithelial strand in *Fig. 5*, an interdental col formed, covering by enamel epithelium which fuses with oral epithelium at both the buccal and lingual ends of the col. × 19

Fig. 7. The mesio-distal section of newly formed interdental col showing the juxtaposition of the reduced enamel epithelium of both teeth. The tip of this pyramid is the central point of the col. × 69.5

Fig. 8. A diagram showing the structure of an interdental col. CA. contact area. EE. enamel epithelium. OE. oral epithelium.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