A CASE OF THE DENTINAL TUBULES OF ENORMOUS SIZE AND CAPILLARIES FOUND IN HUMAN TOOTH

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The size of ordinary dentinal tubules is in the range from 1.0 to 4.0 microns in diameter, except for those dentinal tubules of 5.0 micron⁶⁾ found occasionally in the crown part of molars. So far dentinal tubules over 6.0 micron in diameter have not been reported.

On the other hand, with regard to occurrence of capillaries of dentine, it is well known that they are present in secondary dentine in calcified state, and in certain species of fish they occur as the vasodentine serving as nutritive channels.

The present authors found unexpectedly in the crown dentine of a third molar (horizontal semi-impacted) occurrence of dentinal tubules of enormous size and capillaries, which were thought to represent considerable deviation from the normal.

The findings are as follows.

A material tooth was decalcified with Plank and Rychlo's⁷⁾ mixture consisting of 2.0 g. of $AlCl_3$, 8.5 ml of HCl , 5.0 ml of formic acid, and distilled water to a total of 100 ml. Following the routine procedure, the tooth was embedded in celloidin, and serial cross-section from 10 to 15 microns were prepared, and these were stained with hematoxylin-eosin, Gomori's silver methods.

As shown in Diagram, in the crown portion of dentine (cusp dentine), there were found the tubules of enormous size approximately 8.0 to 12.5 microns in diameter sparsely distributed. These abnormal forms were not seen throughout the entire length of the dentinal tubules, but they were only local enlargement of the tubules occurring in the middle layer of crown dentine, and in the range from 100 to 300 microns in length. The dentinal fibers in the tubules shrank considerably.

On the other hand, there were in the vicinity of the tubules also cap-

illaries, approximately 10 to 16 microns in diameter, a part of which still showing vascular appearance, and another part calcified, and still another showing rudimentary appearance. Also, the capillaries dwindled progressively toward the pulpal direction, and no connection thereto was observed.

DISCUSSION

Available knowledges concerning the dentine formation fail to provide us any plausible explanation as to the true cause of the present cases in the morphological pattern of the dentinal tubules, although we have no doubt about its being some indication of an unusual event that has occurred in the course of the dentine development. As an attempt to provide a working hypothesis for the possibility of occurrence of such an unusual, not yet unexplainable event, an interpretative comment is given as follows.

A traditional and, in a sense, also currently valid theory for the dentine formation in the tooth germ begins first with cellular differentiation of odontoblasts and their arrangement over the entire surface of the dental papilla. Each cell of the odontoblasts recedes from the amelodentinal junction toward the direction of the future pulp, extending respectively several fibers of the dentinal processes from its end. As the recession proceeds, layers of the predentine come to be laid down one after another, and these in turn are calcified from the outermost layer on toward those of innerside, until the whole layers are completely calcified to form the mature dentine.

If such is the true mechanism with respect to the behaviour of odontoblasts in the dentine formation, a conclusion emerges that, with progressive recession of the uppermost layer of odontoblasts, there must ensue a corresponding reduction in the number of odontoblasts, because the surface area of the dental papilla, which had been originally occupied by the host of odontoblasts, becomes naturally reduced with every recession of the odontoblasts toward the inner direction. This is most obvious when one considers a large difference of the surface areas which the dental papilla shows at the initial stage and at the final stage of the odontoblasts recession to reach the pulpal wall.

It follows that, toward the final stage of the dentine formation when the pulp has been largely shaped, there should take place a selection process for the odontoblasts receding toward the inner and narrower spaces as to their survival. This should bring out changes either in the number or in the morphology of odontoblasts to accommodate themselves in

the increasingly narrower areas, some of them disappearing with death and some losing the normal cellular form in this process. Under these circumstances, a question arises as to what would be the fate of the dentinal fibers belonging to those odontoblasts that are suffering death or disfiguring. Our interpretation to this point is that the main stems of these dentinal processes may be sometimes terminated halfway or sometimes be fused with those main stems of neighboring cells to form the dichotomous branches that are usually observable in the deeper layers of the dentine.

There are available two lines of theories proposed for the mechanism of the dichotomous branches formation in the dentinal tubules. Röse (1893)⁵⁾ has stated that individual odontoblast originally had several fibers of the dentinal processes which might under certain conditions undergo a protoplasmic fusion between each other to form the terminal branches and sometimes lateral branches at certain stages of development. However, at much delayed stages of development, the dichotomous branches might be chiefly formed through similar type of fusion of the dentinal processes.

The proposal of Röse has been later partially substantiated by Fujita and Komai (1936)¹⁾, and Nevill (1955)⁴⁾ through their respective studies on the development of superficial layers of the dentine. However, these studies seem to have dealt mainly with the lateral branches, and specially those branches with larger sizes and simpler contours frequently seen in relatively superficial layers of the dentine, rather than with the so-called dichotomous branches. It is, therefore, doubtful whether these studies would serve to explain adequately the occurrence of the dichotomous branches that are usually seen in the middle to deeper layers of the dentine.

On the other hand, Kölliker (1902)²⁾ (1922)³⁾ was of the opinion that the dichotomous branches would be produced in the deeper layers of the dentine when two or more odontoblasts, adjoining each other, were fused into a single cell, or when the dentinal fibers of an odontoblast, after the death of its cell body, came into fusion with those fibers of adjoining cells. This view of Kölliker lacked any detailed description of the matter, nor was it founded on sufficient experimental evidences, and hence, was refuted by Fujita et al. as being unacceptable.

Kölliker's opinion, however, would seem to have explained fairly well certain phases of the problem in question, when we see it from our own viewpoint. The facts that the dichotomous branches more frequently occur in the middle to deeper layers of the dentine, that some of the dic-

hotomous branches show extremely obtuse acute angles in the way of branching, and that normally the odontoblasts, unlike various other cells of the body, can readily make a protoplasmic fusion with neighboring cells by means of their lateral processes, all these facts seem to favor the opinion of Kölliker to explain, even partially, the cause of the dichotomous branches.

In view of the liability of odontoblasts cells to fuse between themselves, it may be reasonable to assume that they are morphologically very adaptable to any extraneous influence whatever, and thus, there may be many chances that a dentinal process belonging to a dying odontoblast can fuse with the one of the adjoining cell at its radical portion to form the characteristic pattern of the dichotomous branch. When this happens, it may be only natural that we observe much more enlarged size of the dentinal tubules, especially at those sites of branching where such fusion had taken place. In fact, these findings are generally observed in our routine preparations of the dentine sections.

Fig. 7 and 8 show the preparations of the dentinal fibers and tubules having diameters of relatively large sizes, both of which were obtained from the same specimens from which were found the tubules of enormous size reported in this communication. If it is allowed to make further inference, dentinal tubules with increasingly larger sizes would be produced in the dentine whenever more severe effects of some abnormal events should intervene into normal process of formation of the dichotomous branch. The present case of the enormous dentinal tubules may have been the products of such aberration of unknown nature occurring in the formative stages of the dentine development.

As to the reason for the presence of blood capillaries in our dentine preparations, we may be allowed to infer that they were originally those capillaries that ran in the periphery of odontoblasts, which came to be mummified in situ in the sudden calcification occurring along with the production of abnormal dentinal tubules described.

Although the present cases of abnormal dentinal tubules have been demonstrated in an abnormally erupted tooth, we are expecting to find similar abnormal dentinal tubules with more or less enlarged diameters even in normal tooth specimens with more extensive studies in this line.

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LEGENDS OF THE DIAGRAM AND FIGURES

Diagram. Showing found portion of the present case.

Fig. 1 The dentinal tubules of enormous size in cross-section with silver staining.

Fig. 2 The dentinal tubules of enormous size in cross-section with hematoxylin-eosin.

Fig. 3 Capillaries embedded, with silver staining.

Fig. 4 High magnification of Fig. 3

Fig. 5 The dentinal tubules of enormous size connected with ordinary one, with silver staining.

Fig. 6 Capillaries of cross-section with silver staining.

Fig. 7, 8 Enlarged dichotomous branch portion of dentinal tubules.

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