Comparative Study of the Single Cilium of Dental Pulp Cells

By

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Generally, the morphology of cilia and flagella has been described extensively and their basic structural uniformity is well known. There are 9 peripheral filaments and 2 central filaments, i.e. a “9+2” filament pattern. Usually this is said to be the regular type of the cilium. Another type of cilium consists of only 9 peripheral filaments in the retinal rod of Rabbits (Robertis, '58), mice (Tokuyasu and Yamada, '58), the parietal eye of lizards (Eakin and Westfall, '58), pituitary of the rat (Hubert, et al., '74), nephrons of rat and human kidney (Webber and Lee, '75), and others. This latter type is a “9+0” filament pattern.

In a previous report an unusual type of cilium was shown in unerupted dog teeth (Kubota, et al., '75). Specimens were taken from pulp cells of unerupted successional canine teeth in young dogs. These cilia varied in their filament patterns. The peripheral ring of tubules numbered 4 to 9. Seven peripheral filaments appeared in 45% of the cases observed. In these cilia, a single central filament was observed in almost all cilia except those with 9 peripheral filaments. The central filament is in the shape of a doublet, the same as the peripheral filaments. When the peripheral filaments number 9 the central filament was absent. This occurred only close to the cell of origin.

Some observers have shown ciliary filaments of the “7+2” type between the odontoblasts in human teeth (Frank, '69, Nagai, '70). However, Han ('68) observed a 9+0 filament pattern in the fibrobrasts of the rat and guinea pig incisor pulp.

Materials and Methods

The Human third molar and adult dog canine teeth were used for this study. The pulp tissue of adult dog canine teeth was taken by the same method as previously described for young dogs (Kubota, et al., '75). Twenty human impacted third molars from subjects of 18 to 23 years old (both sexes) were also used. They were obtained immediately after extraction. These teeth were fractured by means of a dental diamond disk and chisel and were fixed in a solution of 2% glutaraldehyde buffered at pH 7.4 with sodium cacodylate for about 2 hrs. Then the pulp tissue of the pulpal horn area was removed.

Both dog and human material were post-fixed in 2% osmium tetroxide for one hour. They were then dehydrated through graded alcohols, embedded in Epon 812 and sectioned on a Porter-Blum microtome. These sections were then stained with a saturated solution of uranyl-acetate in distilled water and an aqueous solution of lead citrate for transmission electron microscopy (Reynolds, '63).

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Observations

In the pulp tissue of adult dog teeth, the ciliated cell was observed by transmission electron microscopy. Its long ciliary shaft is shown in longitudinal section in Fig. 1, A. The basal portion of the ciliary shaft is located in the cell and is part of a diplosome. The remainder of the cilium projects from the cell body. In transverse section numerous cilia have been observed. When nine peripheral filaments were present the central filament was always absent (Fig. 2, A, B). This pattern appeared in

![Fig. 1. Longitudinal section of cillum. The shaft projects from a diplosome. Adult dog tooth pulp tissue (A) and human (B).](image)

![Fig. 2. Transverse sections of cilia in the adult dog. Some cilia are 9+0 pattern; (A, B). Others are irregular; (C–F).](image)
about 70% of cases observed. This is the 9+0 filament pattern. Other cilia possess various numbers on filaments, usually fewer than eight (Fig. 2, C–F). The arrangement of the filaments on the cilia was irregular. Furthermore, there were various shapes among the filaments such as “doublet”, “singlet” and “hock”. In several cilia (17%), a central filament was present (Fig. 2, C).

In human dental pulp cells, the single cilia were also investigated (Fig. 1, B). These cilia usually arose from a diplosome within the cell body. In transverse section nine dense double filaments are arranged around the circumference. These are disposed in a 9+0 arrangement (Fig. 3, A). Several cilia show an irregular number and arrangement of peripheral filaments (Fig. 3, B–F). In a small number of cilia a central filament is present (Fig. 3, C, D). This central filament corresponds closely to the structure of peripheral filaments in the same cilium. The peripheral filament numbered always less than eight, the same as in adult dog teeth.

Discussion

A comparative review of the ciliary structures with adult dog and human dental pulp tissue was undertaken for purposes of comparison with our previous report of the young dog’s ciliary structure (Kubota, et al., ’75). The cilia described in the previous report differed from the usual pattern in the number of doublets in the peripheral ring. And the unusual central filament was indistinguishable from the peripheral ones. Almost all cilia had fewer than eight peripheral filaments.

In comparison, pulp cells of adult dog and human teeth possess many ciliary shafts that possess 9 peripheral filaments. This difference is present in 30% of the cases observed. This is a 9+0 pattern. The filaments in the center possess a double shape, the same as the peripheral ones. The number of filaments seems to correlate with the germ layer origin of the parent cell. Ectodermal cells have a 9+2 filament pattern while mesodermal cells possess 7+2, 9+0, 8+1, 8+0, 7+1, 7+0 etc. However, since the central filament shape is the same as the peripheral one, it may be
considered that some peripheral filaments may transfer to the central area. As a result the number of peripheral filaments decreases. The irregular patterns among cilia may occur near the tip of the cilium (Stair, '65) as mentioned in our previous report of young dogs (Kubota, et al., '75). The doublet type of filament in the cilium is essentially similar to the arrangement found in retina and others. It is said that they are performing a sensory or conducting function (Barbara, '61).

In 1975, Webber and Lee observed that the cilia of the nephrons of rat and human kidneys had a 9+0 pattern near the base of the cilium and an 8+1 or 7+2 pattern in the middle portion. The pattern then became more irregular on the tip of the shaft. In the middle portion, peripheral doublets were considered to be displaced centrally. Wilsman and Fletcher ('78) also described a similar pattern of ciliary structure in the neonatal articular chondrocytes. These findings are comparable with our data.

In the adult dog and human pulp cells, a single cilium possessing a central filament is very much rarer than in young dog pulp tissue. This could be related to a formative period of the cilium (Sorokin, '68).

In these pulp cells, I never observed a cilium with 2 central filaments. I believe that the cilia of dental pulp cells and other 9+0 ciliary types are the same thing.

Summary

The ciliary structure of adult dog and human dental pulp tissue was studied for purposes of comparison with young dog. In both materials, many ciliary shafts were observed that possess 9+0 pattern. Some of cilia possess various numbers and shapes of filaments. Only 17% of cilia observed possess a central filament. That filament shape is the same as the peripheral one, and the peripheral filament number is always less than eight. These irregular patterns may occur near the tip or may be related to a formative period of the cilium.

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References


