OBSERVATIONS OF HUNTER-SCHREGER BANDS

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DURING the process of studying the physical damage and traumatic effects of various instruments on tooth structure, it became apparent that some consideration should be given to the Hunter-Schreger band formation as it exists in enamel structure. When examined by reflected light, these bands appear as alternating light and dark areas in the enamel portion of a longitudinal ground-tooth section, starting at, or near, the dentino-enamel junction and passing outward toward the enamel periphery.

The Hunter-Schreger bands have been described generally as an optical manifestation of the direction in which the enamel rods have been sectioned relative to their axis. Despite many detailed studies of these bands, their significance, physical structure, and origin still remain obscure. It was because of the need for a better understanding of the physical arrangement of the enamel rods in human tooth enamel that this examination of the Hunter-Schreger bands was undertaken. This report will describe the results obtained when a method for examining Hunter-Schreger bands by means of a shadowed replica technic and shadowed tooth sections is employed. This method differs somewhat from the conventional methods which have been used in the past, that made use of examination of etched and unetched longitudinal ground sections with reflected light, or thin sections by transmitted light, and partially decalcified stained sections.

REVIEW OF LITERATURE

These band formations in tooth enamel were first described by Schreger in 1800,[6] although they apparently were observed as early as 1770 by Hunter.[8]

A microscopic examination of the tooth usually reveals a grouping of enamel rods into bundles or bands that present different orientations to the longitudinal section of the tooth. In some groups or bundles the rods appear to have been sectioned longitudinally, while in adjacent groups the rods appear to have been cut transversely or obliquely. Preiswerk[15, 16] gave the name parazone to the groups of rods that are cut longitudinally, and diazone to those that are cut transversely. The relationship of the parazones and the diazones has furnished the basis for many of the explanations of the phenomenon of Hunter-Schreger bands in enamel.[2-5, 7, 9-11, 13, 14, 17-20, 23-26]

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Various views regarding the origin and significance of the banded formation have been given. Some investigators explain the appearance of the bands as being due to a difference in density of calcification of the alternating zones.[1, 6, 22] Others report the bands to be due to a difference in organic content of the adjacent zones of the enamel.[21] At least one report describes the bands as an optical phenomenon with but little histologic significance,[12] while another investigator considers the regular occurrence of the bands to indicate a definite anatomic arrangement of the structural units of the enamel.[2]

MATERIALS AND METHODS

For this study, freshly extracted teeth, both with and without fillings, which were kept immersed in water following their extraction, were ground various distances pulpally from the mesial, distal, lingual, or buccal aspect of the crown. When the required depth was reached, the surface was polished serially with 0 through 4/0 metallographic polishing paper. Some polished specimens were examined by reflected light without further treatment, while others were etched for a period of 5 to 25 seconds with 0.1 normal hydrochloric acid and dried. A portion of the etched specimens was shadowed with copper in vacuum, while others were coated with 2 or 3 applications of a dilute collodion solution. After the collodion film was dry, the teeth were returned to complete submersion in water for 24 hours, to facilitate the stripping off of the large collodion replicas without tearing. The collodion replicas were then placed in a drop of water on a glass microscope slide and pressed flat, when necessary, with a cover glass. After thorough drying the replicas were shadowed with copper in vacuum, using the technic essentially as reported by Williams and Wyckoff.[29] A total of approximately 650 replicas and sections have been shadowed and examined.

In addition to the above specimens, 40 tooth surfaces were polished through 4/0 polishing paper and replicas were taken of the surfaces both before and after etching. Another group of 40 tooth surfaces were polished in the same manner, after which 20 were etched and 20 were left unetched, and subsequently both groups of teeth were dried and shadowed directly. A fourth group of teeth were cut into thin sections by rotary carborundum disks, after which they were partially decalcified by immersion in 1 normal hydrochloric acid for periods of 1 to 5 minutes, then stained with hematoxylin and examined by transmitted light.

MICROSCOPIC OBSERVATIONS

In Fig. 1 is represented a typical band structure as observed by microscopic examination of an unetched polished section of a molar tooth when examined by reflected light. This tooth was not shadowed with copper, and even though in certain areas the bands can be observed to extend to the enamel periphery, the details of the bands are not sharp and their structure is not clear. This appearance is typically characteristic of polished, unetched sections of teeth.

Repeated efforts failed to reveal any evidence of Hunter-Schreger bands when a collodion replica was made of a polished but unetched enamel surface.

Even though it was possible to observe the boundary of a restoration, and on occasion the dentin-enamel boundary could be distinguished, there was no evidence of difference in surface structure due to band formation. Similar results were observed when the tooth was polished through 4/0 paper and shadowed directly with copper before being etched. Beyond observing the difference in surface texture between enamel and dentin, no structural details were evident. Particularly, no Hunter-Schreger bands were demonstrated by shadowing the polished, unetched tooth section. The checked and cracked enamel was observed which probably was the result of dehydration of the tooth that was necessary for the shadowing operation.

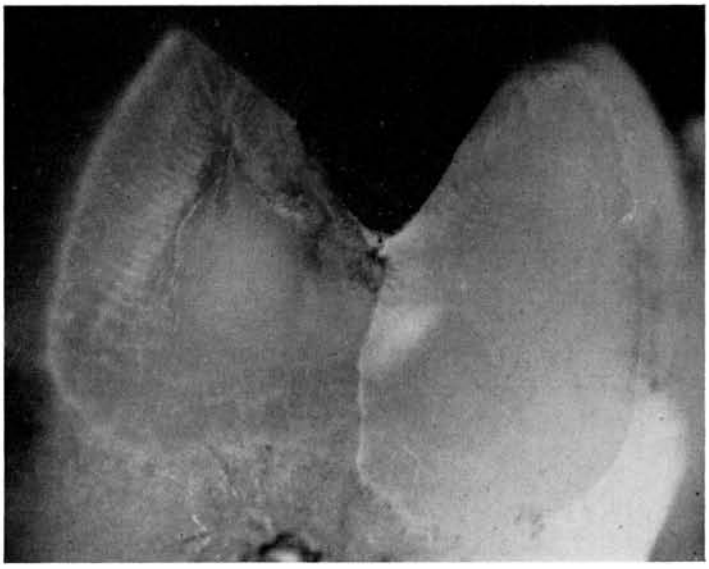

Fig. 1.—Polished but unetched tooth section as observed by reflected light.

When the tooth surface was etched for 15 seconds with 0.1 normal hydrochloric acid, the band structure began to be revealed, as shown in Fig. 2, by a shadowed replica. Shown at only 10 diameters magnification and perhaps an incomplete etch, evidence of the band formation is apparent, extending outward to the enamel periphery. The outline of the metal restoration also can be distinguished.

The etched tooth surface from which the replica was produced for Fig. 2 subsequently was shadowed by copper in vacuum, following the stripping of the collodion replica. The structure revealed by the shadowed tooth is shown in Fig. 3, at 10 diameters magnification, and is a reverse of the shadowed replica shown in Fig. 2. While the band details are not pronounced in either the shadowed tooth (Fig. 3) or the replica (Fig. 2), it is believed that this lack of detail is due to incomplete etching of the tooth, but either the tooth or replica can be used to reveal the band detail.

In Fig. 4 is shown a shadowed replica of a ground tooth surface, etched for 20 seconds, and photographed at the low magnification of 10 diameters. The path of the Hunter-Schreger bands passing outward from the dentino-enamel junction is demonstrated, with the bands appearing to extend to the periphery of the enamel. Numerous examples of teeth revealed the same type of band structure. In particular, they demonstrate clearly a concentric arrangement of the bands in the cuspal areas which has not been widely reported in the past, although at least four investigators have suggested this formation.[2, 23, 27, 28]

Fig. 2.

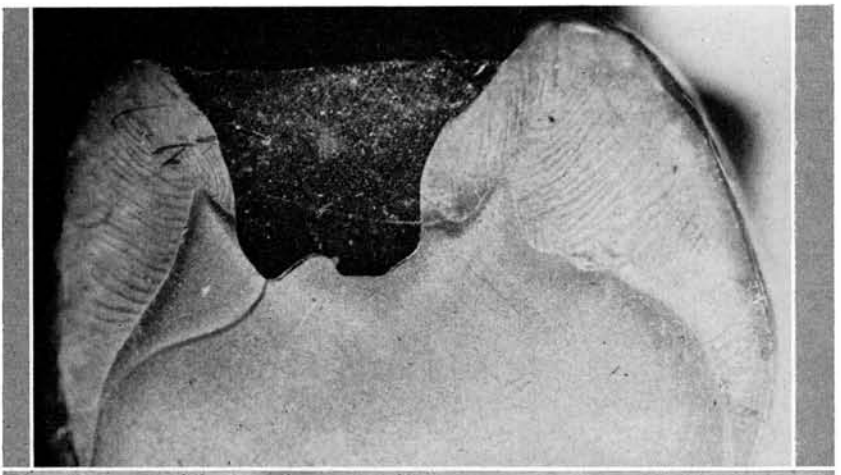

Fig. 3.

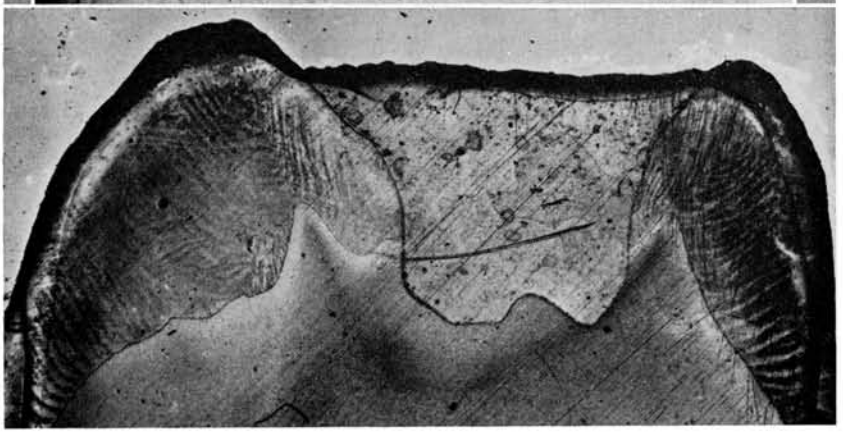

Fig. 2.—Replica of polished section, etched 15 seconds with 0.1 normal hydrochloric acid.

Fig. 3.—Shadowed tooth from which replica was taken for Fig. 2.

The bands represented in Fig. 5 were observed from a polished tooth surface that was etched for 20 seconds with 0.1 normal acid before being shadowed with copper. The longer etch seems to have developed a more pro-

nounced band structure, revealing the concentric arrangement in the cuspal area, and the extension of the bands to the enamel periphery. The outline of a metal restoration is also clearly shown in Fig. 5.

The enamel structure shown in Fig. 6 is that of a shadowed replica of a polished tooth section, etched for 20 seconds with 0.1 normal hydrochloric acid, and photographed at a magnification of approximately 100 diameters.

Fig. 4.

Fig. 5.

Fig. 4.—Replica of polished section, etched 20 seconds with 0.1 normal hydrochloric acid, showing concentric arrangement of bands in cusp area.

Fig. 5.—Replica of polished section containing metal restoration and showing band formation in cusp area.

The area represents the boundary between a metal restoration and enamel. The characteristic light and dark Hunter-Schreger bands can be observed. At this magnification there is evidence of rod ends in the enamel, but a change in rod direction in the alternate bands is not apparent. This was a consistent observa-

tion of the rod direction near the periphery of the enamel, even though the band formation was routinely found in the peripheral third of the enamel structure.

In Fig. 7 is shown the structure resulting from a shadowed replica of a polished enamel surface that was etched for 10 seconds with 0.5 normal hydrochloric acid, and photographed at a magnification of 400 times. Greater detail is registered as a result of the more pronounced etch and the higher magnification. The different orientation of the bands, corresponding to the parazones and diazones, is also evident in this illustration. At a higher magnification of approximately 700, the same area develops the appearance shown in Fig. 8.

Fig. 6.—Enamel structure at margin of restoration showing band formation (×100).

Fig. 9 shows a thin section, partially decalcified in 1 normal hydrochloric acid for five minutes and stained with hematoxylin. The bands are not demonstrated in the outer one-third of the enamel and rarely in cuspal areas when this method is used. Shown in Fig. 10 is a high magnification of an area from Fig. 9. Change in rod direction corresponding to parazones and diazones is demonstrated.

DISCUSSION OF RESULTS

Accepting the fact that this does not represent an exhaustive study of the Hunter-Schreger band formation, it appears, however, that the application of the replica method offers promise in refining our knowledge of histologic structure of dentin and enamel. Throughout the study it has been observed that the replica method is more sensitive for the study of Hunter-Schreger bands than hematoxylin staining. The response to acid varied considerably in different

Fig. 7.

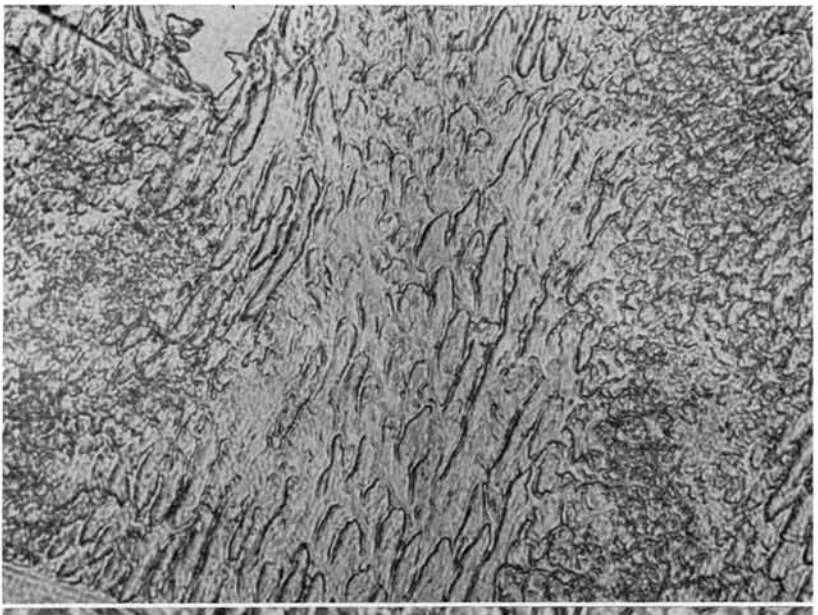

Fig. 8.

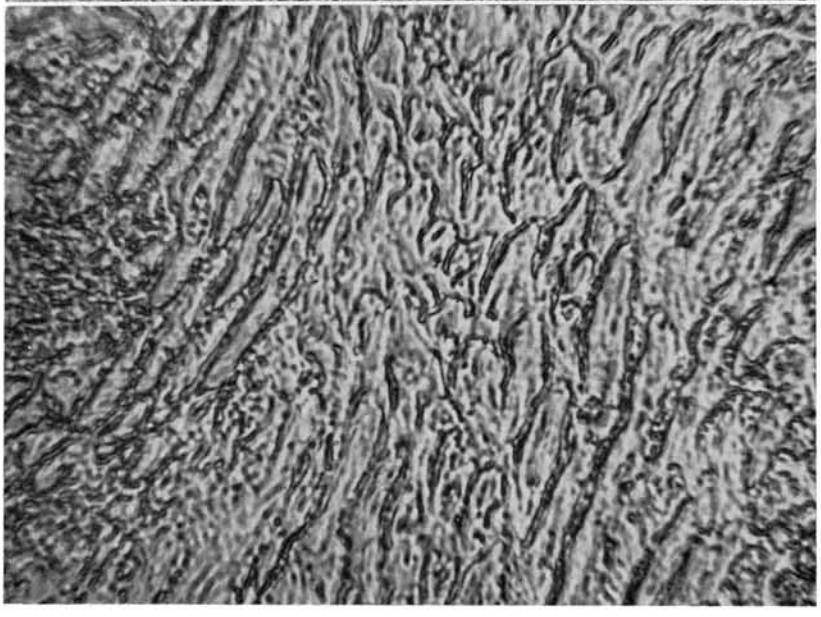

Fig. 7.—Replica section of enamel etched 10 seconds with 0.5 normal hydrochloric acid (approximately ×400).

Fig. 8.—Higher magnification of portion of replica shown in Fig. 7 (approximately ×700).

areas of the same tooth, as has been observed by others, but not in any particular pattern. On some surfaces the response to the etching varied to the extreme of having the appearance of an unfathomable surface in the replica in so far as the detail structure of the enamel was concerned, yet the Hunter-Schreger bands were recorded consistently.

Fig. 9.

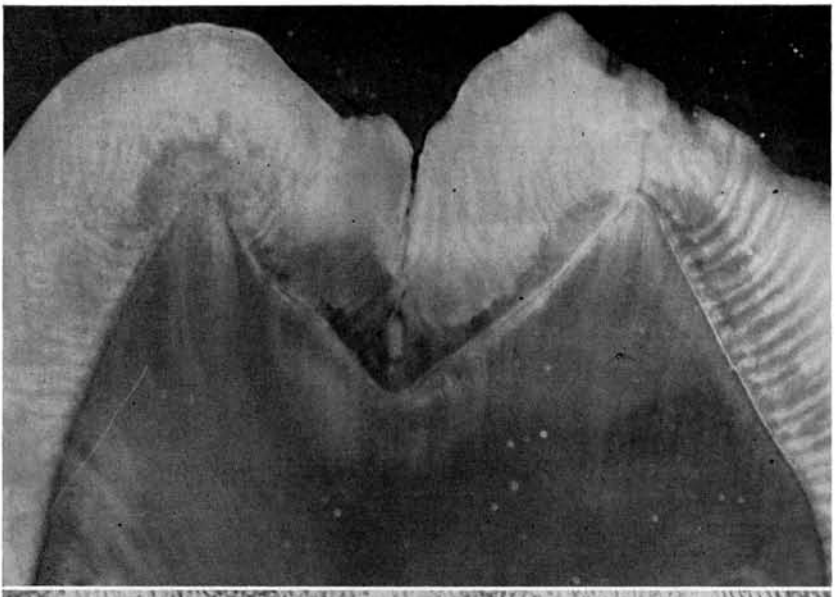

Fig. 10.

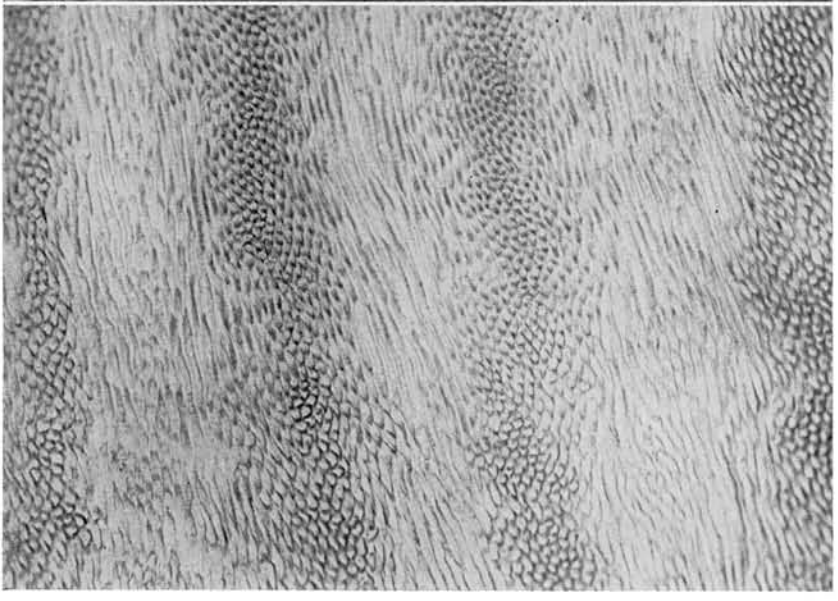

Fig. 9.—Thin section of tooth partially decalcified and stained with hematoxylin.
Fig. 10.—Higher magnification of portion of section shown in Fig. 9.

While areas on replicas were readily found where Hunter-Schreger bands correspond to parazones and diazones, many times these bands were observed in areas where no change in rod direction was apparent. Thus, it would appear that an explanation of the Hunter-Schreger bands entirely on the basis of changes in direction of the rods may be an oversimplification of the process. Some additional study of rod orientation should be useful.

In general, the dark bands in the replicas examined displayed more detailed structure than the light bands. The contrast between the light and dark bands in regard to structure, discernible within the rod sheath, was striking. The structureless appearance within the rod sheaths, regardless of the direction sectioned, was characteristic of the light bands. Staz reported what may be a related observation, that "diazones are more heavily stained than the parazones."[27]

All attempts to record Hunter-Schreger bands in replicas of polished but unetched surfaces of teeth were unsuccessful. Each of the surfaces so studied was etched subsequently with hydrochloric acid, and the shadowed replicas then obtained revealed Hunter-Schreger bands. The shadowing of the surfaces of the teeth directly yielded a similar result, namely, no evidence of the bands until the surfaces were etched. This might be taken as some evidence that the band formation is produced by the physical structure within the enamel and is not entirely optical in nature.

It would appear that the depth of etching alternated somewhat uniformly to demarcate the Hunter-Schreger bands, with the dark bands in the replica indicating areas of relatively deeper etching than the light bands. The dark bands of the replica are interpreted as areas of high content of organic matrix.

It can be demonstrated in some replicas that the optical phenomenon of changing of bands from light to dark, and vice versa, can be produced in the conventional manner of changing the light source by 180°, and also more simply by a small change in the mirror when viewing the bands by transmitted light. Numerous other optical effects could be developed. Further study to explain the optical characteristics of the Hunter-Schreger bands in replicas is desirable.

Three morphologic characteristics of Hunter-Schreger bands seem to be evident from this study. (a) The bands are revealed to extend from the dentino-enamel junction to the periphery of the enamel in many teeth when examined by the shadowed replica method. (b) The bands form concentric arcs in the cuspal areas, as a characteristic formation. (c) The Hunter-Schreger bands may be observed in areas of the enamel where change in rod direction is not apparent.

CONCLUSIONS

1. The Hunter-Schreger bands are a consistent finding in shadowed replicas of etched surfaces of enamel.

2. The shadowed replica offers a method for study of details of Hunter-Schreger bands not previously described.

3. Hunter-Schreger bands do not always start at the dentino-enamel junction, but may exist as concentric arcs in cuspal areas.

4. The detection of typical Hunter-Schreger bands in shadowed replicas of etched tooth surfaces suggests that the mineralization of the tooth is such that alternating bands of greater and lesser resistance to etching exist.

5. The Hunter-Schreger bands can be followed from the dentino-enamel junction to the periphery of the enamel by the use of shadowed replicas.

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