Scanning Electron Microscope Study of Fish Tooth Dentin
(Serrasalmus nattereri KNER)

by

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Introduction

The authors were able recently to obtain two specimens of Serrasalmus nattereri KNER (Piranha nattereri), a fish which has been notorious for its sharp teeth. Although the outer surfaces of these teeth were examined, this study is concerned primarily with the scanning electron microscopic appearance of the fractured surfaces of the dentin.

Material and Methods

The teeth used in this study were obtained from two piranha with a body length of 15cm. The animals were from the Yomiuriland Marine Aquarium in Tokyo. These teeth, with a small amount of attached periodontal tissues, were removed from the upper and lower jaws of these fish. They were fixed in neutral formalin solution, dehydrated with alcohol and acetone and dried at room temperature.

Some of the specimens were coated with gold immediately after drying so that the outer surface could be examined. The other specimens were fractured with a chisel to expose the dentin surfaces, which were then coated with gold. Some of the fractured dentin surfaces were etched with 1/200 N formic acid for 30 seconds before coating. All of the specimens coated with gold were studied under the scanning electron microscope.

Some of the teeth were prepared as conventional decalcified paraffin embedded sections that were stained with H-E and examined with the light microscope.

Results

Although the teeth of the piranha are considered to be razor sharp, the magnified picture obtained with the scanning electron microscope failed to give the impression of teeth with unusually sharp incisal edges. These anterior and lateral views of the piranha teeth are shown in figures 1 and 2.

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Fig. 1 Anterior view of a tooth of piranha.

Fig. 2 Lateral view of a tooth of piranha.
The teeth of the piranha like many other fish have no roots and consist of enameloid, dentin and pulp. The dentin showed ankylosis with the supporting bone. The enameloid covered only 1/2 of the tip of the crown. The dentin as orthodentin contained many canaliculi.

The fractured dentin appeared to have a rougher surface than that of similarly treated human dentin. The dentin matrix fibers were found to run parallel with and surrounding the dentinal tubule as shown in Figures 3 and 4. This is probably due to the poorer mineralization of the piranha dentin matrix fibers as compared with that in the human tooth dentin.

The fractured surfaces of dentin showed dentinal tubules in oblique, transverse and longitudinal sections. The dentinal tubules were smaller in diameter than those of human and other mammalian teeth [1]. The tubule diameters shown in Figure 5 averaged 1.5 microns. Figures 3 and 4 show no differentiated peritubular dentin layer in the dentinal tubule walls. The internal walls of the dentinal tubules of many specimens showed matrix fibers with a reticular pattern as illustrated in Figure 6. In some of the specimens, these matrix fibers were barely visible.

When the fractured dentin surface was etched for 30 seconds with 1/200 N formic acid, a smooth dentin surface was generally obtained. Figure 7 shows that matrix fibers were also more easily recognized in the etched dentin. These matrix fibers were seen more distinctly, particularly on the internal walls of the dentinal tubules as shown in Figure 8.

![Fig. 3 Poor mineralization of dentin matrix in intertubular dentin.](image-url)
Fig. 4 Longitudinal sections of dentinal tubules and intertubular dentin.

Fig. 5 Cross sectioned dentinal tubules.
Human dentinal tubules seen in etched fractured surfaces showed the presence of so-called peritubular dentin layer, whereas no such peritubular structures per se, appeared at all in the dentinal tubule walls of the piranha dentin. Figures 5 and 7 show that the diameter of the dentinal tubules in the piranha dentin did not appear to be increased through etching.

Fig. 6 Reticular network (arrow) of matrix fibers in internal wall of dentinal tubules.

Fig. 7 Intertubular dentin etched by formic acid.
Fig. 8 Matrix fibers in internal wall of dentinal tubules made distinct by etching.

Fig. 9 Rod like substance and sheath-like substance in dentinal tubules.
The non-etched fractured dentin surfaces of several piranha teeth showed scanning images similar to Figure 9. A rod like structure occupied most of the dentinal tubule lumen. However, a sheath-like structure along the wall of some dentinal tubules is also illustrated by the arrow in Figure 9.

Discussion

In the dentin or orthodentin of the teeth of piranha, many dentinal tubules were noted. The dentinal tubules were narrow, with a diameter of about 1.5 microns. ISOKAWA et al.[1, 2, 3] have previously shown photomicrographs of the dentinal tubules of the teeth of porgies (Pagrosomus major and Tauris tumifrons), coelacanth (Latimeria chalumna) and Semicossyphus reticulatus respectively. All of these tubule diameters were less than the human counterparts. KUBOTA et al.[4] reported that the diameter of human dentinal tubules were about 2–3 microns. In the scanning electron micrograph, the difference in diameter between human dentinal tubules and those of piranha seemed to be greater than the actually measured values.

The fact that the diameters of the dentinal tubules of piranha are unchanged through etching with weak acid might indicate the absence of a peritubular dentin layer about the walls of these tubules. Through historadiographic and scanning electron microscope studies, ISOKAWA et al.[1, 2, 3] reported the absence of peritubular dentin in the teeth of some other fishes. SERA[5] studied the peritubular dentin of the teeth of 31 kinds of rodents, historadiographically. He failed to demonstrate the peritubular dentin and concluded that it was absent at the historadiographic level. On the other hand, BOYDE and REITH[6] using rat molars and KODAMA[7] using teeth of rabbits confirmed the presence of peritubular dentin with the scanning electron microscope. In the present study, no peritubular dentin was noted on the fractured dentin surfaces and moreover, no tubular structure[8, 9, 10] developed after etching. These results might indicate that at the level of scanning electron microscopy peritubular dentin is absent in the dentin of the piranha teeth.

The dentin matrix fibers of human teeth run parallel with and surrounding the dentinal tubules. A similar arrangement of fibers seen in Figures 4 (arrows) and 8 in the piranha dentin of this study was not unexpected. The dentin matrix fibers of the piranha teeth appeared however to be less mineralized that those of human teeth[11]. This probably explains why Figures 3, 5 and 8 seem to show a different arrangement of the layer surrounding the dentinal tubule on these fractured dentin surfaces. The occasional sheath-like substance of the dentinal tubule wall indicated also by the arrow in Figure 9 was probably apparent for this reason.

The rod like substance[12] occupying the dentinal tubule is similar to the image seen in the scanning micrograph when the lumen of the human dentinal tubule becomes occluded by an inorganic deposit. However, whether or not the same mechanism is operating to produce these two images, is still undecided.

Conclusions

The jaw teeth of the piranha (Serrasalmus nattereri KNER) were examined for this
The main portion of the study was concerned with the examination of the dentin of the teeth of this fish with the scanning electron microscope. The following conclusions were derived from the study:

1. The teeth of the piranha consisted of enameloid, orthodentin and the dental pulp. The teeth were joined to the underlying supporting bone by ankylosis.
2. The dentinal tubules with an average diameter of approximately 1.5 microns were finer than those of mammalian dentin.
3. No peritubular dentin was observed on the walls of the dentinal tubules.
4. The direction of the dentin matrix fibers was similar to but the degree of mineralization of these matrix fibers appeared to be lower than that in human tooth dentin.

References