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A Study of Osteoclasts

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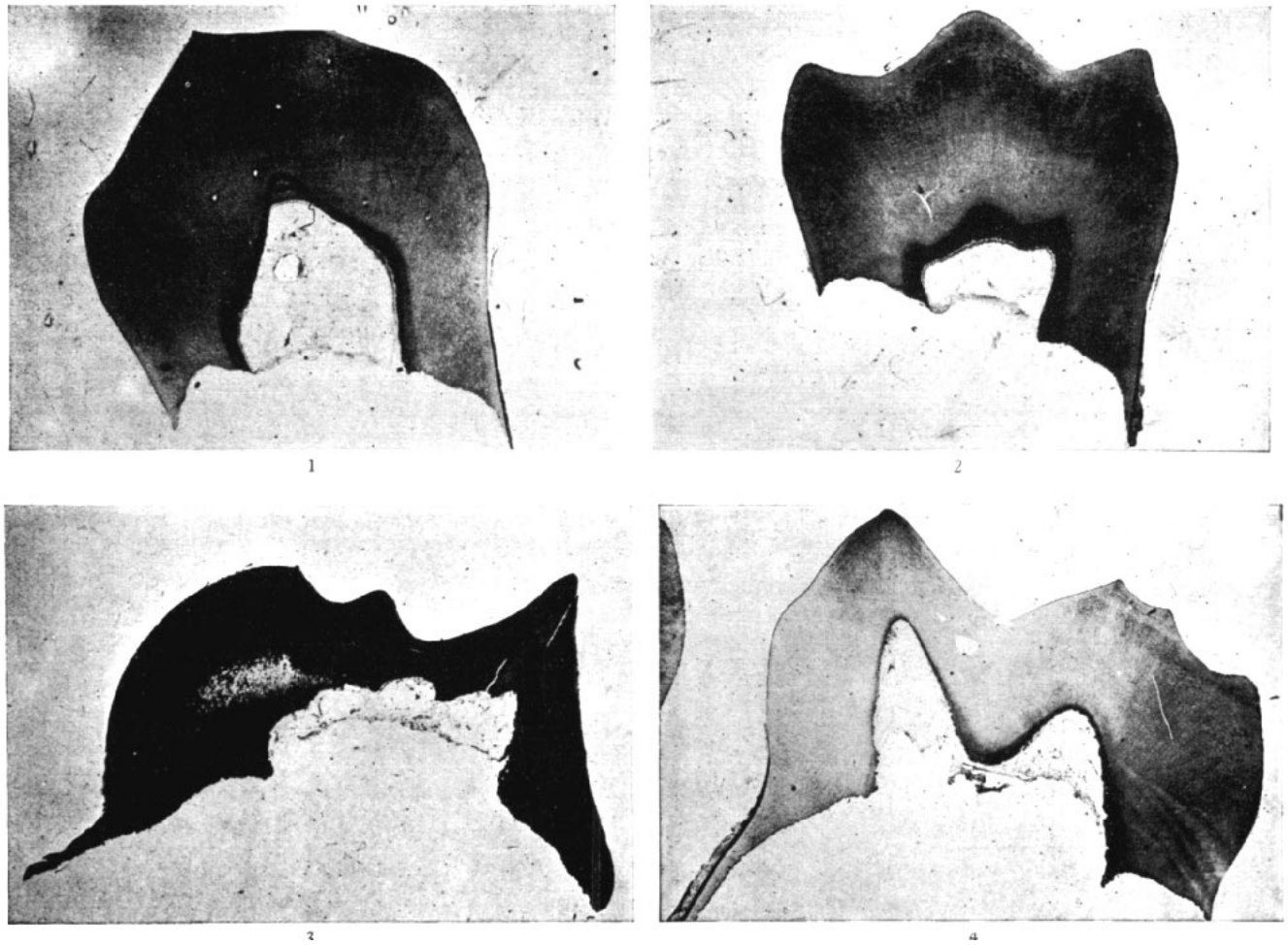
The study of extracted teeth has given such valuable knowledge in connection with the tissue changes in the apical area related to root canal therapy and root filling that it suggested to the author the possibility of applying the same methods to the present field.

Every orthodontist frequently has the opportunity of taking out the crowns of temporary molars and cuspids after the absorption of their roots. An examination of the absorbing surface with a band lens will usually show more or less tissue removed with the crown, especially in depression and absorption bays. For the past year or two, such crowns have been dropped immediately into four per cent formaldehyde, decalcified, sectioned, and stained. The soft tissue is so small in amount that fixation is very perfect and in spite of the necessity of decalcification this material gives a remarkable opportunity for the study of osteoclasts. The author has been particularly interested because in the last few years there has seemed to be a growing tendency to emphasize the biochemical phase of bone formation and bone resorption and to minimize the function of the cell in these processes. Of course, it is understood that all cell activity is ultimately chemical reaction and can be explained only upon this basis. Such expressions as "vital activity" simply mean that we as yet have no knowledge of the chemical processes involved.

In Figures 1, 2, 3 and 4 we have four low power pictures of sections of crowns which illustrate several things which are generally characteristic.



Figures 1, 2, 3 and 4
Sections of the crowns of deciduous teeth—1 and 2 show the remains of the pulp still forming dentine. In 3, the pulp has been partially replaced by new embryonal connective tissue. In 4, the replacement is complete.

The pulps of these temporary teeth are very persistent and retain their identity in the pulp chamber and its horn after the roots have been entirely destroyed. In fact, the impression one gets from viewing these pictures is

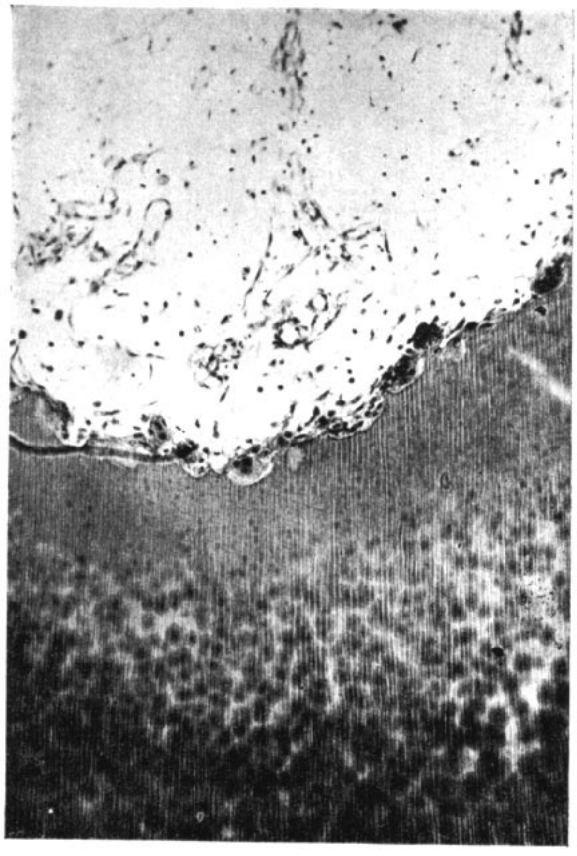


Figure 5

Resorbing surface of dentine. (Obj. 16 m.m., Occ. 10.) Above, embryonal connective tissue showing cells and capillaries. To the right of center, a Howship's lacuna filled with mononuclear cells. Next, to the right of it, a typical young osteoclast. To the left, an osteoclast with reticular, vacuolated cytoplasm.

that the pulp is destroyed along with the roots and apparently by the same agency. The remaining portion of the pulp retains its typical structure and in Figures 1 and 2 there is still active formation of dentine by odontoblasts and the layer of pre-dentine can be seen even in this low magnification. The irregular outline of the absorbing surface of dentine, due to the presence of

Howship's lacunae, can be easily seen in all the sections and in some places stained osteoclasts can be seen even with this magnification. It is very striking that all these surfaces of resorption show the scalloping of Howship's lacunae through their entire area. The only meaning the author can give

Figure 6
Part of the same field shown in Figure 5. Note the connective tissue cells. (Obj. 8 m.m., Occ. 10.)

to this is that when the resorption was active there were osteoclasts occupying these lacunae. Usually the pulp retains its individuality until it is invaded or replaced by round, active, embryonal connective tissue cells and osteoclasts do not appear until this transformation has taken place. The common method seems to be that the young connective tissue extends from

the resorbing surface around into the pulp chamber and along its wall. Finally all of the pulp tissue is destroyed or pushed away from the surface of the dentine. Resorption often extends until all of the dentine of the

Figure 7
All of the osteoclasts in this picture are united, forming a continuous sheet of cytoplasm. Note the appearance of the cytoplasm next to the dentine.

crown has been removed and then it continues to attack the inner surface of the enamel. The author has occasionally seen crowns of temporary molars in which the full thickness of the enamel had been destroyed in areas and the crown separated into two pieces. It often happens that the attachment is broken either on the buccal or lingual side and the remnants of these temporary teeth are only hanging on by part of their circumference. As soon as there is a break of the attachment at some part of the margin, the fluids of the mouth are admitted to the space beneath the crown and there is more or less inflammatory reaction in the tissue. Also the epithelium of the mouth cavity grows in and attempts to cover the exposed connective tissue. Such epithelial extensions have been found in many of the sections.

It seems generally true that the activity of the osteoclasts is decreased as the inflammatory reaction increases and, judging entirely from the appearances of sections, the resorptive activity seems most energetic where the adjoining embryonal connective tissue is most vigorous and without inflammatory reaction.

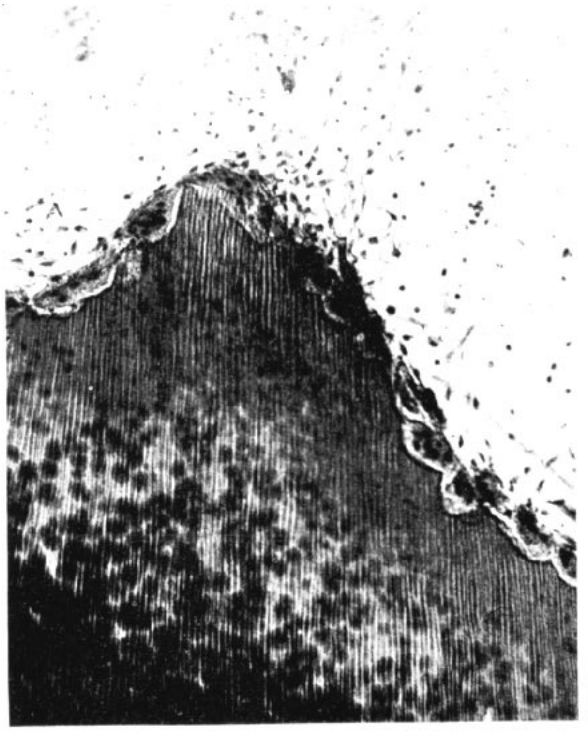


Figure 8
Osteoclasts. Note the continuous cytoplasm in those that are at the point of the dentine.

Osteoclasts

The osteoclasts in this material present a great variety of form and character. These can, perhaps, best be described by studying the photomicrographs and drawings. In Figure 5, at a point a little to the right of the center of the resorbing surface, is shown a Howship's lacuna which is occupied by a number of small mononuclear cells which appear to be packed into this area. Such appearance can often be seen in places where apparently a new attack is beginning to be made. These individual cells become fused

into the typical giant cell osteoclasts. (In Figure 5—the next lacuna.) These are large, well defined giant cells with compact and fairly intensely staining cytoplasm which appears to be "jammed" full of well defined oval nuclei, each with a small, sharply outlined nucleolus near its center. These

Figure 9
Drawing, showing osteoclasts of various forms. Note the cytoplasmic bridges and the reticular, vacuolated borders. The connective tissue cells of the embryonal tissue are very accurately drawn.

nuclei are apparently poor in chromatin. Occasionally more than one nucleolus will be found. These osteoclasts usually entirely fill the lacuna and the cytoplasm is closely in contact with the definite matrix. To the left, in Figure 5, will be seen an osteoclast of entirely different character. The cystoplasm is reticular, staining very poorly and has the appearance of being full of minute vacuoles. The nuclei are less numerous and less compact, and there seems to be a tendency for the cytoplasm to separate from the dentine matrix.

In Figure 5 the printing is made to show the dentine and osteoclasts at the expense of the connective tissue but the characteristics of the active embryonal connective tissue can be seen. New capillary blood vessels are

always abundant and there are a great number of typical, undifferentiated connective tissue cells as described by Maximow. Figure 6, a portion of the same field taken with an eight millimeter objective and ten ocular, is printed to show the embryonal connective tissue at the expense of the osteoclasts.

Figure 10
Osteoclasts. Note the cell-like borders. The connective tissue cells are accurately reproduced.

One of the most remarkable things appearing in this material is the uniting of the adjoining osteoclasts by numerous large cytoplasmic bridges. In many areas this seems to amount to the formation of a syncytium in which a mass of cytoplasm, packed full of nuclei, is spread over the area of five or six Howship's lacunae. This is shown in Figures 7 and 8. In Figure 7, also, there is a marked difference in the appearance of the cytoplasm toward and in contact with the dentine matrix. Some authors have described cilia extending from the osteoclasts to the bone or material being resorbed and

have even contributed to them a function in the resorption. It seems to the author that this appearance is more probably explained in one of two ways. In some fields it seems almost certain that there are a large number of vacuoles in the cytoplasm and what would appear like cilia are the portions

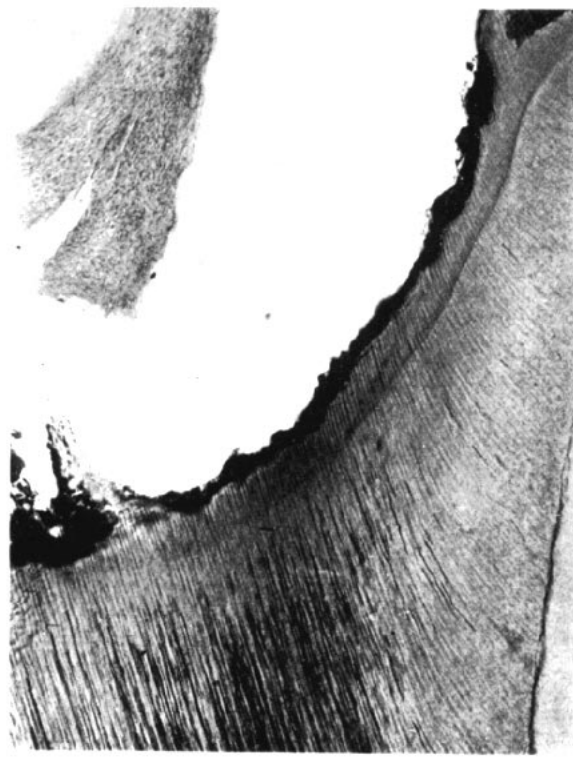


Figure 11

Ground section, (Obj. 16 m.m., Occ. 10) stained with Haematoxylin and Eosin. Note the appearance of decalcification of dentine in a layer parallel to the resorption surface.

of cytoplasm between adjoining vacuoles. In some places two layers can be distinguished, the first with small and the second with larger vacuoles. In such places the larger ones always seem to be toward the dentine matrix.

In Figure 8, all of the osteoclasts in the field are apparently united by cytoplasmic bridges and at the point of the dentine the union of osteoclasts is very easily seen. In this photograph also the difference in the appearance of the cytoplasm toward the dentine can be easily observed.

Figures 9 and 10 have been very carefully drawn by Mrs. Frain and are very accurate reproductions of microscopic fields.

Origin of Osteoclasts

There has been much discussion in regard to the origin of osteoclasts

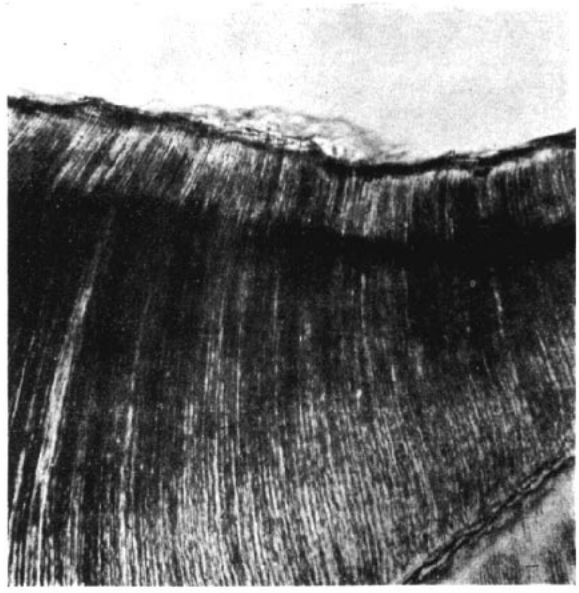


Figure 12

Ground section unstained. (Obj. 16 m.m., Occ. 10.) Apparent decalcification of the dentine.

and two diametrically opposite hypotheses have been suggested. Dr. Arey has championed the view that osteoclasts are derived by the fusion of worn out or degenerated osteoblasts. Maximow has been the most prominent advocate of the theory that both osteoblasts and osteoclasts are derived from undifferentiated embryonic connective tissue cells. In the present material there are no osteoblasts in the immediate neighborhood. In every field in which osteoclasts appear there is an adjoining zone of young, connective embryonic tissue. There seems to be very positive evidence that these cells gather in a mass upon the surface of the dentine and fuse to form osteoclasts. It seems also probable that the resorption of dentine matrix begins with the earliest stages of this fusion or even before there is fusion but that

in the most rapid resorption there are not only giant cells formed but that these are united over considerable areas. There seems to be no evidence that the osteoclasts break up into single cells which return to their embryonal character. It would rather seem that the osteoclasts finally degenerate and are removed. Some of the crowns that were removed, after fixation, were embedded in celloidin which was hardened by evaporation and the sections were ground without decalcification. This is a slow process and to the present time only a few such sections have come under the lens. The appearance of the first two, however, is so unexpected that they are shown here in Figures 11 and 12. The crown from which Figure 11 was taken was stained with hematoxylin and eosin before embedding. The dark edge is caused partly by the hematoxylin stained tissue-remains and partly by the fact that the edge of the section is oblique. A distinct layer, approximately parallel with the resorbed surface, is seen in the entire specimen. It is impossible to say what the meaning of this is but it has every appearance of a decalcification of the dentine matrix.

Figure 12 is photographed from a small ground section but without staining. What the meaning or importance of this observation may be cannot be told.

In this study, Miss Alta E. Kamnetz has prepared all of the histological material; Dr. I. Schour has assisted in the preparation of ground sections; Mrs. N. M. Frain has made the drawings and Mr. Toerielli the photographs of the entire crowns.

Summary

1. The pulp persists until a late stage of resorption and disappears last in the horns of the pulp chamber.

2. The pulp is invaded by embryonal connective tissue and from this osteoclasts are formed.

3. Osteoclasts are formed from undifferentiated connective tissue cells which fuse to form the typical giant cell.

4. In the most active areas of resorption, the osteoclasts are united by protoplasmic bridges or form continuous sheets of cytoplasm with many nuclei.

5. There seems to be decalcification of dentine matrix to a greater or less depth in advance of resorption.