Histology of Newly-formed Dentin

by

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Introduction

Histological observations of the pulpal responses of a large number of teeth treated by direct and indirect pulp capping revealed differences in the kinds and amounts of dentin present in the teeth under observation. Since it has been repeatedly shown by others that the kind and amount of new dentin formed in teeth is related to a number of different factors, it was decided to test the effect of some of these factors on the kinds and amounts of dentin present in the teeth under observation. The factors which have been chosen for study include, besides the two types of treatment, the type of tooth, whether primary or permanent, multi-rooted or single rooted, the state of root development or resorption, the length of the post-operative observation period, and patient age and sex. In addition, it has been possible to consider the effect of the amount of carious and sound dentin allowed to remain in the indirect pulp capped teeth.

The information presented at this time is limited to the effect of the two types of treatment, indirect and direct pulp capping, the length of the post-operative observation period, and the amount of carious and sound dentin allowed to remain in the indirect pulp capped teeth.

Literature Review

As early as 1907, REICH[1] made an extensive study of the occurrence and varieties of secondary dentin in human teeth. He differentiated between primary and secondary dentin in the normal tooth on the basis of regularity and number of dentinal tubules per unit area. He maintained that this tissue formed during the period in which the tooth was in function, and accordingly called this dentin of the "functional period".

BUNTING and HILL[2] (1940), suggested that different individuals exhibit reactions which vary in response to similar irritating conditions. They also maintained that secondary dentin is rarely observed in deciduous teeth. The investigation by IRELAND[3] (1941), on the other hand, clearly indicates that secondary dentin does form in deciduous teeth, and he concludes, "secondary dentin is formed in the deciduous teeth in response to caries, abrasion and chemical and thermal irritation much the same as in permanent teeth".

In the 50's interest in the subject increased and among the authors we find KRAMER and MCLEAN[4] (1952), as the first to use a qualitative evaluation by using plus signs to indicate the different amounts. The experiments were done on human teeth.

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KRUGER and RAKUTTIS[5] (1952), assert that secondary dentin of different kinds may vary in X-ray absorption according to the age of the tooth and become more calcified than the adjacent dentin. AMPRINO and CAMANNI[6] (1956), report the difference in calcification may depend on the relative age of secondary dentin, and during chronic caries it may be equal to or 6-10 % higher than that of primary dentin.

In 1959, JAMES, SCHOUR and SPENCE[7] proposed the use of an ID index to evaluate the pulpal response to inflammation (**I**) and to secondary dentin (**D**) and reported a study on human, noncarious, cavity-prepared teeth. They graded secondary dentin formation, **D**, on basis of the amount formed and stated that it must be pointed out that the amount and quality of secondary dentin depends on the factors of rate and time.

KALNIN[8] (1962), found that dentinal bridges develop as irregular dentin of varied appearance, such as fibrillar dentin, osteocementum or in a few instances as regular dentin.

YOSHIDA and MASSLER[9], studying the pulpal reactions to dental caries, indicated that reparative dentin formation began in the superficial active lesion, then slowed during the arrested period. The reparative dentin that formed under superficial carious lesions was very regular, while under deep carious lesions it was very irregular.

Thus it has been shown that a number of factors influence the quantity and the quality of the new dentin formation.

Materials and Method

The permanent teeth studied were all deeply carious and vital. They had originally been assigned to treatment groups in random fashion. Following cavity preparation using ultraspeed instruments, calcium hydroxide methyl cellulose was applied to the exposure site where direct pulp capping was performed or to the carious and sound dentin of the pulpal and axial walls where indirect pulp capping was indicated. Zinc oxide-eugenol or zinc phosphate cement bases were placed over the calcium hydroxide and the cavities were restored with silver amalgam restorations. The vitality of the teeth was tested clinically before they were removed at intervals post-operatively. The apices were cut off and the teeth were prepared for histological examination. The 6 micron serial sections were stained with hematoxylin and eosin.

A total of 227 permanent teeth were treated by direct pulp capping, 82 were prepared for histological study. A sample of 42 of these teeth is included in the present information. 135 permanent teeth were treated by indirect pulp capping and of the 48 prepared for histological study, 24 are included in this report. The remaining teeth in these groups are still under study.

Results and Discussion

Table 1 lists the numbers of teeth treated by each method and the age of subjects and the length of post-operative observation periods.

It was possible to characterize the type of new dentin formed as cellular fibrillar as shown in Figure 1, globular as shown in Figure 2, or tubular as shown in Figure 3.

The distribution of these three forms of dentin among the teeth studied is shown in Table 2. It can be seen that following direct pulp capping there were approximately

Figure 1

1-A

1-B

- A. Photomicroradiograph representing a section from a tooth treated with the direct pulp capping procedure. Note the formation of the dentinal bridge which covered the exposed part of the pulp with a good layer of odontoblasts.
- B. A high magnification of "A" above. Noth the non-oriented cellular fibrillar bridge type.

Figure 2

Photomicroradiograph representing a high power view of a portion of bridge which formed under a direct pulp capped treated tooth. Note the lack of tubular pattern. There were no cellular elements observed as was seen in Figure 1. A & B. This was called the globular type.

Figure 3

Photomicroradiograph representing the tubular type dentin. Please compare this with figures 1 and 2. Also note the representing of the odontoblastic layer and the presence of the pulpo-dentinal membrane. This is mainly observed in teeth treated for a period over three months.

25 to 30 % of teeth with vital pulps which had formed no dentin bridges, some of them in a period as long as 4 to 36 months. Cellular fibrillar dentin occurred in approximately 16 % of the teeth, globular form in about 10 % and some evidence of tubular dentin in about half of the cases.

Similar observations are presented for the indirect pulp capped teeth with respect to cases with no new dentin formed and those with evidence of tubular dentin. It is regrettable that the observations are incomplete with respect to the type of dentin formed during the first four months after treatment by indirect pulp capping ; however, it seems unlikely that many instances of cellular-fibrillar alone would appear since there were none to be seen after four months.

In measuring the width of new dentin it was, of course, simple enough to measure the width of the dentin bridge, where there was one, following direct pulp

TABLE 1

The Number, Age and Length of Post-operative Treatment in Teeth treated with the Direct and Indirect Pulp Capping Procedures

	Direct capping	Indirect capping
No. of teeth	42	24
Avg. age range	29 yrs. 11-53	16 yrs. 9-40
Avg. time obs. range	4.4 mos. 1-39	12 mos. 4-35

capping. Three measurements were taken through a representative area of the bridge and averaged.

The measurement of new dentin following indirect pulp capping presented a special problem. Since it was not practical to mark the dentin *in vivo* to indicate its status at the time of treatment, it has been assumed that the basophilic line most distant from the pulp represented the calcio-traumatic line formed in response to the treatment and measurements were made of the dentin between that line and the pulp. In the few instances where there was a distinct calcio-traumatic line and a second basophilic line in the dentin between it and the pulp, the line farthest from the pulp was presumed due to the carious lesion and the line closest to the pulp was presumed to be the treatment procedure. The dentin width was measured only from this inner line to the pulp. If there were no basophilic or calcio-traumatic lines present in the dentin, it was assumed that no new dentin had been formed either due to caries or treatment.

Figure 4 shows a typical basophilic line between the primary and new dentin. Measurement of new dentin was taken from this line to the pulp.

Table 3 shows the width of dentin bridges at less than 4 months and at 4 to 36 months following direct pulp capping. It is suggested that the bridges grow in width faster during the first four months and that they attain approximately the same width as the new dentin formed

Figure 4

Photomicrograph showing a line in the area of the pulpal horn. This is the calcio-traumatic line which stained deep blue in H & E routine stain.

TABLE 2

Types of New Dentin

	Direct capping		Indirect capping
Time obs.	4 mo.	4-36 mo.	4-36 mo.
Type -O	8	4	9
C-F	5	2	0
G	3	0	0
G-T	9	5	4
T	4	2	11
Total	29	13	24

O = no dentin bridge, G = globular,
T = tubular

TABLE 3
New Dentin Formation

	Direct capping	Indirect capping
Time obs.	No. Width	No. Width
4 mos.	12 Av. 107 u R. O.-420	
4-36 mos.	30 Av. 153 u R. O.-540	24 Av. 180u R. O.-684

after indirect pulp capping. Unfortunately, our observations are too limited to present information about the width of new dentin in less than four months after indirect pulp capping.

An attempt is underway to determine the effect of the amount of carious and sound dentin allowed to remain following indirect pulp capping on the formation of new dentin. No definitive report can be made at this time, although it appears likely that teeth with thinner remaining dentin form somewhat more new dentin over the same time period. By grouping teeth with less than 750 microns, of carious and sound dentin remaining, which averaged 180 microns, it was found that the average amount of new dentin formed was 244 microns. Teeth with more an average amount of 760 microns remaining showed an average amount of 100 microns of new dentin.

Summary and Conclusion

Presently available observations from these examinations of teeth treated by direct and indirect pulp capping suggest that the dentinal response to indirect pulp capping is mild, as evidenced by the numbers of cases with tubular dentin or no new dentin formed after treatment. It appears likely also that if the rate of new dentin formation is greater during the first three months following direct pulp capping, it does not remain so since there is some evidence that both treatments eventually result in about the same amount of new dentin.

The absence of a dentin bridge following direct pulp capping is of unknown significance in cases where clinical and histological examination reveal a normal pulp.

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