Age Change in the Permanent Upper Canine Teeth

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Histologic study of a graded series of sections of human upper permanent canines revealed that age rather than external irritation is primary factor in production of irregular secondary dentin. The amount of irregular secondary dentin in upper canines is noticeably less than that of upper incisors for same age group.

Previous reports1,2 have described changes in the permanent upper central and lateral incisors from the time of eruption to old age. After completion of the apex, two types of secondary dentin, regular and irregular, are normally formed simply with advancing age and are unrelated to the progress of attrition.3

The present histologic study of uniformly prepared, unstained, ground sections of a graded series of permanent upper canines, from the time of eruption to old age, was done to determine the changes in the primary and secondary dentin (regular and irregular) in this tooth and to compare these changes with those determined earlier in the permanent upper central and lateral incisors.

Materials and Methods

The 315 permanent upper canines studied (Table 1) were arranged by age in 13 groups. Each group covered a five-year span from 11 (11 to 15, 16 to 20, and so on) through 71 and more years old. The sources of human teeth of known age, as well as the method of preparation of ground sections for this study, were identical with those described in previous papers.1,2 Although all sections were examined, low power enlargements (×20) were made of only one section from each of seven of the 13 age groups, with the exception of the 16- to 20-year age group, (two sections). All sections shown in photomicrographs were ground labiolingually.

Results

Examination of all canines revealed a progressive increase of irregular secondary dentin in the pulp chamber of the crown with increasing age, regardless of attrition. In the earliest stage, irregular secondary dentin formed more on the lingual than on the labial and incisal walls of the pulp chamber. This formation was later than in the incisors, but it coincided with the completion of the root apex. A much smaller amount of irregular secondary dentin appeared in the canines than in the central or lateral incisors of the same age group.

Enamel attrition was not seen in the 11 to 15 year and the 16- to 20-year age groups (Fig 1-3). In 26- to 30-year and 31- to 35-year age groups, enamel attrition was slight (Fig 4, 5). Exposure of the dentin was seen

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TABLE 1

<table>
<thead>
<tr>
<th>Age Groups</th>
<th>Appearance of Interglobular Spaces (No. of Teeth)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Opalescent</td>
</tr>
<tr>
<td>11-15</td>
<td>13</td>
</tr>
<tr>
<td>16-20</td>
<td>11</td>
</tr>
<tr>
<td>21-25</td>
<td>4</td>
</tr>
<tr>
<td>26-30</td>
<td>6</td>
</tr>
<tr>
<td>31-35</td>
<td>4</td>
</tr>
<tr>
<td>36-40</td>
<td>9</td>
</tr>
<tr>
<td>41-45</td>
<td>7</td>
</tr>
<tr>
<td>46-50</td>
<td>4</td>
</tr>
<tr>
<td>51-55</td>
<td>3</td>
</tr>
<tr>
<td>56-60</td>
<td>3</td>
</tr>
<tr>
<td>61-65</td>
<td>1</td>
</tr>
<tr>
<td>66-70</td>
<td>1</td>
</tr>
<tr>
<td>71 and older</td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>66</td>
</tr>
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</table>

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in 46- to 50-year and 56- to 60-year age groups (Fig 6, 7).

In the first specimen (Fig 1), the root apex and primary dentin were almost completed. At this stage, slight traces of regular secondary dentin were formed on the walls of the pulp chamber of the crown. After the completion of the apex, a small amount of irregular secondary dentin was first observed.

Fig 1.—Unstained central section of an upper canine represents the late stage in the 11- to 15-year age group. A, Unworn enamel; B, opaque primary dentin tubules; C, traces of regular secondary dentin; D, open apex.

Fig 2.—Unstained central section of an upper canine from the 16- to 20-year age group. A, Unworn incisal enamel; B, opaque primary dentin tubules; C, first formation of irregular secondary dentin on lingual wall of pulp chamber of crown; D, root canal with closed apex.
More formed on the lingual than on the labial and incisal walls of the pulp chamber of the crown (Fig 2). The regular secondary dentin was formed in traces on the other walls of the pulp chamber of the crown and root. From that stage, however, progressive deposition of irregular secondary dentin was apparent with increasing age. It was especially noteworthy that the oldest specimen had almost no enamel attrition but had the greatest amount of irregular secondary dentin (Fig 8). A definite relationship between the inclined plane of attrition of the incisal edge and the location and formation of irregular secondary dentin could be seen (Fig 4–8).

Extensive labial caries occurred in the 16- to 20-year age group (Fig 3), but irregular secondary dentin had not formed on the labial wall of the pulp chamber of the crown under the carious lesion. However, a superficial labiocervical lesion in an older group (Fig 7) had a “plug” of irregular secondary dentin in line with the affected tubules.

In young specimens, most of the opaque tubules of primary dentin of the crown extended to the dentinoenamel junction (Fig 1, 2). In older specimens (Fig 4–8), the opaque tracts became progressively transparent at the periphery of primary dentin near the dentinoenamel junction and corresponded to the extent of irregular secondary dentin formation. However, the opaque tracts extended beyond the dentin exposed by attrition (Fig 6, 7).

Observations of interglobular “spaces” were made at a uniform magnification (×79). They were classified according to their appearance and tabulated as opaque, transparent in part, and transparent (Table 1). In younger specimens (Fig 1, 2, 4), the interglobular “spaces” were opaque and occupied the peripheral zone of the primary dentin, from the cervical region of the root to the middle of the crown. In the older specimens (Fig 5, 6), the interglobular spaces became progressively more transparent and were restricted to the cervical region. In the oldest age groups (Fig 7, 8), they had almost disappeared and were difficult to illustrate by low-power photomicrography.

Discussion

It is clear that the pattern of irregular secondary dentin formation cannot be accounted for by current standard interpreta-

Fig 3.—Unstained central section of an upper canine from the 16- to 20-year age group. A, Unworn incisal enamel; B, extensive labial caries of enamel with characteristic changes in dentin; C, lack of protective plug of irregular secondary dentin; D, opaque dentin tubules of root.
been found that irregular secondary dentin begins to form after the completion of the root apex,\textsuperscript{1,2} which presumably initiates a change or disturbance of the circulation and metabolism in the pulp\textsuperscript{7} or a change in the rate of the replacement of the odontoblasts.\textsuperscript{8} It would seem that changes in primary dentin are subsequent to changes within the pulp

and the formation of irregular secondary dentin.

Functional pressures may account for the greater formation of irregular secondary dentin on the lingual wall than the labial wall of the pulp chamber of the upper incisors\textsuperscript{1,2} and of the upper canines also. This hypothesis concerning functional pressures presents a basis for correlating the lingual location

Fig 4.—Unstained central section of an upper canine from the 26- to 30-year age group. A, Slight enamel attrition; B, opaque dentin tubules; C, irregular secondary dentin on the walls of the pulp chamber of the crown, more formed lingually and incisally and less formed labially.

Fig 5.—Unstained central section of an upper canine from the 31- to 35-year age group. A, Lingual inclination of enamel attrition; B, opaque dentin tubules; C, lingual formation of irregular secondary dentin; D, partly transparent interglobular spaces.
of the irregular secondary dentin formation with the lingual inclined plane of incisal attrition. It is suggested that this inclined plane merely indicates the direction of functional pressures.

The amount of irregular secondary dentin formed in the upper canine is much less than that formed in the upper incisors of the same age groups through all stages of the life cycle.\textsuperscript{1,2} Several factors seem to be involved in the formation of this comparatively small deposit, none of which precludes the others. One may be that the deposit occurs as it does because the calcification and eruption times differ in the canines and the incisors. Another may be that the larger pulp chamber

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fig6.png}
\caption{Unstained central section of an upper canine from the 46- to 50-year age group. \textit{A}, Lingual inclination of enamel and dentin attrition; \textit{B}, opaque dentin tubules; \textit{C}, lingual formation of irregular secondary dentin; \textit{D}, partly transparent interglobular spaces.}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fig7.png}
\caption{Unstained central section of an upper canine from the 56- to 60-year age group. \textit{A}, Lingual inclination of enamel and dentin attrition; \textit{B}, opaque dentin tubules, corresponding with extent of irregular secondary dentin formation at \textit{C}; \textit{D}, labiocervical caries with plug or irregular secondary dentin under affected tubules.}
\end{figure}
A chamber under the superficial cervical carious lesion (Fig 7). This deposit may be due to the reversed high osmotic pressure in caries described by Atkinson, Fosdick et al., and Berg. This reversed high osmotic pressure and fluid flow would allow many ions to migrate and become trapped on the wall of the pulp chamber in line with the carious lesion, thus forming the plug of irregular secondary dentin. Consequently, osmotic pressure may account for the location of irregular secondary dentin in a region where it was not previously formed as a result of age.

In a young tooth with a large labial carious lesion, there was no plug of irregular secondary dentin on the labial wall of the pulp chamber (Fig 2). At this early age, after completion of the apex, irregular secondary dentin had just started to form, but the reversed osmotic pressure in caries had not caused formation of irregular secondary dentin on the labial wall of the pulp chamber. However, a transparent zone had formed under the lesion in the middle of the primary dentin. This change may be explained again in terms of the migration of ions such as Ca$^{++}$ and PO$_4^{3-}$, which are deposited in that zone. Similarly, pain in dentin can be explained, according to Anderson and Ronning, as a sudden fluid disturbance transmitted through the dental tubules to the pulp cells.

The explanation of all opaque or transparent tubules is not so easily given; although tubules are present in the whole tooth, they have different environments in the clinical crown and root. For that reason, each tubule requires a different interpretation that depends on the age and type of the tooth, the region involved, and whether the tooth is healthy or diseased. For example, many opaque tubules in the crowns of young specimens (Fig 1, 2) seemed different from those in older teeth (Fig 4, 8). The opaque tubules and their terminal branches in young teeth reached the dentinoenamel junction. In older specimens, a transparent zone formed on the periphery of the primary dentin of the crown. This difference in appearance may be explained in terms of gradual changes in structure and of the flow of fluid through the dentin tubules.

Takuma has shown in dentinogenesis that, by the formation of the peritubular matrix, the predental tubules become narrowed at the predentin-dentin junction. The

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Fig 8.—Unstained central section of an upper canine from the 71+ year age group. A, Slight enamel attrition; B, opaque dentin tubules; C, transparent ring at periphery of primary dentin; D, extent of formation of irregular secondary dentin in pulp chamber of crown.

of canine than the incisor results in better circulation and metabolism.

In an old tooth, a plug of irregular secondary dentin is formed on the wall of the pulp...
peritubular matrix continues to form throughout the entire life of the tubules, until they are ultimately occluded. Thus, the intertubular matrix is increased at the expense of the peritubular matrix. In older teeth (Fig 4–8), after the gradual formation of irregular secondary dentin and maturation of enamel, the entrapped primary dentin tubules in the region appear transparent at the dentino-enamel junction. The transparency may result from the difficulty of taking up nutrients and minerals from the pulp vascular system and from the passage of fluid ions or molecules through the tooth toward the pulp. Less-organized calcific deposits of the opaque primary dentin tubules would thus migrate to the periphery and there produce transparency by occlusion of the tubules and their terminal branches.

The interglobular spaces change from opaque to transparent. This process takes place with age and is due to gradual calcification.

Conclusions

Histologic study of a graded series of permanent upper canines, from people 11 to 71 or more years old, revealed a trend toward increased amounts of irregular secondary dentin in the pulp chamber of the crown with increasing age, unrelated to the degree of incisal attrition.

Regular secondary dentin was first formed in traces on all the walls of the pulp chamber of the crown and root. Irregular secondary dentin was then formed; more formed on the lingual than on labial and incisal walls of the pulp chamber of the crown. The direction of functional pressure accounts for the location of the greater amount of irregular secondary dentin on the lingual wall. This differs from current interpretations of the pattern and cause of irregular secondary dentin formation. Noticeably less irregular secondary dentin was formed in the canines than in the upper incisors of the same age group.

In primary dentin tubules, changes from opacity to transparency began at the periphery and occurred with increasing age. Similar changes in the interglobular spaces occurred with age. Both phenomena were ascribed to progressive calcification.

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References