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A QUANTITATIVE ANALYSIS OF THE NUMERICAL DENSITY AND THE DISTRIBUTIONAL PATTERN OF PRISMS AND AMELOBLASTS IN DENTAL ENAMEL AND TOOTH GERMS.

IV. THE NUMBER OF PRISMS PER UNIT AREA ON THE OUTER SURFACE OF HUMAN PERMANENT CANINES

by
GISLE FOSSE

INTRODUCTION

The object of the study described in this paper was to obtain numerical expressions pertaining to the number of prisms per unit area, or prism density, and the average prism diameter in certain defined regions on the outer surface of the enamel mantle of human permanent teeth.

Thus it might be possible to find out if the prism density varies systematically with enamel thickness and curvature. If the density appeared to be inversely proportional to localized surface growth of the enamel, this finding would give a strong support of the theory that the total number of prisms on the outer enamel surface equals the total number on the inner surface.

A systematic charting of prism density on the outer surface to this end, has not been undertaken by earlier investigators with the exception of *Eisenberg* (1938). The problem of supplementary prisms on the outer surface has been more directly attacked by measuring prism diameters on the outer and inner surfaces in given or unspecified zones of the enamel.

Pickerill (1913) measured the prism diameters at the inner and outer enamel surfaces on longitudinal tooth sections. He found a mean value of 5.7 μ on the outer surface. The highest values were measured in the cuspal zone, where an average diameter of 6.5 μ was found.

Chase (1927) published the results of his measurements of the prism diameters on the outer surfaces of several teeth, representing the complete permanent human dentition. He found an average diameter of 6.06 μ. Having measured the total outer surface of every type of tooth in the permanent dentition, he calculated for each tooth the number of prisms on the outer enamel surface.

Eisenberg (1938) measured the diameters of the prisms in three zones, an incisal or cuspal, a middle zone and a gingival zone on the outer enamel surface of 50 different teeth. On each tooth 50 prisms were measured. Thus the investigation comprised 2,500 separate measurements. He concluded that the prism diameter increases from the gingival zone towards the cusp. According to his measurements the mean prism diameters in the three zones were 6.8 μ, 5.7 μ and 4.5 μ.

Yosida (1938) measured the diameters on the inner and outer surfaces of the enamel mantle of teeth from different animals and from human material. On the outer surface of the human enamel mantle he found an average prism diameter of 4.5 μ at the cingulum, and 3.4 μ *(sic)* in the incisal zone.

Fosse (1964) tried to calculate the total number of prisms on the inner surface and the total number on the outer surface of the same tooth. He applied his method on two different human permanent teeth, and found a mean number of 29,584 prisms per mm^2 on the outer surface of the first specimen and a mean number of 21,903 prisms per mm^2 on the second specimen. The corresponding result for a third specimen, whose data were not presented in the same paper, was 19,880 prisms per mm^2. The method applied did not offer any numerical expression concerning the conception prism diameter. The author presented a diagram illustrating the variation in the number of prisms per linear unit on the inner and outer enamel surfaces.

Eisenberg and Yosida presented values concerning the prismatic diameters in given zones on the outer surface of the human enamel mantle. Their results were contradictory.

Pickerill and Chase gave mean values for the prismatic diameter on the outer surface. Their results were compatible and also agreed with the results given by Eisenberg.

Without explicity stating where the measurements had been carried out in the enamel mantle, other authors have presented data concerning the prism diameter. The results of their measurements vary from 3 to 6.4 μ (*Nishimura,* 1926; *Bödecker,* 1927; *Marcus,* 1931).

With the exception of Chase who reported that the interprismatic substance had been included in his measurements, none of the authors listed above, defined the conception prism diameter.

By means of the method described in part III the author intended to chart the variation of the numerical prism density on the outer enamel surface of one given tooth by conducting measurements in numerous regions in even distribution over the surface. Thus it might be possible to establish if there were a gradual increase of prism density in any directions on the outer enamel surface of one obviously normal tooth.

However, the first object of the present study was to establish if the numerical prism density in the cervical region is systematically different from the density in the cuspal region on the outer surface of human enamel. It was further the aim to establish if the prism density is particularly high in regions where there has been little or no local surface growth of the enamel during amelogenesis.

The second aim was to demonstrate whether the distributional pattern of the prisms on the outer enamel surface of the examined teeth were symmetrically hexagonal or whether there were a systematic distortion in any direction.

MATERIAL AND METHODS

In the human permanent dentition the canines have the least complicated enamel surface.

Four permanent canines from the upper jaw were chosen. They were all without visible attrition or enamel defects. Until used they were conserved in 4 % formol.

It was assumed by the author that the four specimens were representative of all normal human maxillary permanent canines. It was further assumed that the relationship between prism size and surface growth of the enamel mantle is identical for all human permanent teeth.

Method of calculating prism density, pattern and diameters

In part III the author described his method of calculating the number of prism ends or cross-sectioned prisms per mm^2, their distributional pattern and their diameters by measuring the central distances between pairs of adjacent prisms within enamel regions whose actual size was equal to or exceeded 15,000 μ^2. In the present study the constant area of the regions wherein measurements were conducted was 26,817 μ^2.

It is necessary that the reader refers to that paper to comprehend the expressions and results given in the present paper.

Choice and marking of regions within which central distances were measured

From adhesive cellotape straight strips were cut, 0.5 mm in width. These were attached to the enamel in the middle of the labial, mesial, palatinal and distal surfaces, along lines parallel to the longitudinal axis of each tooth, dividing each surface in two equal parts.

The crowns with the strips were dipped in melted wax. When the wax had cooled, the strips were carefully torn off, leaving on each crown four narrow segments uncovered by wax. The tooth was then immersed in 5.2 % HNO_3 for 20 secs., rinsed in water and finally dipped in Harris haematoxyline for 30 secs. Having stained the 4 main segments in the manner described above, the wax was completely removed by immersing the teeth for 2 hours in toluol.

One of the teeth was provided with 4 additional segments, each between two of the original ones, by repeating the procedure outlined above. This latter specimen will henceforth be designated by C_1, while the other three specimens will be designated by C_2, C_3 and C_4.

Figs. 1 and 2 represent C_1, where the 8 axial segments contain the regions to be examined.

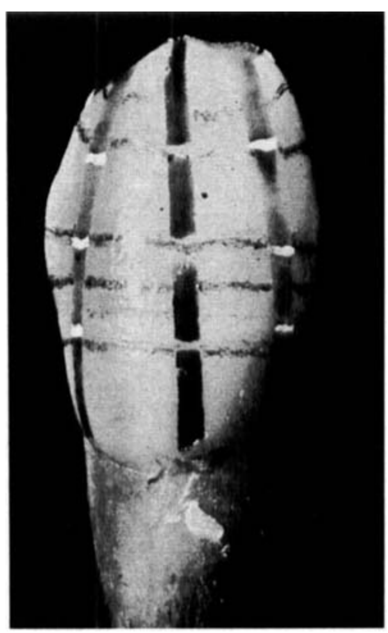

Fig. 1. The labial surface of C_1 with perikymata accentuated by graphite, and the stained distolabial, labial and mesiolabial vertical segments. Each segment is divided into 4 segment quarters.

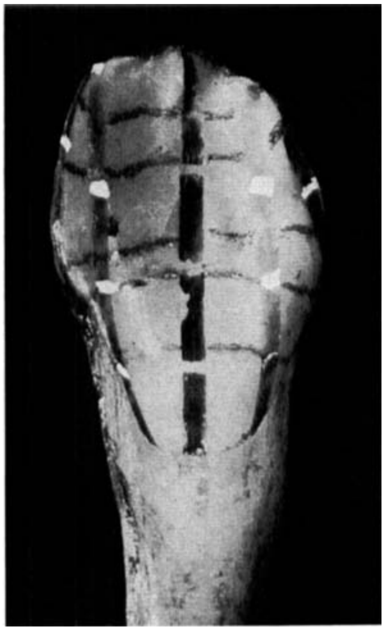

Fig. 2. The palatinal surface of C_1 with accentuated perikymata and the mesiopalatinal, palatinal and distopalatinal segments. The mesial and distal segments are also perceived.

By graphite markings, each segment was divided into 4 parts of approximately equal length. There were, accordingly, 32 such stained segment quarters on the enamel surface of C_1.

The thin curved horizontal lines are perikymata, accentuated by a sharp pencil under a binocular dissecting microscope.

Microphotography of regions within the segment quarters

To facilitate the alignment of any region on the enamel surface with the focal plane of the microscope, the author applied the Leitz U-stage which may be rotated about 5 independent axes. Fig. 3 represents this stage.

On the enamel surface of C_1, the measurements were conducted within regions photographed at either end of each of the 32 segment quarters. In addition, 16 regions, situated in the centers of the segment quarters on the labial, mesial, palatinal and distal surfaces, were photographed for measurement.

Thus 80 regions were photographed on C_1.

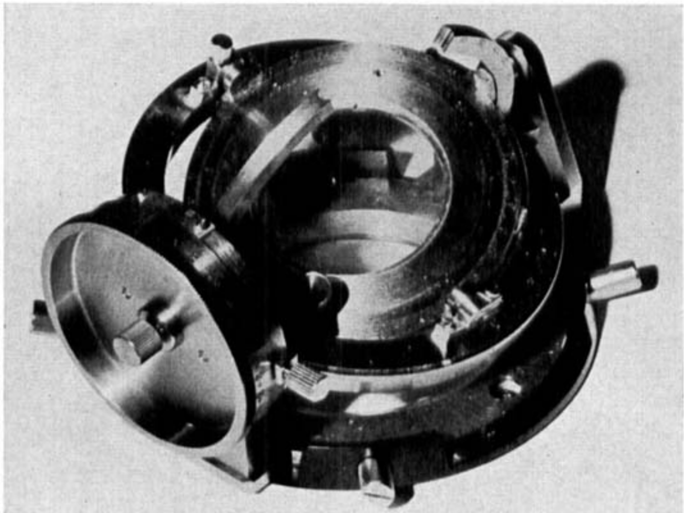

Fig. 3. The Leitz U-stage with 5 axes for rotation of the specimen.

Numeration of regions

It has already been pointed out that in each segment quarter one region was photographed in the apical end and one in the cuspal end.

The numeration of these regions starts cervically in the labial segment and continues over the cusp and ends cervically in the palatinal segment. Then the numeration continues from the cervical part of the mesial segment over the cusp to the cervical part of the distal segment. On each of the remaining segments the numeration continues in an apical direction and in this sequence: Mesiolabial, distolabial, mesiopalatinal and distopalatinal.

Figs. 4 and 5 are diagrammatic representations of the labial and palatinal surfaces of C_1. The ordinal numbers are enclosed in small circles.

RESULTS

Arcades

The prisms were generally arcade shaped. With few exceptions the arcades were orientated with the convexity pointing towards the cusp. (Compare *Chase*, 1927 and *Smreker*, 1930).

Within the regions numbered 41 and 42, the arcades were orientated 90° to this main direction.

Within four different regions near the cusp the arcades were orientated in

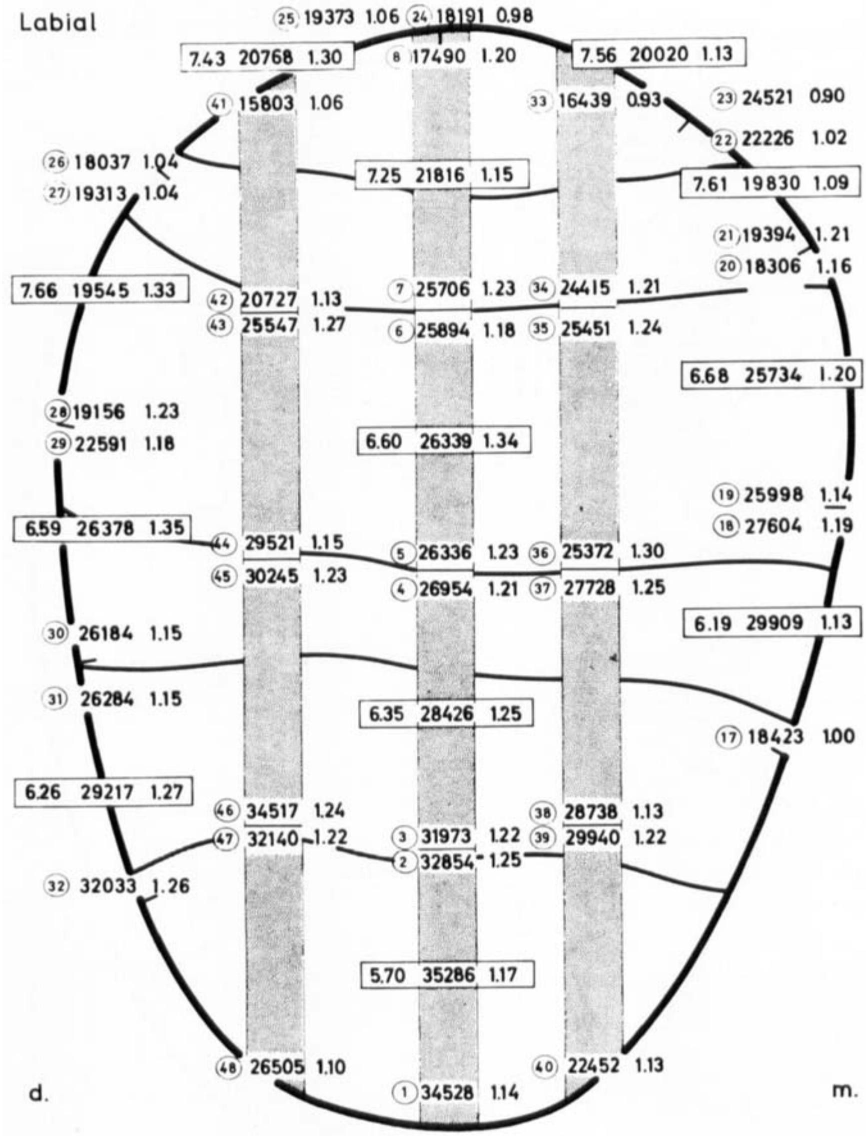

Fig. 4. Diagrammatic representation of the labial surface of C_I. The shaded areas represent the segments. In the extreme ends of the segments and on either side of the partition lines between segment quarters a region was microphotographed for measurements of central distances. These regions are represented by their a_{dyx}- and K_{dyx}-values in the diagram and may be compared mutually. Their ordinal numbers are enclosed in circles. In the distal, labial and mesial segments a region has also been microphotographed in the center of each segment quarter. These regions are represented by their $\langle D \rangle$-, a_{reg}- and $\langle K \rangle$-values which are enclosed in rectangles. The main pattern of perikymata is represented by 5 horizontal lines which continue to the palatinal surface, see Fig. 5.

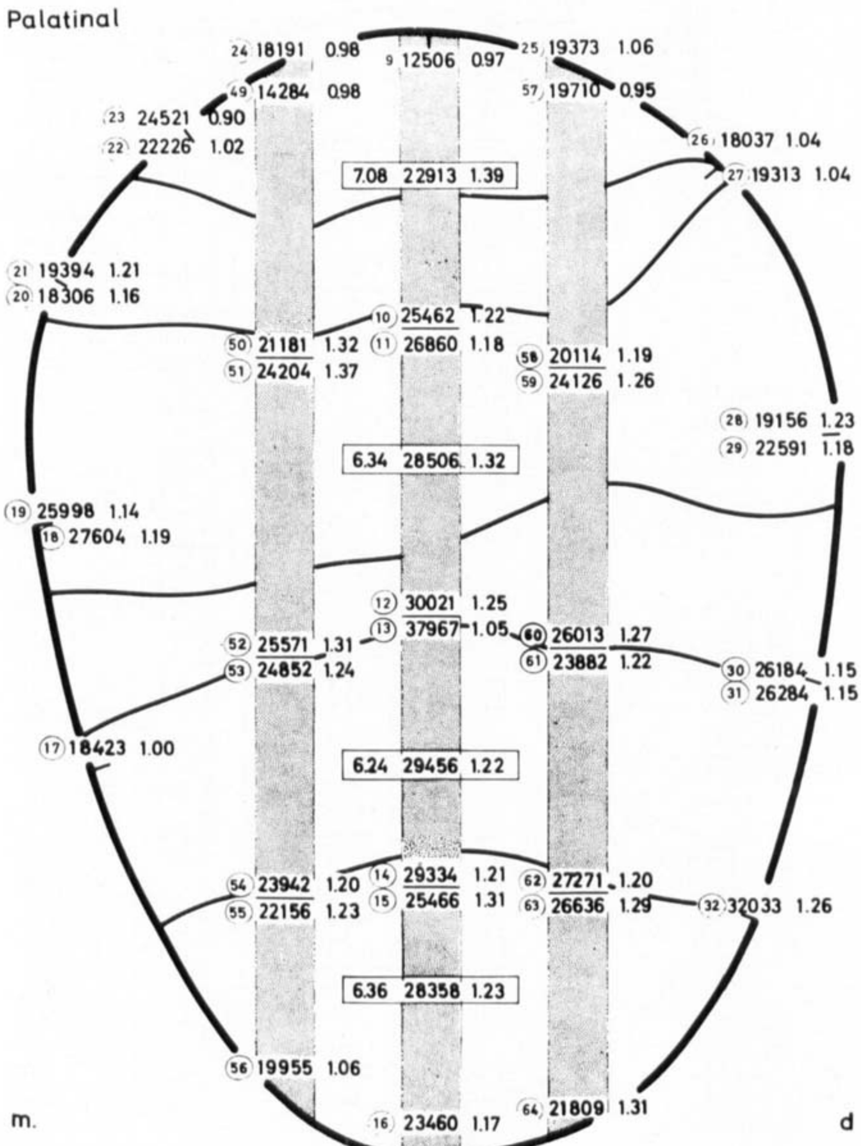

Fig. 5. Diagrammatic representation of the palatinal surface of C_1, with the numbered regional a_{dyx}- and K_{dyx}-values and the $\langle D \rangle$-, a_{reg}- and $\langle K \rangle$-values enclosed by rectangles in the palatinal segment. The latter values belonging to the mesial and distal segments are presented in the diagrammatical representation of the labial surface, see Fig. 4.
The 5 horizontal lines are the same perikymata that were represented in Fig. 4.

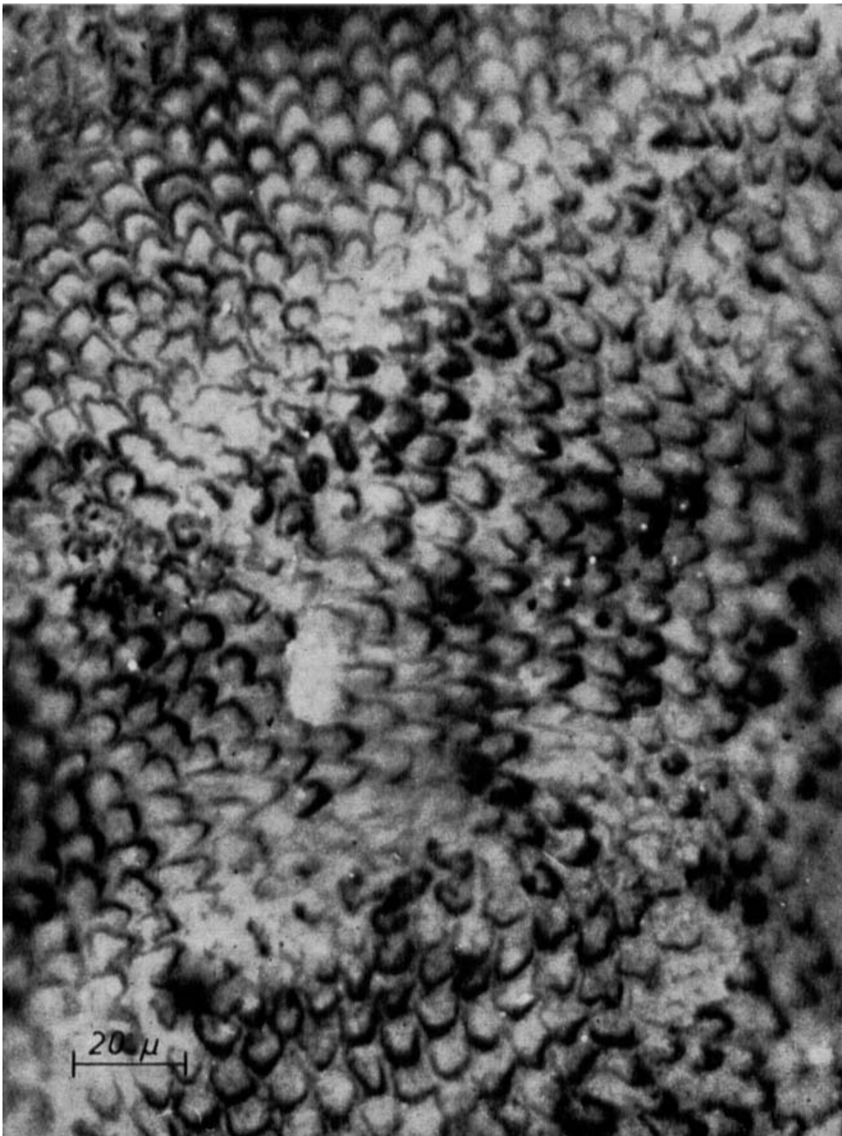

Fig. 6. Region 25 on C_1. The arcades are pointing in three different directions.

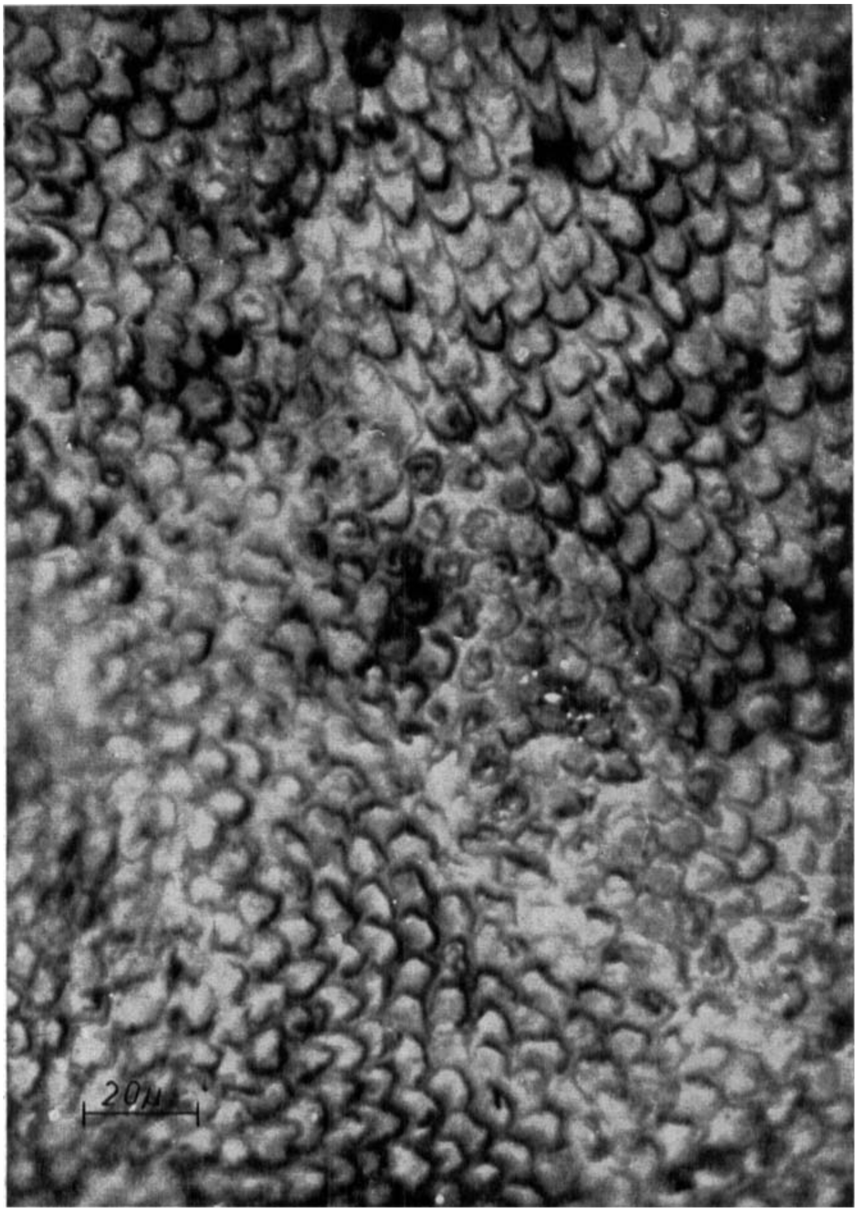

Fig. 7. Region 57 on C_1. The arcades are orientated in two different directions. In a central zone of the photomicrograph are seen »closed» round or polygonal prisms with a central body.

different directions. Fig. 6 represents region 25 with arcades pointing in three different directions. Fig. 7 represents region 57 where the arcades point in two different directions. In a zone between the two groups are seen »closed» round or polygonal prisms with a central body. All photographs are orientated with the long border in the longitudinal axis of the tooth.

Perikymata

On C_1 the author found that the symmetry axes of the arcades were generally orientated perpendicularly to the perikymata. In region 41 and region 42 the symmetry axes were parallel to the perikymata, however.

The regional prism densities and patterns on C_1

The a_{dyx} — and K_{dyx}-values. All the symbols presented in this and the following chapter have been defined in part III.

Figs. 4 and 5 are schematic representations of the labial and palatinal surfaces of C_1. In the locations corresponding to the photographed regions, are positioned the a-values within the shaded bands representing the segments. The numbered regions in the diagram are represented by the adyx- and the Kdyx-values. These values were calculated directly from the mean values of the central distances within the region and are thus easily obtained by a table calculator.

The values written in rectangles in the middle of 16 segment quarters stand from left to right for ⟨D⟩, a_{reg} and ⟨K⟩ *and may not be compared unconditionally with the a_{dyx}- and K_{dyx} values in the numbered regions.* In part III the author demonstrated the magnitude of the difference between a_{dyx} and a_{reg} for three test regions.

The lowest a_{dyx}-values on C_1 were calculated for the cuspal zone, limited apically by the most cuspal perikymata accentuated by graphite.

In the palatinal region 9 was found the lowest a_{dyx}=12506 corresponding to a mean central distance equalling 9.60 μ. Fig. 8 represents a part of this region. The regions 49, 41 and 33 are represented by only slightly greater a_{dyx}-values. Apart from the cuspal zone only region 17 in the cervical zone is represented by an equally low a_{dyx}-value, namely 18423 prisms per mm^2.

The highest value of 37967 prisms per mm^2 was found in region 13 in the palatinal segment. Fig. 9 is a photographic representation of this region. All photographs are reproduced in the same scale.

The relative magnitude of the a_{dyx}-values. Fig. 4 demonstrates that the a_{dyx}-values decrease fairly evenly in the labial sector from the cervical towards the cuspal zone.

Fig. 8. Region 9 on C_1. This region contained the greatest prisms, ther D_{dyx}-value being 9.60μ.

If one disregards the most cervical regions, there is also a similar decrease of values towards the cuspal zone in the mesiolabial and distolabial segments. The conditions are more complicated in the mesial segment, since the lowest a_{dyx}-values are found in regions 17, 20, 21 and 24. In the distal segment there is an even decrease towards the cusp. In the remaining 3 segments on the palatinal surface the highest values are concentrated in the middle part, corresponding to the flat portion of this surface.

With the exception of region 1 in the labial segment and region 32 in the distal segment, all a_{dyx}-values in the most cervical zone are lower than the values cuspal to them in the same segments.

The K_{dyx}-values on the outer surface. The smallest K_{dyx}-values are found in the cuspal zone, and are thus related to the smallest a_{dyx}-values on C_1, with the exception of region 8.

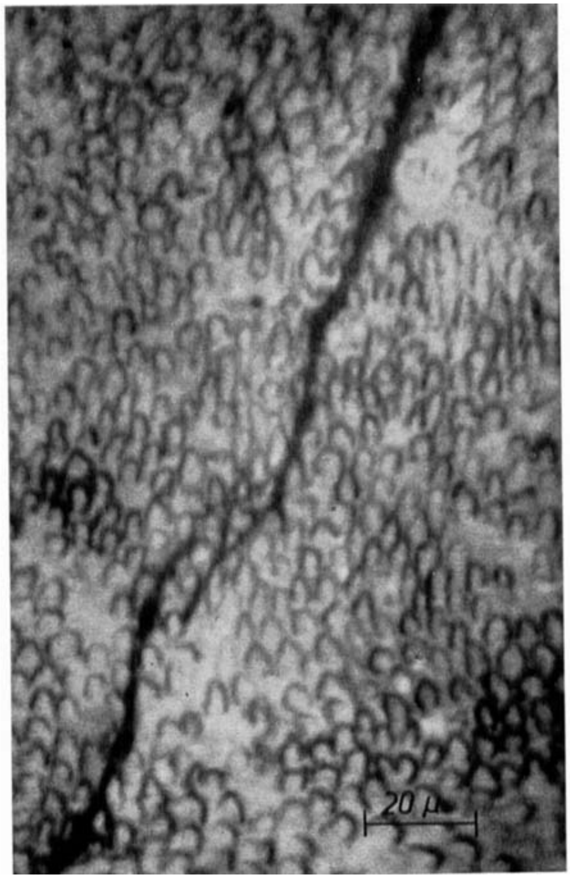

Fig. 9. Region 13 on C_1. This region contained the smallest prisms, their D_{dyx}-value being 5.51 μ.

Otherwise it is not possible to see any systematic distribution of the K_{dyx}-values in the separate segments or along the separate traced perikymata. For all the numbered regions on C_1, the mean of the K_{dyx}-values equals 1.18.

One of the highest K_{dyx}-values was calculated for region 64 in the disto-palatinal segment, where $K_{dyx} = 1.31$. Fig. 10 represents this region.

One of the lowest values was calculated for region 24 in the mesial segment where $K_{dyx} = 0.98$. This region is represented by Fig. 11. The difference in pattern is immediately seen by comparing these photographs.

The a_{reg}-, $\langle a_{gr} \rangle$-, $\langle K \rangle$- and $\langle D \rangle$-values on C_1. Table I presents the $\langle a_{gr} \rangle$-, $\langle K \rangle$- and $\langle D \rangle$-values and their standard deviations for the regions situated

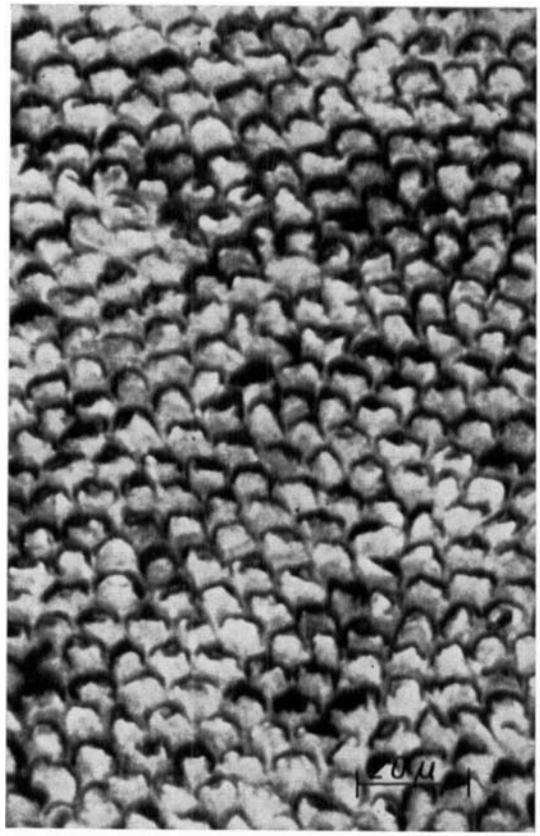

Fig. 10. Region 64 on C_1. The highest vertical compression of prism pattern was calculated for this region, where $K_{dyx} = 1.31$.

in the middle of each segment quarter in the labial, mesial, palatinal and distal segments. The table also lists the a_{dyx}- and a_{reg}-values for these 16 regions. In the table the values for a_{reg}, $\langle K \rangle$ and $\langle D \rangle$ are underlined. These are the values framed by rectangles in Figs. 4 and 5.

It is distinctly demonstrated by the table that the a_{dyx}-values deviate more from the a_{reg}-values than do the $\langle a_{gr} \rangle$-values.

a_{reg} is probably the best approximation to the »true» density of prisms within a given region. But the statistical comparison between two regions as to prism density was based on $\langle a_{gr} \rangle$ and S_{agr}.

Fig. 12 is a graphical representation of the $\langle a_{gr} \rangle$-values, with the double standard deviations added and subtracted. Each quarter of the diagram con-

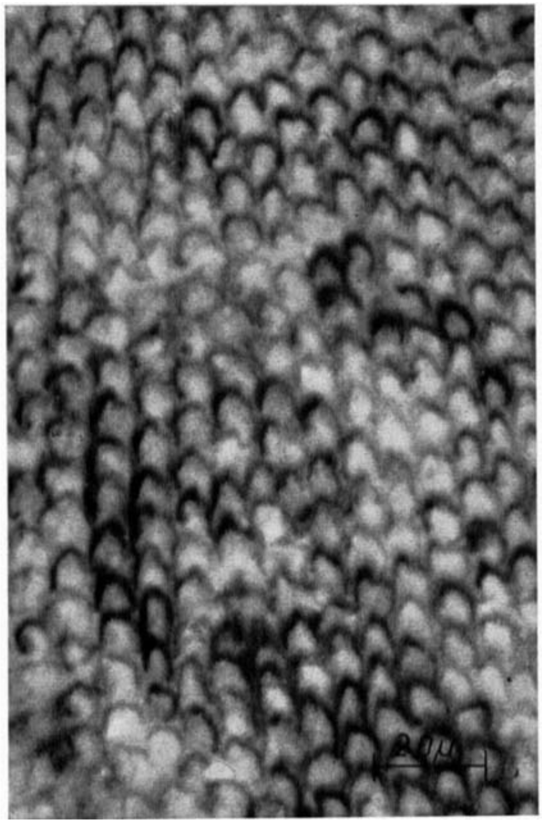

Fig. 11. Region 24 on C_1. The lowest vertical compression was calculated for this region where $K_{dyx} = 0.98$.

tains the four regional values from one segment and in a sequence from left to right that corresponds to the numeration of the regions in the four main segments. Thus the cusp corresponds to the 1st and 3rd vertical partition lines, while the cervical zone corresponds to the extremes and the middle part of the diagram.

Testing of $\langle a_{gr} \rangle$*- and* $\langle D \rangle$*-values on* C_1. Fig. 12 demonstrates the decrease of the $\langle a_{gr} \rangle$-values from the cervical zone towards the cusp in all 4 segments.

For each segment the most cervical and the most cuspal $\langle a_{gr} \rangle$-values were tested against each other by a t-test.

P was always less than 0.1 %, which means that statistically the difference between the cuspal and the cervical $\langle a_{gr} \rangle$-values is significant.

Table I

The prism density, the vertical compression of prism pattern and the central distances between adjacent prisms in the 16 regions in the labial, palatinal, mesial and distal segments on C_1, a human permanent canine. The three thick horizontal lines separate the values of the different segments; the first and the third line correspond to the cusp, while the central line together with the top and bottom of the table correspond to the cervix of C_1.

Segment quarter	Triangles	Groups	Number of prisms per mm²				Vertical compression		Central dist.	
			adyx	areg	⟨agr⟩	Sagr	⟨K⟩	SK	⟨D⟩	SD
1—2	114	16	34442	*35286*	35423	2936	*1.17*	0.21	*5.70*	0.37
3—4	129	17	28161	*28426*	28614	2532	*1.25*	0.18	*6.35*	0.46
5—6	138	16	25970	*26339*	26349	1913	*1.34*	0.16	*6.60*	0.42
7—8	123	14	21446	*21816*	21931	1529	*1.15*	0.19	*7.25*	0.53
9—10	110	16	22002	*22913*	22815	1379	*1.39*	0.28	*7.08*	0.50
11—12	119	15	28177	*28506*	28361	2464	*1.32*	0.38	*6.34*	0.51
13—14	127	17	29348	*29456*	30152	2542	*1.22*	0.20	*6.24*	0.46
15—16	134	14	28146	*28358*	28558	1442	*1.23*	0.16	*6.36*	0.37
17—18	108	18	29320	*29909*	29602	2644	*1.13*	0.26	*6.19*	0.44
19—20	90	15	25132	*25734*	25959	1548	*1.20*	0.19	*6.68*	0.38
21—22	83	14	19474	*19830*	20667	1916	*1.09*	0.19	*7.61*	0.48
23—24	83	13	19593	*20020*	20072	2197	*1.13*	0.25	*7.56*	0.72
25—26	66	14	20487	*20768*	20905	2159	*1.30*	0.20	*7.43*	0.56
27—28	69	14	19315	*19545*	20172	2470	*1.33*	0.24	*7.66*	0.50
29—30	87	14	26259	*26378*	26606	3251	*1.35*	0.25	*6.59*	0.53
31—32	98	19	28676	*29217*	29370	3022	*1.27*	0.22	*6.26*	0.49
Mean:				25781			1.24		6.74	

To control these results, t-tests were also carried out for the ⟨D⟩-values representing the same regions. The results corroborated those pertaining to the ⟨agr⟩-values, P being always less than 0.1 %.

Thus it seems safe to say that on C_1 the cuspal prisms are significantly greater than the prisms in the cervical region.

Testing of ⟨K⟩-values. t-tests may be carried out between ⟨K⟩-values representing different regions. As an example the cuspal ⟨K⟩ = 1.39 was tested against the cervical ⟨K⟩ = 1.23 on the palatinal surface, see table I. The calculation gave a $P < 0.1$ % meaning that the difference was statistically significant.

However, since the significance of the regional ⟨K⟩-differences is not known yet, it seems futile to test them.

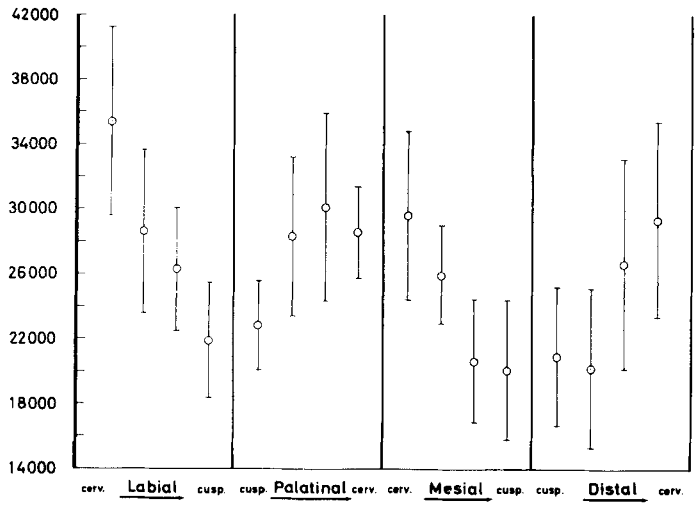

Fig. 12. Graphical representation of $\langle a_{gr} \rangle$-values in the labial, palatinal, mesial and distal segments of C_1. To each value is added and subtracted the double standard deviation. Each segment is represented by 4 values corresponding to the 4 regions situated in the center of each segment quarter.
The 1st and 3rd vertical partition lines correspond to the cusp, the extreme ends and the 2nd partition line to the cervix of C_1.

Comparison between identical regions on C_1, C_2, C_3, and C_4

The a_{reg}-, $\langle a_{gr} \rangle$-, $\langle K \rangle$- and $\langle D \rangle$-values. The investigation concerning C_1 served to chart the prismatic density and pattern on the outer enamel surface of one single and seemingly normal tooth, by means of numerous evenly distributed regions.

On C_2, C_3 and C_4 only 4 regions were photographed for plotting on each tooth. Their location corresponded to regions 2, 7, 13 and 15 on C_1. Thus it might be possible to verify if the difference between prism densities and patterns in these regions on C_1 were characteristic for human permanent canines and would be repeated on other similar teeth. For this reason the a_{reg}-, $\langle a_{gr} \rangle$-, $\langle K \rangle$- and $\langle D \rangle$-values had been calculated for these four regions on C_1, C_2, C_3 and C_4.

Table II presents the $\langle a_{gr} \rangle$-, $\langle K \rangle$- and $\rangle D \rangle$-values and their standard deviations of the 4 regions on the 4 specimens. The a_{reg}-values are also presented in this table.

Fig. 13 is a graphical representation of the $\langle a_{gr} \rangle$-values. Connecting lines have been drawn between the values for each tooth. The similarity in $\langle a_{gr} \rangle$-distribution is evident.

Table II

The prism density, the vertical compression of prism pattern and the central distances between adjacent prisms in regions 2, 7, 13 and 15 on the outer enamel surface of C_1, C_2, C_3 and C_4, four human permanent canines.

Specimen	Region	Triangles	Groups	Prisms/mm²			Vert. compr.		Central dist.	
				areg	⟨agr⟩	Sagr	⟨K⟩	SK	⟨D⟩	SD
C_1	2	145	16	33181	33071	2606	1.27	0.23	5.88	0.38
	7	165	22	25970	26122	2448	1.23	0.20	6.64	0.49
	13	96	17	38916	38701	4400	1.10	0.18	5.42	0.44
	15	123	16	25670	25854	2538	1.32	0.19	6.69	0.45
C_2	2	101	10	34052	34153	1113	1.43	0.28	5.81	0.29
	7	81	12	18383	18708	2061	1.32	0.24	7.89	0.65
	13	103	11	34205	34712	2123	1.27	0.22	5.79	0.37
	15	150	14	32639	32671	1907	1.26	0.17	5.43	0.38
C_3	2	106	10	24602	25208	2175	1.19	0.24	6.82	0.55
	7	120	12	21741	21976	2069	1.29	0.22	7.26	0.61
	13	111	14	28138	29076	3859	1.43	0.33	6.38	0.56
	15	79	12	23453	24256	2540	1.17	0.21	6.99	0.59
C_4	2	121	18	33034	33625	4788	1.18	0.27	5.87	0.63
	7	125	14	21365	21655	1356	1.10	0.17	7.33	0.49
	13	130	12	36306	36529	3025	1.17	0.30	5.62	0.45
	15	161	12	30164	30314	3457	1.18	0.21	6.61	0.49

On all four specimens prism density was highest in region 13. The second highest value on each tooth was in region 2. On C_2, C_3 and C_4 the second lowest value was found in region 15 and the lowest in region 7. On C_1 the lowest density was found in region 15.

Testing of ⟨agr⟩- and ⟨D⟩-values in the 4 regions on C_1, C_2, C_3 and C_4. On each specimen the ⟨agr⟩-value representing region 7 was tested against the ⟨agr⟩-value representing region 2. Choosing a 5 % level of probability, the results demonstrated a statistically significant difference, P being always less than 0.1 %.

To control these results, t-tests were also carried out for the ⟨D⟩-values representing the same regions. The results corroborated those pertaining to the ⟨agr⟩-values.

Regions 13 and 15 have also been tested against each other in the same manner. The results demonstrate a significant difference. P was always less than 2.5 %.

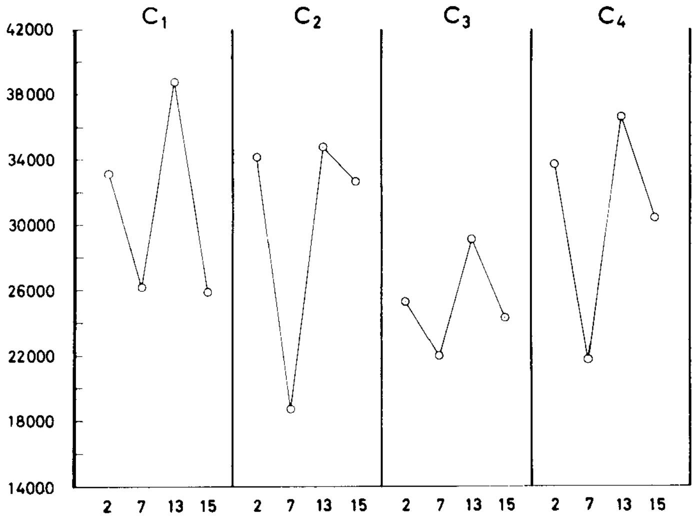

Fig. 13. Graphical representation of ⟨agr⟩-values in regions 2, 7, 13 and 15 on C_1, C_2, C_3 and C_4. Between the values of each tooth have been drawn connecting lines to demonstrate the similarity in distribution.

⟨K⟩-values on C_1, C_2, C_3 and C_4 in the four regions. The means of the four ⟨K⟩-values for region 2, region 7, region 13 and region 15 were 1.26, 1.23, 1.24 and 1.23 respectively.

From this material, therefore, one cannot conclude that these 4 regions may be characterized by their ⟨K⟩-values.

DISCUSSION

Own findings

If it is assumed that the number of prisms on the inner enamel surface equals the number on the outer surface of one tooth, and if it is further assumed that prism density is fairly equal in different regions on the inner surface, then the prism density on the outer surface must be lowest in zones or regions where the enamel has the greatest thickness or the smallest radius of curvature.

The results presented in this paper seem to be compatible with this theoretical conclusion, since the cervical ⟨agr⟩-values were higher than the cuspal values on all four specimens, and since the values on the flat central part of the palatinal surface were higher than in the other regions on the same specimens.

But neither of the two assumptions stated in the beginning of this chapter has ever been proven, and neither of them is dependent on the other.

Generally, therefore, no conclusions may be drawn as to the total number of prisms on the inner surface or the distribution of regional prism densities on this surface from the presented findings. They constitute strong evidence, however, of the theoretical equality of prism numbers on both enamel surfaces.

On the outer surface of the permanent canines, the prism pattern was found to be compressed in a direction parallel to the longitudinal axis of the tooth. This means that, generally, the central distances which were approximately transversal to the longitudinal axis of the tooth, were longer than the central distances in the V_2 and V_3 directions (cf. part III).

Since the central distances may be regarded as prism diameters in three given directions, this vertical compression means that the transversal prism diameters are greater than prism diameters measured in any other direction.

The vertical compression which the present author has found on all types of human permanent teeth might theoretically be caused by the lateral distension of the ameloblastic layer during amelogenesis if each ameloblast were responsible for one prism. In that case the compression would be less towards the amelodentinal junction.

The magnitude of the compression expressed by the $\langle K \rangle$-values for regions 2, 7, 13, 15 on C_1, C_2, C_3 and C_4 did not seem to vary systematically according to regional location. If this were the case the $\langle K \rangle$-value for region 13 in the flat part of the palatinal surface should systematically be lower than the $\langle K \rangle$-values in other regions. Besides, one would expect the highest values in the cuspal regions.

The cause of the compression is therefore not obvious.

The results of other authors

In each of the 4 main sectors on C_1 the most cuspal $\langle D \rangle$-value was greater than the most cervical $\langle D \rangle$-value. In each sector this difference was statistically significant on the 5 % level. The mean of the 4 most cuspal values was 7.33 μ, while the mean of the most cervical values was 6.12 μ.

On C_1, C_2, C_3 and C_4 the $\langle D \rangle$-values representing region 7 were significantly greater than the $\langle D \rangle$-values representing region 2. The mean of the four $\langle D \rangle$-values representing region 7 on these teeth was 7.28 μ and the mean representing region 2 was 6.09 μ.

The latter means, however, do not represent exactly the same locations as those representing the most cuspal and the most cervical values for C_1 alone.

These results are compatible with those of *Eisenberg* (1938) and *Pickerill* (1913), concerning the difference between cuspal and cervical central distances. Eisenberg found a mean value of 6.8 μ for the cuspal diameters, and a mean cervical value of 4.5 μ.

The results of *Yosida* (1938) contrast with the findings of Eisenberg and the present author. Yosida found a mean cuspal value of 3.4 μ and a mean cervical value of 4.5 μ (cingulum).

Eisenberg's values concerning the prism diameters were lower than the mean central distances in corresponding zones measured by the present author.

This may be caused by the fact that Eisenberg had not included the interprismatic substance in his measurements. The reason may also be that the diameters on canines are generally higher than the mean diameter on all types of permanent human teeth. Thirdly, the discrepancy may be due to the fact that Eisenberg had measured the diameters in vertical directions. Such measurements would give smaller mean values than measurements performed in the transversal directions because of the vertical compression.

Chase (1927), who specifically stated that he had included the interprismatic substance, found an average prism diameter of 6.06 μ based on measurements on the outer enamel surfaces of all types of human permanent teeth.

The average ⟨D⟩-value for the total outer surface of C_1 was 6.74 μ. This value seems to be in good agreement with Chase's value although reservations must be made as to the direction in which Chase carried out his measurements. The a_{reg}-value is probably the best approximation to the true number of prisms within a given region. The average a_{reg}-value for C_1 was 25,781. *Fosse* (1964) had calculated the average prism density on the outer enamel surface of a bicuspid. This value equalled 21,903 prisms per mm^2. Although this finding is in agreement with the value for C_1, the two values can not be compared, since the method applied on the bicuspid was based on counting of prisms in the transversal planes only.

The present results do not unequivocally corroborate the findings of any other author, since there exist no universal definition of the conception prism diameter; concerning the inclusion of the interprismatic substance, or the direction relative to the longitudinal tooth axis in which the measurements are to be carried out. Neither is there a general agreement as to the locations of the cervical and cuspal enamel zones.

Also, considering the great variation of the form and area of prism ends on one single tooth and between regions of the same location on several teeth, a discrepancy between the findings of many investigators must be expected.

CONCLUSIONS

On the outer enamel surface of human maxillary permanent canines the prism density is lower in the cuspal than in the gingival zone on the labial surface. A very high density exists in the flattest region on the lingual surface, higher than in the cervical region on the same surface.

The conclusions above may lead to the following hypothesis: The prism density on the outer enamel surface of human permanent teeth tends to be proportional to the radius of enamel curvature and inversely proportional to the thickness of the enamel.

On the outer enamel surface of human maxillary permanent canines the prism pattern is compressed in a direction parallel to the longitudinal axis of the tooth.

This means that the prism diameters including interprismatic substance are on an average greatest in the transversal planes.

The latter conclusion is probably valid for all types of human permanent teeth.

SUMMARY

On the outer enamel surface of 4 human maxillary permanent canines without attrition, the author selected four regions of definite locations. Two regions were situated on the labial surface; one in the cuspal and one in the cervical zone. The other two were situated on the palatinal surface; one in the central flat part and one in the cervical zone. Within each region measurements of the distances between the apparent centers of adjacent prisms were carried out. With certain reservations the central distances might be regarded as prism diameters.

From these measurements within each region were calculated the mean central distance, the mean numerical prism density and the compression ratio ⟨K⟩ which described the deformation of the prismatic pattern in the vertical direction.

The differences between the mean prism densities were statistically tested. On all four specimens the highest prism density was found in the flat part of the palatinal surface. On the labial surface the prism density was higher in the cervical than in the cuspal zone.

The author arrived at the following hypothesis: The prism density on the outer enamel surface of human permanent teeth tends to be proportional to the radius of enamel curvature and inversely proportional to the thickness of the enamel.

In practically all the regions on the outer enamel surface of these 4 specimens, the prism pattern was compressed in a vertical direction, which means that the central distances were greatest in the transversal planes. The author offered no explanation as to the cause of this vertical compression.

By means of tables and diagrams the variation of prism density and the compression of pattern was demonstrated.

RÉSUMÉ

LE NOMBRE DE PRISMES PAR UNITÉ DE SURFACE Á LA SURFACE EXTÉRIEURE DES CANINES PERMANENTES HUMAINES

Sur les surfaces extérieures de 4 canines permanentes supérieures humaines n'ayant pas subi d'attrition, l'auteur a choisi 4 régions de positions déterminées. Deux des régions étaient situées sur la face vestibulaire, l'une au niveau de la cuspide et l'autre dans la région du collet. Les deux autres régions étaient situées sur la face palatine, l'une dans la partie centrale plane et l'autre dans la région du collet. Dans chaque région, on a pratiqué la mesure des distances entre les centres apparents des prismes adjacents. A certaines réserves près, les distances centrales pouvaient être considérées comme les diamètres des prismes.

Sur la base de ces mesures, on a calculé dans chaque région la distance centrale moyenne, la densité numérique moyenne des prismes et le taux de compression ⟨K⟩ qui décrit la distorsion du mode de distribution des prismes dans la direction verticale.

Les différences entre les densités moyennes des prismes ont fait l'objet d'un test statistique. Sur les 4 échantillons, la densité prismatique la plus élevée a été trouvée dans la partie plane de la face palatine. Sur la face vestibulaire, la densité prismatique était plus élevée dans la région du collet que dans la région de la cuspide.

L'auteur aboutit à l'hypothèse suivante: La densité prismatique à la surface extérieure de l'émail des dents permanentes humaines tend à être proportionnelle au rayon de la courbure de l'émail, et inversement proportionnelle à l'épaisseur de l'émail.

Pratiquement dans toutes les régions de la surface extérieure de l'émail de ces 4 échantillons, le mode de distribution des prismes était comprimé en direction verticale, ce qui signifie que les distances centrales étaient plus grandes dans les plans transversaux. L'auteur n'a pas proposé d'explication quant à la cause de cette compression verticale.

La variation de la densité prismatique et la compression de leur mode de distribution ont été représentées sous forme de tables et de diagrammes.

ZUSAMMENFASSUNG

DIE ANZAHL DER SCHMELZPRISMEN PER FLÄCHENEINHEIT AUF DER OBERFLÄCHE DER MENNSCHLICHEN BLEIBENDEN ECKZÄHNE

Auf der Schmelzoberfläche von 4 menschlichen bleibenden Eckzähnen wurden 4 Regionen in bestimmten Entfernungen und Positionen gewählt. Zwei Regionen waren auf der Labialfläche lokaliziert; die eine bei der Schneidekante, die andere bei dem Zahnhals. Die dritte Region war in dem mittleren platten Gebiet der Lingualfläche lokaliziert, die vierte bei dem Zahnhals dieser Fläche.

Innerhalb jeder Region wurden Messungen der Abstände zwischen den scheinbaren Zentren benachbarten Prismen ausgeführt. Diese Zentralabstände möchten als Prismendurchmesser aufgefasst werden.

Mittels der Messresultate wurden der mittlere Zentralabstand, die mittlere numerische Dichtheit und die Kompression, ⟨K⟩ berechnet. Der letzte Ausdruck beziechnet die Zusammenpressung des Verteilungsmusters der quergeschnittenen Prismen längs der Achse des Zahnes.

Die Differenzen zwischen den Werten der mittleren Prismendichtheiten wurden statistisch geschätzt. Auf allen 4 Zähnen wurde die höchste Zahl der Prismen per mm^2, im mittleren platten Gebiet der Palatinalfläche gefunden. Auf der labialen Fläche wurde die höchste Zahl (grösste Dichtheit) beim Zahnhals gefunden.

Der Verfasser gelang an die folgende Hypothese: Die numerische Prismendichtheit und der Krümmungsradius des Schmelzmantels in einem bestimmten Punkt auf der Schmelzoberfläche der menschlichen bleibenden Zähne, sind ungefähr proportional. Anderseits sind die Dichtheit und die Dicke des Schmelzes umgekehrt proportional.

In fast allen Regionen auf der Schmelzoberfläche dieser 4 untersuchten Zähne, war das Prismenmuster in der Längsachse des Zahnes zusammengepresst. Das bedeutet dass die Prismen auf der Oberfläche in der transversalen Richtung dicker waren, als in einer Richtung parallel mit der Zahnachse. Der Verfasser konnte die Ursache dieser Kompression nicht angeben.

Vermittels Tabellen und Diagrammen wurde die Variation der Prismendichtheit und die Prismenkompression dargestellt.

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