Dimensions and Relations of the Dentogingival Junction in Humans

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IN 1921, Gottlieb's discovery of the epithelial attachment of the gingiva opened new horizons which served as the basis for a better understanding of the biology of the dental supporting tissues in health and disease. Three years later his pupils, Orban and Kohler (1924), undertook the task of measuring the epithelial attachment as well as the surrounding tissue relations during the four phases of passive eruption of the tooth. Gottlieb and Orban's descriptions of the epithelial attachment unveiled the exact morphology of this epithelial structure, and clarified the relation of this structure to the enamel of the tooth.

In recent years the prevailing concept of the epithelial attachment was challenged by Waerbaug.[3] He returned to the old concept of a potential space extending from the gingival margin to the cementoenamel junction. Waerhaug's altered convictions were based upon several observations. These are: (1) he was able to insert a thin steel blade into this space without pressure. From histologic sections, he claimed that there was no difference between the epithelium of the intact areas and in the area where the blade was inserted. (2) In addition he claimed that after a gingival flap had been pulled away from the enamel surface and the flap repositioned, no difference could be seen between the operated and the non-operated areas. Repetition of these procedures by Orban[4] have shown Waerhaug's findings could not be verified under similar experiments. Gottlieb's discovery was in the least reconfirmed; however Waerhaug's challenge was not without benefit. The so-called strength of adherence of the epithelial attachment, and the organic nature of the attachment had to be reconsidered. The author's are now inclined to subscribe to Weski's[5] idea; mainly that the epithelium after enamel maturation, produces a cementing substance that attaches the epithelium to the enamel surface and later to the surface of the cementum. It now seems impossible that Gottlieb's original idea of a union between ameloblast and the forming and maturing enamel rods could survive the final calcification of the enamel matrix.

Discussions with Sicher (1959)[6] lead to the reconsideration of the mode of attachment and the formulation of a physiologic division of labor of the supporting tissues at the "dento-gingival junction." This established the concept of the dentogingival junction as a functional unit composed of two parts: (1) the connective tissue fibrous attachment of the gingiva and (2) the epithelial attachment. The two separate components share a division of function.

The biologic protection of the dentogingival junction is the function of the epithelial attachment. The epithelium attaches to the circumference of the tooth as a broad band the "attached epithelial cuff." The epithelial attachment to the tooth is not firmly attached in spite of the fact that it is stronger than the individual cohesiveness of the epithelial cells. The firmness of the gingival attachment to the tooth is derived by the fibrous connective tissue bound to the cementum, alveolar bone and gingiva.

Because of the dynamic alterations in the component parts of the dentogingival junction it is important to know their positions in all phases of eruption under normal conditions. The importance of this relation is enhanced when one considers the imbalance of these components in periodontal disease. Thus, these dimensions can serve as a base line for future studies involving the pathologic status of the dentogingival junction and serve as "the physiologic dentogingival junction."

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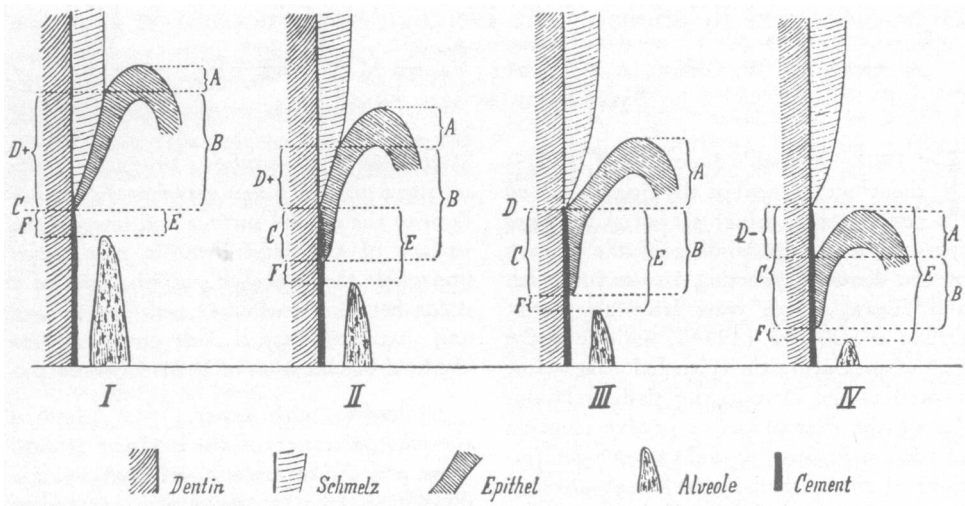


Figure No. 1

The present study consisted of two parts; first to re-evaluate the measurements in the Orban-Kohler paper, but now as part of the dentogingival junction and not as a single isolated structure; and second to add new measurements. It also establishes a norm for the dentogingival junction in all phases, chronologic ages, surfaces and six measured distances.

MATERIAL AND METHOD

The material for this study were the measurements obtained from human autopsy specimens by Dr. Balint Orban in earlier studies. Additional measurements were obtained from 30 human jaws in the collection of Dr. Rudolph Kronfeld. All specimens were taken at autopsy as block sections in order to obtain the component parts of the dentogingival junction intact. The age range was from 19 to 50 years. The specimens were fixed in 10% formalin, embedded in cellodin and 15-20u sections cut. The sections were stained in hemotoxylin and eosin.

The measurements were made from the microscopic specimens of 30 jaws, 287 individual teeth and their respective dentogingival components. A total of 325 surfaces were measured; of these 83 were on the mesial surface, 82 were on the distal surface, 82 on the vestibular surface and 78 on the oral surface. All specimens were free of extensive pathology and fulfilled the requirements of clinically normal specimens. The actual measurements were made with a disc micrometer, and all are recorded in millimeters.

A total of six different measurements were made for each individual specimen. These areas changed their relations in the four different phases of eruption in which measurements were made. In Figure 1, one can observe the various phases of passive exposure as established by Orban and Kohler in 1934.

The areas measured were: a) depth of the gingival sulcus, b) length of the attached epithelium, c) most apical point of the epithelial attachment from the cemento-enamel junction, d) distance from the base of the sulcus to the cemento-enamel junction, e) distance of the cemento-enamel junction from the alveolar bone, f) distance from the most apical point of the epithelial attachment to the alveolar bone (connective tissue).

FINDINGS

The findings from each of the phases were analyzed according to the six individual measurements. All surfaces (mesial,

TABLE I
Phase I Analysis

Measurement	*Range (mm)*	*Mean Average (mm)*
A. Sulcus depth	0.00 to 2.62	.80
B. Attached epithelium	0.28 to 3.72	1.35
C. Apical point of Epithelial Attachment below Cemento-Enamel Junction	0.00 to 0.00	0.00
D. Bottom of Sulcus from Cemento Enamel Junction	+0.28 to 3.36	+1.35
E. Cemento Enamel Junction to Alveolar Bone	0.04 to 3.36	1.08
F. Deepest point of Epithelial Attachment to Alveolar Bone	0.04 to 3.36	1.08

distal, vestibular, oral) were placed in one average value for the given measurement. The analysis first was done according to each of the individual phases of eruption in the dynamic relation existing at the dentogingival junction throughout life. Results of the measurements were as shown in the following tables.

The number of specimen surfaces in the phase I analysis were 25. The total length of the dentogingival unit, (from the tip of the gingival margin to the crest of the alveolar bone) A+B+F, represents the magnitude of the dentogingival junction. For phase I this magnitude was 3.23 mm. The total attachment (B+F) was 2.43 mm. The average age for phase I was 24.5 years and the specimens ranged from 19 to 43 years.

Due to the definite anatomy of phase I, measurement C was zero, those for B, and D; and E, and F, were equal. However, this relation is altered as the epithelial attachment progresses in an apical direction in the later phases.

One hundred and twenty-six (126) specimen surfaces were analyzed in phase II. The total length of the dentogingival unit (A+B+F+) was 3.06 mm. The total attachment (B+F) was 2.45 mm. The average age for phase II was 31.4 years, and ranged from 19 to 50 years.

Phase III is a highly precise arrangement of the dentogingival apparatus, and the least number of specimens were found at this phase. In phase III eleven specimen surfaces were measured.

There was no recorded reading for "D" since in the phase III relation, the base of the sulcus is just at the cemento-enamel junction.

TABLE II
Phase II Analysis

Measurement	*Range (mm)*	*Mean Average (mm)*
A. Sulcus depth	0.00 to 5.36	.61
B. Attached epithelium	0.34 to 2.90	1.10
C. Apical point of Epithelial Attachment below Cemento-Enamel Junction	0.03 to 2.36	0.43
D. Bottom of Sulcus from Cemento Enamel Junction	+0.02 to 2.60	+0.68
E. Cemento Enamel Junction to Alveolar Bone	0.35 to 5.00	1.55
F. Deepest point of Epithelial Attachment to Alveolar Bone	0.02 to 4.38	1.07

TABLE III
Phase III Analysis

Measurement	*Range (mm)*	*Mean Average (mm)*
A. Sulcus depth	0.00 to 0.94	.61
B. Attached epithelium	0.16 to 1.04	.74
C. Apical point of Epithelial Attachment below Cemento-Enamel Junction	0.16 to 1.04	.74
D. Bottom of Sulcus from Cemento Enamel Junction	0.00 to 0.00	0.00
E. Cemento Enamel Junction to Alveolar Bone	0.88 to 3.20	1.71
F. Deepest point of Epithelial Attachment to Alveolar Bone	0.16 to 2.37	1.06

The total length of the dentogingival unit (A+B+F) was 2.41 mm. The total attachment (B+F) was 1.80 mm. The average age for phase III was 32.3 years, and ranged from 22 to 50 years.

One hundred and sixty-three (163) specimen surfaces were measured in phase IV. The total length of the dentogingival unit (A+B+F) was 2.53 mm. The total attachment (B+F) was 1.77 mm. The average age for phase IV was 39.7 years, and ranged from 20 to 50 years.

The previous analysis was a total average of all surfaces. In order to obtain the total mean average all tooth surfaces were measured for each of the distances, thus one can calculate the mean average for each of the 4 tooth surfaces. From this one can see the variance which occurs on the four different surfaces of the same tooth and for the same area measured. See Tables V to X.

In an earlier paper by Stanley[7] he states that "the type of tooth and type of tooth surface (mesial or distal) has no effect on the mean lengths of the distances." As can obviously be seen from the present study, the tooth surface is rather variable in the total circumference, and on each of the individual teeth.

DISCUSSION

This work has indicated that there is a somewhat definite proportional dimensional relation between the dentogingival junction and the other supporting tissues of the tooth.

The validity of the concept of the dentogingival junction has been fortified, and the duality of its components (epithelial and fibrous connective tissue) has been identified as an orderly one.

One can no longer speak of passive exposure only being associated with the apical

TABLE IV
Phase IV Analysis

Measurement	*Range (mm)*	*Mean Average (mm)*
A. Sulcus depth	0.00 to 2.25	1.76
B. Attached epithelium	0.08 to 2.65	0.71
C. Apical point of Epithelium Attached below Cemento-Enamel Junction	0.39 to 6.08	1.41
D. Bottom of Sulcus from Cemento Enamel Junction	−0.03 to 5.84	−1.14
E. Cemento Enamel Junction to Alveolar Bone	1.10 to 10.88	2.81
F. Deepest point of Epithlial Attachment to Alveolar Bone	0.00 to 6.52	1.06

TABLE V
Measurement A.—Sulcus Depth

Phase	*Mesial*	*Distal*	*Vestib-ular*	*Oral*	*Total Average*
I	1.09	.84	.87	.40	.80
II	.51	.64	.76	.53	.61
III	.94	.50	.62	.41	.61
IV	.81	.87	.82	.57	.76

migration of the epithelial attachment. The correct interpretation of the gingiva and its relation to the tooth with increasing age can only be understood, if the connective tissue attachment is also considered. (See Table XI).

The physiologic apical shift of the dentogingival junction from stage to stage during passive eruption, is responsible for the passive exposure of the tooth and is not merely due to the "peeling back" of the epithelial attachment.

From chart XI, one can readily see that the epithelial attachment is our most variable, while the connective tissue attachment is the most constant measurement. This observation further supports Stanley's[7] finding that the "epithelial attachment appeared to be the most variable anatomic structure within the periodontium." Thus, during passive eruption the magnitude of the epithelial attachment diminishes. Early in phase I the amount of epithelial attachment is 1.35 mm. and decreases in phase IV to 0.71 mm., this represents a significant diminution. In correlating the epithelial attachment with age it was seen that there was less attachment with an increase in dental and physiologic age. *On the other hand the connective tissue component appears to be a constant through the stages of passive eruption.*

TABLE VI
Measurement B.—Length of Attached Epithelium

Phase	*Mesial*	*Distal*	*Vestib-ular*	*Oral*	*Total Average*
I	1.56	1.37	1.35	1.14	1.35
II	1.35	1.20	1.08	.80	1.10
III	.44	.88	.87	.77	.74
IV	.83	.88	.63	.53	.71

Upon closer interpretation the meanings of these data indicates a need for a revision of the phases of passive eruption. A further alignment of measurements, it is seen that the four phases of eruption can rightfully be classified into two divisions. The basis for this statement is further emphasized from Table XI. It is seen that the attached epithelium is significantly greater in phase I and II, than the attached epithelium is in phase III and IV. The significant thing is that the total attachment (B+F) measures similar in phase I and II (Division A); and phase III and IV (Division B). Therefore it is thought that we truly have only two divisions of passive eruption.

TABLE VII
Measurement C.—Distance of Attached Epithelium Below Cemento Enamel Junction

Phase	*Mesial*	*Distal*	*Vestib-ular*	*Oral*	*Total Average*
I	.00	.00	.00	.00	.00
II	.51	.45	.40	.36	.43
III	.44	.88	.87	.77	.74
IV	1.76	1.10	1.68	1.11	1.41

In addition it can be seen the greater amount of attached epithelium in phase I and II, and the greater amount of connective tissue attachment in phase III and IV. From this one can also see that in division A (phase I and II) the total attachment is of a greater magnitude than that of division B (phases III and IV).

In analyzing each of the measurements for the four phases we can make some rather revealing observations. In measurement A, sulcus depth, note that under circumstances of normal physiology this remains rather constant. For measurement B, the length of the attached epithelium, note that as one progresses from phase I to IV there is less attachment of epithelium to the tooth surface. From these findings one can see that there has been approximately

TABLE VIII

Measurement D.—Distance of Bottom of Sulcus from The Cemento Enamel Junction

Phase	*Mesial*	*Distal*	*Vestibular*	*Oral*	*Total Average*
I	1.56	1.37	1.35	1.14	+1.35
II	.88	.74	.68	.45	+.68
III	.00	.00	.00	.00	.00
IV	.93	1.14	1.06	1.45	−1.14

TABLE IX

Measurement E.—Distance of Cemento-Enamel Junction from Alveolar Bone

Phase	*Mesial*	*Distal*	*Vestibular*	*Oral*	*Total Average*
I	.75	1.10	1.01	1.49	1.08
II	1.39	1.42	1.86	1.56	1.55
III	1.46	1.58	2.40	1.42	1.71
IV	2.66	3.08	2.82	3.10	2.81

a 50% loss in magnitude from phase I to (1.33 mm.) to phase IV (.71 mm.). In measurement C., the most apical point of the epithelial attachment below the cemento-enamel junction, there is an increase in the clinical crown which is a normal course from phase I to IV as the epithelial attachments shifts in an apical direction. Measurement D, the distance of the bottom of the sulcus from the cemento-enamel junction, is another shift in an apical direction with a progression from phase I to IV.

Measurement E, distance of the cemento-enamel junction from the alveolar bone, is a value which increases from phase I to IV. This is interesting in that as the tooth undergoes active eruption the alveolar bone crest doesn't appear to keep "pace" with the cemento-enamel junction. However, this no doubt is due to the passive exposure of the tooth at the dentogingival junction

TABLE X

Measurement F.—Distance from Base of Attached Epithelium to Aveolar Bone (Connective Tissue Attachment)

Phase	*Mesial*	*Distal*	*Vestibular*	*Oral*	*Total Average*
I	.75	1.10	1.01	1.49	1.08
II	.81	.96	1.21	1.32	1.07
III	1.02	.69	1.53	1.03	1.06
IV	.89	1.09	1.22	1.07	1.06

which is occurring simultaneously with active eruption. Measurement F, the distance from the base of the epithelial attachment to the alveolar bone, represents the connective tissue attachment of the gingival fibers and appears to be the most constant value that the normal dentogingival junction possesses. The values were so close that 3 of the 4 phases almost duplicate each other to the hundredth of a millimeter.

TABLE XI

Dentogingival Junction
Total Attachment
(Measurement B+F)

	Phase and Environment	*Total Attachment (mm)* *Length of Epithelial Attachment—B*	*Connective Tissue Attachment—F*	*B+F*
	I Attachment on Enamel	1.35	1.08	2.43
DIVISION A				
	II Attachment on Enamel and Cementum	1.10	1.07	2.17
	III Attachment on Cementum	0.74	1.05	1.80
DIVISION B				
	IV Attachment on Cementum	0.71	1.05	1.77

TABLE XII
DENTOGINGIVAL JUNCTION
Total Average Magnitude
Sulcus Depth (A)
Epithelial Attachment (B) and
Connective Tissue Attachment (F)

	Average Measurement in mm.
Sulcus Depth (A)	.69 mm.
Length of Epithelial Attachment (B)	.97 mm.
Connective Tissue Attachment (F)	1.07 mm.

The total magnitude, or length of the dentogingival junction is seen to decrease from phase I to IV. From this observation we can see an apparent loss of total attachment to the tooth enamel and cementum. This is evidenced by the fact that the magnitude in phase 1 is 3.23 mm. and regresses to 2.53 mm. in phase IV.

While the preceding findings are of great value in themselves, one must fully realize the impetus this has upon pathology of the dentogingival junction and what the effect of surgical encroachment upon these areas has on the final dimensional proportions. This study will serve as a basis by which to understand the results obtained in osseous surgery and other approaches which denude and expose the dentogingival junction.

In an analysis of age, these findings would support the fact that about any chronologic age can be found in any of the four phases. Usually phase III and IV were absent in the chronologic ages below 21 years. In addition the average age here reported can create a false impression since only a given age range of 19 to 50 years was used.

SUMMARY

The prevailing concepts of the dentogingival junction are reviewed to re-emphasize the importance of this functional unit with its two component parts, 1) The connective tissue fibrous attachment and, 2) the epithelial attachment.

The dimensions of the dentogingival junction in four phases of passive eruption were ascertained from earlier studies of Orban and from thirty additional human jaws. A total of six different measurements were made on all types and surfaces of teeth. Upon comparison of all measurements we can observe that the previous four phases of eruption can be categorized in two divisions.

Of the measurements made, the distance from the base of the epithelial attachment to the crest of the alveolar bone (connective tissue attachment), is the most constant. It had a mean average length in all phases of 1.07 mm. The most variable part of the dentogingival junction was the length of the epithelial attachment.

This study will permit a better understanding of the alterations which occur at the dentogingival junction following osseous surgery, and surgical exposure of the dentogingival junction.

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