Relationship of Occlusion and Periodontal Disease: Part IX— Incisor Inclination and Periodontal Status

ARNOLD M. GEIGER, B.A., D.D.S.
BERNARD H. WASSERMAN, B.S., D.D.S.

Clinical observers and investigators have provided conflicting opinions about the effect of malocclusions on the periodontium.[1-10] However, very few quantitative studies have been reported,[11-22] and in the absence of reliable data the prediction of pathologic consequences from specific aberrations of occlusion, its primary or secondary role, must be considered as little more than conjecture.

Indices of malocclusion have been used to survey populations and to establish criteria for orthodontic treatment in public health programs.[23-26] Such indices seem to emphasize the psychological and social consequences of unaesthetic tooth malpositions and skeletal disharmonies rather than the potential role of malocclusion in the development of periodontal disease. It was therefore deemed advisable in a study of the interrelation of occlusion and periodontal disease that specific aspects of malocclusion which could be defined by existing and generally applied criteria be tested for their pathologic potential.

The primary purpose of this paper is to report on the relationship of incisor inclination (cephalometric) to periodontal health. However, introductory material is presented to summarize pertinent findings previously reported about some other characteristics of occlusion as well as to acquaint the reader with the methods and criteria employed in the over-all study.

A study of individuals from the clinic population at Columbia University School of Dental and Oral Surgery was designed to seek the effect of occlusal variations on the periodontium in the presence of other local and general factors. The study group consisted of 516 adults, 21 years of age and over, who had registered at the dental clinic for initial diagnosis and subsequent treatment.

The study population was selected at random and excluded only those individuals with a history of orthodontic and periodontic treatment, those having multiple fixed or removable prostheses, and those having fewer than twenty teeth.

Each patient received a full series of intraoral radiographs, a cephalometric x-ray, and a complete clinical examination of the occlusion and periodontium. General background characteristics of the individuals were obtained by use of a questionnaire. The details of the examination, method of recording and the type of population have been described.[27-29]

Among those examined, 66.1% were female and 33.9% male. The racial distribution of the population was 64.5% Caucasian, 31.2% Negro and 4.3% other racial groups.

From the questionnaire the history of previous dental experience suggested a reasonable level of dental care and

From the Division of Periodontics, Columbia University School of Dental and Oral Surgery.

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oral hygiene consciousness rather than a population which exhibited gross dental neglect. There was a relatively high educational level with 41% of the individuals having completed high school.[29]

The age distribution was as follows:

Age	*Number*	*Percent*
Less than 25	104	20.1
25-34	126	24.4
35-44	114	22.1
45-54	101	19.6
More than 55	71	13.8
Totals	516	100.0

To establish the status of the periodontium within the study population, periodontal destruction, gingival inflammation and mobility were considered as independent signs of periodontal pathology. These were measured for surfaces of teeth and individual teeth wherever applicable. Existing indices were reviewed and found inadequate for this study.[30-34]

Periodontal destruction was determined in the following manner. Pocket depth, gingival recession and enlargement were measured with a calibrated probe on all surfaces of each tooth. A tissue destruction score for each surface was calculated by application of the formulae:

Pocket depth + Recession = Corrected Periodontal Destruction

Pocket depth — Enlargement = Corrected Periodontal Destruction

From these surface scores, individual tooth scores were derived (Tissue Destruction Index) having a range of severity from 1-6. Scores of 1 and 2 were representative of normal or incipient disease.[27]

Gingival inflammation was observed clinically for all six surfaces of each tooth and handled in a similar manner. Tooth scores were derived with normal gingiva having a score of one.[35]

Mobility was established by rocking each tooth with the handles of two dental instruments and the degree of buccolingual movement relative to the adjacent teeth was observed as slight, moderate or severe. Each tooth was also tested for intrudability and, when detected, the tooth was given the next higher score.[36]

Tooth scores were converted to segment scores whenever desired by averaging the tooth scores in that segment.

Full dentition or mouth summary scores required for many comparisons were calculated as an *average severity score* and as an *incidence summary score*. These were calculated in the following manner:

$$\text{An average severity score} = \frac{\text{sum of abnormal scores}}{\text{number of teeth with abnormal scores}}$$

$$\text{Incidence summary score (in \%)} = \frac{\text{count of abnormal scores}}{\text{number of teeth present}}$$

When these mouth summary scores for periodontal destruction, gingival inflammation and mobility were compared, it was found that incidence percent was a more sensitive indicator of the pathology present in a dentition than was average severity. By averaging, the presence of severe disease in a relatively few teeth was generally obscured by the preponderance of the slightly involved teeth in each dentition. Severely diseased teeth had to be extensively distributed throughout a dentition to overcome the masking effect of averaging. Therefore, in all comparisons for the full dentition, percent incidence was used rather than average severity.[28,35,36]

Periodontal Status of the Study Population

The distribution of periodontal destruction, gingival inflammation and mobility was studied for all teeth ex-

amined as well as for variations among individuals. A brief summary of the most salient findings follows:

A. Periodontal destruction, gingival inflammation and mobility all exhibited a bilateral symmetry of health and disease. The pattern of symmetry was different for each factor suggesting the influence of multiple etiologic factors and variations in resistance of anatomically different teeth.

B. On the basis of frequency and severity individual teeth were ordered from the most to the least affected for periodontal destruction, gingival inflammation and mobility. When these were compared, no relationships were found.

C. In individuals with slight periodontal destruction (1-10% of teeth affected) disease was primarily unilateral and limited almost entirely to the molar teeth.[28] As the incidence of pathology increased, disease restricted to the molars was more frequent than that for all other teeth. The next most frequent disease pattern found involved both the molar-bicuspid teeth. Other patterns of disease included molar-anterior and molar-bicuspid-anterior combinations in that order of frequency.

When only anterior teeth were diseased (11% of the study population), the mandibular incisors were more frequently involved than the maxillary incisors.

In individuals with slight or moderate disease, the maxillary teeth were more severely involved. However, in those cases with extensive disease both arches exhibited similar incidence of involvement.

D. Age was significantly correlated with periodontal destruction. However, among older individuals there was a considerable number of disease resistant individuals who had very healthy periodontiums (25% above 55 years of age).

E. In full dentitions the incidence of gingival inflammation was greater with the increase in periodontal destruction. Although a very high incidence of inflammation was found in most dentitions with severe periodontal disease, 35.2% of these cases showed inflammation about fewer than six teeth. On the other hand, among those cases having little periodontal disease (1-10% of teeth affected) approximately 96% showed some inflammation. Age was not correlated with the incidence of gingival inflammation.

Further study of the data suggested that clinically-evident gingival inflammation, though considered a precursor of periodontal destruction, did not necessarily evolve into a destructive periodontal lesion.

F. A positive correlation was found between the mouth incidence scores for mobility and periodontal destruction.[36]

However, in the study of segments and individual teeth significant differences were found between anterior and posterior teeth. The latter showed relatively little mobility in the presence of disease as compared with the anterior teeth. On the other hand, in the absence of periodontal destruction a significant number of anterior teeth were mobile. It was concluded that anatomic form was a primary element in the resistance to mobility in the presence of disease and that other mobility inducing factors exist in addition to and independent of periodontal destruction.

In earlier papers, we have reported on comparisons of individual characteristics of the occlusion with the parameters of periodontal disease. A brief summary of these findings follows:

Classification of Occlusion (Angle)

There were 23 cases of normal occlusion (4.5%) which exhibited signifi-

TABLE I

PERIODONTAL DESTRUCTION BY ANTERIOR OVERBITE MAXILLARY INCISORS

Periodontal Destruction Average Severity Score*	Anterior Overbite in Millimeters 0-1.9mm N	%	2-3.9mm N	%	4-5.9mm N	%	6mm & Over N	%	Open Bite N	%	Total N	%
1.0-2.0	129	79.6	140	76.5	100	77.5	21	61.8	4	50.0	394	76.3
2.1-4.0	28	17.3	37	20.2	23	17.9	10	29.4	3	37.5	101	19.6
4.1-6.0	5	3.1	6	3.3	6	4.6	3	8.8	1	12.5	21	4.1
Total	162		183		129		34		8		516	

* Average of the TDI scores of incisor teeth.

cantly greater periodontal health than the remainder of the study population. These individuals were relatively young and the absence of disease was judged to reflect age rather than occlusal excellence.[37]

Class I malocclusions showed a trend toward more periodontal destruction than Class II cases in mouth summary and segment comparisons. When selected individual teeth were studied, this trend was not confirmed. No relationships to gingival inflammation were found.

The Division 1 and Division 2 distoclusions were compared for their effects on the incisors. No differences in periodontal destruction or gingival inflammation were found between these occlusal types.

Among individuals having unilateral Class II occlusions the periodontal statuses of the normal and malocclucded posterior segments were compared. No differences in periodontal destruction were found. There was a slight increase in gingival inflammation on the distocluded side which was not statistically significant. It was concluded that Class II malocclusions had no significant influence on the health of the periodontium.

Anterior Overjet

Anterior overjet was measured by a millimetric rule with the teeth in maximum intercuspation.[38] Comparison for periodontal destruction, gingival inflammation and mobility with anterior overjet for the full dentition, anterior and posterior segments, and individual teeth showed no correlations except among the 47 individuals (9.7% of the sample) having an overjet of more than 6 mm. In this group more pathology was evident.

Anterior Overbite

Anterior overbite was recorded in two ways. With the dentition in maximum intercuspation, the amount of overbite was measured by millimetric rule and observed clinically for the degree of overbite. No relationship was found between age and greater or lesser overbite.

Periodontal destruction, gingival inflammation and mobility were not correlated with increased overbite in comparisons for the full dentition, segments and individual teeth. A slight increase in disease which was not statistically significant was found among the severe overbite cases[36,38] (Table I). Since frank tissue trauma observed in some severe overbites was not specifically identified at the initial examination, the probable presence of a few such cases could explain this trend toward more disease.

Anterior Overjet and Overbite Combined (Incisal Guidance)

Clinicians have presented conflicting opinions about the potentially destructive effects of overbite when accompanied by a different amount of overjet.

TABLE II
STUDY SAMPLE BY INFLAMMATION AND CROWDING
MANDIBULAR INCISORS

Inflammation Average Severity Score*	Average Severity of Crowding 1 N	%	1.1-2 N	%	2.1 & Over N	%	Total N	%
1	49	28.9	69	25.8	17**	20.9	135	26.2
1.1-2.0	75	44.8	120	45.0	33***	40.9	228	44.2
2.1-3.0	35	20.9	57	21.3	21	25.9	113	21.9
3.1-4.0	9	5.4	21	7.9	10	12.3	40	7.7
Total	168		267		81		516	

* Average of tooth scores of mandibular incisors.
** Includes 2 cases of crowding, scores 3.1-4.
*** Includes 3 cases of crowding, scores 3.1-4.

To study the effect of incisal guidance the study individuals were divided into two main groups: those having slight to moderate overjet and overbite and those having severe. The four possible combinations of overjet and overbite were compared with periodontal destruction for anterior and posterior segments.[38] A significant correlation to disease was found in only those individuals having a severe anterior overjet (more than 4 mm). No other combinations of incisal guidance showed an association with disease.

Crowding

Contrary to the commonly accepted view, the distribution of crowding among the study individuals was not related to age.[39] Full dentition, segment and tooth comparison of crowding with periodontal destruction showed no relationships. For gingival inflammation, however, a slight increase was found in the anterior segments; this finding was not statistically significant (Table II).

Incisor Inclination and Periodontal Status

Cephalometric analyses of incisor inclination to various landmarks of the dentofacial complex have been used to establish normal ranges of incisal inclination. Such norms have been considered the optimal inclination for stability after orthodontic therapy and for long-term periodontal health.[40-45]

Moorrees et al.[46] recently "question whether specific traits of characteristics of malocclusion initiate or accelerate periodontal pathosis." Gianelly and Goldman,[47] although supportive of the concept that "tooth position is an important aspect of the health, function and longevity of the stomatognathic complex," review the biologic significance of incisor inclination and feel that such "claims have yet to be verified." Earlier, Geiger[16] in a study of periodontally diseased dentitions reported that mandibular incisor inclination was not related to the severity of periodontitis.

In this study population the relationship of periodontal health and incisor inclination was examined to test the hypothesis that "abnormal incisor inclination might be associated with periodontal disease.

Incisor Inclination

Each study individual received a lateral cephalometric radiograph. These radiographs were traced and measured by a technician under the supervision of an experienced orthodontist. A template was employed for greater uniformity in the tracing of the incisor.

The following angles were measured: maxillary incisor to SN and the mandibular incisor to GoGn. Angulation of

the incisor was recorded to the nearest degree.

Based upon the work of earlier investigators,[42,45] the accepted norm for incisor inclination was 100°-107° to SN for the maxillary incisor, and 85°-95° to GoGn for the mandibular incisor. The incisor angulations found in this study population were grouped as in Table III.

When age was compared with incisor inclination, no relationship was found.

Periodontal Comparisons

When the tissue destruction scores (T.D.I.) of the maxillary right central incisor were compared with incisor angulation, slightly less disease was found in those incisors having lingual or normal inclination (less than 100°). However, no progressive increase in disease was found as the inclination increased labially beyond 100° (Table IV). Similar comparison of the tooth tissue destruction scores of the mandibular central incisor showed no relationship except among the 34 cases having a lingual inclination (less than 85°). These individuals showed a slight trend toward more disease (Table V).

Comparisons of incisor inclination were also made with the periodontal destruction found on the labial and lingual surfaces of the incisors. The surface tissue destruction scores for the maxillary incisors showed no correlations with incisor inclination. In the mandible slightly more disease was found on the labial surface of the central incisor in the 34 cases having inclination of less than 85°. In all other cases no associations were found.

TABLE III

Maxillary Incisor		
Degree	*Number of*	*%*
Less than 95	72	13.9
95-99	82	15.9
100-106	146	28.3
107-111	102	19.8
More than 111	114	22.1
Totals	516	100.0

*Mandibular Incisor**		
Degree	*Number of*	*%*
Less than 85	35	7.4
85-94	170	36.2
95-101	138	29.4
More than 101	127	27.0
Totals	470	100.0

* 46 cases were omitted because of prosthesis, missing central incisors or unacceptable radiograph.

Gingival Inflammation

About 90% of both the maxillary and the mandibular central incisors had tooth scores for gingival inflammation of 1 or 2 indicating none or slight inflammation, respectively.[35] Compari-

TABLE IV

PERIODONTAL DESTRUCTION AND MAXILLARY INCISOR INCLINATION

Periodontal Destruction Tooth Score	Angle of Maxillary Incisor to Sn: Less Than 95		95-99		100-106		107-111		More Than 111		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
1	14	19.7	18	22.5	32	22.7	18	18.4	24	21.6	106	21.2
2	52	73.2	53	66.3	85	60.3	66	67.3	67	60.4	323	64.5
3	2	2.8	8	10.0	16	11.3	7	7.1	11	9.9	44	8.8
4	2	2.8	1	1.2	2	1.5	3	3.1	3	2.7	11	2.2
5					3	2.1	3	3.1	3	2.7	9	1.8
6	1	1.5			3	2.1	1	1.0	3	2.7	8	1.5
Total	71		80		141		98		111		501*	
Total %		14.2		16.0		28.1		19.7		22.0		100

* Maxillary right central incisor missing in 15 cases.

TABLE V
PERIODONTAL DESTRUCTION AND MANDIBULAR INCISOR INCLINATION

Periodontal Destruction Tooth Score	Angle of Mandibular Incisor to GoGn: Less Than 85 N	%	85-94 N	%	95-101 N	%	More Than 101 N	%	Total N	%
1	9	26.5	29	17.4	41	30.8	36	28.3	115	24.9
2	17	50.0	114	68.3	73	54.9	76	59.8	280	60.7
3	4	11.8	12	7.2	8	6.0	7	5.5	31	6.7
4			3	1.8	4	3.0	2	1.8	9	2.0
5	1	2.9	4	2.4	1	0.8	4	3.2	10	2.2
6	3	8.8	5	2.9	6	4.5	2	1.4	16	3.5
Total	34		167		133		127		461*	
Total %		7.4		36.2		28.9		27.5		100

* Mandibular right central incisor missing in 9 cases.

son of gingival inflammation scores of the maxillary central incisor with axial inclination showed a tendency toward more health with linguoversion (less than 95°). All other degrees of inclination showed no progressive increase of disease with increased angulation.

Similar comparisons for the mandibular incisor showed no relationships. Labial surface scores for inflammation of both maxillary and mandibular central incisors also showed no relation to incisor angulation. However, on the palatal surface of the maxillary incisor somewhat more inflammation was found among labially inclined incisors.

Age

Although the distribution of incisor inclination was not related to the age of the individuals studied, the possibility that age might affect the relationships found between the angle of the incisor and periodontal health was investigated by means of three-way comparisons.

Study of the relationships of angle of the maxillary and mandibular incisor to tooth scores for periodontal destruction and gingival inflammation in each age grouping showed no variations and suggested that age had no significant influence on the inclination-periodontal relationship.

Gingival Recession

At the initial examination the amount of facial, lingual, mesial and distal recession of the gingiva was measured from the cemento-enamel junction to the margin of the free gingiva with a coded Merritt probe. The coded probe scores were: 1) = 0 mm, 2) = 0-1.9 mm, 3) = 2-3.9 mm, and 4) = 4 mm and over.

The angulation of the maxillary and mandibular incisors was compared with the respective labial and lingual recession scores.

Maxillary incisor: no relationship was found between incisor angulation and labial recession. There was, however, a slightly greater lingual recession as incisor angulation increased.

Mandibular incisor: Labial recession was significantly related to incisor angulation of less than 85° (linguoversion). Progressively less recession was found as the incisor angulation reflected a labial inclination (Table VI). Lingual recession showed no relation to incisor inclination.

Tooth Mobility

As reported previously,[36] among the anterior segments exhibiting mobility almost two thirds had no clinically measurable periodontal destruction. Study of the influence of incisor incli-

TABLE VI
GINGIVAL RECESSION LABIAL AND MANDIBULAR INCISOR INCLINATION

Gingival Recession Labial	Angle of Mandibular Incisor to GoGn									
	Less Than 85		85-94		95-101		More Than 101		Total	
	N	%	N	%	N	%	N	%	N	%
1	16	47.0	124	74.3	105	78.9	105	82.6	350	75.9
2	11	32.4	26	15.6	20	15.0	16	12.6	73	15.8
3	4	11.8	13	7.8	5	3.8	3	2.4	25	5.4
4	3	8.8	4	2.3	3	2.3	3	2.4	13	2.9
Total	34		167		133		127		461	
Total %		7.4		36.2		28.9		27.5		100

nation on mobility for the maxillary and mandibular incisor showed no relationships. This was contrary to expectations based on clinical *impressions* that upright and lingually inclined maxillary incisors are more mobile.

Occlusal Comparisons

A basic principle inherent in the study design of this investigation was to search for secondary as well as primary associations in occlusal-periodontal relationships. Therefore, the possible effect of incisor inclination as a secondary influence on the associations previously found between periodontal status and overjet, overbite and crowding was studied. This was accomplished by the use of three-way comparisons and the results are described in Table VII.

Anatomic Relationships

It was felt that a description of the anatomic relationships of incisor inclination to anterior overjet, overbite and crowding in this study population would be of interest.

Anterior Overjet

The study individuals showed no association between overjet and maxillary incisor inclination. This was surprising in view of the clinical expectation that increased maxillary incisor inclination would be associated with overjet. Since overjet is a composite of many factors affecting maxillary and mandibular incisor position such as maxillary and mandibular arch size, or the interrelationship of the axial inclination of both incisors, it is apparent that the expected influence of axial inclination was overwhelmed by other factors. Similarly surprising was the finding that the mandibular incisors with a greater labial inclination were associated with increased overjet.

Anterior Overbite

Anterior overbite was measured by a millimetric rule and also observed clinically for the degree of overbite. In both methods cases with increased inclination of the maxillary incisor showed less overbite. Those individuals with lingually inclined incisors did not differ in their amount of overbite from those having normally inclined incisors, despite the clinical impression that linguoversion is associated with deep overbite. In the mandible the inclination of the incisor showed no relationship to overbite. This lack of some interplay of factors, even for incisors having a lingual inclination, emphasizes the multi-faceted nature of the overbite relationship.

Crowding

There was no association between crowding and maxillary incisor inclination. In the mandible more individuals with labially inclined central incisors (over 95°) had an absence of crowding of those teeth. In cases in which the right central incisor was crowded, however, no association with incisor incli-

TABLE VII

RESULTS OF SIMULTANEOUS COMPARISON OF FACTORS

Occlusal Periodontal Factors	*Incisor Angulation*	
	Maxillary	*Mandibular*
Anterior Overjet		
Period. Destruction	Less disease associated with severe overjet and linguoversion (less than 100°)	More disease associated with severe overjet and labioversion (more than 95°)
Gingival Inflammation	No effect	No effect
Overbite mm		
Period. Destruction	No effect	No effect
Gingival Inflammation	More inflammation with labioversion and normal overbite	No effect
Overbite degree		
Period. Destruction	Slightly more disease with labioversion and normal overbite	No effect
Gingival Inflammation	Slightly more inflammation with labioversion and normal overbite	No effect
Crowding		
Period. Destruction	No effect	No effect
Gingival Inflammation	No effect	No effect

nation was found.

Facial Alveolar Bone Thickness

The thickness of the facial alveolar bone was estimated by clinical observation of the alveolar process and was recorded for all segments. The criteria for scoring was:

1. Average: where the facial alveolar bone moderately masks the root contours and has a moderate appearance of bulk.

2. Thick: where the facial alveolar bone appears bulbous and may have ledges present at the gingival margins.

3. Thin: Where the facial alveolar bone follows the contours of the roots with little apparent bulk.

The facial alveolar bone thickness for the maxillary incisor was judged to be average in 75% of the study individuals; while in 7.6% it was thick and in 17.4% it was thin. For the mandibular incisor facial alveolar bone thickness was scored as average in 58.3% of the cases, thick in 9.8%, and thin in 31.9%.

Periodontal destruction on the labial surface of the right central incisor was compared with facial alveolar bone thickness. In the maxilla individuals having thin alveolar bone had minimum amounts of periodontal destruction. Those having thick alveolar bone showed significantly more disease (Table VIII. In the mandible, however, only a slight increase in disease was found.

Similar comparisons for gingival inflammation and facial alveolar bone thickness showed no relationship for the maxillary central incisor. The mandibular incisor, however, showed an increase in inflammation in those cases having thick facial alveolar bone.

The influence of axial inclination of the incisor on these relationships was investigated. Variations in incisor inclination had no effect on either the periodontal destruction or gingival inflammation-facial alveolar bone relationships reported above for the maxillary and mandibular incisors.

TABLE VIII

FACIAL ALVEOLAR BONE THICKNESS AND LABIAL PERIODONTAL DESTRUCTION OF THE MAXILLARY CENTRAL INCISOR

Periodontal Destruction Labial Surface	Facial Alveolar Bone Thickness							
	Average		Thick		Thin		Total	
	N	%	N	%	N	%	N	%
0-1.9mm	254	67.8	17	44.8	74	84.1	345	68.9
2-3.9mm	116	30.9	20	52.6	12	13.9	148	29.5
4-6.9mm	2	0.5	1	2.6	1	1.0	4	0.8
7mm and over	3	0.8			1	1.0	4	0.8
Totals	375		38		88		501*	
Total %		74.9		7.6		17.5		100

* Maxillary right central incisor missing in 15 cases.

Summary and Conclusions

In this study population the following observations have been made:

Periodontal destruction, gingival inflammation and mobility were not significantly related to axial inclination of the incisor teeth.

Labial gingival recession of the mandibular incisor was related to linguoversion (less than 85° to GoGn). No other associations between incisor inclination and labial or lingual recession were found.

Age was not related to either maxillary or mandibular incisor inclination. The periodontal-incisor inclination relationships reported above for periodontal destruction and gingival inflammation were not altered by the factor of age.

Study of the secondary influence of incisor inclination on the relationships of selected occlusal factors and periodontal pathosis showed:

A. Severe overjet (more than 6 mm) had been found to be associated with more periodontal destruction. With severe overjet maxillary incisors in linguoversion (less than 100° to SN) were somewhat healthier than all others. Among the same cases of severe overjet mandibular incisors in labioversion had slightly more disease than all others.

B. The absence of a significant correlation between anterior overbite or crowding reported previously was not influenced by incisor inclination.

C. Facial alveolar bone thickness, observed clinically, was studied for its relation to periodontal destruction and gingival inflammation. Thick facial alveolar bone was found to be associated with increased pathosis. This finding was not consistent for the maxillary and mandibular incisor and the influence of other factors might be suspected.

Incisor inclination had no effect on the bone thickness-periodontal disease findings.

30 East 40th St.
New York, New York 10016

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