From: The Royal School of Dentistry, Stockholm
Department of Oral Surgery
(Head: Professor JOHN HERTZ, M. D.)
Department of Radiology
(Head: Professor GUSTAF HERULF) and
The Royal Institute of Technology,
Division of Photogrammetry
(Head: Professor BERTIL HALLERT, Techn. Dr.)

RADIOGRAPHIC MEASUREMENTS OF BONE CHANGES IN THE ALVEOLAR LIMBUS IN A CASE OF MARGINAL PERIODONTAL DISEASE

by

N. BERGHAGEN

P. HJELMSTRÖM

By the term *periodontium* is understood the gingiva, the alveolar bone, the periodontal membrane and the root cementum. A disease involving the marginal periodontium is consequently called *marginal periodontal disease*. This condition is generally characterized by a chronic rarefying inflammatory process extending from the gingival border and associated with the destruction of the supporting tissues of the teeth (*Norberg*, 1934). The symptoms are invariably fairly insignificant, and the disease may be overlooked in its early stages unless a thorough radiographic examination of the whole dentition is performed.

A pathologically deepened *gingival pocket* ("periradicular pocket formation") is common clinical evidence and is often mentioned as a cardinal symptom of this disease. Many ways of recording the gingival pocket have been suggested. They have, however, often been based on subjective observations. This is hardly surprising in view of the structure of the pocket and the difficulty of correctly introducing a measuring instrument. Radiographic measurement has also presented problems, partly owing to the absence of contrast in the soft tissues that form the pocket and partly because the fundamental properties of the radiograph have too frequently been disregarded.

The gingival pocket formation is often accompanied by changes in the bone, leading to a weakening of the investment of the tooth. The relationship between the presence of gingival pockets

and the dissolution of the alveolar margin with the formation of bone pockets varies considerably. However, the radiograph often misrepresents the condition of the periodontal attachment, possibly owing to unsuitable projection, film sensitivity, exposure time, development or to hardness of the rays. We must therefore remember that radiographic examination in periodontal disease should be regarded only as an aid to diagnosis and should never take the place of careful clinical examination.

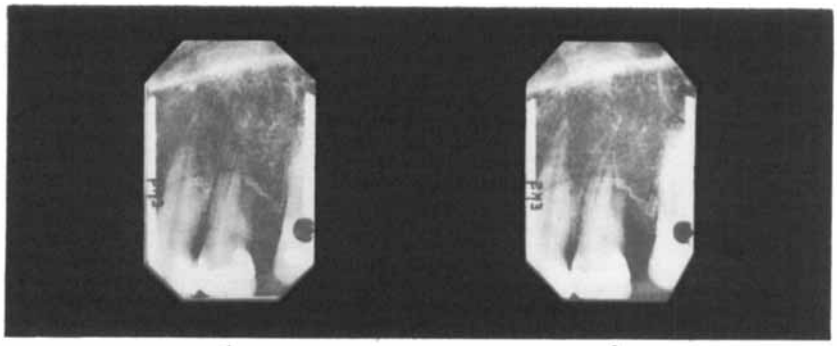
Herulf (1950) made a study of the marginal alveolar bone in students. Some of the radiographs — "apical pictures" — were taken in accordance with the bisector rule of *Dieck-Cieszynski;* others — "collum pictures" — with the rays incident on the region of the neck of the tooth, the film being placed parallel to the long axis of the tooth. *Herulf* studied the difference in the distance from the enamel margin to the level of the septum contour in the apical and collum pictures. He found that there was a significant difference between the two projection techniques, the distance being ⅓ mm greater in the collum pictures. According to *Herulf*, the collum technique gives a true representation of distances in the marginal region — for example, the enamel and bone margins.

Reichborn-Kjennerud maintains that "radiographs to be used for examination of marginal periodontal disease should preferably be taken in a special manner; the central ray should be incident on the gingival border and not on the apical region as for the usual survey radiographs. On any one picture there are always several septa, but only the septum on which the central ray is incident is reproduced on the film, so that the relationship between two points can be judged with reasonable certainty. On the right and left of that septum the dimensions are often so distorted that the radiograph is of little diagnostic value".

Recent American literature has stressed the importance of using the *long cone technique,* which is claimed to give radiographs with less distortion than those obtained by the "free" procedure using the bisector law.

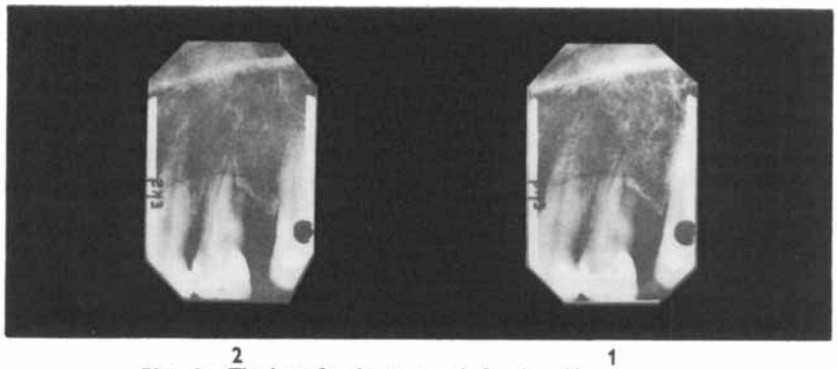
Of the studies mentioned, *Herulf's* makes the more valuable contribution to our knowledge of the properties of the radiograph, since the geometric conditions in radiography are given primary consideration.

Illustrations of stereo-radiographs



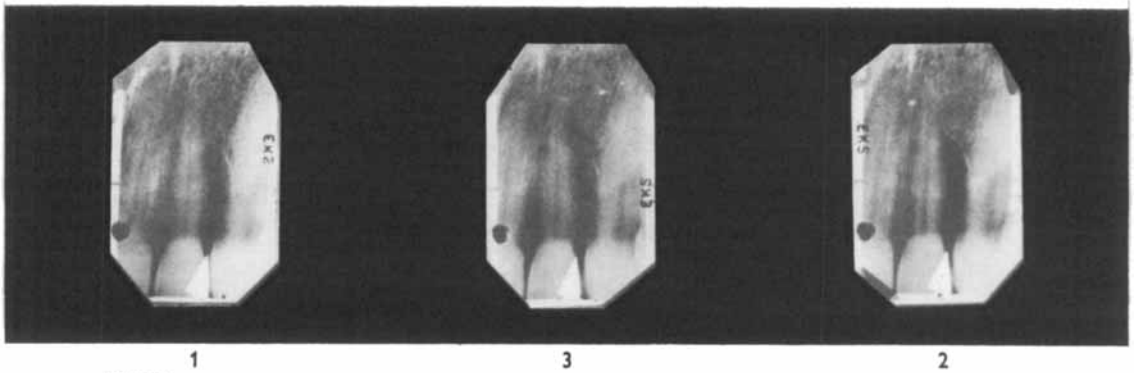
1 2

Plate 1 The base for the stereopair 1—2 = 10 mm
The stereopair 1—2 gives orthoscopic effect



2 1

Plate 2 The base for the stereopair 2—1 = 10 mm
The stereopair 2—1 gives pseudoscopic effect (Mirror image)

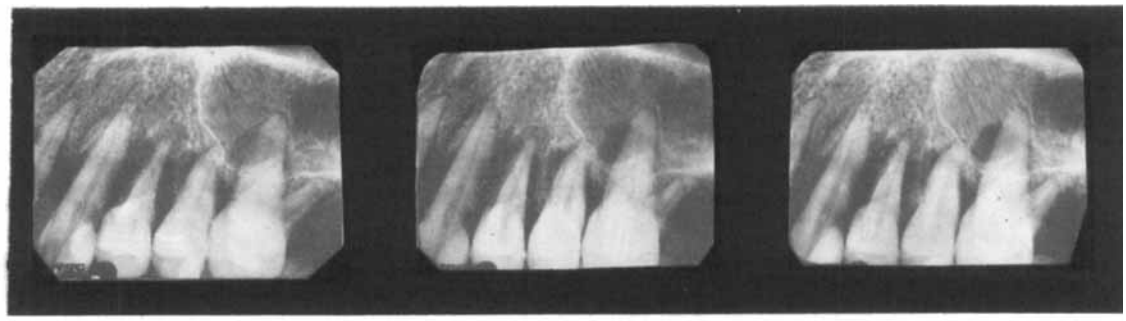


1 3 2

Plate 3

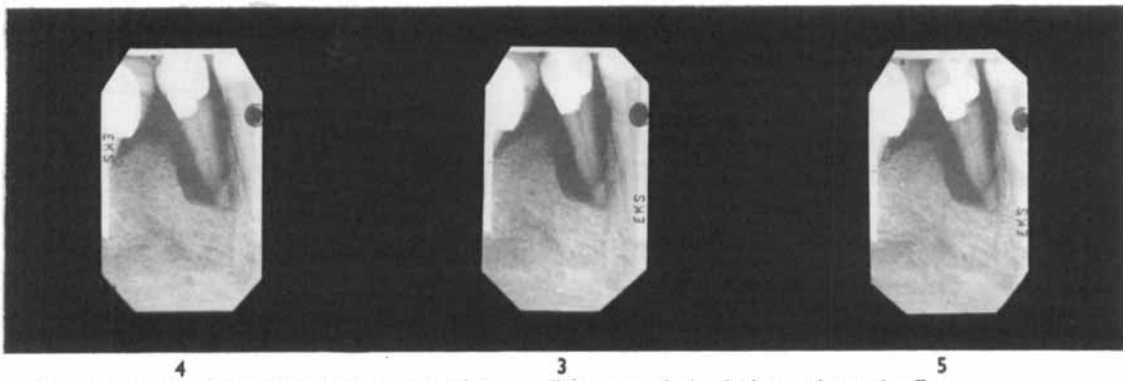
The stereopair 1—3 gives orthoscopic effect
The stereopair 3—2 gives pseudoscopic effect (Mirror image)

For the stereopair 1—3 the base is 20 mm
For the stereopair 3—2 the base is 10 mm



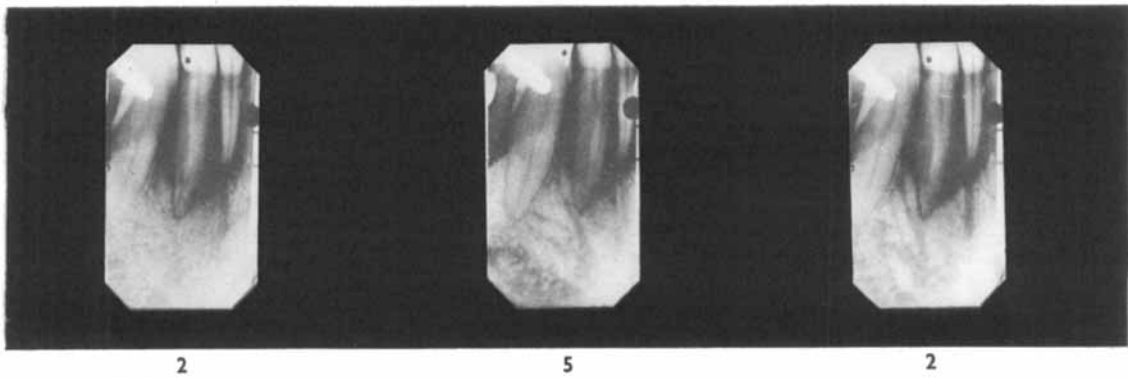
1 3 2

Plate 4 The base for the stereopair 1—3 = 20 mm — The stereopair 1—3 gives orthoscopic effect
The base for the stereopair 3—2 = 10 mm — The stereopair 3—2 gives pseudoscopic effect (Mirror image)



4 3 5

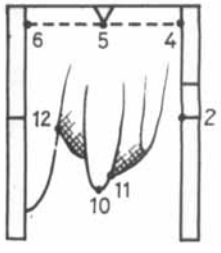
Plate 5 The base for the stereopair 4—3 = 10 mm — The stereopair 4—3 gives orthoscopic effect
The base for the stereopair 3—5 = 30 mm — The stereopair 3—5 gives pseudoscopic effect (Mirror image)



2 5 2

Plate 6

The stereopair 2—5 gives pseudoscopic effect (Mirror image)
The stereopair 5—2 gives orthoscopic effect
For the stereopair the base is 30 mm



The points 2, 4, 5, 6, 10, 11 and 12 are used for measurements.

Berghagen & Hjelmström (1951, 1954, 1956) have devised a radiographic technique that may increase the information obtainable from radiographs. These radiographs may be used separately, but from a diagnostic aspect stereoscopic viewing is a distinct advantage (Plates 1—6). By observing alternately in and against the direction of projection (orthoscopic and pseudoscopic viewing) definition is increased. The present paper describes a new method for following the development of marginal periodontal disease by measuring the bone changes in relation to the apex of a tooth. Further details of the radiographic technique are given in the publications mentioned.

MENSURATION EXPERIMENTS

Radiographs were taken in the region of the lower right lateral incisor and canine, where there was pronounced rarefaction of the bone (Plate 6). To study how the interpretation of the radiographs is related to the change in the direction of projection three stereo-radiographs were made, each with a different outer orientation. One of these was repeated four times, the bite impression being changed each time so that the variation of the outer orientation obtained solely by changing the impression could be calculated. This variation for the first three exposures is illustrated in the sketch (Fig. 1) where the orthogonal pro-

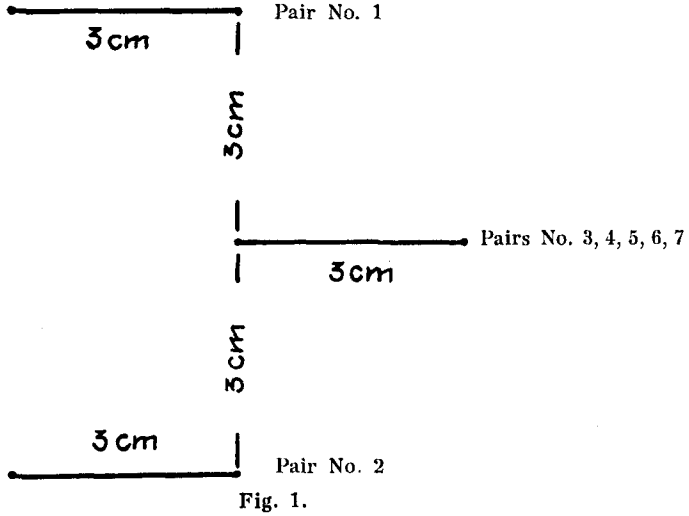


Fig. 1.
(Scale 1: 1)

jections of the focus on the film plane are given and combined in pairs.

A root tip and two points on the bone characteristic of the pocket were chosen in the first pair. These three points are denoted 10, 11 and 12. On each pair, measurements were also made of the following points to permit a complete co-ordinate calculation: left frame mark, 2; orientation cone, 5; two auxiliary points, 4 and 6, situated on the frame on each side of 5. The measurement of the last three points makes it possible to determine the random mutual orientation of the stereo-pair and to eliminate the positional error of the pair in the measuring instrument. From the mensuration data the co-ordinates for object points 10, 11 and 12 were determined first in a system with three perpendicular axes, two of which are parallel to the film plane. Using the same system for pairs 3 to 7 the variation of the outer orientation due to change of impression may be derived directly from the co-ordinates of the points in this series. The measurements and calculations of the co-ordinates were performed according to formulae and instructions given in the Appendix to "Photogrammetric principles applied to intra-oral radiodontia" (1951) by *Berghagen* and *Hjelmström*.

From the co-ordinates for points 10, 11 and 12 the distances (in millimetres) 10—11 and 10—12 were calculated

	Pair no:						
Distance:	1	2	3	4	5	6	7
10—11	2.70	2.49	2.54	2.69	2.76	2.80	2.82
10—12	10.52	10.11	10.49	10.35	10.42	10.31	10.31

The material was divided into two groups, group 1 containing pairs 1, 2 and 3, taken with the same impression but different outer orientation, and group 2 containing pairs 3, 4, 5, 6 and 7, taken with different impressions; the following results were obtained

Group 1 (unit mm/100)

Distance:	Mean:	mean error: s (one measurement)	D.F.:
10—11	258	11.0	2
10—12	1 037	22.8	2

Group 2	(unit mm/100)		
Distance:	Mean:	mean error: s (one measurement)	D.F.:
10—11	272	11.3	4
10—12	1 038	7.8	4

If the variance ratio is tested at the 95 per cent level, no difference is obtained between the groups for the distance 10—11, while the distance 10—12 gives the ratio v^2 (2.4) = 8.6; that is, a significant difference in variance.

Since each point in the measuring instrument is adjusted twice (certain points several times) the mean error s — i.e. an estimate of the standard deviation — in the radiograph co-ordinates and parallaxes may be calculated. Such mean errors were calculated first separately for each co-ordinate, parallax and object point, and significant differences were found in some instances. As the mean errors are so small as to be negligible for practical purposes they are not reported individually but are combined and expressed as one value for each of the two radiograph co-ordinates Y_1 and Y_3 and the parallax *p*.

Magnitude:	Mean error	D.F.	(unit mm/100)
Y_1	2.2	21	
Y_3	2.2	21	
p	1.03	21	

The mean error in p is transformed to the mean error in Y_2 by multiplying by 7.0, giving the number $7.2.10^{-2}$ mm.

A closer examination of the variation in the outer orientation on changing the impressions was made by calculating (a) the movements of the object figure's centre of gravity relative to the bite tray (translations in the three directions of the axes), and (b) the changes in inclination in relation to the film plane for the longer of the measured distances (10—12)

Axis direction:	Mean error in centre of gravity:	D.F.
Y_1	0.53 mm	4
Y_2	0.83 mm	4
Y_3	0.63 mm	4

The slope of the distance 10—12 with length 10.4 mm is given by the height for 12 minus the height for 10, these being the vertical heights above the plane of the film

Pair	$h_{12}—h_{10}$
3	— 0.51 mm
4	— 0.60 mm
5	+ 0.37 mm
6	+ 0.59 mm
7	+ 0.12 mm
Mean	— 0.006 mm. Mean error: 0.53. D.F.: 4.

For comparison with the systematic variation of the outer orientation given in Fig. 1 these figures may be increased by the factor 226/10.4; this gives the movements of the focus in orthogonal projection on the film plane. The mean error in the focus position arising on varying the impression but keeping the same adjustment of the stereo-apparatus is found to be 11.6.

RESULTS

1) The mensuration values bear out the assumption that the variation in the outer orientation affects the interpretation of the radiographs.

2) The variation in the outer orientation resulting from changing the impression has proved to be of a moderate order of magnitude; this implies that this source of error is probably of little importance in the measurement of the variation for any one patient.

Instructions for viewing the plates on the following pages.

People with normal sight can learn to view a double image stereoscopically without the aid of a stereoscope. The eyes must be accommodated for a near point without the optic axes being convergent. This is easily accomplished by looking at the images with the eyes on each side of a sheet of paper, the paper being held so that each eye is able to view only one of the two pictures. Plates 3, 4, 5 and 6 are arranged in such a manner that one is able to see teeth and bone from the labial and the palatal or linguai sides at the same time.

Owing to the small scale difference between the foreground and background the pseudoscopic effect is practically equivalent to an orthoscopic mirror image.

3) Any inaccuracy in the adjustment of the measuring instrument appears to be quite unimportant for practical purposes.

4) The accuracy in the mensuration data has been expressed in terms of the mean error (estimated standard deviation).

CONCLUSIONS

1. The method permits periodic measurements to be made of the changes in the bone in marginal periodontal disease — for control of treatment, for example.
2. Since it is not necessary for the periodic radiographs to be exactly identical, impressions need not be retained between visits.
3. When the subsequent radiographs are taken the film holder is placed so that the reference cone is as nearly as possible in the same position in relation to the patient's teeth; this may be checked against the first radiograph. If the film holder is placed in the same relation to the focus of the X-ray apparatus by means of the scale readings for the first radiograph, the perspective will be very nearly the same.
4. After a series of radiographs has been taken, two points on the object appearing on all of them are chosen as reference points (for example, the apices of two teeth). From these measurements may be made to some characteristic points of the marginal bone, such as the top of the alveolar crest and the bottom of a pocket. If during a control period the root tip (or the reference point) should change — e.g. through resorption — some other point appearing on all the radiographs may be used. It is thus unnecessary to decide beforehand on any particular point.

SUMMARY

The authors first discuss the value of radiographs in the diagnosis of periodontal disease, stressing in particular the importance of making stereoscopic radiographs and of examining both the orthoscopic and the pseudoscopic effects. A new method

is proposed for the objective registration of changes occurring in the bone in periodontal cases. Finally, an account is given of the mensuration results.

RÉSUMÉ

MENSURATION PAR LA RADIOGRAPHIE DES MODIFICATIONS DE L'OS DU LIMBE ALVÉOLAIRE DANS UN CAS DE PARODONTOPATHIE

(Les mensurations ont été exécutées par rapport à l'apex de la dent)

Les auteurs discutent d'abord la valeur de la radiographie pour le diagnostic des parodontopathies. Ils soulignent particulièrement l'importance qu'il y a à se servir d'images radiographiques stéréoscopiques en utilisant pour l'examen des effets aussi bien ortoscopique que pseudoscopique.

Ils proposent une nouvelle méthode pour enregistrer objectivement les modifications de l'os dans les cas de parodontopathie. L'article se termine par un compte rendu des résultats des mensurations.

ZUSAMMENFASSUNG

MESSUNGEN AN RÖNTGENAUFNAHMEN VON KNOCHENVERÄNDERUNGEN IM LIMBUS ALVEOLARIS BEI EINEM PARODONTOPATHIEFALL

(Die Messungen wurden in Relation zum Apex des Zahnes ausgeführt)

Zunächst wird der Wert der Röntgenaufnahme für das Diagnostizieren der Parodontopathien diskutiert. Dabei wird besonders auf die Wichtigkeit der Verwendung von stereoskopischen Röntgenaufnahmen hingewiesen und auf die Verwendung des ortoskopischen wie auch des pseudoskopischen Effektes bei der Betrachtung. Die Verwendung einer neuen Methode für die objektive Registrierung der Knochenveränderungen bei Parodontopathien wird vorgeschlagen. Der Artikel wird mit der Vorlage von Messungsergebnissen abgeschlossen.

RESUMEN

MEDIDA RADIOGRAFICA DE LAS MODIFICACIONES DEL HUESO DEL LIMBO ALVEOLAR, EN UN CASO DE PERIODONTOPATIÁ

(Las medidas han sido llevados acabo con relación al ápice del diente)

Los autores discuten primero, el valor de la radiografía en el diagnóstico de las periodontopatías, insistiendo particularmente en la importancia de tomar radiografías estereoscópicas y examinar tanto los efectos ortoscópicos como los pseudoscópicos.

Proponen un nuevo método para registrar objetivamente las modificaciones del hueso en los casos de periodontopatía. Al final del artículo se da una información acerca de los resultados obtenidos en las medidas.

REFERENCES

Berghagen, N.: Photogrammetric principles applied to intra-oral radiodontia. Thesis, Stockholm 1951.

Berghagen, N. och P. Hjelmström: Intra-oral röntgenfotografering i belysning av tredimensionell geometrisk beskrivning. Svensk Tandl. Tidskr. *47*, 1954, 135.

Berghagen, N. and P. Hjelmström: Three-dimensional intra-oral radiography, Acta odont. Scandinav. *14*, 1956, 189.

Herulf, G.: Om det marginala alveolarbenet hos ungdom i studieåldern — En röntgenstudie. Svensk Tandl. Tidskr. *43*, 1950, 44.

Lönberg, P.: Peridontalrummet i röntgenbilden. Svensk Tandl. Tidskr. *41*, 1948, 257.

Norberg, O.: Om indikation och prognos vid den marginala paradentitens behandling. Svensk Tandl. Tidskr. 27, 1934, 1.

Norberg, O.: Biologi och terapi i det marginala paradentiets sjukdomskomplex. Svensk Tandl. Tidskr. *34*, 1941, 1.

Reichborn-Kjennerud, I: Marginala Paradentitter. Textbook. Elanders Boktryckeri Aktiebolag, Göteborg 1948.

Addresses:

N. Berghagen
Kungl. Tandläkarhögskolan,
Stockholm 3
Sweden

P. Hjelmström
Försvarsstaben
Stockholm 90
Sweden