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A technique for the radiographic assessment of marginal alveolar bone

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OPSOMMING

'n Eenvoudige, akkurate en reproduseerbare tegniek vir radiografiese ondersoeke word beskryf. Dit maak gebruik van 'n lang konus paralleling-skakelingsarm, 'n metaal sfeer en 'n metingstafel. Die gebruik van 'n lang konus paralellingtegniek verseker redelik distorsievrye binnemondse radiogramme; 'n metaal sfeer op die film of tand dui aan of daar distorsie of vergroting van die beeld is; die metingstafel verseker voorafbepaalde vergroting en maak dit moontlik om die oriëntasiepunte makliker te onderskei, terwyl die aftrekpapier op die tafel 'n metode van optekening besorg. Geen noemenswaardige statistiese verskille is tussen 'n serie metings verkry nie. Dit bevestig dat die tegniek reproduseerbaar is en dat 'n konstante beeld deur die ondersoeker verkry word.

SUMMARY

A technique of radiographic examination is described which is simple, accurate and reproducible. It combines the use of a long cone paralleling arm, a metal sphere and a measuring table. The long cone parallel technique ensures reasonably distortion-free intra-oral radiographs; the use of a metal sphere on the film or tooth indicates whether there is distortion or magnification of the image; the measuring table ensures predetermined magnification, and makes it possible to see the landmarks more clearly, while the tracing paper on the table provides a recording method. No statistically significant differences were found between a series of measurements confirming the reproducibility of the technique, and consistent observation by the investigator.

The position and shape of the alveolar margins are indices of health and disease to both the general dentist and the periodontist. In examining these, the use of radiographs plays an important diagnostic role: however radiographs alone may give an incorrect impression of bony lesions. For example Theilade (1960) adapted fine wires to the alveolar edges on all four surfaces of the teeth of dry mandibles, and to the base of intrabony deformities, placing wires of different gauges on the lingual and buccal aspects. Radiographs were then made of the same mandibles with and without the wires, and it was apparent that without the wires there was a notable underestimation of bone loss, in view of the lack of clear definition of bone levels on the buccal and lingual aspects of the teeth in an ordinary radiograph.

Goldman and Stallard (1973) examined vertical periodontal defects in autopsy specimens and then, after filling them with radiopaque paste, radiographed the defects. They were unable adequately to visualise these periodontal defects on dental radiographs. Their experiments agreed with the observations of Shackman and Harrison (1948) and of Adam (1951) who were unable to correlate radiographic and visual appearances of bony lesions elsewhere in the body. Goldman and Stallard's findings are, however, contrary to the findings of Rees, Biggs and Collings (1971) who reported that proximal and furcational defects could be identified with a high degree of accuracy by radiographic examination.

It is possible that the lack of correlation reported by some investigators between actual and radiographic appearances results from errors in radiographic technique. Although distortion of radiographic images often occurs, clinicians have sought an accurate and reproducible method of radiographic examination to overcome this. Among the many suggested, a reliable technique is that of Updegrave (1951, 1961, 1968) who recommended the right-angle long-cone technique to minimise dimensional distortion. His method goes a long way towards ensuring the radiographic portrayal of anatomical structures in their correct sizes and relationships.

A method of determining the position of the alveolar crest is the use of graduated silver points (Hirschfeld 1953), which are inserted into periodontal lesions and then radiographed. Everett and Fixott (1963) devised a radiopaque grid with lines 1 mm apart, running both lengthwise and crosswise. Every fifth millimeter is accentuated by a heavier line to facilitate measurement when the grid is superimposed on the radiograph.

Direct measurements from X-ray films using dividers was used by Regan and Mitchell (1963) who compared actual bone heights with those of their radiographs of cadaver jaws. Their most accurate radiographic measurements were of the lower posterior segments.

A method for assessing alveolar bone loss and establishing a radiographic index was devised by Bjorn, Halling and Thyberg (1969), who mounted intra-oral radiographs in frames and projected the images onto a back-projection table on which a scale had been drawn. They established bone heights relative to tooth lengths by means of this method.

The cemento-enamel junction and the alveolar margin may be used to determine the degree of tooth eruption. Boyle, Via and McFall, (1973), used these two landmarks to investigate radiographically, the interproximal alveolar crest levels in clinically healthy mouths of patients of different ages. Their technique included the use of a metal sphere of known diameter which was attached to a tooth prior to exposure of the X-ray film, providing a scale of reference for their measurements.

The purpose of the present study was to combine features of some of the methods summarised above into a simple, accurate and reproducible technique for radiographic assessment of the position of the dental alveolar bony margin.

MATERIALS AND METHODS

The study comprised two parts: firstly the selection of radiographic landmarks for measurement purposes; and secondly the determination of the accuracy and reproducibility of intra-oral radiographs taken under standardised conditions.

An upper incisor tooth in a dried skull was radiographed with the tip of a pin situated on the

(i) labial cemento-enamel junction

(ii) palatal cemento-enamel junction

(iii) labial alveolar margin

(iv) palatal alveolar margin.

Fig. 1 shows the pointer at a cemento-enamel junction. The procedure was repeated 5 times. As it proved impossible without prior knowledge of where the pin tip was situated, to determine which was the palatal or labial cemento-enamel junction on the radiograph, this landmark was not used in the rest of the study.

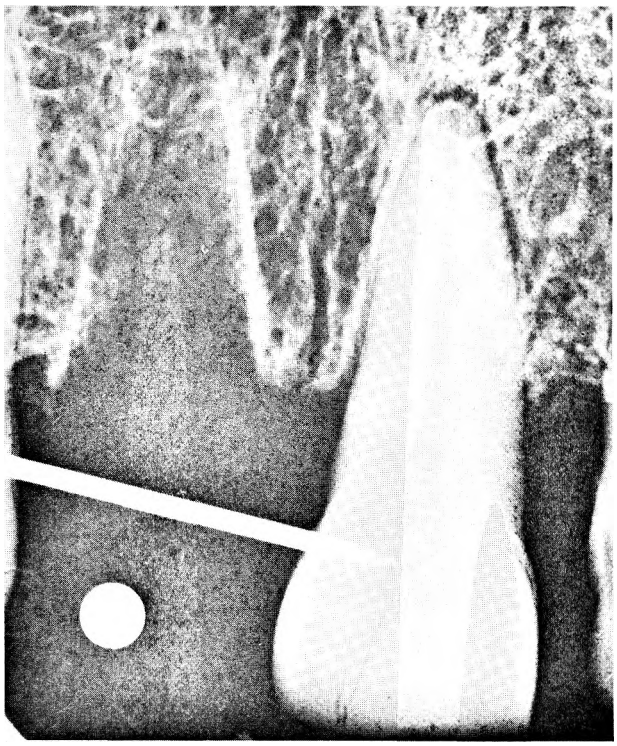

Fig. 1. An upper central incisor with metal pointer placed at the cemento-enamel junction. A 2 mm steel sphere is seen. In this case it is attached to the radiographic film.

In the second phase of the study, the upper anterior teeth of a dried skull were radiographed using a Rinn XCP Instrument (Rinn Corporation, Elgin, Illinois). The rigid paralleling arm was fitted by means of a perspex ring to the long cone of a dental X-ray machine. The film to anode distance was 33 cm and remained constant throughout the study (Fig. 2). The intra-oral X-ray film package (Kodak Size DF58) with a steel sphere 2 mm in diameter attached to the surface of the film packing was held at right angles to the tube by means of the Rinn attachment (Fig. 2). A 2 mm steel sphere was attached on the labial surface of the experimental central incisor also (Fig. 3).

After exposure of each film, the apparatus was removed from the skull, the position of the skull altered, then repositioned, and a parallel position established once again. All exposures were for 0,9 sec at 55 Kv with an anode current of 7 milliamperes.

Nine films were taken, and developed together. Fig. 4 is an example of a radiograph with the images of the two steel spheres.

The radiographs were mounted in 35 mm slide frames, and projected onto a measuring table (Volchansky, Austin and Cleaton-Jones 1975) which comprised a slide projector and 45° metal mirror which reflected the image onto a transparent top on which tracing paper was placed (Fig. 5). The slide projector was fixed at a distance which provided a 5-times magnification as determined by measuring the image of the steel sphere.

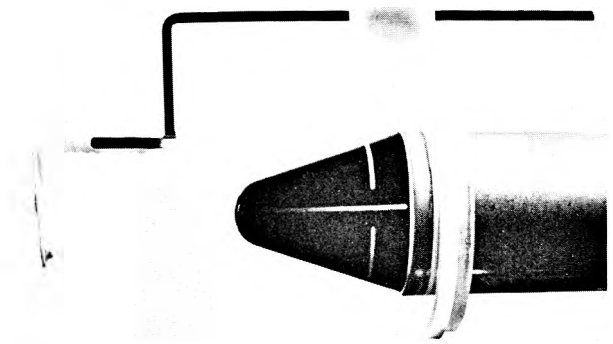

Fig. 2. A long cone radiographic tube to which was fitted a "Rinn" paralleling arm, fixed to the tube by a perspex ring. The X-ray film with a steel sphere at a set distance.

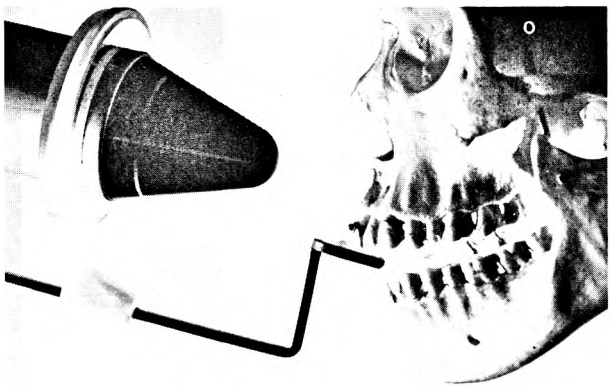

Fig. 3. Shows the manner in which the radiographs were taken. The film to tube distance was fixed by the paralleling arm. A 2 mm steel sphere is on the incisor tooth.

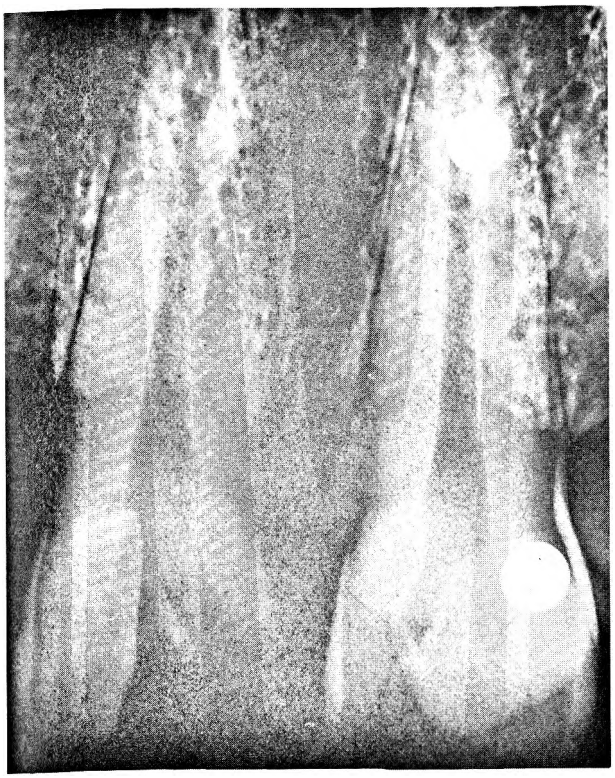

Fig. 4. A radiographic film with the two 2 mm steel spheres. The coronal sphere is on the tooth, while the apical one, is on the film.

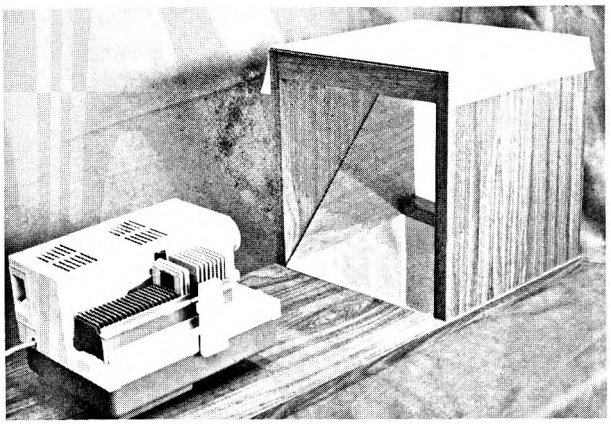

Fig. 5. A photograph of the slide projector and measuring table. The 45° mirror and tracing paper may be seen. The distance of the slide projector to the mirror determined the magnification of the film.

The following measurements were made: (1) steel sphere on the tooth; (2) steel sphere on the film; (3) cemento-enamel junction to the alveolar margins between the central incisors as indicated in Fig. 6. Measurements were made to the nearest 0,1 mm using vernier calipers. The 9 films were coded and rearranged by a third person and measured a total of 10 times on 5 different occasions. The code was broken at the completion of the experiment.

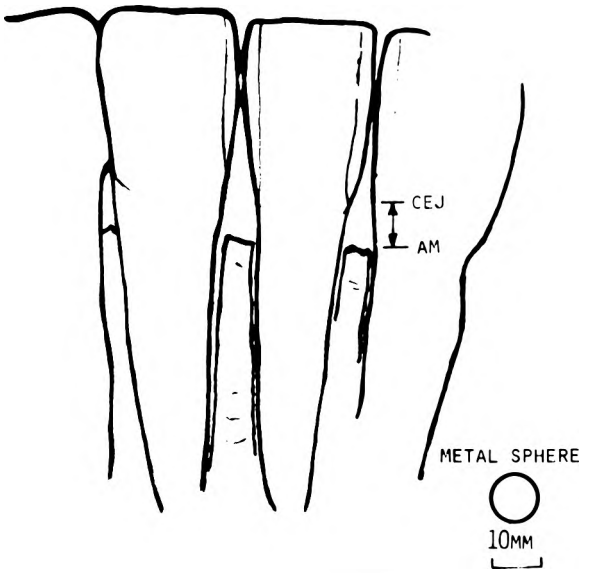

Fig. 6. A diagram of lower incisors showing the measuring reference points, namely CEJ = cemento-enamel junction, AM = alveolar margin, as well as a metal sphere of 10 mm diameter.

RESULTS

Phase one of the study was discontinued when it was found impossible to ascertain accurately the labial or palatal cemento-enamel junction on the radiographs. The interproximal cemento-enamel junction and interdental alveolar margin were therefore chosen as the landmarks to be measured.

Table I lists the mean measurements obtained when each of the 9 radiographs were examined on 10 occasions. In Table II the pooled mean measurement values are listed together with the results of an analysis of variance. No statistically significant differences were found between the measurements, confirming the reproducibility of the technique, and the consistency of observation by the investigator.

TABLE I

MEAN MEASUREMENTS (± STANDARD DEVIATION) OF EACH OF THE ENLARGED RADIOGRAPHS (9 RADIOGRAPHS) REPEATED ON 10 DIFFERENT OCCASIONS

Measurement		Radiograph Measurement Sequence and Mean Measurements in cms								
		1	2	3	4	5	6	7	8	9
Tooth steel sphere	$\bar{X}$	1,19	1,15	1,13	1,13	1,18	*	*	1,17	1,17
	SD	0,02	0,02	0,02	0,02	0,01	*	*	0,02	0,03
Film steel sphere	$\bar{X}$	1,09	1,09	1,07	1,07	1,07	1,09	1,09	1,08	1,08
	SD	0,03	0,03	0,02	0,02	0,02	0,02	0,03	0,03	0,03
Cemento-enamel junction to alveolar margin	$\bar{X}$	2,00	1,82	1,85	1,83	1,85	1,92	1,90	1,83	1,89
	SD	0,08	0,08	0,09	0,08	0,09	0,08	0,08	0,09	0,09

*Tooth steel spheres only partially on films.

TABLE II

POOLED MEASUREMENTS OF THE ENLARGED IMAGE (× 5) OF THE 9 RADIOGRAPHS

			Analysis of variance
Tooth steel spheres	$\bar{X}$	1,16	F = 0,12
	SD	0,05	(n = 70)
Film steel spheres	$\bar{X}$	1,08	F = 0,11
	SD	0,02	(n = 90)
Cemento-enamel junction to alveolar margin	$\bar{X}$	1,85	F = 0,41
	SD	0,09	(n = 90)

The mean measurement values obtained for the steel spheres on the teeth as well as the radiographic films were compared using the Student's t test. No statistically significant differences were found between them (t = 0,45). This indicates that either of the two positions for siting of the spheres may be used, to determine an accurate scale of measurement.

DISCUSSION

In a study such as this the determination of landmarks for measurement are of prime concern. Ritchey and Orban (1953) showed that the cemento-enamel junction and the alveolar margins are two landmarks that may be seen on intra-oral radiographs, and utilizing these landmarks, produced a comprehensive dissertation on the configuration of the interdental alveolar septa. Once reliable points of reference can be found on radiographs, these can then be used for the purpose of measurement. Prichard (1961) however stated that whatever radiographic method is used, there are two important limitations in the use of radiographs; namely, that they do not show the structures on the buccal and lingual aspects of the teeth and that they seldom show soft-to-hard tissue relationships.

Marshall-Day and Shourie (1949) considered the optimum position for the alveolar crest to be 1 mm from the cemento-enamel junction, and measured bone loss as a percentage of the maximum bone height. Schei *et al* (1959), using the same criteria as Marshall-Day and Shourie, developed their own measuring device. This was a translucent plastic ruler onto which a 1 mm line was drawn and corresponded to the normal distance from the alveolar crest to the cemento-enamel junction. Ten radii were then drawn from the base line. The ruler was placed over the radiograph and the height of bone assessed. Bjorn and Holmberg (1966) utilizing the method of Schei *et al.*, described the actual bone level as a fraction of the maximum bone height.

The choice of the interproximal cemento-enamel junction and interdental alveolar margin as landmarks for measurement in this study was made primarily after the experience derived in the initial phase; and on the evidence of the work of Ritchey and Orban (1953), and that of Boyle *et al* (1973).

The method described by Hirschfeld (1953) has the quality of being able to assess elongation or shortening of the image by measuring the graduated silver point to ascertain its actual length. The method is, however, not suitable for the purpose of measuring from the cemento-enamel junction to the alveolar margin in cases where there are no periodontal pockets.

The measuring grid of Everett and Fixott (1963) was found difficult to use accurately as the graduated lines did not always correspond to one or other of the landmarks, and one was forced to estimate the distances. The use of wires or radiopaque dyes are not practical in clinical situations.

The method employed in this study combined certain features of the methods of Updegrave; Boyle, Via and McFall; and Bjorn, Halling and Thyberg; with the additional use of the measuring table. It has proved simple and reliable.

The long cone parallel technique ensures reasonably distortion-free intra-oral radiographs; the use of a metal sphere on the film or tooth, indicates whether there is distortion or false magnification of the object or not; and the measuring table onto which the radiographs are projected at predetermined magnification makes it possible to see the landmarks more clearly, while the tracing paper on the table provides a recording method.

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