

A REPRODUCIBLE METHOD FOR CARIES EVALUATION IV

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Introduction

In a previous paper (1) a röntgenologic method was described for the accurate evaluation of dental caries of the proximal surfaces of the posterior teeth, specially adapted to scientific surveys of large groups of children. By means of a special apparatus, bitewing films were fixed in the mouth in a standard position. In this way reproducible röntgenograms could be obtained, so that different röntgenograms from the same mouth were nearly identical with regard to projection and overlapping. Even on röntgenograms taken at intervals of 18 months, 95% of the surfaces were depicted in the same way at both exposures. The estimation of dental caries from these röntgenograms proved to be quite reliable. Two experiments based on this method have been published (2, 3).

Though these results in itself were satisfactory, a survey of the molar region alone gives a rather incomplete picture of proximal dental caries, the more so, as the caries frequencies in anterior and posterior teeth are not correlated (4). Thus, the value of the method was restricted unless it could be adapted to the anterior teeth. Such an adaptation is the subject of this paper.

Now, the röntgenological estimation of caries in lower anteriors is especially unreliable as many surfaces show serious overlapping on röntgenograms. Furthermore, bitewing röntgenograms of the anteriors show much distortion owing to the differences in inclination of the upper and lower teeth. As the caries frequency in the lower anteriors is very small — at least in the younger age groups — and hardly affects the total caries score we deliberately restricted ourselves to the upper anteriors. We abandoned the bitewing principle in favour of röntgenograms of the upper anteriors alone.

MATERIALS AND METHODS

A. Films and X-ray tube

Kodak periapical ultraspeed films no 1 size, 1 by 1½ inch (D.F. 55) were used. The same kind of film was used for the posterior teeth. An exposure time of 2¼ seconds and a primary voltage of 205 V during ex-

posure produced the best radiograms. To keep the voltage constant during exposure a variable resistance was used, which was checked during each exposure.

B. *Apparatus for positioning films in the mouth*

To obtain undistorted pictures of the curved upper arch three exposures are required. On the left and on the right side one film was so adjusted as to depict the lateral in the centre, showing also the mesial surface of the cuspid and the distal surface of the central. A third film was taken in the middle and depicted the mesial surfaces of both centrals.

The film can be placed in the mouth in two extreme positions: either parallel to the axis of the teeth or in the occlusal plane. As a film parallel to the axis of the teeth either is distorted or hurts the palate we started with films in the occlusal plane. Though reasonable results were obtained, interpretation of the pictures was sometimes difficult. Teeth with little inclination — exposed to much from above — gave distorted pictures. In the radiograms of the centrals the projection of the nose interfered with the evaluation. After some trials we fixed the film with an inclination of 25 degrees from the occlusal plane.

The reproducibility of the röntgenograms was guaranteed by an apparatus holding the film in a fixed position with regard to teeth and

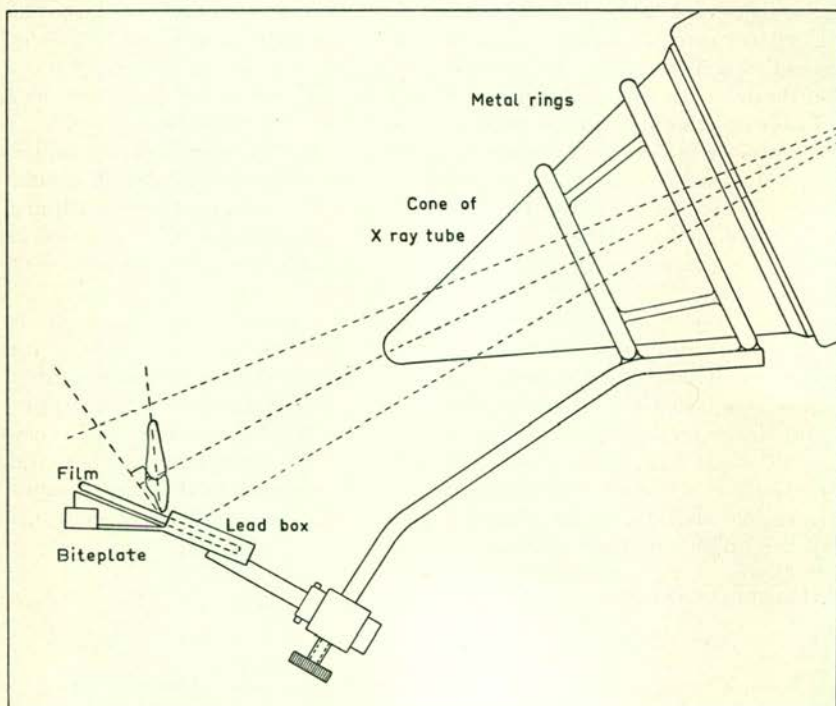


Fig. 2a. Position of filmholder in respect to teeth and X-ray tube.

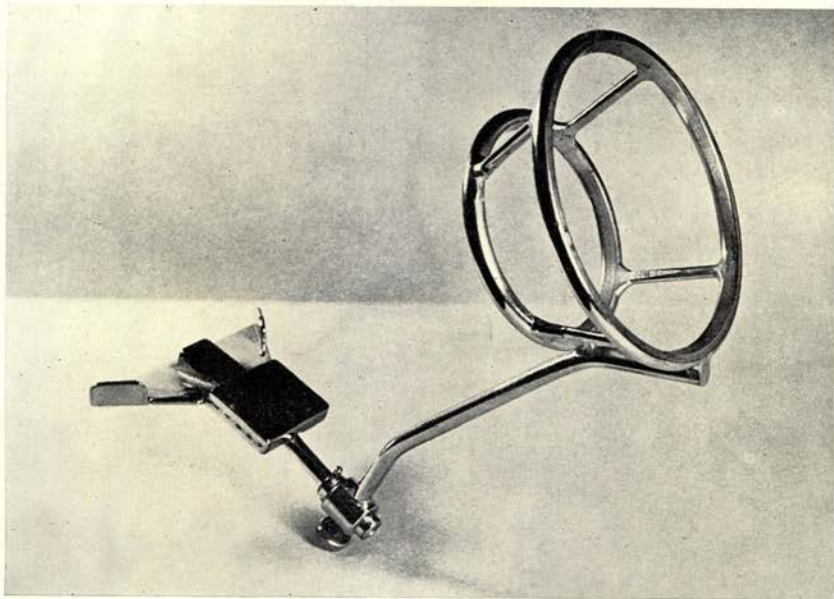
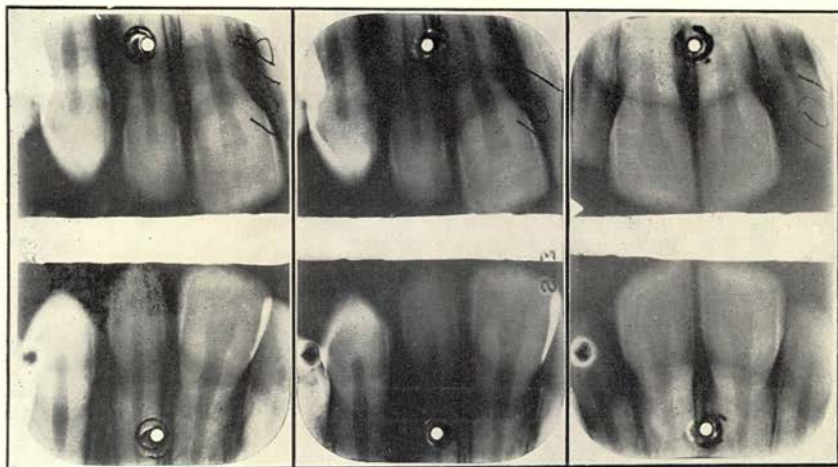


Fig. 1. Apparatus for a reproducible positioning of incisor films in the mouth.



A

B

C

Fig. 3. Radiograms of the cipper incisors. A and B are duplicate exposures, like the top and bottom half of film C. On the top half of the films from left to right are depicted the right cuspid, the lateral and both centrals while on the bottom half of the films from right to left—upside down—both centrals again, the left lateral and the cuspid are shown.

X-ray tube. This apparatus (fig. 1) consists of two parts; a metal biteplate carrying the film at a slight angle and a pair of metal rings in which the cone of the X-ray tube fits exactly. These two parts are connected by a rigid bar and a bayonet catch.

The biteplate is provided with two small vertical wings and a small lead box shielding half of the X-ray film. The shielded part is used for the next exposure. The position of the X-ray tube and the film in the

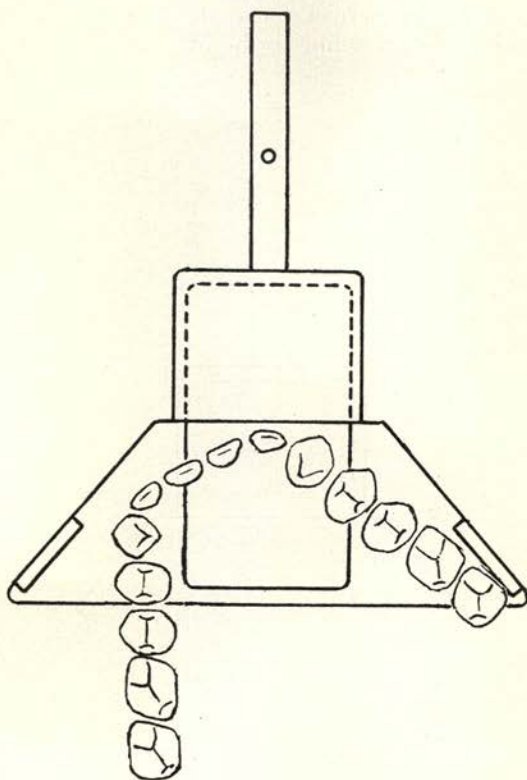


Fig. 2*b*. Position of film and holder for exposure of the right lateral incisor.

mouth is shown by fig. 2*a*. The röntgenographic technique is as follows. The apparatus is fitted in the mouth in such a way that the centre of the film coincides with the centre of the right lateral while the vertical wing of the plate rests against the upper molars (fig. 2*b*).

The patient having closed his mouth, the cone of the X-ray tube is slipped into the rings and the exposure made. For the radiogram on the left side, the film is turned 180° so that its exposed half is now covered by the lead box. The exposure is accomplished in the same way on the left. For the mesial surfaces of the centrals the apparatus is fitted exactly

in the median line (fig. 2c). As we always take a duplicate set of röntgenograms the other half of this film is used for the second exposure of the centrals. Fig. 3 shows a duplicate set of röntgenograms made in the way described above.

C. Patients

The data of two groups of 533 and 530 children respectively (11—15 years), will be discussed here. From each child two sets of three röntgenograms were made according to the method described. The first set

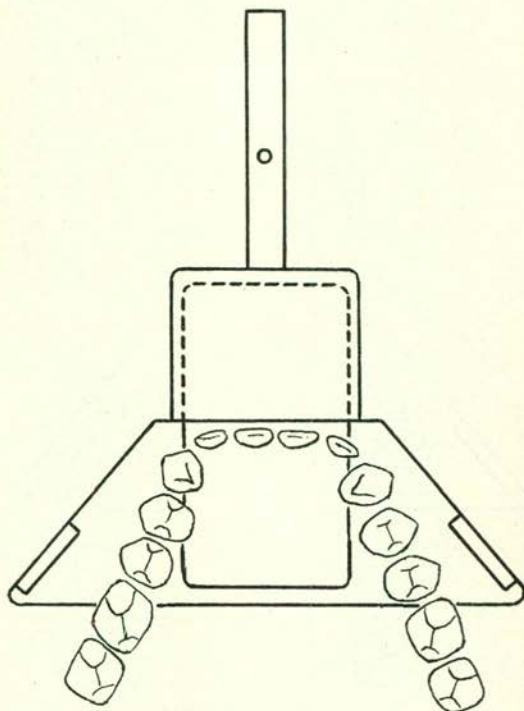


Fig. 2c. Position of film and holder for exposure of the centrals.

(A) was taken by a dentist while the second set (B) from the same children was made by a technician.

D. Caries evaluation on exposed films

The diagnosis of the proximal carious lesions of the anterior teeth was based on the same classification as was used with the posterior teeth. The following notation was used.

.	= sound
..?	= dubiously sound
I?	= dubiously caries
I	= distinct enamel caries
II	= slight dentin caries
III	= deep dentin caries
IV	= caries with pulp involvement
F	= filled
X	= seriously overlapped or not visible on the photograph
×	= extracted
—	= not erupted.

In calculations the limit between caries and sound was arbitrarily put between ..? and I?. The limit between enamel caries and dentin caries was taken between I and II.

In former studies each duplicate set of röntgenograms was evaluated by two dentists and these four observations entered in four score-charts. Re-evaluation of differences between the two observers reduced the number of charts to two which were then averaged to give the final score. This method was complicated and had the disadvantage that the re-examined surfaces received undue attention. It has now been abandoned in favour of the following procedure.

As each packet contains two films (A and A') and two exposures (A and B) were made, two identical sets of radiograms (A B and A' B') could be composed. The AB set was examined by a dentist and the A'B' series by a trained technician. The average result of these two evaluations is taken as the final caries-score.

In 50% of those cases in which different diagnoses had been made by the two observers, the röntgenograms were re-examined. These results were not used, however, but served only as a check between the examiners. Furthermore the evaluation of a few — carefully checked — series of röntgenograms was arbitrarily taken as a standard. To keep the evaluation to standard levels, the test series were examined regularly by each of the observers.

To examine the six thousand röntgenograms within a reasonable time two teams of examiners were necessary. To obviate systematical errors and to balance contingent differences in the standard of evaluation between the observers the following procedure was devised. The two dentists (a and b) and the technicians c and d could be arranged into four possible teams (a—c, b—d, a—d or b—c). The röntgenograms were divided in batches of about 300, referring to groups of 50 children of the same age. After the examination of every batch the teams were shuffled according to a prearranged schedule.

RESULTS

A. *Reproducibility of röntgenograms*

The first condition for a reproducible caries evaluation is, as has been stated, a reproducible röntgenographic technique. This means, that one has to be able to take two röntgenograms of the same patient at long intervals on which the same teeth are represented in the same projection.

The aim of the described apparatus is to obtain these radiographs. Such an apparatus always has the disadvantage of being made for the average patient, consequently it is not very suitable for the extreme cases. But after all it is not meant for the individual case, but for large groups of children in a caries experiment. And here it is of the greatest importance, that the groups be evaluated continually in the same way.

One measure for the reproducibility is the percentage of the surfaces that are simultaneously either present or absent on the two radiographs which had been taken independently from one another. (Present in this notation means well depicted, not overlapped and apt for caries evaluation, surfaces not up to these standards are considered absent).

Table I shows us the number of surfaces, present or absent on photo A and B. The radiographs A and B were taken by different investigators and refer to a group of 533 children (11—15 years old).

TABLE I

	Present A	Absent A	Total B
Present B	4773	28	4801
Absent B	11	518	529
Total A	4784	546	5330

The theoretically possible number of surfaces on these anterior radiographs is ten for each child (mesial Cuspid left to mesial Cuspid right), which gives a total of 5330 surfaces in this group. From these 4773 + 518 surfaces are simultaneously either present or absent on both radiographs, while 11 + 28 surfaces are represented on one radiograph only.

Thus the reproducibility of the radiographs is $\frac{4773 + 518}{5330} \times 100 = 99.3\%$. This means that out of every 100 surfaces more than 99 are represented in the same way.

Of the surfaces absent on both radiographs of course a number is absent in the mouth too (not erupted; extracted; fractured). Now it is also possible to check how many surfaces which are present in the mouth are

absent (= not well depicted) on both radiographs. This appeared to be the case with 87 surfaces (1.8%). Thus about 98% of the surfaces present in the mouth can be evaluated.

Of the second group (530 children, 11 to 15 years of age) the reproducibility of the radiographs appeared to be 99.5% while 106 (= 2.1%) of the surfaces present in the mouth could not be used for caries diagnosis on either radiograph.

B. Reproducibility of caries estimation

1°. Number of carious lesions

The total number of lesions evaluated on radiographs AB and A'B' are shown in table II in the „caries I—F” column. The lesions extending into the dentin are given in column „II—F”. The data refer to the first group of 533 children.

For the second group of children the numbers are shown in table III.

TABLE II

	Number of surfaces	Caries I — F	Caries II — F
Series AB	4806	1095	606
Series A'B'	4806	1087	601

TABLE III

	Surfaces	Caries I — F	Caries II — F
Series AB	4894	1013	547
Series A'B'	4894	1007	547

In the tables II and III all the AB films were examined by a dentist and all the A'B' films by a technician. The caries numbers hardly differ.

By comparing the results of these anterior röntgenograms with those of the posterior teeth in previous publications (1) one has to keep in mind, that these numbers are derived from two evaluations while those of the molar röntgenograms are based on four evaluations.

2°. The number of deviations

From the tables mentioned it is impossible to gather how many surfaces have been diagnosed differently by the two investigators as positive and negative deviations will cancel out to a great extent. It is the number of errors, however, that will lead to a measure for the reliability of the diagnosed number of carious lesions.

It will be recalled that eight different classifications (., .?, I?, etc.) were used. Now many deviations in diagnoses between the two examiners are irrelevant to the ultimate result. Therefore only those deviations that influence the number of carious lesions are involved in the estimation of reliability.

For the total caries score only differences between caries free (., .?) and caries (I?—F) were important (deviations I). For the score of dentin caries differences crossing the limit between I and II were taken into account (deviations II).

The numbers of deviations for the first group of 533 children are given for each surface separately in table IV as + and — differences. A positive deviation means a higher evaluation of a surface by the technician (c and d). A negative deviation means a higher evaluation by the dentist (a and b).

TABLE IV
Number of surfaces in which the diagnoses differed

	Right					Left					To- tal
	C		I ₂		I ₁	I ₁		I ₂		C	
	m	d	m	d	m	m	d	m	d	m	
positive deviations I*	3	7	9	13	8	17	10	10	5	5	87
negative deviations I*	10	12	17	6	9	8	12	11	5	5	95
Total of +I and —I	13	19	26	19	17	25	22	21	10	10	182
Difference between +I and —I	—7	—5	—8	+7	—1	+9	—2	—1	0	0	—8
positive deviations II†	0	1	5	2	3	5	2	0	2	0	20
negative deviations II†	3	3	2	2	4	4	2	1	2	2	25
Total of +II and —II	3	4	7	4	7	9	4	1	4	2	45
Difference between +II and —II	—3	—2	+3	0	—1	+1	0	—1	0	—2	—5

Data derived from a group of 533 children.

* I = differences concerning the total number of proximal lesions (I—F)

† II = differences concerning the number of proximal dentinal lesions (II—F)

C = cuspid m = mesial surface

I₂ = lateral incisor d = distal surface

I₁ = central incisor

From the 4806 estimated surfaces in this group (table II), as far as the total number of lesions is concerned (I—F), in $4806 - 182 = 4624$ surfaces the diagnosis was not in doubt. Consequently the reproducibility

of diagnosis is $\frac{4624}{4806} \times 100 = 96.2\%$. The total of differently evaluated surfaces is not very high. Moreover the positive and negative differences compensate each other reasonably.

For the second group (530 children) these numbers are fairly identical (table V), the reproducibility of diagnosis being 96.6% (see also table III).

TABLE V

Number of surfaces in which the diagnoses differed. Second group of 530 children

	+	—	Total of + and — signs	Differences of + and — signs
I	82	83	165	— 1
II	19	19	38	0

For legend see table IV

Subdivision of the material into 5 groups of 100 children of the same age showed that the deviations were scattered at random through the material. The largest number of deviations for one subgroup was 25 + and 33 — deviations. The reproducibility of caries estimation in this subgroup was still 94.3%.

The + and — deviations for the score of dentin caries (II—F) were also in balance (table IV). The reproducibility in the first group appears

to be $\frac{4806 - 45}{4806} \times 100 = 99.1\%$ and in the second group

$\frac{4894 - 38}{4894} \times 100 = 99.2\%$. In the age group with most deviations

(of 4+ and 13—) the reproducibility of the evaluation appears to be 98.9%.

3°. *The standard deviation of the observed number of carious lesions*

The theoretical base of the method used in calculating the standard deviation has been described in a previous paper (1). The standard deviation is calculated from the number of differently evaluated surfaces. The surfaces that have twice been diagnosed identically have no standard deviation ($\sigma = 0$). The surfaces that have once been diagnosed as carious (1) and once as sound (0) have a mean = $\frac{1}{2}$ and apparently have a standard deviation of $\sigma = \sqrt{\frac{1}{4}}$.

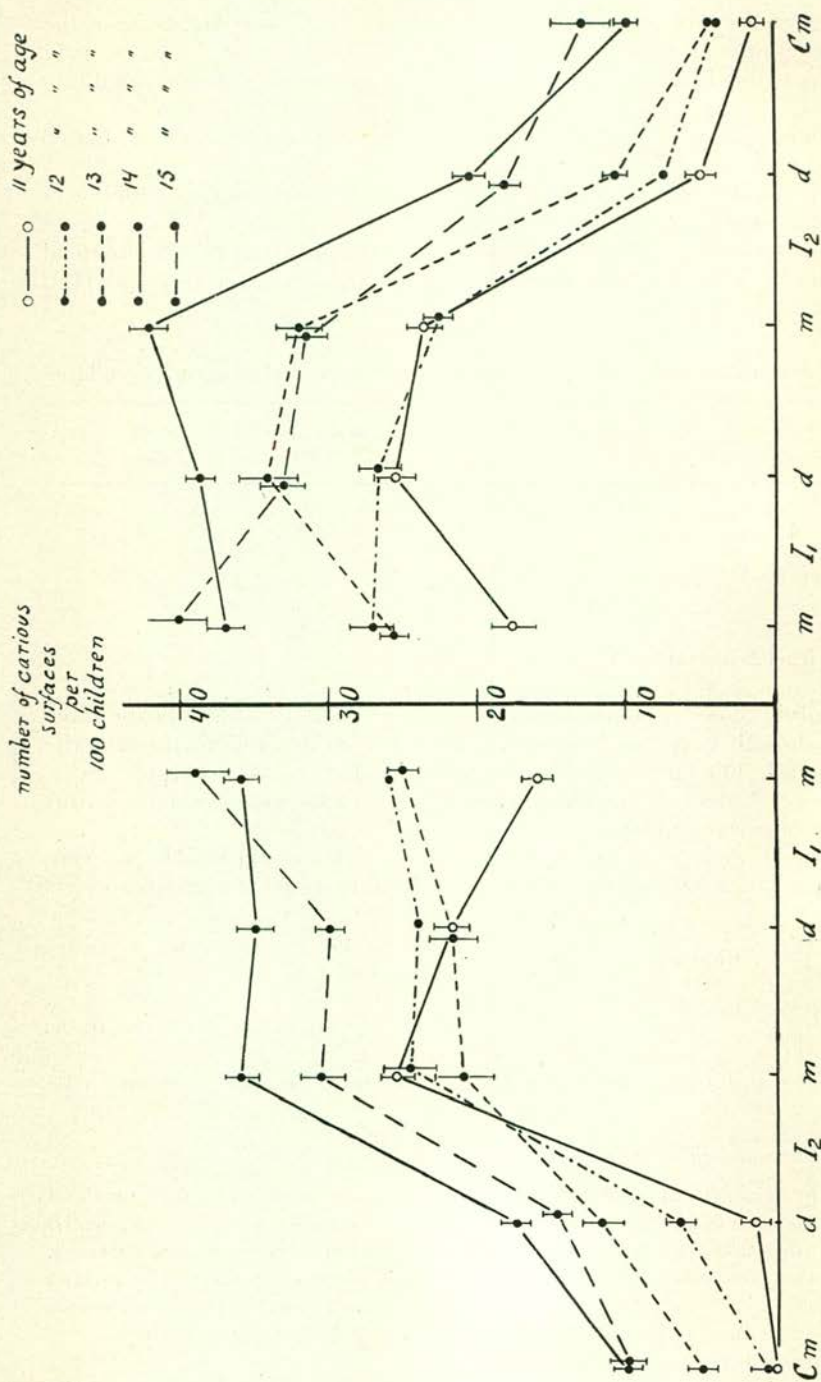


Fig. 4a. Number of proximal carious surfaces (I-F) per 100 children. The length of the short vertical lines corresponds to two times the standard deviation. For legend see also table IV.

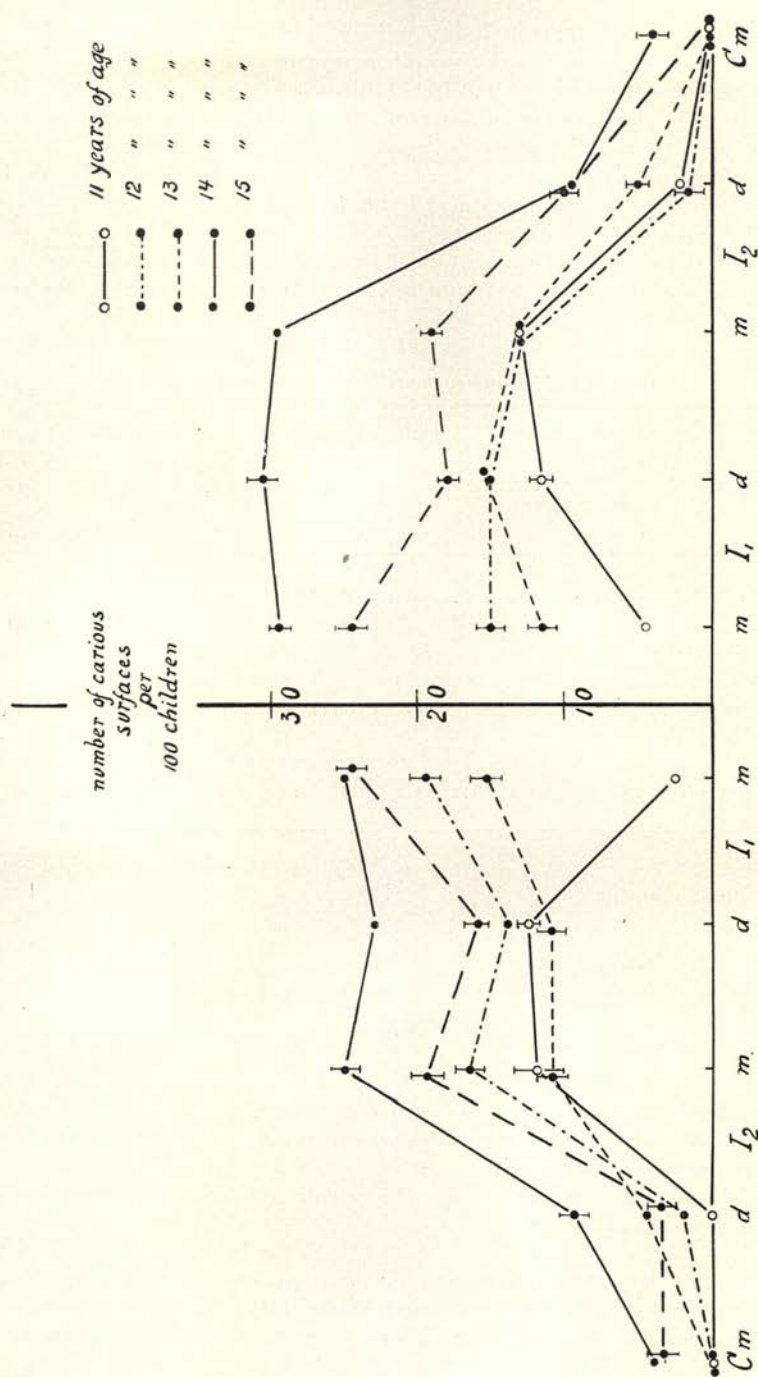


Fig. 4b. Number of proximal surfaces with dentin caries (II-F) per 100 children. For legend see fig. 4a.

If there are p differently diagnosed surfaces the standard deviation of the average number of carious surfaces is $\sigma m = \sqrt{\frac{1}{p}}$.

In this way of each group of 100 children of the same age the standard deviation of the average number of carious surfaces was calculated for each type of surface separately.

As the various groups show but little differences we will give the results of one sub-group only. In table VI the data are given of a group of 104 children of 14 years of age. The carious lesions (lesions I—F and lesions II—F separately) and the standard deviation (σm) are first given for the total number of children and next calculated per hundred children.

TABLE VI
Number of carious surfaces with standard deviations

	Right					Left					Total
	C		I ₂		I ₁	I ₁		I ₂		C	
	m	d	m	d	m	m	d	m	d	m	
number of observed surfaces	99	95	97	98	99	100	100	100	95	97	980
caries I—F	10	18	37	36	37	38	40	44	21	10	294
number of differences in diagnoses	3	4	3	3	3	3	2	6	3	1	31
standard deviation (σ_m)	1.2	1.4	1.2	1.2	1.2	1.2	1	1.7	1.2	0.7	3.9
caries I—F per 100 children	10	17	36	35	36	37	38	42	21	10	283
σ_m per 100 children	1.2	1.3	1.2	1.2	1.2	1.2	1	1.6	1.2	0.7	3.8
caries II—F	4	10	26	24	26	30	32	31	10	4	198
number of differences in diagnoses	1	2	2	0	0	1	2	0	0	2	10
standard deviation (σ_m)	0.7	1	1	—	—	0.7	1	—	—	1	2.2
caries II—F per 100 children	4	10	25	23	25	29	31	30	10	4	194
σ_m per 100 children	0.7	1	1	—	—	0.7	1	—	—	1	2.1

Data derived from a group of 104 children, 14 years of age.

The caries numbers obtained by our method of calculation are not always whole numbers but often end in halves. In the tables only whole numbers are given. Also caries per 100 children is given without decimal fractions. This explains why totals do not always tally. For legend see table IV.

The standard deviations for each type of surfaces are small. Including the other subgroups not mentioned in the table they varied between 0 and 2.2 with an average of 1.1 for caries (I—F) and of 0.4 for caries (II—F).

The last column shows the total number of observed surfaces, carious lesions and standard deviations.

For the other subgroups of about 100 children the standard deviations of the number of lesions for 100 children are but slightly different. The standard deviations of the carious lesions I—F differ from 3.5 to 5 (with an average of 3.9) and of the lesions II—F from 1.3 to 2.8 (with an average of 1.8).

In fig. 4*a* and 4*b* for every age group the number of carious surfaces is given for each proximal surface separately. The standard deviations are drawn in as vertical lines representing one time the standard deviation in both directions.

Summary:

In a previous paper a röntgenologic method was shown to achieve a reproducible caries evaluation of the proximal surfaces of the posterior teeth which is indispensable for scientific caries surveys. In this paper the method is adapted to the upper anterior teeth (including the mesial surfaces of both cuspids) by constructing an apparatus which fixes the film in the mouth so as to produce reproducible röntgenograms.

This method was tested on a group of about 1,000 children (11—15 years of age). From each child two series of three radiographs were taken. The analysis of the results permits the following conclusions.

Out of every 100 surfaces present in the mouth 98 could be diagnosed on the radiographs. Owing to the crowded position of some frontals not every surface could be pictured clearly.

The reproducibility of the röntgenograms (the first condition for a reproducible caries evaluation) was found to be more than 99%.

The caries evaluation took place in two classifications, namely the total number of carious lesions and those lesions which involved the dentin. For groups of 100 children of the same age the average reproducibility of the caries evaluation amounted to 96.5%, for the total number of lesions and for the dentin caries 99.1%.

The standard deviations of the number of carious surfaces were quite small. Calculated as percentages, the average standard deviations for each group of a hundred children, was 0.4% for the total number of carious surfaces and 0.2% for the dentin caries.

In spite of the fact that these sets of röntgenograms were evaluated only twice (the molar sets in previous examinations four times) the reproducibility appeared to be quite satisfactory. The caries evaluation of the radiographs by a trained technician apparently gives good results.

This method seems suitable for use in conjunction with the standardised molar röntgenograms. Even small differences in caries frequency may be evaluated significantly.

The time needed to take a set of posterior and anterior radiographs (5 exposures), in a routine examination, is less than 5 minutes. The evaluation of such a set of röntgenograms takes 5 to 10 minutes.

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