U. S. NAVAL SUBMARINE MEDICAL CENTER

Submarine Base, Groton, Conn.

REPORT NUMBER 543

HEAD POSITIONING FOR THE PANOREX X-RAY MACHINE

by

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Bureau of Medicine and Surgery, Navy Department
Research Work Unit MR005.19-6042.02

Released by:

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COMMANDING OFFICER
20 August 1968

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SUBMARINE MEDICAL RESEARCH LABORATORY
NAVAL SUBMARINE MEDICAL CENTER REPORT NO. 543

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SUMMARY PAGE

THE PROBLEM

Longitudinal studies of oral health require a reproducible method of exposing X-rays of the oral structures so that changes may be observed. The Panorex X-ray system has great promise in this regard but a method for precise head positioning is required.

FINDINGS

A head positioning device was fabricated which permits exact orientation of the subject in all planes and permits duplication of this position for serial exposures.

APPLICATIONS

This head positioning device can be used for precise head position for all Panorex exposures. Its greatest use will be for serial X-ray exposures in longitudinal dental studies.

ADMINISTRATIVE INFORMATION

This investigation was conducted as a part of Bureau of Medicine and Surgery Research Work Unit MR005.19-6042 — Study of Preventive Dental Principles and Methods in Military Populations. This report has been designated as Submarine Medical Research Laboratory Report No. 543. It is report No. 2 on this Work Unit, and was approved for publication as of 20 August 1968.

PUBLISHED BY THE NAVAL SUBMARINE MEDICAL CENTER

ABSTRACT

A device was fabricated to enable a subject's head to be positioned so that successive comparable Panorex X-ray exposures could be made of the oral structures.

Evaluations of the device were conducted using a dry skull with and without a bite impression to aid in orientation. The results indicate a lesser variability in the measurements obtained when a bite impression is used, but for practical purposes the results obtained without a bite impression seemed entirely adequate for most projected uses. The coefficient of variability was generally less than 2%.

It is concluded that the head positioning device serves its intended purpose to enable the Panorex X-ray exposure to be used as a longitudinal monitoring tool for periodontic, orthodontic, and other dental studies.

HEAD POSITIONING FOR THE PANOREX X-RAY MACHINE

by William R. Shiller, Commander (DC) USN

INTRODUCTION

The idea of a panoramic X-ray machine has been particularly attractive to those concerned with the need for conducting good screening examinations on large numbers of people. A popular model, the Panorex machine,* was developed with this need in mind (1).

This machine has been evaluated in various use areas (2, 3, 4). The Panorex machine would appear to be particularly useful in a longitudinal oral health study of rather large numbers of individuals. Such a study is being inaugurated in the United States Navy's Submarine Force, and a Panorex machine has been installed at the Submarine Medical Research Laboratory for this reason.

Preliminary evaluation of the machine as a longitudinal study tool uncovered one very real defect, the difficulty of positioning the subject's head precisely so that all exposures could be truly comparable to each other. The chin rest provided with the machine seems amply sufficient for routine clinical needs; however, for serial duplications of exposures it was found to be inadequate.

A device was therefore developed at the Submarine Medical Research Laboratory to overcome the problem of precise head positioning.

DESCRIPTION

Details of the fabricated head positioning device are illustrated in Figures 1, 2, and 3. The majority of the components are fabricated of clear plastic so that no interference with the passage of the X-rays will result.

Basically, the device is designed to stabilize the head in all three planes: lateral, anterior-posterior, and superior-inferior. The various components are attached to the base (X) which is attached to the subject's chair by means of a steel bar (I).

Earpieces (A) are attached to the adjustable arms (J). These earpieces may be positioned snugly in the subject's ears by advancing a screw (D) at the base of the device. This screw causes a separation of the earpiece arms below their pivots and a resulting contraction of the space between the earpieces (A). Tension is maintained on the earpiece system by means of two straight springs (E) acting on the lower portion of the earpiece arms. The entire arm assembly moves forward and back when the wing nut (c) is loosened.

The bite plane device (B) is a detachable plastic plate on which the subject bites during exposure. This plate fits snugly in slots (F) placed in the bite pillar (G). By selection of the proper slot, the subject's bite plane is placed in the correct position for exposure. In order to achieve the proper anterior-posterior position, the subject's nose is placed to just contact the nose bar (H).

In operation, the subject is seated in the chair, the earpieces (A) are fitted snugly into the subject's ears by adjustment of the earpiece arms (J) with the screw (D). The subject then brings his head forward until his nose just touches the bite plane assembly nose bar (H). The bite plane (B) is placed in the proper slot (F) and the subject bites on the bite plane. This has the subject

* X-ray Manufacturing Corporation of America, Great Neck, New York.

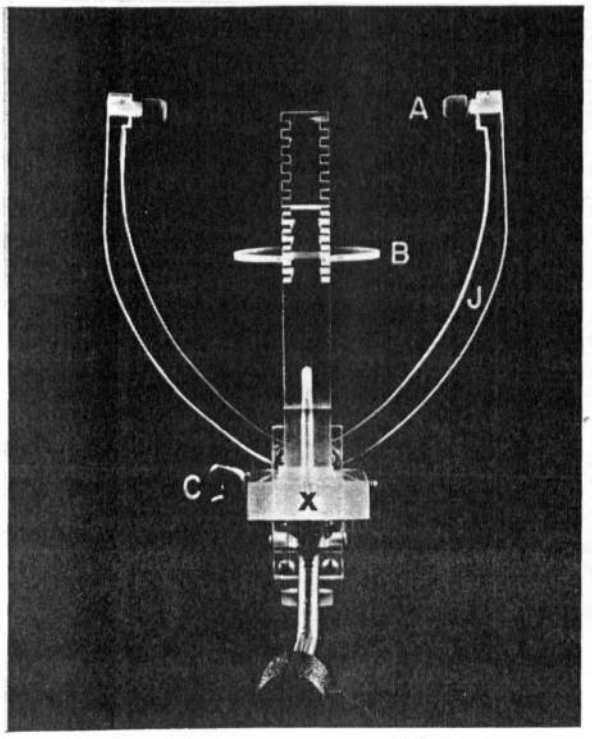

Figure 1. Positioning device, front view.

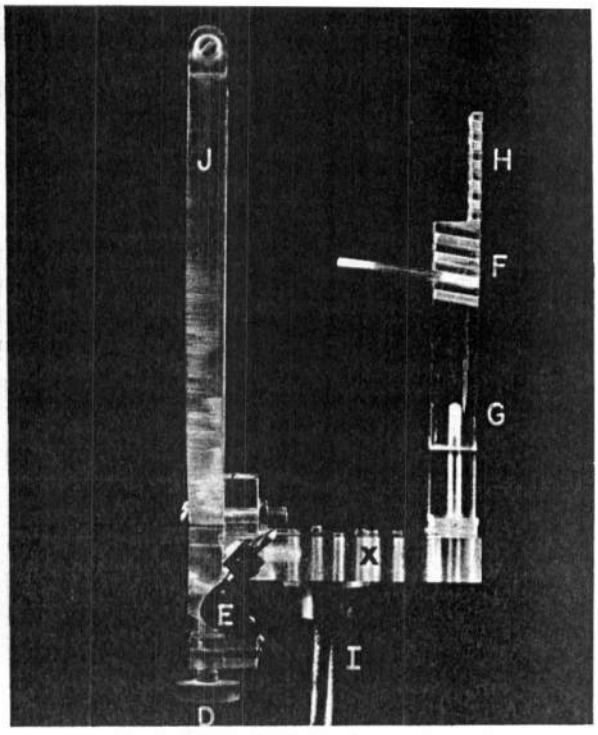

Figure 2. Positioning device, side view.

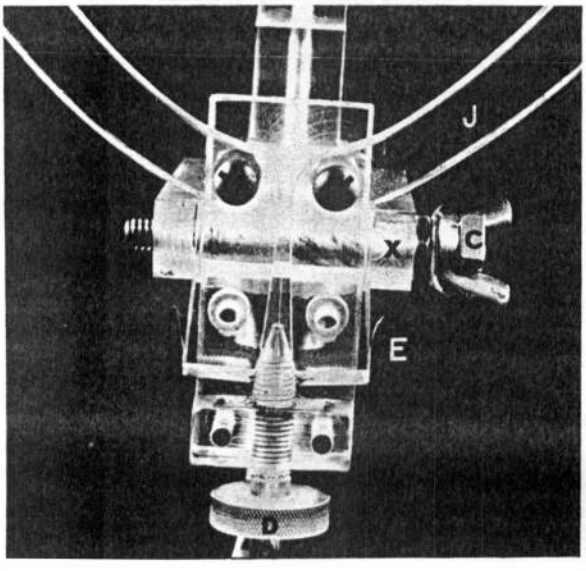

Figure 3. Positioning device ear piece arm adjustment.

Figure 4. Positioning device in use.

properly positioned for taking a Panorex X-ray, and by recording the slot number (F) the position may be duplicated for future exposures. The actual patient positioning is illustrated in Figure 4.

EVALUATION METHODS

In order to assess the degree of reproducibility of the head position, a series of exposures were made of a dry human skull. The radiation exposures were held constant at 52 kilovolts and 2 milliamperes, and Kodak blue brand medical X-ray film was used throughout. The following procedures were employed to evaluate the various factors involved in duplicating the position:

Control Series. The skull was fixed in the device and six exposures were made without removing the skull between exposures.

Bite Impression Series. A bite impression was made on the bite plane from green stick compound and the teeth were placed in this impression for each exposure. Six exposures were again made but the skull was removed from the positioning device after each exposure.

Plain Bite Series. This series of six exposures was identical to the bite impression series with the exception that no compound was used on the bite plane.

The resulting eighteen developed films were then randomized and selected blind measurements were made by two examiners, the author, and Mr. John E. Wiseman, of the laboratory staff. Each examiner performed the measurements on each film twice at widely separated time periods in order to permit assessment of intra examiner error.

Structures were selected for measurement so that both horizontal and vertical dimentions would be involved. Items were included which are considered to be of interest to oral surgeons, orthodontists, and periodontists. The measurement items were as follows:

A. Narrowest anterior-posterior dimension of the right mandibular ramus.

B. Superior-inferior dimension of the mandible just distal to the left second premolar.

C. Bone height on the distal surface of the right mandibular second premolar.

D. Bone height on the distal surface of the left mandibular second premolar.

E. Overall length of the right mandibular second premolar.

F. Overall length of the mandibular left second premolar.

G. Dimension of right mandibular posterior arch segment (mesial of first premolar to distal of second molar teeth).

H. Dimension of left mandibular posterior arch segment.

I. Dimension of right maxillary posterior arch segment.

RESULTS

The data are summarized overall in Table I (values expressed are means in millimeters plus or minus standard deviations). Inspection reveals a remarkably small degree of variability in these data.

Since the evaluation was designed to test the between and within examiner effects on the measurements, analyses of variance were performed in which a 3 x 2 x 2 factorial design was employed to compartmentalize the observed variances. The resulting tables are presented as Tables II through X. Again, the extremely small variances are noted in all cases. With but two exceptions (measurement series C and D), the method of positioning for exposure accounted for the significant portion of observed variation. In these two instances the examiner factor accounted for the significant portion. Obviously, criteria for measurement of bone height differed between the two examiners.

In order to more fully depict the low variability in the measurements, data for the first set of each measurement series are given for each examiner in Tables XI and XII. The coefficients of variation are also given (CV = standard deviation ÷ mean x 100). These coefficients are generally very low. It is also of interest that in each method

Table I
Results of Measurement on Panorex Series

	Control				Group 1 Exposures				Group 2 Exposures			
	Examiner A		Examiner B		Examiner A		Examiner B		Examiner A		Examiner B	
Measurement	1st exam	2nd exam	1st exam	2nd exam	1st exam	2nd exam	1st exam	2nd exam	1st exam	2nd exam	1st exam	2nd exam
A	30.25 ±.16	30.52 ±.24	30.30 ±.30	30.23 ±.27	30.45 ±.23	30.75 ±.44	30.55 ±.37	30.43 ±.21	31.85 ±.52	31.92 ±.37	31.72 ±.65	31.83 ±.54
B	31.45 ±.08	31.63 ±.16	32.03 ±.20	31.97 ±.26	31.67 ±.21	31.75 ±.18	31.95 ±.12	32.12 ±.13	30.42 ±.13	30.50 ±.34	30.77 ±.23	30.80 ±.21
C	14.70 ±.16	14.52 ±.08	14.95 ±.15	14.92 ±.10	14.78 ±.19	14.75 ±.40	14.87 ±.18	15.07 ±.19	14.65 ±.08	14.60 ±.06	15.02 ±.17	14.93 ±.08
D	15.17 ±.23	14.63 ±.21	15.27 ±.18	15.50 ±.11	15.17 ±.27	14.87 ±.30	15.38 ±.13	15.65 ±.24	15.00 ±.37	14.78 ±.24	15.03 ±.26	15.05 ±.34
E	24.40 ±.18	24.02 ±.30	24.32 ±.08	24.30 ±.25	24.57 ±.19	24.37 ±.38	24.43 ±.12	24.55 ±.14	24.17 ±.45	24.27 ±.21	24.12 ±.24	24.20 ±.23
F	24.92 ±.19	24.68 ±.30	25.00 ±.14	25.10 ±.17	24.80 ±.28	24.62 ±.13	24.90 ±.24	25.03 ±.21	24.42 ±.15	24.45 ±.14	24.18 ±.25	24.28 ±.23
G	42.52 ±.04	42.52 ±.16	42.47 ±.14	42.48 ±.12	42.65 ±.35	42.73 ±.36	42.68 ±.34	42.63 ±.33	40.35 ±1.75	41.02 ±1.95	40.53 ±1.73	40.45 ±1.75
H	43.85 ±.20	43.67 ±.08	43.87 ±.12	44.10 ±.37	42.93 ±.18	42.93 ±.18	43.00 ±.21	43.07 ±.25	39.55 ±.63	40.33 ±1.88	39.62 ±.58	39.65 ±.50
I	35.80 ±.16	35.68 ±.15	35.75 ±.08	35.87 ±.10	35.43 ±.12	35.72 ±.23	35.55 ±.27	35.62 ±.37	36.63 ±.50	36.75 ±.44	36.72 ±.50	36.68 ±.55

Table II
Factorial Analysis (Measurement Series A)

SOURCE OF VARIANCE	SUM OF SQUARES	DEGREES FREEDOM	MEAN SQUARE	F
Method of positioning	31.66	2	15.83	22.89*
Examiner	0.22	1	0.22	0.32
Examinations	0.16	1	0.16	0.23
Interactions (first order)				
Method X Examiner	0.00	2	0.00	0
Method X Examination	0.00	2	0.00	0
Examiner X Examination	0.24	1	0.24	0.35
Second order interaction	0.16	2	0.08	0.11
Within groups (error)	41.5	60	0.69	

*$P < .01$

Table III
Factorial Analysis (Measurement Series B)

SOURCE OF VARIANCE	SUM OF SQUARES	DEGREES FREEDOM	MEAN SQUARE	F
Method of positioning	23.16	2	11.58	24.55*
Examiner	2.45	1	2.45	5.20**
Examinations	0.11	1	0.11	0.23
Interactions (first order)				
Method X Examiner	0.07	2	0.04	0.07
Method X Examination	0.02	2	0.01	0.02
Examiner X Examination	0.03	1	0.03	0.06
Second order interaction	0.04	2	0.02	0.04
Within groups (error)	28.30	60	0.47	

*$P < .01$

** $P < .05$

Table IV
Factorial Analysis (Measurement Series C)

SOURCE OF VARIANCE	SUM OF SQUARES	DEGREES FREEDOM	MEAN SQUARE	F
Method of positioning	0.11	2	0.06	0.86
Examiner	1.53	1	1.53	23.79*
Examinations	0.01	1	0.01	0.16
Interactions (first order)				
Method X Examiner	0.08	2	0.04	0.62
Method X Examination	0.13	2	0.07	1.01
Examiner X Examination	0.07	1	0.07	1.09
Second order interaction	0.02	2	0.01	0.08
Within groups (error)	3.86	60	0.06	

*P < .01

Table V
Factorial Analysis (Measurement Series D)

SOURCE OF VARIANCE	SUM OF SQUARES	DEGREES FREEDOM	MEAN SQUARE	F
Method of positioning	0.98	2	0.49	3.11
Examiner	2.42	1	2.42	15.36*
Examinations	0.11	1	0.11	0.70
Interactions (first order)				
Method X Examiner	0.43	2	0.22	1.36
Method X Examination	0.09	2	0.05	0.29
Examiner X Examination	1.34	1	1.34	8.50*
Second order interaction	0.18	2	0.09	0.54
Within groups (error)	9.46	60	0.16	

*P < .01

Table VI
Factorial Analysis (Measurement Series E)

SOURCE OF VARIANCE	SUM OF SQUARES	DEGREES FREEDOM	MEAN SQUARE	F
Method of positioning	1.11	2	0.56	5.93*
Examiner	0.01	1	0.01	0.11
Examinations	0.05	1	0.05	0.53
Interactions (first order)				
Method X Examiner	0.08	2	0.04	0.43
Method X Examination	0.25	2	0.13	1.34
Examiner X Examination	0.22	1	0.22	2.35
Second order interaction	0.10	2	0.05	0.48
Within groups (error)	5.62	60	0.09	

*$P < .01$

Table VII
Factorial Analysis (Measurement Series F)

SOURCE OF VARIANCE	SUM OF SQUARES	DEGREES FREEDOM	MEAN SQUARE	F
Method of positioning	4.89	2	2.45	16.46*
Examiner	0.19	1	0.19	1.28
Examinations	0.001	1	0.001	0.007
Interactions (first order)				
Method X Examiner	0.83	2	0.42	2.79
Method X Examination	0.06	2	0.03	0.20
Examiner X Examination	0.25	1	0.25	1.68
Second order interaction	0.06	2	0.03	0.17
Within groups (error)	8.91	60	0.15	

*$P < .01$

Table VIII
Factorial Analysis (Measurement Series G)

SOURCE OF VARIANCE	SUM OF SQUARES	DEGREES FREEDOM	MEAN SQUARE	F
Method of positioning	64.25	2	32.13	14.46*
Examiner	0.14	1	0.14	0.06
Examinations	0.20	1	0.20	0.09
Interactions (first order)				
Method X Examiner	0.10	2	0.05	0.02
Method X Examination	0.32	2	0.16	0.07
Examiner X Examination	0.38	1	0.38	0.17
Second order interaction	0.44	2	0.22	0.10
Within groups (error)	133.3	60	2.22	

*$P < .01$

Table IX
Factorial Analysis (Measurement Series H)

SOURCE OF VARIANCE	SUM OF SQUARES	DEGREES FREEDOM	MEAN SQUARE	F
Method of positioning	221.06	2	110.53	26.69*
Examiner	0.00	1	0.00	0.00
Examinations	0.45	1	0.45	0.11
Interactions (first order)				
Method X Examiner	0.96	2	0.48	0.12
Method X Examination	0.57	2	0.29	0.07
Examiner X Examination	0.04	1	0.04	0.01
Second order interaction	1.00	2	0.50	0.12
Within groups (error)	248.48	60	4.14	

*$P < .01$

Table X
Factorial Analysis (Measurement Series I)

SOURCE OF VARIANCE	SUM OF SQUARES	DEGREES FREEDOM	MEAN SQUARE	F
Method of positioning	17.06	2	8.53	21.22*
Examiner	0.01	1	0.01	0.02
Examinations	0.09	1	0.09	0.22
Interactions (first order)				
Method X Examiner	0.02	2	0.01	0.02
Method X Examination	0.11	2	0.06	0.14
Examiner X Examination	0.01	1	0.01	0.02
Second order interaction	0.14	2	0.07	0.16
Within groups (error)	24.12	60	0.40	

*$P < .01$

Table XI
Variation in Methods of Subject Placement (Examiner, J. W.)

Measurement Series	Control (N=6)	Bite Impression (N=6)	No Bite Impression (N=6)
A	30.25[+] ± 0.16[++]	30.45 ± 0.23	31.85 ± 0.53[*]
	C.V. = 0.53	C.V. = 0.74	C.V. = 1.64
B	31.45 ± 0.08	31.67 ± 0.21	30.42 ± 0.13[*]
	C.V. = 0.26	C.V. = 0.65	C.V. = 0.43
C	14.70 ± 0.16	14.78 ± 0.19	14.65 ± 0.08
	C.V. = 1.05	C.V. = 1.31	C.V. = 0.57
D	15.17 ± 0.23	15.17 ± 0.27	15.00 ± 0.37
	C.V. = 1.54	C.V. = 1.75	C.V. = 2.46
E	24.40 ± 0.18	24.57 ± 0.19	24.17 ± 0.45
	C.V. = 0.73	C.V. = 0.75	C.V. = 1.86
F	24.92 ± 0.19	24.80 ± 0.28	24.42 ± 0.15[*]
	C.V. = 0.77	C.V. = 1.11	C.V. = 0.60
G	42.52 ± 0.04	42.65 ± 0.35	40.35 ± 1.75[**]
	C.V. = 0.09	C.V. = 0.82	C.V. = 4.33
H	43.85 ± 0.20	42.93 ± 0.18[*]	39.55 ± 0.63[*]
	C.V. = 0.44	C.V. = 0.40	C.V. = 1.58
I	35.80 ± 0.16	35.43 ± 0.12[*]	36.63 ± 0.50[*]
	C.V. = 0.43	C.V. = 0.34	C.V. = 1.35

[+]Mean measurement in millimeters.

[++]One standard deviation.

[*]Mean significantly different from control ($P < .01$).

[**]Mean significantly different from control ($P < .05$).

Table XII
Variation in Methods of Subject Placement (Examiner, W. S.)

Measurement Series	Control (N=6)	Bite Impression (N=6)	No Bite Impression (N=6)
A	30.30[+] ± 0.30[++]	30.55 ± 0.37	31.72 ± 0.65[*]
	C.V. = 0.30	C.V. = 0.37	C.V. = 0.65
B	32.03 ± 0.20	31.95 ± 0.12	30.77 ± 0.23[*]
	C.V. = 0.61	C.V. = 0.38	C.V. = 0.76
C	14.95 ± 0.15	14.87 ± 0.18	15.02 ± 0.17
	C.V. = 1.01	C.V. = 1.17	C.V. = 1.14
D	15.27 ± 0.18	15.38 ± 0.13	15.03 ± 0.26
	C.V. = 1.14	C.V. = 0.86	C.V. = 1.71
E	24.32 ± 0.08	24.43 ± 0.12	24.12 ± 0.08
	C.V. = 0.30	C.V. = 0.49	C.V. = 0.99
F	25.00 ± 0.14	24.90 ± 0.24	24.18 ± 0.25
	C.V. = 0.56	C.V. = 0.95	C.V. = 1.02
G	42.47 ± 0.14	42.68 ± 0.34	40.53 ± 1.73[**]
	C.V. = 0.32	C.V. = 0.80	C.V. = 4.27
H	42.87 ± 0.12	43.00 ± 0.21[*]	39.62 ± 0.58[*]
	C.V. = 0.27	C.V. = 0.48	C.V. = 1.45
I	35.75 ± 0.08	35.55 ± 0.27	36.72 ± 0.50[*]
	C.V. = 0.23	C.V. = 0.74	C.V. = 1.37

[+] Mean measurement in millimeters.

[++] One standard deviation.

[*] Mean significantly different from control ($P < .01$).

[**] Mean significantly different from control ($P < .05$).

studied the bone height (measurements C and D) would be expected to vary from the mean by only one millimeter or less 99% of the time (99% confidence limit of mean with 5 degrees of freedom = 4.03 x standard deviation). There were instances of significant differences between means of the two subject placement methods compared with the control (t test), but this should not be given undue weight over the observed variations within each method.

DISCUSSION

An evaluation of an X-ray procedure by means of measurements must give thought not only to the X-ray techniques but also to the measurement techniques. In this study there was, generally, very close agreement both between and within examiner categories. The significant differences between examiner variances in the case of bone height measurement undoubtedly resulted from slightly differing measurement criteria in the two examiners. This points up the fact that in a longitudinal study there should either be a strict agreement of criteria or all examinations should be performed by one individual.

The fact that there were no significant degree of interaction variances involving the method indicates that the evaluation methods themselves should not affect the assessment of the exposure techniques.

The data indicate that the control exposure and the exposures in which a bite impression was used gave results more similar than between the control and exposures with no bite impression. This deserves some comment. Actually, the same bite impression was used for the control series in which the skull remained in place while six successive exposures were made. Thus, the results of the t test for mean differences should not be given much practical weight except in indicating the obvious conclusion that techniques should not be varied during a longitudinal study.

The real practical significance to this study lies in the variances observed within each technique. The real practical question posed is: "Can a technique using this head positioning device result in data with a small enough variability to be of practical value?" It is believed that the answer is "yes."

It is obvious that the degree of variation differs between the methods of head placement during exposure. Thus, the use of a bite impression to orient the mouth for successive exposures adds to the reproducibility of measurements. For many purposes, the use of such an impression probably would be unnecessary in view of the very small variances obtained without the impression. Parenthetically, the chief source of variability when not using a bite impression seems to result from the slight anterior-posterior shifts in the mandible. This is born out when the variability of the right maxillary and mandibular arch segments are compared (measurement series G and I). Modifications in the device are being made to prevent this mandibular shift.

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