Head Holder for Panoramic Dental Radiography

J. Ordman
P. Cleaton-Jones
E. Mizrahi
L. P. Fatti

A radiolucent head holder for the Pancentric Panorex dental x-ray machine is constructed and evaluated. Features include a wooden pointer to orient the head in the midsagittal plane, movable components adjustable into a number of fixed positions and a spirit level on an ear rod fitting.

KEY WORDS: • PANORAMIC RADIOGRAPHY • RADIOGRAPHY • X-RAY •

Panoramic dental radiography is commonly used as part of diagnostic and ongoing treatment assessment in clinical orthodontics. Among the first machines available for general clinical use were the Panorex, the Orthopantomograph, and the GE-3000. Following the introduction of panoramic dental x-ray machines in 1957, it was soon apparent that improvements in the head-holding devices were desirable. The only support for the head in the original Panorex machine was a vertically adjustable plastic chin cup (KITE ET AL. 1962).

IN 1967, KANE replaced the plastic chin cup with a device patterned after the Broadbent-Bolton cephalostat. It consisted of zygomatic arch holders, a chin holder, and a pointer directed at orbitale. There were metric calibrations for each component, to allow for repositioning the head for future exposures. Using this headholder, Kane showed a 93% correlation between original and duplicate measurements on both right and left radiographic images of the mandible.

A number of reports have been published since on head holders for these machines (RICHARDSON ET AL. 1969, ZACH ET AL. 1969 ROSENBERG 1972, RYAN ET AL. 1973,

Dr. Ordman is in private orthodontic practice in Johannesburg. He is a dental graduate (B.D.S., M.Dent.) of the University of the Witwatersrand, Johannesburg.

Dr. Cleaton-Jones is Professor of Experimental Odontology and Director of the Medical Research Council / University of the Witwatersrand Dental Research Institute. He is a graduate in Dentistry (B.D.S.), Medicine (M.B., B.Ch.) and Science (Ph.D.) from the University of the Witwatersrand, Johannesburg.

Dr. Mizrahi is in private orthodontic practice in Johannesburg and is an honorary research fellow in the Medical Research Council / University of the Witwatersrand Dental Research Institute. He is a graduate in Dentistry (B.D.S., Ph.D.(Dent.)) from the University of the Witwatersrand, and holds M.Sc. from the University of Manchester and Dip. Orth., F.D.S.R.C.S. from the Royal College of Surgeons of England.

Dr. Fatti is Professor of Statistics and Head of the Department of Statistics at the University of the Witwatersrand. He is a graduate in Science of the University of the Witwatersrand (B.Sc.(Hons.), Ph.D.) and the University of London (M.Sc.).

Author Address:

Dr. J. Ordman
MRC/University of the Witwatersrand
Dental Research Institute
WITS 2050
SOUTH AFRICA

Alpern 1979). With these systems, the occlusal plane is visually oriented to an approximately horizontal position by tilting the head, using either the Frankfort horizontal or the tragus-ala line as a plane of reference. The midsagittal plane of the head is adjusted by visual estimation.

From these studies, it is clear that the most precise head holder for panoramic dental radiographic systems to date is that described by ALPERN (1979). A disadvantage of that apparatus is that there is no device to precisely center the head in the midsagittal plane.

A summary of the features of the various head holders designed for panoramic dental radiography is listed in Table 1.

A number of authors (KANE 1967, RICHARDSON ET A. 1969, ROSENBERG ET AL. 1972, RYAN ET AL. 1973) have stated that once a dependable head holder is available, and a head positioning method is established, clinical research using panoramic radiography should be more feasible.

The present study is aimed at constructing a head holder suitable for use with the Panorex machine to produce a standardized head position, and test the precision of that head holder and the reproduceability of results.

— Materials and Methods —

Design and construction were directed toward meeting the following objectives:

- To center the patient in the machine
- To be rigid enough to prevent significant deflection of component parts
- To be calibrated for recording dimensional positions for individual patients

Not only must the head be centered, but tilting movement in any direction must be prevented. For improved accuracy in positioning, some components should be adjustable into a number of different fixed positions, rather than continuously adjustable through movement along slots, as in ALPERN's device (1979).

Radiolucent clear acrylic sheet, dimensionally thick enough to maintain rigidity of the parts, was used for most of the components, assembling with adhesive

Table 1

Features of Head Holders for Panoramic X-ray Machines

	CS	FS	TP	ZAP	T–A	FH	MsP	Abb	VLC
Panorex	×			×	×	×			
Orthopantomograph	×	×	×		×	×	×		
GE-panelipse	×			×	×	×	×		
Paneléte	×		×			×	×	×	
Panex	×	×	×			×	×	×	
Rotograph	×	×	×			×	×		
OrthoOralix	×	×	×		>>>	×			
Orthopantomograph	×	×	×			×	×	×	
Panoura	×			×		×	×		

CS — Chin Support
FS — Forehead Stop
TP — Temporal Positioners
ZA — Zygomatic Arch Positioners
T–A — Tragus-Ala line est.
FH — Frankfort Plane est.
MsP — Midsagittal Plane est
Abb — Ant. Bite Block
VLC — Vert. line Cuspid Align.
>>> — Light beam

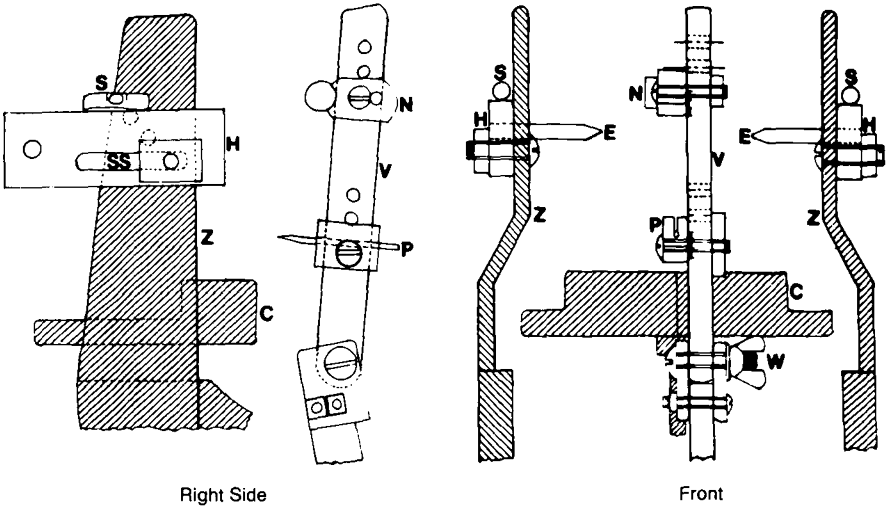

Fig. 1 Sketches of head holder, showing right side and front views. Standard parts are cross-hatched; the chin rest is marked C, and zygomatic arch holder Z. The added parts are the horizontal component H, with slot SS, spirit level S, ear rods E, and the midline vertical column V, with nasion rest N, incisor pointer P, and locking wing-nut W.

and aluminium bolts. Parts not in the path of the x-ray beam were assembled with steel bolts and nuts. Standard size wooden pegs 9cm long and 2mm in diameter were used as disposable pointers. Millimeter rules and glass spirit levels were also stock items.

Sketches of the components are shown in Fig. 1. The chin rest is a standard part of the Pancentric head positioner. The off-center vertical column is attached to the Pancentric base by two bolts with wing nuts, so that it can be rotated downward away from the face, or up into an upright position against a stop close to the face. At the lower end of this column in a holder for a disposable wooden pointer, and the nasion rest is attached to the upper end.

The wooden pointer and the nasion rest may be bolted in three different fixed positions in the vertical plane, designated I1, I2, and I3, and N1, N2, and N3. In addition, the nasion rest has two fixed horizontal positions, designated A and B.

The wooden pointer is positioned directly in the midline of the Pancentric, centering the head holder by rotating the pointer downward and aligning it with the midline on the chin rest. Lines on the nasion rest and wooden pointer attachments, which rotate in the horizontal plane, are registered against a millimeter rule on the front of the vertical column (Fig. 2).

Round ear rods are attached to horizontal blocks, each of which has a spirit level fixed to the upper surface (Fig. 3). Slots in these blocks enable them to slide anteroposteriorly along bolts attached to the zygomatic arch holders. The blocks may be bolted in three different fixed vertical positions, designated RE1, RE2, RE3, and LE1, LE2 and LE3.

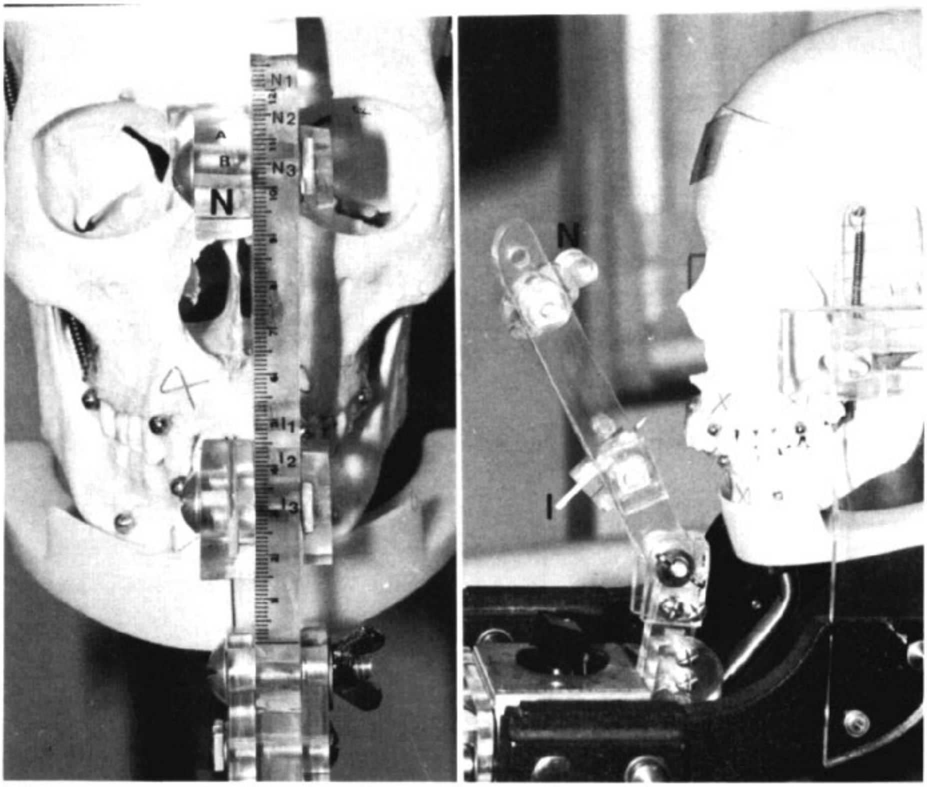

Fig. 2
left, **Front view, showing the vertical column in place with the nasion rest N in position. The nasion rest position is recorded from calibrations N1, N2, N3, and the position of the wooden pointer from I1, I2, and I3. The wooden pointer is aligned with the scribed midline on the original chin rest for initial alignment, then rotated up to position the dental midline.**
right, **the vertical column is rotated away from the skull.**

Millimeter graduations are also placed at the back of the zygomatic arch holders and on the upper surfaces of the horizontal blocks.

Skull Study

Human subjects should not be exposed to radiation for experimental purposes (The South African Medical Research Council 1979); thus, for ethical and health reasons dry skulls were used in this study. Five intact adult human skulls were selected, ranging in size from small to large; inter-zygomatic arch widths ranged from 10.5–13.0cm (Fig. 4). Dentitions were complete, and the teeth occluded well.

Radiopaque Markers

Radiopaque markers were placed on the skulls to produce fixed reference points on the radiographs. The relationship of

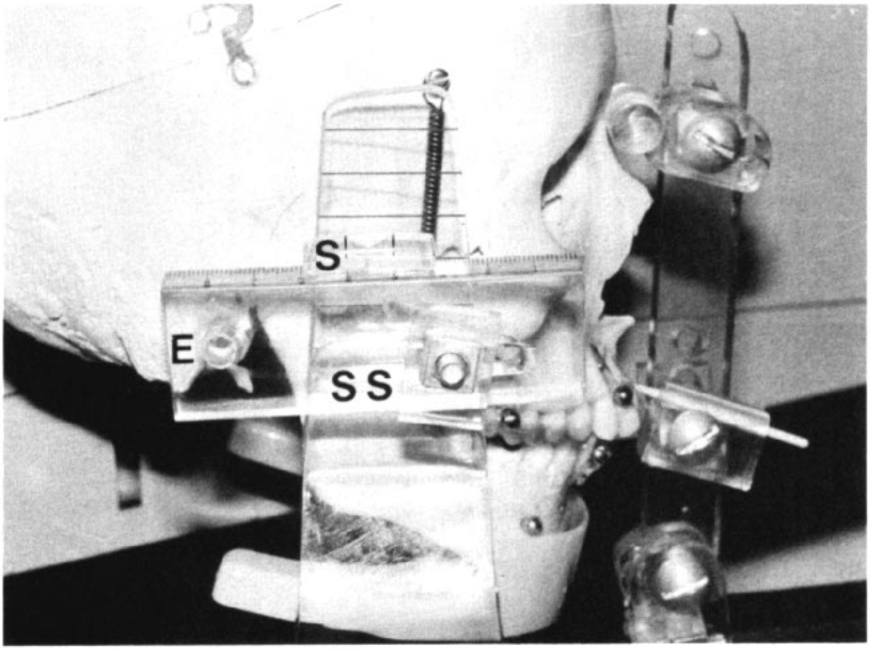

Fig. 3 Side of head holder showing horizontal block with ear rods E, slot for anteroposterior movement SS, and spirit level S.

Fig. 4 Skulls used in the study, showing the range in size.

these markers to other fixed points on the radiographs could then be measured to assess variation and reproducibility of the head position. Ten markers in the form of 1cm crosses were constructed of 0.020″ stainless steel wire. These markers were firmly fixed with clear adhesive tape in the following bilateral positions throughout the experiment (Fig. 5):

1 medial to the neck of the condyle,
2 medially at the gonial angle of the mandible,
3 on the front of the mandible near the apices of the roots of the cuspid and lateral incisor,
4 on the front of the maxilla near the apices of the roots of the cuspid and lateral incisor,
5 on the lateral surface of the maxilla between the root apices of the first and second molars.

The positions for the markers were arbitrarily selected within the areas that would be imaged on the film. Markers 1 and 2 were placed medially to be closer to the area of sharpest beam focus, which is a horse-shoe shape approximately 24mm wide that turns medially in the posterior region (Lund and Manson-Hing 1975).

The X-ray Cassette

The cassette was 12.7×30.5cm, flat, equipped with Dupont super Pan-o-Screen intensifying screens.

Standard cassettes allow some clearance between the film edges and the inner dimensions of the cassette. The internal dimensions of the experimental cassette were reduced to the exact film dimension with stops of acrylic sheet at the top and on the right side, so that film position would be consistent in all test exposures.

Vertical and horizontal reference lines were produced on the films by a rectangular grid design produced on the front intensifying screen with graphic arts transfer media. The grid rectangles were 1cm wide and 2cm high. The vertical lines were lettered A-Z and the horizontal lines numbered 1-6, using similar transfer lettering directly on the screen.

Since patient exposure was not a consideration, single-emulsion Kodak SB panoramic dental x-ray film was used.

Twenty radiographs were made of each of the five skulls, each labeled with the identifying letter of the skull and the exposure number on a radiopaque adhesive tape label placed on the outside of the cassette prior to exposure.

Radiographic Method

One hundred radiographs of the skulls were made in a random manner by preparing all of the radiopaque tape numbers in advance and drawing them from a box one at a time. As each label was drawn, the relevant skull was then placed in the head holder and a test exposure made.

The first time that each skull was placed in the head holder, the nasion rest, wooden pointer, and ear rods were adjusted to fit that skull and their positions recorded. The wooden pointer was placed between the upper central incisors at the alveolar margin. The ear-rod attachments were adjusted to a horizontal position by reference to the spirit level bubble.

For human subjects, the chin rest scale and horizontal arm scale are adjusted to correspond. For the skull radiographs, the chin rest scale was placed on line 4, while the horizontal arm holding the tube head and the cassette was indexed on line 3½, two notches lower than that of the chin rest. This was to allow for the absence of soft tissue on the dry skulls.

On the Panorex model used for these tests, the exposure time and milliamperage are fixed, and the kilovoltage is adjustable from 54 to 90. All skull exposures were made at 54 kilovolts.

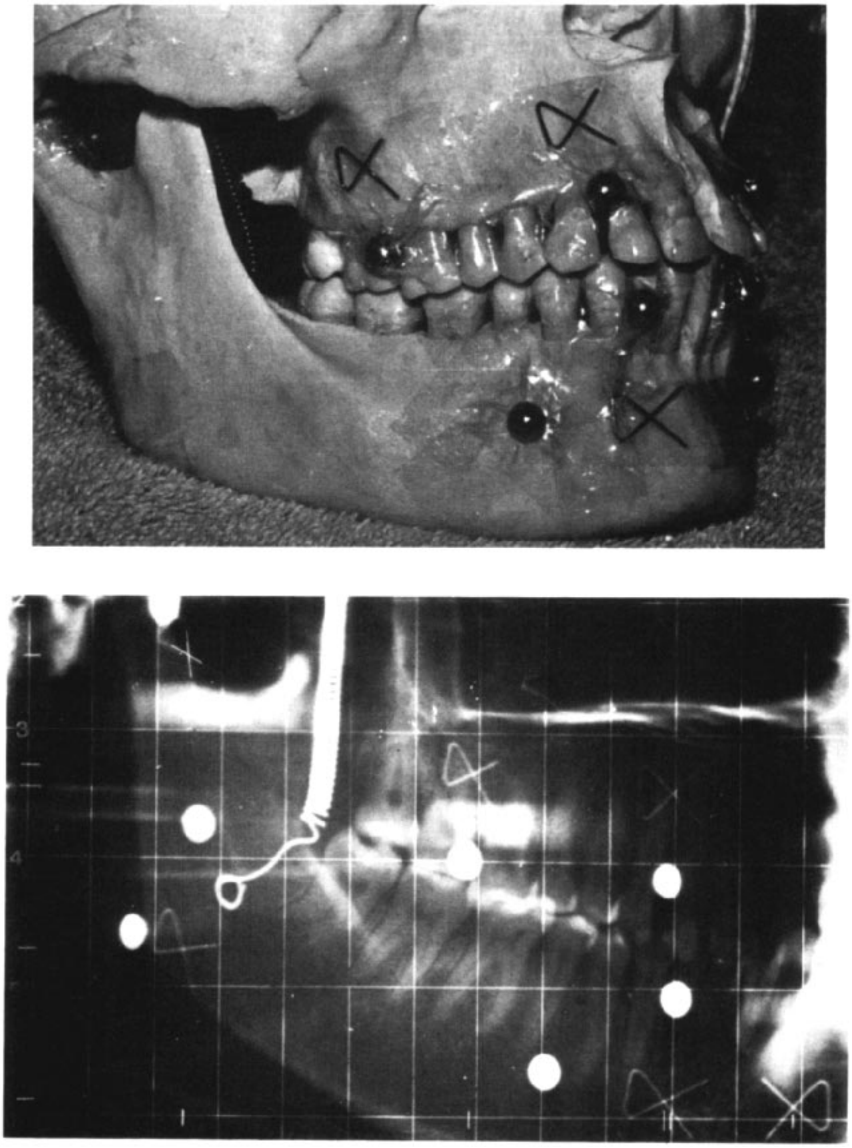

Fig. 5 Skull and resulting radiograph, showing wire cross markers fixed with clear adhesive tape. Ball bearings were placed for a separate study of landmark distortion.

Radiograph also shows reference grid image from lines on intensifying screen, and scratch marks on line A (vertical line on the left), and line 6 (lowest horizontal line), used for measurement.

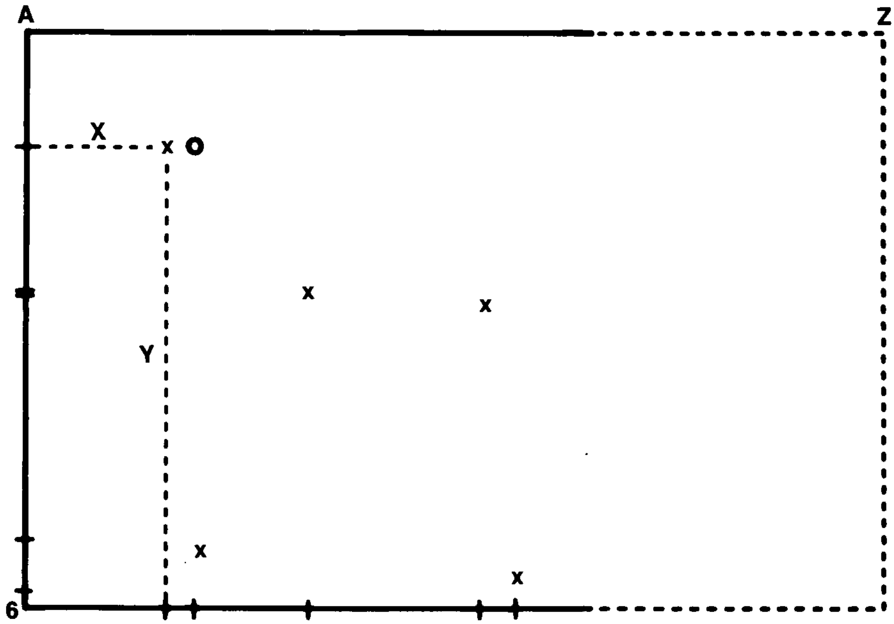

Fig. 6 **Diagram of radiograph showing vertical lines A and Z, and horizontal line 6, and the X and Y axis coordinates used in this study.**

X-ray Film Processing

Each exposed film was removed from the cassette in a darkroom and stored in a light-proof box. On completion of the 100 exposures, the films were tank processed by hand in batches of four, using a specially constructed frame, in standard chemicals.

Preparation of Processed Radiographs for Measurement

The processed films were placed on a light box and the X and Y coordinate positions of each cross-marker at vertical lines A and Z and horizontal line 6 were determined with a square and scratched on the emulsion side of the film with a sharp needle (Fig. 6).

The films were shuffled, recoded, and measurements made to the 10 cross markers with an electronic digitizer with 0.1mm precision (MOP Digiplan Image Analyzing System, Kontron Messgeräte).

— Results —

Statistical analysis utilized a three-way analysis of variance with radiographs and marker positions crossed and both nested within skulls (Dixon and Brown 1981). All three factors were considered as random effects.

Intra-examiner variation was assessed by remeasuring 5 markers for 20 radiographs. No statistically significant differences were found using Student's t-test for related samples.

The means and standard deviations were calculated for the 20 readings of each X and Y coordinate value for the 5 markers on each skull. The standard deviations are small (Table 2) indicating a high degree of precision.

For the X coordinate measurements, the analysis showed no significant variation from radiograph to radiograph. For the Y coordinate measurements there was a significant variation from radiograph to radiograph ($p < 0.001$).

— Discussion —

Adequate evidence has not been available to demonstrate that patients' heads could be repositioned in any of the earlier head holders described previously with sufficient accuracy to provide radiographs suitable for research studies. The present study addresses that question within the bounds of ethical experimentation, recognizing that skulls eliminate some of the variables imposed by soft tissue that would degrade the accuracy in clinical practice.

The significant variation found for the Y coordinates was not expected, and contrasts the lack of significant variation for X coordinate measurements. Two possible explanations might be considered. It is possible that the head holder allows more accurate repositioning in the horizontal than in the vertical plane. It is also possible that distortion on the radiograph may be greater in the vertical plane than in the horizontal plane.

The latter explanation is supported by two observations. First, the estimated standard deviation for X coordinate measurements between radiographs is zero, while the 5.4mm value for Y coordinates indicates greater variation in the vertical plane. Second, images of ball bearings which had been placed on the skulls at the same time as the cross-markers for a future study of distortion on the radiographs showed distortion in the vertical plane. This is in agreement with similar findings regarding vertical distortion on Panorex (Christen and Segrest 1968) and Panelipse (Alpern 1979) radiographs.

A further consideration is the fact that panoramic radiographs are unique in that only the vertical dimension is affected by the radiographic projection factors common to conventional radiographs. The horizontal distortion is unaffected by those factors, but caused instead by the mechanical movements of the machine.

Although the experimental results in this investigation have been obtained by repositioning of skulls in the head holder, the facial soft tissues should not preclude the accurate application of this head holder for human subjects.

We are most grateful for the expert typing of Mrs. Ruth Norman.

Table 2

Range of Standard Deviations
millimeters

	Horizontal S.D.	Vertical S.D.
Highest	1.64mm	1.04mm
Lowest	0.30mm	0.37mm

REFERENCES

Alpern, M. C. 1979. Analysis of panoramic cephalometrics using a skeletal cephalostat. *Angle Orthod.* 49:110-120.

Dixon, W. J., Brown, M. B. 1981. *BDMP. Biomedical computer programmes* Berkeley, University of California Press.

Christen, A. G. and Segrest, V. A. 1968. Distortion and artefacts encountered in Panorex radiography. *J. Am. Dent. Assoc.* 77:1096-1101.

Kane, E. G. 1967. A cephalostat for panoramic radiography. *Angle. Orthod.* 37:325-333.

Kite, D. W. et al. 1962. Radiation and image distortion in the panorex x-ray unit. *Oral Surg.* 15:1201-1210.

Lund, T. M. and Manson-Hing, L. R. 1975. A study of the focal troughs of three panoramic dental x-ray machines. *Oral Surg.* 39:318-328.

Richardson, J. E., Langland, O. E. and Sippy, F. H. 1969. A cephalostat for the orthopantomograph. *Oral Surg.* 27:642-646.

Rosenberg, H. M. and Law, D. B. 1972. Panoramic radiography in dental arch space analysis. *J. Dent. Child.* 39:125-129.

Ryan, J. B., Rosenberg, H. M. and Law, D. B. 1973. Evaluation of head positioner for panoramic radiography. *J. Dent. Child.* 40:97-102.

The South African Medical Research Council 1979. *A guide to ethical considerations in medical research.* Compiled by Dr. J. de V. Lochner 32.

Zach, G. A., Langland, O. E. and Sippy, F. H. 1969. The use of the orthopantomograph in longitudinal studies. *Angle Orthod.* 39:42-50.