A Cephalostat for Small Animals

YEHYA A. MOSTAFA AND ARMAND P. CARIAN

A technique and device for cephalometric radiography of animals as small as the mouse are described. Removable earposts are used, so there is no obstruction of the image of anatomical structures. Dental film packets provide maximum detail.

Dr. Mostafa is a dental graduate (B.D.S.) of the Cairo University Faculty of Dental Medicine, and holds an M.S. degree in Orthodontics from Marquette University.

Mr. Carian is supervisor of dental equipment maintenance at Marquette University School of Dentistry.

Address:

Dr. Yehya A. Mostafa
Marquette University
School of Dentistry
604 North Sixteenth St.
Milwaukee, WI 53233

This work was supported in part by the Kroc Foundation. The authors also acknowledge with gratitude the help and advice of Dr. Ralph A. Meyer, Jr.

Knowledge concerning craniofacial growth has been derived principally from cross-sectional and longitudinal studies. In 1941 Brodie[1] reported on the growth of the human male skull from the third month to the eighth year of life based on cephalometric radiography. This investigation has been followed by similar studies of the craniofacial development of nonhuman primates.[2,3]

Most of these studies have been done on monkeys. Monkeys are considered to be ideal experimental animal models for craniofacial studies because of their similarity to man.[6] However, they are becoming increasingly expensive to work with. The use of rats and rabbits in craniofacial studies is becoming more popular.[4,5,7,8] They offer ready availability, lower cost, and a life span that is relatively short with comparably rapid development.

Inherited craniofacial abnormalities have been recently discovered in several species of small mammals.[9] These experimental animal models open the door for a new era in the study of craniofacial anomalies in which the factors responsible for anomalous

growth can be studied and the requirements for a normal physiologic growth accounted for.

Longitudinal craniofacial growth studies in these animals require a simple and precise cephalostat. Soon after Broadbent[10] developed the first radiographic cephalometric device for human use, Spence[11] applied the technique to animal studies. Our purpose was to develop a cephalostat to provide improved precision for use in small animal studies.

Materials and Methods

X-Ray Apparatus:

A standard dental x-ray tube-head is clamped into a fixed position in a custom-made frame. The open-end cylindrical collimator of the x-ray housing is aligned with a lead frame secondary collimator with a 1 cm × 1 cm square opening to limit the x-ray beam to the area of interest. The target-film distance is fixed at 152.4 cm (5 feet).

Head-holding Apparatus:

A special apparatus holds the head of the animal in a firm and constant position so that the radiographs taken at various times will be comparable (Fig. 1). Ear rods are aligned with the x-ray beam. The animals are anesthetized using Nembutal, administered intra-peritoneally, and placed in

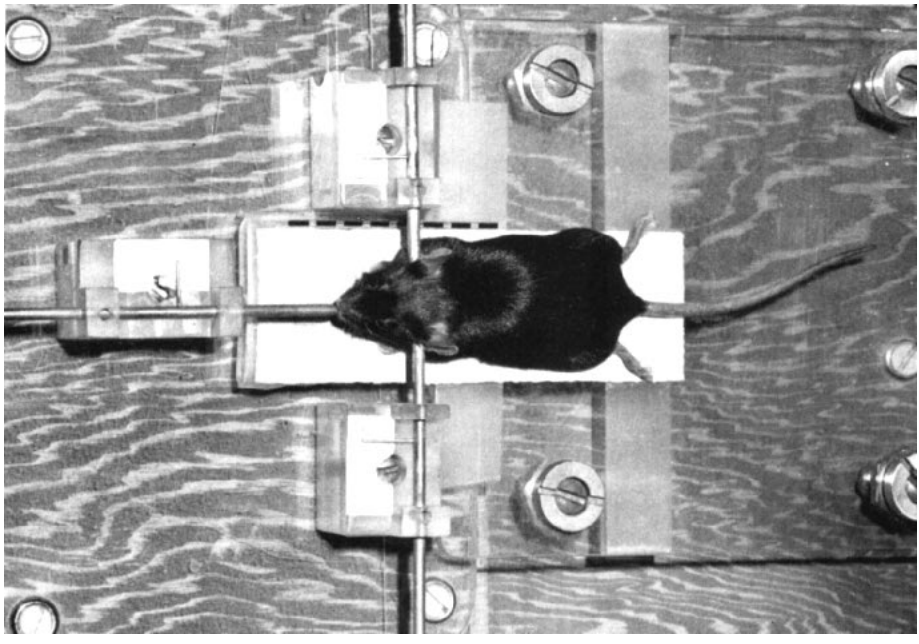

Fig. 1 Top view of cephalostat with a mouse in position but earposts not yet removed for film insertion and exposure. The dashed line indicates the slot for holding the dental film packet. The four slotted screws in the animal support plate provide vertical adjustment. The pointer projecting over the white scale from each earpost and from the sagittal stabilizing rod facilitates centering and repositioning.

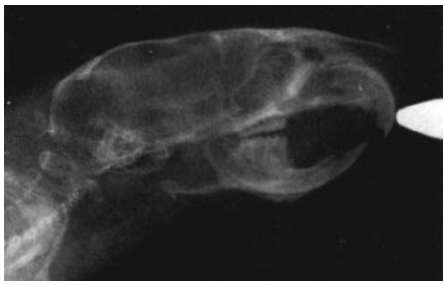

Fig. 2 Lateral radiograph of the head of a mouse.

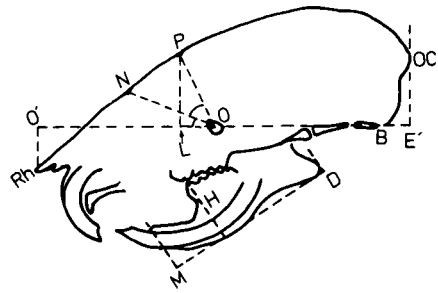

Fig. 3 Tracing showing landmarks for linear and angular measurements in mouse or rat.

the cradle. Elevation screws are adjusted until the external auditory meati are at the same height as the ear rods. The head is oriented by the movable ear rods, which are withdrawn for the film exposure.

An incisal pin is placed between the upper central incisors and remains in position during the exposure. The incisal pin is located so that its long axis is perpendicular to the axis of the ear rods. Both ear rods are calibrated so that the midsaggittal plane can be standardized. A line projected from the incisal pin intersects the ear rod axis midway between the ear rods.

The x-ray film is standard dental periapical film. A groove in the cradle holding the body of the animal holds the x-ray film. The cradle itself is made of clear plastic and is adjustable vertically to accommodate different size animals. The different components are mounted on an acrylic sheet fixed to a horizontal wooden platform.

Precision of the Apparatus:

The precision of the apparatus was determined by comparing the measurements obtained from a series of ten lateral radiographs of a single mouse. The animal was anesthesized, positioned in the head-holding device for a lateral view as described above, one film exposed, and the animal completely removed from the apparatus. This was repeated until 10 radiographs had been exposed.

Standardized enlarged (17×) prints (Fig. 2) were made of all ten radiographs. These were traced and the following points identified; basion (B), nasion (N), rhinion (Rh), the center of the optic foramen (O), the most posterior point on the frontal bone (P) and the most posterior point on the occipital bone (OC) (Fig. 3).

A line drawn between point (O) and point (B) was used as a base line, with perpendicular lines extended from the different cranial points to this base line. The following linear and angular measurements were constructed and measured; O'E', PL, NO/O'P', NO/OP. A tangent to the lower border of the mandible (mandibular plane) was used as a reference plane for mandibular measurements MD and H. All linear measurements were recorded to the nearest 0.5 mm on the enlargement (about 0.02 mm actual size). Angular measurements were recorded to the nearest one-half degree. The mean values, standard error, standard deviation and the coefficient of variation of each group of ten measurements were calculated.[12]

TABLE 1

Measurements from Tracings of Ten Enlarged Cephalometric Radiographs of a mouse (17 ×)

	Mean	Standard error	Standard deviation	Coefficient of variation
		Linear Measurements (cm.)		
O'E'	11.1	0.11	0.34	3.10
PL	2.19	0.02	0.06	2.81
MD	5.5	0.06	0.18	3.20
H	2.3	0.02	0.09	3.40
		Angular Measurements (degrees)		
NO/OO'	28.7	0.50	1.57	5.46
NO/OP	39	0.28	0.88	2.25

Results

From Table I, a small standard error is seen in the groups of linear and angular measurements recorded from the ten trial cephalogram tracings. The coefficient of variation was less than 4 percent in all the measurements, except for NO/OO' where it was 5.46. This small percentage includes variation in animal positioning, enlargement and variation in anatomical landmark identification.

Discussion

The main problem encountered with the construction and use of any cephalostat is the accurate positioning and stabilization of the head during radiography. A method involving the implantation of radiographic markers for the alignment of monkeys' heads by means of fluoroscopy prior to exposure of the cephalogram has been reported.[13] Ness and associates have described a technique utilizing a modified cephalostat which is coupled to a surgically implanted rod protruding from the frontal area of monkey skulls.[14] This technique requires extensive surgical manipulation which small mammals may not be able to survive. Spence[11] has described a cephalostat designed to study the skull development of the living rat. A simple positioning device differing from conventional cephalostat orientation has also been used for serial ventrodorsal view radiographs of rabbit heads.[15]

The cephalostat constructed in this study was designed so that it can accommodate a wide range of animal sizes. This was accomplished by the adjustability of the clear plastic movable cradle. Careful attention was given to drawbacks seen in previous designs. The presence of two lateral ear rods and one incisal pin assures accurate positioning of the mid-sagittal plane perpendicular to the central x-ray beam. The fixed x-ray source-film distance (5 feet) standardizes enlargement.[16] It is to be noted that this is the first cephalostat which can be used for the study of craniofacial development in mammals as small as mice.

REFERENCES

1. Brodie, A. G.: On the growth pattern of the human head from the third month to the eighth year of life. Am. J. Anat., 68:209-262, 1941.
2. Gans, B. J. and Sarnat, B. G.: Sutural facial growth of the Macaca rhesus monkey: A gross and serial roentgenographic study by means of metallic implants. Am. J. Orthod., 37:827-841, 1951.
3. Elgoyhan, J. C., Riolo, M. L., Graber, L. W., Moyers, R. E. and McNamara, J. A., Jr.: Craniofacial growth in Juvenile Macaca mulatta: A cephalometric study. Am. J. Phys. Anthrop., 36:369-376, 1972.
4. Selman, A. J. and Sarnat, B. G.: Sutural bone growth of the rabbit snout: a gross and serial roentgenographic study by means of metallic implants. Am. J. Anat. 97:395-408, 1955.
5. Sarnat, B. G.: The face and jaws after surgical experimentation with the septovomeral region in growing and adult rabbits. Acta Otolaryng. 258 (Suppl): 1-30, 1970.
6. Enlow, D. H.: The Human Face, pp. 168-193, Hoeber Medical Division Harper and Row, Publishers, New York, 1968.
7. Kvinnsland, S.: Autogenous transplantation of the nasal septum cartilage in the rat. Arch. Oral Biol. 19:767-770, 1974.
8. Moss, M. L., Meehan, M. A. and Salentijn, L.: Transformative and translative growth processes in neurocranial development of rat. Acta Anat. 81:161-182, 1972.
9. Wolfe, H. G. and Coleman, D. L.: Pigmentation, In: Biology of the Laboratory Mouse. 2nd ed., pp. 405-425. McGraw-Hill, New York, 1966.
10. Broadbent, B. H.: Bolton Standards and technique in orthodontic practice. Angle Orthodont., 7:209-233, 1937.
11. Spence, J. M.: Method of studying the skull development of the living rat by serial cephalometric roentgenograms. Angle Orthod. 10:127-139, 1940.
12. Zar, H. H.: Biostatistical Analysis, Prentice-Hall, Inc. Englewood Cliffs, N.Y., 1974.
13. Henry, H. L. and Cleall, J. F.: Radiographic cephalometric method of assessment of craniofacial growth in monkeys. J. Dent. Res., 53:369-374, 1974.
14. Ness, A. L. V., Merrill, O. M. and Hansel, J. R.: Cephalometric roentgenography for non-human primates utilizing a surgically implanted head positioner. Am. J. Phys. Anthrop., 43:141-147, 1975.
15. Selman, A. J. and Sarnat, B. G.: A head holder for serial roentgenography of the rabbit skull. Anat. Rec. 115:627-634, 1953.
16. Thurow, R. C.: Atlas of orthodontic principles. 2nd ed., p. 159, St. Louis, C. V. Mosby, 1977.