The Influence of Environment on the Growth of the Craniofacial Complex—A Study on Domestication

MAURICE MCKEOWN, D.Orth. R.C.S. (Eng.), Ph.D.

The relative role of genetic and environmental factors in skull growth has long been the subject of major controversy. It has often been said that domestication causes cranial deformation and this is usually attributed to environmental factors such as nutrition.[2] Studies on general body growth in many species including man have revealed that the organism is capable of substantial response to environmental variability.[8] There have, however, been very few studies on skull growth in man or animals which attempt to assess the nature and magnitude of these general influences. Jeffries[4] has shown that altered litter size in rats and, presumably, nutritional plane, alter growth rates. McCance *et al.*[6] have demonstrated that severe undernutrition in pigs can result in major retardation of skull growth. Environmental influences on adult form however remain uncertain. Some attempts have been made using twin comparisons to quantify environmental effects in man.[3,5] The results are statistical in nature and cannot be applied to the individual for useful clinical prognosis. Laboratory experiments on animals have the serious drawback that they study the influence of altering one or more factors under highly artificial circumstances. The human patient is subject to a wide spectrum of influences through growth. For many well-known reasons it is very difficult to study the general influence of environment on the growing human skull. Thus an animal species living in both wild and domestic environments was chosen for examination.

This investigation will compare the adult skulls of groups of foxes living in wild and domestic conditions in an attempt to assess the influence of the altered environmental circumstances.

MATERIALS AND METHODS

A study was made of the large collection of foxes held by the Royal Ontario Museum, Toronto, and a fur farm group of 265 adults from eight farms in central and eastern Canada.

Fifty adults were chosen without bias from the large collection of wild foxes. All these skulls were clinically examined. Dental formula, the incidence of tooth crowding, caries, calculus deposits, periodontal bone loss and any other pathology was recorded. The incisor tooth relationship was also noted.

Accurate photographic records were then made on the 50 wild foxes and 100 fur farm animals. The latter group contained all those found to have crowding among the original group of 265, as it was considered essential for studies being carried out on the cause of crowding.

The photographic technique, photocephalometry, records the dry skull held in a specially built cephalostat in various orientations at right angles to one another. Records are taken using a single lens reflex camera with 400 mm telephoto lens placed 6 metres from the skull. The resulting negatives are printed on dimensionally accurate photographic paper.

ANALYSIS

The analysis of the 90° basilar photograph of the skull (without mandible) is presented here. A series of points, precisely defined, was derived (Fig. 1). A strip chart digitiser linked

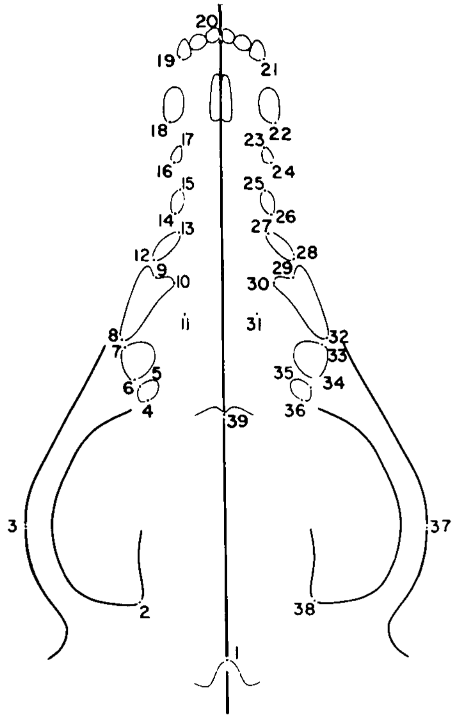

Fig. 1 Showing the anatomical points plotted (in sequence) on the fox skull.

to an IBM printing card punch was used to record in sequence the points in Figure 1. A computer program[1] then supplied any required intersite distances or angles.

The size of each tooth, the angular shape of the dental arch and the orientation of the teeth to the centre plane of the palate (the midline suture) was recorded. For example, the orientation of the fourth premolar was defined as the angle between the extension of the line joining 8-9 and the midpalatal line 39-20.

Studies on general skull growth have shown that the skull grows in a series of precisely definable curvatures.[7] The growth of two points A and B occurs in the general direction of the arrows until cessation at adulthood (Fig. 2). Adult positions for each point are represented by each individual dot. The intercondylar axis and the left external

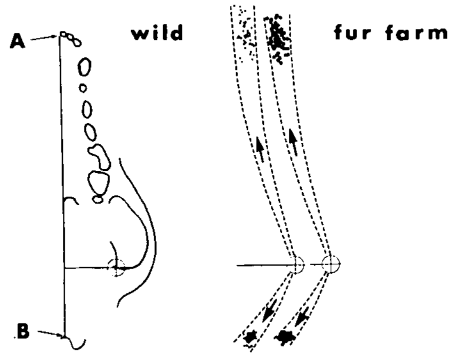

Fig. 2 Showing the anatomical points chosen, and their distribution in the two groups of *adult* foxes.

condylar point are used for registration.

Results

General Skull Examination

Variation in dental formula was assessed. The dental formula of the fox is $\left(\frac{I_3\ C_1\ P_4\ M_2}{I_3\ C_1\ P_4\ M_3}\right)$. No extra teeth were observed in the wild foxes. Four fur farm animals had extra teeth, all premolars. Missing teeth were observed in 18% of the wild and in 23% of the farm foxes. Among the wild group four had missing lower third molars bilaterally, four missing on the left side only and one on the right. In the farm animals thirty-seven had missing lower third molars bilaterally, fourteen the left side only and three on the right. Five animals had no first premolar and three showed absence of a lower left second molar.

Tooth crowding (defined as insufficient space to accommodate the mesiodistal diameter of the tooth in question) was present in 6% of wild and 3.4% of fur farm foxes. No dental caries was recorded. Calculus deposits were of negligible amount in wild animals but often extensive in the farm animals. Periodontal bone loss was rare in wild animals and more common in the farm animals although it did not appear to be related to the degree of calculus deposition. No gross bone pathology was observed in either group. Jaw relationship was examined in all the fox skulls in the museum. Only one animal, a wild fox, exhibited a substantial lower jaw protrusion. Variations in jaw relationship were so infrequent and limited in magnitude that no precise measurement analysis was considered useful. In the wild fox group of 50, 18 did not have contact between upper and lower central incisors in centric occlusion, 17 were very mild Class II type and one a mild Class III. The discrepancy was never more than 2 mm anteroposteriorly. Among the 265 farm animals only 10 failed to have incisor contact and these were all very mild Class II types with a similar discrepancy of only 1-2 mm.

Overall Skull Form

This was recorded using the intercondylar axis and condyle registration point. The distribution of each group for points A and B is shown in Figure 2. It can be seen that the region occupied by each is similar with a slight tendency for the farm animals to be smaller. The skulls of the two groups could not be differentiated from one another on visual examination.

Dental Arch Analysis

Arch shape as defined by the angles (8-20-32-20) and (18-20-22-20) is recorded in Table I. The means for each group are almost identical and the standard deviations particularly for angle I are remarkably small and similar.

Tooth Variations

Measures of the incidence of tooth crowding do not give an accuate indication of variation in angular orientation of each tooth (Fig. 1 and Table I). This was calculated for all upper teeth, except the second molar, as error tests showed that the error on that tooth was substantial.

It can be seen that the two groups are generally similar although P_1 shows some variation in mean values. The standard deviations are small particularly when compared with animals such as domestic dogs.

TABLE I

Arch Shape

Angle I (8-20-32-20)	*Fur Farm*	*Wild*
Mean	38.67	37.62
S D	1.85	1.71

Angle II (18-20-22-20)	*Fur Farm*	*Wild*
Mean	62.84	62.52
S D	4.02	3.58

Tooth Orientation to Centre Plane (Degrees)

		Fur Farm *Right*	Fur Farm *Left*	Wild *Right*	Wild *Left*
M 1	Mean	8.99	11.99	12.55	13.19
	S D	4.22	4.05	3.44	3.33
P 4	Mean	24.53	26.56	24.56	26.27
	S D	2.55	2.55	2.91	2.43
P 3	Mean	33.76	31.32	31.45	29.65
	S D	4.30	5.90	4.03	4.41
P 2	Mean	15.97	13.10	15.56	15.35
	S D	6.32	6.55	5.71	4.96
P 1	Mean	33.06	25.55	24.99	22.55
	S D	8.37	6.80	10.43	7.17

Points used to derive the above tooth angles (see Fig. 1)

M 1 = 7-6/20-39
P 4 = 8-9/39-20
P 3 = 12-13/39-20
P 2 = 14-15/39-20
P 1 = 16-17/39-20

Linear Tooth Size

The mean mesiodistal diameters and their standard deviations for each upper tooth were calculated and found to correspond very closely in the two groups indicating a close similarity in tooth size.

Discussion

The results show that both groups are very similar with respect to general skull form, arch and tooth dimension, and tooth orientation.

There is no indication that tooth crowding is more common in domestic foxes, nor do they have a higher incidence of jaw disproportion. There are differences in the incidence of calculus deposits and periodontal bone loss suggesting dietary differences. There is a higher incidence of departure from the usual dental formula in the farm animals. Variation generally is confined to certain teeth, particularly lower third molars. The data from the wild population compare favourably with data from other wild fox populations presently being investigated by the author. The lack of variation in the farm animals is in marked contrast to the extensive variability recorded in domestic dogs.[7] The problem with the type of comparison made in this study is that the genetic relationship and variability of each group is largely unknown. However, if there were a measurable environmental contribution to abnormality in teeth and jaws brought about in domestic conditions, it should have registered as a difference between the groups.

There appears therefore to be no justification for the commonly held contention that domestic conditions invariably lead to an increased incidence of dental and skeletal abnormalities. It also suggests that environmental factors can only have a limited influence on adult skull form in the fox.

Department of Orthodontics
College of Dentistry
University of Saskatchewan
Saskatoon, Saskatchewan

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