Original article

Non metric traits of the skull and their role in anthropological studies

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Abstract

Anthropological and paleoanthropological studies concerning the so called epigenetic cranial traits or non-metrical cranial traits have been increasing in frequency in last ten years. For this type of study, the trait should be genetically determined, vary in frequency between different populations and should not show age, sex and side dependency. The present study was conducted on hundred dry adult human skulls from Northern India. They were sexed and classified into groups of various non metrical traits. These traits were further studied for sexual and side dimorphism. None of the traits had shown statistically significant side dimorphism. Two of them (Parietal foramen and Exsutural mastoid foramen) however had shown statistically significant sexual dimorphism. Since the dimorphism is exhibited by very less number of traits, it can be postulated that these traits are predominantly under genetic control and can be effectively used for population studies.

Keywords: double hypoglossal canal, epigenetic variants, non-metric cranial variants, supraorbital foramen, zygomaticofacial foramen.

1 Introduction

Anthropological and paleoanthropological studies concerned with the epigenetic traits or non-metrical cranial traits have been increasing in frequency in the last ten years. Analysis of non-metrical traits remains an important approach to the tracing of genetic relationships among ancient populations as they permit the measurement of biological distances between past populations. They can also be used for the assessment of the existence of parental structures within a community or as taxonomic indicators.

These non-metrical cranial traits can be effectively used as anthropological characters (CHAMBELLAN, 1883 apud DORSEY, 1983). They play an important role in population studies (WOOD–JONES, 1931). This idea was put into practice (LAUGHLIN and JORGENSEN, 1956). Further some viewers gave the opinion that these variants could be used to calculate a distance statistics between population samples (BERRY and BERRY, 1967).

The employment of discontinues traits in anthropology has certainly been spurred by their apparent ease of scoring and the fact that they are genetically determined, even though partly under environmental control.

The aim of this study is to present the frequency of various non-metrical cranial variants in adult human skulls and to investigate side and sexual dimorphisms for these traits. Further it was concluded whether these traits could be used effectively for population studies.

2 Material and methods

Hundred dry adult human skulls from Northern India, having no deformity or fracture were examined. The skulls were sexed and classified into groups of various non metrical traits.

Sexing of the skulls was done by assessing the contour of the supraorbital margin. A large piece of plasticine was pressed onto the supraorbital margin to produce an impression of its contour. The plasticine was removed carefully so as not to distort it. These were cut vertically and the shape was assessed in cross section. The impression was classified on a seven grade scale as given by previous observer (GRAW, CZARNETZKI and HAFFNER, 1999) as follows:

- 1, 2, 3 = Trough shaped profile suggestive of male;
- 5, 6, 7 = Angulation of inner aspect suggestive of female;
- 1 = Definite male;
- 4 = Uncertain;
- 7 = Definite female.

The accuracy of identification of sex using this method was found to be 70%. After sexing the skulls were looked for the presence or absence of various non-metrical traits (grouped as follows).

2.1 Variants related to foramina of nerves and vessels

- Supraorbital foramen (Figure 1);
- Supraorbital notch (Figure 2);
- Frontal Foramen;

- Frontal notch;
- Zygomaticofacial foramen (Figure 3);
- Double hypoglossal canal (Figure 4).

2.2 Variants related to the foramina of blood vessels

- Parietal foramen (Figure 5);
- Absence of mastoid foramen (Figure 7);
- Exsutural mastoid foramen (Figure 8);
- Patent condylar canal(Figure 6).

Each trait was noted for its presence or absence in male, female and uncertain skulls separately. Variants occurring bilaterally were scored each time they occurred and also on right and left side separately to note side dimorphism (Tables 1 and 3). Sexual dimorphism for the variants was observed (Tables 2 and 4). The results obtained were subjected to the Chi- square test to note the dimorphisms if present were statistically significant (Tables 5 and 6).

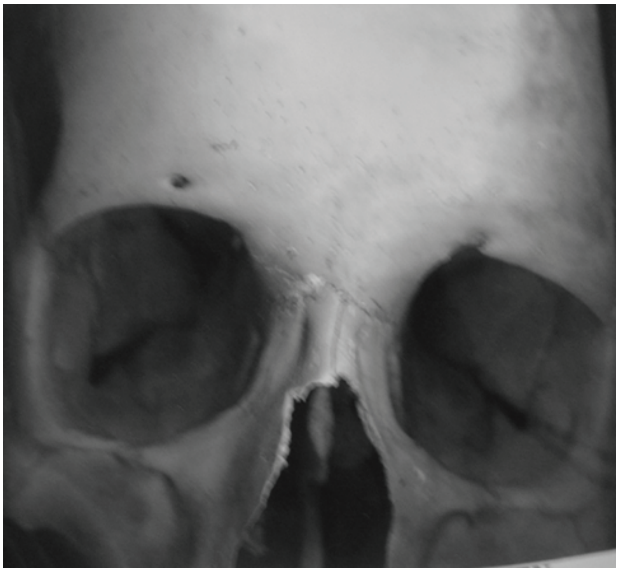

Figure 1. Supraorbital foramen (Right side).

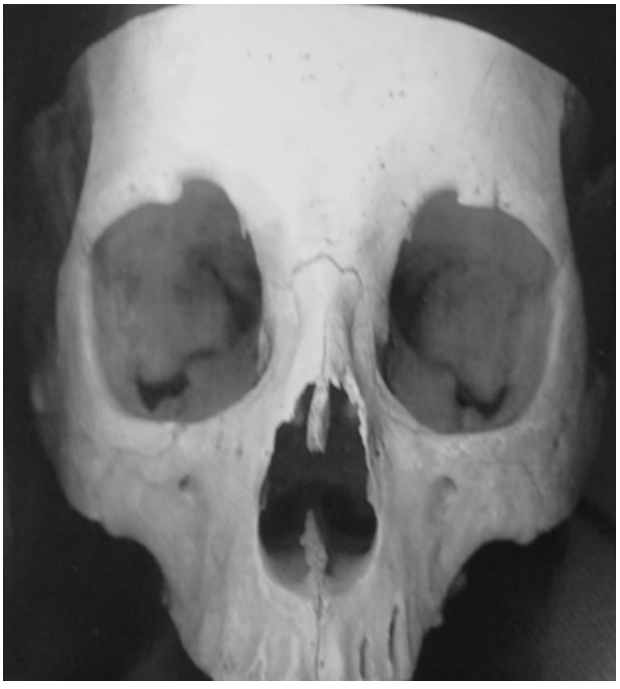

Figure 2. Supraorbital notch (Both sides).

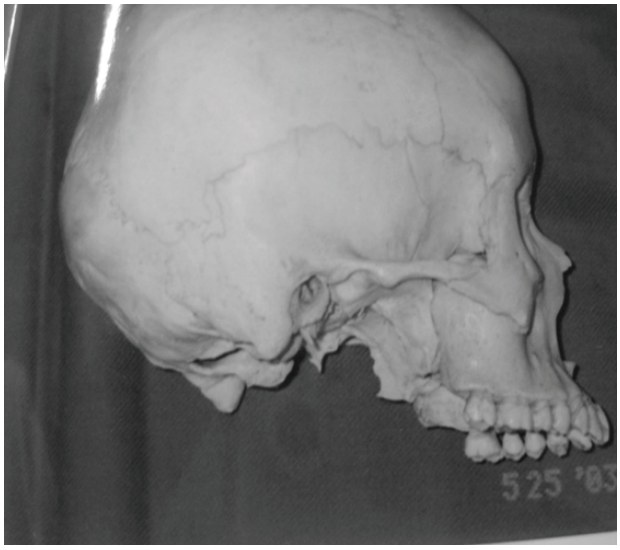

Figure 3. Double Zygomaticofacial foramen (Left side).

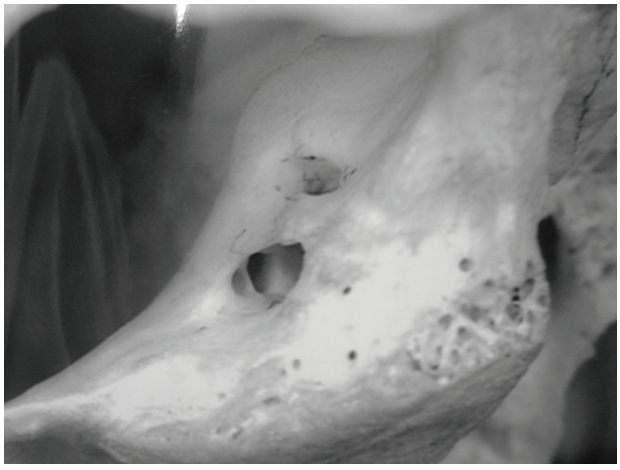

Figure 4. Double hypoglossal canal (Left side).

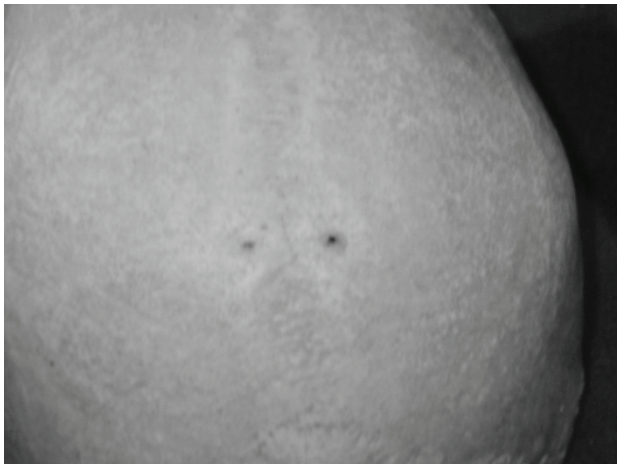

Figure 5. Parietal foramen (Both sides).

Table 1. Incidence of variants related to the foramina of nerves and vessels.

Cranial traits	Male (UL) Rt (57)	Male (UL) Lt (57)	Male (BL) (114)	Female (UL) Rt (33)	Female (UL) Lt (33)	Female (BL) (66)	Uncertain RT (10)	Uncertain LT (10)	Uncertain BL (20)
	n %	n %	n %	n %	n %	n %	n %	n %	n %
Supraorbital foramen	6 10.5	6 10.5	30 26.3	6 18.2	4 12.2	20 30.3	1 10	1 10	10 50
Supraorbital notch	4 7	6 10.5	50 43.9	3 9.1	7 21.2	30 45.5	0 0	1 10	8 40
Frontal foramen	2 3.5	2 3.5	4 3.5	1 3	4 12.2	4 6.1	0 0	0 0	0 0
Frontal notch	1 1.75	1 1.75	0 0	0 0	1 3	0 0	0 0	0 0	0 0
Zygomaticofacial foramen	9 15.8	6 10.5	56 49.1	1 3	3 9	36 54.5	3 30	2 20	10 50
Double hypoglossal canal	2 3.5	4 7.0	6 5.3	2 6.1	2 6.1	2 3	1 10	0 0	2 10

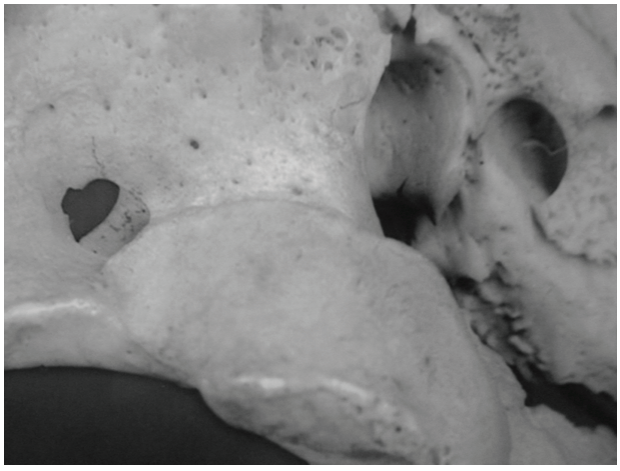

Figure 6. Patent condylar canal (Right side).

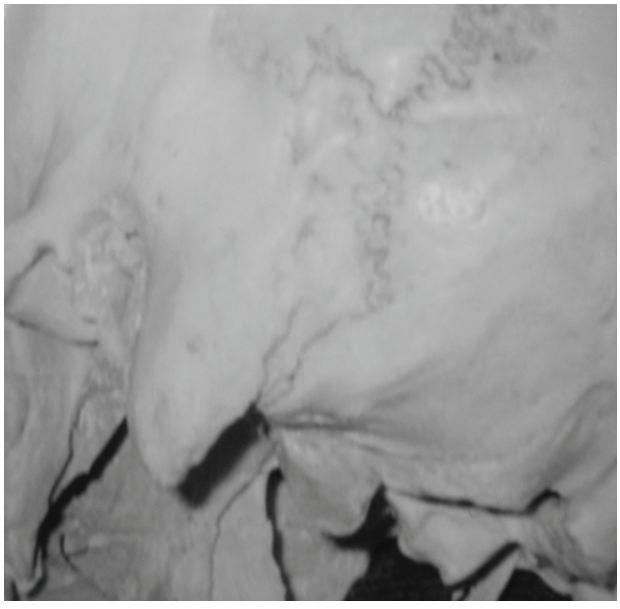

Figure 7. Absence of mastoid foramen (Left side).

3 Results

The different variants exhibited side and sexual dimorphisms as follows:

3.1 Variants related to the foramina of nerves and vessels

Side Dimorphism: Zygomaticofacial foramen had shown the highest incidence (60%), followed by Supraorbital notch (54%) and the Supraorbital foramen (44.5%). Frontal notch is found in only 1.5% of the skulls. Supraorbital foramen, Frontal foramen and Frontal notch showed no side dimorphism in males. Supraorbital notch had higher incidence on the left side and Zygomaticofacial foramen had shown preponderance for right side in males (Table 1) but these differences were not statistically significant (Table 5). Supraorbital notch, Frontal foramen and Zygomaticofacial foramen were more frequently found on left side in females (Table 1) but again these differences were not statistically significant (Table 5).

Sexual dimorphism: Supraorbital foramen, supraorbital notch and Frontal foramen had shown an affinity for females. However, these differences were not statistically significant (Table 6). Zygomaticofacial foramen, Frontal notch and Double hypoglossal canal had shown similar frequencies in both males and females (Table 2).

3.2 Variants related to foramina of blood vessels

Side Dimorphism: Exsutural mastoid foramen and Parietal foramen had shown high incidences of 58.5% and 51% respectively followed by Patent condylar canal, 42.5%. Parietal foramen and Patent condylar canal were more frequently seen on right side in males. Exsutural mastoid foramen was more frequent on left side (Table 3). But these side dimorphisms were not statistically significant (Table 5).

Sexual dimorphism: Parietal foramen was more frequently found in females (60.6%) when compared to the males, 45.6%.Exsutural mastoid foramen had shown, male preponderance (68.4%).These differences displaying sexual dimorphism were statistically significant ($p < 0.05$, Table 6).

Table 2. Sexual dimorphism of variants related to the foramina of nerves and vessels.

Cranial traits	Male (114)	Female (66)	Uncertain (20)	Total (200)
	n %	n %	n %	n %
Supraorbitalforamen	42 36.8	30 45.5	1260	84 42
Supraorbital notch	60 52.6	40 60.6	9 45	109 54.5
Frontal foramen	8 7.0	8 12.1	5 25	21 10.5
Frontal notch	2 1.6	1 1.5	0 0	3 1.5
Zygomaticofacial foramen	71 62.3	41 62.1	15 75	127 63.5
Double hypoglossal canal	12 10.5	6 9.1	3 15	21 10.5

Table 3. Incidence of variants related to the foramina of blood vessels.

Cranial traits	Male (U57)	Male (U57)	Male (B114)	Female (U 33)	Female (U 33)	Female (B 66)	Uncertain (U 10)	Uncertain (U 10)	Uncertain (B 20)
	RT n %	LT n %	n %	RT n %	LT n %	n %	RT n %	LT n %	n %
Parietal foramen	4 7	2 3.5	46 40.4	3 9.1	3 9.1	34 1.5	2 20	2 20	4 20
Absence of mastoid foramen	8 14	8 14	12 10.5	4 12.1	4 12.1	4 6	2 20	0 0	0 0
Exsutural mastoid foramen	6 10.5	1017.5	62 54.4	6 18.2	3 9.1	16 24.2	3 30	2 20	6 40
Patent condylar canal	1221.1	9 15.8	24 21.1	7 21.2	2 6.1	22 3.3	0 0	1 10	8 40

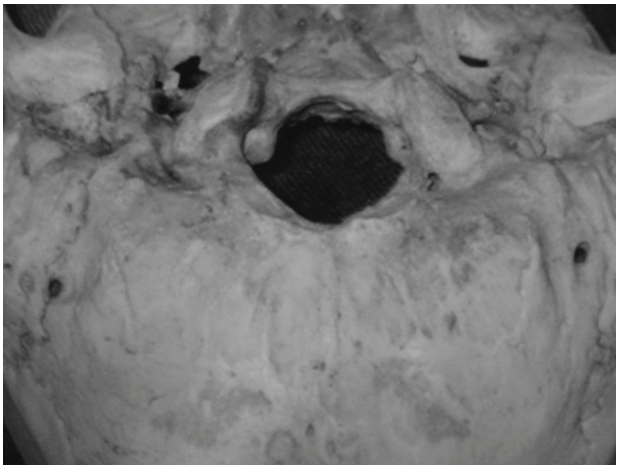

Figure 8. Exsutural mastoid foramen (Right side).

Table 4. Sexual dimorphism of variants related to the foramina of blood vessels.

Cranial traits	Male (114) n %	Female (66) n %	Uncertain (20) n %	Total (200) n %
Parietal foramen	52 45.6	40 60.6	10 50	102 51
Absence of mastoid foramen	28 24.4	12 18.2	2 10	42 21
Exsutural mastoid foramen	78 68.4	25 37.8	13 65	116 58
Patent condylar	45 39.5	31 47	9 45	85 42.5

4 Discussion

The non-metrical variants can be effectively used for anthropological studies only if they are under genetic control. Their usefulness as anthropological tools is markedly reduced if environmental factors significantly affect variant expression. It is desirable for population studies that the trait should be genetically determined, vary in frequency between populations and should not show age, sex and side dependency. Different investigators hold varied views in this regard.

These variants were named as quasi- continues after their laboratory studies in mouse (GRUENBERG, 1952).They are determined by two processes the underlying continues variables influenced by the action of a number of genes and the discontinuity imposed during different developmental processes. The second epigenetic component could be affected to some degree by non genetic influences such as parity or maternal physiology but this does not mean that these quasi-continues variants are not inherited entities (GRUENBERG, 1952). A variant may segregate in different members of a human family so as to mimic Mendelian inheritance, but these cases can be interpreted most easily as being due to a chance association of allelomorphs in that particular family. The developmental genetics of the variants in the mouse show that these traits are not determined by single gene loci. It is the incidence of a variant in a population that is a genetical character and not its segregation in a family.

Later on the studies were carried out on the inheritance of analogous variants in inbred strains of mice (GRUENBERG, 1963). It was summarized that these minor variants were under complex multigenic control. In humans suitable experiments to elucidate the degree of genetic control are impossible. But as the human variants are morphologically analogous to the variants in mice, the genetic background of these variants in humans is also strongly supported.

Table 5. Statistical significance of side dimorphism.

Cranial traits	Male rt n(%)	Male lt n(%)	Chi-square test	Female rt n(%)	Female lt n(%)	Chi-square test
Supraorbital foramen	6(10.5)	6(10.5)	_	6(18.2)	4(12.2)	0.48
Supraorbital notch	4(7)	6(10.5)	0.56	3(9.1)	6(21.2)	1.89
Zygomaticofacial foramen	9(15.8)	6(10.5)	0.69	1(3)	3(9)	1.17
Double hypoglossal canal	2(3.5)	4(7.0)	0.88	2(6.1)	2(6.1)	_
Frontal foramen	2(3.5)	2(3.5)	_	1(3)	4(12.2)	1.85
Frontal notch	1(1.75)	1(1.75)	_	0(0)	1(3)	1.39
Parietal foramen	4(7)	2(3.5)	0.88	3(9.1)	3(9.1)	_
Absence of mastoid foramen	8(14)	8(14)	_	4(12.1)	4(12.1)	_
Exsutural mastoid foramen	6(10.5)	10(17.5)	3.33	6(18.2)	3(9.1)	1.12
Patent condylar canal	12(21.1)	9(15.8)	0.54	7(21.2)	2(6.1)	3.14

Table 6. Statistical significance of sexual dimorphism.

Cranial traits	Male n %	Female n %	Chi square test
Supraorbital foramen	4236.8	30 45.5	1.18
Supraorbital notch	60 52.6	40 60.6	1.19
Zygomaticofacial foramen	71 62.3	40 60.6	0.18
Double hypoglossal canal	12 10.5	6 9.1	0.08
Frontal foramen	8 7.0	8 12.1	1.57
Frontal notch	2 1.6	1 1.5	1.10
Parietal foramen	52 45.6	40 60.6	3.86*
Absence of mastoid foramen	28 24.4	12 18.2	1.18
Exsutural mastoid foramen	78 68.4	25 37.8	17.59**
Patent condylar canal	45 39.5	31 47	0.81

Incidence recorded on 2^n basis *$p < 0.05$.

According to some of the viewers these traits are inherited by a dominant gene with incomplete penetrance (JOHNSON, GORLIN and ANDERSON, 1965, SUZUKI and SAKAI, 1960).

Though these variants are genetically determined but there is a possibility of imposition by environmental factors on them during development. The term epigenetic as these variants are called, implies imposition of phenotypic continuity during development rather than at zygote formation. Some observers have demonstrated the effects of maternal physiology such as diet, parity and maternal age (DEOL and TRUSLOVE, 1957; SEARLE, 1954a, b).They suggested that though the external environment may affect the trait variability but the genetic factor predominates.

In the present study also, none of the traits had shown statistically significant side dimorphism ($p < 0.05$). Statistically significant sexual dimorphism was however shown only by two of them (Parietal foramen and Exsutural mastoid foramen). In the previous studies no significant side differences existed for any of the traits. Significant sex differences were observed for only four of them (PAL, ROUTAL and BHAGWAT, 1988). In other study, only one of the traits had shown such difference (FINNEGAN, 1972). According to other viewers, no significant side differences existed in both sexes except for the foramen parietale (COSSEDDU, FLORIS and VONA, 1979). The significant sexual dimorphism ($p < 0.05$) was however noted for only four variants. These studies including the present one thereby suggest that the non-metric traits are predominantly under multigenic control and can be effectively used for population and anthropological studies.

Moreover, though several differences may occur in human crania, but there is little consistency in the occurrence of these dimorphisms. The incidence of a variant may be more in females in one sample and same may be more in males of another sample. This confirms the idea that they are the outward manifestations of the activity of genetic, epigenetic and environmental forces. This does not invalidate their usefulness as anthropological tools because if sufficient variants are used, the proportion of genome represented by them is so much greater than when single gene characters are used. However, an opinion was given that if we keep the number of males and females nearly equal in each population samples, we have adequately corrected for frequency differences displaying sexual dimorphism. Where possible, it is wiser to include equal number of crania of each sex in samples under investigation. Others suggested that, provided a large number of variants are used, the overall control of these variants was genetic (DEOL and TRUSLOVE, 1957).

5 Clinical importance

Each epigenetic variant is an indicator of an embryological process; the variants possessed by an individual are a record of certain aspects of development. The epigenetic variants give us an opportunity to study embryology without actually dealing with embryos. Epigenetic variants are an expression of the genes affecting development. Thus the differences in

the incidences of variants in different populations certainly reflect genetical differences between those populations. Further, in laboratory studies on mouse very few correlations of joint occurrence of pairs of variants have been found. This indicates that variant differences in a pair of populations can be summed and used as a measure of genetic distinctiveness or divergence between that pair of populations. Further it was suggested that these traits could be used to compare allometric patterns in different populations (TROTTER and GLESSER, 1952).They permit measurements of the biological distances between past populations. This type of study represents important component of contemporary physical anthropological investigation. Their use can provide answers to evolutionary and micro evolutionary questions and investigation of archeological problems such as models of setting and cultural stability as well as paleodemographic and paleopathological topics.

6 Conclusions

Epigenetic variants have considerable advantages over morphological measurements for anthropological purposes. The measures of divergence calculated with the help of non-metric traits reflect genetic differences more accurately than those calculate from metrical data. The lack of age, sex and inter trait correlations makes the computation of multivariate statistics much simpler, quicker and easier than is the case for metrical characters. In the present study also, none of the traits had shown statistically significant side dimorphism. However two of them (Parietal foramen and Exsutural mastoid foramen) had shown statistically significant sexual dimorphism. Since the significant dimorphisms were found for very few traits, it can be inferred that these traits are predominantly under genetic control and can be effectively used for population studies.

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