Original Article

VARIATION IN FREQUENCY OF OS INCAE IN HUMAN SKULL

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ABSTRACT

Occurrence of variation of the Inca bones was observed in majority of human populations around the world. India has more Inca bones than do neighboring countries. Various geographical and ethnological patterns of frequency variation of the Inca bones were already found. Present study was done on 148 human skulls for the presence or absence of the Inca bones. We classified these bones as class I to class V. They were analyzed for gross incidence and number of fragments of bone. Gross incidence of the Inca bones was found to be 4.054%. The present study besides reporting the variation in the Inca bones also highlights possible genetic and evolutionary mechanism behind its presentation.

These are important findings and the knowledge of the Inca bones is of importance to the neuroanatomists, neurosurgeons, radiologists, anthropologist and morphologists.

INTRODUCTION

The squamous portion of the occipital bone consisting of the interparietal part is sometimes divided by a transverse suture in the position of the highest nuchal line and is called as Os Inca. It was first described by Saint-Hilaire (1823)[1] as the non-wormian epactal or interparietal bone, Tschudi (1844)[2] labeled this as Os inca.

Occurance of the inca bones is rare as compared to the intersutural bones, also called as wormian bones. They were first studied in Peruvian skull by M.E. Rivero and S.J Tschudy in 1851 (Oetteking (1930)[4]; Matrin & Saller (1959[5]); and Ossenberg, (1969)[6]1[2]. Inca bones are bounded by lamdoid suture and sutura mendosa. They were previously known as os-Incae, os-ipactal or Goethe's ossicles[7]. **(Image no.1)** Later on, Shapiro & Robinson (1976)[8] reported the frequency of the inca bones i.e. 5-23% in Inca tribales in south Andes-America 1200-1597 A.D.

The frequency distribution of the Inca bones in recent human populations has been reported by several investigators such as in native Americans, by Oetteking (1930)[4] and Ossenberg (1969)[6]; in subsaharian Africans, by Saxena et al (1986)[9]; in modern Japanese by Dodo (1975)[10]; in Indian sub continental populations by Srivastava (1977)[11] Pal et al. (1984)[12]; and in worldwide populations by Martin & Saller (1959)[5].

With the occurrence of these variations in fossils hominoids, Ossenberg (1969)[6] pointed out that the mutations transforming the occiput initiated human evolution, and the modern distribution of Occipital sutural variations supported this theory.

The presence of Os Inca in a skull is of great importance to Neurosurgeons, Radiologists, anthropologists and anatomists. Taking all these considerations in mind, the present study is focused on the presentations of the incidence and variations of the Inca bones using uniform criteria.

The study is conducted on the population of central Maharashtra of western India.

MATERIAL AND METHOD

One hundred and forty eight macerated adult human skulls were studied, from both genders and unknown ethnicity. All the skull bones were obtained from the bone bank available in the department of anatomy Government medical college, Aurangabad. The skulls were macroscopically observed with naked eye and photographs were taken for further analysis.

In the present study we followed Hauser & De Stefano (1989)[13] and Kadanoff & Mutafov (1986)[14] for criteria and nomenclatures of the variants of the Inca bones.

According to Kadanoff & Mutafov (1968)[14] the Inca bones are classified as under

1. Single mid line inca bone also termed as median Inca bone. (Image no. 1)

   Depending on the number of additional longitudinal sutures dividing the Inca bone itself

the inca bones are termed as.
(Depicted in the figures (Images 2-4).

2. Bipartite
3. Tripartite &
4. Multipartite
5. Partial Inca bone when the inca bone is divided by one or more longitudinal sutures but the transverse suture itself is incomplete.

6. Typing according to Kadanoff & Mutafov (1968)[14]

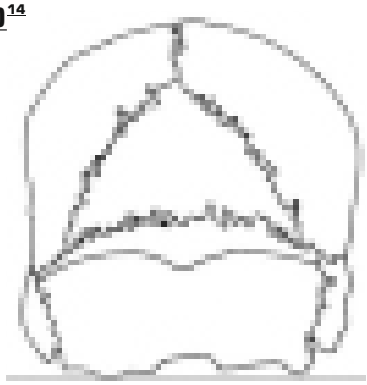

Image1: undivided median Inca bone (os incae totum)

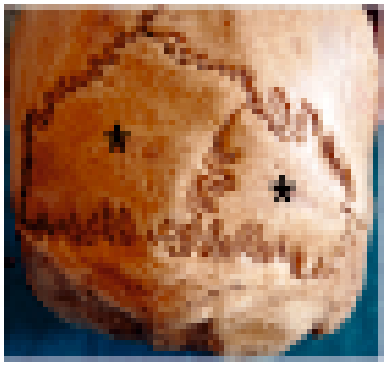

Image2: incomplete asymmertric bipartite Inca bone (os incae duplex asymmetricum)

Image3: complete multipartite Inca bone

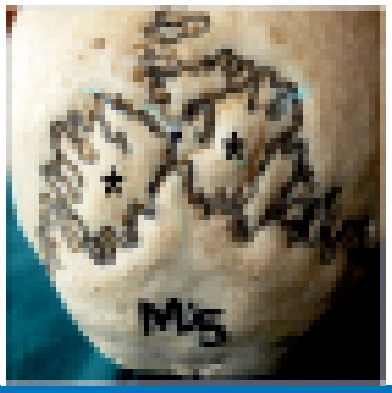

Image 4: incomplete symmetric bipartite Inca (os incae duplex asymmetricum)

Hauser & De Stefano (1989)[13] opted a different way to describe the various patterns of the os Inca bones. They classified the os Inca bones as Type I to type V. Image 5 depicts the schematic presentation of various patterns of the os Inca bones.

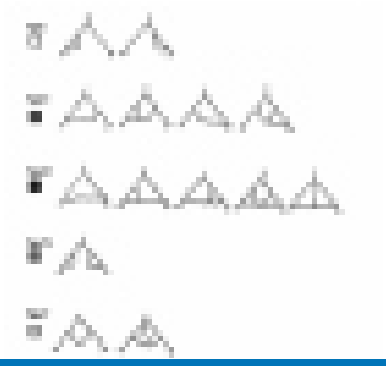

Image 5: schematic diagram to show classification of the Inca bones from Type I – Type V

Observations regarding various types of Inca bones were than noted and respective photodocumentations done.

Typing according to Hauser & De Stefano (1989)[13]

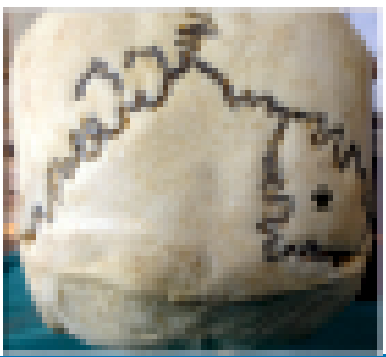

Image 6: Type I Inca bone

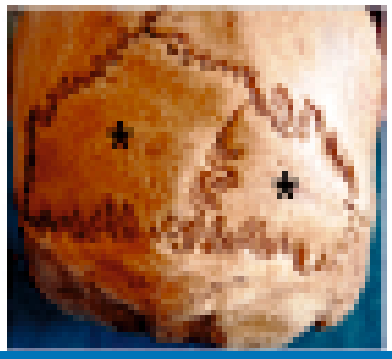

Image7: Type II Inca bone

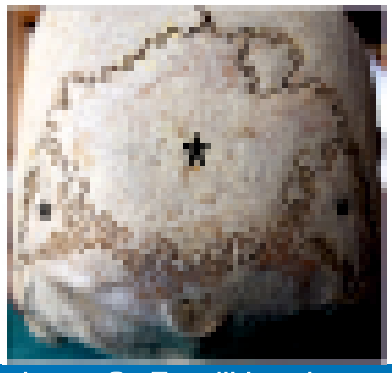

Image 8: Type III Inca bone

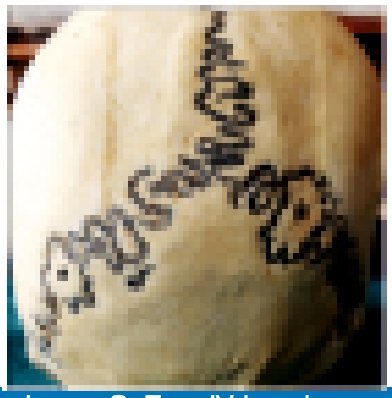

Image 9: Type IV Inca bone

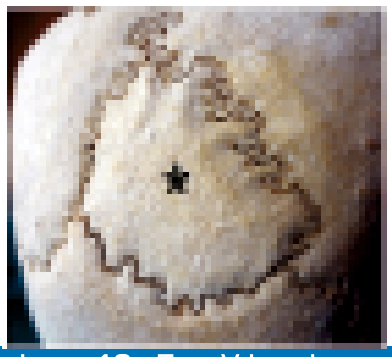

Image10: Type V Inca bone

OBSERVATION

Out of 148 skulls (98 male and 50 female) studied six skulls showed the presence of os inca bone. The distribution of their classification is as follows.

Tabulation according to Hauser & De Stefano (1989)[13] criteria.

Sample name	**Present study**
Sample size	**148**
Inca bones	**6**
Total (%)	**4.054(%)**
Type I	**1 case (0.675%)**
Type II	**1 case (0.675%)**
Type III	**1 case (0.675%)**
Type IV	**2 cases (1.351%)**
Type V	**1 case (0.675%)**

Table No. 1: Incidence of Os incae(Hauser criteria)

Figures in the respective rows indicate actual number of cases observed in the study population. Figures in brackets indicate percentage of occurrence.

Type IV was seen in two cases. One case of each type (Type I, II, III and V) was seen out of the 148 skulls studied. The respective percentages being total 4.054%. Type IV –1.351% and Type I, II, III and V each 0.675 %. Respective images of the above mentioned types are numbered and the gender of the observed skulls is also recorded.

Inca bone no.	**Type**	**Sex**
1 (Image 6)	I	M
2 (Image 7)	II	M
3 (Image 8)	III	M
4 (Image 9)	IV	F
5 (Image 10)	V	F
6 (Image 4)	IV	M

Table No. 2: Showing gender of the skulls with Os Incae

When Kadanoff & Mutafov (1968)[14] criteria was applied the incae bones showed following trend.

Sr. no	Type	No of cases observed. out of 148
Total		6
1.	Median	1
2.	Bipartite	1
3.	Tripar tite	0
4.	Multipartite	1
5.	Partial	3

Table No. 3: Typing of the Os Incae by Kadanoff & Mutafov (1968)[14]

DISCUSSION

The squamous part of the occipital bone consists of two parts, supraoccipital and interparietal. Interparietal part above the highest nuchal line develops in membrane from two pairs of ossification centers. The first pair of centers consists of medial and lateral nuclei and forms two lateral plates and the second pair of centers include upper and lower nuclei and appears between two lateral plates and forms the medial plate. Thus in short the occipital bones ossify in four centers; one for membranous squamous part, one for the basal cartilaginous part and two for the condylar part of the occipital bone.[11]

There is some controversy in the literature regarding the limits and ossification of membranous portion of occipital bone, known as interparietal bone in man.[11]

Most authors opined that the portion of the occipital bone above the superior nuchal lines ossifies in membrane. [Gray (1860)[15]; Schaffer et al. (1915)[16]; Frazer, (1937)[17]; Keith (1948)[18]; Hamilton(1976)[19]]. However, Brash (1951)[20], Pal (1987)[21] and Williams et al. (1995)[7] stated that the portion of the occipital bone, above the highest nuchal line, only develops in membrane. So it's a matter of debt whether the portion of the occipital bone between the superior and highest nuchal lines develops in membrane or in cartilage. This particular portion of bone is called as **Torus occipitalis transversus**. This portion forms a distinct projection in anthropoids and to a lesser extent in earlier races of man (Schaffer et al 1915)[16].

H. C. Srivastava (1992)[11] concluded that torus occipitalis transversus i.e. portion of bone lying between the superior and a highest nuchal line, is ossified in membrane by a pair of centres. This segment of bone is also labelled as the intermediate segment which probably never separates from the cartilaginous supraoccipital part.

Hanihara and Ishida (2001)[3] studied the variations in frequency of Inca bones in major human populations around the world. They found that the new world populations have generally high frequencies of Inca bones. Finally they concluded that geographical and ethnographical patterns of the variation in the frequency of Inca bones found in their study indicate the possible genetic background for the occurrence of this bone.

Ossenberg (1969)[6] postulated that groups practising cranial deformation not only have, as a rule a higher incidence of wormian bones but in general has a slower rate of suture closer than other populations. She also found that wormian bones are more common in crania with an Inca bone than in those without.

Wu & Wu (1985)[22] stated that the frequent presence of The Inca bone was characteristically a primitive feature found both in Chinese Homo erectus and early Homo sapiens. Based on both the findings The Inca bone is regarded as one of the characters that form the morphological basis of the multiregional model for the origin of anatomically Modern human. (weidenreich 1939[23], 1943[24])

Togersen (1951)[25] studied the Pedigree analysis and concluded that the Inca bone is inherited as a dominant trait, with approximately 50% penetrance. Also Deol & Truslove (1957)[26] suggested the strong genetic control regarding inheritance of Inca bone, based on their experimental studies on mice.

	Total bones	No. of Inca bones	Incidence	Male	Female
Berry and Berry (1967)[27]	--	---	---	4.6%	2.9%
Marathe RR (2010)[28]	380	5	1.315%	3(1.428%)	2(1.176%)
Present study (2012)	148	6	4.054%	4 (4.081%)	2(4%)

Table No. 4: Comparison of present study with that of Berry and Berry (1967)[27] and Marathe RR (2010)[28]

It can be observed from the above table that the sexual dimorphism seen in the frequency of Inca bone is identical in all the studies including the present one. However the incidence of total inca bones is more in the present study which can be explained by the differences in genetic factors since the studies are on different populations.

Typing of the Os Incae	Kadanoff & Mutafov (1968) Method	Present study (2012)
Median	1.74%	0.675%
Bipartite	0.82%	0.675%
Tripartite	0.14%	Nil
Multipartite	0.14%	0.675%
Partial	---	2.0270%

Table No.5: Comparison of present study with that of Kadanoff & Mutafov (1968)[14]

The differences in relative percentage of the Os Inca in the present study and that of Kadanoff & Mutafov (1968)[14] can be explained by the genetic differences of the population groups of the studies.

The present study being conducted on the population of central Maharashtra of western India.

CONCLUSION

Thus from the above study it can be concluded that the incidence of inca bones is variable in different populations and hence requires studies on different racial/ population basis. The sexual dimorphism is identical being more in males.

The incidence and patterns of Inca bones in population is of extreme importance in fields like anthropological studies, anatomical studies and is also useful on a day to day basis to Neurosurgeons and orthopedic surgeons.

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