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Original Research Article

A HOSPITAL BASED PROSPECTIVE STUDY TO FORMULATE A PRACTICAL METHOD OF ESTIMATION OF AGE BASED ON THE CLOSURE OF CRANIAL SUTURE USING THE DATA COLLECTED AT TERTIARY CARE CENTER

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Abstract

Background: The scientific estimation of age is not an easy task especially in adult age group. In adults mainly there are macro and microscopic methods of age estimation. The use of cranial sutures for age estimation has always been a matter of considerable debate and its reliability within the parameter has not been demonstrated conclusively by various researchers. The aim of this study to formulate a practical method of estimation of age based on the closure of cranial suture using the data collected at tertiary care center. **Materials and Methods:** A hospital based prospective study was conducted on cases coming for medico-legal postmortem examination to the mortuary of Department of Forensic Medicine, Government Medical College, Ratlam, M.P., India, during a one-year period. 50 cases of age 20 and above were studied. Documentary proof of age was collected. After reflecting the scalp, coronal, sagittal, lambdoid sutures were studied applying Acsardi-Nemeskeri scale endocranially. Mean endocranial closure stages were calculated for the three main sutures by adding the scored closure stages of the different sections and dividing the result by number of sections which compose the suture in question. **Result:** Maximum numbers of cases were seen in 20-29 age groups, least in above 70 years age group. When comparison between male and female subjects were made, females have late closure, mean for total cases 9.16 vs 7.30 (except in20-29 age groups). When males to female comparison were made for all three sutures, there was no significant correlation (applying Levene's test for equality of variances, p value>0.05) found. It implies that there is no significant difference in sex in union of sutures in all age groups. **Conclusion:** Age estimation from morphological changes in bone has always been a matter of debate as it is very erratic and affected by various factors such as climatic, dietetic, hereditary, nutritional, sociological, racial, environmental, geographical etc. Cranial sutures are no exception to that. So, much study is needed in estimation of age from cranial sutures.

INTRODUCTION

The determination of age is needed for employment, marriage, majority, management of property, voting right, competency as witness and testamentary capacity. The significance of determination of the age is most important in the criminal cases, such as rape, infanticide, kidnapping, prostitution, juvenile delinquency and criminal responsibility.[1]

Reasonably a correct estimation of age in elderly people is essential in legal, medical, social and administrative matters i.e. to fixing of age for regularization of employment, superannuation, pension settlements, senior citizen benefits, old age and good behavior of the prisoner.

The assessment of age is done by anthropologist, archeologist, anatomist and persons engaged in medico legal works. Among all these, the work of Forensic expert requires special attention because his

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findings are directly related to the administration of the law and his conclusions are debated in court of law.[1]

The scientific estimation of age is not an easy task especially in adult age group. Usually, the age estimation up to 25 years is done by physical examination, appearance of secondary sexual characters, data from dental eruption, and maturity of bones, appearance and fusion of various ossification centers. However these data to some extent are influenced by heredity, climate, race, diet, hormone level, disease process etc.[1]

In adults mainly there are macro and microscopic methods of age estimation. The principal macroscopic changes are metamorphosis of pubic symphysis, closure of cranial sutures and degenerative changes in vertebral bodies and joints.[2]

The use of cranial sutures for age estimation has always been a matter of considerable debate and its reliability within the parameter has not been demonstrated conclusively by various researchers. Only handful of studies has been conducted in India, and data on heterogeneous population of Malwa region is virtually nonexistent. It may not be difficult to determine the age of the person with certain degree of accuracy from birth onwards as far as up to 25 years. Sutures are analogous to the epiphysio-diaphysis plane, in which both are loci of growth and have a sequence of time of closure.[2]

The texture of a young adult skull is smooth on both the inner and outer surfaces (Krogman 1986)3. Krogman (1986)3 provides the following cranial morphological age sequence: 1) from the age of 25, muscular markings become increasingly evident, especially on the temporal, occipital and on the lateral side of the mandible; 2) around 35 to 45 years, the surface begins to assume a matted, granular appearance; 3) on the inside of the skull, the Pacchionian depressions, both deepen and occur with much more frequency;4) after the age of 50, the diploe become less vascular channeled and there is an increasing replacement by bone. However, there is no consistent age change in the thickness of the cranial bones.

The bones of the skull have two layers, the tabula interna and externa, which are separated by a vascular spongy bone space (diplöe) (Krogman 1986)3. These bones are separated by sutures which, in a series, are analogous to the epiphysio-diaphyseal planes that in both are loci of growth, and that both have a sequence of timing and union (Krogman1986)3. Just as the epiphysio-diaphyseal union most frequently begins centrally and proceeds peripherally, so does suture closure begin endocranially and proceed ecto-cranially. In many cases, complete closure will obliterate any signs of the cranial sutures (Krogman 1986).[3]

The metopic suture, which is present at birth between the right and left halves of the frontal bone, usually closes around the age of two. However, in some individuals, it is persistent into later adult life.

Forensic anthropologists are frequently called upon to derive as much information as possible from very limited or poorly preserved remains. The method of determining age by cranial suture closure has always been more generally used, due not only to the greater interest in the skull, but because the cranium is frequently the best-preserved portion of the recovered skeleton. As such, osteologists have developed numerous techniques which, when applied in concert, increase the accuracy of identification (Lovejoy et. al. 1985).[4]

Use of suture closure as an age estimate is predicated upon the hypothesis that suture closure is part of the aging process. However, when suture closure patterns were first studied at the beginning of this century, there were two schools of thought (British and Italian) on this issue (Hershkovitz et. al. 1997).[5] The British school maintained that sutural ossification and cranial immobility were normal conditions, whereas the Italian school maintained that they were pathologic in mature human adults. In time, probably due to the increasing prominence of the English language in the scientific literature, the British approach toward suture closure became the dominant model in physical anthropology (without actually testing that hypothesis) (Hershkovitz et. al.1997).[5]

Despite being used since the 16th century, the use of cranial sutures for determining age at death is regarded by many forensic anthropologists as an overall weak methodology (Meindl and Lovejoy 1985)4. According to Hershkovitz et. al. (1997),[5] standard aging methods based on suture closure make use of two arbitrary assumptions: 1) that the different degree of suture closure (usually four stages) represents a normal progressive process, and2) that different ontogenetic processes operate in different segments of the same suture. Hershkovitz et Al,[5] (1997) believe that these assumptions have no factual basis, and that their application is very subjective for the following reasons: the division between segments of the same suture are not clear cut in many skulls, and more than 20% of skulls do not follow the classic Pattern of sutural segmentation. The aim of this study to formulate a practical method of estimation of age based on the closure of cranial suture using the data collected at tertiary care center.

MATERIALS AND METHODS

A hospital based prospective study was conducted on cases coming for medico-legal postmortem examination to the mortuary of Department of Forensic Medicine, Government Medical College, Ratlam, M.P., India, during a one year period.

Inclusion criteria

1. The cases of known age coming for medicolegal postmortem examination. Age was confirmed by documentary evidences like birth certificate, identification cards, ration card, etc.
2. Subjects of more than 20 years of age were taken.

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Exclusion criteria

1. Unknown, unclaimed bodies where exact age cannot be confirmed.
2. Cases showing deformed or diseased or fractured skull, which may hamper the study of suture closure.

Methods

50 cases of age 20 and above were studied. Documentary proof of age was collected.

After reflecting the scalp, coronal, sagittal, lambdoid sutures were studied applying Acsardi-Nemeskeri scale endocranially, after removing the calvaria by craniotome taking due care to include complete coronal and sagittal suture. Lambdoid suture was studied in-situ. The calvarium was cleaned of soft tissues and was dried, which made the sutures more prominent. The obliteration of the sutures was ascertained endocranially. Degree of closure was scored in 16 parts of the main cranial sutures as has been done by Acsardi-Nemeskeri.[6]

The coronal suture was studied in three parts on right side and left side each; sagittal suture in four parts and lambdoid sutures in three parts each on right and left side. Endocranial sutures were simply divided in sections of equal length.

Scale for closure: Acsardi-Nemeskeri complex method

0 = open. There is still little space left between edges of adjoining bones.

1 = incipient closure. Clearly visible as a continuous often zigzagging line.

2 = closure in process. Line thinner, less zigzags, interrupted by complete closure

3 = advanced closure. Only pits indicate where the suture is located

4 = closed. Even location cannot be recognized.

Mean endocranial closure stages were calculated for the three main sutures by adding the scored closure stages of the different sections and dividing the result by number of sections which compose the suture in question.

Statistical Methods

To estimate the possible relation between suture closure and age at death, appropriate statistical tools were used (spearman rank correlation coefficients, Levene's test for equality of variances, student's test for equality of means, SPSS 22.0v software). $p < 0.05$ was considered as significant.

RESULTS

Maximum numbers of cases were seen in 20-29 age groups, least in above 70 years age group. When comparison between male and female subjects were made, females have late closure, mean for total cases 9.16 vs 7.30 (except in20-29 age groups). Where closure was seen earlier in females [Table 1].

Sagittal suture, endocranially starts fusing at the age of 20-29 years. More or less complete union >3 is attained at 40-49 age group (mean 3.09, maximum 3.29 for S4). It is totally fused by the age of 60-69 years (mean value 3.63).

In coronal suture near complete closure occurs by the age of 40-49 age and total closure occurs by 50-59 years. (Mean value 3.09 in 40-49 years and 3.53 by 50-59 years of age).

Lambdoid suture starts fusing during 20-29 age group and closes by 40-49 years but the complete closure occurs during 50-59 years (mean values 0.75, 3.05, 3.24 respectively for 20-29 yrs, 40-49 yrs and 50-59 yrs). Over all coronal suture closes earlier followed by sagittal and lambdoid suture endocranially (Mean values 2.17,2.14, and 2.12).

In sagittal suture S3 (pars obelica) closes earlier than other parts. [Table 2,3]. S3 closes early followed by S4, S1 and S2. (Mean value 2.28, 2.22, 2.02 and 2.00). In coronal suture C2 (pars complicata) closes earlier than C1 and C3 (mean value 2.20, 2.18 and 2.06). In lambdoid suture L3 (pars esterica) closes earlier fallowed by L2 (pars intermedia) and L1 (pars lambdica) (Mean value of 2.15, 2.04 and 2.03).

Right and left side of coronal and lambdoid sutures were compared endocranially, there were no significant difference after applying student test (p value>0.05). It implies that there is no bilateral variation in endocranial suture closure. When males to female comparison were made for all three sutures, there was no significant correlation (applying Levene's test for equality of variances, p value > 0.05) found. It implies that there is no significant difference in sex in union of sutures in all age groups.

Table 1: Comparison of mean value of age in male and female

Age Group (yrs)	Male	Female	Mean±Sd (Male)	Mean±Sd (Female)
20-29	14	5	2.90±3.415	4.48±3.926
30-39	8	4	11.04±4.127	5.06±5.001
40-49	4	1	12.30±3.376	12.02±0.000
50-59	4	2	13.28±3.234	8.16±6.867
60-69	4	2	15.10±2.216	13.30±4.527
>=70	2	1	16.00±0.000	16.00±0.001
Total	36	14	9.16±6.067	7.30±5.622

Table 2: Comparison of age wise endocranial suture closure

AGE GROUP (years) Mean±SD	S1	S2	S3	S4	CR1	CR2	CR3
20-29yrs (N=19)	.75±0.936	.78±0.945	.94±1.058	.83±0.936	.72±0.877	.81±1.012	.88±-.928
30-39 yrs (N=12)	2.19±1.401	2.02±1.382	2.54±1.389	2.35±1.586	2.06±1.284	2.26±1.412	2.21±1.375
40-49 yrs (N=5)	3.09±.873	2.82±.910	3.21±0.910	3.29±.667	3.01±.945	3.09±.736	3.09±.735

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50-59 yrs (N=6)	2.92±1.301	3.01±1.176	3.01±1.176	3.01±1.176	3.53±.674	3.53±.674	3.44±.787
60-69 yrs (N=5)	3.22±1.658	3.48±1.270	4.02±0.001	3.92±.315	3.62±1.266	4.00±0.001	3.62±1.266
>70 yrs (N=3)	4.00±.000	4.00±.000	4.00±.000	4.00±.000	4.00±.000	4.00±.000	4.00±.000
Total (N=50)	2.02±1.568	2.00±1.542	2.28±1.566	2.22±1.593	2.06±1.568	2.20±1.580	2.18±1.536

Table 3: Comparison of age wise endocranial suture closure

AGE GROUP (years) Mean±SD	CL1	CL2	CL3	LR1	LR2	LR3	LL1	LL2	LL3
20-29 yrs (N=19)	1.25± 3.52	.73± .856	.86± .932	.72± .836	.72± .836	.83± .854	.73± .820	.73± .820	.85± .856
30-39 yrs (N=12)	1.83± 1.312	2.07± 1.442	2.00± 1.410	1.95± 1.173	1.93± 1.220	2.00± 1.286	1.95± 1.273	1.93± 1.220	2.00± 1.286
40-49 yrs (N=5)	3.01± .944	3.09± .736	3.09± .736	2.82± .788	3.02± .473	3.38± .698	2.82± .786	3.02± .473	3.38± .698
50-59 yrs (N=6)	3.35± .807	3.35± .807	3.46± .685	3.19± 1.252	3.19± 1.252	3.26± 1.190	3.19± 1.252	3.19± 1.252	3.26± 1.190
60-69 yrs (N=5)	3.60± 1.266	4.00± .000	3.60± 1.266	4.00± .000	4.00± .000	4.00± .000	4.00± .000	4.00± .000	4.00± .000
>70 yrs (N=3)	4.00± .000	4.00± .000	4.00± .000	4.00± .000	4.00± .000	4.00± .000	4.00± .000	4.00± .000	4.00± .000
Total (N=50)	2.20± 2.530	2.11± 1.545	2.11± 1.545	2.04± 1.520	2.03± 1.528	2.15± 1.540	2.03± 1.528	2.04± 1.521	2.15± 1.540

DISCUSSION

Obliteration of skull sutures in late age, practically when all the teeth have erupted and epiphysis have fused i.e. after 21 years of age, gives a fairly accurate idea but here also we find that the determination of age can only be in decades, based on sole criterion of suture obliteration.

In later years of life all the teeth have erupted, practically all the epiphyses have united with the diaphysis, the height and weight are of no significance to determine the age. Gustafson has done the work in which he has given the idea to determine the age on the basis of changes that occur in teeth.[6,7] Literature is full of certain changes such as lipping of the bones, graying of the hair, appearance of arcus senilis in the cornea, opacity in lens, atherosclerotic changes in the arteries, wrinkling of the skin especially of the face. They are too vague to be considered for determination of age in Medico-legal work.

In our present study we have found that the sagittal suture, endocranially, starts fusing at the end of 20-29 years and completion is perfected at the age of 60-69 years, and this observation conforms with that reported by Todd & Lyon (1924),[8] who indicated endocranial commencement of sagittal suture at a much later age at about 40 years. These latter workers have reported on very scanty specimens so it can't be considered as authentic.

According to J.B.Mukherjee, estimation of age from suture closure of skull can be given in a range of 5-10 yrs in age of 30-60 yrs, the range may even be more in higher age groups.[9]

This finding was compared with study by Dr.S.V. Khandare et all found that the sagittal suture, endocranially, started fusing at the end of 26 years and completion at the age of 61-65 years in Ist part of sagittal suture, 46-50 years in IInd part of sagittal suture, 41-45 years in IIIrd part of sagittal suture and 26-30 years in IVth part of sagittal suture.[10] In study by Ullas Shetty have found that the sagittal suture, endocranially, starts fusing at the end of 20-29 years and completion is perfected at the age of 60-69 years. Similar finding also found in observation with that reported by Todd & Lyon (1924).8 It was in contrast to the observation reported by Pommerol (1869), and Topinard (1885), who indicated endocranial commencement of sagittal suture at a much later age at about 40 years. These latter workers have reported on very few specimens so it could not be considered as authentic.[11,12]

Lambdoid endocranially, starts fusing at the age of 20-29 years in the present context which shows that it is a year earlier than that reported by Todd and Lyon (1924),[8] while completion in our study is 50-59 years. The other workers have not reported on lambdoid suture. Our Indian data compare well with those of the male whites (Todd & Lyton1925).[13] Negro skull show ever show an earlier date of commencement and closure.

All the previous work was done in France, Germany and United States of America, under different climatic conditions and in diverse racial groups. Though consensus of opinion in our country is that the obliteration of the skull sutures in females is somewhat earlier than that of males, in the present study no substantial difference was noticed. This finding is in conjunction with Meindl and Lovejoy4. Perizonius,[14] studies the time of suture closure in 174 male and 82 female skulls of non-Jewish inhabitants of Amsterdam whose ages were between 20 and 99 years. He examined the sutures endocranially by introducing a small lamp through the foramen magnum. He did not find any difference in the time of closure of the sutures in two sexes or on the two surfaces. According to him, the obliteration of sutures was related to age in the age group of 20-49 years but not thereafter. Validity of his observations is questionable as it is not possible to observe the lateral parts of the lambdoid sutures endocranially by the procedure followed by him.

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CONCLUSION

We concluded that endocranial union starts 20-29 age groups but progression is not uniform. Complete closure (mean value > 3.5) of sagittal and lambdoid sutures occurs in the age group of 60-69 years whereas in the coronal it occurs by 50-59 years. Age estimation from morphological changes in bone has always been a matter of debate as it is very erratic and affected by various factors such as climatic, dietetic, hereditary, nutritional, sociological, racial, environmental, geographical etc. Cranial sutures are no exception to that. So, much study is needed in estimation of age from cranial sutures.

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