A Prospective Study to Determine the Timing of Complete Fusion of Spheno-Occipital Synchondrosis Using Computed Tomography

Hariprasad T. Nambiar[1], Aysha Mehanaz[2], Nitika C. Panakkal[3], Suresh S[4], Visakh T[5]

[1]Intern, [2]Intern,[3]Assistant Professor, Department of Medical Imaging Technology, Manipal College of Health Professions, Manipal Academy of Higher Education, Manipal, [4]Assistant Professor, Department of Radio-diagnosis and Imaging, Kasturba Medical College, Manipal Academy of higher education, Manipal, [5]Assistant Professor, Department of Medical Imaging Technology, Manipal College of Health Professions, Manipal Academy of Higher Education, Manipal

Abstract

Background: The Spheno-occipital synchondrosis (SOS) has a significant role in role in the field of forensic, medical and anthropological sciences for age analysis. Therefore, SOS can help estimating age depending on different stages of closure. Therefore, the present study aimed to evaluate the timing of complete fusion of Spheno-occipital synchondrosis using computed tomography.

Methods: A prospective study including 110 subjects was conducted in which 55 males and 55 females between the ages of 15-25. All CT examinations were performed on a 128 slice incisive CT, Philips and 16- slice big bore CT, Philips. The sagittal image was used for analysis the stage of spheno-occipital fusion. Based on the stage of fusion of SOS, patients were categorized into stage 0 indicating partial/no fusion and stage 1indicating complete closure of the SOS. An experienced radiologist scored all images.

Conclusion: The mean age of male cases with complete SOS closure was 20.3 ± 3 years for males and 20 ± 3.1 years for females. The study results show that by age of 20, no individual will belong to stage 0 irrespective of gender and all individuals would have completely fused SOS.

Keywords: *Spheno-occipital synchondrosis, computerized tomography, age determination*

Introduction

The Spheno-occipital synchondrosis (SOS) is a hyaline cartilage growth center joining the sphenoid and occipital bones and is largely present during the development of skull base and later gets ossified throughout maturation [(1).] This has a significant role in facial development and the thorough examination of skeletal ossification plays an important role in the field of forensic, medical and anthropological sciences for age analysis. Therefore, SOS can help estimating age depending on different stages of closure. The fusion stage can help determine if the individual is minor as the SOS is undergoing fusion or considered as adults if the fusion is complete. As per literature, the SOS fuses between 11-16 years of age, however this remains controversial, as there are variable reports in literature of SOS fusion in individuals as late as 25 years [(2-10)]. This variation of fusion reported in studies can be as a result of different methods of analysis employed, variation in population, sample sizes or age ranges [(11)].

Corresponding Author:
Nitika C. Panakkal
Assistant Professor-senior scale
Department of medical imaging technology
Manipal College of health professions
Manipal, Phone number: 8861615165
Email id: nitika.cp@manipal.edu
nitikacp@gmail.com

The various method of analysis include dry skull method, histological sections, conventional radiographs, computed tomography and magnetic resonance scanning. Conventional radiographs provide superficial information and therefore it is difficult to visualize areas of the skull due to superimposing structures. Although, direct inspection methods are cost effective and the most commonly used method in forensic anthropology [11], computed tomography are high resolution and provide opportunities to perform three-dimensional investigation. Therefore, they can detect the state of fusion earlier due to superior visualization of skull base and is considered to have a greater accuracy in determining closure [4]. Although a lot of studies have utilized SOS for age estimation, it is a well-known fact that standards vary in different populations and ethnic groups, there is a need for anthropological data that is specific to population [4, 12]. Therefore the present study was aimed to evaluate the timing of complete fusion of Spheno-occipital synchondrosis (SOS) using computed tomography.

Materials and Methods

A prospective study including 110 subjects was conducted in a tertiary care hospital, Dakshina Kannada region. The study approval was obtained from the institute research and ethical committee, Kasturba hospital. The study population included 55 males and 55 females between the ages of 15-25. The participants included in the study were referred for CT scan of brain, spine, and temporal bone as part of their diagnostic package. Patients with congenital anomalies, developmental disorders and recent trauma were not included in the study. Informed consent was obtained from all patients and all the CT examinations were performed on a 128 slice incisive CT, Philips and 16 slice big bore CT, Philips. The patients were positioned in supine and placed head first. The scan was performed at 120 kVp and automatic tube current modulation. The image were acquired in 5 mm thickness and later reconstructed into thinner sections (1mm). The image was reformatted to sagittal plane using Multi Planar reconstruction technique and scored by an experienced radiologist. Based on the stage of fusion of SOS, patients were categorized into stage 0 and stage 1. Stage 0 indicated partial or no-fusion of SOS and stage 1 indicated complete closure of the SOS as shown in figure 1. The mean age of patients coming under each grade was calculated and noted for both genders.

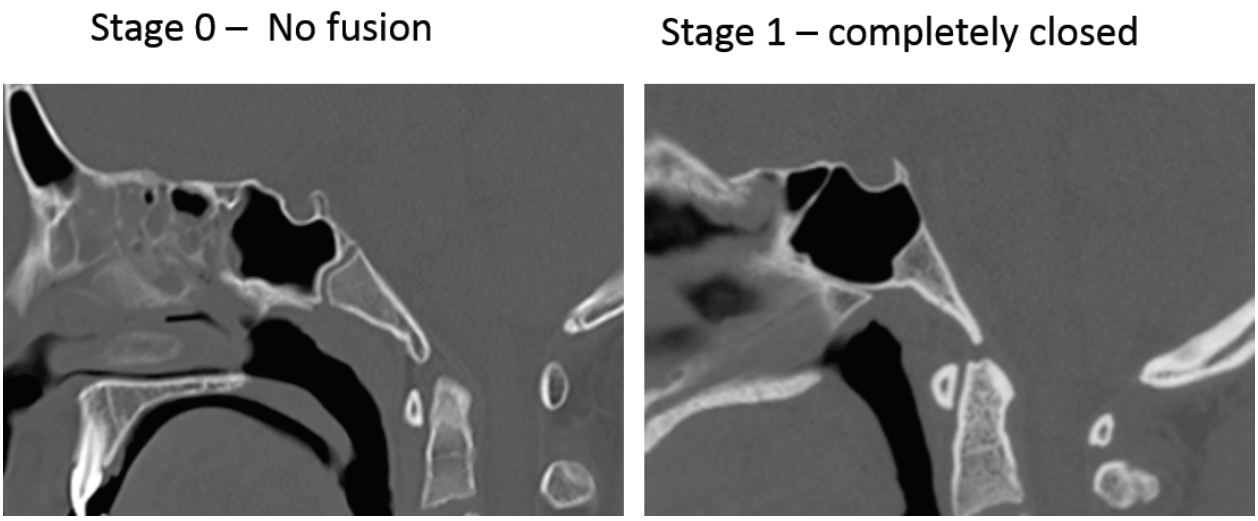

Figure 1: Stages of SOS fusion in the mid sagittal plane

Statistical Analysis

The statistical analysis was done using R analysis. Age estimation in both genders as per spheno-occipital synchondrosis fusion stage was described in terms of mean, standard deviation, minimum and maximum values. Status of complete closure was compared in males and females using independent t test. To test the association between age and stage logistic- regression was used.

Results and Discussion

Among the 110 subjects included in the study, four male subjects of age 15 and 16 years showed partially closed Spheno-occipital synchondrosis, with the rest of them categorized into stage 1 indicating complete closure of SOS. The average age of male participants with open/partially fused suture was 15.5±0.5 years. In stage 0, the highest age of partially closed suture was 16 years. From the 110 subjects, 106 individuals showed complete fusion of spheno-occipital synchondrosis in which 51 were males and 55 were females. The mean age of male cases with complete SOS closure was 20.3 ± 3 years for males and 20 ± 3.1 years for females. The lowest age of complete suture closure was at 15 years for both males and females (table 1).

Table 1: Number of individuals in each stage of fusion for males and females.

AGE (years)	Stage 0 (Open/Partially closed)		Stage 1 (Completely fused)	
	Males (n)	Females (n)	Males (n)	Females(n)
15	2	-	3	5
16	2	-	3	5
17	-	-	5	5
18	-	-	5	5
19	-	-	5	5
20	-	-	5	5
21	-	-	5	5
22	-	-	5	5
23	-	-	5	5
24	-	-	5	5
25	-	-	5	5
TOTAL	4	-	51	55
Mean ± SD	15.5±0.5	-	20.3 ± 3	20 ± 3.1

The study results showed no significant difference (p= 0.9) among gender in stage 1 of complete SOS closure. To evaluate the effect of age on fusion stages, logistic regression was performed. The test gave an odds ratio of 10.4 indicating that as the age increases by one unit the chance of getting stage one is 10 times more than the stage 0. The study results show that by age of 20, no individual will belong to stage 0 irrespective of gender and all individuals would have completely fused SOS.

The study on SOS development and its important role in age estimation is been studied over the years. By estimating the fusion of the joint, it is possible to determine the age of an individual that will be helpful in solving criminal activities like sexual offenses, child labour. The late stage of fusion of this particular joint has its own significance in forensic analysis as well as in medical and anthropological fields [5]. The objectives of this research was to identify the time of complete-fusion of SOS in both males and females. As per the mean age of our study, we found there was complete SOS at 20.3 ± 3 years for males and 20 ± 3.1 years for female. Similarly, a study conducted by Rajeshwar et al also showed similar results. His study included 198 samples within the central Indian population in which 117 were males and 81 were females. The study reported that SOS closure occurs at a mean age of 20.2 and 21.4 year among females and males respectively [8]. The mean age of fusion can vary according to the population as well as genders. Although our study did not show a significant variation in mean age for SOS closure among genders, a notable amount of studies report variation in mean age of complete SOS closure between males and females [3, 7, 10, 11, 13]. However, a study conducted by Richard B et al reported complete spheno occipital fusion by the age 17 years for both genders[4]. He also reported that after an age of sixteen years there was no remarkable change in the progression of the fusion among genders. This was similar to the present study, which showed no significant difference of SOS fusion progress after an age of sixteen years in males and fifteen years in female. Table 2 demonstrates summary of these research along with the present study showing age range, number of participants and mode of analysis for complete fusion of spheno-occipital synchondrosis.

Table 2:: Various study as reported in literature in comparison with the current study to illustrate the timing of complete SOS.

Author	Year	Mode of Analysis	Sample size(n)		Location	Mean age of complete fusion	
			M	F		M	F
Richard B (4)	2010	CT	458	208	Australia	16-17	16-17
Alper Sinanoglu (5)	2015	Cone Beam CT	90	148	Turkey	20	18
Rajeshwar Sambhaji (8)	2018	Direct inspection	117	81	Central India	21.4	20.2
Ismail Ozgur (14)	2013	CT	399	139	Turkey	20.3	18.2
Mitra Akhlaghi (15)	2010	Direct Inspection	190	186	Tehran	21.1	19.7
Salina Hisham (16)	2018	CT	336	164	Malaysia	20.84	19.78
Oguzhan Ekizoglu(17)	2016	MRI	455	623	Istanbul, Turkey	18.4	17.7
Present study	2019	CT	55	55	Dakshina Kannada (India)	20.91	20.84

The differences in the results can be due to methodological difference used for determination of SOS, also differences in population, selection of sample size, socio-economic status are factors that could influence the result[8]. The present study evaluated the SOS closure-using computer tomo-graphy. However, a lot of studies have been done to estimate age of SOS closure using direct inspection methods in cadavers, cone beam CT, MRI, X-ray etc. [1, 4, 7, 8, 13, and 17]. Our study is also in accordance with various studies in literature that report an interdependence of age with stage of closure. The study demonstrated that, by the age of 18 years the SOS is complete for both males and females as no notable progression occurs in SOS closure after 17 years of age. Therefore, an open suture or an incomplete SOS can indicate that the individual may be less than 18 years. Further population specific studies can be done to estimate age of unknown individuals.

The current study did have certain limitations, as it was a time-bounded study; the obtained sample size was small. The present study only investigated timing of closure of spheno-occipital synchondrosis, which as shown in the study occurs earlier than expected in females, therefore, further studies including a larger population involving younger children (7-14 years) is recommended.

Conclusion

As there is no significant progression in SOS fusion seen after an age of 15-16 years in both females and males, we can conclude that male subjects with open/ semi closed suture will be below the age of 16 years and females with open/semi closed suture will be less than 15 years. In addition, the study indicates that SOS fusion stages increases with age. Therefore, it can be helpful in prediction of age.

Ethical Clearance: Institute ethical Committee**,** KMC, Manipal

Conflict of Interest: Nil

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References

1. Anwar Alhazmi, Eduardo Vargas, J Martin Palomo, Mark Hans. Timing and rate of Spheno-Occipital Synchondrosis Closure and its relationship to puberty. PLOS ONE.2017;12(8):1-1
2. Ingervall, B, & Thilander, B. (1972). The Human Sphenooccipital Synchondrosis I. The Time of Closure Appraised Macroscopically. Acta Odontologica Scandinavica, 30(3), 349–356.
3. Lottering N, MacGregor DM, Alston CL, Gregory L. Ontogeny of the spheno-occipital synchondrosis in a modern Queensland, Australian population using computed tomography. American Journal of Physical Anthropology. 2015; 157:42-57.
4. Bassed RB, Briggs C, Drummer OH. Analysis of time of closure of the spheno-occipital synchondrosis using computed tomography. Forensic Science International 2010;200:161–164.
5. Sinanoglu A, Kocasarac HD, Noujeim M. Age estimation by an analysis of spheno-occipital synchondrosis using cone-beam computed tomography. Legal Medicine (Tokyo) 2016;18:13–19.
6. Okamoto K, Ito J, Tokiguchi S, Furusawa T. High-resolution CT findings in the development of the sphenooccipital synchondrosis. American Journal of Neuroradiology 1996;17:117–120
7. Shirley NR, Jantz RL. Spheno-occipital synchondrosis fusion in modern Americans. Journal of Forensic Science 2011;56:580–585.
8. Rajeshwar S, Chaitanya V. Age determination by spheno-occipital synchondrosis fusion in central Indian population. Journal of forensic an legal medicine.2018;54:39-43.
9. Williams PL. Gray's anatomy-the anatomical basis of medicine and surgery. 38th Ed. London: ELBS with Churchill Livingstone; 1995.
10. El-Sheikh ME, Ramadan S. Age of closure of the spheno-occipital synchondrosis in the Arabian Gulf region. Forensic Physical Anthropology Proceedings of American Academy of forensic Sciences 2002-2011.
11. Kewal K, Tanuj K.Evaluation of Spheno-occipital Synchondrosis: A review of literature and

considerations from forensic anthropologic point of view.2013; 5(2):72-76.

12. Krishan K, Kanchan T, Passi N. Estimation of stature from the foot and its segments in a sub-adult female population of North India.J Foot Ankle Res 2011;4:24.
13. Sahni D,Neelam S. Time of fusion of the basi-sphenoid with the basilar part of the occipital bone in north west Indian subjects. ForesicSci Int.1998; 41(1-2)
14. Ozgur I, Oguzhan E. Forensic age estimation by Spheno-occipital synchondrosis fusion degree: Computed tomography analysis. The journal of craniofacial surgery. 2014;25(4): 1212-1216
15. Mitra A, Fakhredin T. Age-at-death estimation based on the macroscopic examination of Spheno-occipital sutures. Journal of forensic and legal medicine.2010; 17:304-308.
16. Salina H, Ambika F. Quantification of spheno-occipital synchondrosis fusion in contemporary Malaysian population. Forensic science international.2018; 284:78-84.
17. Oguzhan Ekizoglu, Elif Hocaoglu,. Spheno-occipital synchondrosis fusion degree as a method to estimate age: a preliminary, magnetic resonance imaging study. Australian Journal of Forensic Sciences.2016; 48:2, 159-170