The prevalence of persistence metopic suture (metopisim) among Kurdish populations of Erbil city

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Background and objective: A fully developed frontal bone consists mainly of two portions separated by a vertically oriented suture called metopic, frontal or inter-frontal suture, it's considered to be the first skull suture to close metopic suture physiologically closes at different times of age and could occur from birth through age 8 years,In some individual (and as a normal variant) a persistent metopic suture can be seen in the midline running down the frontal bone and the condition is referred to as metopisim. The study aims to investigate the prevalence of metopisim among the Kurdish population of Erbil city,type of metopisim, gender and/or environmental or racialimpact will also be assessed.

Methods: This retrospective/radiological study was conducted on conveniently selected PA (Caldwell view) plain radiographic images of 613 Kurdish individuals of mixed genders, ages ranging between 10 to 64 years and images were taken from the periods between April 2020 to May 2022 for various medical reasons but mostly were for assessment of blunt head trauma.

Results: Out of 613 assessed P.A. radiographs only in 17 cases showed the presence of metopisim, (12 females and 5 males), metopisim was of complete type in just 4 cases; 3 were females and just 1 of them was a male case and it was incomplete in 13 of the cases; 9 females and just 4 were among males.

Conclusion: It's of crucial importance to identify the metopic suture persistence and its interracial and ethnic diversity as its existence presence could be mistaken and misdiagnosed as a vertical or an oblique cranial fracture upon assessments of radiological images.

Keywords: Prevalence, Frontal bone, Metopisim, Metopic suture, Frontal suture, Inter-frontal suture, Kurdish peoples, anatomical variations.

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Introduction

The frontal bone is a shield-shaped, single (unpaired) bone of the skull that used to be made out of two separate compartments prenatally (during its early stages of development) and at early post-natal periods (right from birth and up to the first few years of life) that later on fuses together to form a single, flat cranial bone which is located in the most anterior, relatively superior aspect of the skull or the forehead region.[1,3] A fully developed frontal bone consists mainly of two portions, one is vertical and the other one is relatively horizontal, the vertically oriented flat part is called the squamous part, and the horizontally oriented is called the orbital process of the frontal bone, making up the floor of anterior cranial fossa, the bony part of the forehead, part of the roof of the orbital cavity that contains the eye ball, and part of superio-lateral aspect of the bony part of the nose.[2, 3] The development of the frontal bone begins as two separate compartments with the initial formation of primary ossification centers during the intra-uterine life between the 6th and 8th week, the ossification of all parts of the frontal bone is intramembranous and it continues until the

complete fusion of the metopic suture takes place, generally between the 4th-5th years of postnatal life although the time of physiological closure of the metopic suture varies from birth to 8 years of age it may even extend into adulthood.[1, 4] The metopic suture separates the two halves of the frontal bones before birth and physiologically it's considered to be the first skull suture to close and in some individuals as a normal variant a persistent metopic suture can be seen in the midline running down the frontal bone and the condition is referred to as metopisim. [1,2,3] To fully understand metopisim firstly we must first understand; what are sutures, what are cranial sutures, what is their clinical significance and what kind of impact or influence they pose when they tend to close prematurely or persist beyond their normal closure time.[1,3]

Sutures are fibrous joints (These joints are also functionally definedto be fixed or immovable joints) that connect the bones of the skull ,they are joints in which fibrous tissue connects the bones (hence the naming) and they primarily lack a joint cavity, the fibrous joints that link the skull's bones are known as the sutures of the skull, or cranial sutures, the adhesion of the cranial bones in general during the development and closure of the cranial fontanelles are marked by these seemingly complicated, thin lines and they resemble fine, delicate linear junctions that show where the bones are attached to one another. [4,12] Collagen makes up the majority of these dense fibrous tissues that joins the sutures (hence the naming of the joint type; fibrous joints) [1]. These joints have no hollow potential spaces (joint spaces) and are permanent and immovable hence (synostosis) is another name for them. The sutures in a fetal skull are wide and permit some mobility during birth, but as the child grows older, they tighten and become fixed.[1,3,13]

Metopic suture is a kind of dentate (toothed like) cranial suture and metopism can be defined as failure of fusion of the two compartments of the frontal bone past its time or persisting frontal (metopic suture) whether partially or totally that extends in the midline across the center of the frontal bone in a vertical or an oblique from the nasion (is where the human skull's two nasal bones and frontal bone meet) to bregma (it's a cranial point where the coronal suture meets the sagittal suture)[1,5,6,8,9]. The increase in the width of the anterior portion of the calvaria is the responsibility of the metopic suture and a single major center, one in each half of the frontal bone is responsible for the intramembranous ossification during fetal development, during the 9th week of gestation and the ossification spreads from this point, by the 11th week of gestation, the frontal bones are located at the midline near the nasal region and around the 16th intrauterine week, the space between the two frontal bones in the midline begins to close, by the 28th week starts moving superiorly toward the anterior fontanelle.[1,17,18] The MS seems to close at the supranasal region during the 32nd week of gestation, then the closure progresses superiorly toward the anterior fontanelle.[11] The MS is documented to be the first to get close physiologically and it fusion is gradually starting at the nasion and finishing superiorly at the anterior fontanelle (future site for bregma). [1] 93-96% of the normal population reaches complete normal fusion of MS between the ages of 3 and 15 months, with an estimated average time of completion of 9.18 months and this process of unification takes about 3–4 months to finish after starting on average 5 months ago, it requires less time to finish the fusion process when it begins at an earlier age in certain individuals, the MS, though, reportedly remains patent for at least another year.[1, 18] It has been established that adult skulls with metopisim or metopic skulls possess a unique neurocranium arrangement that is defined by a large forehead and wider inter orbital - and inter-frontal spaces as well as broader forehead or greater frontal curvature as a clinical sign.[17, 18]

The metopic suture on its own has got few morphological varieties; the complete metopic suture which defined as anMS that extends between nasion and bregma, and there is also incomplete metopic suture which is defined as a metopic suture thattravels a short distance either from the nasion upward or from bregma downward vertically or just obliquely, while the incomplete metopic suture type is sub-divided, either into nasion incomplete type of metop-

ic (NIMS) suture and the bregma Incomplete type of metopic suture (BIMS) depending on the location they emerge from both may or may not reach glabella (a cephalometric landmark that is justsuperior to the nasion, basically midway between the supracilliary arches represented by a bony depression between nasion and bregma)' [1, 12, 13] Based on shape, the incomplete type is subclassified to possess either a linear, U or V-shaped styles, it has been established that the MS mostly exists alongside with other bony developmental variations especially those that occur in frontal bone like the underdevelopment (frontal sinus hypogenesis) or even the total lack of it! (frontal sinus agenesis).[16, 19] In clinical practice though the existence of the metopism is described to be a rare- coincidental radiological finding yet in emergency settings a persisted metopic suture may get easily miss-diagnosed as or confused for vertical fractures of the frontal bone [7,11] hence a sound knowledge of the development, anatomy and normal existing variants of the frontal bone together with proper pre-surgical radiographic assessment of the frontal bone especially in adult patients is quite necessary for proper treatment of the patient and avoiding misdiagnosis and time consumption for treatment which is crucial at emergency wards.

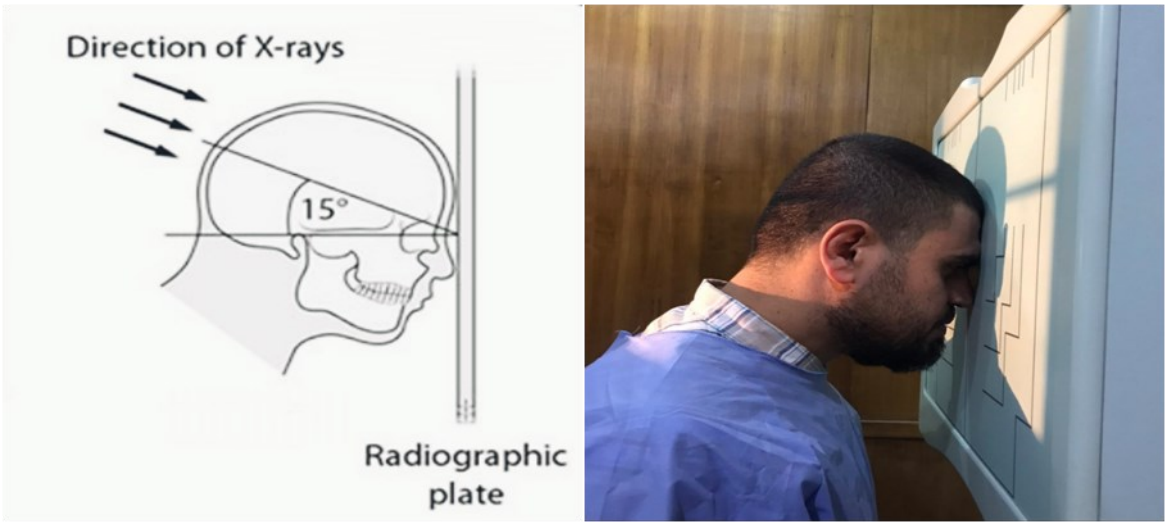
Methods

This retrospective multi-centric radiological study involved the assessment 613occipto-frontal (PA) radiographs (also called Caldwell view) of kurdish individuals of mixed genders (297 males and 315 females) ages ranged between 10 to 64 years (mean age being 37 years) and we utilized the digital data bases of the following local teaching hospitals; east emergency , west emergency and Hawler teaching hospitals at Erbil city at KRG/Iraq images originally were taken from the periods between April 2020 to May 2022 and each radiograph was taken for a particular medical reason but the majority were of patients that originally subjected to radiography due to closed craniofacial injuries, after careful examining each of the patient's x-ray films their medical records were also traced to exclude those aged less than 10 years (as according to the majority of current literature if metopic suture persists beyond 8-9 years then and only then it will be regarded and counted for as a case of metopisim) , non-Kurdish individuals and those with history of open/compound or invasive craniofacial fractures as it may obscure or superimpose the visualization of the suture being studied.Caldwell's view (also known as Occipitofrontal view) is a radiographic view of the skull in which the X-ray plate is passing perpendicular to the orbitomeatal line (which is a positioning line used in skull radiography. It travels between the eye's outer canthus and the center of the external auditory meatus). The rays are oriented at 15-20° to the radiography plate and travel from behind the skull to its far anterior aspect with the head being positioned in a way that the forehead and the nose touch the x-ray plate, Figure 1 [6,8,9], it is widely used in clinical practice to improve visibility of the ethmoid and frontal sinuses. Basically, this particular view is a P.A. view with 15-20 degrees of caudal angulations with minimal radiation to the orbit. The Caldwell view is intended to be more detailed than a typical PA skull scan in showing the frontal sinus. This study was carried out following the applicable, approved rules, regulations, and Helsinki declaration ethics standards, and was also approved by the relevant department's ethics committee and there were no potential risk or dangers linked with this study as there was no direct contact with the patients and to get more accurate readings the images kkkkk

were viewed on the computer screen with the help of a specialist radiologist. Persistent frontal or metopic suture (metopisim) was defined as the persistence of the frontal or metopic suture in the adult human skull, which is the condition of possessing a persistent metopic suture beyond its normal physiological time of closure.
Each radiographical image was viewed on two PCs with 20.3 cm LCD monitors with the same screen resolution setting, sharpened accordingly in a darkened environment to get the most accurate readings.

Chi-square test was used and data analysis was performed utilizing SPSS (statistical package for social sconce) software version 23, simple descriptive statistics about the patients' ages, genders, and the presence or absence of unilateral (incomplete) or bilateral (complete) aplasia was supplied. Continuous data were presented as M±SD (with m representing the mean and SD representing the standard of deviation), whilst categorical data were presented as numbers and frequencies and $P<0.05$ was considered to be statistically significant.

Statistical analysis



Figures 1: Explaining the technique for Caldwell view of PA radiographs; note the direction of the x-ray beam, the angle of exposure and the head positioning

Results

This study is a retrospective multi-centric radiological study and it involved the assessment of (613) occipto-frontal (PA; Posterio-anterior) radiographs (also called Caldwell view) of Kurdish individuals of mixed genders (298 males and 315 females) aged between 10 to 64 years (mean age being 37) years from the digital data bases of the east emergency , west emergency Raparin and Hawler teaching hospitals in Erbil city KRG/Iraq, Radiographs were taken for a variety of medical reasons but the majority were of patients that originally k

subjected to radiography due to closed craniofacial injuries, after carefully examining each of the patient's x-ray films their medical records were also traced to exclude those aged less than 10 years , non-Kurdish individuals and those with history of open/ compound or invasive craniofacial fractures. Out of the total sample size of (n=613); only in 17 cases (2.65%) the presence of remnant metopic suture/ metopisim were observed, 12 in female patients (1.87%) and 5 among the male patients rrrrrr

(0.78%), the type and the pattern of the remnant metopic or interfrontal suture varied it was complete (extending from the bregma to nasion as relevant cranometric points) in 4 out of the 17 (0.63%) of diagnosed metopsim ; 3 were females (0.49%) and just 1 of them was a male (0.16%) and incomplete (about half the extension of the complete type and not reaching from bregma to nasion) in 13 of the cases (2.02%); 9 cases (1.47%) were females and just 4 (0.63%) of the cases were among males. Among the incomplete group; we observed that only 3 of them (0.49%) were the NIMT (Nasion reaching incomplete metopisim) while the reminder (10 cases) was of BIMT (Bregma reaching incomplete metopisim) subtype (1.6%). Table -1- and figure-1- are summarize this study's findings. Aside from their types and subtypes the 17 cases of metopisim that their PA radiographs were assessed in this study aged between 14-61 years; the mean age being 37.5 years. The relevant data of this study have been summarized in Table-1- and the results are shown in figures 2-4 showing representative Caldwell view plain radiographs of both types and subtypes of metopism accompanied by relevant information regarding each cases gender and age.

Table 1: shows the frequency of metopisim in our study

Gender	n	Metopic suture frequency		Total
		Complete	Incomplete	
Female	315 (51.47%)	3 (0.49%)	9 (1.47%)	12 (1.87%)
male	298 (48.63%)	1 (0.16%)	4 (0.63%)	5 (0.78%)
Total	612 (100%)	4 (0.63%)	13 (2.02%)	17 (2.65%)
		17 (2.65%)		

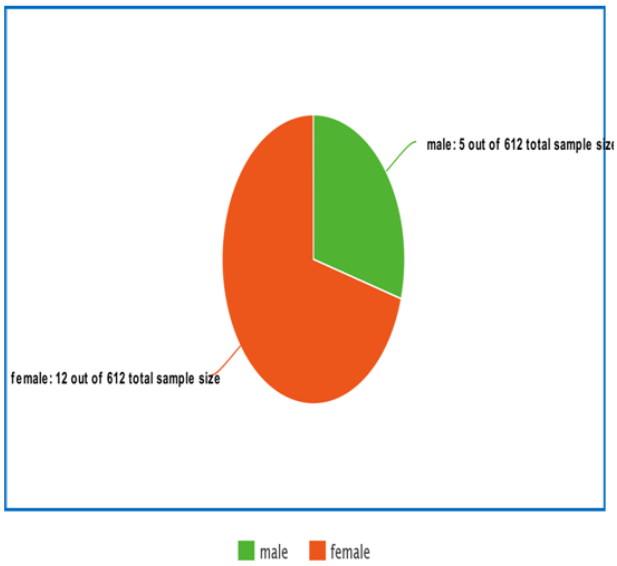


Figure 2: shows the gender frequency of distribution of metopisim

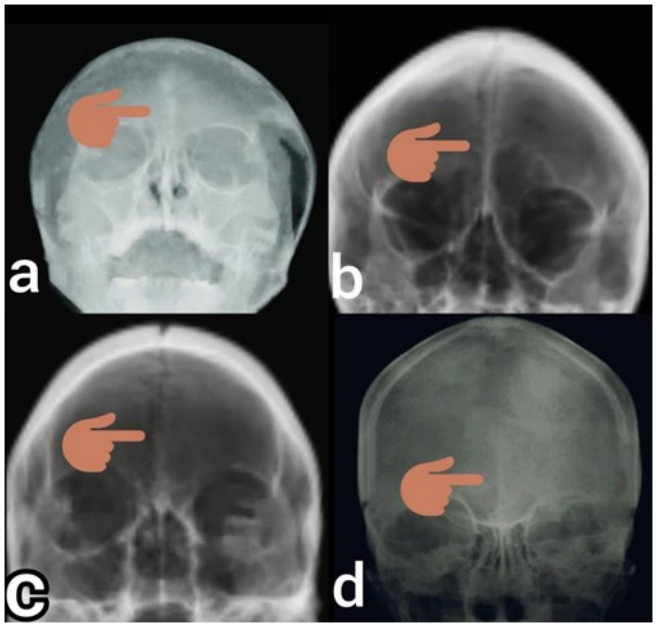


Figure 3: PA; posterior-anterior or OF; occipito-frontal (Caldwell) views of complete-persisting mitopic suture (complete metopisim) in; -a- 14 years old female -b- in 12 years old male –c- 45 years old female –d- 61 years old male

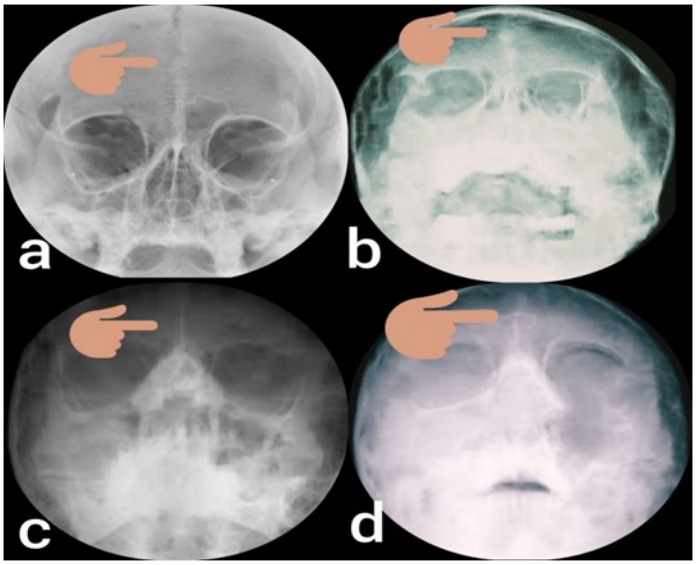


Figure 4: posterior-anterior or OF; occipito-frontal (Caldwell) views of incomplete-persisting mitopic suture (partial metopisim) in; -a- 21 years old male with BIMT subtype, -b- in 59 years old female also with BIMT subtype–c- 63 years old male –d- 461 years old female with NIMT subtype

Discussion

The growth, development and expansion of the infant's brain are highly reliant on the sutures and fontanelles also due to their limited flexibility the cranial bones can overlap one another during normal delivery or child birth thus preventing the baby's head from pressing against the baby's brain and causing damage [11, 12, 13]. Prenatally the metopic or frontal suture is normally present between the two compartment s of the frontal bone as sagittal sinus's anterior extension but at some point and after completing its task it must fuse and get closed [1,2,4,6]. The timing for closure of the metopic or frontal suture is highly debatable and still sort of controversial and seems to have ethnic or inter-racial variations and across the provided medical literature both old and current, the normal closure time for this par-

ticular suture seems to be ranged from 2 to 8 years and in some studies it goes as high as 10 years and it's been established that any suture that persists beyond 10 years is regarded as a case of metopsim [6,8, 9, 14, 15.]

In the current study we found the incidence of the metopism among the local Kurdish population of Erbil city to be (2.65 %) and it was relatively more incident in females than males; 1.87 % and 0.78% respectively, Bademci *et al* and Levine *et al* also found it to be more frequent in females than males yet [7, 12.], while Bryce &Young found it to be more frequent among male populations[8]. According to (Carolinberry & Berry) the incidence of metopsim globally from the international data surveys ranges from less than 1 % to approximately up to 12 % based on many influencing factors seemingly ethnicity is the major one [9,10,11 13] with incomplete metopic suture being reported to be greatly more incident than complete type among most ethnic groups[10,14,13] which was the same as the findings of our study. According to the majority of authors who studied metopism its incidence, variations in its types, shape and pattern aregreatly influenced by ethnicity and race as the rate or frequency turned out to be high among some ethnic populations while in certain others the rate declines to less than 1% [10,14,15,18.]

The rate varies internationally across different populations and ethnic groups from less than 1% among the Lebanese[20], 2-2.7 % among Negros's[15], 3.4 % to 4.6% among Chinese and east Asians[16,21],4.7 among the Japanese[17], 4.8% in Australians[8], just 5.3 % Nigerians[15], 4.8 % in Brazilians[10], 5-5.6 % cross different Indian populations[14], 7-10 in European populations[5]other studies reported 8.3 % in western Europeans[5.9,11], 9.7 % in Scottish in particular[6] and approximately 11.2 % among Mongoloids[21], the rate goes as high as 13.1 % among south Polynesians in particular according to one study [9,18].Table -2- is summarizing the frequency of metopsim across different ethnic groups.It also worth's mentioning that Caffey et al. reported that metopism persisted up to the 6th year and even throughout life in about 10% of cases in skull studies [11].

When it comes to etiology; the causative factors of metopisim are still unclear and it is still debatable and controversial at the same time Manzaranes et al., demonstrated that the active resorption process carried out by the chondroid tissue is what causes sutural closure and keeps the sutural area open [6]. Levine et al., showed the essential role of the DMSC (dura mater-suture complex) in assessing the patency of metopic sutures using animal models [11.] It has been noted that some cytokines appeared to express themselves more strongly during active cranial suture fusion, according to Nikolova *et al.*, and most and osteoclastic resorption is preserving the sutural fissure's open states [19]. Finally, why the fusion of the two frontal bones occurs while the other sutures in the skull remain!? That was a critical question raised firstly by Torgersen and their justification for their own question was that the two prenatal compartments of the frontal bone of the fetus drifted away as two by the sutural space, which is composed of fibrous tissue and mesenchymal cells that are believed to be responsible for the growth of frontal bones and later differentiate either into bone or cartilage [18].

Several authors have proposed the hypothesis that persisting metopic suture could be related to or exist along other anatomical variations especially those that occur in frontal bone like frontal sinus aplasia and hypoplasia or even hyperplasia (same as our findings; as shown in***figures 3***) it also could be related to a variety of medical conditions like the abnormal growth of cranial bones to even an a metopism that is triggered by other causes like; growth interruption, hydrocephalus, sexual influence, heredity factors , stenocrotaphia, heterospecific factors, atavism, scaphocephaly, plagiocephaly, even mechanical causes and hormonal dysfunction [12,13,16,19]. Genetics could also

influence metopism as has been proposed by Torgersen [18].

It's of crucial importance to identify the metopic suture persistence and its interracial and ethnic diversity as its existence presence could be mistaken and misdiagnosed as a vertical or an oblique cranial fracture upon assessments of radiological images.

Conclusion:

The present study provides data on prevalence of persisting metopic/ frontal suture among the Kurdish population in KRG of Iraq which could help the involved medical specialties (radiologists, neurosurgeons, maxilla-facial surgeons, E.N.T. specialists ….etc.) to keep in their mind that this rare anatomical variant could exist and they might encounter it with just about any patient also to help them differentiate between vertical frontal bone fractures and a persisting metopic suture (especially at emergency settings) in assessing any forms of head trauma patient or during craniotomy procedures through the frontal bone. Further research is needed at molecular and sub-molecular levels by the embryologist and molecular biologists to make the etiology of persisting metopic sutures much clearer.

Conflict of interest

The author reported no conflict of interests.

References

Table 2: showing the frequency of metopism across different ethnic groups by different authors

Author(s)/ researcher(s)	*Ethnic groups/ race*	*n (sample seize)*	*Frequency of metopisim / %*
Our resrearch.	Kurdish	613	2.65
Batan et al	Lebanese	325	0.87
Ajmani / Carolinberry & Berry	Africans mixed	822-917	2.1-2.7
Kim and Woo	Chinese and east Asians	753-1106	3.4-4.6
Qui et al	Japanese	631	4.7
Young and Brice	Australians	322	4.8
Mittel et al	Nigerians	956	3.4
Delois et al	Brazilians	652	4.8
Das et al	Indians/mixed	1246	3.31
Sommer and Hoffmann	Europeans/ mixed	210-345	7.3- 10.1
Caffey et al	Western Europeans	312	8.3
Manzanares	Scottish	195	9.7
Woo J K	Mongoloids	295	11.2

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