Incidence and Variation of Interpretably Bone (Os Incae) in Northeastern Thailand

Chaiwit Thanapaisal MD*,
Pichayen Duangthongpon MD*, Amnat Kitkuandee MD*,
Kowit Chaiciwamongkol MD**, Vilaiwan Morthong MD**

** Division of Neurosurgery Department of Surgery, Faculty of Medicine, Khon Kaen University, Khon Kaen, Thailand*
*** Department of Anatomy, Faculty of Medicine, Khon Kaen University, Khon Kaen, Thailand*

Background: *The squamous segment of occipital bone consists of cartilaginous and membranous origin. The cartilaginous part develops to supra-occipital bone. The membranous part has three primary ossification centers on each side. The first pair ossification center lies above the cartilaginous part between the superior nuchal line and the highest nuchal line and fuse with the cartilaginous part to form a supra-occipital segment of occipital bone. The second and third pairs have two nuclei each forming lateral and medial plates. All of these ossification centers fuse to form squamous segments of occipital bone. The fusion failure between ossification centers of second and third pair nuclei with each other or supra-occipital segment causes separated bone(s) called interparietal bone(s) or os incae. The interparietal bone should be differentiated from Wormian (intrasutural) bone. The incidence from various studies ranges from 0.37% to 9.50% of the population.*
Objective: *To study the incidence and variation of interparietal bone in Northeastern Thailand as compared with other studies.*
Material and Method: *A total of 400 Thai native skulls (276 male and 124 female) from the collection of Anatomical Museum of the Faculty of Medicine Khon Kaen University aged from 16 to 93 years old were examined by naked eye and photographed. Wormian bone was excluded by shape and site. The statistical method used was percentage of relative frequency.*
Results: *The incidence of interparietal bone in Northeastern Thailand is 7.25% (29 from 400). Males have a two times higher incidence rate than females, (8.33% versus 4.84%). Eleven patterns of interparietal bone were found. Fusion failure of a third pair ossification center is more common than second pair.*
Conclusion: *Knowledge of interparietal bone is useful for neurosurgeons and radiologists to avoid missed diagnosis of skull fracture. Presented interparietal bone may cause difficulty in surgery of occipital and parietal bone. Forensic scientist can use interparietal bone for personal identification.*

Keywords: *Interparietal bone, Os incae, Thailand*

J Med Assoc Thai 2013; 96 (Suppl. 4): S117-S123
Full text. e-Journal: *http://jmat.mat.or.th*

The occipital bone has dual origin from cartilaginous and membranous ossification. It develops in four parts: basiocciput, right and left exocciput and squamous segments. The first three segments have cartilaginous origin. The squamous segment consists of cartilaginous and membranous origin. The cartilaginous part develops in the supra-occipital bone. The membranous part has three primary ossification centers on each side[1-3]. Occipital bone ossification starts at fourth fetal month[4,5]. The first pair ossification center lies above cartilaginous part between the superior nuchal line and the highest nuchal line is known as torus occipitalis transverses or intermediate segment. These centers fuse with the other side and cartilaginous part to form a supra-occipital part of occipital bone. The second pair ossification center lies above the first pair and have two nuclei on each side of the medial and lateral forming a lateral plate. Medial nucleus fuses with the first pair ossification center early while lateral nucleus is separated and forms lateral fissure or mendosal suture. The third pair ossification center lays in vertical orientation with two nuclei superior and inferior segments(?) forming a medial plate. The second and third pairs fuse together to form interparietal bone[1] (Fig. 1).

Interparietal bone of marsupials and alligators is separated from parietal and occipital bone but unites with parietal bones in a sea cow. In human and most mammals the interparietal bone fuses with the supra-occipital part to form a squamous segment of occipital bone[3].

Correspondence to:
Thanapaisal C, Department of Surgery, Faculty of Medicine, Khon Kaen University, Khon Kaen 40002, Thailand.
Phone & Fax: 043-363-123
E-mail: Chaiwit@kku.ac.th

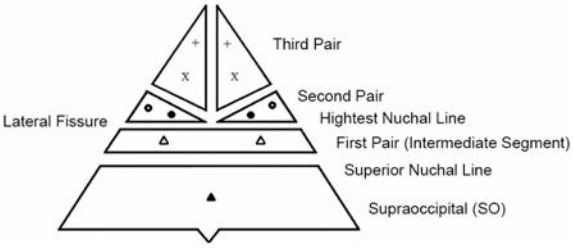

Fig. 1 Diagram of ossification centers and nuclei of occipital bone.
+ superior nucleus of third pair X inferior nucleus of third pair.
○ lateral nucleus of second pair ● medial nucleus of second pair.
△ nucleus of first pair ▲ center of cartilaginous bone.

The fusion failure between ossification centers of second and third pair nuclei with each other or supra-occipital bone causes separated bone(s) called interparietal bone(s) or os incae. The interparietal bone should be differentiated from wormian (intrasutural) bone by shape and site. Wormian bones lie within the cranial sutures or frontanelle and appear in additional ossification centers mostly along lambdoid suture. The mendosal suture normally fuses prior to birth but may remain in adult[6-9].

Brief history

Olaus Wormius (1671) the Danish anatomist wrote a letter to Thomas Bartholin in which he mentioned bone in suture line of skull. Bartholin named it os wormianum (wormian bone). Bartolomeo Eustachi (1744) described additional suture at occipital area and drew a picture from Albinus. Geoffroy Saint-Hilaire (1823) had studied skulls from museum and reported additional bone behind parietal bones and called os interparietale (interparietal bone). Bellamy (1842) described transverse suture at the occipital area of a mummy skull from Peru. Tschudi (1844) studied a number of skulls from Peru and found the same evidence and named os incae. There are a number of terms used to describe this bone: interparietal bone, os incae, os transversum crania, os epactale, os interparietale. The popular names are interparietal bone and os incae[3].

Material and Method

A total of 400 Thai native skulls (276 male and 124 female) from the collection of Anatomical Museum of Khon Kaen University aged from 6 to 93 years old were examined with the naked eye and photographed. Wormian bone was excluded by shape and site. The statistical method used was a percentage relative to frequency. In the present study the incidence and variation of interparietal bone in Northeastern Thailand has been studied and compared with other studies.

Results

The interparietal bones were founded in 29 from 400 skulls (7.25%). In male skulls, 23 from 276 interparietal bones were found with an incidence of 8.33% and 6 from 124 in female skulls with the incidence of 4.84%.

The 29 skulls with interparietal bones have 11 patterns.

Pattern 1 was found in skull number 5, 52, 153, and 276. Both superior nuclei of third pair fused together but failed to fuse with the rest and created horizontal suture close to lambda. The authors would like to name “superior transverse suture”. The skull number 276 in Fig. 2 shows one wormian bone in right lambdoid suture.

Pattern 2 was found in skull number 74, 165, 203, and 342. Both superior and inferior nuclei of third pair fused together but failed to fuse with the rest and a created diamond-shape bone. The skull number 74 in Fig. 2 shows one wormian bone in lambdoid sutures.

Pattern 3 was found in skull number 56, 105, 272, and 358. Additional “median vertical suture” to pattern 2 from lambda to superior transverse suture was observed which separated right superior and inferior nuclei from the other side.

Pattern 4 was found in skull number 154. Both superior nuclei and left inferior nucleus of third pair fused together but failed to fuse with the rest.

Pattern 5 was found in skull number 40, 155, and 220 and is the mirror image of pattern 4.

Pattern 6 was found in skull number 291. Lateral nucleus of left second pair failed to fuse with the rest.

Pattern 7 was found in skull number 183, 274, 286 which is the mirror image of pattern 6.

Pattern 8 was found in skull number 41, 152, 195, 289, and 301. All nuclei of second and third pair fused together but failed to fuse with intermediate segment which developed from first pair and created “inferior transverse suture” at the level of highest nuchal line. This pattern is classical interparietal bone or Os Incae and the most common in the present study.

Pattern 9 was found in skull number 161 and 337. This pattern is like pattern 8 with additional “lateral vertical sutures” on both sides, separated by lateral

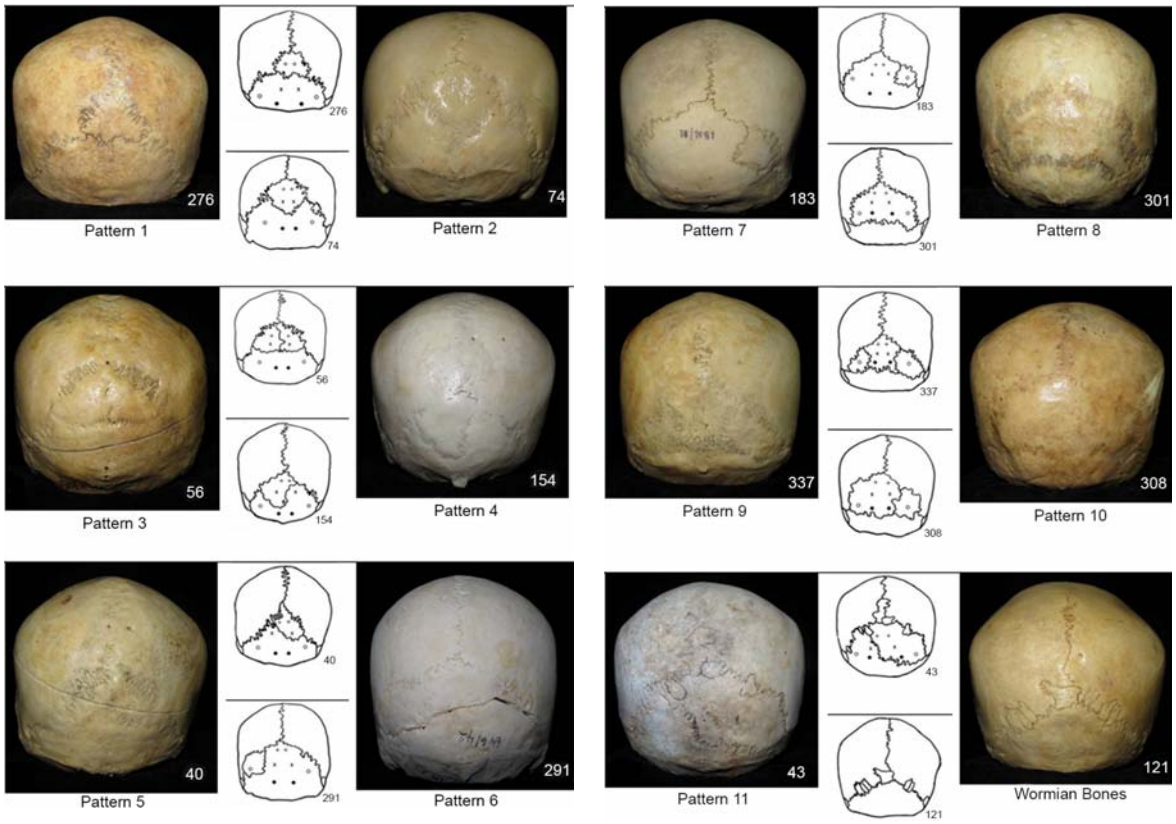

Fig. 2 Example of each pattern of interparietal bones and wormian bones.

nuclei of both right and left second pair to another piece of bones.

Pattern 10 was found in skull number 308 and like pattern 8 with one "lateral vertical suture" on the right side.

Pattern 11 was found in skull number 43. Both superior and right inferior nuclei of third pair fused with medial and lateral nuclei of second pair but failed to fuse with the left inferior nucleus of second pair and left second pair nuclei. The skull number 43 in Fig. 2 shows two wormian bones in right, three in left lambdoid sutures and one in sagittal suture.

The other picture showed example of wormian bone in both lambdoid and sagittal sutures.

Pattern 1-5, 6, 7, 8-11 are failures of fusion of third pair, second pair and both pair ossification centers, respectively. Pattern 4-7 and 10 are asymmetric. Asymmetric patterns had 10 from 29 skulls with the incidence of 34.48%.

Discussion

The brain of cyclostomes is protected by one single cartilage. In the line of evolution, bony scale of fishes derived from membranous bone and cover roof of cranium. Remarkable growth of cerebral cortex expands the membranous roof of the skull. The cartilaginous bone in origin covers only floor and lower back of the brain. Phylogenetically, interparietal bone fuse with parietal bone in sea cows, fuse with both parietal and occipital bones in rats, is separated from both bones in birds and alligators. In human and most mammals, interparietal bone fuses with the supra-occipital part to form squamous segment of occipital bone[1,3].

Ranke (1913) described two pairs of ossification centers of membranous occipital bone with occasionally the third pair (pre-interparietal) at the superior angle[10]. Srivastava (1977) confirms three-pair center described by Ranke[6]. Pal (1984) pointed out that "pre-interparietal" is misleading and its use should be discontinued[8].

According to Srivastava[6,7] and Matsumuro et al[4,50], the intermediate segment which lays between the superior nuchal line and the highest nuchal line is developed from the first pair ossification center of membranous bone origin and always fuses with

cartilaginous bone in origin to form a supra-occipital segment. The second pair above the first pair has medial and lateral nuclei in horizontal orientation forming a lateral plate. Medial nuclei fused earlier, lateral nuclei are separated from the intermediate segment by lateral fissure or mendosal suture which is clearly demonstrated in the fetus. The mendosal suture is closed after birth. The third pair is vertical orientation and also has two nuclei superior and inferior forming a medial plate. Interparietal bone is formed by fusion of nuclei of second and third pair ossification centers. The failure of fusion between ossification centers of second and third pair nuclei with each other or the supra-occipital bone causes separated bone(s) called interparietal bone(s) or os incae. There are varieties of interparietal bone with limited classification.

The incidence of interparietal bone is high in sub-Saharan Africa, northeast India and low in west Asia, Europe and Australia[11] ranging from 0.37% to 9.50% (Table 3) with exceptional high 27.10% in pre-historic Chile[12]. The skull with interparietal bone has more frequent wormian bone[13]. The present of interparietal bone is increased in association with coronal, metopic but not sagittal synostosis[14]. The present of interparietal bone can be misinterpreted as skull fractures[15-17].

In the present study the incidence of interparietal bone is 7.25%. Males have a two-times-higher rate than females (8.33% and 4.84%). Eleven patterns of interparietal bone were found in the present

Table 1. Incidence of Interparietal bone

	Number	Interparietal bone	Percentage
Male	276	23	8.33
Female	124	6	4.84
Total	400	29	7.25

Table 2. Interparietal bone by sex and ossification center

Ossification center	Male		Female		Total	
	Number (276)	Percentage	Number (124)	Percentage	Number (400)	Percentage
Fusion failure						
Third pair	13	4.71	3	2.42	16	4.00
Second pair	3	1.09	1	0.81	4	1.00
Second and third pair	8	2.90	1	0.81	9	2.25

Table 3. Interparietal bones from various study

Publication year	Authors	Country	Numbers	Percentage
1977	Shrivastava[6]	India	620	0.80
1978	Malhotra[18]	India	1,500	0.37
1979	Singh et al[19]	India	500	1.60
1984	Pal et al[8]	India	348	2.60
1985	Cireli et al[20]	Turkey	150	4.00
1986	Saxena et al[21]	Nigeria	40	2.50
1990	Magden & Muftuoglu[22]	Turkey	420	1.60
1992	Gopinathan[23]	India	125	0.80
1993	Aycan[24]	Turkey	91	6.60
1995	Katkici & Gumusburum[25]	India	302	0.99
1998	Yucel et al[26]	Turkey	540	2.80
2001	Zambare[27]	India	310	0.99
2010	Marathe et al[28]	India	380	1.30
2010	Da Mata et al[29]	Brazil	104	1.92
2011	Kumud[30]	India	150	2.70
2011	Bhanu et al[31]	India	84	9.50
2013	Present study	Thailand	400	7.25

study. Patterns 1-5 are failures of fusion of third pair, patterns 6-7 are failures of fusion of third pair and patterns 8-11 are failures of fusion of both pairs. Most of the interparietal bones have symmetric patterns, 19 from 29 skulls with the incidence of 65.52%. Asymmetry was found in pattern 4-7 and 10 and has 10 from 29 skulls with the incidence of 34.48%. The ratio of symmetry and asymmetry is 2:1.

Conclusion

Knowledge of interparietal bone is useful for neurosurgeons and radiologists to avoid missed diagnosis of skull fractures. Presented interparietal bone may cause difficulty for surgery on occipital and parietal bone. Forensic scientists can use interparietal bone for personal identification.

Acknowledgement

The authors wish to thank the Department of Anatomy for permitting access to skulls in the Museum and the Center of Cleft Lip-Cleft Palate and Craniofacial Deformities, Khon Kaen University in association with the "Tawanchai Project" for publication support.

Potential conflicts of interest

None.

References

1. Williams PL, Bannister LH, Berry MM, Collins P, Dyson M, Dessek LE, et al. The skull. In. Gray's anatomy. 38th ed. London: Churchill Livingstone; 1995: 583-606.
2. Shapiro R, Robinson F. Embryogenesis of the human occipital bone. AJR Am J Roentgenol 1976; 126: 1063-8.
3. Shapiro R, Robinson F. The os incae. AJR Am J Roentgenol 1976; 127: 469-71.
4. Matsumura G, Uchiumi T, Kida K, Ichikawa R, Kodama G. Developmental studies on the interparietal part of the human occipital squama. J Anat 1993; 182: 197-204.
5. Matsumura G, England MA, Uchiumi T, Kodama G. The fusion of ossification centres in the cartilaginous and membranous parts of the occipital squama in human fetuses. J Anat 1994; 185: 295-300.
6. Srivastava HC. Development of ossification centres in the squamous portion of the occipital bone in man. J Anat 1977; 124: 643-9.
7. Srivastava HC. Ossification of the membranous portion of the squamous part of the occipital bone in man. J Anat 1992; 180: 219-24.
8. Pal GP, Tamankar BP, Routal RV, Bhagwat SS. The ossification of the membraneous part of the squamous occipital bone in man. J Anat 1984; 138: 259-66.
9. Pal GP. Variations of the interparietal bone in man. J Anat 1987; 152: 205-8.
10. Ranke, J. Uber das Interparietale und die Verknocherung des Schadeldachs bei Affen. S. B. Bayer Akad Wiss 1913: 223-69. Cited by Schafer EA, Symington J, Bryce TH. Quain's elements of anatomy. Vol. IV, Part I. 11th ed. London: Longman, Green; 1915: 53-55.
11. Hanihara T, Ishida H. Os incae: variation in frequency in major human population groups. J Anat 2001; 198: 137-52.
12. Garcia-Hernandez F, Murphy-Echeverria G. Frecuencia del hueso interparietal o incaico en craneos atacamenos (licanantai) prehispanicos del norte de chile. Int J Morphol 2008; 26: 629-34.
13. Das S, Suri R, Kapur V. Anatomical observations on os inca and associated cranial deformities. Folia Morphol (Warsz) 2005; 64: 118-21.
14. Wu JK, Goodrich JT, Amadi CC, Miller T, Mulliken JB, Shanske AL. Interparietal bone (Os Incae) in craniosynostosis. Am J Med Genet A 2011; 155A: 287-94.
15. Fujita MQ, Taniguchi M, Zhu BL, Quan L, Ishida K, Oritani S, et al. Inca bone in forensic autopsy: a report of two cases with a review of the literature. Leg Med (Tokyo) 2002; 4: 197-201.
16. Choudhary AK, Jha B, Boal DK, Dias M. Occipital sutures and its variations: the value of 3D-CT and how to differentiate it from fractures using 3D-CT? Surg Radiol Anat 2010; 32: 807-16.
17. Sanchez T, Stewart D, Walvick M, Swischuk L. Skull fracture vs. accessory sutures: how can we tell the difference? Emerg Radiol 2010; 17: 413-8.
18. Malhotra VK, Tewari PS, Pandey SN, Tewari SP. Interparietal bone. Acta Anat (Basel) 1978; 101: 94-6.
19. Singh PJ, Gupta CD, Arora AK. Incidence of interparietal bones in adult skulls of Agra Region. Anat Anz 1979; 145: 528-31.
20. Cireli E, Ustun EE, Tetik S. Os occipitale varyasyonlarive radyolojik Ozellikleri. Ege Universities Tip Faultesi Dergisi 1985; 24: 3-35.
21. Saxena SK, Chowdhary DS, Jain SP. Interparietal bones in Nigerian skulls. J Anat 1986; 144: 235-7.
22. Magden O, Muftuoglu A. Insan democraniumunda sutural ve epectal kemiklerin varyasyonlari.

Istanbul Universities Cerrahpasa Tip Fakultesi Dergisi 1990; 21: 319-23.
23. Gopinathan K. A rare anomaly of 5 ossicles in the pre-interparietal part of the squamous occipital bone in north Indians. J Anat 1992; 180: 201-2.
24. Aycan K. Development of Interparietal bones and their variations. Erciyes Universities Saglik Billimleri Dergisis 1993; 2: 70-6.
25. Katkici U, Gumusburun E, Erdil H, Sevim A, Gulec E. A study of incidence of the interparietal bone. J Anat Soc India 1995; 44: 1-17.
26. Yucel F, EGilmez H, Akgun Z. A Study on the interparietal bone in man. Tr J Med Sci 1998; 28: 505-9.
27. Zambare BR. Incidence of interparietal bones in adult skulls. J Anat Soc India 2001; 50: 11-2.
28. Marathe R, Yogesh A, Pandit S, Joshi M, Trivedi G. Inca - interparietal bones in neurocranium of human skulls in central India. J Neurosci Rural Pract 2010; 1: 14-6.
29. Da Mata JR, Da Mata FR, Aversi-Ferreirs TA. Analysis of bone variations of the occipital bone in man. Int J Morphol 2010; 28: 243-48.
30. Kumud D. Os incae morphologic, clinical and medicolegal perspectives. J Anat Soc India 2011; 60: 218-23.
31. Bhanu PS, Sankar KD. Interparietal and pre-interparietal bones in the population of south coastal Andhra Pradesh, India. Folia Morphol (Warsz) 2011; 70: 185-90.

อุบัติการณ์และรูปแบบของกระดูกอินเตอร์พาไรทอล (กระดูกอินคา) ในภาคตะวันออกเฉียงเหนือประเทศไทย

ไชยวิทย์ ธนไพศาล, อำนาจ กิจควรดี, พิชเยนทร์ ดวงทองพล, โกวิท ชัยศิวามงคล, วิไลวรรณ หม้อทอง

ภูมิหลัง: *กระดูกออกซิปิทอลส่วนสแควร์มัส ประกอบด้วยกระดูกที่เจริญมาจากกระดูกอ่อนและกระดูกแบน ส่วนที่เป็นกระดูกแบนมีจุดกำเนิดกระดูกสามชุดในแต่ละข้าง คู่แรกอยู่เหนือส่วนที่เป็นกระดูกอ่อนระหว่างเส้น ซูพิเรียนิวคอลและเส้นไฮเอสนิวคอล เชื่อมกันเป็นส่วนซุปราออกซิปิทอลของกระดูกออกซิปิทอล คู่ที่สองและสาม แต่ละข้างจะมีสองนิวเคลียสซึ่งเจริญไปเป็นแผ่นด้านข้างและด้านใน จุดกำเนิดกระดูกที่กล่าวมาทั้งหมดจะเชื่อมกันเป็น กระดูกออกซิปิทอลส่วนสแควร์มัส ความล้มเหลวของการเชื่อมระหว่างจุดกำเนิดกระดูกคู่ที่สองและสาม ทำให้เกิดชิ้นกระดูกที่แยกออกมาเรียกว่า กระดูกอินเตอร์พาไรทอล หรือกระดูกอินคา ซึ่งต้องแยกจากกระดูกวอร์เมี่ยนซึ่งอยู่ในซูเจอร์ อุบัติการณ์ของกระดูกอินเตอร์พาไรทอล จากการศึกษาต่าง ๆ อยู่ระหว่างร้อยละ 0.37 ถึง 9.50 ของประชากร*

วัตถุประสงค์: *เพื่อศึกษาอุบัติการณ์และรูปแบบของกระดูกอินเตอร์พาไรทอล ของประชากรในภาคตะวันออกเฉียงเหนือของประเทศไทยและเปรียบเทียบกับการศึกษาอื่น ๆ*

วัสดุและวิธีการ: *เป็นการศึกษาจากกะโหลกศีรษะจำนวน 400 กะโหลก (เพศชาย 276 และเพศหญิง 124) จากพิพิธภัณฑ์กายวิภาคศาสตร์ของคณะแพทยศาสตร์มหาวิทยาลัยขอนแก่นอายุ 16-93 ปี โดยการดูจากตาเปล่าและถ่ายภาพ แยกจากกระดูกวอร์เมียนโดยรูปร่างและตำแหน่ง สถิติที่ใช้เป็นร้อยละและความถี่*

ผลการศึกษา: *อุบัติการณ์ของกระดูกอินเตอร์พาไรทอล ของประชากรในภาคตะวันออกเฉียงเหนือของประเทศไทย คือ ร้อยละ 7.25 (29 จาก 400) เพศชายมีอุบัติการณ์ สูงเป็นสองเท่าต่อเพศหญิง (ร้อยละ 8.33 และ ร้อยละ 4.84) มีรูปแบบที่พบ 11 รูปแบบ ความล้มเหลวของการเชื่อมของจุดกำเนิดของกระดูกคู่ที่ 3 พบได้บ่อยกว่าคู่ที่ 2*

สรุป: *ความรู้เรื่องกระดูกอินเตอร์พาไรทอล เป็นประโยชน์กับรังสีแพทย์และประสาทศัลยแพทย์ ที่จะป้องกัน ไม่ให้วินิจฉัยกะโหลกศีรษะแตกผิดพลาดและใช้ในการทำผ่าตัดของช่องสมองเล็ก กระดูกพาไรทอลและออกซิปิทอล นักมานุษยวิทยาสามารถใช้เพื่อการศึกษาวัฒนธรรม และนักวิทยาศาสตร์นิติเวชสามารถใช้ในการระบุตัวบุคคลได้*