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THE HUMAN SPHENO-OCCIPITAL SYNCHONDROSIS

I. THE TIME OF CLOSURE APPRAISED MACROSCOPICALLY

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The spheno-occipital synchondrosis and clivus in 32 males and 21 females, aged 2 days to 24 years 11 months, were studied *post mortem* to ascertain the time of closure of the synchondrosis. The material studied consisted of the major part of the clivus and dorsum sellae, which were decalcified and serially sectioned in the sagittal plane. The first sign of closure of the synchondrosis was the appearance of a bony bridge in the superior part. Closure was found to occur about 2 years earlier in girls than in boys. The synchondrosis was never completely open in any of the females above 13 years 9 months, the corresponding age for the boys was 16 years. The major part of the dorsum sellae of preparations from young subjects consisted of cartilage and minor cartilaginous areas were seen in almost all preparations from subjects below 17 years and occasionally also from subjects above this age.

The spheno-occipital synchondrosis is regarded as an important growth centre of the cranio-facial skeleton (*Björk*, 1955; *Ford*, 1958; *Scott*, 1958 a; *Stramrud*, 1959; *Koski*, 1960). Being derived from the fetal chondro-cranium it should be an active, expansive growth centre because of its tissue-separating power (*Baume*, 1958, 1961; *Petrovic*, 1969). Some authors, however, believe the growth of the synchondrosis to be passive and to be dependent on stimulation by the expanding brain (*Koski*, 1960, 1968; *Rönning, Paunio & Koski*, 1967) in accordance with the theory of Moss (*Moss & Salentijn*, 1969).

No matter whether the spheno-occipital synchondrosis is an active growth centre or not, it can influence the cranio-facial growth only as long as it is open. But the few opinions on the actual time of closure of the synchondrosis differ substantially from one another. In Homo the problem has been studied on skull materials and roentgenographically *intra vitam*. Closure is widely believed to occur late in the growth period, *i.e.*, at 20—25 years

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(*Ford*, 1958) or at 17—20 years (*Scott*, 1958 b). Tomographic studies by *Irwin* (1960) and by *Powell & Brodie* (1963), however, suggest that incipient closure of the synchondrosis already may be diserned at the beginning of puberty. Using indicators and roentgen cephalometry on Indian skulls *Melsen* (1969) found that closure of the synchondrosis occurs in the interval between eruption of the second and the third molars, *i.e.*, at a time later than that given by *Irwin* and by *Powell & Brodie*.

It is thus obvious that no unanimity has been achieved on the time of closure of the spheno-occipital synchondrosis. This may be explained to some extent by ethnic differences between the materials studied and by the use of different methods. In investigations of skull materials the age and sex distribution is uncertain and in living individuals it is difficult to determine the time of closure with certainty. The most reliable method appears to be histological examination.

It was against the background of the above considerations that the present gross histological investigation of the time of closure of the spheno-occipital synchondrosis was undertaken.

MATERIAL AND METHODS

The material consisted of preparations from 53 subjects (32♂ and 21♀), aged 2 days to 24 years 11 months (Table I).

Table I.

Age and sex distribution of subjects from whom preparations were obtained

Group	Age Years, months	♂	♀
I	0.0— 4.11	8	8
II	5.0— 9.11	6	1
III	10.0—14.11	4	4
IV	15.0—19.11	7	3
V	20.0—24.11	7	5
Total		32	21

The material included no preparations from subjects who had died from diseases that might be thought to affect growth. Most of the deaths were due to some sort of accident.

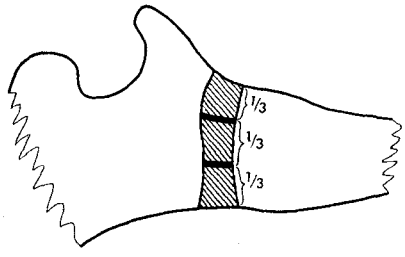


Fig. 1. Sites of measurement of width of synchondrosis.

The preparations, which usually consisted of the major part of the clivus and of dorsum sellae, were fixed in neutral formalin and decalcified in 50 per cent formic acid and 15 per cent sodium formiate. Serial sections were cut in the sagittal plane. Seven successive sections (12 μ) were stained with haemalun — eosin (Mayer) resorcin fuchsin (Weigert), picrofuchsin (van Gieson), azan (Heidenhain), htx-eosin (Bock), toluidine blue and with periodic acid (Schiff reaction).

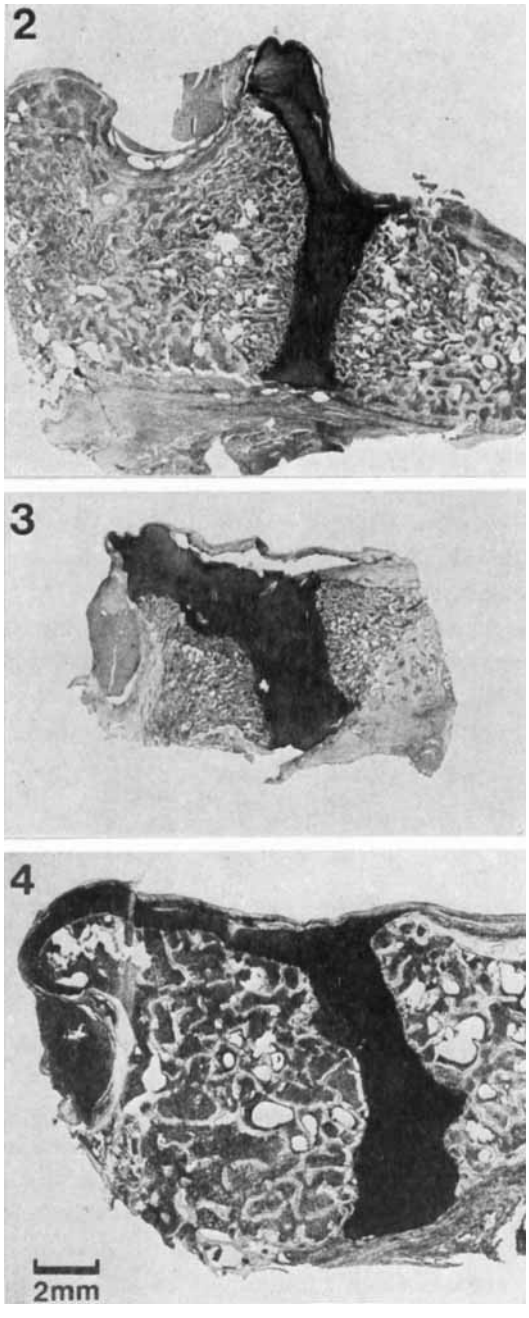
Sections from the medial part of the synchondrosis stained with toluidine blue were photographed in 4 times enlargement. The width of the synchondrosis was measured on the photographs at two sites (Fig. 1). The measurements were made to the nearest tenth of a millimeter with sliding calipers.

RESULTS

In the lowest two groups (0—10 years) the synchondrosis was invariably open. The individual widths varied from 1.5 mm to 3.0 mm (average: about 2.0 mm). In the youngest individuals (<1 year) there was a broad layer of cartilage between the synchondrosis and the dorsum sellae (Fig. 2). In newborns this cartilaginous layer was almost as wide as the synchondrosis (Fig. 3), but became narrower with increasing age (Fig. 4). In most of the cases in group II (5—10 years) it was incomplete.

Of the females in group III, the synchondrosis was open in two (10 years, average width 1.4 mm), closed in one (13 years 9 months), and it was just beginning to close in one (13 years 10 months). On the other hand, it was open in all 4 males (aged 10 years 6 months to 14 years 11 months) and had an average width of about 1.5 mm.

As for group IV, the synchondrosis was closed in all of the females (the youngest 15 years 8 months). Of the males, incipient closure was observed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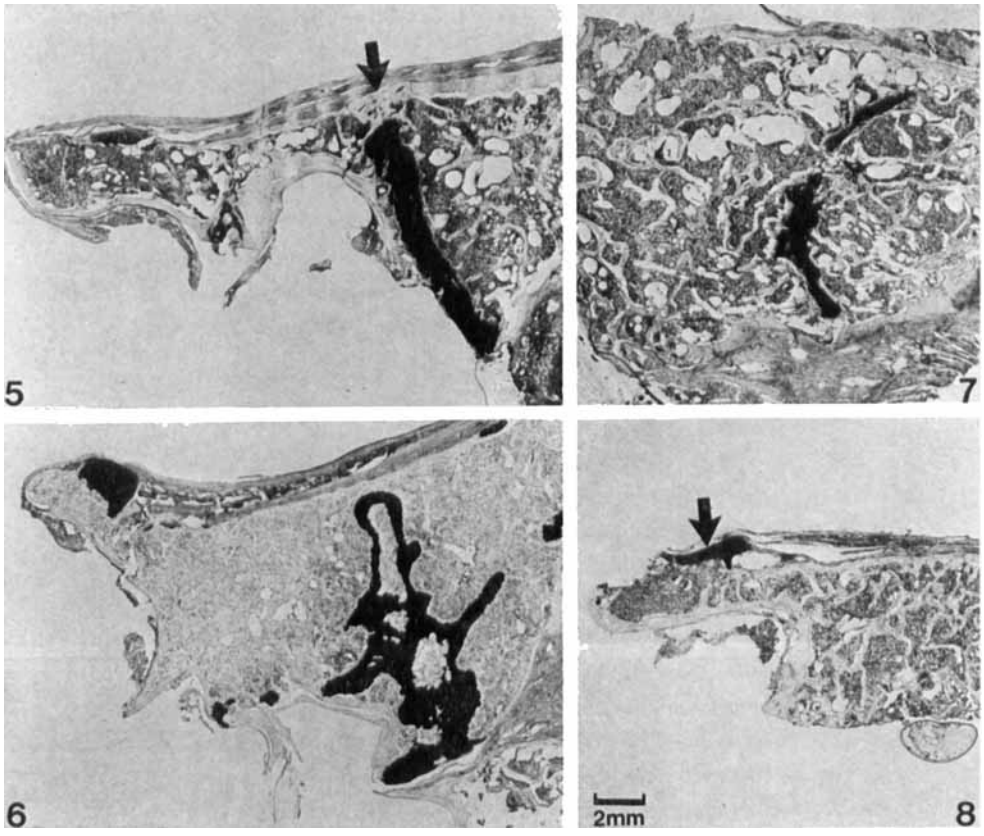

Fig. 2. Spheno-occipital synchondrosis and sella turcica in 7 month old boy. Toluidine blue, × 4.

Fig. 3. Spheno-occipital synchondrosis in 3 day old boy. Observe the broad cartilaginous layer between the synchondrosis and dorsum sellae. Toluidine blue, × 4.

Fig. 4. Spheno-occipital synchondrosis and dorsum sellae in 3 year old boy. Toluidine blue × 4.

Fig. 5. Incipient closure of synchondrosis in 16 year old boy. Note the bony bridge (arrow) in the superior part of the synchondrosis. Residual cartilaginous fragments on the dorsum sellae. Toluidine blue, × 4.

Fig. 6. Closure of synchondrosis in progress in 15 year old girl. Residual cartilaginous fragments from synchondrosis and on dorsum sellae. Toluidine blue, × 4.

Fig. 7. Residual cartilaginous fragments from synchondrosis in 17 year old boy. Toluidine blue, × 4.

Fig. 8. Residual cartilaginous fragments (arrow) on dorsum sellae in 21 year old woman. Toluidine blue, × 4.

at the earliest at 16 years and the synchondrosis was always closed at higher ages (16 years 3 months and older).

In group V (20—25 years) the synchondrosis was invariably closed. Incipient closure was manifested by the development of a bony bridge in the superior part of the synchondrosis (Fig. 5). As closure advanced the cartilage along the entire synchondrosis was replaced by bone. During this process fragments of cartilage were seen temporarily in both the upper and the lower part (Figs. 6 & 7). Minor areas of cartilage on the dorsum sellae were seen in almost all of the preparations from subjects below 17 years and occasionally also in those from older subjects (Fig. 8).

DISCUSSION

The initial sign of closure of the spheno-occipital synchondrosis was the appearance of a bony bridge in its superior part. This is in agreement with *Irwin's* (1960) and *Powell & Brodie's* (1963) observation that the closure of the synchondrosis starts in the superior part and proceeds downwards. The time of this closure varied widely with sex. Thus, incipient closure was seen on one girl, aged 13 years 10 months, and closure was complete in another of the same age. In the boys, it occurred later (16 years). The existence of a difference with sex has been pointed out earlier by *Powell & Brodie* (1963), who reported that closure may occasionally begin at such an early age as 8 years 6 months in girls and 10 years 10 months in boys. No such early closure was found in the present material.

Neither are the present findings compatible with those reported by *Irwin* (1960). He gave no sex difference in time of closure but reported that closure of the superior part of the synchondrosis occurs as early as 11—13 years. The discrepancy can presumably be explained by differences in the methods used; tomography can hardly be as reliable and precise as histology in the investigation of closure of the synchondrosis. The time of closure reported by *Melsen* (1969), *i.e.* after eruption of the second molars and before eruption of the third, is well compatible with the findings in the present investigation since in Scandinavian children the second molars are fully erupted by the age of 12 years 8 months, on the average, in girls and by 13 years 4 months in boys (*Helm*, 1970). The age given by *Ford* (1958) and by *Scott* (1958 b) for the time of closure, (20—25 years and 17—20 years, respectively), however, was much higher.

In the present investigation the sex difference in time of closure was roughly the same as that between the onset of puberty. The maximal pubertal

growth in body height, in the sutures of the upper face, and in the mandibular condyles, occurs, on the average, at 12 years 6 months in girls and at 14 years in boys (*Björk*, 1966). Closure of the spheno-occipital synchondrosis appears to occur 1—2 years after the maximal pubertal growth period and appears to coincide with the time of closure of the epiphyseal line in the distal phalanx of the thumb (*Björk*, 1971).

The present finding that the dorsum sellae contains fragments of cartilage up to adolescent age has previously escaped attention because earlier investigations were carried out on skull preparations or roentgenographically on living persons. *Björk* (1955) found on roentgenograms an increase of the outline of the sella and of the size of the tuberculum and dorsum sellae from 12 to 20 years of age. The increase in size of the tuberculum and the dorsum sellae as seen in the roentgenogram was ascribed to appositional growth. The present findings suggest that the roentgenographically demonstrable increase of the dorsum sellae may be due in part to ossification of cartilaginous fragments in the dorsum sellae.

Closure of the synchondrosis was studied only macroscopically in the present investigation and was judged only from the time the cartilage was replaced by bone. This does not necessarily mean that growth in the synchondrosis continued until that time. Information on this point requires investigation with histological methods and will be the subject of a forthcoming paper.

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