THE PARAMASTOID PROCESS

A survey of 890 Maltese skulls *

J. L. PACE

M.D. (MALTA), B.PHARM., PH.D. (LOND.)

Lecturer, Department of Anatomy, Royal University of Malta.

Summary: A study has been made of the paramastoid process. Its aetiology, incidence, morphological characteristics, its functional significance in animals, and the clinical manifestations it can give rise to are described.

A survey of 890 Maltese skulls revealed the presence of paramastoid process in 18 of them — an incidence of 2.02%. 4 of the cases were of the articular type and there were 2 rare cases of atlanto-paramastoid synostosis — one unilateral, and the other bilateral and accompanied by synostosis of both atlanto-occipital joints.

The paramastoid process is a bony projection on the lateral part of the undersurface of the jugular process of the occipital bone. It is constant in the skull of certain animals but occurs only as an occasional anomaly in man.

The terminology used to describe the process is confusing. In the human skull it has been referred to as the paramastoid, paroccipital, paracondylar, parajugular or estiloid process. Corner (1896) calls it paroccipital, reserving the term paramastoid for the process on the inner lip of the digastric groove. The homologous process in animals is usually referred to as the jugular or estiloid process, though it has also been called paramastoid and paroccipital. The B.N.A. refers to it as the "processus paramastoideus", and it is this terminology which is here adhered to.

The paramastoid process was first described in the human skull by Meckel in 1815, and its articulation with the transverse process of the atlas by Cruveilhier in 1851. Recently cases have been reported by Greig (1930), Mascitti and Strejilevich (1961) and others.

In the human skull the jugular process of the occipital bone often presents bony prominences of various shapes and sizes. According to Amadei (1880), only those which exceed 6 mm in height should be considered as paramastoid processes, though Chaine (1920) thinks that what determines a paramastoid process is not so much its size as its position and relations.

Most authors give the incidence of paramastoid process in the human skull as 0.5 to 1% *(Table 1)*. Chaine (1920), however, includes all processes seen on the surface of the occipital jugular without consideration to size and so gives the high frequency of 52%. A survey was carried out of 890 Maltese skulls, including 29 Punic and 6 Neolithic ones. Adopting the criteria of Amadei (1880), we found a total of 18 skulls — a general incidence of 2.02%. Of these, 17 were found in modern skulls, one being present in the Punic group.

The paramastoid process is constantly present in certain animals where it has functional necessity. It is more fully developed in the herbivorous than in the carnivorous type. It is present in the dolphin, lizard, sloth, dog, cat *(Fig. 1a)*, horse *(Fig. 1b)*, pig *(Fig. 1c)*, tiger, bear, camel and hippopotamus but not in the elephant. It is developed in some monkeys but not in gorillas, chimpanzees or in the orangutan though Corner (1896) thinks that in the orangutan it is present and occasionally very large. Smith (1909) states that it reaches its maximum size in some of the marsupials as in the kangaroo, but

* **The survey was carried out by medical students C. Gauci and R. Farrugia Randon and by the writer.**

Greig (1930) disagrees and thinks that, relative to the skull, it is much larger in the common pig. Mascitti and Strejilevich (1961) mention it as being abnormally long in the stag.

That the paramastoid process is more fully developed in herbivorous than in carnivorous animals suggests that its presence may be related to some peculiar movements of the mandible found in one and not in the other. Powerful muscles of mastication and deglutition often arise from it — the digastric and jugulo-hyoid muscles in the dog and the jugulo-mandibular in the horse, both muscles being depressors of the mandible. It seems that this process is supplementary to the jugular process of the occipital bone, providing a wider bony surface and more stable attachment to these muscles than the occipital jugular could alone afford. In this way it may be concerned with the side to side grinding movements of the mandible on the maxillae; it is in fact found in all those animals exhibiting such movements, except in the elephant. In man there is no extra muscular development to call into being a paramastoid process and its presence in the human does not therefore suggest an undue or abnormal use of the mandible.

There is no doubt as to the aetiology of the paramastoid process in the human skull. Le Double (1908) thinks it represents the inferior articular process of the occipital cranial vertebra, and Poirier and Charpy (1931) its transverse process. It is possible that the paramastoid process is a true congenital defect, being a manifestation of an occipital vertebra due to the scleromere of the third occipital sclerotome not becoming incorporated in the cranium completely (McRae and Barnum, 1953). This congenital origin is however questionable for, though the process is hereditary in certain animals, it has not been proved to be so in man (Greig, 1930). Many attribute the process to pathological fication in structures which extend between the jugular process of the occipital and the transverse process of the atlas, viz. part or all of the rectus capitis lateralis muscle (Amadei, 1880), the ligamentous apparatus (Macalister, 1894), or some fibrous band the homologue of the ligamenta transversaria (Greig, 1930).

The paramastoid process may be unilateral or bilateral; the former, the more frequent, may occur on one side or the other, while the bilateral type may be symmetrical or asymmetrical. In the present investigation there were 12 unilateral cases (7 right and 5 left) and 6 bilateral (1 symmetrical and 5 asymmetrical) *(Table 2)*.

The shape of the paramastoid process is subject to considerable variation and accordingly several kinds are described (Corner, 1896, Chaine, 1920, Dehaut, 1948). *Table 2* shows that the paramastoid process of the cases described in this investigation were conical (18), saw-like (4), and molar (1) in type.

The paramastoid process does not usually make contact with the atlantal transverse process. When contact is made, it is either by ankylosis or articulation.

Ankylosis occurs by cartilage or by bony fusion (synostosis). It is doubtful if this fusion should be interpreted as the synostosis of 2 originally separate elements or the failure to become independent *ab initio* of these elements. Cave (personal communication) thinks that they are originally independent and well-formed and only later does fusion take place, though old-standing pathological fusion of vertebral elements is almost impossible to distinguish from a congenital malformation.

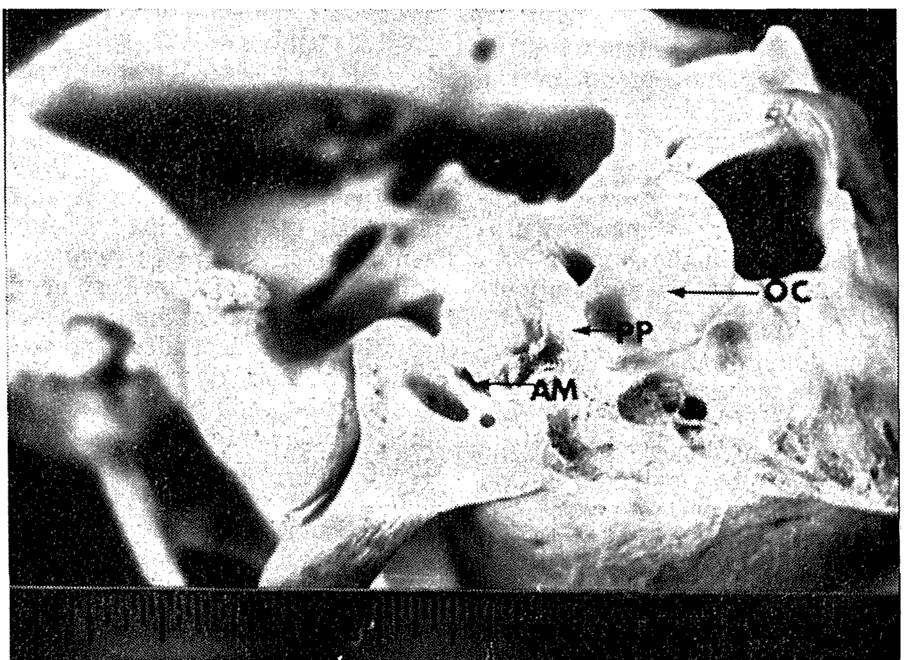
Articulation is by diarthrosis, the atlanto-paramastoid joint having a proper capsule and synovial sheath. Macalister (1894) described 3 ways in which contact between the paramastoid process and the transverse process of the atlas may take place, namely by a down-growing paramastoid process and a rising atlas spur, a paramastoid process descending to the atlas, or an upgrowth atlas coming into contact with a small paramastoid.

Cave (personal communication) thinks that ascending processes from the transverse process of the atlas towards the occipital are very uncommon. Le Double (1912) illustrates (p. 113, figure unnum-

TABLE 1
The Incidence of Paramastoid Process in the Human Skull

Investigator		*No. of cases of Paramastoid Process*	*No. of skulls Examined*	*%*	*Remarks*
1. Hyrtel	quoted by Mascitti	3	600	0.50	
2. Romiti	and Stretjile-	2	300	0.66	
3. Russel	vich (1961)		1160	0.70	N. American skulls – ancient & modern
4. Amadei (1880)		8	2197	0.36	
5. Le Double (1908)			3782	0.80	
6. Chaine (1920)				52.00	
7. Mascitti and Strejilevich (1961)		4	196	2.00	
8. Present Investigation (1968)		18	890	2.02	Maltese skulls – ancient & modern

FIGURE 1



a. Cat

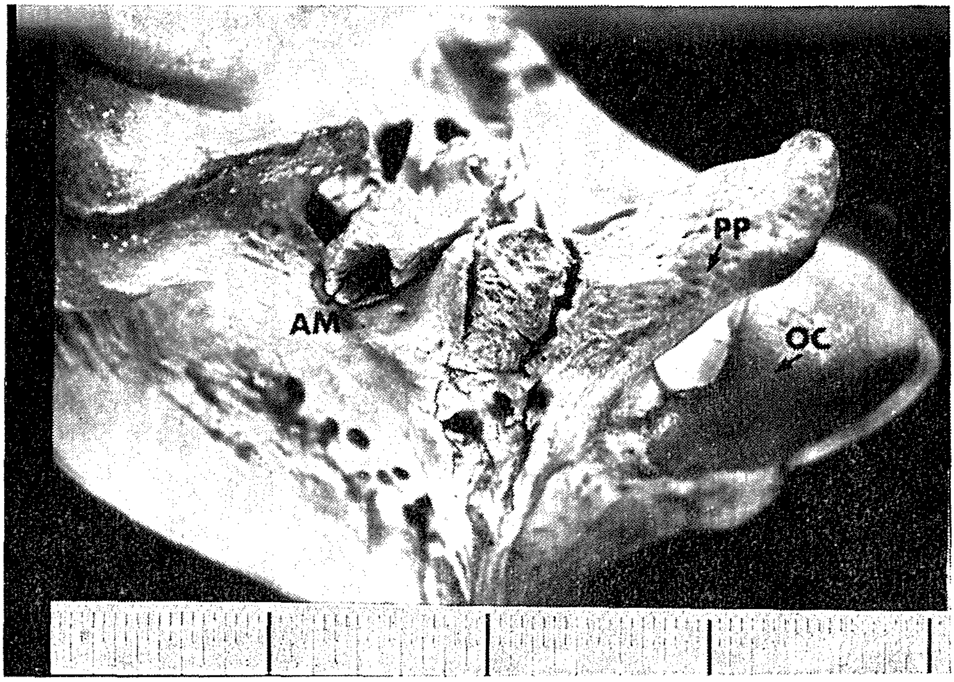
Lateral view of the skulls of the:

a. Cat
b. Horse
c. Pig

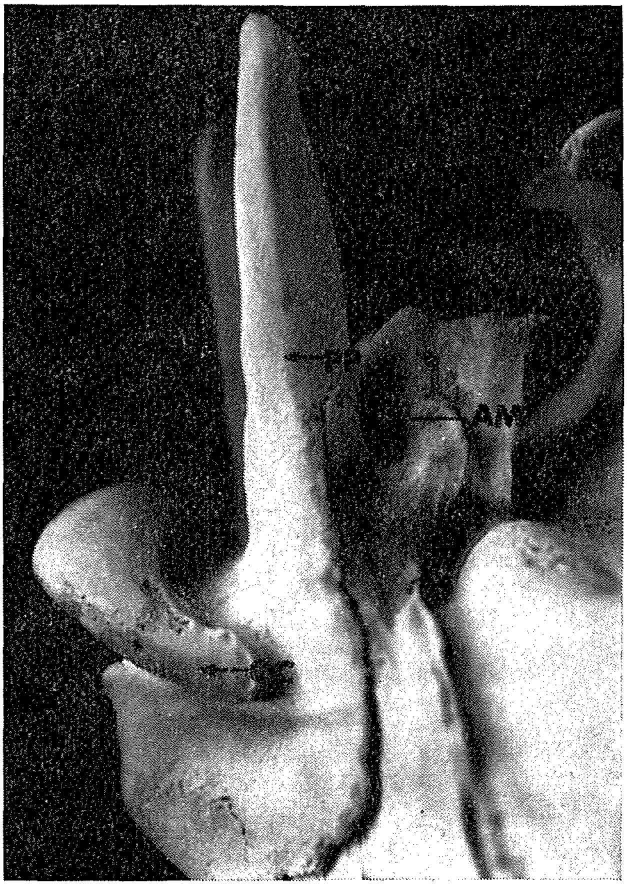
to show the difference in size of the paramastoid (jugular) process (PP) in animals of different dietary habits, and its large size in the pig.

OC indicates the occipital condyle and M the external auditory meatus.

Scale: inches.



b. Horse



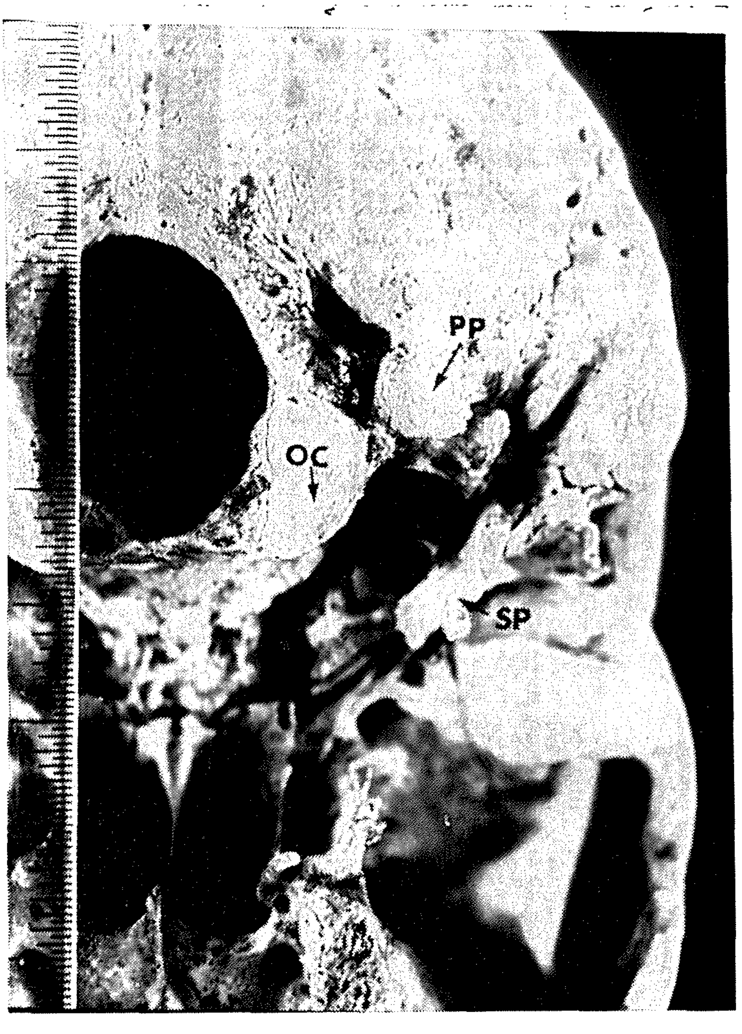
c. Pig

TABLE 2

Details of the paramastoid processes found in Maltese skulls.

Skull N.	Unilateral Right	Unilateral Left	Bilateral	Type (Chaine, 1920)	Height (mms)	Articular Surface
1			+	R saw-like	9	—
				L conical	7	
2	+			conical	17	+
3		+		saw-like	15	—
4			+	R conical	16	+ (marked)
				L conical	7	
5	+			conical	10	—
6			+	R conical	8	
				L molar	8	
7		+		—	—	complete synostosis with transverse process of atlas.
8	+			conical	23	—
9	+			conical (with saw-like)	11	+
10	+			conical	7	—
11			+ (symmetrical)	R conical	8	
				L conical	8	
12			+	R conical	7	—
				L conical	6	—
13		+		conical	8	—
14			+	R conical	20	*Right:* Fused with posterior aspect of atlantal transverse process but identinfiable as a separ ate process.
					—	*Left.* Complete synostosis with atalantal transverse process.
15		+		conical	9	+
16	+			saw-like	13	—
17		+		conical	8	—
18 (Punic)	+			conical	8	—

FIGURE 2



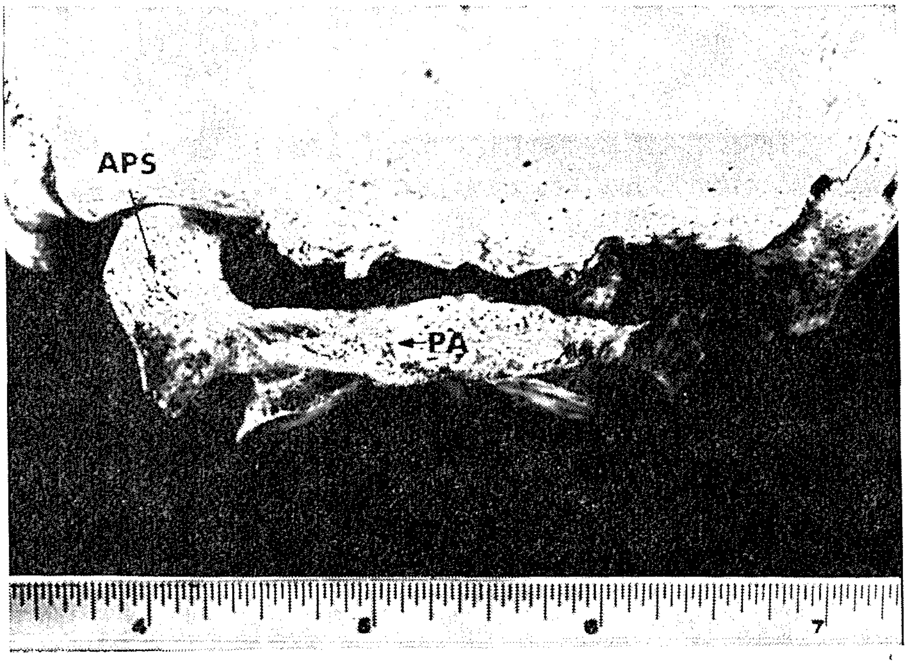
Base of human skull 4 (c.f. Table 2) to show the articular type of paramastoid process (PP) in surface view.

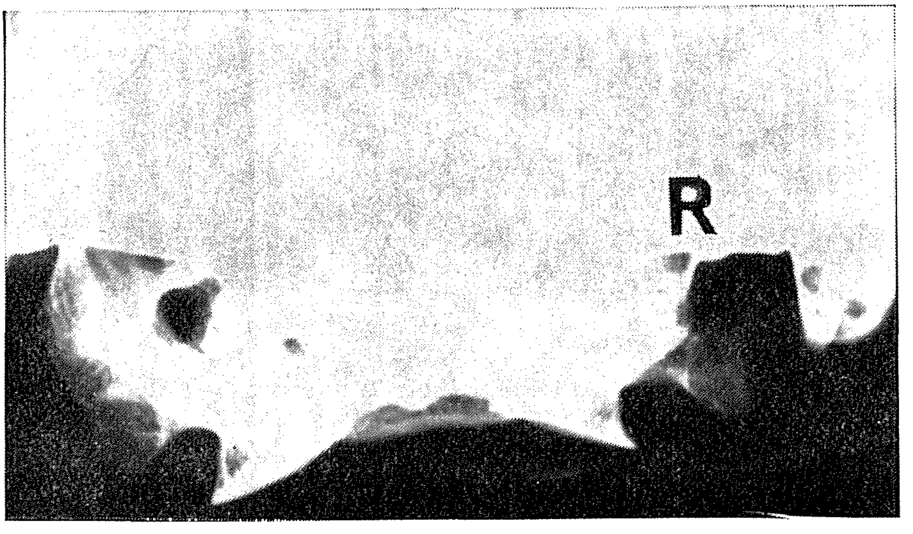
The articular surface on the paramastoid process faces laterally, posteriorly and downwards and articulates with the transverse process of the atlas.

OC indicates occipital condyle, SP the styloid process.

Scale: inches.

FIGURE 3





Human skull 7 (c.f. Table 2) to show complete unilateral atlanto-paramastoid synostosis (APS).

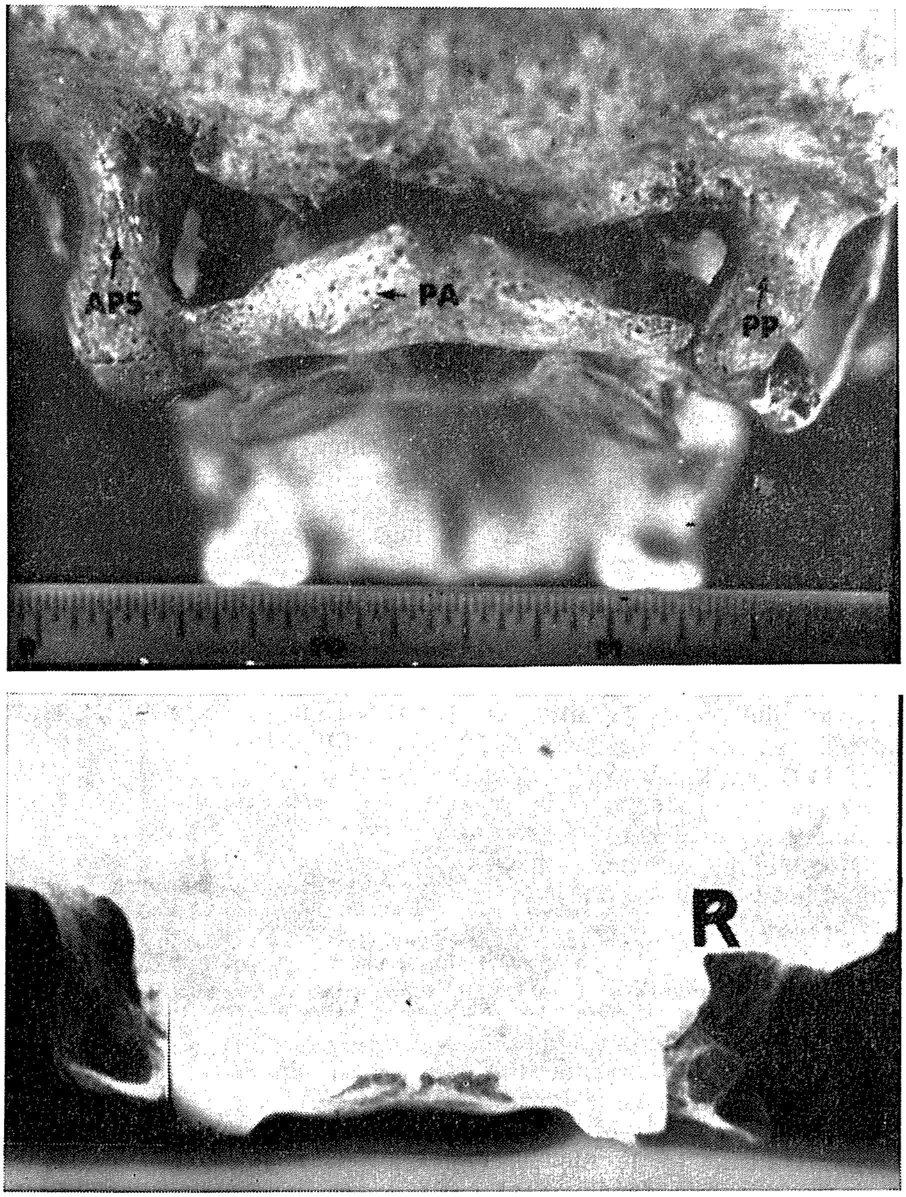
a. posterior view

b. X-Ray posterior view

PA indicates the posterior arch of the atlas.

Scale: inches.

FIGURE 4



Human skull 14 (c.f. Table 2) to show bilateral atlanto-paramastoid synostosis (this was accompanied by bilateral atlanto-occipital synostosis).

On the right the paramastoid process (PP) is fused with the transverse process of the atlas but identifiable as a separate process; on the left there is complete atlanto-paramastoid synostosis (APS).

Posterior view

a. Posterior view

b. X-Ray posterior view

Note the asymmetry and irregularity of the posterior margin of the foramen magnum. The inferior articular facets of the atlas appear normal.

PA indicates the posterior arch of the atlas.

Scale: inches.

bered) such a process (which is unilateral and of the articular type) and Cave came across one example several years ago (unpublished).

In the present investigation there were 4 paramastoid processes of the articular type (skulls 2, 4, 9 and 15 in *Table 2);* that of skull 4 is shown in *Figure 2.* There were also 3 processes of the ankylosed type (skulls 7 and 14 in *Table 2).* In skull 7 *(Fig. 3a)* there was complete synostosis of the paramastoid process with the transverse process of the atlas; its X-ray is shown in *Fig. 3b.* In skull 14 *(Fig. 4a)* the right paramastoid process was fused with the posterior aspect of the transverse process of the atlas, but was still identifiable as a separate process, while that on the left was completely synostosed to the transverse process; in addition there was complete synostosis of both atlanto-occipital joints; its X-ray is shown in *Fig. 4b.* Cave (personal communication) studied the skull and thought that both the occipital condyles and the left paramastoid process were probably primarily free and that their coalescence with the atlas supervened late in embryonic life; the fusions were certainly present since birth. Nodding — probably much limited — would have taken place at joints below the occipito-atlantal joint, though the atlanto-axial diarthrosis did not show any change. If the paramastoid process fused first with the atlas, the occipito-atlantal joint would be splinted and immobilised and fusion, superficially, of the condyles and atlas could have followed from ossification of the occipito-atlantal joint capsule; this seems to be the case here. Whatever happened in development, it seems that all parts were originally separate, that an adventitious paramastoid process contacted the atlas and merged with it, and that subsequently the occipito-atlantal joints were denied movement.

The presence of a paramastoid process may give rise to clinical manifestations, including torticollis ossea with permanent lateroflexion and rotation and limited dorsiflexion at the atlanto-occipital joint (Kvasnicka, 1958); this may be associated with asymmetry of the face (Dwight, 1904).

Acknowledgements

My thanks are due to Professor A.J.E. Cave for valuable advice and for studying skull 14, to Professor C. Coleiro, Chief Government Medical Officer, for permission to examine skulls from the Addolorata Cemetery, and to Captain C. G. Zammit, Director of the National Museum, for permission to examine Neolithic and Punic skulls. I am grateful for the help received from Mr. J. Apap, Radiographer at St. Luke's Hospital.

References

Amadei, G. (1880). Arch. antropol .e etnol. *10*, 265.

Cave, A.J.E. Personal communication.

Chaine, J. (1920). C. R. Acad. Sci. *170*, 1014.

Corner, E.M. (1896). J. Anat. & Physiol *30*, 386.

Cruveilhier, J. (1851). Traité d'anatomie descriptive. 3rd. Ed. Labé. Paris.

Dehaut, G. (1947). C. R. Acad. Sci. *224*, 1383.

Dwight, T. (1904). J. Med. Research. *12*, 17.

Greig, D.M. (1930). Edin. Med. J. *37*, 582.

Kvasnicka, I. (1958). Fortschr. Rontgenstrahl. *88*, 744.

Le Double, A.F. (1908). Traité des Variations des os du crâne de l'homme. Vigot, Paris.

Le Double, A.F. (1912). Traité des Variations de la coloune vertébrale chez l'homme. Vigot, Paris.

Macalister, A. (1894). J. Anat. & Physiol. *27*, 519.

Mascitti, T.A. and Strejilevich, L. (1961). Prensa Med. Argent. *48*(*i*), 829.

McRae, D.L. and Barnum, A.S. (1953). Amer. J. Roent. *70*, 23.

Meckel, J.F. (1815). Handbuch der menschlichen Anatomie. Berlin.

Poirier, P. and Charpy, A. (1931). Traité d'anatomie humaine. 4th Ed. Masson, Paris.

Smith, W. (1909). Trans. 8th Session Australasian Med. Congress, Melbourne, Victoria, *ii*, 203.