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Anatomical and morphological study of the petrous bone in camels (*Camelus dromedarius*)

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Abstract

The present study presents a detailed anatomical description of the petrous bone of the camel skull. The petrous temporal bone in camels has a distinctive shape. Not all parts were visible. This work gives a detailed gross anatomical description of the petrous bone in the camel's skull. The skulls were prepared by using boiling and maceration techniques. The study showed that the petrous part is the main part of the temporal bone in the skull and forms part of the lining of the cranium. The study showed that the petrous temporal bone consists of the following parts: the mastoid process, the external auditory meatus, the muscular prominence, and the styloid process, as well as the petrous part. The petrous part has a base, an apex, three angles (cranial, caudal, and ventral), and three surfaces: the medial, the lateral, and the ventral surfaces. The lacerate sulcus was described in this study as a groove that runs the ventrally basilar part of an occipital bone side to the pterygoid canal. The results obtained from this study were important in enriching comparative anatomy in different animals.

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Introduction

The previous studies on the anatomy of the petrous temporal bone in the camel were almost non-existent. The petrous temporal bones of the camel are located between the occipital bone and parietal bone cranially and the tympanic part lateroventrally. The external appearance of the head of animal species depends strongly on the shape of the skull (1). These studies have been undertaken in many domestic species such as camel (2), goats (3) and dog (4). an attempt to provide baseline anatomic information about the anatomy of skull (5). Complex temporal region anatomy consequently a description accurate anatomy in horse (6). The petrous temporal consisted of a petrous and tympanic part of which petrous and tympanic parts respectively as earlier reported in camels (7), in ox (8) and domestic animals (9,10). The petrous bone was overlapped by the squamous part laterally in domestic animals (9,10). The petrous part of the temporal bone is relatively small and has an irregular shape. The mastoid process is fused with a base of the paracondylar process caudally. While the styloid process lies directly caudoventrally in camel (7) and prominent and lateral composed in cattle (10) it was flattened in cattle (11) and well developed in the horse (12). The tympanic bull is flattened rostrocaudally and extends ventrally beyond the paracondylar process in camel (7). It was prominent and laterally compressed in cattle (10-12) Unobtrusive, not prominent, and situated medial to the styloid process in the horse (10-12). A detailed anatomic description is desirable when examining the temporal region for fractures owing to the complex nature of the anatomy and inexperience examining the temporal bone in the transverse plane (13).

The aim is to provide a scientific understanding of the bones that are essential for nervous passages. This present research contributes to filling a hole in the field of veterinary comparative anatomy.

Materials and methods

Ten skull camels of different sexes and ages (1-2 years) old, were used for this study. The skull of camels was obtained from an anatomy laboratory, and a typical Buraidah slaughterhouse post-slaughtering in the Al Qassim region, KSA. Each skull was boiled in water with sodium hydroxide 30% (NaOH) after removing the skin and accompanying structures. Next, the skulls were dried at room temperature for two-three days, they were whitened by dipping them in hydrogen peroxide solutions and sundried for three days (14-20). Then, the petrous bone was separated carefully to be studied in detail. The petrous bone of the skull was studied by examined by the naked eye, and photographs were taken using a megapixel camera.

Ethical Approval

The ethical approval letter (No.24 in 28/10/2022) is given by dean of the college of Agriculture and Veterinary Medicine, Qassim University to conduct this scientific work, data collection permit is covered in this study.

Results

The petrous temporal bones of the camel are located between the occipital bone caudally and parietal bones rostrodorsally, the frontal bone dorsally, and the sphenoid bone ventrally. The petrous bone is paired and forms the temporal bone base forming the majority of the temporal bone. It has two parts: the visible part on the lateral side of the skull and the invisible one on the medial side (the petrous portion). The temporal petrous bone is divided into five parts: Squamous part, Mastoid process, Styloid process, Tympanic bull, and Petrous portion (Figures 1-5).

Squamous part (Pars squamosa)

Forming the dorsal and cranial portion of the temporal bone, the squama is a thin, scale shape. The lateral surface is smooth and forms a convex shape and it carries a temporal line, a curved ridge running dorsocaudally. The dorsal border of the squamous part is thin and nip-up the squamous border of the parietal bone, forming with it the squamosal suture and is connected with the zygomatic bone by temporozygomatic sutures. While the cranioventral border of the squamous part of the articulation with the wing of the sphenoid and occipital bone by temporooccipital and temporosphenoid sutures. The petrous portion is characterized by having a complex structure and it is fused with the squamosal part of the temporal bone (Figures 1-4).

The mastoid process (Processus mastoideus)

Is the first segment of the petrous temporal bone. It integrates with the jugular process, where the jugular process is not sufficiently expanded. The mastoid process is not thick. It is serrated and attached rostrally to the external acoustic meatus and extended ventrolaterally to the stylo-mastoid foramen. Caudally, the sulcus of the caudal meningeal artery is between the mastoid process of the petrous temporal bone and the jugular process of the occipital bone. Between the mastoid process and the external acoustic meatus and rostrally to the mastoid process, there is the stylomastoid foramen (Foramen stylomastoid), it represents the external opening of the facial canal of the facial nerve (Figures 1, 2 and 5).

The external acoustic meatus (Meatus caustic externa)

It locates caudally to the zygomatic arch. It has an average length of about 4 cm, and its average diameter is 0.8 cm. It is the osseous canal. It has a large oval opening that extends from the base of the temporal bone. It directs ventrally and then rostolaterally (Figures 1 and 2).

The styloid process (Processus styloideus)

It extends from the base of the temporal bone, lies rostral to the stylomastoid foramen and rostroventrally to the external acoustic meatus, as well as craniomedially to the mastoid process. The styloid process is the cylindrical structure that has a gradually tapering thickness, forming the styloid process apex. It is made up of two parts, a proximal and a distal segment. The proximal segment: the fan shape, consists of the base of the process, which is attached to the external acoustic meatus. The distal one is shafting thickness decreases slightly to its apex (Figures 1, 2 and 5).

Tympanic bull (Tympanica bulla)

It is a rounded prominence bulge flat whose surface wall is nearly rough; it forms the tympanic cavity. It is located medial to the styloid process directed cranioventrally. The ventral and caudal borders are surrounded by the jugular and internal carotid artery incisurae. The basis of the tympanic bulla merges with the basilar part of the occipital bone at the foramen lacerum. The boundary between the tympanic bull and the petrous portion is represented by the presence of the tympanic petrous fissure (Figures 1-5).

The muscular process (Processus muscularis)

Appears as a short primary muscle process such as the spine. is located rosterolateral obliquely to the tympanic bull (Figures 1-5).

The petrous part (Pars petrosa)

The petrous segment is one of the main compounds of the skull bones and contributes to forming of the endocranium. It is pyramid-shaped. It is wedged in at the base of the skull between the sphenoid and occipital bones and has a pyramidal form. it's craniomedially direction. It has a base, an apex, three angles, and three surfaces. The base is united to the internal walls of the mastoid process and squamous temporal bone part (Figure 3). The apex: is fixed, rough, and angular, and it is situated at the angle between the basilar

portion of the occipital bone and the caudal border of the wing of the sphenoid bone; it makes to form the internal orifice of the carotid canal, and forms the caudolateral margins of the lacerate groove (Figures 3 and 5).

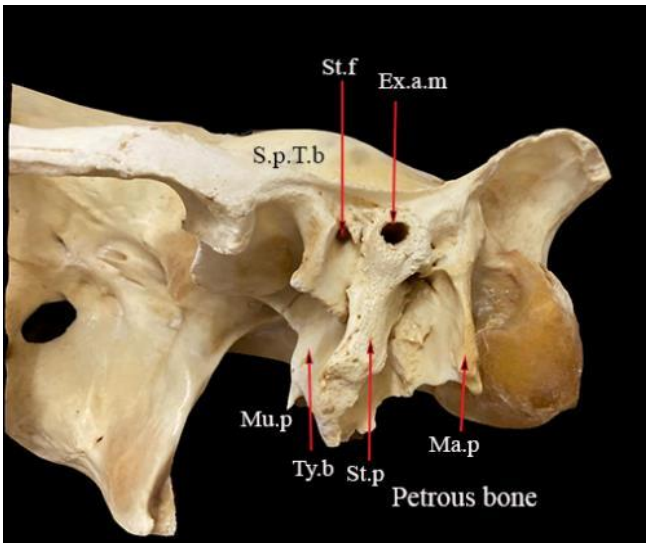

Figure 1: lateral view of the camel skull showing the site of the petrous and temporal bones. (S.p.T.b) Squamous part of temporal bone, (St.f) Stylomastoid foramen, (Ex.a.m) External acoustic meatus. (Ma.p) Mastoid process, (Mu.p) Muscular process, (St.p) Styloid process and (Ty.b) Tympanic bull.

Angles

It has three angles; dorsal, caudal, and cranial. The dorsal angle: The longest and deepest angle for the dorsal petrosal groove. The cranial angle is divided into two parts; A lateral portion that is attached to the squamous part of the cranial angle and a medial, free part that articulates with the sphenoid spinous. While the caudal angle is intermediate between the cranial and the dorsal angles (Figure 3). It has the jugular fossa with the jugular notch forming the jugular foramen (Figure 5).

The cranial (lateral) surface

Forms the caudal part of the middle cranium fossa of the skull and is in contact with the internal surface of the squamosal part of the temporal bone. It has the features following: The arcuate eminence (eminentia arcuata) (Figure 4) lying in the middle of the cranial surface. Cranial and a little lateral to the arcuate eminence, a depression determines the position of the tympanic cavity. Also, the cranial surface has an of little depth groove double, in some specimens was single, and leads caudolateral to an opening for passage of the greater petrosal nerve and a small groove for a petrosal artery (Figure 4). The cranial surface has a near the apex limit (termination) the carotid canal wall is incomplete cranially represent by the cranial carotid foramen (Figure 5). Dorsal to the carotid canal appears the shallow trigeminal impression.

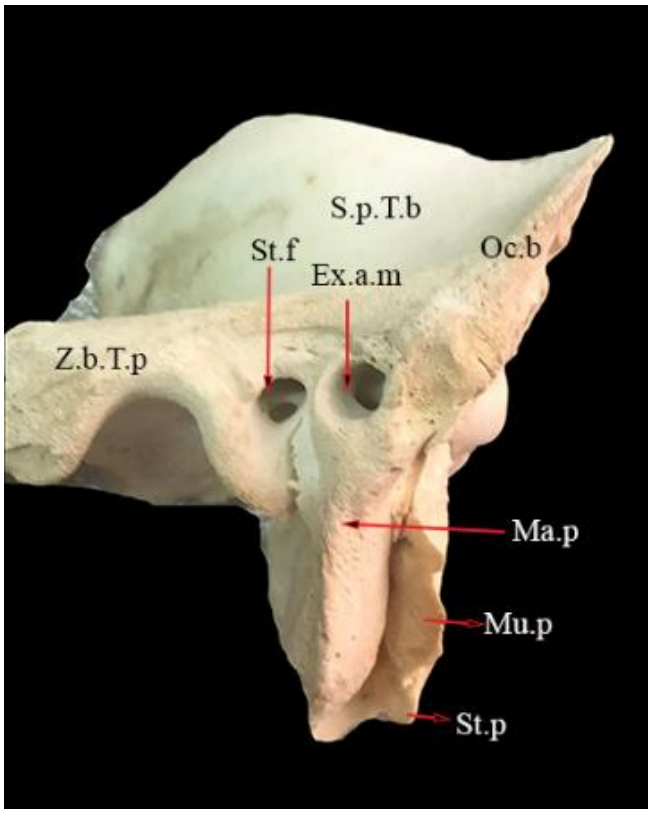

Figure 2: lateral view of the camel skull showing the petrous bone separated. (Ex.a.m) External acoustic meatus, Ma.p) Mastoid process, (Mu.p), Muscular process, (St.p) Styloid process (Z.p.T.b) Zygomatic process (St.f) Stylomastoid foramen, (S.p.T.b) squamous part of temperal bone and (Oc.b) Occipital bone.

The caudal (medial) surface

Forms the rostral portion of the caudal cranium fossa of the skull base, which contains the brainstem and cerebellum It has the internal acoustic opening (Porus acoustics internus) (Figure 4) located in the middle of the medial surface, its margins are smooth and it leads a short canal that the internal auditory meatus. Opening of vestibule Aqueduct (Aquaeductus vestibule): it is located in the lower part of the medial surface of the petrous bone and caudodorsally and above the middle of the lateral margin, ventral from the internal acoustic meatus, is a small slit almost hidden by a thin plate of bone, leading to a canal the aqueducts vestibule (Figure 4). Opening of the cochlear canal (Canaliculus cochleae) it is located below the external opening of the aqueduct of the vestibule (Figure 4). Petro-occipital fissure (Fissure Petro-occipitalis) gathers the above-mentioned orifices in a single and vast hiatus occipito-sphenotemporal.

The ventral surface

Is an irregular and rough shape and forms part of the external base of the skull. It has a large circular orifice in the internal carotid foramen (Figure 5), is located at the basilar part of the occipital bone, it forms the caudolateral boundary of the lacerate foramen (foramen lacerum).

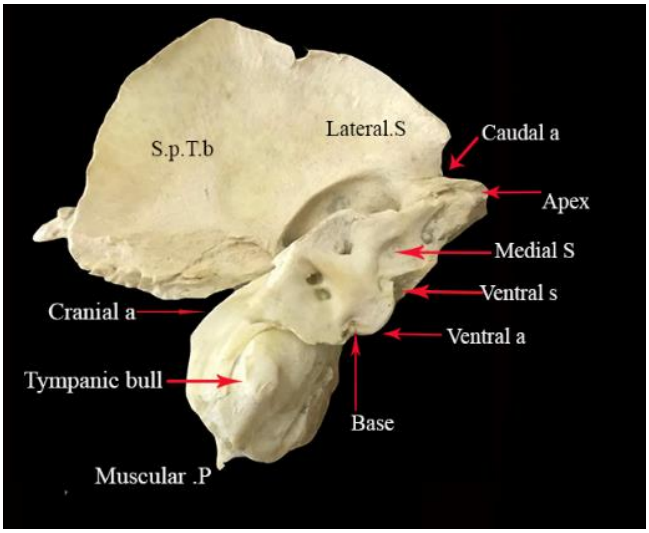

Figure 3: Photo showing the general description of the medial view of the temporal petrous bone in skull camels. (a) angle, (s) surface.

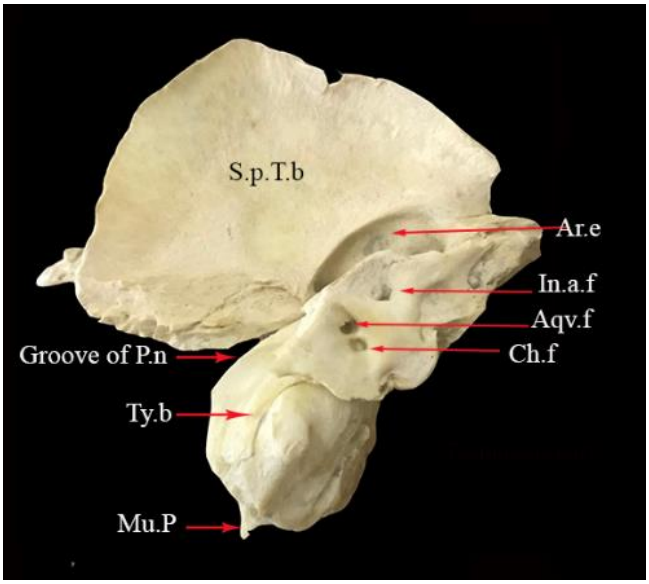

Figure 4: Photo showing the medial view of the petrous bone in skull camels. (S.p.T.b) Squamous part of temperal bone (Ar.e) arcuate eminence, (In.a.f) internal acoustic foramen, (Aqv.f) Vestibule Aqueduct foramen, (Ch.f) foramen of the cochlear canal, (Mu.p) Muscular process, (Ty.b) Tympanic bull and (Groove of P.n) Groove for petrous nerve.

The lacerate groove (Sulcus lacerum)

Is a groove that lies ventrally on the side of the basilar part of the occipital bone until it reaches the canal of the pterygoid bone (Figure 5). The jugular foramen forms rostrolateral margin of the lacerate sulcus, while the caudal edge of the lacerate sulcus, is formed by the carotid foramina. The jugular foramen and the internal carotid foramen are belonging to the petrous part and participate in forming a similar indentation of the occipital bone (Figure 5).

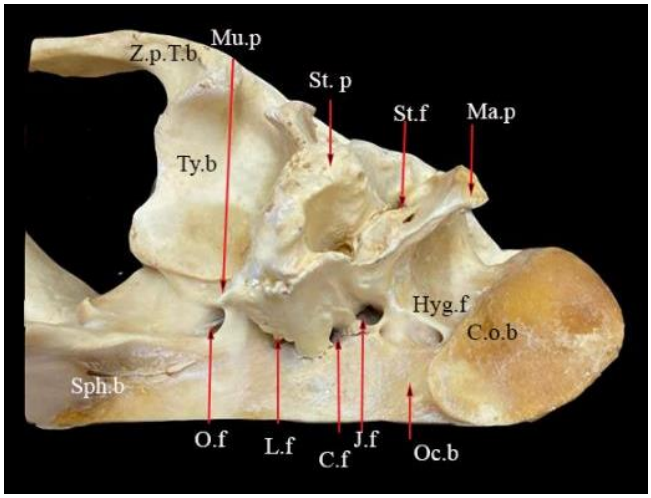

Figure 5: Photo showing the ventral view of the petrous bone in skull camels. (Z.p.T.b) Zygomatic process , (Ty.b) Tympanic bull, (St.p) Styloid process, (St.f) Stylomastoid foramen, (Mu.p) Muscular process, (Ma.p) Mastoid process, (C.o.b) Condyle of occipital bone,((Hyg.f) Hypoglossals foramen, (Oc.b) Occipital bone, (J.f) Jugular foramen,(C.f) Carotid foramen,(L.f) Lacerta fissure, (O.f) Oval foramen and (Sph.b) Sphenoid bone.

Discussion

The petrous temporal bone is the most important in the skull. Especially since its location is inside the skull, it is not visible in some parts of the bone. It is considered the pathway nerves, especially the nerves of hearing, and therefore any changes in the morphological anatomical features, it will reflect badly on the job for which it is responsible. Rashid, and Kausar (21) compared camel skull to that of others domestic mammals. More recently Yahaya team studied different morphometric aspects of camel skull (22-26).

The petrous temporal bone in the camel was investigated and it was revealed that located in the base of the skull between the occipital and sphenoid in the temporal region, overlapped externally by the squamous temporal. These findings agree with that of Smuts and Bezuidenhout (7) in camels, Raghavan (8) and Getty (9) in ox and Dyce *et al.* (10) in domestic animals and Kumawat *et al.* (27) in chital deer. Dyce *et al.* (10) Stated that the petrous bone is separate

from the squamous bone in horses, but contrary in the rest of the animals; On the other hand, the petrous and tympanic parts were united by the occipital-tympanic suture as reported in chital (27) but was not similar in ox and horse (28). In this study, the mastoid process fused with the jugular process, not thick, and serrated, related rostrally to the external acoustic meatus. The mastoid process was prominent and lateral composed in cattle (11), whereas in small ruminants the process was not more than a roughened area (28).

The results of this study agree with El-allali *et al.* (29) who reported that the mastoid process is united with the jugular process which is not well expanded in camels. The shapes of the external acoustic meatus, tympanic membrane, and lever system of the ossicular chain of the Bactrian camel all have their properties (30-33). In contrast to the findings of this study that disagree with Budras and Habel (11) in bovine, Smuts and Bezuidenhout (7) and Singh (34) in camels, Singh and Patel (35) in goats and blackbuck. Choudhary and Singh (36) who mentioned that the mastoid process was absent.

In the present work, the styloid process is a cylindrical structure that has a thickness that gradually tapers. It consisted of two segments, a proximal segment was a base, and a distal one was a shaft. Similar funding to in camel (7), in cattle flattened (9-11) in horse well developed (12). Barone and Simoes (37) revealed that the styloid process is well visible in Equine and ruminants, weak or absent in other species. While the styloid process was thin and prismatic in Indian Blackbuck (36). On the other hand; this work results are like to Abuhaimed *et al.* (38) who reported different in length, angulation, and other morphological features between specimens studied. Although these physiological differences are often found incidentally in humans.

Concerning the muscular process, the results of this work showed was a short primary muscle process such as the spine that which differs from that reported by Dyce *et al.* (10) which recorded it was very developed in the horse. Also, Barone and Simoes (37) reported that the muscular process was very long and pointy in Equidae and small ruminants. On the other hand, similar findings were in agreement with those previously published in the dog (28) and camels (34).

The present study demonstrated that the external acoustic meatus is the osseous canal that extends from the floor of the temporal bone. Present study finding not agree with what was reported by Raghavan (8) in buffalo and Budras and Habel (11) in cattle stating that the external acoustic meatus was circular and short in length, the length and diameter of external acoustic meatus in buffalo more than in cattle. Also, the external acoustic meatus was curved in sheep, goats, and dogs (10). The results were similar found between the recorded by Smuts and Bezuidenhout (7), Singh (34) and Barone and Simoes (37) in camel that explained external acoustic meatus, its moderate length of about 4 cm. It has a large oval opening that extends from the base of the temporal bone. It directs ventrally and then rostolaterally. This explains the prevention and obstruction of the rapid spread of any epidemics or infections or lesions of the tympanic membrane.

In camel, the tympanic bulla was a rounded prominence flat whose surface wall is nearly rough. The established in this study are similar to the study previously recorded by Raghavan (8) in buffalo, Budras and Habel (11) in bovine, EL allali (29) and Zuoliang (31) in camel. It has been reported that the found different in the description is significant the tympanic bull is not prominent in cattle Budras and Habel (11) and in horse Budras *et al.* horses (12) while Walker *et al.*(13) recorded that the tympanic bulla was relatively small in ruminants but enormous and well-rounded in Carnivorous Barone and Simoes (37) stated that the tympanic bulla has become enlarged into a visible protrusion at the base of the skull and morphology of the tympanic bullae varies markedly among different species.

The lacerate sulcus in the present study represented the carotid and jugular foramina fused. the results were similarly found between the recorded by Smuts and Bezuidenhout (7) and Singh (34) in camel. On the other hand, his finding disagrees with that was reported by Dyce *et al.* (10) in different animals who described the lacerate foramen as combining the oval or jugular foramen caudally and the carotid foramen rostrally. Also, the lacerate foramen is an irregular opening lying in the middle cranial fossa at the base of the skull which differs from that reported by Bazroon and Singh (39) in different animals.

These results disagree with Walker *et al.* (13) in different animals who described the lacerate foramen was the cranial part combines the oval and carotid foramen and we agreed generally with Zuoliang (31) in camels who reported that the lacerate sulcus is a groove running ventrally on the border of the basisphenoid bone until it reaches the pterygoid canal and. the caudal part is the equivalent of the jugular foramen. while the rostral part is the equivalent of the carotid foramen. Recently, the anatomy the Petro-temporal through (CT and MRI) was identified by referring to anatomy textbooks and anatomic specimens of the temporal bone (40,41). Computed tomography (CT) and magnetic resonance imaging (MRI) have been used to understand the anatomy of the temporal region in horse (42-48).

Conclusion

The results showed that the petrous bone has a distinguished structure. It lies in the internal part of the skull. It has a pyramid shape, processes, and many nerve foramina. It appears from the lateral, ventral and medial sides of the skull. The petrous bone forms a lacerate fissure in camels, this fissure is a foramen in other animals.

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Conflict of interests

The authors declare that it has no financial or personal relationships, which may have inappropriately influenced them in writing this article.

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دراسة تشريحية وعيانية للعظم الصخري في الإبل

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الخلاصة

تقدم الدراسة الحالية وصفا تشريحياً مفصلاً للعظم الصخري لجمجمة الجمل .إذ يتميز العظم الصخري الصدغي في الإبل بشكله مميز .أذ لم تكن جميع أجزائه مرئية .يقدم هذا العمل وصفًا تشريحيًا مفصلاً للعظم الصخري في جمجمة الإبل .حيث تم تحضير الجماجم باستخدام تقنية الغليان والنقع .وقد أظهرت الدراسة أن الجزء الصخري هو الجزء الرئيسي للعظم الصدغي في الجمجمة ويشكل جزءا من بطانة القحف .أظهرت الدراسة أن العظم الصخري الصدغي يتكون من البروز الخشائي، الصماخ السمعي الخارجي عبارة عن قناة عظمية لها فتحة بيضاوية تتمتد من قاعدة العظم الصخري وتتجه أماميا بطنياً، البروز العضلي والنتوء الإبري وكذلك الجزء الصخري .يملك الجزء الصخري قاعدة وقمة وثلاث زوايا هي الزاوية الأمامية والخلفية والبطنية وثلاثة أسطح هي السطح الأنسي والسطح الوحشي والسطح البطني .تم وصف الثلم الممزق في هذه الدراسة بأنه أخدود يمتد من الجزء القاعدي البطني للعظم القفوي إلى القناة الجناحية .كانت نتائج التي تم الحصول عليها هذه الدراسة مهمة في إثراء علم التشريح المقارن في الحيوانات المختلفة.

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