Research & Reviews: Journal of Zoological Sciences

e-ISSN:2321-6190
p-ISSN:2347-2294

The Chondrocranium Development of *Mus musculus domesticus* (Rodentia: Muridae) I Stage I

Mai A Al-Mosaibih and Rawan M Al-Maimony

Department of Zoology, University of Jeddah, Jeddah, Saudi Arabia

Research Article

Received date: 05/11/2019
Accepted date: 14/11/2019
Published date: 20/11/2019

***For Correspondence**

Rawan M Al-Maimony, Department of Zoology, University of Jeddah, Jeddah, Saudi Arabia, Tel: +966530049343

E-mail: roro1413@gmail.com

Keywords: Anatomy, Chondrocranium, Development, Muridae, *Mus musculus domesticus*, Laboratory mice.

ABSTRACT

The aim of this research is to study the development chondocranium In one species of rodentia white laboratory mouse which originating from the it focuses on two main axes, the first is an accurate microscopic anatomical study of the chondrocranium and knowing the changes that occur for a comparative study of chondrocranium development during mouse embryos growth, how they occur and synchronize before reaching to ossification stage, as well as monitoring changes that occur in the sense capsules. The second axis is a descriptive comparative analysis of the study sample with some other mammals previously studied by researchers, to clarify the characteristics of the genus followed by the research sample according to the characteristics of the chondrocranium and formation method. The total length of the embryo body in this stage 18 mm, the embryo was obtained and prepared by using some tissue steps to make serial sections for head region, and it has been examined by light microscope then use the Ken-a-vision microprojector for graphic reconstruction of the chondrocranium, and describe it in three views: dorsal, ventral, and lateral. However in this embryo we found some cartilaginous structures are not yet formed (absent). Whereas, the nasal capsule appeared Small and incomplete of the rostrul region, lacks some cartilaginous structures and contain Jacobson's organs. The optic capsule is medium in size and appears not connected to the cranial base and contains interorbital septum and lacks the optic roots. The auditory capsule consists of one part is canalicular part and the semicircular canals was appear very clear.

ABBREVIATIONS

AL.OR.C: Ala orbitalis cartilage, AN.SECI.CN: Anterior semicircular canal, ACH.C: Acrochordal cartilage, B.PL: Basal Plate, BCAP. FI: Basicapsular fissure, CA.PT: Canalicular part, CR.SECI: Crista semicircular, CU.N.PO: Cupula nasi posterior, E: Eye, ETUR: Ethmoturbinals, ETUR I: Ethmoturbinals I, EXOCCAP.CM: Exoccipitocapsular commissure, F.C: Frontal cartilage, FO.M: Foramen magnum, FTUR: Frontoturbinals, HG.FO: Hypoglossum foramen, HPH.C: Hypophysial cartilage, HPH.FE: Hypophysial fenestra, INOR.SE: Interorbital septum, J.OR: Jacobson's organ, L.SECI.CN: Lateral semicircular canal, LA.T.PO: Lamina transversalis posterior, MTUR: Maxilloturbinals, N.SE: Nasal septum, N.TE: Nasal tectum, NTUR: Nasoturbinals, OC.A: Occipital arch, OR.C: Orbital cartilage, ORN.FI: Orbitonasal fissure, P.CAP.CM: Paritocapsular commissure, P.PL: Parital plate, PCH.C: Parachordal cartilage, PCY.PR: Paracondylar processus, PTG.PR: Pterygoid processus of ala temporalis, PN.C: Paranasal cartilage, PN.SE: Paranasal septum, PSE.FI: Paraseptal fissure, PO.SECI.CN: Posterior semicircular canal, SAC: Sacculus, SC.TY: Scala tympani, SC.V: Scala vestibule, SL.AN.L: Sulcus anterior latiralis, SL.PO.L: Sulcus posterior latiralis, SPETH.CM: Sphenethmoid commissure, UT: Utricle

INTRODUCTION

Since 55 million years ago of mammals development, the order *Rodentia* has had a growing success in terrestrial mammalian group. No less than 330 to 400 genera, and 1800 to 2300 species, have been registered in the recent fauna, and the last number represents half of all species of mammals. All continents and all islands were settled down by these small animals, sometimes with the aid of human himself. In deserts, mountains, rivers and cities, rodents are joining to human in many of his activities, including utilization of the earth. *Rodents* have had a direct effect on many human activities. This is evident in their negative effect

e-ISSN:2321-6190
p-ISSN:2347-2294

on the growing and storage of crops, pastures, disruption of irrigation systems by burrowing, and in the diffusion of diseases in domestic animals and in wildlife. A lot of species of rodents are sources of human diseases. Nevertheless, *rodents* have made important contributions in solving many of the problems of humans and modern societies. They were one of the main laboratory mammals that serve the sciences of medicine and biology and have been used to obtain extensive information and knowledge in anatomy and physiology in vertebrates, and have served and continue to serve a great deal in genetics and molecular biology. There are some species of *rodents* live in close association with human which is: *Rattus rattus, Rattus norvegicus, Mus musculus, Bandicota bengalensis, and Mastomys natalensis* [1].

Mus musculus domesticus (House mice) species is spread in Asia and Europe, and is spread in the kingdom in the western and eastern region, and resembles the black rat, but it is smaller and the color of fur is pale brown and the color of the sides is sandy while the bottom of the abdomen is yellowish pale, and the oldest color is white and has a tail covered with short hairs and not covered by scales, It living in houses and gardens, also there are white mice (Albino), which is used in experiments and research, where it is active at night and the ability to dig tunnels in the appropriate places, and these mice have high hearing capabilities, especially the ultra-frequencies. Also, it has an efficient sense of smell that helps to diagnose food, predatory enemies and pheromones. *Maic* is characterized by weak vision because the retina possesses a few cones so cannot respond to color vision and it is different from human abilities in color vision. Laboratory mice that originated from *Mus musculus* characterized also by aggressive behavior.

The length of the laboratory *mice* between 12-15 centimeter from the top of the snout until the end of the tail and the length of the tail is equal to length of maic body. The small individuals weigh on the first day of birth between 1-2 grams Where, Its weights increase rapidly during a breast feeding [2].

Mus musculus domesticus (House mice) have been selected for number reasons: first, they are small, easy to get them, and they have ability to adapt well to various environmental conditions from the Polar Regions to tropics regions, as well as their rapid reproduction and shortened life periods.

The chondrocranium is that part of the endoskeleton that protects the brain and sense organs and it is organized into regions that are named for their anatomical contribution to protecting the brain and sense organs: nasal capsule, optic capsule, optic capsule and braincase [3]. The braincase consists of the floor, roof, and lateral wall, which protect the brain also support the eyes. The nasal capsule protects the olfactory tissues, whereas the optic capsule, consist of the cochlearis part and canalicularis part, contains the hearing and balancing organs protecting the saccule and cochlear duct, and protecting the semicircular canals and utricle [4].

Mus musculus domesticus (House mice) embryos were selected because it is considered the first study on mammals in Saudi Arabia and for lack research about development of chondrocranium, Also to study the stages of development of the chondrocranium how and when it occurs, knowing the changes that occur in different lengths of embryos, As well as to find out the characteristics of mouse, whereas the most internal anatomical changes occur in the skull, which requires the study of the development of chondrocranium by Study embryos of different lengths and compare them to each other a descriptive anatomical comparison by make serial sections of the head region and drawing it by Ken-a-vision microprojector, whereas The formed cartilage was described accurately in each region and sense capsuls of the skull. However, the development of the chondrocranium was described in detail for various vertebrate species, including humans and various primates, in the late nineteenth and early twentieth centuries by several investigators e.g., (Gaupp, Goodrich, 1930) (De beer, 1937) and they did not study the laboratory mouse, which is considered a basic and important model in the laboratory experiments [5-7]. McBratney-Owen's [8] studied the development of cranial base and tissue origin in mouse.

MATERIALS AND METHODS

Embryos were obtained from King Fahd medical research center, Jeddah, Saudi Arabia. We fixed the embryos head by put them in 10% formalin for 24 -48 hr, then washed it from the fixative by 70% alcohol and dehydrate them. After that, the samples were stained in toto by borax carmine, and embedded in paraffin wax, then we cut the heads in transverse sections (serial sections) at 5µ by using a microtome, then we were stained the samples by Hematoxylin and Eosin. After that, we used the light microscope to examined the sections and used the Ken-a-vision microprojector for graphic reconstruction of the chondrocranium [9,10].

RESULTS

Total body length: 18 mm.

Below we describe the chondrocranium of *Mus musculus domesticus* in many regions: cranial base, lateral walls of the chondrocranium, chondrocranium roof and also describe sense capsuls: nasal capsul, optic capsule, and auditory capsule.

The Nasal Capsule

Nasal capsule in the study sample begins by the appearance of a nasal tectum (N.TE.), which is considered nasal capsule roof and it peripheral edges is limited by paranasal cartilage (PN.C.), which is extend back and connect to the frontal cartilage

e-ISSN:2321-6190
p-ISSN:2347-2294

(F.C.) from the dorsal view and these frontal cartilages from their outer peripheral edges are connected to the side walls of the nasal capsule, which appear as a broad cartilaginous segment known as the sphenethmoid commissure (SPETH.CM.).

The nasal septum (N.SE.) appears as a short cylindrical cartilaginous stick with a thin start that is not perforated and extends to a wide end forming the interorbital septum (INOR.SE.), and it carry from the abdomenal said two cylindrical cartilaginous pieces known as paranasal septum (PN.SE.) and it is notable that these cartilage carries a sensory organ known as Jacobson's organ (J.OR.) or vomeronasal organ, which is appear narrow from the anterior part. (J.OR.) is a chemical sensory organ used primarily for the discovery of pheromons of animals of the same species for the reproduction cycle and sensing danger **(Figures 1-3 and 4A).**

The (N.TE.) give on both sides of the nasal septum two long, tortuous cartilaginous grooves that extending along the nasal capsule from the ventral view, the anterior part of these grooves is known as sulcus anterior lateralis (SL.AN.L.), while the posterior part is known as the sulcus posterior lateralis (SL.PO.L.). The nasal septum separates these sulcus from each other to right sulcus and left sulcus, and each sulcus is separated from the nasal septum by a long fissure extending along the sulcus known as the paraseptal fissure (PSE.FI.) from ventral view. At the end of (SL.PO.L.) the cupula nasi posterior (CU.N.PO.) was formed, and the sulcus of each side are connected to the interorbital septum end (INOR.SE.), which is considered part of (N.SE.), and This contact forms another horizontal piece called lamina transversalis posterior (LA.T.PO.) which is represents the end of the nasal capsule **(Figures 1 and 2 and 4A).**

The mammalian nasal capsule is complex from inside, because it includes distinctive cartilaginous structures called turbinals that arise from the walls and roof this sulcus. The first types of turbinals are appears from the middle region of the nasal capsule and is known as maxilloturbinals (MTUR.) that originate from the peripheral ends of the nasal capsule. The second type of turbinals is nasoturbinals (NTUR.), which arise from the nasal capsule roof.

From the (sulcus anterior lateralis) arise new cartilaginous projects called crista semicircular (CR.SECI.) where the fourth type of turbinals arise beneath the (CR.SECI.) from the side walls of the nasal capsule also it called frontoturbinals (FTUR.).As well as at the end of nasal capsule from (SL.PO.L.) arise cartilaginous branched structure called ethmoturbinals (ETUR.), which are three types, and In this sample only the primary Ethmoturbinals I (ETUR I.) appeared which is the largest and the most branching and arises from side walls of the nasal capsule beneath the (CR.SECI.) **(Figures 4A-4B).**

The Optic Capsule

The optic capsule begins with formation of two cartilaginous large structures like a large wing in both sides called ala orbital cartilage (AL.OR.C.), and these cartilages are characterized by a narrow fissure known as orbitonasal fissure (ORN.FI.), these wings are separated from each other by (INOR.SE.). The anterior part of (AL.OR.C.) is connected to the posterior edge of nasal side walls in nasal capsule which called (SPETH.CM.), so the (AL.OR.C.) contributes to the lateral wall of the anterior part of chondrocranium from the lateral view, and connect from the superior part to the frontal cartilage (FC.), which appear above it from the dorsal view, and arises from the middle of (AL.OR.C.) distinctive cartilaginous structures called orbital cartilage (OR.C.) and it is not yet complete in development **(Figures 1, 2 and 4C-4D).**

Cranial Base

The cranial base of chondrocranium in study sample begins with hypophysial cartilage (HPH.C.), which is characterized by fenestra in the middle known as hypophysial fenestra (HPH.FE.). And it is separate from Trabecular which is not yet formed. From the lateral edges of (HPH.C.) on both sides two top-shaped cartilaginous structures are extends known as the process us pterygoid (PTG.PR.) from dorsal and ventral view. The (HPH.C.) extends back to connect to acrochordal cartilage (ACH.C.) which is merges with the parachordal cartilage (PCH.C.) beginning. The (PCH.C.) connects to a distinct cartilage structure that limits the foramen magnum (FO.M.) from the front and extends in each side as two wide pieces known as the occipital arch (OC.A.), where extends from its peripheral edges on each side small projection called paracondylar processus (PCY.PR.) from ventral view. the (OC.A.) include small hypoglossum foramen (HG.FE.) limited from the top by basicepular fissure basecula (BCAP.FI.), (ACH.C.), (PCH.C.) and (OC.A.) are merges together to form a plate known as the basal plate (B.PL.) **(Figures 1, 2 and 5A).**

Auditory Capsule

The auditory capsule is consisting of two distinctive parts. The first part is known as the coclear part (CO.PT.), the other part is called the canalicular part (CA.PT.), and the auditory capsule in this sample begins with appearance of the (CA.PT.) which it outer peripheral edge is connected to the parital plate (P.PL.) by a small cartilaginous commissure known as the paritocapsular commissure (P.CAP.CM.) from dorsal and ventral view. (CA.PT.) is separated from the (PCH.C.) by the basicapsular fissure (BCAP. FI.), and the capsule extends backwards and connects to the (PCY.PR.) by exocipitocapsular commissure (EXOCCAP.CM.) **(Figures 1, 2 and 6A-6B).**

The auditory capsule containing the membranous labyrinth which includes both the utricle (UT.) and sacculus (SAC.) between the (CO.PT.) and (CA.PT.) and the (CA.PT.) includes three clear semicircular canals: the anterior semicircular canals (AN.SECI.CN.), the lateral semicircular canals (L.SECI.CN.), and posterior semicircular canals (PO.SECI.CN.), the scala vestibuli (SC.V) and scala tympani (SC.TY.) are also appeared in this sample **(Figures 6A-6B).**

e-ISSN:2321-6190
p-ISSN:2347-2294

Lateral Wall of the Chondrocranium

The lateral walls of the chondrocranium are formed from cartilaginous structures that integrate together continuously and are difficult to determine it accurately, these walls are represented by (SPETH.CM.) from the nasal capsule, which are connected from the posterior part to (AL.OR.C.) that also contributes to the side walls of the optic capsule and it remains free from the posterior end not connected to (P.PL.) which forms the side walls of the occipital region, because orbitoparital commissure (OR.P.CM.) not yet formed (absent) in this sample **(Figures 1 and 2).**

Roof of the Chondrocranium

The roof of the chondrocranium in this sample is represented by the appearance of the first roof (anterior roof) that is the (N.TE.), while the second roof (middle roof) and the third roof (posterior roof) which is represented by posterior tectum (PO.TE.) are not yet formed (absence) **(Figure 1).**

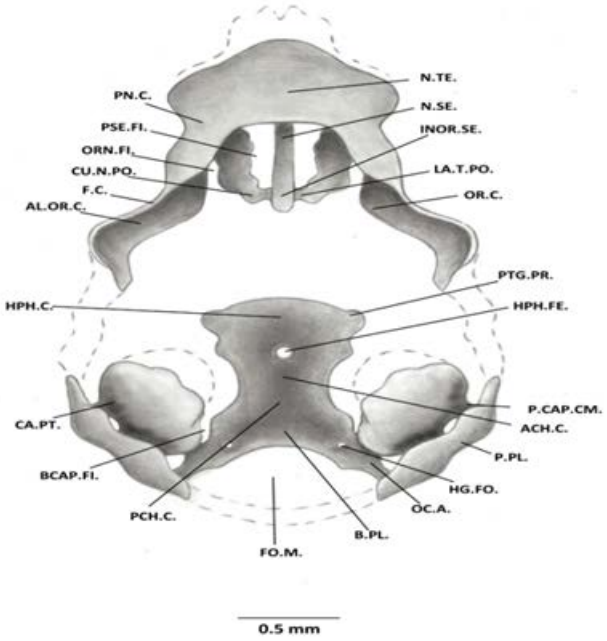

Figure 1. Dorsal view of Graphic reconstruction of *Mus musculus domesticus* chondrocranium.

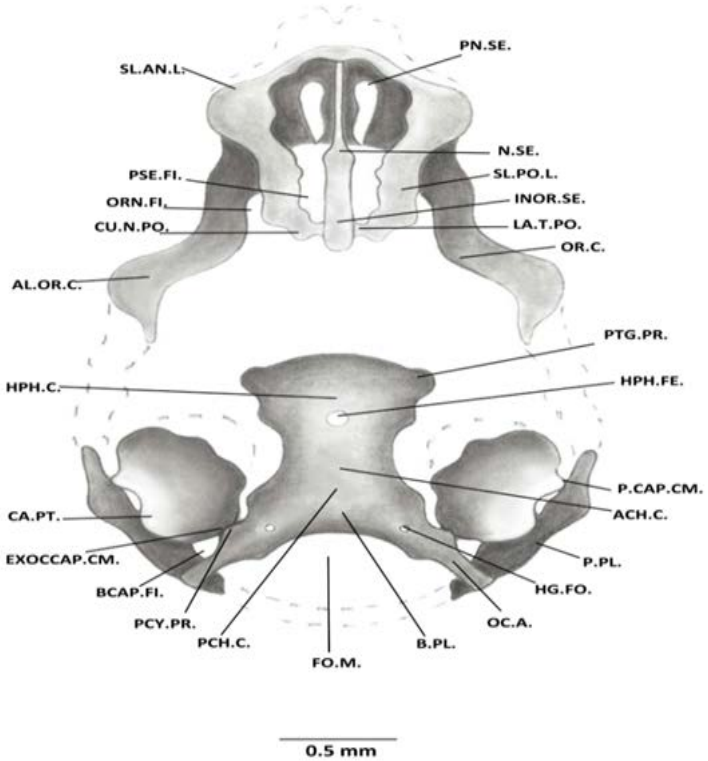

Figure 2. Ventral view of Graphic reconstruction of *Mus musculus domesticus* chondrocranium.

e-ISSN:2321-6190
p-ISSN:2347-2294

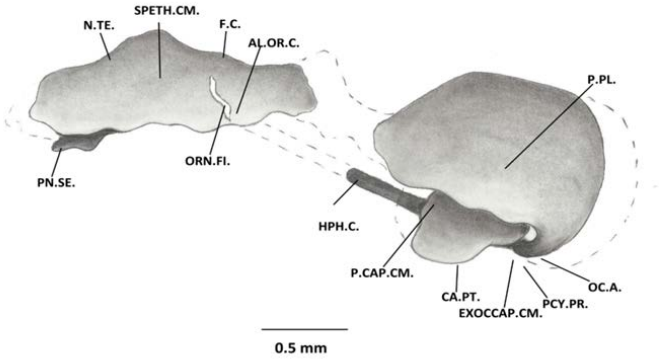

Figure 3. Lateral view of Graphic reconstruction of *Mus musculus domesticus* chondrocranium.

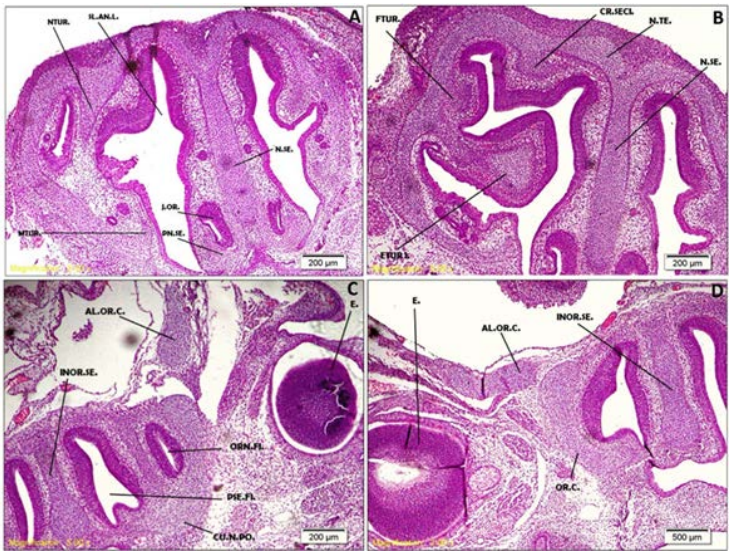

Figure 4. (A): A cross section in nasal capsule shows the nasal septum and paranasal septum with Jacobson's Organ, sulcus anterior lateralis which give two kinds of turbinals maxilloturbinals that arise as a free end of nasal capsule floor and nasoturbinals from nasal capsule roof. (B): A cross section shows the nasal tectum (nasal capsule roof), nasal septum, crista semicircular from capsule roof, frontoturbinals from side wall of capsule and primary ethmoturbinals I that arise beneath the crista semicircular and frontoturbinals. (C): A cross section shows the optic capsule eye with large ala orbital cartilage, paraseptal fissure between orbitonasal fissure and interorbital septum and cupula nasi posterior. (D): A cross section shows the eye with ala orbital cartilage, interorbital septum and orbital cartilage.

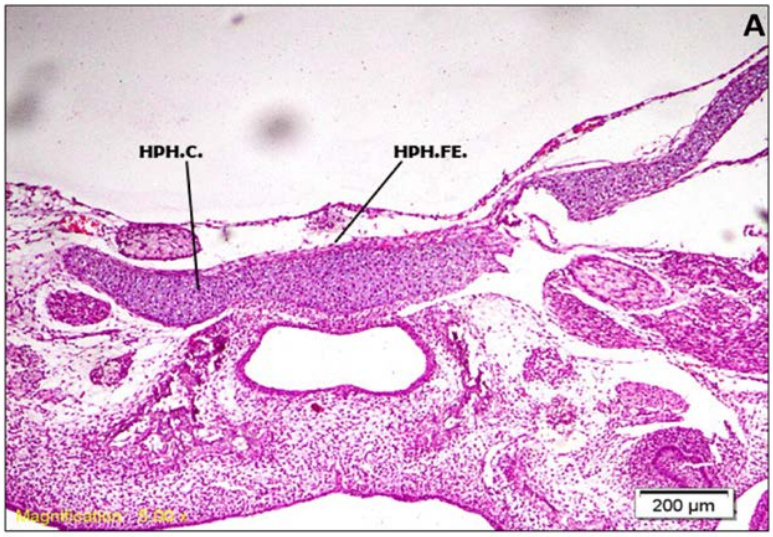

Figure 5. A cross section of cranial base shows hypophysial cartilage with hypophysial fenestrs.

e-ISSN:2321-6190
p-ISSN:2347-2294

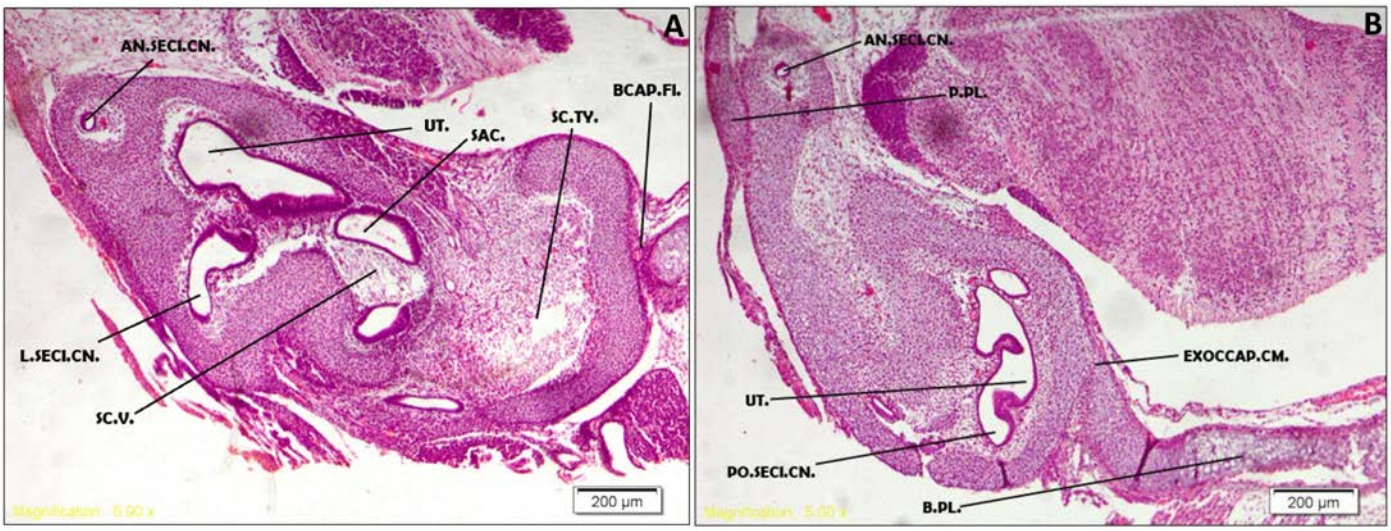

Figure 6. (A): A cross section of auditory capsule shows the utricle and sacculus with clear semicircular canals: the anterior semicircular canals and the lateral semicircular canals, as well as both of the scala vestibuli and scala tympani. The basicapsular fissure is appearing also at this section that separate the canalicular part from parachordal cartilage. (B): A cross section of auditory capsule shows the anterior semicircular canals, the posterior semicircular canals and utricle. Prital plate which it connected to outer peripheral edge of canalicular part, and exocipitocapsular commissure that connects the capsule to paracondylar processus.

DISCUSSION

The chondrocranium of mammals has been described in many studies such as: *Insectivores*, *Rodents*, *Lagomorpha*, *Primates* and other, here we compare the chondrocranium of the *Mus musculus domesticus* with other mammals, and we focused on the sense capsules, cranial base, chondrocranium roof and laterl walls.

The nasal capsule in this study sample (stage I) 18 mm length appears small and the rostral region incomplete lacks some cartilaginous structures, While in the (stage II) 40 mm length it is large, fully developed and the length of nasal capsule less than half length of the central stem, whereas this consistent with most mammals such as *Suncus Murinus*, *Albion Rat*, *Erethizon dorsatus*, as well as in *Microtus Amphibius* while and De beer and Woodger reported that the length of the nasal capsule in *rabbit* is more than half longitude of the central stem [11-16].

The posterior part of nasal capsule in study sample (stage I) 18 mm is connected to ala orbital cartilage by sphenethmoid commissure and this is consistent with both in *Albion Rat* and Niida et al. [11] in *Suncus Murinus*, while De beer and Woodger [16] reported that the anterior part of ala orbital cartilage in *rabbit* connects to paranasal cartilage by sphenethmoid commissure which forms the frontal boundary of the orbitonasal fissure.

The nasal tectum in the study sample (stage I) 18 mm extended back to the ala orbital and it considered the roof of the nasal capsule and the primary roof of chondrocranium and this was agreed with Niida et al. [11] which stated that the nasal tectum in *Suncus Murinus* with a process extending to ala orbital also.

The mammalian nasal capsule is complex because of many distinctive cartilage structures for example, the nasal septum appears clearly and the interorbital septum which is an extension of the nasal septum is connect from posterior part to the lamina transversalis posterior in the study sample (stage I) 18 mm and in the (stage II) 40 mm length, but is not integrated with it, while the lamina transversalis posterior separates from the nasal septum in *Microtus Amphibius*, *Erethizon dorsatus* and *Albino rat* [11-14]. Niida et al. [11] noted in *Suncus Murinus* that the nasal septum connects to the lamina transversalis posterior from the middle not from the end.

The nasal septum in study sample the (stage I) 18 mm length and (stage II) 40 mm length is carried from the ventral view paranasal septum cartilages which is includes vomeronasal organ or jacobson's organ and it is a chemoreception organ helps animal to detect phermons of the same species for reproduction and social behavior, and it has also been seen in *Microtus Amphibius*, *Erethizon dorsatus* and *Albino rat* from *Rodents*, and it also found in *Galago senegalensis* from *Primates* [12-17]. De beer and Woodger [16] reported that the paranasal septum cartilages appear as a pair of discrete independent cartilages located near from ventral edge of the nasal septum in *rabbit* and this has been found in the study sample also. Starck [18] added that the posterior end of the nasal capsule of the *Northern Treeshrew* is pressed by large eyes, also it has incomplete cupula nasi posterior and absence of lamina transversalis posterior is absent.

In the study sample (stage I) 18 mm length, all types of turbinals were present in the nasal capsule except atrioturbinals, ethmoturbinals II and ethmoturbinals III, While in the (stage II) 40 mm length all types of turbinals were present the first types

e-ISSN:2321-6190
p-ISSN:2347-2294

appeared behind the narium fenestra and known as atrioturbinals it continues with the lamina transversalis anterior, also the maxilloturbinals which originate from side wall floor was appeared as well as the nsoturbinals and frontoturbinals. Also we observed crista semicircular from the nasal capsule roof.

The three types of ethmoturbinals were also observed in the study sample and it was found *Microtus Amphibius*, *Erethizon dorsatus* and *Albino rat* where they observed all types of ethmoturbinals except ethmoturbinals II in Most *rodents*, while Starck [18] reported that the nasal capsule in the *Northern Treeshrew* contains the three ethmoturbinals and frontoturbinals [12-14].

The ala orbital cartilage in the study sample (stage I) 18 mm length is large and characterized by orbitonasal fissure and it connect to anterior part of nasal capsule by sphenethmoid commissure, the posterior part of ala orbital cartilage is not connect to parital plate by orbitoparital commissure because not yet formed (absent), while in (stage II) 40 mm length is connect to parital plate by orbitoparital commissure. De beer and Woodger [16] also found that the posterior edge of ala orbital cartilage in *rabbit* is connecting to parital plate by orbitoparital commissure.

The ala orbital cartilage in the study sample (stage I) 18 mm length contribute to the formation of side walls. The interorbital septum is exist, clear, short and wide in the study sample (stage I) 18 mm length, which is considered an extension of the nasal septum, and separates the eyes from each other, Lozanoff et al. [19] stated that the *Macaca mulatta* has interorbital septum, while the interorbital septum is absent in *Albino rat*, *Microtus Amphibius* and *Erethizon dorsatus* [12,14,18].

Voit [15] stated that the *Oryctolagus Cuniculus* has small interorbital septum, De beer And Woodger [16] also observed a small interorbital septum in *rabbit* and they found the mammals that have a well-developed interorbital septum Rodents and Primates, also they classified the interorbital septum based on strength, weakness or lack of development, Starck [18] also observe a clear interorbital septum in *Northern Treeshrew.*

The cranial base of chondrocranium in study sample (stage I) 18 mm length begins with a Hypophysial cartilage and the trabecularm, trabecular communism, and ala temporalis and Pterygoid processus are not yet formed (absent), while in the (stage II) 40 mm length are found. Niida et al. [11] reported that the Hypophysial cartilage arise as three centers in Suncus Murinus, De beer And Woodger [16] reported that the Hypophysial cartilage of central stem in rabbits is narrower than the parachordal cartilage and wider than the trabecular.

The auditory capsule consists of two distinct parts: the cochlear part and canalicular part, where the auditory capsule is begins in study sample (stage I) 18 mm length with the canalicular part which it outer peripheral edge is connected to the parital plate by paritocapsular commissure (P.CAP.CM.), and the capsule is separated from parachordal cartilage by basicapsular fissure. Niida et al. [11] found that the cochlear part in *Suncus Murinus* connecte to parachordal cartilage edge by sphenocochlear commissure, while the posterior part of parachordal cartilage remains distant and detached from the cochlear part by basicapsular fissure, De beer and Woodger [16] also reported that the cochlear part in *rabbit* is independent from parachordal cartilage by basicapsular fissure, Youssef [12] found that the auditory capsule in *Albino rat* connect from anterior part to ala temporal cartilage by alicochlear commissure, and the auditory capsulae is separate from the central stem by basicapsular fissure.

The auditory capsule in the study sample (stage I) 18 mm length containing the membranous labyrinth which includes both the utricle and sacculus, and the canalicular part includes three clear semicircular canals. scala vestibuli and scala tympani are also appeared in this sample, while Youssef [12] found in the *Albino rat* that the cochlear part is representing the anterior part of auditory capsule and canalicular part is representing the posterior part and the last include the semicircular canals, De beer and Woodger [16] added that the auditory capsule in *rabbit* consists of two parts and the canalicular part more larger than the cochlear part and it form a large part of the chondrocranium walls.

The side walls of the study sample (stage I) 18 mm lengths are represented in a group of cartilages that integrate together which is: sphenethmoid commissure, ala orbital cartilage and parital plate. This corresponds with Niida et al. [11] which noted that the ala orbital cartilage in *Suncus murinus* is the first cranial wall that develops in the anterior part of the cranial base, also Youssef [12] said that the ala orbital cartilage in *Albino rat* connect to parital plate by orbitoparital commissure, while Struthers [13] reported that the orbitoparital commissure is absent in *Erethizon dorsatus*, De beer And Woodger [16] added that the parietal plate arise independent and integrate with the supraoccipital cartilage in *rabbit*, and also said that the ala orbital cartilage connect to the nasal capsule by sphenethmoid commissure.

The roof of the chondrocranium in the study sample (stage I) 18 mm length is represented by the appearance of the first roof that is the nasal tectum, While the second roof and the third roof which is represented by posterior tectum are not yet formed (absence), Terry [20] stated that the parietal plate forms the posterior tectum in *Felis* and it connect to occipital arch, while this contrasts with Noordenbos [21,22] who stated that the posterior tectum in *Talpa* arise separate from the parietal plate and occipital arch, also said that the parietal plate arise separate from auditory capsule.

CONCLUSION

This study describes the chondrocranium of *Mus musculus domesticus* in 18 mm length and gets precise anatomical details of cartilages appearance, and comparing these with 40 mm length and other mammils. The study showed that the chondrocranium

e-ISSN:2321-6190
p-ISSN:2347-2294

in this phase is not fully formed, where the nasal capsule lacks the rostral part with some some cartilaginous structures. The optic capsule lacks optic roots and the orbital cartilage is not developed. The cranial base lacks trabecular, Trabecular communis and ala temporalis with pterygoid processus. The auditory capsule lacks the cochlear part and some commissure that connect the capsule to the chondrocranium, the only chondrocranium roof that we found is the nasal tectum, and the middle commissure which is considered as side wall that is called orbitoparital commissure is absent not yet formed, Most of these undeveloped cartilage is found in the second phase (stage II) 40 mm length.

REFERENCES

1. Hartenberger Jl. The order *rodentia*: major questions on their evolutionary origin, relationships and suprafamilial systematics. Institut des Sciences de l'Evolution LA 327, U. S. T. L., Place Eugene Bataillon 34060 Montpellier, France, 1985.
2. Al-Hamoud MH. Vertebrate Biology, Eligibility for Publication and Distribution Chapter. 2005;249:8-278.
3. Moore WJ. The Mammalian Skull. New York, NY: Cambridge University Press, USA, 1981.
4. Kawasaki K and Richtsmeier JT. Association of the Chondrocranium and Dermatocranium in Early Skull Formation. University of Florida, 2017.
5. Gaupp E. Die Entwickelung des Kopfskelettes. In: Hertwig O ed. Entwickelungslehre der Wirbeltiere. Jena: Gustav Fischer, 1906.
6. Goodrich ES. Studies of the Structure and Development of Vertebrates. London: Macmillan, 1930.
7. De Beer GR. The Development of the Vertebrate Skull. New York, NY: Oxford, 1937.
8. McBratney-Owen B, et al. Development and tissue origins of the mammalian cranial base. Developmental Biology, 2008;322:121-132.
9. Tylor W and Van DG. Revised procedure for staining and clearing small fishes and other vertebrates for bone and cartilage study. Cybium. 1985;9:107-111.
10. Feldman AT and Wolfe D. Tissues processing and hematoxylin ana eosin staining. In histopathology, humana press, New York. 2014;pp:31-43.
11. Niida S, et al. Development of the chondrocranial base of the Musk Shrew, Suncus murinus (Insectivora). Exp Anim. 1994:44:79-86.
12. Youssef EH. The chondrocranium of the albino rat. Acta Anatomica, 1966;64, 586-617.
13. Struthers PH. The prenatal skull of the Canadian porcupine (Erethizon Dorsatus). Journal of morphology and physiology. 1927.
14. Fawcett E. The primordial cranium of Microtus amphibius (water-rat), as determined by sections and a model of the 25- mm stage. Journal of Anatomy, 1917;51:309-359.
15. Voit M. Das Primordialcranium des Kaninchens unter Berucksichtigung der Deckknochen. Ein Beitrag zur Morphologie des Saugetierschadels. Anatomische Hefte 1909;38:425-616.
16. De beer GR and Woodger JH. The early development of the skull of the rabbit. Phil Trans Roy SOC Lond B. 1930;218:373-414.
17. Eloff FC. On the organ of Jacobson and nasal-floor cartilage in the chondrocranim of Galago senegalensis. Department of zoology, University of Pretoria, 1951.
18. Starck D. The development of the chondrocranium in pri- mates. In: WP Luckett, FS Szalay (eds.) Phylogeny of the Pri-mates. Plenum Press: New York, 1975; pp: 127-155.
19. Lozanoff S, et al. Prenatal growth of the interorbital septum in Macaca mulatta. Ann Anat. 2004;186:435-442.
20. Terry RJ. The primordial cranium of the cat. Journ Morph. 1917.
21. Noordenbos W. Ueber die Entwicklung des ckondrocraniums der Sauge- tiere, 1 Petrus Camper, 1905.
22. Oisi Y, et al. Development of the chondrocranium in hagfishes, with special reference to the early evolution of vertebrates. Zoological Science, 2013;30:944-961.