

Original Article

Morphometrical Study of the Temporal Bone and Auditory Ossicles in Guinea Pig

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Abstract

In this research, anatomical descriptions of the structure of the temporal bone and auditory ossicles have been performed based on dissection of ten guinea pigs. The results showed that, in guinea pig temporal bone was similar to other animals and had three parts; squamous, tympanic and petrous. The tympanic part was much better developed and consisted of oval shaped tympanic bulla with many recesses in tympanic cavity. The auditory ossicles of guinea pig concluded of three small bones; malleus, incus and stapes but the head of the malleus and the body of incus were fused and forming a malleoincudal complex. The average of morphometric parameters showed that the malleus was 3.53 ± 0.22 mm in total length. In addition to head and handle, the malleus had two distinct process; lateral and muscular. The incus had a total length 1.23 ± 0.02 mm. It had long and short crus although the long crus was developed better than short crus. The lenticular bone was a round bone that articulated with the long crus of incus. The stapes had a total length 1.38 ± 0.04 mm. The anterior crus (0.86 ± 0.08 mm) was larger than posterior crus (0.76 ± 0.08 mm). It is concluded that, in the guinea pig, the malleus and the incus are fused, forming a junction called incus-malleus, while in the other animals these are separate bones. The stapes is larger and has a triangular shape and the anterior and posterior crus are thicker than other rodents. Therefore, for otological studies, the guinea pig is a good lab animal.

Key words: Auditory ossicles, Guinea pig, Morphometrical, Temporal bone

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Introduction

Otological research frequently requires the use of experimental models, mainly guinea pigs and rats because they are easy to handle and their ears are similar to those of humans. Although there are numerous otological studies with guinea pigs and rats, in our bibliographic survey we did not find enough information about the inner and outer ear anatomy of these animals. Knowledge about the anatomy of the ears from these animals is paramount in the field of otology.^{1,2}

According to Schanaider et al (2004) most of the research in the medical field is undertaken with small size animals (mice, rats, hamsters, guinea pig or gerbil) and comprehend almost 90 % of all the species of animals used in a laboratory.³

Oliveira (1989) chose guinea pig for his experiments on the labyrinthine system because its hearing and vestibular system are very similar to those of humans.⁴ Santos (2005) used the rat as an experiment animal because it has practical advantages and because of the anatomical and pathological similarities between its ear and the human ear. Simple access to the rat's middle ear causing minimum morbidity and mortality to the animals.⁵

In order to facilitate the research in the field of labyrinthology using guinea pigs as experimental animals, Oliveira (1989) described the anatomy of temporal bones of these animals, with a dissection under stereoscopic view of the anatomic specimens and microphotographies of surface preparation from cochlear and vestibular epithelium.⁴ Such knowledge is essential, especially in the study of the structural alterations caused by drugs which are toxic to the labyrinth and acoustic trauma. The ear is appropriately termed the vestibulocochlear organ because it includes both the organs of balance and of hearing. The transmission of vibrations from the tympanic membrane across the tympanic cavity to the inner ear

is mediated by the three auditory ossicles; malleus, incus and stapes. Previous researches established the morphology of these ossicles in mammals and some laboratory animals.⁶⁻⁹ However, our present knowledge pertaining to the morphology of the temporal bone and middle ear especially in the ossicles of guinea pig is somewhat limited. The aim of this study was systematic anatomical description of the temporal bone with auditory ossicles in guinea pig. The results would aid in experimental otologic studies.

Materials and Methods

Ten adult male guinea pigs (*Cavia porcellus*) weighing 500 - 600 g were used. The animals were obtained from the Razi Institute in Mashhad, Iran. This study was approved by the Ethics Committee for Animal Experimentation of the Veterinary School of Ferdowsi University of Mashhad. The animals were deeply anesthetized with Ketamine 40 mg/kg and then euthanized by an overdose of the same drug. The investigation adopted traditional techniques for anatomical preparation, observation, photography and measurements. The temporal bones were opened with a pair of dissection scissors, doing a median longitudinal cut on the skull going all the way reaching behind the ears. Afterwards, using the hands in the external auditory meatus as a guide, the tympanic bulla was located with the thumbs and through an outwards movement it was separated from the other structures; having it locked between the fingers it was twisted in a smooth movement to loosen the tissue and release it.

First, systematic anatomical description of the various structures of the temporal bone was performed and then petrosal bones of temporal bone were separated by dissection. The auditory ossicles were gently removed from their situs and features of the ossicles were measured and

photographed by stereomicroscope (Zeiss, Stemi SV 6, Germany). Finally, data were evaluated and analysed using the Sigma Statt statistics software.

Results

The guinea pig's temporal bone is an element of the lateroventral wall of the skull. It consists of the squamous, tympanic and petrous parts. The squamous part forms a considerable fragment of the lateral wall of the skull and joins the zygomatic bone, creating part of the zygomatic arch. The tympanic part was much better developed. It consists of the tympanic ring and the tympanic bulla, and constitutes the ventro-latero-rostral part of the temporal bone. The petrous part was smaller than other parts and forms the middle and posterior cranial fossa and contains the inner ear. Tympanic bulla was oval shape and located between jugular process caudally and foramen lacerum cranially. The tympanic cavity in guinea pig had moreover recess with separated partitions. There was another main air space in dorsal of tympanic cavity and additional air cells in mastoid process of temporal bone. Through stereomicroscope it was possible to see the diameter of the guinea pig's external auditory canal, which is smaller than that of the rat (Figs. 1, 2). The guinea pig's tympanic membrane is much larger than the tympanic ring diameter, in such a way that it creates a hidden space anteriorly to the membrane. Thus, studies regarding the tympanic membrane can be better developed in guinea pig (Fig. 3).

The auditory ossicles of guinea pig observed were three small bones; malleus, incus and stapes but the head of the malleus and the body of incus were fused and forming a malleoincudal complex (Fig. 4). The lenticular bone was a distinct bone and articulated with the tip of the long crus of incus (Fig. 5).

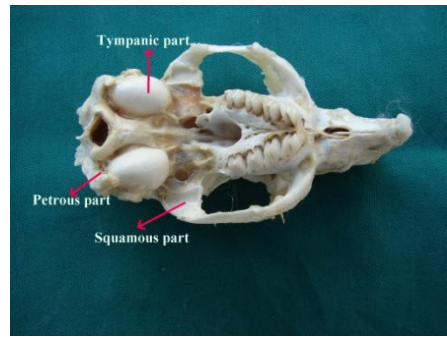


Fig 1. View of the ventral wall of guinea pig skull. Three parts of temporalbone were shown



Fig 2. Fragment of guinea pig skull, left view.1- Squamous part of temporal bone 2 – External acoustic meatus 3 – Interior of the external acoustic meatus 4 –Tympanic bulla

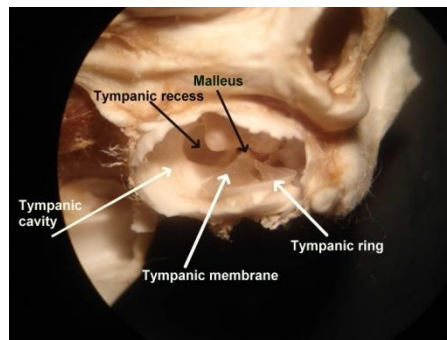


Fig 3. Fragment of guinea pig skull, showing the structures of middle ear.

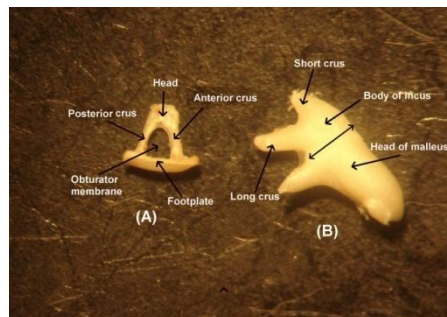


Fig 4. Auditory ossicles of the guinea pig ear. A. Stapes; B. Malleus and incus were fused. Two headed arrow shows the fusing of head of malleus and body of incus.

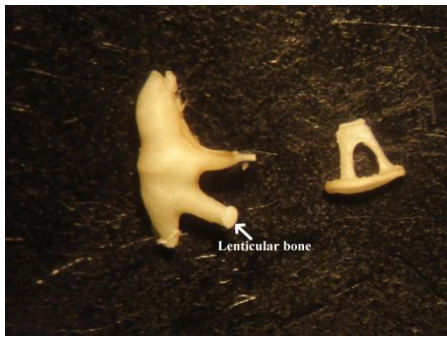


Fig 5. Auditory ossicles of guinea pig ear. The lenticular bone was a distinct bone and articulated with the tip of the long crus of incus.

The malleus, the largest of the three bones consisted of a head that fused with the body of incus and a handle which attached to the tympanic membrane. The average of morphometric parameters showed that the malleus was 3.53 ± 0.22 mm in total length (Fig. 4 and Table 1).

The incus was smaller than the malleus, and had a body with two short and long cruses. The long crus was parallel to handle of malleus and articulated with head of stapes. The average of morphometric parameters showed that the incus was 1.23 ± 0.02 mm in total length (Fig. 4 and Table 1). The stapes was innermost ossicle and consisted of head, footplate and two cruses. The head of stapes had a spherical articular facet, for articulation with the long crus of the incus. The crura were connected at their extremities by a flattened base that called footplate. The anterior crus was longer than posterior one. had a head, Obturator membrane of the stapes was nearly oval. The average of morphometric parameters showed that the stapes was 1.38 ± 0.04 mm in total length. (Fig. 4 and Table 1).

Discussion

The auditory ossicles are important to conduct the sound waves from the tympanic membrane to the cochlea. Morphological studies so far carried out on the auditory ossicles have shown that these bones display peculiar features when

viewed both macroscopically and microscopically.¹⁰

The transmission of sound waves across the tympanic cavity is mediated by the three auditory ossicles known, in lateromedial sequence, as malleus, incus and stapes. The handle of the malleus is embedded in the tympanic membrane so that the head of the malleus protrudes above the membrane by a few millimetres. The head articulates with the body of the incus and the latter articulates with the head of stapes by means of its long crus. The base of the stapes sits in the vestibular window in the medial wall of the tympanic cavity.^{10,11} Otological research frequently requires the use of experimental models, mainly guinea pigs, hamsters and rats because they are easy to handle and their ears are similar to those of humans.^{12,13}

Regarding the labyrinthine system, guinea pig was chosen because its hearing and vestibular systems is very similar to those of humans, and it is an animal that is very good for experiments with the labyrinth.⁴

The auditory ossicles of guinea pig had a similar topography in respect to the rat and mouse.^{12,14} To aid the development of new surgical techniques, researchers have studied the ossicular chain of several animals.^{15,16} In most of studies has shown that during the microdissection stage, the best animal to handle is guinea pig, because of its size and the strength of the temporal bone which allow for a better removal of the tympanic bullas, while in the rat it is smaller and there is a greater likelihood of breaking the tympanic bullas at the time of their removal. Macroanatomical features of the malleus in guinea pig, in general was not similar to other laboratory animals such as rabbit and rat.^{2,14} The latter have malleus and incus separately with distinct structures but in guinea pig the two bones fused and formed a united ear ossicle. Morphology of auditory ossicles of the guinea pig can be used in otologic studies of laboratory animals.

Table1. Measurements of selected size parameters of the guinea pig auditory ossicles. All values are in millimeters and presented as Mean \pm SD, n = 20

Ear ossicles	Parameters	Value
Malleus	Total length	3.53 \pm 0.22
	Head length	0.74 \pm 0.02
	Head width	1.12 \pm 0.1
	Neck length	0.53 \pm 0.01
	Neck width	0.64 \pm 0.01
	Handle length	1.86 \pm 0.01
	Lateral process length	0.70 \pm 0.04
Incus	Total length	1.23 \pm 0.02
	Body length	1.38 \pm 0.04
	Body width	0.75 \pm 0.02
	Long crus length	0.94 \pm 0.08
	Short crus length	0.74 \pm 0.02
Stapes	Total length	1.38 \pm 0.04
	Head length	0.34 \pm 0.02
	Head width	0.59 \pm 0.06
	Anterior crus length	0.86 \pm 0.08
	Posterior crus length	0.76 \pm 0.02
	Base length	1.42 \pm 0.08

In summary, as there was lack of detailed data on the auditory ossicles of the guinea pig, this study made an effort to obtain detailed features of the ossicles of the guinea pig for experimental otologic studies. In guinea pig, the malleus and the incus are fused, forming a junction called incus-malleus, while in the other animals these are separate bones. The guinea pig's stapes is larger and has a triangular shape and the anterior and posterior crus are thicker than other rodents.

It is possible to see that for experiments involving stapes surgery and in surgeries that approach the tympanic membrane, the most proper animal is the guinea pig.

Therefore, for otological studies, the guinea pig is a good laboratory animal, with some advantages; however, other animals such as rats can also be used, as long as the care hereby discussed is taken.

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References

1. Pinilla M, Ramirez-Camacho R, Jorge E, et al. Ventral approach to the rat middle ear for otologic research. *Otolaryngol Head Neck Surg.* 2001; 124: 515 – 517.
2. Calasans-Maia MD, Monteiro ML, Ascoli FO, et al. The rabbit as an animal model for experimental surgery. *Acta Cir. Bras.* 2009; 24:326 – 328.
3. Schanaider A, Silva PC. The use of animals in experimental surgery. *Acta Cir Bras* 2004; 19, 441- 447.
4. Oliveira JAA. *Audio-Vestibular toxicity of drugs.* Florida. CRC Press. 1989; PP 560.
5. Santos PF. And the histological findings otomicrocópicas miringoes-induced atherosclerosis in mice: a critical study of an experimental

- model. *Rev Bras Otorrinolaringol.* 2005; 71:668-74.
6. Huang GT, Rosowski JJ, Flanddermeyer DT, et al. The middle ear of a lion: Comparison of the structure and function to domestic cat. *J Acoust Soc Am* 1996; 101: 12532 – 1549.
 7. Kristensen F, Jacobsen JOG, Eriksen T. *Otology in Cats and Dogs.* 1st edition. LEO, Stockholm 1996; 13 – 15.
 8. Hebel R, Stromberg MW. *Anatomy and Embryology of Laboratory Rat.* 1st edn. Biomed and Vertag. New York 1986; 220-223.
 9. Masuda Y, Honjo H, Naito M, et al. Normal development of the middle ear in the mouse: a light microscopic study of serial sections. *Acta Med Okayama* 1986; 40: 201 – 207.
 10. Dyce KM, Sack WO, Wensing CJG. *Textbook of Veterinary Anatomy.* 3rd edn, Saunders, Philadelphia 2010; 346 – 349.
 11. Konig HE, Liebich HG. *Veterinary Anatomy of Domestic Animals: Textbook and Color Atlas.* 1stedn, Schattauer Company, Stuttgart, Germany. 2004; 284 -286.
 12. Mohammadpour AA. Morphological study of auditory ossicles in the mouse. *J Appl Anim Res* 2010; 37: 269 – 271.
 13. Mclaughlin CA, Chiasson, RB. *Laboratory Anatomy of the Rabbit ,* 3rd edn. Boston: Mc Graw and Hill. 1990; PP 99 – 100.
 14. Wysocki J. Topographical anatomy and measurements of selected parameters of the rat temporal bone. *Folia Morphol* 2008; 67: 11- 119.
 15. Vrettakos PA, Dear SP, Saunders, JC. Middle ear structure in the chinchilla: a quantitative study. *Am J Otolaryngol* 1988; 9: 58 – 67.
 16. Judkins RF, Li H. Surgical anatomy of the rat middle ear. *Otolaryngol Head and Neck Surg.* 1998; 119: 556 – 558.