

The Middle Ear of Ruminants: An Anatomical and Bio-Metrical Comparison between the Lori Sheep and the Native Cow in Shahrekord District

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ABSTRACT

The ossicles consist of three small bones known as the smallest bones in the body that play an important role in transmitting sound to the inner ear. In order to study the details of middle ear ossicles in Lori sheep and native cattle, bio-anatomical parameters of malleus, incus and stapes ossicles were measured. The age factor is not considered and all animals were adult. Investigations showed that there was no significant difference in the levels of the middle ear bone between the two sexes. In this study, the ossicles were carefully described by the appropriate devices and after separation, the ossicles were measured using caliper and digital scales. Bio-anatomical changes were evaluated under stereomicroscope magnification. The results showed that all three bones structure is similar to other animals. Biometric aspects indicated that most of the changes belonged to malleus and incus bone. After examining the two species under study, the least significant change was observed between the two animals in the stapes. In conclusion, this study was able to compare middle ear ossicles between sheep and native cattle in Shahrekord district. Anyway, it is conceivable that the biometric sizes of the middle ear bones may be affected by animal species.

Keywords: Sheep, Cow, Ossicles, Middle ear.

INTRODUCTION

The performance of hearing is a specific feeling are observed among the upper classes of the animal kingdom and is one of the most important sensory inputs to maintenance of life. It seems very interesting, such small structure like the ear performs a vital act of hearing. It is even more surprising that there are three small ossicles, called: a malleus, incus and stapes inside the middle ear (Saha et al., 2017). In discussion of middle ear evolution, primitive tetrapods such as ichthyostega, have a tympanic membrane at the quadrate position. A high degree of extension was observed for the tensor tympani and stapedius muscles, both of them attached to distinct muscular processes (Burda et al., 1992). Wible and Gaudin (2004) reported a lack of processes for muscular fixation in middle ear in *Euphractus sexcinctus*, but they did not indicate the degree of muscular development (Wible and Gaudin, 2004). Next experiences were developed from the reptilian condition and then extend to reptiles and birds, and the mammalian middle ear (Laurin, 1998, Clack and Allin, 2004).

The mammalian middle ear is the most basic morphological features that signalize this class of vertebrates. Middle ear skeletal pattern differs obviously among vertebrates than those of other amniotes and has attracted the attendance of comparative zoologists for years (kuratani, takechi). The middle ear has three ossicles, the malleus, incus and stapes (Allin, 1975, Hall, 2012). Fleischer (2013) demonstrated the more terrestrial mammals can be arranged into two basic middle ear types established upon their ossicular morphologies; with a range of intermediate or transitional morphology between both types. These groups are detected by having a malleus with a long process (processus gracilis) fused to the ectotympanic via a goniale, a wide transversal lamina between the manubrium and the articular surface (for the incus), and a prominent bony mass near the base of the manubrium called the orbicular apophysis (Fleischer, 2013).

Recent genetic analyses in the mouse have provided information about genes central to middle ear formation (Mallo, 2003, Mallo, 2001, Fekete, 1999). However, Goosecoid mutant mice showed defects of the malleus manubrium, processus brevis and

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Received date: November 27, 2020; Accepted date: August 31, 2021; Published date: September 13, 2021

Citation: Fatahian Dehkordi (2021) The Middle Ear of Ruminants: An Anatomical and Bio-Metrical Comparison between the Lori Sheep and the Native Cow in Shahrekord District. Global J Life Sci Biol Res. Vol 7(5):135.

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the ectotympanic and tympanic membrane in the middle ear region (Kuratani et al., 1999). Low-frequency airborne hearing can be improved by relatively large middle ear ossicles with loose ligament attachments, large tympanic membranes and an increased bullar volume (Khanna and Tonndorf, 1969). Therefore, a goal from investigations of auditory genetics and physiology is to express the relation between the middle ear's structure and the function of auditory signal process (Huang et al., 1997). The purpose of the present study was; i) perform a morphological description of the middle ear region with special emphasis in the auditory ossicles; ii) carry out a bi-morphometric comparative study of the middle ear ossicles in the two species Lori sheep and Native cow.

MATERIALS AND METHODS

Animals

The study was a biometrical basically sciences based pragmatic study, performed in the Department of Anatomy in Shahrekord University to monitor the morphological and biometrical differences between ossicles of middle ear for a period of approximately two month, from collecting sample until ossicles separation. A number of sheep and cow (in Shahrekord district) heads from both sexes with entire temporal bones and possessing entire ossicular series in the pattern of with no discontinuity and without erosion/deterioration were selected. Bones that seemed to be worn out in consequence of ear disorders and or complicated diseases were excluded from this investigation. The proposal approval was made by the deputy of the faculty and university in the form of a research project. The methods used to obtain different bones of the ear was somewhat similar to the early stages of "the method of the mastoidectomy" which was carried out by protocol of the some researchers (Hildmann and Sudhoff, 2006). To expose the bones of malleus, incus and stapes, the bulla required to be make accessible by using the very small drill. After that, the middle ear ossicles were separated from the tympanic cavity and examined using an anatomical stereomicroscope (Model Olympus Co., Tokyo, Japan). Issues that were considered; i) description of the anatomical structure of the middle ear ossicles and ii) the measure the biometric parameters of the middle ear ossicles including weight, thickness and diameter. An X-ray (Ralco s.r.l Comp) set was used to take a radiograph of the middle ear bones, including malleus, incus and stapes on a high-resolution mammography films.

Statistical analysis

Statistical analyses in data of middle ear ossicles were carried out by using the SPSS statistical software package version 23.0.0 for Windows. Data are expressed as mean ±standard deviation (SD) and statistical variations were tested by Student-T test. The biometric values of variations, including the weight, length, width and thickness in relation to middle ear ossicles were corrected between two the species and the method used was considered with the criteria of a probability of $p < 0.05$ as statistically significant.

Results

Gross anatomical findings in total available dissected specimens exhibited that the tympanic bulla included three malleus, incus and stapes ossicles (figures 1 to 3).

Figure 1: Ossicular chain link in sheep mature (dorsal view); A: Handle of malleus; B: Incus; C: Stapes.

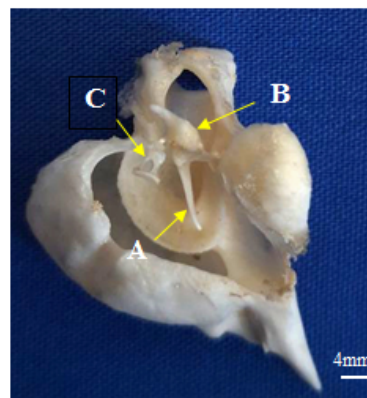
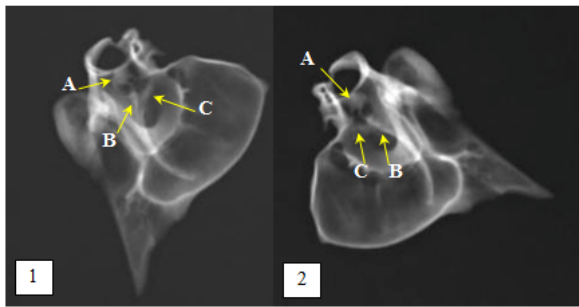


Figure2: Part x, Ossicles in mature cow; I, Incus; M, Malleus; S, Stapes; A, length of malleus; B, width of malleus; C, thickness Of head in malleus; D, length of incus; E, width of incus; F, length of stapes; G, width of stapes; Part y, Ossicles in mature sheep; I, Incus; M, Malleus; S, Stapes; A, length of malleus; B, width of malleus; C, thickness of head in malleus; D, length of incus; E, width of incus; F, length of stapes; G, width of stapes.



Figure 3 demonstrate radiographs of middle ear ossicles in lateral and medial view. The malleus was a hammer-molded small bone which joins with next bone (incus) and is attached to the inner surface of the tympanic membrane. The incus ossicle, a bone in the middle ear, was the anvil- molded small bone which connected to the third middle ear bone (figs. 1 and 2). Stapes, the last bone (figs 1 and 2,), was the stirrup-molded shaped small bone which was placed on other bones, transports these to the oval opening (an opening that leads from the middle ear to the inner ear cavity (Sisson and Grossman, 1947, Grossman and Getty, 1975).

Figure 3: Radiographs of the middle ear ossicles in mature sheep; 1) lateral view; 2) medial view. A, malleus; B, incus; c, stapes.



Data obtained from bio-metric analysis of three malleus bones, incus and stapes in both species (sheep and cow) are shown in Tables 1. The results revealed an obvious increase in length, width, thickness of malleus ossicle in cow than sheep (Table 1). All of measures except the weight of the Malleus ossicle in the cow showed a significant difference compared with sheep ($p < 0.05$). However, only the weight of the Malleus ossicle in the cow no showed a significant difference compared with sheep ($p > 0.05$). There was a significant difference in the biometric dimensions of the length, thickness and width (head, middle and tail) of the malleus ossicle between both species ($p < 0.05$).

A similar pattern was followed among biometric sizes of the incus ossicle in middle ear (Table 1), as the biometric dimensions of the length and width of the incus ossicle in the cow were significantly higher than the sheep ($p < 0.05$). The differences between two species in weight of incus ossicle do not follow a similar pattern like other biometric values; as there were not significant difference in the parameters mentioned between two animal, in spite of increasing weight of incus ossicle in cow compared sheep ($p > 0.05$). The values of the weight, the diameter and length observed concerning stapes ossicle in each two animals are presented in Table 1.

Table 1: Biometric parameter of malleus, incus and stapes between sheep and cow (mm) (Mean \pm SE).

P value	Mean \pm SE	Parameter	species	row
P<0.05	8.97 \pm .363a	m.sh.l	sheep	1
	10.22 \pm .248a	m.c.l	cow	2
P<.0.05	2.01 \pm .028b	m.sh.hwi	sheep	1
	2.20 \pm .051b	m.c.hwi	cow	2
P<0.05	.78 \pm .020c	m.sh.twi	sheep	1
	.85 \pm .025c	m.c.twi	cow	2
P<0.05	3.49 \pm .024d	m.sh.mwi	sheep	1
	3.95 \pm .015d	m.c.mwi	cow	2
p>0.05	.029 \pm .001	m.sh.we	sheep	1
	.040 \pm .004	m.c.we	cow	2

P<0.05	4.90 \pm .020e	inc.sh.l	sheep	1
	5.95 \pm .103e	inc.c.l	cow	2
P<0.05	2.42 \pm .017f	inc.sh.wi	sheep	1
	2.83 \pm .049f	inc.c.wi	cow	2
P<0.05	3.32 \pm .063	inc.sh.b2b	sheep	1
	4.79 \pm .031	inc.c.b2b	cow	2
p>0.05	.030 \pm .029	inc.sh.we	sheep	1
	.060 \pm .001	inc.c.we	cow	2
p>0.05	3.44 \pm .065	st.sh.l	sheep	1
	3.62 \pm .005	st.c.l	cow	2
P<0.05	2.49 \pm .043g	st.sh.wi	sheep	1
	2.69 \pm .014g	st.c.wi	cow	2
p>0.05	.580 \pm .023	st.sh.t	sheep	1
	.670 \pm .020	st.c.t	cow	2
p>0.05	.024 \pm .011h	st.c.we	Sheep	1
	.025 \pm .010h	st.c.we	cow	2

Sh: sheep; C: cow; M: malleus; We: weight; L: length; Wi: width; Hwi: head width; Mwi: middle width; Twi: tail width; Inc: incus; b2b: between two branches; St: stapes; T: thickness. Significant differences between each two values of a single parameter compared between two species are shown with same letters; otherwise there is no letter denotation.

It should be noted that there were significant difference in the width value of the stapes ossicle when compared between two species ($p < 0.05$). The thickness, length and weight biometrical amounts increased in cow compared with sheep during the anatomical evaluation of this bone; but except the weight there was no significant difference between cow and sheep in biometrical amounts of stapes ossicle ($p > 0.05$).

DISCUSSION

Although some researchers evaluated the bony structure of the middle ear from an anatomical viewpoint (Saha et al., 2017, Erdogan and Kilinc, 2010, Padmini and Rao, 2013, Simaei et al., 2017), but the study on the comparison of middle ear ossicles (malleus, incus and stapes) between the two species of cattle and sheep from each two sexes has not been elucidated in detail. Therefore, the present article has evaluated these bone structures as far as possible. Findings in the biometric values of the middle ear ossicles displayed that there were significant differences between the two species, but no observed clear difference about the gender impact on biometric amounts in both animals. The researchers have shown that measuring the

middle ear ossicles plays an important role in the output impedance of the ear (Huang et al., 1997); On the other hand, it can have other effective effects in artificial hearing aid that replace some of the missing parts of the body. In this way, Sodhi et al., (2017) in a demographic study at India on the morphometric dimensions of human ear ossicles of males showed that exact measurements of the ossicles could be very helpful in designing the prosthesis in ossicular chain pathology (Sodhi et al., 2017).

As previously identified, reports revealed that there was no significant difference between middle ear bones in male and female rabbits. This may lead to the result that diversity in the characteristics of middle ear ossicles, particularly bio-anatomical parameters, does not matter so much in terms of the sex (Kurtul et al., 2003), as was agreed with the results of this study. However, although the findings suggest no gender differences in the structure of the middle ear ossicles (Kurtul et al., 2003), but in current study effect of gender factor was taken into account. In a study by Meiring and Oschman (1991) on the morphology of the malleus ossicle of 75 adult human cadaver, in a comparative manner, they were found that there was no significant difference between two sex bones (Oschman and Meiring, 1991). The anatomical gross structure of the malleus, incus and stapes ossicles in this study was similar to recent reports (Huang et al., 1997, Masuda et al., 1986, Schönfelder and Zschäkel, 1985). The findings in few reports show tangible differences, as Kurtul et al., (2003) in rabbit showed that some middle ear ossicles, in anatomical appearance, have a clear difference over the rest of the animals. They in own study found that there were variations greatly especially on the processes and handle in these ossicles (Kurtul et al., 2003).

Regardless of the significant differences between some biometric quantitative values in the middle ear ossicle in this study, the variations indicated a sensible increase in measured values about ossicles of the cattle relative to the sheep. However, with a brief overview at "p-value" of the measured amount of ossicles, we were found that malleus ossicle showed the least alteration between the two species of cattle and sheep. While in the other two ossicles, the most alteration was observed regarding biometrical measurements in incus and stapes ossicles. Researches have shown that between the ossicles, incus is the most fixed ossicle and stapes ossicles have the most variable as far as their morphological changes are of particular importance (Unur and Ülger, 2002, Sarrat et al., 1988, Noussios et al., 2016, Mogra et al., 2014). Previous studies have shown that congenital ossicles anomalies is accompanied by facial nerve abnormalities; furthermore, Padmini and Rao (2013) in evaluating morphological changes of human fetal ear ossicles showed that impoverished human fetuses can be used in form homo-grafts to substitute corroded mature ear ossicles (Padmini and Rao, 2013).

The degree and extent of bony chambers could be reliably predicted by the size of its internal structures (Cherukupally et al., 1998). It seems that the distinct difference that between the bones of the two species under study can be clearly seen, to be closely related to the dimensions of tympanic bone. According

to this point, as is clear, tympanic bone shows a larger dimension in cow than sheep (Sisson and Grossman, 1947, SanMartin et al., 1992). Therefore it's easier to understand, the distinct difference between the measured values in the malleus, incus and stapes ossicles between two animal species; however, some bony values did not show significant differences.

REFERENCES

- Allin, E. F. Evolution of the mammalian middle ear. *J Morphol.* 1975;147: 403-37.
- Burda, H, Bruns, V. Hickman, G. C. The ear in subterranean insectivora and rodentia in comparison with ground-dwelling representatives. I. Soundconducting system of the middle ear. *J Morphol.* 1992; 214: 49-61.
- Cherukupally, S.R, Merchant, S.N, Rosowski, J.J. Correlations between pathologic changes in the stapes and conductive hearing loss in otosclerosis. *Ann Otol Rhinol Laryngol.* 1998; 107: 319-326.
- Clack, J. A. Allin, E. The evolution of single and multiple-ossicle ears in fishes and tetrapods. *Evolution of the vertebrate auditory system* Springer. 2004.
- Erdogan, S. Kilinc, M. Gross anatomy and arterial vascularization of the tympanic cavity and osseous labyrinth in mid-gestational bovine fetuses. *Anat Rec.* 2010; 293: 2083-93.
- Fekete, D.M. Development of the vertebrate ear: insights from knockouts and mutants. *Trends Neuroscience.* 1999; 22: 263-9.
- Fleischer, G. Evolutionary principles of the mammalian middle ear, Springer Science & Business Media. 2013.
- Grossman, J. D, Getty, R. Sisson Grossman's the Anatomy of the Domestic Animals, Saunders. 1975.
- Hall, B. K. Evolutionary developmental biology, Springer Science & Business Media. 2012.
- Hildmann, H. Sudhoff, H. Middle ear surgery Springer Science & Business Media. 2006. 19-23.
- Huang, G. T, Rosowski, J. J, Flandermeyer, D. T, Lynch, T. J, 3rd Peake, W. T et al. The middle ear of a lion: comparison of structure and function to domestic cat. *The Journal of the Acoustical Society of America.* 1997; 101: 1532-49.
- Kurtul, I, Cevik, A, Bozkurt, E. U. Dursun et al. A detailed subgross morphometric study on the auditory ossicles of the New Zealand rabbit. *Anat Histol Embryol.* 2003; 32: 249-52.
- Laurin, M. The importance of global parsimony and historical bias in understanding tetrapod evolution. Part I. Systematics, middle ear evolution and jaw suspension. *Annales des Sciences Naturelles-Zoologie et Biologie Animale,* 1998; 1-42.
- Mallo, M. Formation of the middle ear: recent progress on the developmental and molecular mechanisms. *Dev Biol.* 2001; 231: 410-9.
- Mallo, M. Formation of the outer and middle ear, molecular mechanisms. *Curr Top Dev Biol.* 2003; 57: 85-113.
- Masuda, Y, Honjo, H, Naito, M. Ogura, Y et al. Normal development of the middle ear in the mouse: a light microscopic study of serial sections. *Acta Med. Okayama.* 1986; 40: 201-7.
- Noussios, G, Chouridis, P, Kostretzis, L. Natsis, K. Morphological and Morphometrical Study of the Human Ossicular Chain: A Review of the Literature and a Meta-Analysis of Experience Over 50 Years. *J Clin Med Res.* 2016; 8: 76-83.
- Oschman, Z. Meiring, J. H. A morphometric and comparative study of the malleus. *Acta Anat.* 1991; 142: 60-1.