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Brief Report

Anatomy of the Intertragic Notch of the Auricle May Protect the Ear Canal from Fluids as a Built-In Overflow Spout at an Appropriate Position

Amitava Biswas

University of Southern Mississippi School of Speech & Hearing Sciences, College of Nursing & Health Professions Hattiesburg, Mississippi, USA

ORCID ID of the author: A.B. 0000-0002-9388-1972.

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To observe the utility of the intertragic notch during rain showers, an anatomic replica of the human auricle was studied under an artificial shower system with a video recorder. During the shower, water trickled out through the intertragic notch naturally, avoiding the ear canal. This study finds one utility of the intertragic notch may be the prevention of water flowing into the ear canal during rain showers.

KEYWORDS: Protective anatomical features of external ear, prevention of water in ear canal

INTRODUCTION

From visual appearance, prominent anatomical features of the ears, such as auricles, are obviously associated with the hearing system. Proper functioning of the hearing system is supposed to be significantly dependent on these features. For example, it has been established that human auricles generally account for improved hearing sensitivity by a few decibels [1, 2]. As shown in Figure 1, many quadruped animals have a funnel-like morphology of the external ear, and it seems reasonable to recognize it as a funnel that collects sound. Unlike humans, quadruped animals frequently dip their heads for food and water. They have steerable auricles that can be oriented or flapped when necessary [3, 4].

However, the human ear looks more like a maze than a funnel. The maze-like features, including the helix, anti-helix, tragus, anti-tragus, and intertragic notch are systematic and appear to be generally consistent across individuals of any race, color, sex, and age. Furthermore, humans have non-steerable auricles [5], and they generally maintain a vertical posture during most activities, including locomotion and feeding. Online publications of national mints, museums, and other similar sources have shown innumerous ancient and current coins depicting the side view of a human head where the intertragic notch is visible as a consistent feature. A few examples are presented in Figure 2. Similar to many other consistent features of the human anatomy, these details of the external ear are probably coded in specific genes and may have evolved to current formations from predecessors over many generations to develop certain functional advantages.

Nevertheless, any distinct rationale underlying the evolution of this mysterious morphology of the consistent maze-like anatomy of human auricles has received little attention in the literature. Students interested in the human ear anatomy have enquired about this puzzle that has raised questions that are unanswered in their textbooks. As shown in the right panel of Figure 2, some acupuncturists have reported the detailed utility of specific spots of human auricles that may be pricked with needles to treat disorders in other regions of the body [6]; however, the intertragic notch, being an empty space, may not be pricked with needles. Any utility of the intertragic notch could not be directly derived from the perspective of acupuncture. Therefore, our attention was drawn to a familiar feature that is commonly observed in kitchens.

Many containers used in kitchens have spouts for discharging liquids as shown in Figure 3. There is a remarkable resemblance between the intertragic notch of human auricles and these spouts for pouring liquids. To serve its purpose properly,

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Corresponding Address: Amitava Biswas E-mail: Amitava.Biswas@USM.edu

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Figure 1. A plastic funnel available at several automotive and grocery stores.

spouts should be inserted at the lowest level of the brim of its container. This appears to be the case for the intertragic notch as well. During an erect posture of individuals, the intertragic notch is situated below the ear canal. When the notch is covered with a continuous strip between the tragus and anti-tragus, a pocket that can hold water and harbor bacteria is formed, causing painful otitis externa or swimmers ear. Recurrence of such conditions can lead to loss of hearing sensitivity. After exposure to rain showers, cats and dogs often shake, twist, or turn their heads vigorously and flap their auricles to eject any water off their ears. Such maneuvers are not common among humans. Therefore, we hypothesized that the unique anatomic details of human auricles help keep rainwater away from the ear canal during a normal vertical posture under rain showers and conducted a few preliminary experiments as detailed below.

MATERIALS AND METHODS

An aquatic activity was simulated by building a shower system. The water was continuously circulated by a pump at a rate of 8 L/minute. The water was colored with Bath Dropz tablets (Crayola, New York, NY, USA) to ensure adequate visibility. In one experiment, a mannequin (Hobby Lobby, New York, NY, USA) without any auricles was held upright under the shower of colored water. In another experiment, a model of the human auricle (American Scientific Supply, New York, NY, USA) was held upright under the same shower of colored water. Assuming that approximately 3 minutes of exposure to rain showers may occur before individuals find shelter, these experiments were repeatedly observed for 3 minutes at a time. With the approval of the Institutional Review Board of the University of Southern Mississippi (Protocol: IRB-19-125), one human participant was observed under a rain shower, after obtaining informed consent.

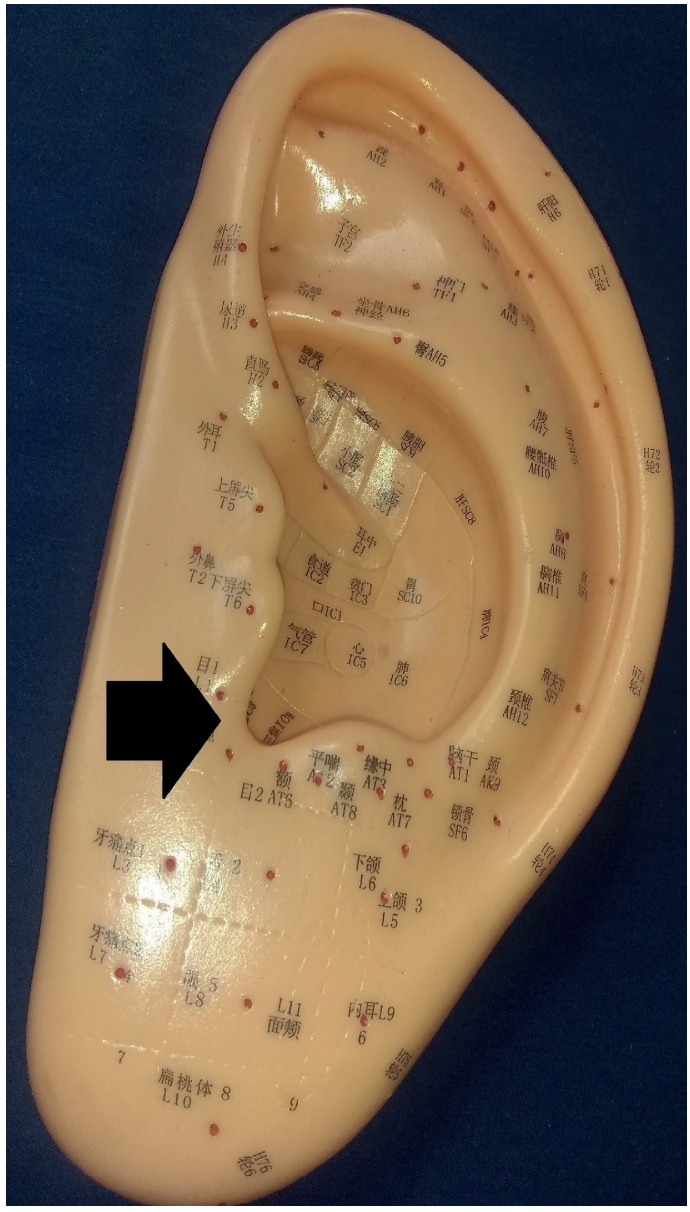

Figure 2. A model of the human auricle, which is available from several online vendors of Chinese merchandise. The intertragic notch is indicated by the dark black arrow.

Statistical Analysis

Statistical analyses were performed using the Binomial statistical test of the Statistical Package for the Social Sciences software, version 21 (SPSS Inc., Armonk, NY, USA). The condition of $p<0.05$ was considered to be statistically significant.

RESULTS

When the experiments were repeated five times for the mannequin without any auricle, water trickled down the entire region covering the expected position of the ear canal at all five instances, as shown in Video 1. However, when these experiments were repeated five times for the human auricle model, water did not reach the ear canal at all five instances, as shown in Figure 4 and Video 2. In these cases, the flow of water was automatically routed along the helix of the human auricle model, preventing the flow of falling water into the ear canal. The tragus

Figure 3. Several containers used in kitchens for handling liquids have spouts instead of funnels as shown in this figure. Spouts must be situated at the lower side of the brim to facilitate pouring of liquids. Given that the intertragic notch is normally situated at the lower side of the auricle, it may similarly channel water away from the ear canal during rain showers.

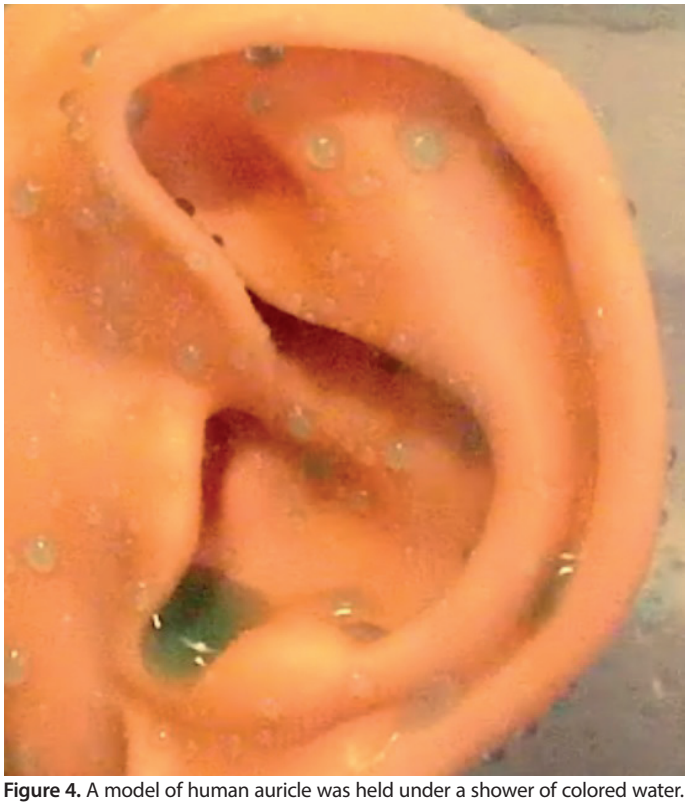

Figure 4. A model of human auricle was held under a shower of colored water. The flow of water was automatically routed along the helix of this auricle, preventing the falling water from flowing into the ear canal. The tragus and anti-tragus barricaded the ear canal from scattered or splashed water from the sides. The intertragic notch drained any accumulated water from the auricular pool, similar to a spout placed at a desired position.

and anti-tragus barricaded the ear canal from scattered or splashed water from the sides. The intertragic notch drained any accumulated water in the auricular pool, similar to the function of spouts in the optimal location Binomial statistical test [7] of the observed data indicated significant statistical difference in the observed frequencies of water reaching the ear canal ($p<0.01$). One human participant was observed under a rain shower. The flow of water along the auricle of the human participant appeared similar to that observed in the human auricle model.

DISCUSSION

These preliminary observations appear to be interesting and consistent with other commonly observed phenomena, such as the function of eyebrows in protecting the eyes from dripping water or perspiration from the forehead and scalp and from flowing water during rain showers. It also resembles parapets, cornices, and gutters of houses, protecting the windows from dripping water flowing from rooftops during rain showers. Although quadruped animals, such as cats and dogs, have mobile auricles, they also have an intertragic notch near the lower boundary of the ear, probably for efficient discharge of any efflux or accumulation of fluids from their ear canals.

CONCLUSION

One utility of the intertragic notch may be prevention of water flowing into the ear canal during rain showers. In this context, we believe that the human brain, which is larger than that of some other animals, is more vulnerable to concussions if the head is shaken vigorously and frequently, and this situation has necessitated the evolution of the maze-like shape of auricles to eliminate the regular need of quadruped animals, such as cats or dogs, who shake their heads vigorously when exposed to rain showers. Although this study has explored a concern over the necessity of the tragus in human auricles, a related issue for further research is the unusually extended tragus in bats, probably to divert and guide rain water away from their ear canals without significantly blocking the reception of sound [8]. This feature may be necessary given that bats often spend a long time hanging upside down. Future studies should also focus on specific details of the pinna, such as (1) the efficiency of discharging accumulated fluids via the intertragic notch and (2) the efficacy of grooves along the periphery of the helix of the pinna in guiding water droplets away from the ear canal. Further research is warranted to fully understand these essential parameters for fabricating artificial auricles to achieve optimal performance, protection, and safety of the middle ear. We also suggest that these exploratory findings be confirmed by other researchers by designing more extensive studies on human and animals. Because of the limited exploratory scope of this study, we would encourage further studies before making definite conclusions.

Video 1. A mannequin without any auricles was held under a shower of colored water, and the water flowed along all possible paths, including the likely position of the ear canal without any hindrance.

Video 2. A model of human auricle was held under a shower of colored water. The flow of water was automatically routed along the helix of this auricle, preventing the falling water from flowing into the ear canal. The tragus and anti-tragus barricaded the ear canal from scattered or splashed water from the sides. The intertragic notch drained any accumulated water from the auricular pool, similar to a spout placed at a desired position.

Ethics Committee Approval: Ethical approval was obtained from the Institutional Review Board of the University of Southern Mississippi (Reference Number: IRB-19-125).

Informed Consent: Informed consent was obtained from all the participants of the study.

Peer-review: Externally peer-reviewed.

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Conflict of Interest: The author have no conflict of interest to declare.

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