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Identification of Merkel Receptors Sheet in Quail Beak

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Research Article

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Abstract

Avian beak considers an important mechanosensing organ. Studying distribution of pressure mechanoreceptors is significance to understand feeding behavior in birds. The current study explored organization of the Merkel receptors in the tip and anterior part of the quail beak. Samples of beak were collected and processed for paraffin and semithin sectioning. The current study investigated organization and distribution of the Merkel receptors in quail beak. Merkel receptors were found in two forms either as Merkel cells or organized in a Merkel corpuscle. In the tip and the anterior part of quail beak, both types of Merkel receptors were identified. Merkel cells were organized as a sheet located under the mucosal epithelium of the tip and the anterior part of the beak. Merkel corpuscles located in the dermal papillae. In conclusion, quail beak was rich in Merkel receptors. Thus, quail beak could be used as a model to study the electrophysiology of the Merkel receptors.

Keywords: Beak; Merkel receptors; Quail

Abbreviations: MC: Merkel Corpuscles.

Introduction

Merkel receptor is a sensory mechanoreceptor located in the epidermis as well as the subepithelial connective tissue. Merkel cells are associated with dilated nerve terminal forming the Merkel cell–neurite complex, or a Merkel disc receptor. Merkel cells locate in the basal layer of the epidermis as well as locate in the outer root sheath of the hair follicle. Merkel receptors occur in glabrous skin such as pig snout, planum nasale of cat and mole [1]. In human, Markel cells occur in whiskers, lips, oral cavity, plantar foot surface. In avian spices, Merkel cells arranged as dermal sensory cells or form Merkel corpuscles. The organization of Markel corpuscles is the alignment of Merkel cells in parallel with the discoid nerve endings which are enclosed by lamellar cells [2,3]. Merkel cells have an oval shape, lobulated nucleus, multiple cytoplasmic processes extending between keratinocytes. Merkel cells have osmiophilic granules and store serotonin. Merkel receptors respond to touch and pressure via releasing of serotonin and stimulate excitation of the serotonergic synapse [1].

Quail is used as an advantageous model as laboratory animals and occupies a prominent position in the field of biological research [4]. The genetic map of the quail species is quite similar to Gallus species [5]. Quail advantages exceed Galliformes that favor quail to be used in laboratory for developmental and experimental investigations. Quail has a small size, easily to be bred in the laboratory, rapid embryonic development and post-natal sexual maturation [6].

Existence of Merkel receptors have been investigated in quail birds [7]. However, accurate organization and distribution of the Merkel receptors in quail beaks have not described. The current study aimed to describe pattering of Merkel receptors organization and distribution in quail beak.

Material and Methods

Sampling

The study was carried out using apparent healthy birds. Beak samples were taken from adult Quail birds (Coturnix coturnix japonicum). Sampling protocol was performed according to Gottschaldt KM, et al. & Gentle MJ [8,9]. Samples were fixed in 10% neutral buffered formalin for paraffin sections and a 2.5% glutaraldehyde. Protocol of sample fixation was performed regarding to Soliman S [10]. Samples processing for preparation of paraffin embedding samples was mentioned Soliman S & Harris HF [11,12]. Beak samples were trimmed into tip of the beak and the anterior part of the beak. Quail beaks measured about 18.79 mm. The tip of the beak extends to 1 mm and the anterior part which measure about 2.5 mm of the whole length of quail beak.

Conventional Histological Staining

Paraffin sections were stained with Hematoxylin and Eosin stain [13], Mallory trichrome [14], Methylene blue [15]. Stained sections were examined by Leitz Dialux 20 Microscope. Photos were taken using a Canon digital camera (Canon Powershot A95). Staining protocols were performed according to Berkhoudt H & Abd-Elhafeez HH, et al. [16,17].

Preparations of Resin Embedding Samples

Protocol of preparations of resin embedding samples were described in Berkhoudt H & Soliman S, et al. [16,18].

Estimation of Merkel Receptors in the Tip and the Anterior Part of the Quail Beak

Density of individual Merkel cells and Merkel cells in the corpuscle were estimated using Image J (5.3 microns3). The average number of Merkel receptors was calculated in the sections. Percentage of the Merkel cells were estimated in the tip measured 1mm and the anterior part measured 2.5mm of the total length of the quail beak.

Results

The current study investigated distribution of the Merkel receptors in quail beak. Merkel receptors were found in two forms either as Merkel cells or organized in a Merkel corpuscle. In the tip and the anterior part of quail beak, both types of Merkel receptors were identified. Merkel cells were organized as a sheet located under the mucosal epithelium of the tip and the anterior part of the beak (Figures 1A-E and Figures 2A & B). Merkel corpuscles located in the dermal papillae (Figure 1C). Distribution of the Merkel receptors sheet was summarized in Figure 3. Percentage of the Merkel cells was estimated in the tip and the anterior part of the quail beak. Merkel receptors located in the tip of the quail beak in higher than the anterior part approximately reached 59% and 41% respectively.

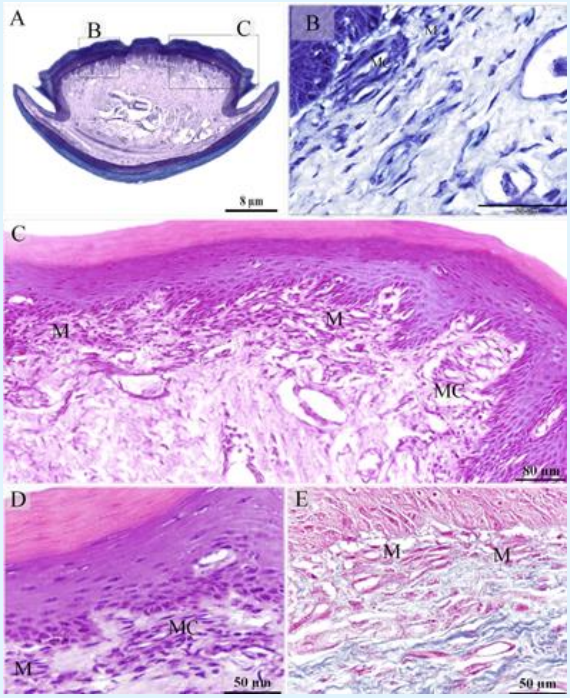

Figure 1: Merkel receptors in the Tip of quail beak. Paraffin sections stained by methylene blue (A,B), H&E (C,D) and Mallory trichrome (E). Subepithelial Merkel cells (M) distributed along the mucosal surface of the tip of the quail beak. Merkel corpuscles (MC) located in the dermal papillae.

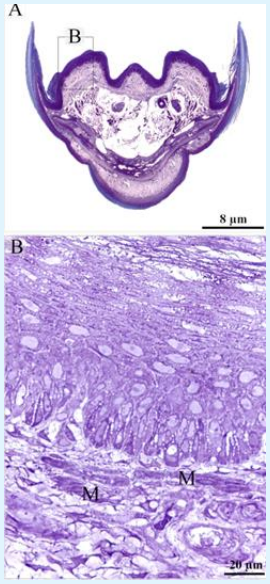

Figure 2: Merkel receptors in the anterior part of quail beak. Semi thin sections stained by toluidine blue. A, B: Subepithelial Merkel cells organized in a sheet along the mucosal surface of the anterior part of the quail beak.

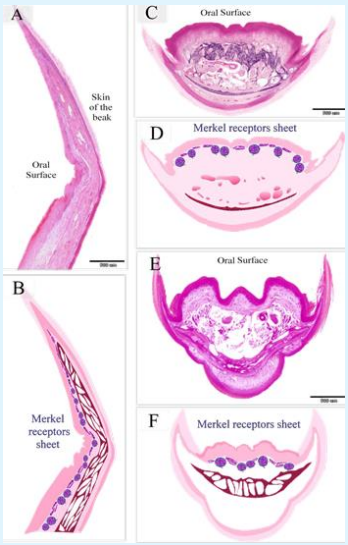

Figure 3: An illustration showed the distribution of the Merkel cell sheet in quail beak. A, B: Sagittal view of quail beak showed distribution of Merkel receptors sheet in the tip of the quail beak. C, D: cross section of the tip of quail beak showed distribution of Merkel receptors sheet. E, F: cross section of the anterior part of quail beak showed distribution of Merkel receptors sheet.

Discussion

Avian beak is one of the mechanosensing organ. Quail beak exhibits various forms of mechanosensation including stretching, vibration and pressure [7]. The current study explored different forms and distribution of Merkel receptors in quail beak.

In the current study, Merkel receptors were identified in two forms; Merkel cells and well-organized Merkel corpuscle. Both types were located in the tip and the anterior part of quail beak. Merkel cells and corpuscles establish a continuous sheet under the mucosal epithelium. Merkel disc and the associated Merkel cells receive single axon. The tip measuring 1 mm contained 59% of Merkel receptors and the anterior part measured 2.5 mm had 41% of Merkel receptors of the examined quail beak. Merkel receptors have been estimated previously in Quail beak. The tip as 65% of the total sensory receptors in the tip of quail measuring to 2.6 mm length. While 14.85% of the total sensory receptors in the tip of quail measuring to 4.02 mm length. The middle portion measuring 5 mm and the caudal portion measuring 7.17 mm are devoid of Merkel receptors [19].

Fifty or more Merkel cells are grouped in the touch sensitive area [20,21]. According to rate of stimulation, mechanoreceptors are classified into rapid and slow adapting response. Slow adapting type is categorized into two subtypes of mechanoreceptors. Slow adapting I receptors exhibit a random variable distribution. While, the slow adapting subtype II receptors maintain the symmetrical frequency distribution [20]. Most types of mechanoreceptors exhibit a rapid adapting response [22]. Merkel receptors functions as rapid and slow adapting receptors [20]. Merkel cells formed specialized sensory units that serve in picking worms. Merkel corpuscles in bird tongue have unique feeding attitude such as seeds husking [22]. Merkel receptors serve as slow adapting pressure-sensitive receptors in tongue and beak of the land birds [23]. Merkel corpuscles act as amplitude-sensitive nerve ending [22].

Avian Merkel receptors have been identified in different organs in which Merkel receptors adopt to perform specific function. The current results suggested that beak Merkel receptors may serve in sensing the food texture during birds feeding. Merkel receptors have been identified in tongue penguins (Spheniscus demersus, Spheniscus humboldti, Pygoscelis Papua, Eudyptes chrysolophus) [24], owl (Athene noctua) and fowl (Gallus gallus) [25] and finch (Lonchura striata) [2]. The highest numbers and most complex formations of Merkel

corpuscles are found in the tongues of birds [26]. Merkel receptors have been also recognized widely in the buccal and pharyngeal cavities of birds [27]. The Merkel receptors are recognized in wings of the flying mammals [28,29]. The most accepted hypothesis of Merkel receptors function in wings that they serve in flight control [29-31]. Merkel receptors are detected in different regions of the fishing bat (Myotis ricketti). They are commonly occur in raised-domes, hair follicles and in the basal epidermis of the skin from their back, abdomen, intercrural membranes, wing membranes and footpads. Higher density of Merkel cells locate in the footpad than in other places [31]. Merkel receptors have been identified in feathered skin where they potentially detect feather posture and serve in bird flight [32].

In conclusion, the tip and the anterior part of quail beak were rich in Merkel receptors that occurred in two forms, aggregations of Merkel cells and Merkel corpuscles. Thus, quail beak could be consider a favorable model for electrophysiological investigations.

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