

# Neuronal Responding Alteration Based on Directional Preference by Unilateral Labyrinthectomy

Nguyen Nguyen<sup>1,2</sup>, Kyu Sung Kim<sup>1,2</sup> and Gyutae Kim<sup>1\*</sup>

<sup>1</sup>Research Institute for Aerospace and Medicine, Korea

<sup>2</sup>Department of Otolaryngology Head & Neck Surg, Korea

\*Corresponding author: Gyutae Kim, Research Institute for Aerospace and Medicine, Korea



## ARTICLE INFO

**Received:** 📅 January 31, 2020

**Published:** 📅 February 10, 2020

**Citation:** Nguyen Nguyen, Kyu Sung Kim, Gyutae Kim. Neuronal Responding Alteration Based on Directional Preference by Unilateral Labyrinthectomy. Biomed J Sci & Tech Res 25(3)-2020. BJSTR. MS.ID.004205.

## ABSTRACT

Dysfunction in the vestibular system caused unbalanced behavioral responses, but the experimental measurements often failed to elucidate their relations to its orientation in the vestibular neural information. To overcome these problems, the Directional Preference (DP) of canal- and otolith-related neurons was suggested, and its underlying neural mechanism was explained in this paper. To construct the vestibular imbalance, Unilateral Labyrinthectomy (UL) was given as a common model for the overall explanation. Based on the alteration in the DP, the ambiguity in the behavioral tests could be overcome, and expected to identify the neuronal characteristics to lead the alteration in the neural responses.

**Keywords:** Directional Preference; Canal-Related Neuron; Otolith-Related Neuron; Unilateral Labyrinthectomy

**Abbreviations:** DP: Directional Preference; UL: Unilateral Labyrinthectomy; SC: Semicircular Canals; OT: Otoliths

## Opinion

The vestibular imbalance fails to control the ocular movements and the postural adjustments, and its sensation is initiated in the labyrinth [1-3]. The Semicircular Canals (SC) and Otoliths (OT) in the labyrinth sense the head rotation and the linear translation, respectively, and the related neural information is sent to the vestibular nuclei (VN) [3]. In VN, then, the vestibular information is heavily convergent with other sensory and motor signals from other systems [1,2,4-7]. The labyrinth possesses three SCs and two OTs, and each of them is neuroanatomically connected to the same structure at the opposite side through the commissural pathways [8,9]. Basically, all SCs and OTs perform their functions in pairs. According to the accumulated neuroscientific results, the neural responses to the external kinetic stimulations were generated based on the mechanical movement by their hair cells [3,4]. The inertial force was generated by the opposite flow of the endolymph to the head moving direction, and the exerted pressure deflected the cupula and stereocilia in SC and OT, respectively [3,4]. Their open deflections excited the connected afferent neurons, and a Unilateral Labyrinthectomy (UL) targeted the physical damages on the hair cells.

The damaged hair cells produced some abnormal behaviors related with the postural balance and the voluntary movement, losing the neural signals from the lesion side. In SC, the orientation of hair cells is consistent with the plane by the pair of SCs, and all cells in each side are polarized to the same direction. For instance, the rightward head rotation increased the firing rate in the right SC while the same head movement decreased that in the left SC. After right UL, the ipsi-preferred neurons lost their dominance in the neural signals, and the dominance in the directional preference became opposite. Once the lesion side was shifted, the dominance in the directional preference was also inverted. Therefore, the directional preference in SC was determined by the lesion side. On the other hand, OT has a complex structure in the generation of the neural signals. Anatomically, the otolith-related neurons receive the kinetic stimulation through the hair cells in the utricle, which has a macule, and it is divided into two parts (pars medialis and pars lateralis) by a thin stripe (striola). Based on the structural separation, both parts have different number of hair cells; two third for

pars medialis and one third for pars lateralis [3]. The linear head translation to the left activates the neurons connected to pars medialis, and those related with pars lateralis increase their firing rate as linear translation to the right [3,4]. Thus, the dominant neuronal response, like directional preference, is constructed by the hair cells related with pars medialis [4,10,11]. Due to the anatomical complexity, the dominance of the directional preference was opposite to that for SC.

After right UL, the ipsi-preference was dominant direction, and the contra-preference was major direction after left UL. Again, the directional preference in OT was also affected by the lesion side, and the damages on the vestibular end organ was clearly shown by the neuronal response of the directional preference. Moreover, the dominance in the directional preference was led by a neuronal characteristic. According to our experimental results, the directional preference in OT was mainly governed by the combined neural signals with the SC and the OT information. On the other hand, the directional preference in SC was led by the pure signals from SC or OT information. Vestibular malfunction induced various behavioral responses, and it has been widely adopted in human and animal experiments to understand the vestibular roles for the postural and motional balance. However, many behavioral tests rarely identify the exact vestibular dysfunction, and it required more tests for the model evaluation. Considering the neural origination of the abnormal behaviors, the neural response after the vestibular loss would be a direct assessment for the condition with the vestibular dysfunction. Especially, the directional preference in the neural responses was generated by the neuroanatomical basis, and it could be the direct indication for the vestibular dysfunction.

### Conflict of Interest

No potential conflict of interest relevant to this article was reported.

ISSN: 2574-1241

DOI: 10.26717/BJSTR.2020.25.004205

Gyutae Kim. Biomed J Sci & Tech Res



This work is licensed under Creative Commons Attribution 4.0 License

Submission Link: <https://biomedres.us/submit-manuscript.php>

### Acknowledgment

This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded partially by the Ministry of Education (2018R1A6A1A03025523 & 2019R111A1A01041450).

### References

1. Angelaki DE, Cullen KE (2008) Vestibular System: The Many Facets of a Multimodal Sense. *Annual Review of Neuroscience* 31(1): 125-150.
2. Borel L, Lopez C, Péruch P, Lacour M (2008) Vestibular syndrome: A change in internal spatial representation. *Neurophysiologie Clinique/Clinical Neurophysiology* 38(6): 375-389.
3. Carey JP, Della Santina CC (2015) Principles of Applied Vestibular Physiology, in Cummings Otolaryngology-Head and neck surgery. In PW Flint, Bruce Haughey, Valerie Lund, K Robbins, J Regan Thomas (Eds.), (7<sup>th</sup> Edn), Elsevier, USA pp: 2494-2524.
4. Fitzpatrick RC, Day BL (2004) Probing the human vestibular system with galvanic stimulation. *Journal of Applied Physiology* 96(6): 2301-2316.
5. Hitier M, Besnard S, Smith PF (2014) Vestibular pathways involved in cognition. *Frontiers in Integrative Neuroscience* 8: 59.
6. Lacour M, Dutheil S, Tighilet B, Lopez C, Borel L (2009) Tell Me Your Vestibular Deficit, and I'll Tell You How You'll Compensate. *Annals of the New York Academy of Sciences* 1164(1): 268-278.
7. Péricat D, Farina A, Agavnian Couquiaud E, Chabbert C, Tighilet B (2017) Complete and irreversible unilateral vestibular loss: A novel rat model of vestibular pathology. *Journal of Neuroscience Methods* 283: 83-91.
8. Smith PF, Curthoys IS (1989) Mechanisms of recovery following unilateral labyrinthectomy: a review. *Brain Research Reviews* 14(2): 155-180.
9. Uchino Y, Kushi K (2011) Differences between otolith- and semicircular canal-activated neural circuitry in the vestibular system. *Neuroscience Research* 71(4): 315-327.
10. Fernandez C, Goldberg JM (1976) Physiology of peripheral neurons innervating otolith organs of the squirrel monkey. I. Response to static tilts and to long-duration centrifugal force. *Journal of Neurophysiology* 39(5): 970-984.
11. Loe PR, Tomko DL, Werner G (1973) The neural signal of angular head position in primary afferent vestibular nerve axons. *The Journal of Physiology* 230(1):29-50.



### Assets of Publishing with us

- Global archiving of articles
- Immediate, unrestricted online access
- Rigorous Peer Review Process
- Authors Retain Copyrights
- Unique DOI for all articles

<https://biomedres.us/>