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From periodontal mechanoreceptors to chewing motor control: A systematic review

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ABSTRACT

Purpose: This critical review summarizes the current knowledge of the structural and functional characteristics of periodontal mechanoreceptors, and understands their role in the signal pathways and functional motor control.
Method: A systematic review of the literature was conducted. Original articles were searched through Pubmed, Cochrane Central database and Embase until january 2016.
Result: 1466 articles were identified through database searching and screened by reviewing the abstracts. 160 full-text were assessed for eligibility, and after 109 exclusion, 51 articles were included in the review process. Studies selected by the review process were mainly divided in studies on animal and studies on humans. Morphological, histological, molecular and electrophysiological studies investigating the periodontal mechanoreceptors in animals and in humans were included, evaluated and described.
Conclusion: Our knowledge of the periodontal mechanoreceptors, let us conclude that they are very refined neural receptors, deeply involved in the activation and coordination of the masticatory muscles during function. Strictly linked to the rigid structure of the teeth, they determine all the functional physiological and pathological processes of the stomatognathic system. The knowledge of their complex features is fundamental for all dental professionists. Further investigations are of utmost importance for guiding the technological advances in the respect of the neural control in the dental field.

Contents

Abbreviations: MN, mesencephalic nucleus receptors; PGP, Protein Gene Product; TG, trigeminal ganglion.

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1. Introduction

Functional movements of the stomatognathic system and their relative forces depend on signals arising from various sensory organs in the orofacial structures.

A special role is played by periodontal mechanoreceptors and their sensory innervation, located in the periodontal ligament, that is the optimal location for detecting the functional forces on the teeth. They are involved in mechanotransduction and chewing motor control, but there are important limitations of knowledge in the field. For exemple (Piancino & Kyrkanides, 2016), even though mastication is a dynamic process, studies regarding periodontal mechanoreceptors are usually conducted in static conditions and mostly in animals, that are characterized by different teeth and occlusion with respect to the humans, often disregarding the functional differences of teeth.

There are, mainly, two type of studies, hystological and electrophysiological, that are not easy to correlate and without agreement as regards the results.

This article aims to review the progress in the field, especially during the last three years, with a special attention to the functional significance of experimental results.

There have been a number of molecular reports; however, to understand the impact of these reports on the mechanisms of motor control we need to go back to the earliest physiological studies and these are briefly described, commented and integrated with recent molecular data.

The main results of basic research will be summarized in the first part of this review, dividing the animal from the human studies, the second part being dedicated to the signal pathways arising from mechanotransduction.

2. Materials and methods

2.1. Search strategy

A systematic review of the literature was conducted. Original articles were searched through Pubmed, Cochrane Central database and Embase until january 2016.

The research has been done with the following free words: periodontal AND ('mechanoreceptor'/exp OR 'mechanoreceptor'), periodontal mechanorecept* NOT dental implant*, periodontal mechanorecept* AND brain NOT dental implant*; and with the following MESH Terms ("Periodontium/innervation"[MeSH Terms]) AND "Neurons/physiology" [MAJR], periodontal AND mechanoreceptor, (("Mechanoreceptors"[MAJR] AND "Physical Stimulation" [MeSH Terms]) AND "Action Potentials" [MeSH Terms]) AND "Axons" [MeSH Terms]", (("Mechanotransduction, Cellular" [MAJR]) AND"Humans"[MeSH Terms]) AND

"Sensory Receptor Cells" [MAJR], (("Mechanoreceptors*/physiology" [MAJR] AND "Physical Stimulation" [MeSH Terms]) AND "Action Potentials" [MeSH Terms]) AND "Axons/physiology" [MeSH Terms], (("Malocclusion" [MeSH Terms]) AND "Integrins" [MAJR]) AND "Humans" [MeSH Terms], (("Brain Stem"[MAJR]) AND "Face" [MeSH Terms]) AND "Sensory Receptor Cells" [MeSH Terms]", (("Humans" [MeSH Terms]) AND "Feedback, Sensory" [MAJR]) AND"Stomatognathic System" [MeSH Terms]", ("Mastication" [Mesh] AND "Malocclusion" [Mesh]) AND "Electromyography" [Mesh] AND "Humans" [Mesh].

Additional studies were taken from reference lists of previous review articles, and citations of relevant original articles were screened. The "related articles" tool was used to improve the PubMed searches, and references of included studies were checked by a research librarian. Unpublished studies, gray literature or studies not published in English were excluded.

3. Results

3.1. Search results

1466 articles were identified through database searching and screened by reviewing the abstracts. 160 full-text were assessed for eligibility, and after 109 exclusion, 51 articles were included in the review process as reported in Fig. 1.

3.2. Type of selected studies

Studies selected by the review process were mainly divided in studies on animal (Chen & Wong, 2013; Higuchi et al., 2008; Hitomi et al., 2009; Honma, Kato, Shi, Yatani, & Wakisaka, 2012; Honma, Taki, Lei, Niwa, & Wakisaka, 2010; Iizuka et al., 2009; Jabbar et al., 2007; Korkmaz et al., 2009; Ma, Gao, Fang, & Yang, 2012; Miki et al., 2015; Ohishi et al., 2009; Rahman et al., 2011; Saito et al., 2009; Umemura et al., 2010) and studies on humans(Huang, Corpas, Martens, Jacobs, & Lambrichts, 2011; Kang, Nam, Kim, & Lee, 2010; Tsutsumi et al., 2013; Ziegler et al., 2010) (Table 1). The selection was decided on data reporting, not on study design, due to the variability of the study project, approach and methods. Morphological, histological, molecular and electrophysiological studies investigating the periodontal mechanoreceptors in animals and in humans were included.

4. Studies in animals

4.1. Histological studies in animals

4.1.1. Cytological features and cytochemistry

Periodontal mechanoreceptors are known to be receptors in the periodontal ligament that respond to surprisingly low contact force levels (<1 N) (Newton) applied to the teeth. The functions of nerve fibers in the periodontal ligament, junctional epithelium and gingiva are coordinated with the dental pulp and dentin