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Karolinska Institutet

Sensory-motor regulation of human biting behavior

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Abstract

In order to control oral motor behavior, such as biting and chewing, we rely on information provided by a variety of sense organs, including periodontal mechanoreceptors (PMRs). The PMRs, located among the collagen fibers in the periodontal ligament that attaches the root of the tooth to the alveolar bone, send signals to the central nervous system when the surrounding collagen fibers are stretched by loading of the tooth. The information they provide is particularly important for sensory-motor regulation of the forces exerted during manipulative actions in mastication. Various types of dental status and treatment might affect the functioning of these receptors. For example, reduction of support by periodontal tissue is associated with a decrease in the number of PMRs, as well as enhanced mobility of the tooth. Connecting several teeth together with fixed bridges attenuates the mobility of each tooth and individuals with implant-supported bridges lack PMRs.

The general aim of the work presented here has been to improve our understanding of the role played by PMRs in regulation of normal jaw function and to elucidate how disturbance of the sensory information they provide, by disease or dental treatment, influences masticatory behavior. In this latter context special focus was directed towards prosthetic treatments, i.e., tooth- and implant-supported fixed bridges.

The subjects performed two motor behavioral tasks – a hold-and-split task (*Study I-IV*) and a novel manipulation-and-split task (*Study V*). In the first of these, holding and splitting morsels of food of differing hardness between the teeth was employed to examine the regulation of small holding forces and of the rate of increase in bite force during the split (the “split force rate”). The participants were instructed to hold the morsel (a piece of peanut or biscuit) between their teeth and not use more force than necessary to control it and then, approximately 3-4 seconds later, to split the morsel. In the latter task motor behavior during food manipulation and the accuracy of the split were evaluated. These participants placed a spherical piece of candy in their mouth, moved it thereafter with their tongue to a position between their front teeth and finally attempted split it into two equal sized parts. Custom-made equipment was used to monitor changes in bite forces, jaw movements and muscle activity with time during these tasks.

The holding forces exerted by individuals with reduced support from periodontal tissue were almost 3-fold higher and more variable than those exerted by the healthy matched controls (*Study I)*. In *Study II*, where different types of teeth were used to perform the same task, the holding force increased distally along the dental arch, being almost 3-fold higher for the molars than the incisors. Application of a local anesthetic to the teeth to block the sensory signals from the PMRs resulted in an approximately 2-3.5-fold elevation in holding forces (*Studies II* and *III*). In *Study IV* individuals with tooth- or implant-supported bridges were found to use holding forces approximately 2- and 2.5-fold higher, respectively, than the control subjects with natural teeth.

Although the splitting forces where the same for all of the groups, the rate at which this force was generated was higher when splitting harder food if periodontal sensibility was normal (*Studies III* and *IV*), an adaptation that was eliminated by periodontal anesthesia (*Study III*). This adaptation was also attenuated in periodontally affected individuals (*Study I*), as well as in the participants with tooth- or implant supported bridges (*Study IV*). In connection with the manipulation-and-split task the latter two groups demonstrated altered motor behavior, with a shorter contact phase prior to the split and a lower capacity than the dentated control group to split the candy into two equal parts (*Study V*).

The present findings demonstrate that sensory signals from PMRs play an important role in fine-tuning the amplitude and direction of bite forces during actions such as positioning and holding food between the teeth for biting. Furthermore, adjustment of the rate of increase in bite force to the hardness of food is carried out by individuals in whom this signaling is intact. In individuals with disturbed PMR signaling due to loss of support by periodontal tissue or bimaxillary full-arch splinting of the teeth (tooth-supported bridges) and in those lacking PMRs (i.e., with bimaxillary implant-supported bridges), regulation of these oral sensory-motor functions is impaired.

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