Archives of Oral Biology 90 (2018) 130–137

Contents lists available at ScienceDirect

Archives of Oral Biology

journal homepage: www.elsevier.com/locate/archoralbio

Spectral components in electromyograms from four regions of the human masseter, in natural dentate and edentulous subjects with removable prostheses and implants

Rodrigo A. Guzmán-Venegas[a,*,1], Felipe H. Palma[a,1], Jorge L. Biotti P[b], Francisco J. Berral de la Rosa[c]

[a] Laboratorio Integrativo de Biomecánica y Fisiología del Esfuerzo (LIBFE), Escuela de Kinesiología, Facultad de Medicina, Universidad de los Andes, Monseñor Álvaro del Portillo 12455, Santiago, Chile
[b] Facultad de Odontología, Universidad de los Andes, Monseñor Álvaro del Portillo 12455, Santiago, Chile
[c] Laboratorio de Biomecánica, Kinesiología y Cineantropometría, Universidad Pablo de Olavide, Carretera de Utrera km 1, Seville, Spain

ARTICLE INFO

Keywords:
Masseter muscle
Dental prostheses
Spectral analysis
High-density EMG

ABSTRACT

Objective: To compare the frequency or spectral components between different regions of the superficial masseter in young natural dentate and total edentulous older adults rehabilitated with removable prostheses and fixed-implant support. A secondary objective was to compare these components between the three groups.
Design: 21 young natural dentate and 28 edentulous (14 with removable prostheses and 14 with fixed-implant support) were assessed. High-density surface electromyography (sEMG) was recorded in four portions of the superficial masseter during submaximal isometric bites. Spectral components were obtained through a spectral analysis of the sEMG signals. An analysis of mixed models was used to compare the spectral components.
Results: In all groups, the spectral components of the anterior portion were lower than in the posterior region ($p < 0.05$). Both edentulous groups showed lower spectral components and median frequency slope than the natural dentate group ($p < 0.05$). The removable prostheses group showed the greatest differences with natural dentate group.
Conclusions: There were significant differences in the spectral components recorded in the different regions of the superficial masseter. The lower spectral components and fatigability of older adults rehabilitated with prostheses could be a cause of a greater loss of type II fibers, especially in the removable prostheses group.

1. Introduction

The masseter muscle is the major muscle of mastication, but it also participates in important functional activities, such as swallowing or speaking (McMillan & Hannam, 1992; Schumann, Scholle, Anders, & Mey, 1994; Widmer, English, & Morris-Wiman, 2007). These activities are possible thanks to its complex architecture (Blanksma, Van Eijden, & Weijs, 1992; Guzmán-Venegas, Biotti Picand, & de la Rosa, 2015; McMillan & Hannam, 1992; Schumann et al., 1994; Widmer et al., 2007). The masseter muscle presents a heterogenous distribution of fiber types, showing a predominance of type I fibers (Korfage, Koolstra, Langenbach, & van Eijden, 2005a; Korfage, Koolstra, Langenbach, & van Eijden, 2005b; Österlund, Thornell, & Eriksson, 2011), besides having a special type of hybrid fibers (Korfage, Brugman, & Van Eijden, 2000; Korfage et al., 2005a, 2005b; Sciote, Horton, Rowlerson, & Link, 2003; Tuxen, Bakke, & Kenrad, 1992; van Eijden & Turkawski, 2001). Despite this tendency, the specific distribution of fiber types in this muscle differs greatly between its superficial and deep fascicles (Korfage et al., 2000, 2005b). However, in the different fascicles of the superficial masseter, the evidence is controversial. On the one hand, studies through histological analyses have found no significant differences in the type of fibers from the anterior and posterior fascicles of the superficial masseter in young people (Österlund et al., 2011); moreover, studies conducted on adult persons have shown a greater concentration of type I fibers in the anterior fascicle (Eriksson & Thornell, 1983; Österlund et al., 2011; van Eijden & Turkawski, 2001). The latter would be supported by high-density surface electromyography (sEMG) assessments on this muscle, where lower activation

Abbreviations: sEMG, surface electromyography; EMG, electromyography/electromyographic; RP, removable prostheses; FIS, fixed implant supported prostheses

* Corresponding author at: Monseñor Álvaro del Portillo 12455, 7620001, Santiago, Chile.
E-mail address: rguzman@uandes.cl (R.A. Guzmán-Venegas).

[1] These authors contributed equally to this work.

https://doi.org/10.1016/j.archoralbio.2018.03.010
Received 20 September 2017; Received in revised form 20 March 2018; Accepted 22 March 2018

thresholds have been shown in its anterior fascicle, which is suggestive of a greater presence of type I fibers (Guzmán-Venegas et al., 2015). However, this evidence is scarce and inconclusive, therefore, it is necessary to conduct studies trying to address more specifically the possible differences in the distribution of fiber types in different regions of superficial masseter and the clinical implications of it.

sEMG is a tool that can help differentiate the type of muscle fibers, under certain conditions, through parameters such as spectral or frequency components (Gerdle, Henriksson-Larsén, Lorentzon, & Wretling, 1991; Gerdle, Wretling, & Henriksson-Larsén, 1988; Komi & Tesch, 1979; Lodetti, Mapelli, Musto, Rosati, & Sforza, 2012; Pincivero, Campy, Salfetnikov, Bright, & Coelho, 2001; Rainoldi, Gazzoni, & Melchiorri, 2008). On this basis, it has been demonstrated that muscles having a greater concentration of type II fibers tend to show higher initial median frequency values (Kupa, Roy, Kandarian, & De Luca, 1995; Pincivero et al., 2001; Rainoldi et al., 2008) and a greater drop in their median frequency during isometric contractions (Kupa et al., 1995). Performing a frequency or spectral analysis of the different regions of the superficial masseter could give a better approach to determine the composition of muscle fibers of each region.

There is evidence suggesting changes in the electromyographic (EMG) variables of jaw muscles in people rehabilitated with dental prostheses. However, most of these studies have been focused on amplitude variables and few of them have studied the spectral components. Dakhilalian et al. (2014), compared the spectral components of sEMG in patients with removable prostheses (RP) and those with fixed implant supported (FIS), without finding any difference between them. Nevertheless, these authors did not consider the topographic distribution of said components nor the potential regional differences that might exist. Knowing the existing differences in the spectral components and its topographic distributions between young natural dentate (ND) and individuals with prostheses can be very useful for understanding the physiological adaptations of the jaw muscles and the changes in the recruitment of motor units associated with total tooth loss. Furthermore, distinguishing between RP and FIS would allow researchers to establish which one has a pattern of muscle recruitment more like ND.

The present study proposes the following hypotheses: There are interregional differences in the topographical distribution of the spectral components of the superficial masseter muscle in ND and total edentulous subjects rehabilitated with RP and FIS. At the same time, we hypothesize that there are differences in the magnitudes of these components between the study groups.

2. Materials and methods

2.1. Design of the study and volunteers

An analytical, observational, cross-sectional study was conducted. To determine the sample size, the mean and standard deviation of the normalized electromyographic amplitude of a previous study (Guzmán-Venegas et al., 2015) were selected as primary variables. Independent measures performed at 20, 40 and 60% of the maximum voluntary bite force between the anterior and posterior fascicle of the superficial masseter were considered. Using a two-sided analysis, a significance level of 5%, and a statistical power equal to 80%, the sample size needed to detect significant differences was 14 per group. Finally, 48 individuals (21 ND, 14 RP and 14 FIS), fulfilled the study's criteria.

The ND group was the same used in a previous study (Guzmán-Venegas et al., 2015). Those volunteers who had symptoms or signs of temporomandibular disorders (according to the diagnostic criteria for temporomandibular disorders [DC/TMD]); type II or III occlusion (according to angle's classification), were excluded. Out of a total of 316 evaluated participants, 21 healthy volunteers were selected. RP and FIS groups were recruited from two odontologic clinics. These volunteers were invited to participate by telephone. Those who accepted were referred to an odontologic control, where a specialist (Biotti J, > 30 years of experience) examined them and selected the total bimaxilar edentulous patients with FIS or RP complete maxillary prosthesis for over a year. All volunteers who had any of the following criteria were excluded from the study: i.- osteomuscular alterations (joint and/or muscular pain, altered mandibular movement patterns, etc.); ii.- pharmacological treatment with psychotropic and/or muscle relaxants; iii.- difficulties in the support or stability of the prosthetic device.

The Bioethics Committee of the Universidad de Los Andes approved the study. All volunteers agreed to participate voluntarily by providing a written informed consent. All procedures were performed according to the principles of the Declaration of Helsinki (1975).

2.2. Measurement protocol

Volunteers sat in a dental chair with the backrest inclined to 110° with a head supporting a head-neck extension of 10°. In this position, the maximum voluntary bite force of each volunteer was assessed using a gnatodynamometer previously used in another study (Guzmán-Venegas et al., 2015). This was obtained to subsequently perform submaximal voluntary bites, equivalent to 20, 40, 60 and 80% of it.

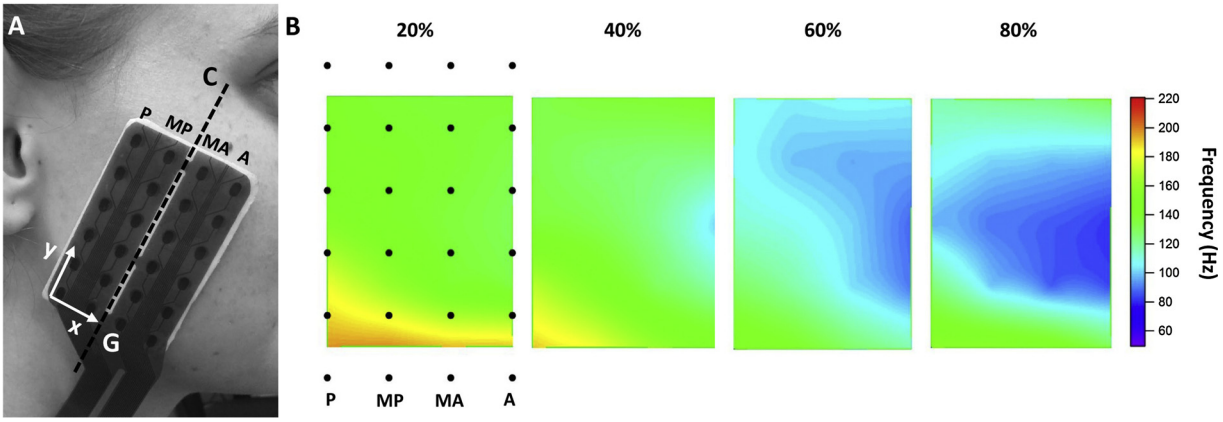

Fig. 1. (a) Placement of the electrode matrix on the superficial masseter muscle, arranged in four columns: A, Anterior; MA, Middle-anterior; MP, Middle-posterior; P, Posterior. G: Gonion; C: Canthus. (b) Examples of topographic maps of the EMG activity raw frequency of the superficial masseter recorded during bites at 20, 40, 60 and 80% of maximum voluntary bite force. Maps were constructed in windows of 500 ms and with an interpolation factor of 8. ●: electrode positions.