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MEASUREMENT OF MOTIONS AND TENSIONS OF ORAL MUSCLES DURING SPEECH AND CHEWING - AN OVERVIEW

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Abstract. *The development of new equipments to assist the evaluation, measurement, treatment and rehabilitation of human organs has been increased as a consequence of the advances in Mechanical Engineering and related fields. An example is the development of electronic tongue and swallowing videofluoroscopy. This study aims to review and analyze publications related to muscle tension motions measures of stomatognathics structures during speech and chewing. It was made searches and selected articles that had agreement with the proposed theme, published within the last five years and related to the areas of engineering, speech therapy and associates. It is observed the need for increased research in these interdisciplinary areas, associating the engineering and the medical fields with respect to the head and neck structures and inherent troubleshooting.*

Keywords: *Structural Integrity, Tribology, Speech, Mastication, Force, swallowing.*

1. INTRODUCTION

The Tribology is a branch of Engineer that study friction, wear, lubrification and systems life. The Biotribology defines the science which studies the friction, wear and lubrication, including the chemical and physical nature of surfaces, its topography and interaction under load and motion of biological elements. (Oshida, *apud* Moura, 2007).

The speech therapy is the science whose object of study human communication, with regard to its development, improvement, disorders and differences in relation to aspects involved in auditory function, peripheral and central, the vestibular function, cognitive function, in oral and written language, speech, fluency, voice, the oral functions and swallowing (CRF 2nd, 2006).

Thereby, the speech therapy is divided in 7 operation areas, these being the Language, Public Health, Education Speech Therapy, Audiology, Dysphagia, Orofacial Motricity and Voice (CRF – 6th Region, 2015). The Orofacial Motricity is the area that aims to (re) habilitation of functions of sucking, chewing, swallowing and speaking, all of these functions controlled by muscles. The Voice area aims at prevention, assessment and treatment of problems related to production of spoken and / or sung voice (CRF – 2nd Region, 2015).

Swallowing, chewing and speech use human body's shared structures. These structures are all those involved in the oral cavity anatomy, anatomy of the larynx, anatomy of the pharynx and anatomy of the esophagus. Thus, for these functions are carried out correctly, there must be structural integrity of the anatomical parts involved in the process. Considering the swallowing as a continuous process that begins in the mouth and ends in the stomach, we can conclude that the integrity of structures such as lips, tongue, cheeks, palates, pharynx, larynx and esophagus needs to be minimally acceptable. It is noteworthy that the movement of these structures depends on the integration of muscles and nerves. (Marchesan, 1999).

Over time, it is natural that these structures lose some capabilities, there being structural and functional impairment with respect to speed, accuracy, resistance, stability, strength and coordination (Siracusa, 2011). These processes can be called presbyphonia (when related to voice) and presbyphagia (when related to swallowing), being nothing less than characteristics from a wearing of muscle caused by the aging process. This wear can also be observed in individuals affected by muscle pathologies (myopathies) or trauma that may compromise one or more previously mentioned structures. Myopathies are muscle disorders that occur without abnormality of the nerve responsible. When the nerve is compromised, we call neuropathies (Carvalho, 2005).

The development of new equipments to assist the evaluation, measurement, treatment and rehabilitation of human organs has been increased as a consequence of the advances in Mechanical Engineering and related fields. An example is the development of electronic tongue and swallowing videofluoroscopy. The interrelationship of the areas can be better visualized in the conceptual map of Fig. 1 together with the information shown above.

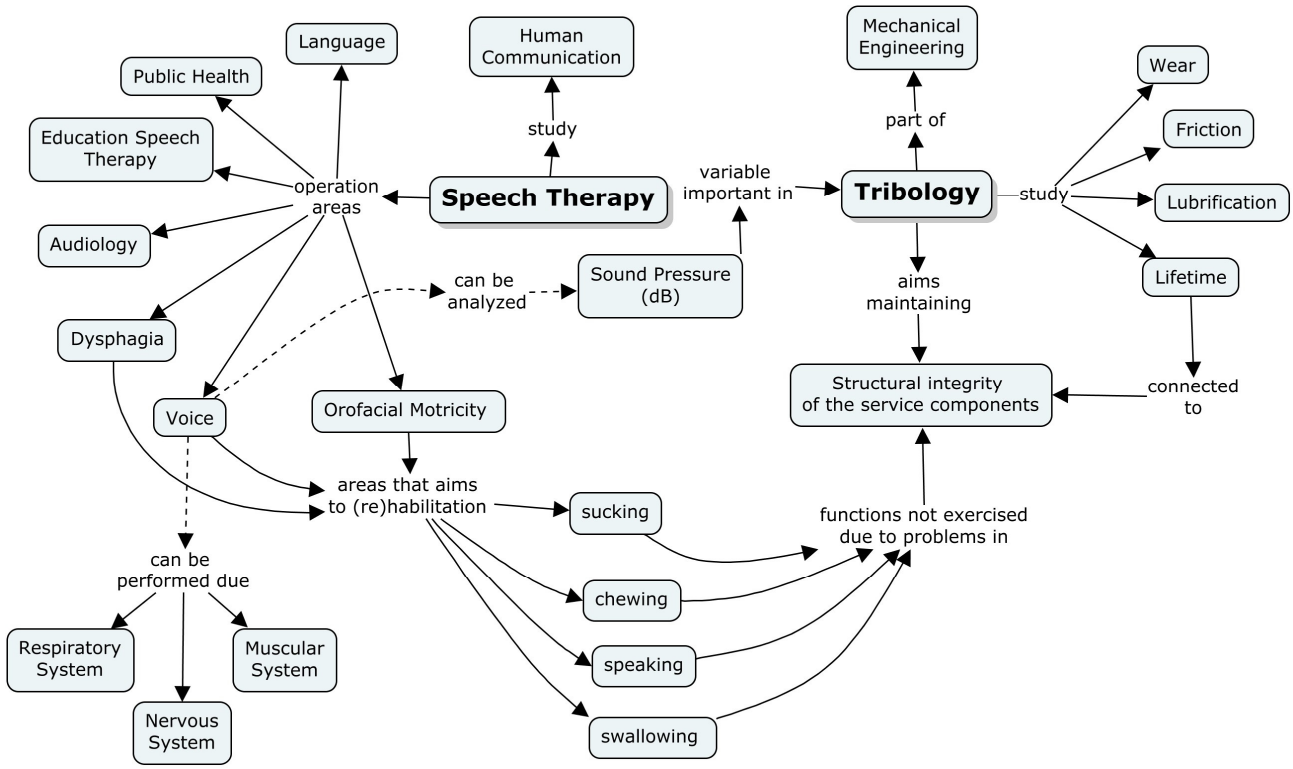

Figure 1. Conceptual map involving Tribology and Speech Therapy

Could be make an important connection between the areas of speech therapy and the knowledge in mechanics, especially with regard the two areas described. The knowledge about dynamic and motion of certain types of pieces, under appropriate conditions, can bring theoretical/practical basement about the movements of muscles our body. So we can represent relatively properly their movement, which will be framed in the study of Biomechanics. This is a science of the biological sciences' group which deals with physical-mathematical analysis of biological systems and, as a consequence, of human movements. These movements are analyzed by mechanical laws and norms in relation to specific parameters of the biological system, according to Amado, 1991.

The scientific productions involving Engineering along with speech therapy are still quite limited, showing that this is a good way to research. This fact is due to the characteristic of the relatively recent development of a specific graduation. In the general, it is possible find a large number of research linking oral biomechanics with dentistry, area that presents great interest in understanding the mechanical processes associated with dental treatments or surgical treatments of face.

Melo said that interdisciplinarity cannot be seen as a process which "put together" different areas of knowledge, but rather a dialog that allows you approach these areas. Then it implies recognizing that, regardless of training asymmetries, there is an exchange of important and significant knowledge, which finance positive results in research. With that in mind, we see the necessity to analyze the academic production on this interrelation in the last five years, so that become possible understand the interest of the academic community in this area.

This study aims to review and analyze publications related to muscle tension motions measures of stomatognathics structures during speech and chewing.

2. MATERIALS AND METHODS

It was performed an integrative review of publications focused on the study of movements and muscle strains during the swallowing and speech functions and their respective quantitative instrumental evaluations.

The study included articles that presented quantitative evaluation of the stomatognathic system structures as well as instrumental and quantitative evaluation of the functions of chewing, swallowing and speech or associated with them. It also included studies on the biomechanics of the stomatognathic functions and their association with the speech evaluation.

It was performed an electronic search in the CAPES database with the following subject descriptors: structural integrity, tribology, speech, muscles of mastication, swallowing and force (Tab. 1).

Table 1. The search terms used in English and Portuguese

English	Portuguese
Structural Integrity	Integridade Estrutural
Tribology	Tribologia
Speech	Fala
Mastication	Mastigação
Force	Força
Swallowing	Deglutição

Due to the quantity of publications found, the descriptors were associated with each other through the junction "and" in order to select the best publications.

The “swallowing” descriptor was included because presents on one of its stages, the chewing, target of our study.

The articles found passed by two selection filters. The first one performed by reading the title and the second by reading the abstract. Another filter for the selection of texts was the publication date, it was included only texts published in the last five years, in other words, papers prior to 2010 were not used in this study. After selections, the articles were read in full and described as a review in the Tab.4 .

The main research base of the texts was the Journal Portal platform, of Higher Education Personnel Improvement Coordination (Capes), created in 2000 in order to gather and make available to educational and research institutions in Brazil the best international scientific production (CAPES,2015).

3. RESULTS

The selection of descriptors was held from discussion among the authors who considered the significance of the words relating to the objectives of the work. The insertion of the keywords in CAPES search base resulted in amounts of items described in Tab. 2. Due to the results very comprehensive of the descriptors “Structural Integrity”, “Force”, “Speech”, “Tribology” and “Swallowing”, was chosen to do a search with those terms associated each other, depending on the relativity of the interrelation of terms. This relation was determined in accordance between the authors of the study according to the study objectives and the significance that a term has next to each other, resulting in more specific research to what is sought. The relations were as follows: Structural Integrity and Mastication, Structural Integrity and Swallowing, Structural Integrity and Speech, Tribology and Mastication, tribologia and Speech, Force and Mastication, Force and Speech and Tribology, Speech and Muscle and Tribology, Swallowing and Mastication and Tribology. We did not observe the necessity to associate Swallowing and Force because swallowing is no direct focus of the research presented.

Table 2. Number of articles per descriptor. 2015.

Descriptors	Portuguese	English
Structural Integrity;	177 found;	42.873 found;
Tribology;	68 found;	22.850 found;
Speech;	4.850 found;	86.406 found;
Mastication;	372 found;	3.249 found;
Force;	3.343 found;	173.888 found;
Swallowing.	456 found;	9.356 found;

The insertion of these associated words in CAPES database resulted on the amounts of publications described in Tab. 3. The selected publications through the subject of the title are also inserted in it. In the first filter were selected a total of 29 items. In the second filter, that was performed through reading the summaries, were a total of 18 selected publications. The chosen publications are described in more detail in Tab. 4. The selection by reading the titles was performed by two assessors and abstracts was performed by a single evaluator.

Table 3. Articles found with the association between descriptors and articles selected by title.

Descriptor		Portuguese	English
Structural Integrity;	Swallowing	2 found 0 selected	4 found 0 selected
	Mastication	0 found 0 selected	15 found 1 selected
	Speech	23 found 0 selected	56 found 1 selected
Tribology;	Mastication	0 found 0 selected	13 found 1 selected
	Speech	0 found 0 selected	1 found 0 selected
Force;	Mastication	51 found 7 selected	640 found 19 selected
	Speech and Tribology	0 found 0 selected	12 found 0 selected
Speech;	Muscle and Tribology	0 found 0 selected	4 found 0 selected
Swallowing.	Mastication and Tribology	0 found 0 selected	2 found 0 selected

Table 4. Selected articles

Author/Title	Objectives	Results	Discussion/Conclusion
Furlan, R.M.M.M., Valentim, A.F., Motta, A.R., Barroso, M.F.S., Costa, C.G., Las Casas, E.B., 2012. "Quantitative methods for assessing tongue force" Rev. CEFAC - Saude e Educação. 2012 Nov-Dez;	Present a review of instruments to measure the strength of the tongue	At the beginning of the research is used gauges. Currently, bulbs and palatal plates with pressure sensors are mostly used. The instruments that use strain gauges have heavy mechanical structure, which due to its low flexibility can cause discomfort to patients. Palatal plates are tailored to the structure of each patient and only allow measurement of force in the cranial direction. Due to its structure, allows the patient to close the mouth and perform the functions almost normally. Despite the mounting of the sensors directly on the palate or teeth be better to measure the forçadurante functions, this method does not allow the sensors are accommodated in predetermined locations. The bulbs have the disadvantage of the difficulty of positioning reproducibility in the oral cavity. A wide range of force values and maximum pressure and average found relates to the wide variety of devices employing various technologies. Electrodes intraoral noninvasive has greater acceptance by users, but to measure the electromyographic activity of the intrinsic muscles of the tongue, are needed	The methods present strength results in Newton, and pressure in kilopascals, proportionally between the two parametros. All methods can help the professional in the orofacial myofunctional evaluation.

		intramuscular electrodes. Quantitative methods for measuring language of force allows monitoring the therapy and better communication between the professionals involved in the treatment.	
Lee et al., 2013. "Effect of bite force on orthodontic mini-implants in the molar region: Finite element analysis". The Korean Journal of Orthodontics - KJO. Oct;43(5):218-224.	To examine the effect of bite force on the displacement and stress distribution of orthodontic mini-implants (OMIs) in the molar region according to placement site, insertion angle, and loading direction.	With regard to placement site, the displacement and stress were greatest for the OMI placed between the mandibular first molar and second molar, and smallest for the OMI placed between the maxillary second premolar and first molar. In the mandibular molar region, the angled OMI showed slightly less displacement than the OMI placed at 90°. The maximum Von Mises stress increased with the inclination of the loading direction.	These results suggest that placement of OMIs between the second premolar and first molar at 45° to the cortical bone reduces the effect of bite force on OMIs.
Dressano, D., 2012. " Electromyographic analysis and strength of the masseter muscle in individuals with distinct craniometric patterns". Dissertation in biology buco-dental. UNICAMP - University of Campinas, SP - Brazil.	Check the electrical activity of the masseter muscle during the movements of mastication and submaximal voluntary contraction (CVSM) in individuals classified into three different cranial standard groups (brachycephalic, pons and dolichocephalic) and observe the existence of a relationship between these movements and the various groups assessed.	The values of the electromyographic signal during the resting situation for each volunteer did not accuse outliers and every moment did not exceed 5 microvolts, thus validating the subsequent results. The brachycephalic group had the highest value in the chewing movement in the masseter muscle of the left hand, while removing the dolicocephalic showed the highest value on the right. The pertecentes individuals to mesocephalic were between the two previously presented, when it came masseter on the right. I.E., for the masseter muscle on the left side there is a statistical difference between the groups and dolichocephalic mesocephalic. To the right is not observed such a difference. The dolichocephalic group showed strong electromyographic signals the beginning of the collection, but in the final moments these signs showed a decrease, can signal a sign of fatigue. The group of individuals classified as brachycephalic achieved a 31% utilization rate of energy force for maintaining CVSM, getting a better utilization compared to dolichocephalic groups and mesocéfalos, who obtained an index of 28% and 27%, respectively.	There is a noticeable difference between groups when comparing the RMS values in motion CVSM and the value generated and maintained in the individual bite transducer. Still it allowed us to find evidence that individuals brachycephalous may exert less force to accomplish the same muscle contraction movement of the masseter muscle when compared to the pons and dolichocephalic groups.

Maciel, M., 2013. Análise da biomecânica dos movimentos mandibulares e da cabeça, durante mastigação de alimento duro e macio, na ausência e presença de obstrução nasal, usando SCAM 3D. 2013. Dissertation in Health Science — University of Brasília. Brazil.	Analyze the chewing movements and posture of the head and body, using a motion capture system coupled to two power platforms.	The time sequence of the masticatory nasal obstruction was reduced 22.7%, corresponding to 4 seconds less on average. There was a tendency to reduction in nasal obstruction for hard food on average 0.79 mm shorter in lateral movements. The data obtained from the traces of chewing cycle, the frontal plane, show reducing the size of the mandibular lateral movements to soft food, in the nasal obstruction condition. It was found association between movement of the jaw and head, where the head accompanies the movements of the jaw, regardless of the breath. There was an increased percentage of weight bearing on his left foot in all individuals to hard food with nasal obstruction on average of 3.16.%, And for soft food, 9 subjects had an increase of 5.02% in average.	The chewing movements were affected by the consistency of food (soft and hard) and the breathing mode (nasal and nasal obstruction). Compared to nasal breathing, chewing movements in the nasal obstruction showed a masticatory sequence shorter and irregular. For soft food in nasal obstruction, had a lower average amplitude of the masticatory cycle in latero medial movements, laterality, which produced a chewing cycle with vertical movements. The behavior of the head during chewing was modulated in response to changes in sensory input jaw. For any changes in the percentage of weight in the discharge force were significant for soft and hard food, nasal obstruction condition.
Sazonov, E.S., Fontana, J.M., 2012. "A Sensor System for Automatic Detection of Food Intake Through Non-Invasive Monitoring of Chewing". IEEE SENSORS JOURNAL, VOL. 12, NO. 5, MAY 2012.	Simple sensor system and related signal processing and pattern recognition methodologies to detect periods of food intake based on non-invasive monitoring of chewing.	The size of the epoch that best represented the chewing signals was selected from three different values. Results of 20-fold cross-validation indicated that a 30 s epoch size presented higher accuracy than 15 s and 60 s epoch sizes.	The most relevant features representing the sensor signals were chosen by a forward selection procedure. The population based model created was able to classify chewing epochs with an averaged accuracy of 80.98% and a time resolution of 30 s. This epoch-based classification approach would allow the monitoring of short events of food consumption, such as snacking. Implementation of this methodology in a wearable device is highly possible due to the use of a simple and inexpensive strain gauge sensor to monitor chews plus a simple classification algorithm that can be easily implemented in a microcontroller.
Lepley, C.R., Throckmorton, G.S., Ceen, R.F. and Buschangd, P.H., 2011. "Relative contributions of occlusion, maximum bite force, and chewing cycle kinematics to masticatory	The purpose of this study was to explore the contributions of occlusion, maximum bite force, and chewing cycle kinematics to masticatory performance.	The MPS was smaller in this study than in other studies with the same test food. ACNC values were shown to be the most important determinants of masticatory performance. Maximum bite force was the second factor that affected masticatory performance in this study.	This study demonstrates that masticatory performance is influenced by many factors (Fig). Importantly, occlusion was clearly shown to be the key determinant affecting masticatory performance. Greater areas of contact and near contact provide better occlusal stability, allowing for more efficient masticatory

performance". American Journal of Orthodontics and Dentofacial Orthopedics 2011;139:606-13			function.
Palinkas, M., Nassar, M.S.P., Cecílio, F.A., Siéssere, S., Semprini, M., Machado-de-Sousa, J.P., Hallak, J.E.C., Regalo, S.C.H., 2010. "Age and gender influence on maximal bite force and masticatory muscles thickness. archives of oral biology 55 (2010) 797–802.	The present study aimed investigate the age and gender influence on maximal molar bite force and at outlining the criteria for normal masticatory muscle development in a sample of 177 Brazilian Caucasian dentate individuals aged 7–80 years	The maximal molar bite force values of the five age groups are presented in Table 2. Effects of group and gender were observed, but with no interaction between them. The ANOVA showed significant differences between groups bilaterally. Bonferroni's test showed that group I had significantly lower bite force means at both sides than all groups except group V. No differences were found between the left and right sides.	Studies have shown that age and gender are important factors that influence the resistance of jaw lifting muscles in terms of their maximal bite force, which seems to remain constant between 20 and 50 years of age and to differ between men and women. Bite force, a well-established clinical parameter, was found to be significantly higher in men bilaterally. The gender factor can influence bite force because muscle mass and size are usually greater in men.
Lodetti, G., Mapelli, A., Musto, F., Rosati, R., Sforza, C., 2011. "EMG spectral characteristics of masticatory muscles and upper trapezius during maximum voluntary teeth clenching". Journal of Electromyography and Kinesiology 22 (2012) 103–109	Assess the surface electromyographic spectral characteristics of masticatory and neck muscles during the performance of maximum voluntary clench (MVC) tasks	Descriptive statistics of the median power frequency computed by FFT in the analyzed muscles are reported. On average, the MPFs did not differ between sexes or sides, but significant effects of muscle, test and time were found, together with a significant muscle ⁄time interaction.	The assessment of the behavior of masticatory and neck muscles may offer valuable information for the diagnosis and treatment of TMD patients. In the dental field, sEMG potentials collected during an MVC on both cotton rolls and in intercuspal position have been reported to have the best inter- and intra-individual repeatability
Le Révérend, B., Hartmann, C., 2014. "Numerical modeling of human mastication, a simplistic view to design foods adapted to mastication abilities". Physiology & Behavior 124 (2014) 61–64	a model that aims to predict bite force at different tooth locations as can bemeasured using a bite force transducer.	An interesting use of this model for the food industry or the food science community at large is to develop guidelines for food size/fracture strength that can be processed in the mouth. It can be seen that more force is available by the molars (closer to the condyle) than by the incisors.	The main limitation of our model is that force is expressed relative to masseter force or incisor force. This could also be its strength, because we did not aim to go into the complexity of models considering very fine details of the human anatomy or the food, we kept our model quite generic so that it can be used for tailored texture development, which cannot be completely individualized, but rather oriented towards clusters of the general population.
Zmudzki, J., Chladek, G., Kasperski, J., 2014. "Biomechanical factors related to occlusal load transfer in removable complete dentures". Biomech Model	Review the current state of knowledge on the biomechanics of mastication with complete removable dentures	The analysis revealed that the interpretation of data collected in vivo is hindered due to the simultaneous overlapping effects of many variables.	In turn, problems with determining the pressure beneath a denture and analyzing frictional processes constitute principal limitations of in vitro model studies. Predefined conditions of finite element method simulations should include the effects of

Mechanobiol DOI 10.1007/s10237-014-0642-0			oblique mastication forces, simultaneous detachment and sliding of the denture on its foundation, and the stabilizing role of balancing contacts. The review establishes that previous investigations may have failed because of their unsubstantiated assumption that, in a well-working balanced occlusion, force is only exerted perpendicular to the occlusal plane, allowing the denture to sit firmly on its foundation.
Furlan, R.M.M.M., Valenti, A.F., Perilo, T.V.C., Costa, C.G., Barroso, M.F.S., de Las Casas, E.B., Motta, A.R., 2010. "Quantitative Evalution of Tongue Protusion Force". International Journal of Orofacial Myology 2010 Nov;36:33-43.	The purpose of this study is to describe and compare the main results obtained in tongue protrusion force measurements in different age groups using this new device.	Average forces, maximum forces, time taken to reach maximum force, standard deviations and coefficients of variation for each subject and each age group.	An important factor observed in results of the study was that in the older population, coefficients of variation related to maximum and average force, were greater than in the other groups, demonstrating that this population is less homogeneous than the groups of either children or adults, even though all participants were classified as having normal tongue strength during qualitative evaluation. The use of the Forling tool in research and in clinical orofacial myology practice can help speech-language pathologists with the quantification of tongue force. This would allow pre- and post-treatment assessment which would provide measurable gain, without a large amount of time required for the calculation.
Woda, A., Mishellany-Dutour, A., Batier, L., François, O., Meunier, J-P., Reynaud, B., 2010. "Development and validation of a mastication simulator". Journal of Biomechanics 43 (2010) 1667–1673..	In this study a calibration–validation procedure was based on comparison between the particle size values of food boluses obtained in subjects with good masticatory apparatus and those obtained with the AM2.	The number of masticatory cycles at swallowing was 26+/-7.8 for peanuts and 33+/-11.05 for carrots. A significant decrease in the d50 along the three boluses collection times was observed except for peanuts between 20 and 26 cycles. No significant difference between there peats corresponding to the two boluses collected from each subject was observed.	Consequently, the study of food transformation by mastication is biased when the analyses are conducted on boluses collected from subjects. Simulation of mastication by the AM2 allows the whole nutrient content, including the liquid phase, to be collected at any time during the mastication sequence; although rinsing is technically required for granulometric measures, chemical analysis of the bolus liquid phase produced by the simulator would not imply rinsing.
Hayashia, K., Mizoguchia, I., Lee,	The purpose of this study was to establish a	The fitted values (lines) were virtually identical to the observed	In conclusion, this study provided detailed information

S., Reichc, B., 2010. "Development of a novel statistical model for mandibular kinematics". Medical Engineering & Physics 32 (2010) 423–428	new statistical method for the analysis of masticatory function.	values (points) for all measurements. Theoretically, there is no limit to the number of cycles used to calculate mean curves. At the horizontal axis, 0 indicates the starting point of a chewing cycle, and 1 indicates the end point of a chewing cycle. (For interpretation of the references to color in this figure caption, the reader is referred to the web version of the article.) In dimension 1 (anterior–posterior dimension), there was a significant difference in the 18.4–90.0% range of all-range of a cycle. This result indicated that the average chewing cycle in the crossbite group was shifted posteriorly with regard to the curve of the normal-bite group. In dimension 2 (horizontal dimension), there was a significant difference in the 15.3–29.3% and 36.9–70.1% ranges of all-range of a cycle.	about jaw movement for comparing crossbite to normal occlusion by calculating Population mean curves of the position vector of the incisor target point. This study focused on the use of a new statistical model for assessing jaw motion, and the results demonstrated that the calculation of population mean curves is effective for clarifying the characteristics of functional data, such as in mandibular movement.
Shimada, A., Yamabe, Y., Torisu, T., Baad-Hansen, L., Murata, H., 2012. "Measurement of dynamic bite force during mastication". Journal of Oral Rehabilitation 2012 39; 349–356 Journal of Oral Rehabilitation	The aims of this study were to develop a new intraoral bite force recorder which would allow the study of natural mastication without an increase in the occlusal vertical dimension and subsequently to analyze the relation between electromyographic (EMG) activity of jaw-closing muscles, jaw movements and bite force during mastication of five different types of food.	Masticatory force: Post hoc tests showed significantly higher impulse values for chewing gum compared to cookies. The time to peak of bite force was significantly influenced by food and cycles with no interaction between factors. Jaw movement: Post hoc tests showed larger jaw gape values for cheese compared to chewing gum. The time of the opening phase was significantly influenced by food and cycles with no interaction between factors. EMG activity: The ANOVA of the duration of the EMG burst demonstrated a significant effect of cycles in MAL and MAR, interaction between factors in MAL and MAR but no effect of food.	In summary, this study has shown that intraoral force recordings are feasible and can provide new and clinical relevant information on the dynamics of human mastication.
Commisso, M.S., Martínez-Reina, j., Ojeda, J., Mayo, J., 2015. "Finite element analysis of the human mastication cycle". Journal of The Mechanical Behavior of Biomedicinal Materials 41(2015)23–	The main objective of this work is to propose a comprehensive biomechanical model of the masticatory system that allows the study of a mastication cycle and the stresses generated in the mandible and in the TMJ during it. Another objective is to check if	The synchronous activation of the right and left muscles of case1 produced an almost identical movement in the ongoing and return displacement of the jaw. On the contrary, asynchronous activations (cases 2 and 3) led to the typical “tear dropshape” movement. A later activation of the left (contralateral) muscle (case 2) generated a movement of the jaw from the left to the right.	A FE model of the mandible including the TMJ has been used to simulate chewing. The model presented here tries to overcome the limitations of previous studies and to present a powerful methodology to analyse the functioning of the human jaw. The activation of the lateral pterygoid muscle was seen to affect significantly the opening movement of the

35..Spain.	the activity of the lateral pterygoid muscle has a significant influence on the movement of the jaw during chewing.	Instead, the prior activation of that muscle (case3) produced a movement in the opposite direction.	jaw. Aprior activation of the ipsilateral muscle is need in order to obtain the typical "tear drop shape" movement of the incisal edge.
WANG, H.M.D. et al. Three-Dimensional Finite Element Analysis of Mechanical Stress in Symphyseal Fractured Human Mandible Reduced With Miniplates During Mastication. Journal of Oral Maxillofacial Surgery. V. 68, p.1585-1592. 2010. China.	The aim of this study was first, propose and analyze a 3-dimensional (3D) FE model simulating the behavior of fractured mandibles after reduction with miniplates of osteosynthesis. Second, we use this model to study the response to 2 different masticatory conditions of the mandible that is treated with one or 2 miniplates in the symphysis region, and compare our results to that obtained from an intact mandible.	Mandibular stress distribution in intercuspal position (1) and during left unilateral molar clenching (2) was analized. Intact mandible:1. During ICP, the stress was symmetrically concentrated on the bilateral mandibular corpora, subcondylar region and anterior aspects of the coronoid processes. We obtained a maximum stress value of 27.778 MPa in the Von Mises stress norm at anterior aspects of the coronoid processes and the mandibular alveolar that received the bite force. 2. The stress concentrated on the bilateral mandibular corpora, chin, and subcondylar region, whereas the stress value in the ramus was small. Stress distribution at the biting side differed from the contralateral side: the subcondylar stress value was higher on the right (nonbiting) side than on the left mandibular side. Symphyseal Fractured Mandible: 1. Similar to the intact mandible. 2. As in the intact mandible, the maximum stress value in the Von Mises stress norm occurred at the alveolar process of the biting side.	The significance of these findings is that a loss of mandibular continuity may also lead to a decrease in bite force. Guaranteeing an effective method of fracture stabilization and improving fracture stability at the fracture site by producing a secure joint of the fracture segments, 2 miniplates have an advantage over 1 miniplate for restoring bite force.
Lin, K., Chang, C., Liu, T., Lin, S., Lin, C., 2011. "Experimental and numerical estimations into the force distribution on an occlusal surface utilizing a flexible force sensor array". Journal of Biomechanics 44 (2011) 1879–1884.	The present study thus proposes an MLCC-based flexible sensor array with a simple and rapid method for force measurement. The force distributions on the occlusal surface of an artificial tooth will be experimentally and numerically evaluated in the study.	Results show that the total force (the sum of the forces from the nine MLCC sensors) was 191 N, which is very close to the value of 200 N for the applied force, indicating that the developed force sensor array has an error of less than 5%. The nine output values from the MLCCs were mapped to a response pattern as output fingerprints for determining the applied force. The force response pattern of the sensor array was used to reconstruct the stress distributions on the occlusal surface with the assistance of the FE simulation.	A flexible force sensor array fabricated using industrial-grade MLCCs for bite force measurements was demonstrated. The MLCC force sensors are capable of sustaining large forces (above 500 N), making them suitable for measuring the forces on the tooth crown. Moreover, the sensors also presented good force response and excellent repeatability. The simulations and the experiments confirm the good sensing performance of the developed MLCC sensor arrays. Results indicate that the sensor produced unique stress response patterns under a given set of loading conditions.
Palinkas, M., 2010.	The aim of this article	The values find for maximum	For thickness: observe

"Influence of Age and Gender on the Maximum molar Bite Force and Thickness of Mastigation Muscles". Dissertation. Ribeirão Preto: School of Denstry of University of São Paulo.	is to find evidence of muscular interaction with craniofacial development over the years.	molar bite force on the right and left show statistically significant difference between the five age groups analized. We can observe that the factor gender influences statistically, where, for men, the maximum bite force was almost 1/3 bigger.	gradative increase of masseter and temporal muscles; Decrase of masseter and temporal muscles of old people. For bite force: younger has more bite force compared with other ages. Men have more muscular potencial, compared with women.

4. CONCLUSION

We observed in this study that the publications relating to the proposed theme are scarce yet, requiring therefore an increase in research on the relationship between speech, chewing and mechanical movements.

Regarding the articles found, we can conclude that there is great deal of researches relating mechanical movements and chewing, especially with regard to dental treatment and research with surface electromyography of facial muscles.

The researches that relate speech and mechanical movements were nil. Several reasons could be behind this result. Chewing is a precursor process of the swallowing, vital function for the survival of the being, and therefore understood as a key process in research. In addition, the speech therapy is a recent academic branch compared to other branches such as engineering, medicine, dentistry and others.

The development of new equipment for evaluation of muscle movements and pressure measurement in chewing and speaking are needed, mainly with regard to cost reduction and practicality.

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