

Relationship between perception of tongue position and measures of tongue force on the teeth

Relação entre a percepção da posição de língua pelo indivíduo e medidas de força da língua nos dentes

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ABSTRACT

Purpose: To verify whether there are differences of tongue force on the teeth at rest and during swallowing between individuals who report appropriate tongue position and those who report tongue thrust. **Methods:** Tongue forces on the teeth were evaluated in 28 participants aged 19 to 31 years. To this end, a Flexiforce[®] resistive sensor was fixed to the palatal surface of the maxillary right central incisor (tooth 8) and was connected to an amplifier circuit, a data acquisition board, and a computer. Measurements were taken at rest and during saliva swallowing. Participants were asked about their habitual tongue position and where the apex of tongue touched when they swallowed. The Mann Whitney test was used for statistical analysis at 5% significance level. **Results:** At habitual position, tongue force on the teeth was 0.00 N both for participants that reported tongue touch and for those who did not. At directed swallowing, tongue force was 0.34 N for the group of individuals whose tongues touch the teeth and 0.08 N for the group of individuals whose tongues do not touch the teeth. This difference was significant. **Conclusion:** No significant difference was found between the tongue forces of participants of both groups at habitual position. However, participants with tongue thrust during directed swallowing presented greater force than those whose tongues do not touch the teeth during this task.

RESUMO

Objetivo: Verificar se existe diferença nos valores de pressão da língua nos dentes entre participantes que percebem a posição de língua adequada e alterada, tanto em repouso como em deglutição. **Métodos:** Avaliou-se a força da língua sobre o dente de 28 participantes hígidos com idades de 19 a 31 anos. Para tal, um sensor resistivo Flexiforce[®] foi fixado na face palatina do dente incisivo central superior direito e conectado a um circuito amplificador, a uma placa de aquisição de dados e a um computador. Foram realizadas medições em posição habitual e deglutição de saliva. Além disso, o participante foi questionado sobre qual era sua posição habitual de língua e onde o ápice da língua tocava durante a deglutição. Utilizou-se o teste Mann Whitney ao nível de 5% para análise estatística. **Resultados:** Durante a posição habitual, a força da língua no dente foi de 0,00 N, tanto para os participantes que relataram toque da língua nos dentes como para os sem toque. Na deglutição dirigida, a força foi de 0,34 N para o grupo com língua tocando os dentes nesta tarefa e 0,08 N para o grupo sem toque, sendo a diferença significativa. **Conclusão:** Não houve diferença nos valores de força de língua sobre os dentes de participantes que apresentavam posição habitual da língua tocando os dentes e os que não apresentavam. Porém, na deglutição dirigida, participantes que relataram anteriorização de língua apresentaram valores maiores de força da língua nos dentes do que aqueles com deglutição sem toque nos dentes superiores.

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INTRODUCTION

Inappropriate positioning of the tongue is a major cause of occurrence of poor oral occlusion relapse^(1,2). At rest, pressure from the tongue is slight but long lasting and, therefore, can move the teeth⁽³⁾.

In contrast, a recent literature review found that atypical swallowing can cause occlusion alterations, but that the opposite also occurs, that is, malocclusion can cause atypical swallowing - considered adapted⁽⁴⁾, which demonstrates the close relationship between morphology and function.

Habitual tongue position, which is usually perceptibly assessed, is an important aspect to be analyzed. The speech-language pathologist observes the position of the tongue in the oral cavity of patients and asks them where the apex touches when they are at rest; therefore, the result depends on the patients' perception^(5,6). This hinders the evaluation because perception of tongue position by individuals is information of low reliability⁽⁷⁾.

One of the techniques used to assist in the assessment of tongue position is the teleradiography with barium sulfate contrast^(5,8). However, this test cannot evaluate tongue position during the dynamic process of swallowing.

A possible way to evaluate swallowing is to request the patient to put a sip of water in the mouth and not to swallow it; after that, the examiner positions the index finger under the patient's chin and places the thumb under the patient's lower lip; the examiner then asks the patient to swallow the water. When the examiner perceives the movement of the tongue with the index finger, they pull the patient's lower lip downwards to observe the position of the tongue. Finally, the patient is asked to describe how they perceive the tongue position⁽⁹⁾.

Regarding the quantification of forces, the literature addresses issues related to maximum tongue strength⁽¹⁰⁻¹³⁾; however, the method herein developed aimed to assess issues more closely associated with the functionality of the stomatognathic system.

With the same purpose, in an attempt to quantify the forces exerted by the orofacial structures on the teeth or palate, researchers from various countries have developed instruments composed of sensors or force/pressure transducers to evaluate the lips⁽¹⁴⁾, the tongue⁽¹⁵⁻¹⁹⁾, or both⁽²⁰⁻²²⁾.

One of these studies associated force and position of the tongue with the posterior teeth. The authors measured the pressure of the tongue and cheeks on the maxillary second molars (teeth 2 and 18) and found that individuals at cervical (neck) hyperextension showed lower tongue pressure on these teeth compared with that of individuals at natural head position, suggesting that neck position is a predictor of tongue position in relation to the maxillary arch⁽²³⁾.

The Biomechanical Engineering Group of the Federal University of Minas Gerais, which had already developed and tested instruments for measuring maximum strength of the tongue⁽²⁴⁾ and lips⁽²⁵⁾, proposed a method⁽²⁶⁾ that would enable similar research in Brazil, given that the instruments used in most studies are not yet marketed and are available only for research.

There are no studies in the literature associating the perception of participants on tongue position with quantitative data measured by these instruments. Thus this study investigates how much force the tongue exerts on the teeth and how it relates to the position perceived by individuals at rest and during swallowing.

As the perceptual evaluation of tongue position is one of the few low-cost resources available in speech-language pathology treatment, it is important to investigate whether participants realize that their atypical tongue position actually exert more force on the teeth compared with those who consider having appropriate tongue position. Therefore, the objective of this study is to verify whether there are differences in the values of tongue pressure on the teeth, at rest and during swallowing, between participants who report appropriate tongue position and those who report tongue thrust.

METHODS

This study was approved by the Ethics Research Committee of the Federal University of Minas Gerais under process number 0253/11. The sample was composed of 28 individuals (10 men and 18 women) aged 19-31 years (mean age 23.2 ± 2.9 years). Inclusion criteria were as follows: being older than 18 years and having signed the Informed Consent Form agreeing to participate in the research. Exclusion criteria included presence of glossectomy, paralysis or paresis of tongue and/or lips, cognitive impairment, use of orthodontic braces or having concluded orthodontic treatment less than two years before the assessment, use of dental contention in the maxillary arch, be under speech-language pathology therapy, or present nasal obstruction at the time of examination. These data were obtained using patient information and/or observed during the assessment.

First, the participants had to answer two questions: 1) Where do you perceive the apex of your tongue when at rest? 2) Where does the apex of tongue touch during swallowing? Prior to responding to the second question, participants were asked to swallow saliva and observe their swallowing.

The participants replied by pointing the spot or saying what they perceived. Regarding the first question, individuals who reported tongue thrust or tongue touch on the maxillary teeth at rest were considered as "tongue touch on the teeth", whereas the others were regarded as "without touch". As for the second question, individuals who reported tongue thrust or tongue touch on the maxillary teeth during function were considered as "tongue thrust", whereas the others were reckoned as "typical".

Subsequently, tongue forces on the teeth were assessed. To this end, a Flexiforce Tekscan[®] resistive sensor was sanitized with 70% alcohol, coated with PVC film (polyvinyl chloride), and fixed with dental adhesive (Corega[®]) to the palatal surface of the maxillary right central incisor (tooth 8) of the participant (Figure 1). The sensors were connected to an amplifier circuit, a data acquisition board, and a computer. Sampling frequency was 70 Hz and the data were displayed on a program developed in the LabVIEW software, which shows the force graph over time.

After fixing the sensors, a time interval of 30 seconds was observed for the sensors to accommodate in the oral cavity. Next, participants were instructed to swallow saliva (first test); this performance was recorded. Swallowing also served to guide the examiner with respect to the profile of forces in the swallowing of each individual, so that these forces could be identified throughout the next measurement. After that, a new measurement was conducted, requesting the participants to remain with the tongue and lips at the habitual position, swallowing when they felt like (second test). During this time, the individuals participated in a hearing distractive activity, in which they listened to a recorded text and had to mentally count how many times a particular word was mentioned. This distraction activity was designed to draw the participants' attention away from their tongue habitual position, so that it was as natural as possible. This test lasted approximately 1 minute and 30 seconds. When participants showed no visible spontaneous swallowing during the second test, they were requested to perform directed swallowing two extra times until the end of the measurement (third test). Therefore, all participants performed deglutition at least three times.

For assessment at rest, three rest periods of 10 seconds each were selected during the second test - one at the beginning, one in the middle, and one at the end of the measurement. Mean and maximum tongue forces on the teeth were evaluated. Mean tongue force was obtained by calculating the average of the 700 force values collected in each rest period; after that, the average of the three sections was obtained, which was considered as the mean of each participant. Maximum tongue force was calculated using the average of the greatest forces obtained in the three sections. Maximum tongue force was assessed with respect to directed swallowing (first and third tests) and spontaneous swallowing (second test). When the participant showed no evident peak of tongue force during directed swallowing,

the maximum force value was considered as the maximum value found in this measurement task (maximum value of the first test). Thus these participants presented only one tongue force value during deglutition (regardless of how many times they swallowed) and were excluded from the evaluation of spontaneous swallowing.

The nonparametric Mann-Whitney test, which assumes dependent observations, was used to verify whether there were differences between the forces according to the perceptual classification of tongue position at rest (replies to the first question) and during swallowing (replies to the second question). Values smaller than 5% were considered statistically significant ($p < 0.05$).

RESULTS

The responses to the questions asked at the beginning of the assessment were used to divide the participants into groups. Regarding the first question, 11 individuals reported tongue touch on the teeth at habitual position and 17 individuals did not. With respect to the second question, 16 participants presented tongue thrust and 12 participants showed appropriate tongue position during swallowing. In relation to spontaneous deglutition, 11 participants showed no spontaneous swallowing with visible peak of tongue force, which precluded the calculation of force and, consequently, excluded them from this analysis.

Table 1 shows the correlation between participant perception of habitual tongue position and values of tongue force on the teeth. Table 2 shows the correlation between the perceptual analyses of participants regarding the tongue position during swallowing with values of tongue force on the teeth.

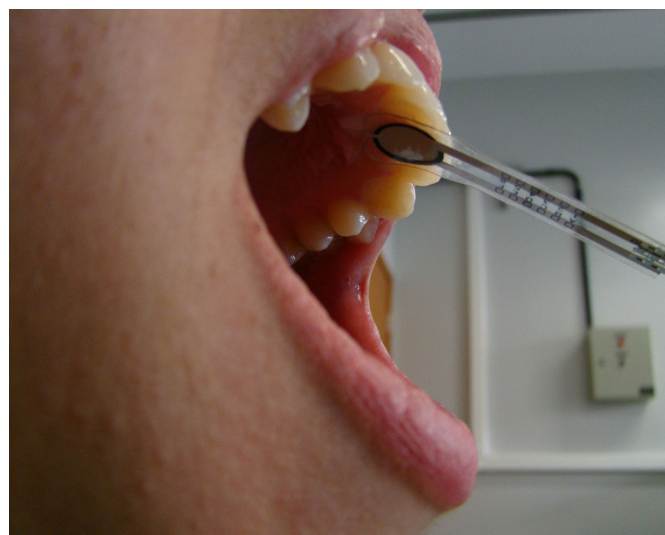


Figure 1. Resistive sensor fixed to the palatal surface of the maxillary right central incisor

Table 1. Comparison of tongue force at rest (in Newtons)

Force analyzed	Group	n	Minimum	Maximum	Median	p value ¹
Mean force	Without touch	17	0.00	0.01	0.00	0.576
	Tongue touch on the teeth	11	0.00	0.01	0.00	
Maximum force	Without touch	17	0.01	0.08	0.03	0.327
	Tongue touch on the teeth	11	0.00	0.04	0.02	

Caption: n = number of individuals; ¹ = nonparametric Mann-Whitney test

Table 2. Comparison of tongue force during swallowing (in Newtons)

Force analyzed	Group	n	Minimum	Maximum	Median	p value ¹
Directed swallowing	Typical	12	0.02	0.96	0.08	0.004
	Tongue thrust	16	0.02	1.67	0.34	
Spontaneous swallowing	Typical	6	0.08	0.87	0.13	0.960
	Tongue thrust	11	0.02	3.12	0.12	

Caption: n = number of individuals; ¹ = nonparametric Mann-Whitney test

DISCUSSION

The present study aimed to analyze tongue position only with regard to the maxillary teeth. Due to technical difficulties, it was not possible to fix a resistive sensor on the mandibular teeth because the cable would have to bypass the lower lip and it could be parted.

Regarding the assessment at rest, the results of tongue force on the teeth corroborate those of other studies which reported forces of 0.0005 N⁽²¹⁾ and 0 N⁽²⁷⁾.

In the correlation of these forces with the perceptual analysis of participants, contrary to expectations, individuals who reported tongue touch on the maxillary teeth at rest showed no difference in mean and maximum forces compared with participants who presented habitual position without touch. A possible explanation for this fact is that the resistive sensor may have been recognized as a foreign body in the oral cavity, which might have altered the habitual tongue position of participants. When an instrument is inserted into the mouth, it is possible that the usual physiological activity be altered by its presence⁽²⁸⁾. The tongue may avoid touching the resistive sensor, especially if it causes some discomfort⁽²⁹⁾. Another possibility is that participants may not have correctly perceived the place of their habitual tongue position, considering that, as already verified in other studies⁽⁷⁾, this information presents low reliability.

There is also the possibility that the forces may have been so small that the resistive sensor could not detect them, considering that it is subject to errors such as hysteresis and of reproducibility, which may have been greater than the value of the measured force. However, no other commercially available resistive sensor was found with similar characteristics of size, flexibility and atoxicity, or with better precision within the operation range. Furthermore, this very sensor has been used in a similar study found in the literature⁽¹⁴⁾.

With regard to deglutition, the values found in function were lower than those observed by other authors for the anterior palate⁽¹⁸⁾ and greater than those found in other studies, e.g., 0.025 N⁽²¹⁾, 0.0168 N⁽²²⁾, 0.0075 N⁽¹⁷⁾, and 0.008 N⁽²⁷⁾. These variations in force among studies are expected because of methodological differences, especially regarding the fixing of sensors (one study used sensors on the palate⁽¹⁸⁾), material swallowed (two studies used water^(17,22)), and characteristics of study sample (two studies assessed children^(21,27)).

Another noteworthy aspect is the individual variability in the measures collected, which has also been reported by other authors^(18,22).

Participants with tongue thrust during deglutition presented greater force values than those with typical tongue position, but only for directed swallowing. It is believed that the presence of correlation between perceptual analysis and tongue force measures during deglutition may suggest that participants have better perception of their tongue position during function than at rest, considering that swallowing is a dynamic process that involves a movement of the tongue. Another possibility is that the swallowing function is less likely to be modified by

the presence of a foreign body than the habitual position and, thereby, was less altered with the fixing of the resistive sensor.

This statistical difference was not observed in spontaneous swallowing. It was possible to evaluate this type of deglutition in only 17 of the 28 participants, as already reported in the results section. The smaller sample size may have influenced the significance in this analysis; significance would possibly be manifested if the sample were larger.

This study shows that other resources should be sought to assist in the diagnosis of habitual position of the tongue in clinical practice, considering that no correlation can be found between participant perceptual analysis and tongue force measurements. In addition, forces in directed and spontaneous deglutition were slightly different, which shows the importance of evaluating them in both. We suggest that further studies use larger samples and conduct stimulation and training on perceptual analysis of tongue position. We also suggest the use of sensor that could be fixed to the mandibular teeth as well, so that intraoral forces could be mapped and tongue position could be better establish.

CONCLUSION

No statistically significant difference was found for values of tongue force between participants who reported tongue touch on the teeth at habitual position and those who did not. However, participants with tongue thrust during directed swallowing presented greater force than those whose tongues do not touch the maxillary teeth during this task.

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Author contributions

AFV was responsible for the study design, literature review, collection and analysis of data, and writing of the manuscript; RMMM and TVCP were responsible for the literature review, analysis of data, and writing of the manuscript; ARM and EBLC were responsible for the design and supervision of the study and correction of the manuscript.