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Oral motor control and orofacial functions in individuals with dentofacial deformity

Controle motor oral e funções orofaciais em indivíduos com deformidade dentofacial

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ABSTRACT

Purpose: To determine the correlation between oral motor control and orofacial functions in individuals with dentofacial deformity (DFD). **Methods:** Sixteen individuals from 18 to 40 years, (average 28.37 years) participated. Seven individuals were class II (three women and four men) and nine were class III (five women and four men). They were evaluated for diadochokinesis (DDK) using the emissions /pa/, /ta/, /ka/ and /pataka/. The chewing, swallowing, and speech functions were filmed and analyzed by three speech specialists, using the MBGR protocol. The correlation results between DDK and the orofacial functions were obtained through the Spearman test. **Results:** A positive correlation was observed between the DDK instability parameters in issuing the "pa" and "ka" and the chewing function. There was a positive correlation between swallowing and DDK for "pa" emission regarding the instability. As for the speed, there was a negative correlation for the DDK mean rate and a positive correlation for the average DDK period at "pa" emission. As for the speech, there was a negative correlation for "pa" emission for the instability parameter. **Conclusion:** The oral motor control was related to the severity of the change in chewing and swallowing functions regarding the DDK speed and instability paramenters.

Keywords: Malloclusion; Mastication; Deglutiton; Speech; Stomatognathic system abnormalities; Dentofacial deformities

RESUMO

Objetivo: Verificar se há relação entre o controle motor oral e as funções orofaciais em indivíduos com deformidade dentofacial (DDF). **Métodos:** Participaram 16 indivíduos entre 18 e 40 anos, média de 28,37 anos, sendo sete indivíduos padrão II (três mulheres e quatro homens) e nove, padrão III (cinco mulheres e quatro homens). Foi realizada avaliação da diadococinesia (DDC) das emissões /pa/, /ta/, /ka/ e /pataka/. As funções de mastigação, deglutição e fala foram analisadas por consenso entre três fonoaudiólogas especialistas na área, a partir da filmagem, utilizando o protocolo MBGR. A correlação entre os resultados da DDC e das funções orofaciais foi obtida por meio do teste de Spearman. **Resultados:** Foi observada correlação positiva entre os parâmetros de instabilidade da DDC na emissão do "pa" e "ka" e a função de mastigação. Houve correlação positiva entre deglutição e DDC para a emissão do "pa" no que se refere à instabilidade das emissões e, quanto à velocidade, houve correlação negativa para a média da taxa da DDC e correlação positiva para a média do período da DDC na emissão do "pa". Quanto à fala, houve correlação negativa para a emissão do "pa", para parâmetro de instabilidade. **Conclusão:** O controle motor oral mostrou-se relacionado à gravidade da alteração das funções de mastigação e deglutição, no que se refere aos parâmetros instabilidade e velocidade da DDC.

Descritores: Má oclusão; Mastigação; Deglutição; Fala; Anormalidades do sistema estomatognático; Deformidades dentofaciais

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INTRODUCTION

Orofacial functions are performed from the interaction of hard and soft tissues, the vascular system and also the neural control. The function and morphology are closely linked; not only the harmonic condition of these structures interfere directly in the balance of muscle behavior, but also the functions interfere directly in craniofacial growth and development[1].

This balance might be broken by the presence of dentofacial deformities (DFD), defined as malocclusions associated with skeletal disorders, which are characterized by the disharmony between the maxilla and the mandible[2]. Since maxilla and mandible are the basis for the dental arches, changes in their growth can alter the occlusal relations and functions, which may lead to malocclusion and/or malfunction[3].

Individuals with maxillomandibular disproportions have orofacial myofunctional characteristics related to the type of DFD presented[2].

There is a facial disproportion in cases of Class III malocclusion: the lower third is higher than the middle third; there is a deficiency in the zygomatic and paranasal regions; there are changes in the anteroposterior of the upper lip and the lower lip is hypotonic. In addition, the labial occlusion is unsatisfactory, with the tongue resting on the mouth floor, adapting to its space, since the lower third is larger[4]. The chewing muscles in these individuals present lower masseter thickness when compared to the control group[5,6].

On the other hand, the orofacial characteristics of patients with class II malocclusion may be the result of a mandible development deficiency. Lips are parted, with hypofunction of the upper lip, lower lip eversion, and closure adaptation due to hyperfunction of the mentalis muscle[7]. The space reduction caused by mandible retrusion accommodates the tongue, making it adapt with a high dorsum and a low tip[8].

Obviously, chewing also changes in individuals with DFDs[9]. There is a prevalence of upright movements in class III DFD. The dorsum of the tongue is used to crush food against the palate and there is also little or no action of the buccinator muscles. Cases with class II and III malocclusion were compared to a control group and showed abnormalities in the chewing efficiency, although the authors have not found differences between individuals with the deformity[10].

Chewing becomes faster, especially in class II DFD, with a shortening of the chewing cycles. When associated with a long facial type, the lack of lip sealing, little use of the mouth orbicular and buccinators muscles, a reduction of lateralization of tongue movement[11] have also been observed. The chewing of patients with retrognatia was compared to a control group. The experimental group showed lower values for chewing efficiency, maximum bite force, EMG during maximal clenching and EMG[12]. Similarly, we found a lower electrical activity and a more asymmetrical distribution of this activity during the maximum voluntary isometric contraction test in the anterior temporal and masseter muscles in the DFD group[13].

As for the association between class II malocclusion and disorders related to speech, chewing, swallowing, and phonation, authors have concluded that structural changes of the face are related to orofacial myofunctional disorders. Craniofacial disharmony results in pathophysiological changes in the functions performed by this system[14].

Changes were observed in an experiment with class III malocclusion patients. Individuals had difficulty in crushing food and there was an intense participation of the dorsum of the tongue in the food crushing for the chewing function. Dolicocephalic individuals showed an altered breathing mode (oral or oronasal), their swallowing was done with tongue interposition and an exaggerated participation of perioral muscles, while speech presented mandible deviation[15].

The swallowing function was also assessed taking in consideration aspects of lips and tongue posture, food containment, contraction of the mouth and mentum orbicular muscles. Speech was assessed considering aspects of opening and mandible deviation, lip movement, and articulation accuracy. The study found statistically significant difference when comparing individuals with DFD class II and III and the control group, with a greater change in the swallowing function. As for the speech, individuals with class II DFD fared worse compared to the control and to class III individuals[16]. A clinical case with class III DFD found the tongue positioned in the oral cavity floor; chewing with tongue compensatory movements; swallowing with tongue anterior projection; decreased dorsum elevation; reduction of oral ejection for liquid; and complete pharyngeal clearance for liquids and solids[17].

Studies have shown that speech is also compromised in DFD cases, when clinical evaluations are performed. Authors reported articulation changes in patients with malocclusion, distortion in the sounds /s/, /z/, /t/, /d/, /l/, /n/ in class III individuals, distortion of /r/ in class II[18] and distortions in fricatives in class III[19]. Mistakes in articulation accuracy have also been described in patients with class II and III malocclusion[20]. Other studies found articulatory mistakes characterized by substitution and distortion, although the type of malocclusion did not influence the speech performance[21].

One of the tests used to assess speech articulation in an instrumental way was Diadochokinesia (DDK). DDK tests the ability to perform rapid repetitions of relatively simple patterns, comprising oppositional contractions. It also shows the adequacy of cerebral maturing and the individual's neuromotor integration, providing information about the rate, rhythm and the precision of articulation movements and the position of articulators[22].

Differences between DFD individuals and individuals with dentofacial balance regarding the speed and several DDK stability parameters show that the changes in the structures responsible for speech may affect the DDK results and not just the neurological control of movement[23].

Given that the dental and skeletal disproportions present in individuals with DFD may contribute to changes in oral motor performance, impacting the oral functions, the study of these aspects may contribute to the understanding of the DFD occurrences, to better direct the phonoaudiological rehabilitation process in motor orofacial area after an orthodontic-surgical intervention.

Thus, the objective of this research was to determine whether there is a correlation between oral motor control and the chewing, swallowing and speech functions in individuals with DFD.

Figure 1. Assessing Oral diadochokinesis

METHODS

A cross-sectional observational study approved by the Research Ethics Committee of Bauru Dental School, *Universidade de São Paulo* (USP), under process number 049/2009. All participants signed the consent form.

Sixteen DFD individuals were evaluated. They were aged 18 to 40 years, (average 28.37 years), standard deviation of 6.91, seven patients with class II (three women and four men) and nine class III (five women and four men), in orthodontic preparation for orthognathic surgery. Inclusion criteria were: age (between 18 and 40), DFD (malocclusion) and be near completion of the preparatory orthodontic treatment for orthognathic surgery.

Subjects were diagnosed by a maxillofacial surgeon dentist who used facial and occlusal analysis, cephalometry and imaging tests to determine the type of malocclusion. All procedures were performed as part of the protocol prior the orthognathic surgery.

Exclusion criteria were: history of intellectual impairment, neurological and psychiatric problems, chronic lung disease, smoking, voice disorders, previous laryngeal surgery and prior speech therapy. Such information was obtained through a questionnaire answered by the participants.

Recordings of DDK emissions were made in an acoustically treated studio, directly into a computer through an AKG™ headset microphone, C444PP model, connected to the Creative™ Audigy II sound card, positioned laterally at 60 degrees to 10 cm distance of corner of the lips, as shown in Figure 1.

DDK was assessed through the recordings of repetitions of syllables “pa”, “ta”, “ka” and the three syllable sequence “pataka” in Sound Forge 9.0 (Sony®) software, at 44,100 Hz sampling rate, Mono channel in 16 bit (Figure 2). Each emission was recorded for eight seconds, the first two and the last two seconds of the sample were excluded.

Subjects were instructed to “Keep the emissions as fast as possible” during the period determined by the evaluator. They were allowed to train for as long as they wished, before performing the recording of each sequence. The training was performed until the individual understood the process of emitting, i.e., emissions were to be carried out with rapid succession, keeping a clear and accurate articulation, with comfortable loudness and strong voice, with no respiratory pauses.

The eight seconds recording was edited and four seconds were used for analysis. Based on a previous study[24], editing was performed as follows: initially, four seconds of the sample were set by moving the cursor two seconds from the start of the recording; if the initial cursor interrupted a syllable, it would be moved to the left until reaching the start of the syllable; the four-second interval was set from that point. After these procedures, a final sample was determined and analyzed by a software that generated the values for the studied parameters.

The analysis of the syllable “pa”, “ta” and “ka” was performed using the Kay-Pentax™ Speech Engine Advanced Profile 5141 (MSP) software. We used 11.025 Hz sampling rates to adjust the recording setting. Emissions are represented by a graph in which the period (seconds) is shown by the horizontal axis and the energy (dB) on a vertical axis. The MSP software determines a line on the center of energy in dB of the vertical axis, which represents the mean intensity of the sample (DDKava). However, some emissions caused instabilities in the graph, so, we considered that the analysis line could be raised or lowered, so that the underpeaks were not included (Figure 3).

The DDK analysis of syllables and vowels was performed for the parameters generated by the program: average period (ms), average rate (s), period standard deviation (ms), period variation coefficient (%), perturbation of DDK period (%), DDK peak intensity variation coefficient (%).

The DDKs for the three syllable word /pataka/ were quantitatively analyzed through the Kay-Pentax™ Multi-Speech Main Program software, Model 3700, using the sampling rate of 11.025 Hz in spectrographic analysis. The counting of fricative sequences and three syllables words per second was performed manually by the researcher, with the support of visual and audio track, after determining the period to be analyzed.

Orofacial functions were assessed through the images of chewing, swallowing and speech tests, as stipulated by the MBGR protocol[25] in the myofunctional examination.

Chewing was assessed using three identical servings of a wafer. From the criteria suggested by MBGR protocol for

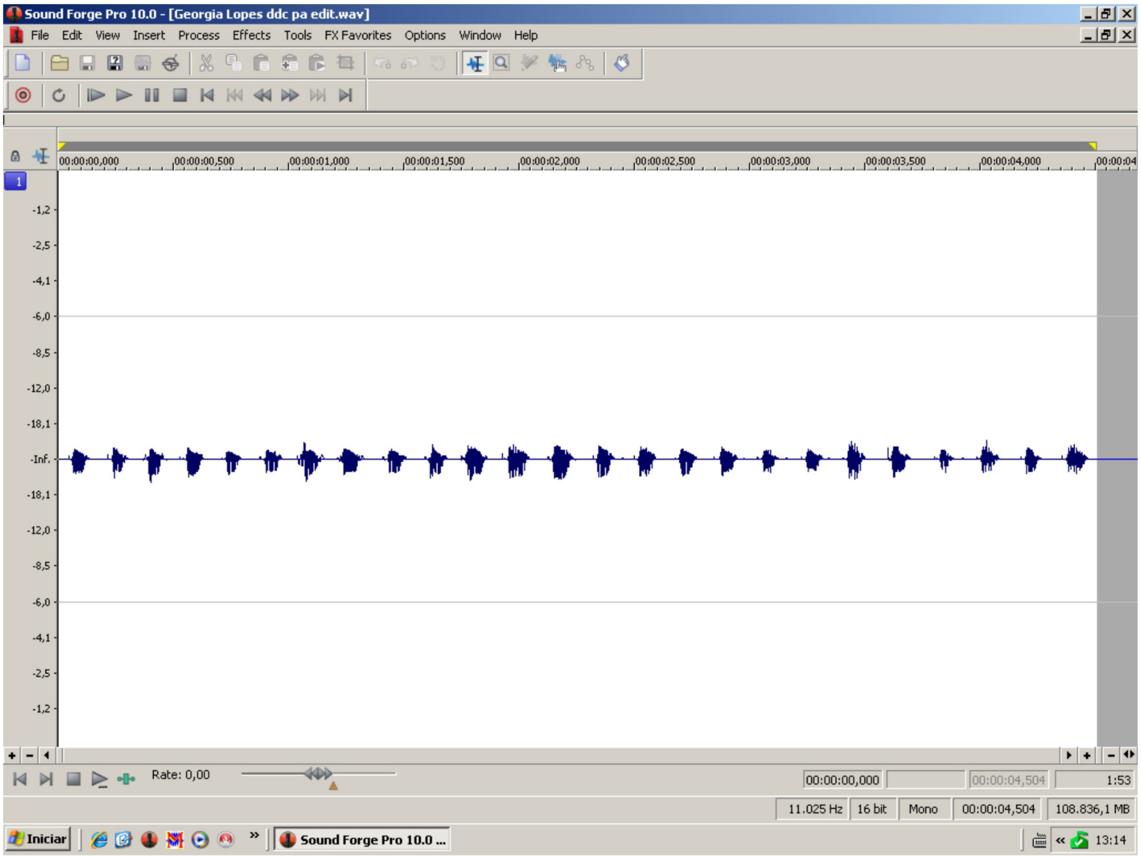

Figure 2. Recording of speech samples with the Sound Forge 9.0 (Sony®) software

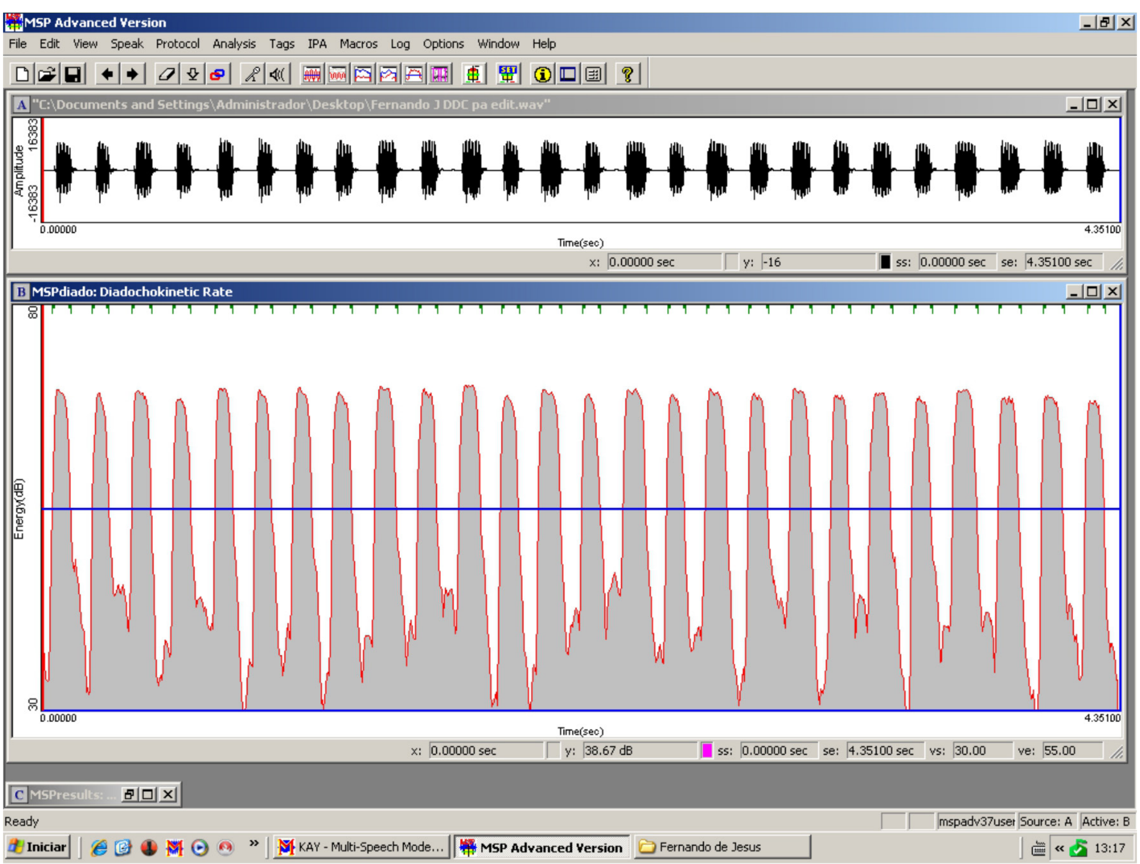

Figure 3. Analysis of speech samples by the Kay-Pentax™ Motor Speech Profile Advanced software

analysis of chewing, we observed the chewing pattern (chronic unilateral, bilateral simultaneous or alternate) as well as the presence of atypical muscle contractions. Liquid swallowing (water) was assessed through lip closure (appropriate, partial or absent); tongue posture (behind teeth, against the teeth, interdental, or not observable); lower lip posture (in contact with the upper tooth or behind the upper teeth); containment (adequate, partial or inadequate); contraction of the orbicular and mentum muscles; head movement; and the coordination of swallowing.

Speech was assessed using samples of picture naming, number counting 0-20 and spontaneous speech, revealing the presence or absence of changes such as exaggerated or blocked utterances, reduced or exaggerated lip movement, mandible deviation and articulation accuracy.

The filming analysis was performed by three speech therapists specialized in Orofacial Myology. Scores were given to each of the investigated items. Only the opinion of the majority of the examiners was considered for each evaluated individual, i.e., at least two examiners. If no agreement was reached, they were asked to jointly evaluate these aspects, thus obtaining a consensus.

In the filming analysis, the sum of the individual scores was used to obtain the total score for each function. A zero value was assigned whenever it seemed appropriate. When they were changed, higher values were given (the higher the score, the greater the change). Thus, the data used from their evaluation were tabulated in a specific database for the relevant statistical tests.

DFD class II and III were considered for statistical analysis. We were not able to carry out the statistical analysis separately due to the small size of the sample.

The correlation between the findings of the DDK and the evaluation of swallowing chewing and speech functions was obtained using Spearman correlation test, significance of $p<0.05$.

RESULTS

The average and standard deviations of DDK parameters in the various emissions of individuals with DFD (class II and III malocclusion) are shown in Table 1. The average, average standard deviation, median, minimum and maximum scores DFD individuals received for each function are shown in Table 2, using the MBGR Protocol.

Significant correlations for some of the DDK parameters and for the scores of chewing and swallowing functions were observed when applying the Spearman correlation test, as shown in Table 3.

A moderate ($0.50<r<0.75$) and significant ($p<0.05$) positive correlation was found between the chewing function and the DDK for the syllable “pa” in the parameters dpP, cvP, jitP and cvI and of syllable “ka” in jitP, indicating that the greater the

Table 1. Values for oral diadochokinesis of individuals with dentofacial deformities, during “pa”, “ta”, “ka”, e “pataka” emissions

Parameters - emission	Mean (±SD)
avp “pa” (ms)	164.550 (±15.49)
avp “ta”(ms)	158.952 (±13.11)
avp “ka” (ms)	165.671 (± 42.36)
avr “pa”(/s)	6.125 (± 0.55)
avr “ta”(/s)	6.331 (± 0.52)
avr“ka”(/s)	5.749 (± 0.49)
avr “pataka”(/s)	2.224 (± 0.23)
sdP “pa”(ms)	11.605 (±4.85)
sdP “ta”(ms)	12.969 (±6.71)
sdP “ka”(ms)	16.648 (±6.91)
cvP “pa”(%)	6.968 (±2.41)
cvP “ta”(%)	8.171 (±4.29)
cvP “ka”(%)	9.622 (±4.12)
jitP “pa”(%)	1.396 (±0.56)
jitP “ta”(%)	1.500 (±0.80)
jitP “ka”(%)	1.949 (±0.70)
cvI “pa”(%)	2.102 (±0.92)
cvI “ta”(%)	2.164 (±0.87)
cvI “ka”(%)	2.642 (±1.01)

Note: DDK = diadochokinesis; avp = average DDK period; avr = average DDK rate; dpP = DDK period standard deviation; cvP = variation coefficient of the DDK períod; jitP = perturbation of DDK period; cvI = variation coefficient of intensity peak

Table 2. Descriptive measurements of scores of dentofacial deformities individuals given to each orofacial function, according the MBGR protocol

Orofacial functions	Mean ± SD	Median	Maximum	Minimum
Chewing	1.81±1.11	1	3	0
Swallowing	5.56±2.13	5	10	2
Speech	4.12±3.91	3	12	0

Note: SD = standard deviation

Table 3. Correlation values for chewing, swallowing, speech and oral diadochokinesis

	Parameters - emission	R-value	p-value
Chewing	dpP-“pa” (ms)	0.53	0.02*
	cvP- “pa” (%)	0.66	0.00*
	jitP – “pa” (%)	0.60	0.01*
	jitP – “ka” (%)	0.46	0.03*
	cvI – “pa” (%)	0.60	0.02*
Swallowing	mP “pa” (ms)	0.56	0.02
	dpP-“pa” (ms)	0.70	0.00*
	cvP – “pa” (%)	0.65	0.00*
	jitP –“pa” (%)	0.68	0.00*
	avp-“pa (/s)	-0.56	0.04*
Speech	cvI - “pa” (%)	-0.29	0.04*

* Significant values ($p<0.05$) – Spearman Correlation test

Note: DDK = diadochokinesis; dpP = standard deviation for the DDK period; cvP = variation coefficient for the DDK period; jitP = perturbation of DDK period; cvI = variation coefficient of peak intensity instability of the emission of the syllable “pa” and “ka”, the more altered the chewing function.

A moderate (0.50<r<0.75) and significant (p<0.05) positive correlation was found between the swallowing function and the DDK of the syllable “pa” at parameters dpP, cvP and jitP, showing that the greater the instability of the emission, the more altered the swallowing. As for the speed parameters, there was a moderate (0.50<r<0.75) and significant (p<0.05) positive correlation between the swallowing and the DDK of the syllable “pa” in avp parameter, and a moderate negative correlation and significant (p<0.05) between the swallowing and the DDK of the syllable “pa” in avr parameter.

A weak and significant negative correlation was found between the speech function and the presence of DFD, for the cvI parameter, in the emission of the syllable “pa”, indicating that the higher the instability of the emission, the less impaired the speech. This data is not in accordance with what it was expected, however, this may be related to the presence of regular correlation (0.25<r<0.50).

DISCUSSION

DDFs may lead to imbalances in the stomatognathic system, causing changes that may impair the orofacial functions. Therefore, this study investigated the relationship between phonoarticulatory control and the chewing, swallowing and speech functions in individuals with malocclusion in the period prior to orthognathic surgery.

Changes related to chewing, swallowing and speech were found in the orofacial functions studied in all of investigated DFD individuals. Several authors have described changes in orofacial functions in patients with class II and III malocclusion[10,15,17,26], similar to that seen in this study.

Only the results with a positive and negative moderate correlation between DDK and those functions will be discussed. This criterion was adopted because regular and weak correlations do not present reliable results. The results for the chewing function showed that the higher the instability of the emission of syllables “pa” and “ka”, the more altered this function. The positive correlation between DDK and changes in chewing function may be related to muscle imbalance, for the small number of occlusal contacts results in the impairment of bite force and in the chewing performance with necessary compensation and adaptations[24,25]. Moreover, retrognatia can lead to anterior mandible sliding in order to increase the intraoral space during chewing, triggering faster, shorter chewing cycles[26] and prognathism. The lateral and rotational movements of the jaw are impaired due to the maxilla position relative to the jaw[15].

Although we did not find studies relating DDK to the chewing function in individuals with DDF, the DDK has been related to chewing on elderly individuals who use prosthetic rehabilitation. Tongue movement has been reported, demonstrating that the tongue can compensate for missing teeth on chewing performance[26]. Another study looked into the relationship between the motor control of the tongue and chewing. It was verified that the tongue motor skills and the chewing performance of dentate elderly and people with dentures were lower, when compared with the dentate adults[27].

The results showed a correlation between DDK and swallowing: the greater the instability of the emission of the syllable “pa”, the more altered this function. This can be explained: individuals with prognathism, swallow using the anterior tongue thrust with the participation of the perioral muscles while individuals with retrognathism present anterior mandible sliding, tongue posteroanterior movement, participation of the perioral muscles and tongue thrusting[26]. Other authors observed that patients with Class III malocclusion presented swallowing with anterior tongue projection, decreased rising in the dorsum of the tongue, and reduced force of liquids oral ejection[16]. These characteristics may have interfered in the oral motor performance of individuals with DFD.

As for the DDK speed parameters, there was a correlation with the swallowing function: it was positive for the period average and negative for the average emission rate of “pa”; therefore, the greater the change in the swallowing, the longer the period. This shows that individuals with impaired swallowing repeated the emissions more slowly.

Therefore, in the same way as the findings related to the emissions instability, the change in the function together with the malocclusion may have also affected the speed of oral motor production. However, looking at our results, we can say that both DFDs (class II and III) affect the action of orofacial muscles and the adjacent functions, which act on each other and, similarly, on the muscles on the bony part, evidencing the binomial form and function.

The analysis of the speech function in individuals with skeletal Class III malocclusion found no mandibular deviation. However, we noticed that other aspects of speech were influenced by the facial pattern: the dolicocephalic had higher articulation changes when compared to those with an average face[15]. Similarly, another study also found speech disorders in individuals with class II malocclusion, such as anterior jaw and lateral and anterior mandible sliding, besides tongue projection in class II individuals. These changes differentiated them from those with class I[14].

In this study, the correlation between the DDK data and the clinical evaluation of speech was negative, i.e., the greater the DDK instability, the smaller the change in the speech. This goes against what is expected and described in the literature; however, the value of “r” indicates a regular correlation, which may explain the dispute.

DDK is an instrumental examination that evaluates the speech articulation, promoting an acoustic index of the speed of the articulation movement. Therefore, it would be expected that the change in speech found in DDK would also be observed during the analysis of the speech filming. However, it should be considered that the clinical assessment of speech may not be sensitive enough to diagnose changes, and instrumental assessment (for example, the acoustic analysis of speech) would provide more specific parameters. Therefore, one must consider that new studies on different methodological research proposals on speech assessments might be important.

Therefore, there is a possibility for DFDs to impair the oral functions, and consequently the articulation. The DDK that assesses the functions of the phonoarticulatory structures was altered in some cases. Thus, this study calls attention to the fact that the DDK can be a useful tool in clinical treatments, which will help assess, and allow proper monitoring of DFD cases.

Further studies, with a larger number of subjects, addressing the oral motor control and orofacial functions after surgery will help to enhance the research in the area, contributing to the assessment and treatment of individuals with DFD.

CONCLUSION

We found a correlation between the oral motor control and the chewing and swallowing functions for the instability and speed diadochokinesis parameters.

REFERENCES

1. Felício CM. Desenvolvimento normal das funções estomatognáticas. In: Ferreira LP, Befi-Lopes DM, Limongi SCO, organizadores. Tratado de fonoaudiologia. Rio de Janeiro: Roca; 2004. p.195-213.
2. Okazaki LK. Quando indicar uma cirurgia ortognática. In: Araújo A. Cirurgia ortognática. São Paulo: Santos; 1999. p. 7-18.
3. Moyers ER. Ortodontia. Rio de Janeiro: Guanabara Koogan; 1979. p. 212-37.
4. Laureano Filho JR, Cypriano RV, Moraes RPA, Freitas MQ. Avanço maxilar: descrição da técnica e relato de caso clínico. Rev Cir Traumatol Buco-maxilo-fac. 2003;3(2):25-31.
5. Trawitzki LVV, Dantas RO, Mello-Filho FV, Elias-Júnior J. Effect of treatment of dentofacial deformity on masseter muscle thickness. Arch Oral Biol. 2006;51(12):1086-92. http://dx.doi.org/10.1016/j.archoralbio.2006.06.004
6. Trawitzki LVV, Dantas RO, Elias-Júnior J, Mello-Filho FV. Masseter muscle thickness three years after surgical correction of class III dentofacial deformity. Arch Oral Biol. 2011; 56(8):799-803. http://dx.doi.org/10.1016/j.archoralbio.2011.01.012
7. Altmann EBC. Myofunctional therapy and orthognathic surgery. Int J Orofacial Myology. 1987;13(3):2-12.
8. Sarver DM, Johnston MW. Orthognathic surgery and aesthetics: planning treatment to achieve functional and aesthetic goals. Br J Orthod. 1993;20(2):93-100. http://dx.doi.org/10.1179/bjo.20.2.93
9. Berretin-Felix G, Jorge TM, Genaro KF. Intervenção fonoaudiológica em pacientes submetidos à cirurgia ortognática. In: Fernandes FDM, Mendes BCA, Navas ALGP, organizadores. Tratado de fonoaudiologia. 2a ed. São Paulo: Roca; 2010. p. 545-57.
10. Picinato-Pirola MNC, Mello-Filho FV, Trawitzki LVVoi. Tempo e golpes mastigatórios nas diferentes deformidades dentofaciais. J Soc Bras Fonoaudiol. 2012;24(2):130-3. http://dx.doi.org/10.1590/S2179-64912012000200007
11. Marchesan IQ, Bianchini EMG. A fonoaudiologia e a cirurgia ortognática. In: Araujo A. Cirurgia ortognática. São Paulo: Santos; 1999. p. 351-62.
12. Braber W, Glas HW, Bilt A, Bosman F. Masticatory function in retrofnathic patients, before and after mandibular advancement surgery. J Oral Maxillofac Surg. 2004;62(5):549-54. http://dx.doi.org/10.1016/j.joms.2003.06.016
13. Di Palma E, Gasparini G, Pelo S, Tartaglia GM, Sforza C. Activities of masticatory muscles in patients before orthognathic surgery. J Craniofac Surg. 2010;21(3):724-6. http://dx.doi.org/10.1097/SCS.0b013e3181d841c6
14. Mezzomo CL, Machado PG, Pacheco AB, Gonçalves BFT, Hoffmann CF. As implicações da classe II de angle e da desproporção esquelética tipo classe II no aspecto miofuncional. Rev CEFAC. 2011;13(4):728-34. http://dx.doi.org/10.1590/S1516-18462010005000079
15. Pereira AC, Jorge TM, Ribeiro Júnior PD, Berretin-Felix G. Características das funções orais de indivíduos com má oclusão Classe III e diferentes tipos faciais. Rev Dental Press Ortodon Ortop Facial. Maringá. 2005;10(6):111-9. http://dx.doi.org/10.1590/S1415-54192005000600013
16. Sovinski SRP. Estética facial e funções orofaciais em indivíduos com deformidade dentofacial. [dissertação]. Bauru: Universidade de São Paulo, Faculdade de Odontologia de Bauru; 2012.
17. Sígolo C, Campiotto AR, Sotelo MB. Posição habitual de língua e padrão de deglutição em indivíduo com oclusão classe III, pré e pós-cirurgia ortognática. Rev CEFAC. 2009;11(2):256-60. http://dx.doi.org/10.1590/S1516-18462009005000022
18. Farret MMB, Jurach EM, Brandão L, Moraes DCF, Brandão SRS, Santos S. Relationship between malocclusion and fonoarticulatory disorders. Int. J Orofacial Myology. 1998;24:20-6.
19. Lee ASY, Whitehill TL, Ciocca V, Samman N. Acoustic and perceptual analysis of the sibilant sound /s/ before and after orthognathic surgery. J Oral Maxillofac Surg. 2002;60(4):364-72. http://dx.doi.org/10.1053/joms.2002.31221
20. Ward EC, McAuliffe MJ, Holmes SK, Lynham A, Monsour F. Impact of malocclusion and orthognathic reconstruction surgery on resonance and articulatory function: an examination of variability in five cases. Br J Oral Maxillofac Surg. 2002;40(5):410-7.
21. Whitehill TL, Samman N, Wong LLN, Ormiston I. Speech errors associated with dentofacial abnormalities in Cantonese speakers. J Medical Speech-Lang Pathol. 2001;9(3):177-90.
22. Baken RJ, Orlikoff RF. Speech movements. In: Baken RJ, Orlikoff R F. Clinical measurement speech and voice. 2nd ed. San Diego: Singular Thomson Learning; 2000. p. 511-57.
23. Prado DGA. Características fonoarticulatórias e respiratórias de indivíduos com deformidade dentofacial [dissertação] Bauru: Universidade de São Paulo, Faculdade de Odontologia de Bauru; 2011.

24. Modolo DJ, Berretin-Felix G, Genaro KF, Brasolotto AG. Oral and vocal fold diadochokinesis in children. Folia Phoniatric Logop. 2011;63(1):1-8. http://dx.doi.org/10.1159/000319728
25. Genaro KF, Berretin-Felix G, Rehder MIBC, Marchesan IQ. Avaliação miofuncional orofacial protocolo MBGR. Rev CEFAC. 2009;11(2):237-55. http://dx.doi.org/10.1590/S1516-18462009000200009
26. Coutinho TA, Abath MB, Campos GJL, Antunes AA, Carvalho RWF. Adaptações do sistema estomatognático em indivíduos com desproporções maxilo-mandibulares: revisão da literatura. Rev Soc Bras Fonoaudiol. 2009;14(2):275-9. http://dx.doi.org/10.1590/S1516-80342009000200021
27. Kikutani T, Tamura F, Nishiwaki K, Kodama M, Suda M, Fukui T et al. Oral motor function and masticatory performance in the community-dwelling elderly. Odontology. 2009;97(1):38-42. http://dx.doi.org/10.1007/s10266-008-0094-z