REVISTA CEFAC
SPEECH, LANGUAGE, HEARING SCIENCES AND EDUCATION JOURNAL
Rev. CEFAC. 2022;24(5):e8122 https://doi.org/10.1590/1982-0216/20222458122

Original articles

Duration of mastication and oral phase of swallowing in the elderly with different dental conditions: a clinical analysis

Tatiane Totta Salgado[1]
https://orcid.org/0000-0001-9593-6888

Marina Gatti[2]
https://orcid.org/0000-0002-5273-9283

Katia Flores Genaro[2]
https://orcid.org/0000-0002-5218-760X

Luiz Fernando Pegoraro[3]
https://orcid.org/0000-0002-6059-6817

Giédre Berretin-Felix[2]
https://orcid.org/0000-0002-8614-2805

[1] Universidade de São Paulo, Hospital de Reabilitação de Anomalias Craniofaciais, Bauru, São Paulo, Brasil.

[2] Universidade de São Paulo, Faculdade de Odontologia de Bauru, Departamento de Fonoaudiologia, Bauru, São Paulo, Brasil.

[3] Universidade de São Paulo, Faculdade de Odontologia de Bauru, Departamento de Prótese e Periodontia, Bauru, São Paulo, Brasil.

Research support source: Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP) (Process 06/60336-9) e Coordenação de Aperfeiçoamento Pessoal de Nível Superior (CAPES).

Conflict of interests: Nonexistent

Received on: October 2, 2022
Accepted on: November 20, 2022

Corresponding address:
Marina Gatti
Alameda Doutor Octávio Pinheiro Brisola, 9-75
CEP: 17012-901 - Bauru - São Paulo, Brasil
E-mail: marina.gatti@usp.br

ABSTRACT

Purpose: to measure the total time of mastication and oral phase of swallowing in healthy elderly people, considering different food consistency, the presence of natural teeth, and the type of prosthetic oral rehabilitation, as well to compare dental conditions and consistencies.

Methods: a cross-sectional study with 57 healthy elderly people, aged between 60 and 82 years, divided into: dentate group (D) (n=15); and rehabilitated groups; PD: fixed or removable partial dentures in one or both arches (n=15); CRD: maxillary and mandibular complete removable dentures (n=15); ISCD: complete dentures – maxillary removable denture and mandibular implant-supported dentures (n=12). The duration time (seconds) of chewing and of the oral phase of swallowing was measured in the consistencies: solid (a roll slice), pudding (10 ml) and liquid (10 ml).

Results: healthy dentate elderly subjects had the following intervals: liquid=1.07±0.35 s; pudding=3.48±1.76 s; and solid=27.88±7.11 s. Statistically significant differences were observed between the D and ISCD groups (p=0.0056) and between D and CRD (p=0.0056) for liquid. For all groups, there was a statistically significant increase between liquid and solid consistencies and between pasty and solid ones (p<0.001).

Conclusions: the dentate elderly had shorter oral phase time of swallowing for liquids than the rehabilitated edentulous elderly, but not different from the elderly with partial dentures. Chewing and swallowing time for solid food was longer than that for the other consistencies, regardless of dental condition.

Keywords: Aging; Deglutition; Mastication; Dentition, Permanent; Dental Prosthesis

INTRODUCTION

Aging goes along with physiological changes in mastication, responsible for the functions of pulverizing the food into particles, mixing them with saliva and forming a bolus for swallowing[1], and also in the oral phase of swallowing, represented by the ejection of food to the back of the oral cavity, aiming at its passage towards the pharynx[2], which negatively affects the feeding process, favoring the occurrence of oropharyngeal dysphagia[3,4]. The reduction in the number of teeth, common in the elderly, is correlated to swallowing disorders[4] and changes in chewing capacity[5], generating a negative impact on their quality of life[6]. In addition, totally edentulous elderly people show better swallowing performance when fitted with complete removable dentures (CRP) as compared to their absence, since the use of CRP improves bolus formation, decreases pharyngeal transit time and the risk of laryngotracheal aspiration[7].

Although divergent, the literature reports differences in chewing and swallowing functions according to the different types of oral rehabilitation used. Individuals rehabilitated with CRP present more difficulties in chewing, longer chewing time and number of chewing cycles[8]. Replacing the CRP with implant-supported denture (ISP) improves chewing capacity[9], bite force[10], *ability to reduce food particle size, and distinguish between different food consistencies*[11]*. It also provides reduced liquid intake during feeding, reduced choking and coughing, and improved oral transit for swallowing solids*[12].

There are still few studies that evaluated the mastication and/or swallowing time in the elderly[5,11,13-17], the evaluation by means of instrumental tests and in young and adult population[18] being more common. Out of studies that investigated the time of the oral phase of swallowing in dentate elderly without swallowing complaints, the mean swallowing time of 1.8 seconds for men and women, in the mean ingestion of 14 ml of liquid[13], mean oral phase time of 17.6 ± 8.3 seconds during ingestion of thin and thickened liquid, pasty and solid[19] and longer oral transit time compared to young individuals, during the ingestion of liquid[14,15], solid and pasty[20], were verified.

The chewing time and the number of chewing cycles vary according to the type of prosthetic rehabilitation, 14.63 seconds being the chewing time for individuals with complete denture during the ingestion of apple, with 24.94 chewing cycles, while individuals with removable partial denture present 13.5 seconds and 23.72 cycles[8].

The clinical measurement of chewing time and the oral phase of swallowing in healthy elderly aims at contributing to the understanding of physiological characteristics of aging, helping the interdisciplinary work among professionals who do not have access to instrumental tests resources.

This study aimed at measuring the total time of chewing and the oral phase of swallowing in healthy elderly subjects, taking into account different food consistencies, the presence of natural teeth and the type of prosthetic oral rehabilitation, as well as comparing dental conditions and food consistencies. It is hypothesized that food consistency will influence the parameters studied and that the dentate elderly will have chewing time and the oral phase of swallowing similar to that of partially dentate groups rehabilitated with partial denture, either fixed or removable, and the elderly rehabilitated with upper complete removable dentures and complete implant-supported dentures in the lower arch.

METHODS

This is a cross-sectional study which is part of a larger project approved by the Ethics Committee on Human Research of Faculdade de Odontologia de Bauru da Universidade de São Paulo, Brazil (No. 111/2006). It was carried out with the agreement of the recruited cases, who signed the Informed Consent Form.

The sample comprised 57 elderly subjects aged between 60 and 82 years (median = 68.5 years), divided into four groups according to the presence of teeth or type of prosthetic rehabilitation received. One group consisted of dentate elderly subjects (D), with occlusal contacts at least up to the second premolar (short arch), six men and nine women (n=15).

The PD group consisted of partial edentulous individuals, eight women and seven men, who used fixed partial dentures or removable partial dentures in one or both arches (n=15); the CRD group consisted of individuals rehabilitated with upper and lower complete removable dentures, ten women and five men (n=15); and the ISCD group consisted of eight women and four men who used complete dentures, removable in the upper arch and implant-supported fixed in the lower arch (n=12).

For individuals with oral rehabilitation, the following inclusion criteria were considered: satisfactory, stable

and adapted definitive denture with appropriate vertical dimension of occlusion (VDO)[21], with a minimum wearing time of six months and maximum of ten years, evaluated by a dentist. For all groups the following criteria were adopted: good general health status; adequate cognitive performance, as assessed by the Mini-Mental State Examination Scale[22], the average score being 26 points.

Upon dental evaluation, the following exclusion criteria were selected: dentofacial anomalies or deformities, tooth mobility or loss of bone support, exaggerated or premature occlusal contacts and/or wear caused by parafunctional habits, history of neurological diseases, head and neck oncological ones, psychological or psychiatric diseases; alcoholism; long-time smoking; users of medications that could cause xerostomia or impair swallowing, such as antispasmodics, bronchodilators, antidepressants, anticholinergics, antihistamines, and sedatives.

The measurement of the duration of chewing time and of the oral phase of swallowing was performed during the ingestion of liquid, pudding, and solid food, and the consistency and volume offered were standardized:

Liquid: 10 ml of filtered water, volume gauged by using a 10 ml syringe and placed in a plastic cup;

Pudding: 10 ml of Clight® grape juice, volume offered with a dessert spoon, the consistency being obtained from 30 ml of filtered water added to 2 g (1/5 of the sachet) of juice powder and thickened with 3 g of NUTILIS instant thickener (Support Produtos Nutricionais Ltda., Rio de Janeiro, RJ, Brazil)[12].

Solid: a slice with a thickness of 1 cm and diameter of approximately 4 cm of a roll, made on the day and period of the evaluation and always purchased at the same commercial establishment.

The assessed elderly were instructed to put, at different times, the liquid and pudding contents in their mouth and swallow them only after verbal guidance from the evaluator, while the solid food should be taken to the mouth, chewing was performed in its various phases, followed by voluntary swallowing. For the liquid and pudding consistencies, the measurement occurred upon verbal guidance from the evaluator for the subject to swallow, the chronometer being started concomitantly to the beginning of swallowing.

The swallowing time was represented by the duration of the propulsion of the bolus by the tongue before swallowing until the beginning of the hyolaryngeal complex elevation[23], when the chronometer was turned off, including, in this time interval, the measurement of more than one swallow, if necessary for the purification of the consistency offered. As for the solid consistency, the stopwatch was started when the food was placed in the oral cavity, incision of the food and subsequent lip occlusion, until the swallowing act itself[24,25], based on the moment when the laryngeal elevation occurred.

For data analysis the evaluation was recorded using a Panasonic digital video camera (Palmcorder VJ98) and later the time was measured using a stopwatch by two speech therapists with training and experience in the evaluation of swallowing and chewing, with 100% agreement between them for the beginning and end of the measurement. Analysis of Variance (ANOVA) was used for comparisons between groups when normality and homoscedasticity conditions were verified. When these conditions were not met, the Kruskall Wallis test was used, followed by Dunn's test for individual comparisons. A significance level of 5% was adopted.

RESULTS

The comparison of the swallowing times between the individuals in the different groups showed a significant difference between groups D and ISCD ($p=0.0056$) and D and CRD ($p=0.0056$), for the liquid consistency (Table 1). For the other consistencies, although most of the values in group D were lower than the mean, there was no significant difference between the groups either in the soft consistency ($p=0.3217$), seen in Table 2, or in the solid consistency ($p=0.3093$), as shown in Table 3.

Table 1. Time of the oral phase of swallowing (seconds) of the liquid consistency for the groups studied

Groups / Subjects	Swallowing Oral Phase Time			
	D (n=15)	PD (n=15)	CRD (n=15)	ISCD (n=12)
Mean	1.07[a]	1.83a[b]	2.13[b]	2.08[b]
SD	0.35	1.07	1.72	0.98
Median	1.06	1.68	1.87	1.75
First Quartile	0.85	01.31	01.15	01.57
Last Quartile	01.97	04.65	07.94	04.45

(a) Distinct lower case letters indicate a statistically significant difference (p<5%) between groups, according to Kruskal Wallis and Dunn tests.
Captions: D = Dentate; PD = Partial Dentures (Fixed or Removable); CRD = Complete Removable Dentures; ISCD = Implant-Supported Complete Dentures.

Table 2. Time of the oral phase of swallowing (seconds) of the pudding consistency for the groups studied

Groups / Subjects	Swallowing Oral Phase Time			
	D (n=15)	PD (n=15)	CRD (n=15)	ISCD (n=12)
Mean	3.48[a]	4.91[a]	4.26[a]	5.56[a]
SD	1.77	3.14	2.38	4.26
Median	3.03	4.32	3.34	3.82
First Quartile	2.29	3.27	2.53	2.62
Last Quartile	07.21	13.93	10.30	16.02

* (a) Distinct lower case letters indicate a statistically significant difference (p<5%) between groups, according to ANOVA test.
Captions: D = Dentate; PD = Partial Dentures (Fixed or Removable); CRD = Complete Removable Dentures; ISCD = Implant-Supported Complete Dentures

Table 3. Mastication time and oral phase of swallowing (seconds) of solid consistency for the groups studied

Groups / Subjects	Time of Chewing and the Oral Phase of Swallowing			
	D (n=15)	PD (n=15)	CRD (n=15)	ISCD (n=12)
Mean	27.88[a]	29.63[a]	29.07[a]	35.63[a]
SD	07.11	10.86	12.34	13.87
Median	26.60	25.03	27.96	36.70
First Quartile	23.08	22.30	22.88	23.61
Last Quartile	41.36	46.95	55.08	60.49

* (a) Distinct lower case letters indicate a statistically significant difference (p<5%) between groups, according to ANOVA test.
Captions: D = Dentate; PD = Partial Dentures (Fixed or Removable); CRD = Complete Removable Dentures; ISCD = Implant-Supported Complete Dentures

In the comparisons of chewing and swallowing time between each consistency for the same evaluated group (Table 4), a statistically significant difference (p<0.01) was observed for all groups (D, PD, CRD and ISCD), when comparing the liquid and solid consistencies (p=0.0000) and for pasty and solid (p=0.0000). However, no significant difference was found for swallowing time between the liquid and pasty consistencies.

Table 4. Distribution of values related to mastication and swallowing time of liquid, pasty and solid consistencies for the groups studied

Food / Group	Swallowing time (seconds, milliseconds)		
	Liquid	Pasty	Solid
D (n=15)			
Mean±DP	01.07±00.34[a]	3.48±01.76[a]	27.88±07.11[b]
Median	01.06	03.03	26.60
First Quartile	00.85	02.29	23.08
Last Quartile	01.97	07.21	41.36
PD (n=15)			
Mean±DP	01.82±01.06[a]	04.90±03.13[a]	29.63±10.85[b]
Median	01.68	04.32	25.03
First Quartile	01.31	03.27	22.30
Last Quartile	4.65	13.93	46.95
CRD (n=15)			
Mean±DP	02.12±01.72[a]	04.25±02.38[a]	29.06±12.33[b]
Median	01.87	03.34	27.96
First Quartile	01.15	02.53	22.88
Last Quartile	07.94	10.30	55.08
ISCD (n=12)			
Mean±DP	02.07±00.97[a]	05.55±04.25[a]	35.63±13.87[b]
Median	01.75	03.82	36.70
First Quartile	01.56	02.62	23.61
Last Quartile	04.45	16.02	60.49

Captions: D = Dentate; PD = Partial Dentures (Fixed or Removable); CRD = Complete Removable Dentures; ISCD = Implant-Supported Complete Dentures; SD = standard deviation.
* (a) Distinct lower case letters indicate a statistically significant difference ($p<0.01$) between the groups, according to paired t-test..

Parametric statistics were calculated as well, by applying the paired t-test to compare the results obtained for each consistency within the same evaluated group (intra-group), a significance level of $p<0.01$ being accepted.

DISCUSSION

This study aimed at measuring the total mastication time (from the perspective of this function as part of the oropharyngeal swallowing process) and the oral phase of swallowing among different food consistencies in healthy dentate elderly subjects, and compare them to elderly subjects with different oral rehabilitation. Although age-related changes result in delayed onset of swallowing[26,27] and declining neuromuscular control, there is, currently, little literature investigating aspects of swallowing, such as the timing of the oral phase, in dentate elderly who are considered healthy.

The hypothesis tested was that elderly dentate patients would have a performance of mastication time and oral phase of swallowing similar to that of the groups with partially dentate elderly patients rehabilitated with PDs and the elderly rehabilitated with upper CRDs and lower complete implant-supported dentures. The authors based their reasoning on the existence of greater sensory input from the periodontal mechanoreceptors of the remaining teeth (in the cases of the CRD group), and on the performance similar to that of dentate patients found in the ISCD group, described in the literature.

However, in the present study, the hypothesis was not entirely confirmed, with similar mean swallowing times for the dentate elderly and the PD group, these being lower than those of groups with totally edentulous rehabilitated elderly. However, in the pudding and solid consistencies, although there was a trend towards lower time values in the dentate group, there were similar performances in all groups, with no significant differences generated by the different types of prosthetic oral rehabilitation.

In the present study, a swallowing time of 01.07±0.35 seconds was found for the liquid consistency, consisting with the findings of Yoshikawa, et al. (2005)[14] and Yoshikawa, et al. (2006)[15], who measured the oral phase by means of videofluoroscopic analysis.

The values found can be considered increased when compared to the values of the study by Cassiani et al. (2011)[28], which assessed 30 healthy individuals, with an age range between 29 and 77 years, the oral transit time found for this population being 0.42±0.23 for liquids and 0.41±0.28 for pasty.

The differences between different age groups may be justified by the fact that the elderly population has greater difficulty swallowing in the oral phase, even in the elderly without complaints of dysphagia[26], and there is also a higher frequency of laryngeal penetration by decreasing viscosity[29].

With regard to the influence of the oral condition, the significant difference (p=0.0056) found for the mean swallowing times between groups D and CRD and between D and ISCD could be justified by the influence of the absence of afferent information coming from the periodontal mechanoreceptors[30], as well as lower sensory perception in the palate region (caused by the dentures), generating less control of the oral phase and impairing the action of the palate in anchoring the tongue movement in the production of pressure to generate swallowing[31] in the liquid consistency of the total edentulous elderly patients studied.

As shown in the study by Sato et al. (2013)[31], dentulous adults who used dentures showed a worsening in the visual analog scale and in the bolus formation indices on the first day after fitting, returning to the usual pattern on the seventh day, but with a greater number of chewing cycles to compensate for a worse masticatory performance and to provide better bolus formation for a comfortable swallow. However, this study involved chewing and swallowing a solid consistency (rice).

Regarding the pasty consistency, the oral phase time was 3.48±1.76 seconds and for the solid, 27.88±7.11 seconds. The solid consistency presented statistically higher values of chewing time and oral phase when compared to liquid and pasty (p<0.001) for all groups (D, PP, CRD and ISCD). No studies were found in the literature involving the relationship of food consistency with quantitative swallowing parameters in healthy elderly considering the fully dentate condition. The study by Newman et al. (2016)[32] found that changes in the viscosity of the bolus lead to changes in swallowing biomechanics, such as the increase in oral and pharyngeal transit, lingual pressure, hyoid displacement, time for closure of the laryngeal vestibule, duration of upper esophageal sphincter (UES) opening, and bolus velocity.

To time the oropharyngeal deglutition time for the solid consistency, the addition of the chewing time was considered, since this function is an integral part of the oral preparatory phase of deglutition[33], obtaining the mean value higher than that of liquid and pasty ones, justifying the difference between the findings for the different consistencies tested.

This result was similar to that of Melo et al. (2006)[25], who measured the time to chew bread in 40 adults and found a value of 26.3s±8.8 seconds. Such findings highlight the similarity of time intervals obtained in the evaluation of swallowing for the solid consistency when the preparatory oral phase of oropharyngeal swallowing is considered. This may be justified by the relationship with the greater sensory input generated by the oral preparatory phase, involving greater mastication control[34] and oral stereognosy[3], generated by the occlusal contacts of teeth with food, which result in improved motor response of the oral and pharyngeal swallowing phases. And also, regarding the different oral conditions, although the use of ISCD can improve several aspects related to masticatory efficiency[35], no relevant differences were found between the performance of chewing and swallowing time between the groups studied in the present study.

The data also leads to the questioning about the influence of the inhibition of sensory stimulation, generated by the dentures, which may also have generated a worsening of the masticatory performance and the formation of the bolus[30,34], generating a longer chewing time, thus, influencing the final swallowing values.

In agreement with the findings of this study, Cavalcanti and Bianchini (2008)[24] also found no significant differences in the means of chewing times and oral phase of swallowing for bread among adults with complete or partial removable dentures (22.07 s) as compared to dentate ones (19.06 s)[24]. Lucena et al. (2014)[35] found higher averages of chewing time for a loaf of bread (25 g) in adults, considering the interval between the incision of the food with the teeth until the last swallow, times of 2 minutes and 15 seconds being found for men, and 2 minutes and 36 seconds for women.

These data show that research directed to the senile population must take into account the influence of sensory information coming from the teeth or their absence,[3,36]; from physiological aspects related to aging, such as difficulties in controlling and swallowing the bolus found in the oral phase[34], as well as

dysfunctions in the pharyngeal phase such as reduced degree of laryngeal elevation and delayed onset of hyolaryngeal excursion[26], and also the influence of palate coverage with dentures[30] as variables that can influence the results of studies involving the process of mastication and oropharyngeal swallowing.

The advantages of this study are in the identification of normality temporal values compatible with the elderly population considered healthy, seeking greater sensitivity and specificity of clinical tests, since not all professionals can take advantage of instrumental tests.

CONCLUSION

For healthy dentate elderly subjects, the following values of chewing and swallowing times were obtained: 1.07±0.35 seconds for 10 ml of liquid; 3.48±1.76 seconds for 10 ml of pasty, and 27.88±7.11 seconds for solid, demonstrating longer intervals according to the increasing consistency of the food.

Furthermore, dentulous elderly subjects had shorter liquid swallowing times when compared to totally edentulous subjects rehabilitated with complete removable denture and elderly subjects with upper complete removable denture and lower implant-supported complete fixed denture. For all groups (D, PP, CRD and ISCD) there was a statistically significant difference when comparing liquid and solid consistencies, as well as pasty and solid ones.

ACKNOWLEDGEMENTS

Gratitude is extended to Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP) and Coordenação de Aperfeiçoamento Pessoal de Nível Superior (CAPES), fundamental to the development of this study.

REFERENCES

1. Peyron MA, Woda A, Bourdiol P, Hennequin M. Age-related changes in mastication. J Oral Rehabil. 2017;44(4):299-312.
2. Furuta M, Komiya-Nonaka M, Akifusa S, Shimazaki Y, Adachi M, Kinoshita T et al. Interrelationship of oral health status, swallowing function, nutritional status, and cognitive ability with activities of daily living in Japanese elderly people receiving home care services due to physical disabilities. Community Dent Oral Epidemiol. 2013;41(2):173-81.
3. Furuta M, Yamashita Y. Oral health and swallowing problems. Curr Phys Med Rehabil Reports. 2013;1(4):216-22.
4. Okamoto N, Morikawa M, Yanagi M, Amano N, Tomioka K, Hazaki K et al. Association of tooth loss with development of swallowing problems in community-dwelling independent elderly population: the Fujiwara-kyo study. J Gerontol A Biol Sci Med Sci. 2015;70(12):1548-54.
5. Huang YF, Liu SP, Muo CH, Chang CT. The impact of occluding pairs on the chewing patterns among the elderly. J Dent. 2021;104:103511.
6. Cho MJ, Kim EK. Subjective chewing ability and health-related quality of life among the elderly. Gerodontology. 2019;36(2):99-106.
7. Yamamoto H, Furuya J, Tamada Y, Kondo H. Impacts of wearing complete dentures on bolus transport during feeding in elderly edentulous. J Oral Rehabil. 2013;40(12):923-31.
8. Moraru AMO, Preoteasa CT, Preoteasa E. Masticatory function parameters in patients with removable dental prosthesis. J Med Life. 2019;12(1):43-8.
9. Sharma AJ, Nagrath R, Lahori M. A comparative evaluation of chewing efficiency, masticatory bite force, and patient satisfaction between conventional denture and implant-supported mandibular overdenture: an in vivo study. J Indian Prosthodont Soc. 2017;17(4):361-72.
10. Elsyad MA, Khairallah AS. Chewing efficiency and maximum bite force with different attachment systems of implant overdentures: a crossover study. Clin Oral Implants Res. 2017;28(6):677-82.
11. Veyrune JL, Opé S, Nicolas E, Woda A, Hennequin M. Changes in mastication after an immediate loading implantation with complete fixed rehabilitation. Clin Oral Invest. 2013;17(4):1127-34.
12. Berretin-Felix G, Machado WM, Genaro KF, Nary Filho H. Effects of mandibular fixed implant-supported prostheses on masticatory and swallowing functions in completely edentulous elderly individuals. Int J Oral Maxillofac Implants. 2009;24(1):110-7.
13. Moreira GMM, Pereira SRM. Performance of Brazilian elderly on the 100 ml water swallowing test. Rev Soc Bras Fonoaudiol. 2012;17(1):9-14.
14. Yoshikawa M, Yoshida M, Nagasaki T, Tanimoto K, Tsuga K, Akagawa Y et al. Aspects of swallowing in healthy dentate elderly persons older than 80 years. J Gerontol A Biol Sci Med Sci. 2005;60(4):506-9.

15. Yoshikawa M, Yoshida M, Nagasaki T, Tanimoto K, Tsuga K, Akagawa Y. Influence of aging and denture use on liquid swallowing in healthy dentulous and edentulous older people. Am Geriatr Soc. 2006;54(3):444-9.
16. Ramos VF, Silva AF, Picinato-Pirola M. Masticatory function in elderly compared to young adults. Codas. 2021;34(1):e20200364.
17. Namasivayam-MacDonald AM, Barbon CEA, Steele CM. A review of swallow timing in the elderly. Physiol Behav. 2018;184:12-26.
18. Soares TJ, Moraes DP, de Medeiros GC, Sassi FC, Zilberstein B, de Andrade CR. Oral transit time: a critical review of the literature. Arq Bras Cir Dig. 2015;28(2):144-7.
19. Santoro PP, Tsuji DH, Lorenzi MC, Ricci F. A Utilização da videoendoscopia da deglutição para a avaliação quantitativa da duração das fases oral e faríngea da deglutição na população geriátrica. Arq Int Otorrinolaringol. 2003;7(3):181-7.
20. Park HS, Kim DK, Lee SY, Park KH. The effect of aging on mastication and swallowing parameters according to the hardness change of solid food. J Texture Stud. 2017;48(5):362-9.
21. Boven GC, Raghoebar GM, Vissink A, Meijer HJA. Improving masticatory performance, bite force, nutritional state and patient´s satisfaction with implant overdentures: a systematic review of the literature. J Oral Rehabil. 2015;42(3):220-33.
22. Lourenço RA, Veras RP. Mini-Exame do Estado Mental, características psicométricas em idosos ambulatoriais. Rev Saúde Pública. 2006;40(4):712-9.
23. Padovani AR, Moraes DP, Mangili LD, Andrade CRF. Protocolo fonoaudiológico de avaliação do risco para disfagia (PARD). Rev Soc Bras Fonoaudiol. 2007;12(3):199-205.
24. Cavalcanti RVA, Bianchini EMG. Verificação e análise morfofuncional das características da mastigação em usuários de prótese dentária removível. Rev. CEFAC. 2008;10(4):490-502.
25. Melo TM, Arrais RD, Genaro KF. Duração da mastigação de alimentos com diferentes consistências. Rev Soc Bras Fonoaudiol. 2006;11(3):170-4.
26. Jardine M, Miles A, Allen J. A systematic review of physiological changes in swallowing in the oldest old. Dysphagia. 2020;35(3):509-32.
27. Wang CM, Chen JY, Chuang CC, Tseng WC, Wong AM, Pei YC. Aging-related changes in swallowing, and in the coordination of swallowing and respiration determined by novel non-invasive measurement techniques. Geriatr Gerontol Int. 2015;15(6):736-44.
28. Cassiani RA, Santos CM, Parreira LC, Dantas RO. The relationship between the oral and pharyngeal phases of swallowing. Clinics (São Paulo). 2011;66(8):1385-8.
29. Masuda H, Ueha R, Sato T, Goto T, Koyama M, Yamauchi A et al. Risk factors for aspiration pneumonia after receiving liquid-thickening recommendations. Otolaryngol Head Neck Surg. 2022;167(1):125-32.
30. González-Gil D, Dib-Zaitum I, Flores-Fraile J, López-Marcos J. Importance of osseoperception and tactile sensibility during masticatory function in different prosthetic rehabilitations: a review. Medicina (Kaunas). 2022;58(1):92.
31. Sato T, Furuya J, Tamada Y, Kondo H. Impacts of palatal coverage on bolus formation during mastication and swallowing and subsequent adaptive changes. J Oral Rehabil. 2013;40(10):751-7.
32. Newman R, Vilardell N, Clavé P, Speyer R. Effect of bolus viscosity on the safety and efficacy of swallowing and the kinematics of the swallow response in patients with oropharyngeal dysphagia: white paper by the European Society for Swallowing Disorders (ESSD). Dysphagia. 2016;31(2):232-49.
33. Uram-Tuculescu S, Cooper LF, Foegeding EA, Vinyard CJ, De Kok IJ, Essick G. Electromyographic evaluation of masticatory muscles in dentate patients versus conventional and implant-supported fixed and removable denture wearers – a preliminary report comparing model foods. Int J Prosthodon. 2015;28(1):79-92.
34. Van der Bilt A, Burgers M, van Kampen FM, Cune MS. Mandibular implant-supported overdentures and oral function. Clin Oral Implants Res. 2010;21(11):1209-13.

35. Lucena CV, Cunha DA, Oliveira JHP, Silva HJ. Characterization of chewing according to time, prevalence of laterality and number of cycles in young adults. Disturb. Comum. 2014;26(2):304-15.
36. Kumar A, Kothari M, Grigoriadis A, Trulsson M, Svensson P. Bite or brain: implication of sensorimotor regulation and neuroplasticity in oral rehabilitation procedures. J Oral Rehabil. 2018;45(4):323-33.