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RESEARCH ARTICLE

Orofacial Functions and Chewing Efficiency in Elderly Patients with Parkinson's Disease Rehabilitated with Removable Prosthesis

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Abstract:

Background:

Parkinson's Disease (PD) is the second most common neurodegenerative disease after Alzheimer's disease. It is one of the movement disorders that can affect oro-facial conditions. It is more common in the elderly, having an average age of onset of around 60 years.

Objective:

The aim was to study orofacial functions in patients suffering from PD with partial or total edentulism, wearing removable prostheses.

Methods:

Forty-eight (48) elders, rehabilitated with removable dentures, were included: 24 patients suffering from Parkinson's disease constitute the Study Group (SG), and 24 subjects not suffering from Parkinson's disease or neurological degenerative diseases represent the Control Group (CG).

In SG, the severity of Parkinson's disease was assessed according to the Unified Parkinson's Disease Rating objective motor scale III, and orofacial dysfunctions were evaluated using Nordic Orofacial Test-Screening (NOT-S). The duration of the use of dental prostheses expressed in years has been reported. In both the groups, the subjective chewing index for the analysis of masticatory ability and the two-color chewing gum test for the analysis of masticatory efficiency were conducted.

Results:

There was a statistically significant difference between the SG and CG compared to the NOT-S ($P = 0.001$).

Analyzing the study group, a statistically significant correlation was found between the masticatory efficiency and prosthetic years of use ($r_s = 0.436$; $P < 0.05$); instead, no statistically significant correlation was found between the masticatory efficiency and the severity of Parkinson's disease.

Conclusion:

In our study, we did not find differences between SG and CG in terms of the degree of masticatory efficiency; therefore, only a correlation between the duration of use of dental prostheses and the degree of masticatory efficiency was found.

Keywords: Parkinson's disease, Removable prostheses, Orofacial functions, Chewing efficiency, Degenerative disease, Geriatric patients.

Article History

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1. INTRODUCTION

Parkinson's disease is a chronic degenerative disease of the

central nervous system. The prevalence of Parkinson's disease in industrialized countries is estimated to be around 0.3% of the entire population. Relatively rare before the fifties, the prevalence increased up to 1% in subjects over 60 and 4% in subjects over 80 years. In Italy, it is estimated that there are currently 200,000 people suffering from Parkinson's disease [1]. Parkinson's disease is linked to a reduction in dopamine in

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the striatum, a component of the circuit of the base nuclei, consequent to the degeneration of the dopaminergic neurons of the substantia nigra [2]. Dopamine deficiency within the basal ganglia leads to movement disorders characterized by classic parkinsonian motor symptoms: bradykinesia, muscle stiffness, resting tremor and impaired posture and gait.

Parkinson's disease is associated with numerous non-motor symptoms, which may precede motor dysfunctions of years, such as olfactory alterations, cognitive impairment, psychiatric symptoms, sleep disorders, dysfunctions of the autonomic nervous system and sense of fatigue [3].

Parkinson's disease manifests itself with some typical orofacial clinical signs which, if detected early in the clinical course of the disease, respond positively to treatment with dopaminergic agonists, such as L-dopa.

Orofacial signs usually remain unrecognized for a long time and therefore, may be refractory to treatment [4].

We observe an inexpressive facial appearance (“masklike”) due to the reduced activity of mimic muscles, with tremors in the frontal region and eyebrows and involuntary movements of lips and tongue [5].

The tremor and the rigidity of the oro-facial musculature lead to facial pain, alterations of the temporomandibular joint, dental traumatism and bruxism. An increased incidence of periodontal disease was found in patients with Parkinson's disease, due to poor oral hygiene caused by the reduced capacity for fine motor movements and reduced patient dexterity. Patients with Parkinson's disease show a greater tendency for plaque accumulation and food residues as well as greater difficulty in the retention of removable prostheses. Oral-facial tremor and treatment with levodopa therapy could be involved in the genesis of bruxism found in some patients with Parkinson's disease. The stresses on the dental elements, due to bruxism, can be a cause of secondary occlusal trauma, aggravating the periodontal conditions.

In literature, there are some studies that compare the masticatory function among patients with Parkinson's disease, rehabilitated with partial or total removable dental prostheses, and patients not affected by Parkinson's disease rehabilitated with partial or total removable dental prostheses.

Ribeiro *et al.* [6] examined chewing function under several aspects. Patients recruited in this study chewed a silicone sample, performing 40 masticatory cycles; during the test, through a kinesiograph, the range of mandibular motility was evaluated. The masticatory performance was determined in relation to the medium-sized particle obtained after each masticatory test. Finally, the force generated in maximum intercuspation was evaluated by a sensor placed in correspondence with the molar regions bilaterally. The results showed that the group with Parkinson's disease showed lower quality chewing function compared to the control group in relation to all the aspects examined.

The aim of our study was the evaluation of the oral-dental conditions of a group of patients with Parkinson's disease totally or partially edentulous, rehabilitated with removable dental prostheses, in which the clinical-prognostic stage of

neurodegenerative pathology was assessed through the MDS - UPDRS. A complete screening of oro-facial dysfunctions was performed with the use of the Nordic Orofacial Test-Screening (NOT-S) (which consists of a structured interview and a clinical examination of the patients). The analysis of masticatory ability was carried out with the calculation of the subjective chewing index; the chewing efficiency was evaluated with the “Two-color chewing gum test” and, finally, the evaluation of the prosthesis quality was performed in relation to the duration of use of the same, expressed in years (Years of Use).

2. MATERIALS AND METHODS

This retrospective observational study was conducted on 48 elderly subjects divided into two groups: the study group (n = 24, 15 men and 9 women, 71.4 ± 5.9 years) and the age- and gender-matched control group (n = 24, 14 men and 10 women, 71 ± 4.1 years).

All the volunteers involved in this case study were elderly, with total or partial edentulism, rehabilitated with removable dental prostheses.

The Study Group (SG) included 24 patients, suffering from Parkinson's disease, and rehabilitated with total or partial removable dental prostheses, followed by the Neurology Unit of the Policlinico University Hospital in Bari and the Dental School's Department of Dental Prosthesis University of Bari. Patients with parafunctional activities, temporomandibular disorders, joint pathologies, ulcerations of the supporting mucosa, prosthetic stomatitis and remote positive pathological history of fractures of the body, branch or the mandibular condyle were excluded.

The Control Group (CG) consists of 24 patients who were also rehabilitated with total or partial removable prostheses and followed by the Dental Prosthetic Department of the Dental School of the University of Bari, with the exclusion of subjects with temporomandibular disorders, parafunctional activities, ulcerations of the supporting mucosa, prosthetic stomatitis, articular pathologies, previous mandibular fractures and with other neurodegenerative pathology and movement disorders.

At the U.O. of Neurology, for each patient of the study group, a neurological evaluation was carried out through the UPDRS (Unified Parkinson's Disease Rating Scale) [7], which is made up of four parts that analyze:

- Cognitive ability, behavior and mood
- Activities of daily life
- Motor activity
- Motor complications associated with therapy

An overall score is obtained by adding the scores assigned for each section. For the screening of oro-facial dysfunctions, we used the Nordic Orofacial Test- Screening (NOT-S) [8], which consists of a structured interview and a clinical examination.

The interview focuses on six domains:

- Sensory function

- Breathing
- Bad habits
- Chewing and swallowing
- Uncontrolled discharge of saliva from the oral cavity
- Xerostomia.

The physical examination focuses on six aspects:

- Appearance of resting face
- Nasal breathing
- Facial expression
- Masticatory musculature
- Oral motor function
- Articulation of language

Each of the 12 domains contains one to five internal articulations, in relation to the complexity of the specific function investigated. The overall score is obtained from the sum of the individual scores assigned in the various sections of the interview and physical examination.

Analysis of masticatory ability was carried out through the subjective evaluation index of masticatory ability.

The patient will have to express a subjective evaluation, choosing among 4 possibilities:

- Normal condition
- Ability to eat anything, but in extended time intervals
- The ability to eat only soft foods
- Difficulty in eating soft foods also, and in extended time intervals
- Constriction of a liquid diet [9].

The masticatory efficiency of all the volunteers was evaluated by means of the two-color chewing gum test [10], which involved the analysis of the degree of chromatic mixing of chewing gums of two different colors after having been subjected to a predefined sequence of a given number of chewing cycles.

The samples to be used during the masticatory tests and to be administered to each patient were obtained from Hubba-Bubba Bubble Tape[®] with the aroma "Sour raspberry"[®] (azure color) and "Awesome original"[®] (pink color).

For each of the 2 colors, 5 chewing gum strips with a length of 30 mm were prepared.

By adhering the strips of different colors with each other manually, with two strips together, five samples were made of a two-color double layer (characterized by the following dimensions: 30 mm x 18 mm x 3 mm).

The test participant was then required to perform five chewing tests on the preferred chewing side.

- First test: 5 masticatory cycles
- Second test: 10 chewing cycles
- Third test: 20 masticatory cycles
- Fourth test: 30 chewing cycles
- Fifth test: 50 masticatory cycles

Between one test and the next, a time interval of at least 1 minute is passed, in order to minimize the effect of possible muscle fatigue that could arise between two consecutive tests. The total duration of a test is approximately 8 minutes.

At the end of the masticatory test, two operators independently performed a visual evaluation, by which the chewed sample was assigned to one of the following categories:

SA 1: The colors of the double layer did not undergo any mixing; only the cusp of the dental elements was visible on the bolus.

SA 2: Most of the bolus did not undergo any color mixing.

SA 3: Most of the double layer underwent mixing of colors and only limited fractions remained in the original condition.

SA 4: The mixing of the colors took place in the whole bolus, but it was not realized in a uniform way.

SA 5: The two layers of the bolus were perfectly blended and the color distribution was perfectly uniform.

The quality of removable prosthetic devices was estimated in relation to the duration of use of the same expressed in years (Years of Use). During this period, in fact, there was an increasing deterioration of the components of the prosthesis structure, which, especially from the fourth year onwards and after eight years of use, affected the patient's masticatory performance [11, 12].

Comparisons between the data obtained on patients in the study group and those in the control group were conducted using the Mann-Whitney U-test.

The correlations between the degree of severity of Parkinson's disease (motor assessment according to Unified Parkinson's Disease Rating objective motor scale III) and the outcome of masticatory efficiency as well as the duration of use of dental prostheses, expressed in years (Years of Use) and the outcome of masticatory efficiency were analyzed by the Spearman Rank Correlation Analysis. Statistical significance was recorded as $P < 0.05$.

The study was approved by the scientific ethical committee of the Interdisciplinary Department of Medicine in Policlinico University Hospital in Bari.

3. RESULTS

3.1. Oro-Facial Function

The total results obtained in the NOT-S screening test for the evaluation of oro-facial dysfunctions showed a statistically significant difference between the study group and the control group according to gender and sex ($P = 0.001$).

However, no statistically significant differences were observed between the two groups with respect to the subjective chewing index and chewing efficiency (Table 1).

Table 1. Orofacial function and masticatory efficiency in patients with mild to moderate Parkinson's disease compared with age- and gender-matched control subjects.

–	Patients with Parkinson's Disease	Age- and Gender-Matched Control Group	Mann-Whitney U-Test
	(n = 24)	(n = 24)	P-value
Orofacial function	–	–	–
Nordic Orofacial Test-Screening (NOT-S; 0-12)	4.5 ± 2.3	1.08 ± 1.08	0.001
Subjective assessment of masticatory ability (index: 0-4)	1.08 ± 0.99	0.83 ± 0.83	N.S.
Masticatory efficiency*	3.2 ± 0.39	3.5 ± 0.8	N.S.

The data are expressed as mean ± SD

* The data describe the 20th chewing cycle, regarded as the cycle of reference for mixing ability test

3.2. Spearman Correlation Rank Analysis

The execution of the rank correlation test on subjects of the study group showed a statistically significant correlation between the temporal duration of use of a prosthetic device and the degree of masticatory efficiency ($P < 0.05$). There was no statistically significant correlation between the masticatory efficiency and the degree of severity of Parkinson's disease ($r_s = 0.009$) (Table 2).

Table 2. Correlation between years of use of removable prostheses or severity of Parkinson's disease (motor assessment according to Unified Parkinson's Disease Rating objective motor scale III) and masticatory efficiency (assessment according to the outcome data on Two-colour chewing gum Test) in 24 patients with Parkinson's disease.

–	Spearman Rank Correlation Analysis	
	Years of Use r_s (P-Value)	Unified Parkinson's Disease Rating Scale r_s (P-Value)
Masticatory efficiency	–	–
Two-colour Chewing Gum Test (mean of values)	0.436 ($P < 0.05$) *	0.009 (N.S.)

* $P < 0.05$; r_s : Spearman Rank Correlation Coefficient

4. DISCUSSION

Subjects included in our SG were affected by Parkinson's disease with a mild to moderate degree of severity (UPDRS = 9.4 ± 4.4). In our CG, individuals were affected not only by Parkinson's disease but also by other neurological pathologies and movement disorders, which, with evaluation tests of masticatory efficiency similar to that used in this study, proved to be capable of interfering with the chewing performance [13 - 20]. In accordance with the study by Bakke *et al.* [5], in our study, a statistically significant difference was observed in the outcomes of the NOT-S, screening test for oro-facial dysfunctions, performed on subjects of the SG and on the

subjects of the CG. In contrast to the same study [5], the subjective perception of masticatory ability and the objective evaluation of masticatory efficiency did not show statistically significant differences between the SG and CG, which is comparable to the SG as it involved subjects with total edentulism or partially rehabilitated with partial or total removable prostheses. In our opinion, this may depend on the limited range of UPDRS values of the SG patients because in medical therapy, patients were constantly followed by the Neurology Unit of the University Hospital Policlinico in Bari. In addition, an improvement in the quality of life related to the health conditions of the oral cavity (QHRQoL) was observed, resulting from rehabilitation with removable prostheses that occurred both in healthy patients and in patients with Parkinson's disease [21]. Our choice to examine the masticatory efficiency using a Two-color chewing gum test was justified by its simplicity and rapidity of execution. Furthermore, the test is easy to replicate, without causing any discomfort to patients as it involves the use of materials that are readily available and familiar to the subjects of the study. The use of chewing gums to assess chewing efficiency has many advantages. In the masticatory performance by means of chewing gums, the particles of material that could be trapped between the prosthetic thong and osteomucous support tissues are not formed. With this method, there is no risk of swallowing fractions of the sample used and losing useful material for the subsequent analysis phase. The chewing gums are characterized by a remarkable elastic consistency, which allows the possibility of developing maximum muscular activity.

In literature, relevant results have already been obtained explaining the changes in the shape and color of the chewing gums as parameters [10, 22, 23]. Techniques that use the same sample but use the decrease in weight of chewing gum as a benchmark have been successfully adopted in other studies [24]. The chewing test has some disadvantages. For most types of chewing gums, there is the risk of being adhered tenaciously to dental and / or prosthetic surfaces, due to the sticky nature of the material. In addition, chewing gums contain sugars and must be used with caution in specific categories of patients, like in those with diabetes mellitus. The choice to consider as a reference the fifth, tenth, twentieth, thirtieth, fiftieth masticatory cycle gives the possibility of evaluating all the possible levels of masticatory efficiency [10]. The average of the values obtained in each of the significant chewing cycles as a reference value in the statistical analysis was considered. However, among the chewing cycles, the most significant one, whose value is to be used as a reference in mixing-ability tests for estimating masticatory efficiency, is the twentieth [22]. Different methods for the subsequent analysis of the chewed bolus have been reported in the literature: a bolus scan and subsequent digitization of the image or a mere visual evaluation can be used. In the first case, the analysis of the distribution of colors in the pixels of the images obtained with the scanning of wafers, obtained from chewing gum chewed, offered an objective assessment of the degree of chromatic mixing. In the second case, a mere visual evaluation was conducted. Since there are evidence that confirm the comparability of results between these two methods, the

simplest and most immediate visual evaluation was preferred [24]. In the study by Schimmel *et al.* [10], it appeared that at the fiftieth masticatory cycle, all masticatory samples had a nSA5 rating; in our Study Group (SG), instead, this evaluation was attributed only in 11 cases of the total 24. In the remaining 13 cases, the evaluation reached at the fiftieth masticatory cycle was SA4. Moreover, in SG, 50% of the patients had used their prosthetic device for more than eight years, a time limit beyond which there are repercussions on masticatory performance [12]. Therefore, we considered the possibility of a correlation between masticatory efficiency and the duration of use of dental prostheses, expressed in years (Years of Use). It was found that there was a statistically significant correlation between the temporal duration of use of a prosthetic device and the degree of masticatory efficiency ($P < 0.05$). There was no statistically significant correlation between the masticatory efficiency and the degree of severity of Parkinson's disease, but a limitation of our study was that only 24 patients were included.

CONCLUSION

From the study carried out, it emerges that the duration of use of dental prostheses, expressed in years (Years of Use) affects the masticatory efficiency more than the degree of severity of the neurological pathology and, consequently, the quality of nutrition in each patient. It should be emphasized that only 24 patients were included in our study and were affected by Parkinson's disease with a mild to moderate degree of severity.

Hence it is important to inform the patient and his/her family about the patient's condition, so that necessary dental checkups can be achieved over time, in order to monitor the adaptation of the prosthesis to the anatomy of the oral cavity and, if necessary, make new prostheses. The dentist plays a significant role in the interdisciplinary management of patients with Parkinson's disease, because, by proposing the most appropriate treatment options, it can really have a positive impact on the quality of life of patients.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study is approved by the scientific ethical committee of Interdisciplinary Department of Medicine in Policlinico University Hospital, Italy with approval No. ODO0023/2017.

HUMAN AND ANIMAL RIGHTS

Not applicable

CONSENT FOR PUBLICATION

Informed consent was obtained from all individual participants included in the study.

AVAILABILITY OF DATA AND MATERIALS

The data that support the findings of this study are with the corresponding author, [M.C.] and can be made available upon reasonable request.

FUNDING

None

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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REFERENCES

- [1] de Lau LM, Breteler MM. Epidemiology of Parkinson's disease. *Lancet Neurol* 2006; 5(6): 525-35. [http://dx.doi.org/10.1016/S1474-4422(06)70471-9] [PMID: 16713924]
- [2] Kravitz AV, Freeze BS, Parker PRL, *et al.* Regulation of parkinsonian motor behaviours by optogenetic control of basal ganglia circuitry. *Nature* 2010; 466(7306): 622-6. [http://dx.doi.org/10.1038/nature09159] [PMID: 20613723]
- [3] Kalia LV, Lang AE. Parkinson's disease. *Lancet* 2015; 386(9996): 896-912. [http://dx.doi.org/10.1016/S0140-6736(14)61393-3] [PMID: 25904081]
- [4] Friedlander AH, Mahler M, Norman KM, Ettinger RL. Parkinson disease: Systemic and orofacial manifestations, medical and dental management. *J Am Dent Assoc* 2009; 140(6): 658-69. [http://dx.doi.org/10.14219/jada.archive.2009.0251] [PMID: 19491161]
- [5] Bakke M, Larsen SL, Laurrup C, Karlsborg M. Orofacial function and oral health in patients with Parkinson's disease. *Eur J Oral Sci* 2011; 119(1): 27-32. [http://dx.doi.org/10.1111/j.1600-0722.2010.00802.x] [PMID: 21244508]
- [6] Ribeiro GR, Campos CH, Rodrigues Garcia RCM. Parkinson's disease impairs masticatory function. *Clin Oral Invest* 2017; 21(4): 1149-56. [http://dx.doi.org/10.1007/s00784-016-1879-z] [PMID: 27291219]
- [7] Ramaker C, Marinus J, Stiggelbout AM, Van Hilten BJ. Systematic evaluation of rating scales for impairment and disability in Parkinson's disease. *Mov Disord* 2002; 17(5): 867-76. [http://dx.doi.org/10.1002/mds.10248] [PMID: 12360535]
- [8] Bakke M, Bergendal B, McAllister A, Sjögreen L, Asten P. Development and evaluation of a comprehensive screening for orofacial dysfunction. *Swed Dent J* 2007; 31(2): 75-84. [PMID: 17695052]
- [9] Yoshida K, Kaji R, Shibasaki H, Iizuka T. Factors influencing the therapeutic effect of muscle afferent block for oromandibular dystonia and dyskinesia: Implications for their distinct pathophysiology. *Int J Oral Maxillofac Surg* 2002; 31(5): 499-505. [http://dx.doi.org/10.1054/ijom.2002.0291] [PMID: 12418565]
- [10] Schimmel M, Christou P, Herrmann F, Müller F. A two-colour chewing gum test for masticatory efficiency: Development of different assessment methods. *J Oral Rehabil* 2007; 34(9): 671-8. [http://dx.doi.org/10.1111/j.1365-2842.2007.01773.x] [PMID: 17716266]
- [11] Yoshizumi DT. An evaluation of factors pertinent to the success of complete denture service. *J Prosthet Dent* 1964; 14(5): 866-78. [http://dx.doi.org/10.1016/0022-3913(64)90015-0]
- [12] Ribeiro JA, de Resende CM, Lopes AL, *et al.* Evaluation of complete denture quality and masticatory efficiency in denture wearers. *Int J Prosthodont* 2012; 25(6): 625-30. [PMID: 23101044]
- [13] Campos CH, Ribeiro GR, Costa JLR, Rodrigues Garcia RCM. Correlation of cognitive and masticatory function in Alzheimer's disease. *Clin Oral Invest* 2017; 21(2): 573-8. [http://dx.doi.org/10.1007/s00784-016-1923-z] [PMID: 27473718]
- [14] Schimmel M, Leemann B, Herrmann FR, Kiliaridis S, Schnider A, Müller F. Masticatory function and bite force in stroke patients. *J Dent Res* 2011; 90(2): 230-4. [http://dx.doi.org/10.1177/0022034510383860] [PMID: 21118794]
- [15] Corsalini M, Rapone B, Grassi FR, Di Venere D. A study on oral rehabilitation in stroke patients: Analysis of a group of 33 patients. *Gerodontology* 2010; 27(3): 178-82.

- [http://dx.doi.org/10.1111/j.1741-2358.2009.00322.x] [PMID: 20735492]
- [16] Solarino B, Coppola F, Di Vella G, Corsalini M, Quaranta N. Vestibular evoked myogenic potentials (VEMPs) in whiplash injury: A prospective study. *Acta Otolaryngol* 2009; 129(9): 976-81. [http://dx.doi.org/10.1080/00016480802527552] [PMID: 19009456]
- [17] Giuliani M, Troiano G, Cordaro M, *et al.* Rate of malignant transformation of oral lichen planus: A systematic review. *Oral Dis* 2019; 25(3): 693-709. [http://dx.doi.org/10.1111/odi.12885] [PMID: 29738106]
- [18] De Matteis V, Cascione M, Toma CC, *et al.* Silver nanoparticles addition in poly(methyl methacrylate) dental matrix: Topographic and antimycotic studies. *Int J Mol Sci* 2019; 20(19)E4691 [http://dx.doi.org/10.3390/ijms20194691] [PMID: 31546661]
- [19] Favia G, Corsalini M, Di Venere D, *et al.* Immunohistochemical evaluation of neuroreceptors in healthy and pathological temporomandibular joint. *Int J Med Sci* 2013; 10(12): 1698-701. [http://dx.doi.org/10.7150/ijms.6315] [PMID: 24151441]
- [20] Mussano F, Genova T, Corsalini M, *et al.* Cytokine, chemokine, and growth factor profile characterization of undifferentiated and osteoinduced human adipose-derived stem cells. *Stem Cells Int* 2017; 20176202783 [http://dx.doi.org/10.1155/2017/6202783] [PMID: 28572824]
- [21] Ribeiro GR, Campos CH, Rodrigues Garcia RCM. Influence of a removable prosthesis on oral health-related quality of life and mastication in elders with Parkinson disease. *J Prosthet Dent* 2017; 118(5): 637-42. [http://dx.doi.org/10.1016/j.prosdent.2016.12.018] [PMID: 28385436]
- [22] Schimmel M, Christou P, Miyazaki H, Halazonetis D, Herrmann FR, Müller F. A novel colourimetric technique to assess chewing function using two-coloured specimens: Validation and application. *J Dent* 2015; 43(8): 955-64. [http://dx.doi.org/10.1016/j.jdent.2015.06.003] [PMID: 26111925]
- [23] Prinz JF. Quantitative evaluation of the effect of bolus size and number of chewing strokes on the intra-oral mixing of a two-colour chewing gum. *J Oral Rehabil* 1999; 26(3): 243-7. [http://dx.doi.org/10.1046/j.1365-2842.1999.00362.x] [PMID: 10194734]
- [24] van der Bilt A. Assessment of mastication with implications for oral rehabilitation: A review. *J Oral Rehabil* 2011; 38(10): 754-80. [http://dx.doi.org/10.1111/j.1365-2842.2010.02197.x] [PMID: 21241351]

