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# Masticatory performance in oral function assessment: alternative methods

Short title: Masticatory assessment: alternative methods …

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### *Author contributions*

The conception of the study: YI, NC, MO, CG, YS and FM. Recruitment and data collection: YI, NC, MO, RSE. Statistical analysis: PhM. Data interpretation and the first draft of the manuscript: YI, NC, PhM, MS and FM. All authors contributed to and approved the final version of the manuscript.

### *Data availability statement*

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Abstract (280/300)

Background

Masticatory function declines with age or disease, implicating a poor chewing efficiency and an often-unconscious change for a less healthy, yet easy to chew diet. Timely screening of masticatory function may foster an early-onset diagnosis and potential treatment. The aim of this study was to compare alternative diagnostic tools for masticatory function to a Jelly-scan test.

Materials and Methods

Patients aged 70 years and older who were hospitalized for rehabilitation were recruited for this study. A total of four different tests for masticatory function were administered. The Japanese Society of Gerodontology glucose extraction test (Jelly-scan) was used as reference to compare a colour-changing gum test (Gum1-colour) as well as a mixing ability test with a visual (Gum2-visual) and opto-electronical (Gum2-digital) analyses. Receiver operating characteristic (ROC) curves were used to establish the discriminative value, kappa-values were used to estimate individual agreements and correlations were verified using Spearman's tests.

Results

Sixty-one patients (Men n=23, Women n=38) aged 82.4±6.8 years participated in the experiments. The average number of natural teeth was 16.5 ± 10.5, 34.4% of the participants wore removable dentures. For all tests, the sum of sensitivity and specificity was >150%. All test correlated with Jelly-scan (absolute Rho >0.5). With Jelly-scan 51 participants (83.6%) were diagnosed with "masticatory hypofunction". After reducing the cut-off value of the test from 100 mg/dl to 65 mg/dl, only 33 participants (54%) fulfilled the diagnosis. This post-hoc analysis increased the sensitivity of the Gum2-tests and the agreement to kappa >0.5 for all three tests.

Conclusion

All three tests can be considered useful screening alternatives. In its original version, Jelly-scan may tend to over-diagnose masticatory hypofunction, hence a novel cut-off with better agreement between tests is suggested.

Keywords

Oral hypofunction, Gluco Sensor, Masticatory function check gum, Hue-Check Gum

## 1. Introduction

Eating is recognized as one of the main pleasures in late life. Furthermore, in old age, weight is crucial to prevent malnutrition and morbidity[1]. The masticatory function changes over the life-time, and meals do take a longer time.[2] Chewing function is further deteriorated by tooth loss, deterioration of the periodontal status, neurocognitive disorders and poor dental prostheses. [3-7] Often unnoticed by the resident, an adaptation of the diet takes place, replacing food of high nutritional value with a diet that requires little masticatory efficiency.[8] Decreased masticatory function refers to a condition where the occlusal force and motor function of the tongue and peri-oral muscles have declined, resulting in a state that may foster malnutrition.[9, 10] As the condition progresses, masticatory efficiency, food bolus formation and swallowing are impaired, which may negatively affect digestion and absorption of nutrients. Finally, compromised masticatory function may even lead a food intake that is insufficient to meet the amount of nutrition required.[9-12]

A poor oral and facial motor function was termed "oral frailty", and in addition, the Japanese Society of Gerodontology (JSG) has classified "oral function" based on the examination of seven parameters: oral hygiene, oral dryness, occlusal force, tongue-lip motor function, tongue pressure, masticatory function and swallowing. Oral hypofunction is defined as a state when more than three of the above mentioned seven signs are found to be below a given cut-off value.[9, 10] A therapeutic intervention might re-establish a normal oral function, or at least preclude the deterioration of oral hypofunction to oral dysfunction. Hence screening oral functions is important in the elderly population.

Numerous devices and tests for evaluating masticatory function have been described.[13] Within the JSG oral hypofunction test battery, a specific test for masticatory performance was proposed. Its diagnosis is based on the degree of the glucose concentration obtained from a jelly-like test specimen , the patient is asked to chew the specimen for 20 seconds, to sip 20ml of water without swallowing and spitting the test specimen with the water in a cup through a mesh.[14] Traditionally, chewing efficiency and chewing performance were tested a comminution test with breakable test foods such as nuts or silicon cubes with a subsequent particle size analysis using a set of sieves with decreasing mesh sizes, indicating the spread of particles according to their size.[15] A more recent two-colour mixing test uses a bi-coloured gum specimen which, after 20 cycles of mastication, can be judged for the degree of colour mixture and ability for bolus formation.[16] Further analyses could be obtained by a numerical analysis of the degree

of colour mixture after the specimen has been flattened to a 1 mm thick wafer and both sides have been digitized.[17]

Tests which require specific equipment and the intervention of a dental professional may be expensive and time consuming. Moreover the Jelly scan test instructions can be challenging as participants can swallow the jelly specimen or the water compromising the glucose concentration readings from the gluco-sensor. More simple test methods, which could be even used by the patient himself at home, would facilitate the widespread screening of the ever-increasing number of elders in the population with chewing difficulties and would enable treatment before further deterioration to oral function.

The purpose of this study was to compare in hospitalized elders 3 alternative diagnostic methods for masticatory function and describe their sensitivity and specificity with regard to the reference test, the jelly-scan test, which is used in the oral function test battery, as described by the Japanese Society of Gerodontology in 2018.[10] The hypothesis of this study was that there is a positive correlation between the "gold standard" Jelly-scan test and the 3 alternative methods.

## 2. Material and Methods

### 2.1. Ethical approval

The Swiss Cantonal Ethics Committee approved this study on oral hypofunction in hospitalized elders (CCER 2019-01338). In this paper, only the findings from the masticatory function testing are reported.

### 2.2. Participants

Participants were recruited from the pool of patients hospitalized at the Loëx Hospital of the Geneva University Hospitals (HUG) between October 2019 and July 2020. This hospital is a two hundred beds centre for rehabilitation and long-term care. Inclusion criteria comprised being aged 70 years or more, being hospitalized in University Hospitals of Geneva (Loëx), understanding and being able to follow simple instructions, speaking French, having the cognitive ability to answer a questionnaire and signing the consent form. Patients presenting with disorders affecting oral intake were excluded from the participation. Patients with poorly-controlled diabetes, with gastro-intestinal diseases or symptoms (nausea, vomiting, diarrhoea, constipation) affecting oral intake, and those taking an antimicrobial treatment at time of screening were also excluded.

### 2.3. Protocol

A senior physician (R.S.) screened the patients for the inclusion and exclusion criteria. Each participant was informed verbally and in written about the nature of the study. Participants were given at least 24 hours' time, and the possibility to have all pertinent questions answered, before deciding to participate in the study. After again verifying the inclusion and exclusion criteria, written informed consent was obtained. First, the participant's demographic characteristics, medical diagnosis and drug intake were noted from the medical records and added to the clinical record form by a study nurse (S.A.). During the first visit, clinical signs and symptoms of oral hypofunction were measured. The test battery included an oral examination, and assessments of oral hygiene, oral dryness, occlusal force, of the tongue-lip motor function, of the tongue pressure, of the swallowing function and of the masticatory function. Subsequently, further three methods were used to evaluate the masticatory function. All tests were performed by the same operators (Y.I. and M.O.). This paper reports only the comparison of the three additional masticatory function tests with regard to the "gold standard" test.

### 2.4. Masticatory function tests

Four methods for testing masticatory function were performed, the "Jelly-Scan" test recommended by the JSG's oral hypofunction test battery was used as reference.

#### 2.4.1. Reference test "Jelly-Scan"

The Jelly-Scan test uses a test device (Gluco Sensor GS-II, GC Corporation)[6, 14] (Fig. 1a). Masticatory performance is evaluated by measuring the glucose concentration obtained from a chewed gummy jelly specimen (Glucolumn GS- II, GC Co., Ltd., Tokyo, Japan). The participant is asked to chew 2 g of gummy jelly for 20 seconds, the patient is then asked to sip 20ml of water and after retrieval of the crushed jelly, the amount of elutriated glucose is quantified using a glucor-sensor testing machine. When the measured glucose concentration is less than 100 mg/dl, the patient is diagnosed with poor masticatory function.[6, 14]

#### 2.4.2. Alternative test 1 "Colour changing gum"

The first alternative test uses a colour changing gum (Gum1-colour) (Xylitol chewing gum, Oral Care Co., Ltd., Tokyo, Japan) (Fig. 1b). The specimen has a size of 35 × 18 × 3 mm. The gum contains Xylitol and citric acid. The patient is asked to chew the specimen 60 times. The red, yellow and blue dyes change colour when chewed.[18-23] The colour of the chewed gum is

determined immediately after chewing to minimize further time related changes using a colour scale (scale 0 to 9).[18]

2.4.3. Alternative test 2 "Colour-mixing test-visual"

The second alternative masticatory function test consist in chewing a two-colour chewing gum (Hue-Check Gum©, Orophys GmbH, Muri b. Bern, Switzerland) (Gum2-visual) to assess masticatory performance (Fig. 1c). One blue and one pink gum are stuck together manually by slightly wetting them with water and by applying moderate digital force. The resulting gum-complex has a size of 8 × 20 × 12 mm. The patient is asked to chew the gum complex 20 times before the specimen is retrieved from the oral cavity. The masticatory function is evaluated by comparison with the Hue-Check Gum colour scale© (scale; SA1 to SA5).[16, 17, 24] Scores range from SA1 for a little deformed specimen with clearly separated colours to SA5 for a well chewed bolus with perfect colour mixture.

2.4.4. Alternative test 3 "Colour-mixing test-digital"

The third alternative masticatory function test (Gum2-digital) consist also in masticating 20 times the two-colour Hue-Check gum© (Fig 1c). However, for this test, the chewed Gum2 specimen is flattened to a 1 mm thick wafer and subsequently scanned with a flatbed scanner from both sides. The joint images of both sided are evaluated opto-electronically using the ViewGum© software (dhal.com, Greece, Athens).[16, 17, 25] The software analyses the Variance of Hue (VOH) as the degree of colour-mixture.

2.5. Statistical analysis

The sample size was calculated using the program G*Power 3.1.9.2 (Institute of Experimental Psychology, Heinrich Heine University, Düsseldorf, Düsseldorf, Germany)[26] based on the relation between masticatory function and nutritional state. Matsuo et al. compared the average bite force 156 malnourished patients (121.6 ± 126.2 N) with 72 non-malnourished volunteers (209.9 ± 195.0 N). [27] Based on these results, the sample size was calculated using the calculated effect amount d = 0.50 (medium effect size). The required total sample size was calculated to be 54, in agreement with Maxwell et al.[28] and a method corresponding to the effect size of Brydges[29], indicating a medium effect with N = 52 + p, with p being the number of explanatory variables. The latter being in this analysis 3, the resulting sample size is n=55. To account for drop-outs due to the high age and morbidity of the participants, the sample size in this study was determined to be 60.

The normality of distribution of continuous variables was tested by one-sample Kolmogorov-Smirnov test. Age was normally distributed. Two-tailed T-tests were used to analyse the effect of age. Mann-Whitney test was used to compare means of variables not normally distributed. Spearman's correlation test was used to correlate age with the different masticatory diagnostic test (Jelly-Scan, Gum1-Colour, Gum2-visual and Gum2-digital)

Sensitivity describes the percentage participants correctly identified as presenting with poor masticatory function amongst all those who were diagnosed the condition, and Specificity the percentage of participants correctly identified as not presenting with the condition among all those who do not have it.

The Receiver operating characteristic (ROC) curve was drawn based on the Jelly-Scan diagnosis. The Cut-off -points were determined by drawing receiver operating characteristic (ROC) curve. The cut-off point was defined as the minimum distance from the upper left corner of the ROC curve, confirmed further by computing the Youden index. The AUC (Area Under the Curve) was also calculated from the ROC curve.

The kappa-value was calculated to analyse the individual agreement between tests.

SPSS Version 26 (IBM, New York Armonk, United States) was used for the statistical analysis, and the statistical significance level was $p \leq 0.05$.

## 3. Results

### 3.1. Participants

Participants were recruited from the consecutively admitted patients of the Loëx Hospital. 249 patients were screened for inclusion and exclusion criteria. Finally, 66 eligible participants were included, signed the informed consent, of whom 4 left the hospital before the experiments took place. Finally, 61 completed the all masticatory tests and were included in the present analysis. They were mostly hospitalized for physical rehabilitation, fractures, weakness or were waiting for admission to a nursing home. Despite several patients presenting low MMSE scores, all participants were able to follow the instructions and perform the mastication tests. Their mean age was 82.4±6.8 years and 38 (62.3%) of the participants were female. The median number of natural teeth was 19 (Interquartile range IQR: 18); 21 (34.4%) of the participants wore removable dentures.

Masticatory function

The description of the average and median scores from all 4 tests are listed in Table 1.

3.1.1. Jelly-Scan

Jelly-Scan revealed a median glucose concentration of 59 (IQR 34) mg/dl; with 59 mg/dl for men and 64 mg/dl for women (n.s.). With the cut-off for "poor masticatory function" being set as 100 mg/l or lower, according to the Jelly-scan test 51 patients (83.6 %) were categorized as presenting the condition.

3.1.2. Gum1-colour

The ROC curve of Gum1 was drawn with reference to the Jelly-Scan findings, with the AUC being 0.872 (SE=100%, $p<0.05$, 95%CI: 0.780, 0.963) and an optimum cut-off value of 5 (Fig. 2). Sensitivity and specificity were calculated from the optimum cut-off value, with sensitivity = 66.7% and specificity = 100%.

3.1.3. Gum2-visual

The ROC curve of Gum2-visual referred equally to the Jelly-Scan data. Here, the AUC was 0.864 (SE=97.4%, $p<0.05$, 95%CI: 0.757, 0.971) and the optimum cut-off value was 3 (Fig. 2). Sensitivity and specificity were calculated from the optimum cut-off value, with sensitivity = 72.5% and specificity = 90%.

3.1.4. Gum2-digital

Again, the ROC curve of Gum2-digital referred to the Jelly-Scan test. The AUC was 0.835 (SE=90.0, $p<0.05$, 95%CI: 0.722, 0.948) and the optimum cut-off value was 0.43 (Fig. 2). Sensitivity and specificity were calculated from the optimum cut-off value, indicating a sensitivity of 56.9% and a specificity of 100%. The results are summarized in Table 2.

3.3 Post-hoc analysis with novel cut-off value

A post-hoc analysis was performed with a novel cut-off value of 65 mg/dl for the Jelly-scan test. It was selected based on a ROC curve analysis using the number of teeth smaller than 20 as the test (Fig. 3). This analysis showed that the combination "sensitivity/1- specificity" was optimal for 65 mg/dl. With the new cut-off value, only 33 participants (54%) were diagnosed with masticatory hypofunction. The AUC remained similar, the sensitivity increased for both Gum2

tests, with a slight decrease in specificity for all 3 tests. All Kappa values increased to an absolute $K > 0.5$ (Table 2).

### 3.4 Modifying factors and correlations

There were no statistically significant differences between men and women in all four tests for masticatory function. Age was significantly correlated to all four masticatory tests ($p<0.05$), indicating a decrease in masticatory function as age increases; Jelly scan was the least correlated with age (rho=0.29), while Gum-visual was the most correlated (rho=0.47). Correlations of Gum1-colour (rho=0.611), Gum2-visual (rho=0.625), and Gum2-digital (rho=-0.534) with Jelly-Scan were all significantly correlated at the 1% level (Table 3).

## 4. Discussion

In this study, a total of four different tests of masticatory function were performed in patients aged 70 years and older and hospitalized for rehabilitation. The aim was to compare alternative diagnostic tools for masticatory function. Two of the tests were chosen, because they were easy to perform, and did not require specific equipment. One test was selected, as it is used in a large number of studies, especially in Europe. The glucose extraction test (Jelly-scan) was used as reference to compare a colour-changing gum test (Gum1-colour) as well as a mixing ability test with visual (Gum2-visual) and opto-electronical (Gum2-digital) analysis. In Jelly-Scan, 51 patients (83.6%) were categorized as presenting the condition. ROC curves were drawn with reference to the Jelly-Scan findings. Gum1-colour AUC was 0.872, Gum2-visual was 0.864, Gum2-digital AUC was 0.835. A novel cut-off for the Jelly-scan test was applied with 65 mg/dl. Here, the kappa agreement of all three alternative tests was increased to over 0.5. The sensitivity of the Gum2 tests increased, at the same time, the sensitivity of all 3 tests was slightly reduced.

All three alternative test methods investigated in the present experiments correlated with the Jelly-Scan method, hence confirming the study hypothesis. They may be used as alternative screening tools for poor masticatory function. However, all three alternative tests presented a moderate sensitivity, which bears the risk to under-diagnose poor masticatory function. With an excellent specificity, there is little false negative present, avoiding overtreatment of the condition.

Using the Jelly-Scan method, Shiga et al.[30] measured the masticatory performance of 20 healthy and fully dentate individuals in their 20s and reported that the average glucose concentration was 175.0 mg/dl. One year later, Unno et al.[31] repeated the experiments in 65 healthy fully dentate subjects in their 20s, and reported a glucose concentration between 102.5 and 186.8

mg/dl. The patients in the present study were with a minimum age of 70 years significantly older than in these reference studies. Hence in this cohort, the Jelly-Scan test diagnosed 83.6% of the participants with "compromised masticatory function". In addition, the participants in the present cohort were hospitalized for rehabilitation and often presented with multiple chronic diseases requiring medication intake. Furthermore, their average dental state was poorer than in the reference studies[18, 20-23] which might also explain the higher prevalence of poor masticatory function.

The high prevalence of compromised masticatory function with the Jelly-scan, when compared to the alternative methods, may also be related to the defined value of less than 100 mg/dl glucose concentration for diagnosing the condition. Since in all three alternative test methods, only one patient was falsely diagnosed with compromised masticatory function (specificity 100%, 90% and 100%), overtreatment is highly unlikely with these alternative tests. Hence one may assume, that the threshold of the gold-standard test for having the condition may be chosen too low. Given the good correlations with the continuous readings of the tests, raising the threshold for the diagnosis proved to further increase the sensitivity at least of the Gum2 tests, and the kappa agreement with all three alternative tests improved. Hence, this novel cut-off value of 65 mg/dl should be preferred, as in elders who are at risk of malnutrition, a missed positive diagnosis may be more harmful to the patient than the occasional over-diagnosis. However, with the sum of sensitivity and specificity being above 150% for all tests and both cut-off levels, the proposed alternative tests may be considered useful.[32] The excellent correlations between the individual readings from the 4 investigated test methods further confirm, that they may be used as alternative testing methods.

The ROC (receiver operating characteristic) curve analysis is a graphical display that plots cumulative true positive (sensitivity) against the false positive (1-specificity), with the latter being also called as “false alarm”. It allows detecting the diagnostic ability of a binary test. The ROC curve was drawn based on the Jelly-Scan diagnosis. The optimal cut-off value was calculated by defining the cut-off point as the minimum distance from the upper left corner of the ROC curve, further confirmed with the computation of the Youden’s index. As alternative tests for masticatory function, Gum1-colour, Gum2-visual, Gum2-digital have a sensitivity of 67% and a specificity of 68% at worst.

Consequently, the hypotheses could be confirmed, indicating an association and hence a similar diagnostic value for all test methods. The area under the ROC curve (AUC) indicates how many more true positives are present per false positives. The higher this area is, the more reliable the test method is. In the present study, the AUC and sensitivity values were very high in all 3 tests,

with both levels of cut-off value used for analysis, again confirming that they may be useful as alternative tests to the Jelly-Scan.

Although chewing is a rhythmic movement programmed by a central pattern generator in the brain stem, changes occur during physiological aging.[2] Whilst the chewing movements as such change little with age, the chewing sequence gets longer, as more cycles are needed before swallowing.[2] In addition, the chewing function is determined by the dental state[5] and the cycles are modified according to the food texture.[33] Tooth loss implies a smaller total occlusal surface for food comminution, and therefore the likelihood of food-stuffs being interposed between an upper and a lower tooth. Especially when complete removable dental prostheses (CRDP) are present, the maximum bite force may be limited. But the chewing movements may equally be altered subconsciously to avoid displacement of the CRDPs.[34] Furthermore, the chewing forces seems to decrease with age even if the number of occlusal support zones remain, as hard-to-chew food items are increasingly avoided in older age.[7] The loss of periodontal attachment also contributes to reduced masticatory performance.[3,6] Therefore the cut-off for determining a masticatory dysfunction should be adjusted, when applying the tests to an elderly population. For the Gum1-colour test, a cut-off was determined at the Tokyo Medical and Dental University for fully dentate volunteers, with an average age of 27.3 years.[18,20-23] After 60 chewing cycles of Colour changing gum, the cut-off score was 6 on a scale from 0 to 9. Subsequently an electronical analysis using a colour difference meter was employed to analyse the specimen after being flattened to a 1-5mm thick wafer. When introducing the oral hypofunction concept, Minakuchi et al. adjusted this cut-off value for geriatric participants.[9,10]

Evaluating the masticatory function as part of a more general geriatric assessment seems useful to diagnose oral hypofunction in its initial stage and facilitate early-onset therapy for this condition. Given the growing number of elders in the population, delegating the screening to general practitioners, auxiliary personnel, or even non-medical persons like the family or the patient himself, would discharge the health system.[35] Hence this study tried to show, that tests without sophisticated equipment exists and provide similar results to the "gold standard", the Jelly-Scan test. However, before recommending these tests to laypersons, it should be verified if they are able to achieve the same results as the medical and dental personnel.

In the present study, the average age of the participants as well as the prevalence of masticatory impairment were high. However, to test the differences between the various diagnostic tools, it was necessary to include patients presenting with the condition. When aiming to prevent oral

hypofunction, one might want to confirm the equivalence of the alternative screening tools in a younger, non-institutionalized cohort.

Screening masticatory function is also important at admission to a long-term-care institution, where the medical personnel need to know if the elder can chew a normal diet or mixed meals need to be served. Schimmel et al. reported that patients with a SA1 or SA2 score on the colour mixing-visual test would need being served a mixed meal.[17, 36] In principle, chewing is a beneficial activity, as it trains the chewing muscles,[37] lubricates the food bolus with saliva and helps digestion. Even an increased attention span was associated with the chewing activity.[38] Elderly residents should therefore be encouraged to benefit from non-mixed meals for as long as possible.[18, 20-23] When interpreting the findings of the present experiments, some shortcomings have to be born in mind. First, recruiting was difficult, and only 22% of the screened patients agreed to participate. This was due to their poor health status and fatigue, a busy rehabilitation schedule or just different priorities. A higher acceptance rate would have probably provided a larger range of masticatory functional capacity. Another shortcoming is related to the analysis of the same specimen for the Gum2-visual and Gum2-digital tests, respectively. Although the analysis was carried out with a different methodology, the specimens were the same, hence eliminating the intra-individual variability between two consecutive tests.

## 5. Conclusion

All alternative tests for assessing masticatory function in this study correlated positively with recommended Jelly-scan and can be considered acceptable alternatives. In its original version, Jelly-scan may tend to over-diagnose masticatory hypofunction, hence a novel cut-off with better agreement between tests is suggested. Tests like Gum1-colour or Gum2-visual, which do not require special equipment, may be administered even at domicile to screen for deteriorated masticatory function and foster early detection and treatment of the condition. If the patient or their family can administer the test with the same result as a dental professional remains to be confirmed.

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**Figure legends**

**Figure 1.**

a) Gummy jelly-specimen (Glucolumn GS- II), gauze and gluco-sensor device (Gluco Sensor GS-II, GC Corporation) for the Jelly-Scan test.

b) Xylitol gum specimen with the 10 images colour-scale for analysis (Gum1-colour)

c) Hue-Check gum specimen with the visual reference scale (Gum2-visual) and the flatt ened specimen prepared for the opto-electronical analysis (Gum2-digital)

**Figure 2.**

ROC curves displaying the sensitivity versus the 1-specificity of a) Gum1-colour, b) Gum2-visual and c) Gum2-digital with reference to Jelly-scan. For the latter, cut-off values of 100 mg/dl and 65 mg/dl were analysed separately.

**Figure 3.**

ROC curve analysis for Jelly-Scan using the number of teeth smaller than 20 as the test. the combination "sensitivity/1- specificity" was optimal for 65 mg/dl.

**Table legend**

**Table 1.**

Descriptive scores from all 4 masticatory tests.

**Table 2.**

Cut-off values for masticatory hypofunction, Area under the ROC curve (AUC), as well as sensitivity, specificity and the Kappa agreement of the test methods.

**Table 3.**

The correlation between the 4 different tests performed, analysed by Spearman's Rho analyses.

Table 1 : Descriptive scores of all 4 mastication tests

| Test | Unit | Mean | ±SD | Median | IQR | min | max |
|---|---|---|---|---|---|---|---|
| Jelly-Scan | mg/dl | 70.8 | 34.3 | 59 | 34 | 27 | 185 |
| Gum-1 color | Colour scale : 0-9 | 3.8 | 1.9 | 4 | 3 | 1 | 8 |
| Gum2-visual | Hue-Check Gum colour scale© : 1-5 | 2.2 | 1.0 | 2 | 2 | 1 | 5 |
| Gum2-digital | Variance of Hue (0-1000) | 0.43 | 0.25 | 0.41 | 0.52 | 0.03 | 0.81 |

Table 2 : Roc curve analysis using Jelly-scan as gold standard with 2 different cut-off points

| Cut-off value for Jelly-scan | ROC Curve AUC | Cut-off value | Sensitivity % | Specificity % | Kappa |
|---|---|---|---|---|---|
| Gum1-color | | | | | |
| 100 mg/dl | 0.872 | 5 | 67 | 100 | 0.40 |
| 65 mg/dl | 0.853 | 4 | 67 | 89 | 0.55 |
| Gum2-visual | | | | | |
| 100 mg/dl | 0.864 | 3 | 73 | 90 | 0.41 |
| 65 mg/dl | 0.854 | 3 | 88 | 68 | 0.57 |
| Gum2-digital | | | | | |
| 100 mg/dl | 0.835 | 0.43 | 57 | 100 | 0.30 |
| 65 mg/dl | 0.794 | 0.43 | 73 | 82 | 0.54 |

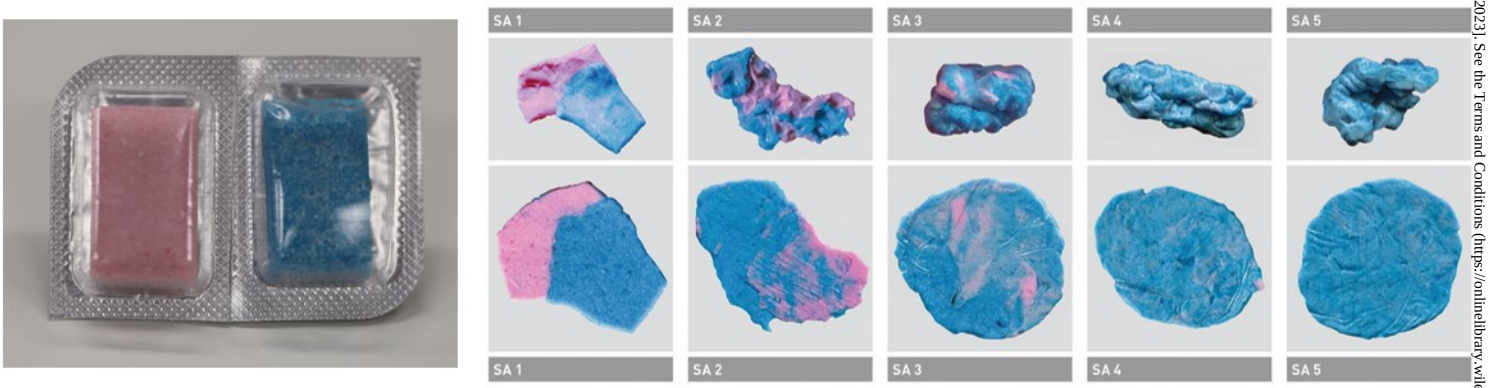
Table 3 : Spearmann Rho correlation coefficients between the 4 masticatory tests

| | Jelly-Scan | Gum1-colour | Gum2-visual |
|---|---|---|---|
| Gum1-colour | .611 | | |
| Gum2-visual | .625 | .855 | |
| Gum2-digital | -.534 | -.817 | -.810 |

All Correlations significant at the 0.01 level (2-tailed).


JOOR_13421_Fig 1a.jpg

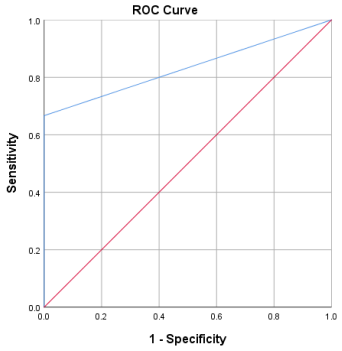

JOOR_13421_Fig 1b.jpg

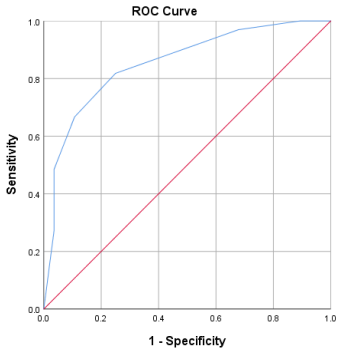



JOOR_13421_Fig 1c.jpg

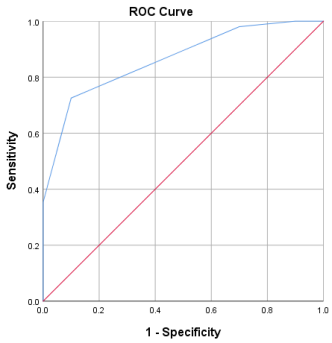
Figure 2.

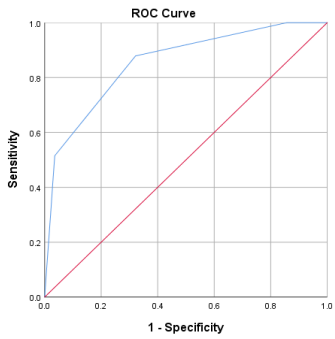
Gum1-colour (100 mg/dl left, 65 mg/dl right)



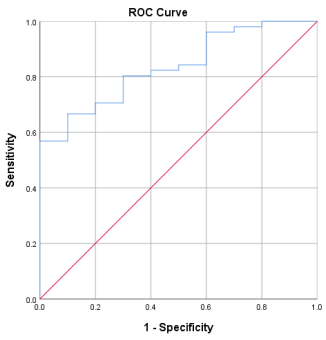




Gum2-visual (100 mg/dl left, 65 mg/dl right)




Gum2-digital (100 mg/dl left, 65 mg/dl right)



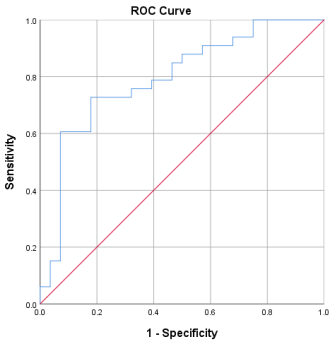



Figure 3.