

To Assess The Relationship between Masticatory Performance and Jaw Movement with the Use of a Colour - Changeable Chewing Gum

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ABSTRACT

Introduction: Both subjective and objective way of evaluation can be used to assess masticatory performance. This study was carried out to find out the association between the masticatory performance and the mandibular movements determined with the use of a colour-changeable chewing gum.

Material and methods: The study was done on 50 dentate adults (25 men, 25 women) with a mean age of 28 years. The subjects were told to chew the gum for a specified number of chewing strokes (20, 40, 60, 80, 120 or 160 strokes). No instructions were given as to the selection of chewing side. Then a colorimeter was used to determine L*, a* and b* values (CIE-L*a*b* color system). After this, the difference in the two colors on the CIE-L*a*b* color space was calculated with the formula. Opto-electric system with six degrees of freedom was then used to record the mandibular movements relating the amplitude, velocity, duration and angle for each cycle with a mean value for 10 cycles in total.

Results: The results calculated by the stepwise multiple regression analysis stated that 18% of variation in DE60 was there.

Conclusion: The results were indicative of increased speed and lower angles of approach to intercuspation to be associated with color changes in the gum.

Keywords: Mandibular Movement, Color-Changing Chewing Gum, Masticatory Performance, Factor Analysis, CIE-L*a*b* Colour System

INTRODUCTION

Both subjective and objective way of evaluation can be used to assess masticatory performance. ¹ Some of the objective methods include measurement of the particle size distribution when a person eats and the food bolus such as almonds, carrots, peanuts etc are evaluated. ²⁻⁴ Also, the final concentrations of certain dissolved solutions like gelatin, sugar or some test pigments have been used for objective evaluation of masticatory performance. These methods are often found to be very complicated and require usage of expensive and big equipment for the result analysis. Although natural foods can be used for simulation of natural chewing process, but these foods get affected by seasonal and quality changes and hence the test results become unreliable. ⁵ If artificial materials like silicone rubber and hydrocolloid impressions are used in place of these natural materials, there is a unclarity about their simulation of natural chewing.

With the coming of a latest color-changeable chewing gum (Masticatory Performance Evaluating Gum XYLITOL*) as a test item, the problems of the earlier objective evaluation

have been solved. The concept behind the usage of this color changing chewing gum in order to access masticatory performance is the measurement of its color change over time when a person chews it. These color changes are measured using hand-held colorimeter or color scale, hence eliminating the need of bulky equipment. ⁶

Two main advantages of using color chewing gum for the measurement are: its ability to simulate natural chewing and its complete recovery for evaluation after chewing as a test item. The change in the color of the chewing gum is affected by various factors relating masticatory performance including muscle activity, movement of the mandible and tongue, occlusal force and the occlusal contact area. ¹⁻³ Proper evaluation of dysfunction of the masticatory system can be done from the factor analysis related to the color-changing chewing gum. Many researchers have evaluated the relationship between the masticatory performance and mandibular movements and presented their views as to a positive relation between masticatory performance and mandibular movements using color changing chewing gum. This study is done one step ahead to find how colour changes in the colour changeable chewing gum are affected by mandibular movements.

MATERIAL AND METHODS

This study was done on 50 subjects including 25 healthy men and 25 healthy women at MB Kedia dental College, Nepal. The mean age of the study group was 29+_8 years. All study protocols were approved by the ethics committee at the college. Random sampling technique was used for selection of the sample candidates. The study was explained to the subjects and an informed consent taken.

Inclusion criteria

Subjects had at least 28 teeth

No caries, periodontal disease or TMJ disorder

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No functional disturbance of mastication eg. Orofacial pain
The masticatory performance was measured using a color changing chewing gum as a test item. This gum contains yellow, red and blue dyes, xylitol and citric acid. The dyes are pH controlled in a way that red dye appears only in alkaline and neutral conditions. Citric acid is one of the components of the chewing gum and it keeps the pH to be low, thus the chewing gum color remains yellowish-green. On chewing the color changes from yellowish-green to red because the blue and yellow dyes seep into the saliva and the citric acid eludes to finally bring forward the red color or the red dye. Number of strokes (20,40,60,80,120 or 160) was instructed to each subject for chewing of the gum irrespective of the chewing side. The whole activity was done in 3 hour fasting subjects. The subjects were told to perform the chewing task at 3 hour interval twice a day, a total number of six chewing tasks performed in 3 days.

For the measuring purpose, the chewing gum, after extracting from the mouth, was compressed between two glass plates and flattened to a thickness of 1.5 mm in polyethylene films. After this, the color was determined using a colorimeter and CIE-L*a*b* colour system was used to evaluate these color changes and represented as three-dimensional coordinates on three axis namely L* axis(lightness of color), a*axis

(position between red and green) and b*axis (position between blue and yellow). Five sites on each side were used to make color readings on the colorimeter and the mean values for the three axis were determined. Following equation was used to calculate the difference between two colours in the CIE-L*a*b* colour space (DE) for 20, 40, 60, 80, 120 and 160 strokes.

Values of L*, a* and b* before chewing were measured as 72.3, 14.9 and 33.0, respectively.

$$DE = [(L^* - 72.3)^2 + (a^* - 14.9)^2 + (b^* - 33.0)^2]^{1/2}$$

Interpolation method was used to calculate the index of masticatory performance (DE60). An opto-electronic system was used to measure the mandibular movement. It consisted of a head frame, LEDs, optical camera, face-bow and a personal computer. Mandibular central incisor was used as a reference point to calculate the chewing trial.

STATISTICAL ANALYSIS

After that the various measurements were done, the values were evaluated using a stepwise multiple regression analysis. The normality of all variables was analysed using the Kolmogorov–Smirnov test.

RESULTS

The results of the selected subjects showed that right side was the preferred side to chew in 60% subjects and the left side in 40%. In this study, no correlation was found between the masticatory performance and the chewing side of preference. Table 1 shows the mean values and the SD for DE60 where the minimum value is shown to be 21.34 and the maximum value was 42.93. Anteroposterior and lateral amplitude, maximum closing velocity and the envelope angle were found to be non-normally distributed on Kolmogorov-Smirnov test.

Table 2 depicts the Pearson correlation coefficients between parameters of mandibular movements and DE60. Maximum closing velocity and the closing angle have been found to be significant predictors on stepwise multiple regression analysis with a significant positive correlation (r=0.37) with DE60 and significant negative correlation (r=-0.38) with

DE60	32.20+ 4.38
Vertical amplitude (mm)	22.64+ 3.01
Lateral amplitude (mm)	6.34+ 1.34
Anteroposterior amplitude (mm)	9.32+ 2.45
Occlusal duration (s)	0.23+ 0.04
Cycle duration (s)	0.70+ 0.12
Opening duration (s)	0.31+ 0.05
Closing duration (s)	0.23+ 0.05
Maximum closing velocity (mm s ⁻¹)	120+ 30.90
Maximum opening velocity (mm s ⁻¹)	128.41+ 32.20
Opening angle (degree)	48.20+ 13.09
Closing angle (degree)	53.97+ 14.01
Envelope angle (degree)	11.60+ 6.01

Table-1: Mean values and standard deviations for DE and mandibular movements (n = 50)

DE60												
Vertical amplitude	0.23											
Lateral amplitude	0.17	0.07										
AP amplitude	0.16	0.65**	-0.04									
Cycle duration	-0.12	0.13	-0.27	0.22								
Occlusal duration	-0.02	0.13	-0.05	0.13	0.61**							
Opening duration	-0.05	-0.02	-0.16	0.13	0.82**	0.26						
Closing duration	-0.16	0.18	-0.35*	0.21	0.73**	0.15	0.43**					
Maximum opening velocity	0.21	0.60**	0.16	0.22	-0.51**	-0.16	-0.65**	-0.24				
Maximum closing velocity	0.35	0.51**	0.20	0.04	-0.55**	-0.15	-0.42**	-0.60**	0.71**			
Opening angle	-0.31	0.13	-0.06	-0.02	0.26	0.46**	0.14	0.01	0.01	0.02		
Closing angle	-0.31	0.01	-0.02	-0.01	0.06	0.02	0.00	0.13	0.15	-0.12	0.24	
Envelope angle	-0.18	-0.50	0.38**	-0.41**	-0.12	-0.08	-0.02	-0.02	-0.024	-0.25	0.11	0.25

Table-2: Correlation coefficients for the relationship between DE60 and mandibular movements (n = 50)

DE60 respectively.

DISCUSSION

A main difference between the present study and the previous studies is that the DE60 value was used as the masticatory performance index as against other studies where a^* was used. It was done because a^* represents just the red and green color variations whereas DE is a combined reflection of L^* , a^* and b^* between standard and sample. Thus, it is believed that DE is a better and accurate way of calculating the difference before and after chewing than the a^* .⁷

Some other studies have used the mean values as index of masticatory performance as against the DE value used in our study.⁵⁻⁸ But DE60 is calculated after a representation of values on an approximate curve and use of interpolation method. The reason behind using DE60 and not 20 or 40 is that the gum was unmixed and not properly chewed at DE 20 or DE 40. Also, the reason behind non-usage of higher values like 80,120,160 is the variability difference between the subjects at this stroke level was small and insignificant. For the mandibular movements, we cannot use the earlier cycles that might be influenced by consciousness of the subject and neither the later ones which might get interrupted by saliva. So, cycle 10 to cycle 18 was used for the analysis. Our study is in consent with the previous studies and the results of stepwise multiple regression analysis show that the closing angle and maximum closing velocity have a significant impact on DE60.⁷ In some studies, vertical amplitude was positively related to masticatory performance but not in our study.⁹⁻¹⁰

CONCLUSION

In the present study, use of color changeable chewing gum for the measurement of masticatory performance and the use of gnathohexagraph for measurement of mandibular movements has shown a lower angle approach to intercuspation and greater speed while chewing to be associated with effective color changes in the gum. Color-changing chewing gum have been shown to be an effective diagnostic tool in such studies.

More factors can be studied for their association with the mandibular movements in future.

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