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Spectrophotometric Study to Evaluate Chewing Efficiency in Partially Edentulous Patient's Pre and Post Fixed Prosthodontic Rehabilitation

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Abstract

Background: In this study, masticatory efficiency of patients with unilateral missing mandibular 1st molar were evaluated pre and post rehabilitation with three unit fixed partial denture prosthesis. Six male and four female patients within the age range of 17-35 years and who had no cranio-mandibular disorder, any obvious malocclusion, or extensive restoration were included. Evaluation of masticatory efficiency was done by spectrophotometry and raw carrot was used as test material. To see the difference, among the groups, pre and post rehabilitation Masticatory efficiency was tested using spectrophotometer once again on experimental side and control side were recorded. Paired samples t-test was applied for statistical data analysis.

Result: The mean and standard deviation of masticatory efficiency for pre and post rehabilitation changes on experimental side was 0.694 0. 749; 0.885 0.752 and for control side was 0.884 0.698; 0.994 0.675 respectively. The difference between the two groups was statistically significant at $p<0.01$ levels.

Conclusion: Masticatory efficiency were decreased on experimental (missing mandibular 1st molar) side as compared to the control side (intact dentition) before rehabilitation. Post rehabilitation, there was an increase Masticatory Efficiency in all the Patients.

Keywords: Masticatory Efficiency; Spectrophotometer; Colorimetry; Fixed Partial Denture; Three Unit Bridge; Prosthodontic Rehabilitation

Introduction

0ne of the most complex and critical neurophysiologic mechanism in human motor functions is mastication. Each tooth is highly specialized in dental arch according to its function. Permanent first molars are the most important units of mastication as they bear the maximum stresses during function. Permanent first molars are often lost early, mainly the mandibular 1st molars which erupt at an early age of six years and therefore are exposed to the oral environment for longer period of time. When a lost single tooth is not replaced, occlusal balance is disturbed. The consequences may be supra-occlusion of the opposing tooth or teeth, tilting of the adjacent teeth, defective proximal contacts, leading to dental caries, and injury to the periodontium with resultant derangement of occlusion. Loss of teeth and occlusal disharmony reduces the chewing efficiency significantly. For replacing a single tooth, the prosthodontic options available are removable partial denture, fixed partial denture and implant-supported prosthesis.

Fixed partial denture is the most widely accepted option for replacement of missing teeth. Dentists have to choose most appropriate options whether to replace a single missing tooth with a fixed or a removable partial denture, unless a fixed bridge restoration is contraindicated for some reason, one cannot justify the use of a removable restoration for arbitrary reason alone" [1]. There is enough evidence to suggest that oral functions such as mastication and speech is optimized with fixed prosthodontics [2]. It is said that changes in the number of natural teeth or replacement with fixed prosthodontic rehabilitation could influence muscle activity and therefore masticatory function [3]. Masticatory efficiency is defined as the number of masticatory strokes required to reduce the food to certain particle size [3], where as masticatory performance is determined by counting the particle size distribution of food when chewed for given number of strokes. Few studies suggest that there was gradual decline in the chewing efficiency proportionate with

the number of missing teeth[4] but positive changes occurred in chewing pattern following restoration of posterior occlusion [5]. Similar observations also conclude that the bolus was placed more posterior with re-establishment of the occlusion [6].

Various clinical and laboratory methods have been developed to measure masticatory function such as fractional sieving [7,8], computer assisted image processing [9], Colorimetry [10]. The first method described was fractional sieving system, later newer method has been developed to test the communition of the food using spectrophotometry or Colorimetry. These techniques are hygienic, accurate, simple and practical for measuring large number of samples. The strain gauge transducer technique that functions on the basis of peizo-electric inputs, mounted on the teeth or implants and has been used to measure functional forces when biting and chewing [11]. Fractional sieving employs sieves of various gradations (sizes) to measure the particle size of the chewed food. However, it is time consuming and laborious. Therefore, the colorimetric method is used subsequently to evaluate surface area of the chewed particles of raw carrots [12]. However, they found it is unsuitable for subjects wearing complete dentures [13].

To make Spectrophotometric analysis easy, reliable and simplified the ideal test material to study masticatory efficiency should be preferably a natural food, and the natural dye of characteristic wavelength. Further, it should not absorb or stain the oral mucosa and the material should not affected by water and saliva. Study shows raw carrots and peanuts were used as a test material among which the carrot was a clean material to work with and practically odorless compared to peanuts [13]. Different kinds of test foods have been used to assess the masticatory function. They include artificial material such as cubes of gelatin hardened by formalin, tablets of Optosil® i.e. silicon impression material and natural food such as almonds, hard bread, carrots, peanuts and bacon. The variation in size, shape and consistency of test food may lead to a wide variation in test results, and lack of objectivity and reproducibility. Therefore, single natural food material such as carrot can be used for assessing the masticatory efficiency [14-16].

Material and Methods

A sample of total 10 patients were selected for this study after informed consent from the patients attending the Prosthodontic Clinic, Department of Prosthodontics, M.B. Kedia dental college, Birganj. The patients were selected irrespective of sex with mean age of 26 years and within the age range of 17-35 years.

Criteria for selection of patients:

Inclusion Criteria:

a. Patients of age range between 17-35 years who have sound periodontal health and good oral hygiene.

b. Intact natural dentition up to 2nd mandibular molar except for missing mandibular 1st molar on one side.

c. Partial edentulousness of 3-6 months duration.

d. Well healed and healthy edentulous ridge.

Exclusion Criteria:

a. Patients who had any carious or unrestored tooth.

b. Patients having any cranio-mandibular disorders, para-functional habits, oral manifestations of systemic diseases, significant supra eruption of opposing maxillary molar and mesial and / or distal tilting of abutment teeth anterior and posterior to the edentulous space.

Methodology

Masticatory efficiency was determined by using spectrophotometry to measure naturally occurring dye (beta-carotene) present in raw carrot, which is released on chewing. This dye was measured by spectrophotometer at 530 nm (Shimadzu UV/ Visible spectrophotometer). We have used uniform pieces of fresh raw carrot, i.e. one piece of carrot weighing 10 grams containing equal concentration of dye. Each piece of carrot was given to the patients for chewing from the affected side (missing mandibular 1st molar) and another piece of carrot was used as control for chewing from contra lateral intact natural dentition side. Each subject was instructed to chew a piece of carrot using 20 strokes without swallowing the particle of the carrot or saliva. After chewing, all the chewed part of carrot and saliva produced during the process was expectorated in a graduated cylinder and distilled water was added to make up the volume to 25 ml. The contents were stirred subsequently for 10 minutes using wooden spatula.

Spectrophotometry

The carrot sample was filtered with filter paper; the absorbance (optical density) reading was then taken in a spectrophotometer at 530 nm against distilled water as blank. One ml volume of sample was taken for absorbance where the absorbance is expressed on the basis of Beer's and Lambert's laws:

a)		=	E cl
b)	E	=	Molar absorbance coefficient.
c)	C	=	Concentration of the solution
d)	L	=	Length of the light path (1cm cuvette)

The same procedure was followed for the opposite side with intact natural dentition. It was used to determine the maximum dye released from the carrot which express the masticatory efficiency of the patients.

Evaluation of Masticatory Efficiency after Rehabilitation

Masticatory efficiency test were performed for each patient after 3 months of fixed prosthodontic rehabilitation again using the same procedure as described above and was compared with pre-rehabilitation recordings. The details of all the cases with date of each procedure performed were recorded in pre-designed Performa.

Statistical Analysis

The data thus obtained was recorded in a master chart and was statistically analyzed using descriptive statistics (Mean± SD) for

each and every variable. To study the difference among the groups we compared pre rehabilitation with post rehabilitation. Paired sample t-test was applied. Mann Whitney test, P=<0.05 has been considered as statistical significance level.

Descriptive Statistics: Mean, Range and Standard Deviation were calculated for the Variables Studied as Follows:

a) Mean

$$X = \sum_{n} X$$

Where,

X = Mean

$\sum X$ = Sum of variables

n = No. of subjects

b) Standard deviation

$$SD = \sum_{n-1} (X - X)^2$$

Where, X = Values of variable

= Summation

n = No. of subjects

X = No. of subjects

c) Paired sample T- test

$$t = d$$

$$S/ = \sqrt{n}$$

Where

$$S^2 = 1$$

$$\Sigma(d - d)$$

$$n - 1$$

Results

a. Comparison of masticatory efficiency on experimental (missing mandibular 1st molar) and control (intact natural dentition) side before rehabilitation (Table 1 and Figure 1).

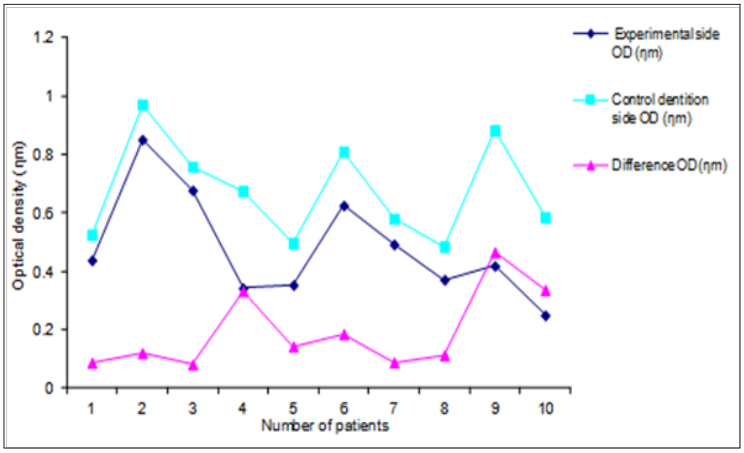

Figure 1: Comparison of Chewing Efficiency before Rehabilitation.

Table 1: Comparison of Masticatory Efficiency on Experimental and Control Side before Rehabilitation in Optical Density (ηm).

Serial no. Patients	1	2	3	4	5	6	7	8	9	10
Experimental side	0.438	0.851	0.677	0.342	0.353	0.625	0.492	0.371	0.418	0.249
Control Side	0.525	0.971	0.758	0.674	0.496	0.810	0.580	0.484	0.883	0.585
Difference OD (ηm)	0.087	0.12	0.081	0.332	0.143	0.185	0.088	0.113	0.465	0.336

OD = Optical density, ηm = Nano meter

The optical density (OD) of the filtrate was compared in both types of sample groups before rehabilitation. There was low value of the optical density of the filtrate solution on experimental side in comparison to the control side. The masticatory efficiency level in all the patients was also different.

b. Comparison of masticatory efficiency on experimental and control side (here should be- experimental and control side after rehabilitation or before and after rehabilitation) after rehabilitation (Table1,2 and Figure 2).

Table 2: Comparison of Masticatory Efficiency on Experimental and Control Side after Rehabilitation in Optical Density (ηm).

Serial no. of Patients	1	2	3	4	5	6	7	8	9	10
Experimental side OD (η m)	0.490	0.971	0.950	0.748	0.410	0.718	0.625	0.862	0.688	0.358
Control dentition side OD (η m)	0.530	0.998	0.985	0.751	0.649	0.809	0.712	0.895	0.885	0.580
Difference OD (η m)	0.04	0.027	0.035	0.003	0.239	0.091	0.087	0.033	0.197	0.222

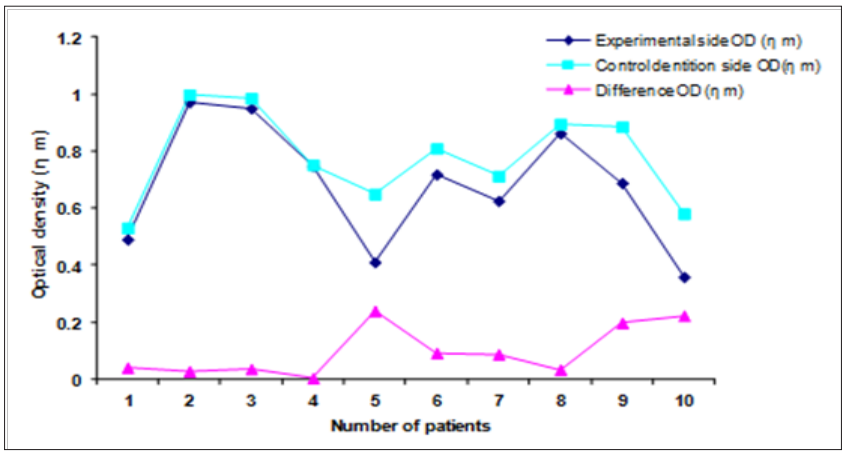

Figure 2: Comparison of Chewing Efficiency after rehabilitation.

The decrease in difference of optical density between experimental and control side in post rehabilitation of missing mandibular 1st molar showed there was increase in masticatory efficiency in compared to pre rehabilitation efficiency in all the patients. Comparison of masticatory efficiency between experimental and controls side of pre and post rehabilitation (Table 3). Paired sample t-test was applied for statistical analysis for comparison between groups for masticatory efficiency. The mean and standard deviation of pre and post rehabilitation changes on experimental side for masticatory efficiency was 0.694 0. 749; 0.885 0.752 and for control side was 0.884 0.698; 0.994 0.675 respectively. The difference between the two groups was statistically significant at p<0.01.

Table 3: Comparative Statistics of Pre and Post Rehabilitation Changes in Masticatory Efficiency.

Variable	Pre Rehabilitation	Post Rehabilitation	Significance		
	Mean OD (ηm)	SD ( ) OD (ηm)	Mean OD (ηm)	SD ( ) OD (ηm)	
Experimental side	0.694	0.749	0.885	0.752	0.003**
Control side	0.884	0.698	0.994	0.675	0.046*

**P<0.01= highly significant, *=p0.05*= Significant.

Discussion

Mastication is one of the main functions of the stomatognathic system. Number of posterior tooth contact and the neuromuscular coordination of the masticatory muscles are essential to a harmonious functional relationship in the masticatory system. In our study, uniform pieces of fresh, raw carrot were used as a test material for all the patients because it is natural food, natural dye (β-carotene) having characteristic wavelength and not influenced by oral mucosa, water and or saliva. The test material used in pre and post rehabilitation were analyzed spectrophotometrically which is most effective method among various methods available to provide a biochemical evidence to study masticatory efficiency in partially edentulous patients.

The concentration of the filtrate and transmittance of the solution was the criteria for calculation of the masticatory efficiency, which was obtained as optical density (OD,ηm) and compared between experimental side and the control side before and after rehabilitation.

To exclude any chances of bias, contra lateral intact dentition was taken as a control to compare the efficiency in the same individual. Unilateral mastication was performed for 20 strokes for all the subjects and there were no subjective criteria for calculation. During unilateral mastication the chewing of food was performed by working as well as non-working side contacts. This brings out the differences between the chewing and non-chewing sides (functional) and the working and nonworking sides (kinematics), whereas from functional point of view the side where the bolus is kept should be called the chewing side and other side should be non-chewing side [18].

Changes in m Masticatory Efficiency on Experimental and Control Side before Rehabilitation: There was significant difference observed in masticatory efficiency between the experimental and control side before rehabilitation. It was possibly because of the less number of the tooth contacts in the posterior teeth especially mandibular 1st molar (which is the key tooth for mastication) on the experimental side as compared to the control side.

Changes in Masticatory Efficiency on Experimental and Control Side After Rehabilitation: In this study after three months of rehabilitation with fixed partial denture, all the patients showed marked increase in masticatory efficiency on the experimental side; as there was decrease in difference in optical density between experimental and control side in pre and post rehabilitation, where as there was no significant change observed on the control side before and after rehabilitation. It means that rehabilitation of missing mandibular 1st molar does affect masticatory efficiency and chewing ability of an individual.

Factors Influencing Masticatory Efficiency: Masticatory efficiency is influenced by several factors such as state of dentition, age, development of neuromuscular functional pattern of jaw movement, number of occluding pairs of teeth, voluntary movement of chewing cycle and type of test food. In this study it was observed that all the above-mentioned factors including group function, canine protection type of occlusion, influences the masticatory efficiency of the individual. A time period of three months seems to be adequate for the adaptive changes in neuromuscular component of masticatory system after replacing mandibular 1st molar. Another major cause for improved masticatory muscle activity could be an increase in number of teeth after replacement of missing mandibular 1stmolar with a three unit bridge which led to increase in total width, surface area of the masticatory table and number of posterior tooth contacts. Previous studies indicate that increase in size and width of the occlusal table tends to increase masticatory muscle activity, improved masticatory efficiency in Toto. It has been observed that, fewer the occlusal contacts, less was the chewing force and thereby efficiency. Conversely, a multiplicity of occlusal contact points resulted in higher muscle activity; therefore masticatory efficiency and function.

Conclusion

Spectrophotometric analysis showed that there was significant improvement in masticatory efficiency on experimental side of post rehabilitation compared to pre rehabilitation without significant change on the control side. It is recommended that future studies may be conducted with a larger sample size, longer follow up and in subjects with multiple missing teeth to study the effects of missing teeth on masticatory efficiency and muscle activity.

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