A CLINICAL STUDY TO EVALUATE TOOTH CONTACT PATTERNS AND CORRELATION WITH MASTICATORY EFFICIENCY IN DENTULOUS SUBJECTS.

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ABSTRACT

A variety of functional tooth contact patterns exist in population of young adult patients. The purpose of the present study is to find the relationship between different lateral tooth contact patterns and dental morphology and their effect on masticatory efficiency. Forty young dentulous subjects were selected and their impression with irreversible hydrocolloid was made. Polyvinyl silicone bite registration paste was used to record lateral tooth contact patterns in functional range of mandibular movement. Overjet and overbite including mesiodistal relation of teeth recorded with cast secured in the intercuspal position and masticatory efficiency was determined by calorimetric method by using raw carrot. Among all subjects 15% having canine protection, 55% group function, and 30% balance occlusion. There is positive correlation between age and masticatory efficiency \[r=+0.656, \ p<.01\] and negative correlation between overjet and masticatory efficiency \[r=-0.409, \ p<0.01\]. In the present study Canine protection occlusion had significantly lower mean masticatory efficiency than group function and balanced occlusion group. This signifies that the masticatory efficiency is dependent on lateral tooth contact patterns.

KEY WORDS: Masticatory efficiency, Canine protected occlusion, Group function, Balanced occlusion.

INTRODUCTION

The intercuspal and lateral tooth contact relationships of teeth greatly influence chewing, swallowing and speaking. When teeth are lost, reestablishment of occlusion and achieving proper functional tooth contacts during lateral excursions of mandible are important and necessary as this helps patient to return to optimum function.

The morphology of cusps, fossae, grooves and marginal ridges should support the mandible in the intercuspal position, eccentric jaw movements and functional activities of mastication.

Functional occlusion has been classified into canine protection, group function and balanced occlusion based on the pattern of occlusal contacts in lateral excursions. As early as 1939 Hildebrand published a report, indicating that mandible attains centric occlusion by sliding of lower teeth on the upper teeth at the end of masticatory cycle. Henrickson showed that masticatory efficiency and ability were partly dependent upon the occlusion and he further explained that normal occlusion group presented higher masticatory efficiency than malocclusion group.

In the previous studies lateral tooth contact patterns were studied at canine edge to edge position, which are actually out of functional range of mandibular movement and they classified lateral tooth contact patterns according to working side tooth contacts only. Non working side tooth contacts which usually more prevalent in functional range of mandibular motion considered less important. Thus in this study, we evaluated and classified lateral tooth contact patterns in functional range of lateral mandibular movements.

The present study was undertaken with following aims and objectives:

1. To evaluate the pattern of occlusal contacts in lateral excursions in young healthy dentulous subjects.
2. To evaluate overjet, overbite, inter molar and intercanine width in young dentulous subjects.
3. To evaluate masticatory efficiency in young dentulous subjects.
4. To find out the influence of type of occlusion on masticatory efficiency and dental morphology.

Materials and Methods

A sample of 40 male subjects was selected from the medical students at the All India Institute of Medical Sciences, New Delhi. Subjects were selected according to the following criteria:

1. Subjects with natural full complement of healthy teeth from central incisors to the second permanent molars in the maxillary and mandibular arches.
2. Subjects with pleasing facial profile.
3. Subjects with sound periodontal health and good oral hygiene and minimal or no attrition of teeth.
4. Subjects without any history of parafunctional habit or temporomandibular joint dysfunction
5. Subjects without history of orthodontic therapy.
6. Subjects without any restorations involving cusps.

Methodology

I. Recording of tooth contacts

Each subject was asked to sit upright on a dental chair with head unsupported making Frankfurt- Horizontal plane parallel to the floor. For recording the lateral tooth contacts, each subject was instructed to close their mouth in the intercuspal position and then to slide the mandible laterally until the buccal cusps of the maxillary and mandibular first premolars were aligned.

To regulate the above lateral position a mark was made on the maxillary central incisor with a water-resistant pencil to the right / left of the mandibular midline (Fig.1). The midlines of the upper and lower natural dentition served as a reference point for the extent of the lateral movement of the mandible. In those cases where maxillary and mandibular midlines did not coincide, a midline was marked on the mandibular incisor coinciding with the upper midline. Following the lateral movement of the mandible, a second reference line was marked on the labial surface of the maxillary central incisor coinciding with the lower midline (actual or drawn). These lines were then used as reference lines for recording occlusal contacts in the predetermined position.

The subject was asked to practice lateral excursive movement to the predetermined position. Subjects who had difficulty in performing lateral movement were guided until smooth lateral movements were achieved. All occlusal surfaces of maxillary and mandibular teeth were then cleaned by water and dried with air syringe.

A silicone bite registration material from the dispenser (twin barrel cartridge) was applied on all occlusal surfaces of the mandibular teeth (Fig.2). The subject was first asked to close his mouth slowly in the intercuspal position and then immediately made to slide to the left or right predesignated lateral position. The subject was maintained in that position until the silicone bite registration material set. The occlusal registration was then observed against light to verify the tooth contact sites (Fig.3). Perforation or translucent areas were identified as tooth contacts and recorded accordingly in the proforma (Fig.4). All occlusal contacts were recorded in the morning hours to avoid any possible diurnal variations.

II. Dental Cast analysis

Dental casts were prepared using irreversible hydrocolloid impression. The vertical and horizontal overlap, including the mesiodistal relation of first molars were measured and recorded with casts secured in intercuspal position.

The linear sagittal measurement recorded by measuring the distance between mesial surfaces of mandibular and maxillary first molars in the intercuspal position. The width of dental arches between canines and first molars for maxillary and mandibular arches were measured with digital vernier caliper (Fig.5). The canine tip was the reference point for canines to measure the intercanine width and if abraded, the approximate centre of the abraded surface was used as a reference point. The reference points for maxillary and mandibular molars were the central fossa to measure the intermolar width.

III. Masticatory Efficiency

Masticatory efficiency was determined by using colorimetry. This method was based on the naturally occurring dye ($\beta$-carotene) present in raw carrot which is released on chewing. This dye was determined spectrophotometrically at 530 nm.

It is essential for each subject to consume homogeneous pieces of carrot containing equal concentration of dye as concentration of dye varied between carrots and within carrots. After proper cleaning, homogenous pieces of fresh carrot were prepared. From this, one piece of carrot weighing 6gms was given to each subject for chewing to determine masticatory efficiency and another piece of carrot was used as standard. Each subject was instructed to employ 20 chew strokes without swallowing. After chewing, all the particles and saliva produced during the process were expectorated in a graduated cylinder and water was added to make up the volume to 25 ml [fig.5]. After filtration, the Optical Density [OD] reading of subject saliva was determined spectrophotometrically at 530nm and was subsequently subtracted from OD reading of sample of same individual.
The OD per gm of carrot was calculated and the results are expressed as a percentage of the maximum amount of dye that had been released from the standard carrot. The standard carrot (6 gms) was crushed, 25ml of water was added and filtered to determine maximum dye released from this carrot. Masticatory efficiencies of subjects were calculated by using the following formula:

\[ ME = \frac{E_1 \times 100}{E} \]

\[ ME \] = Masticatory efficiency
\[ E_1 \] = OD taken (spectrophotometric reading) from samples expectorated by patient after 20 strokes of chewing.
\[ E \] = OD value obtained from standard crushed carrot.

Statistical Analysis
The data thus obtained was analyzed statistically using descriptive statistics (Mean, SD) for each and every variable. To study the differences among the three groups, one way analysis of variable (ANOVA) was applied. The association between all variables was calculated by Pearson’s correlation. To predict the masticatory efficiency from different variables Multivariate regression analysis was done. \( P < 0.05 \) was considered statistically significant.

Results
Observed lateral tooth contact patterns; The results were tabulated as shown in Table 1.

Comparison between groups
(1) Comparison between groups for age (Table II)
The comparison of the difference in these means between the three groups was not statistically significant.

Table I: Distribution of subjects based on lateral tooth contact patterns (n=40)

<table>
<thead>
<tr>
<th>Groups</th>
<th>Lateral tooth contact Pattern</th>
<th>Number of Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Canine Protection</td>
<td>6 (15%)</td>
</tr>
<tr>
<td>II</td>
<td>Group Function</td>
<td>22 (55%)</td>
</tr>
<tr>
<td>III</td>
<td>Balanced Occlusion</td>
<td>12 (30%)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>40 (100%)</td>
</tr>
</tbody>
</table>

Table II: Mean and range of age (years) in different groups

<table>
<thead>
<tr>
<th>Groups</th>
<th>Canine Protection (n=6)</th>
<th>Group Function (n=22)</th>
<th>Balanced Occlusion (n=12)</th>
<th>Total (n=40)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>Mean ±SD</td>
<td>Range</td>
<td>Mean ±SD</td>
<td>Range</td>
</tr>
<tr>
<td>17-29</td>
<td>24.72 ±4.72</td>
<td>18-29</td>
<td>24.73 ±3.16</td>
<td>21-29</td>
</tr>
<tr>
<td>25.10 ±3.35</td>
<td>25.10 ±3.35</td>
<td>25.10 ±3.35</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(2) Comparison between groups for dental morphology
(a) Incisal Relationship (Fig. 6)
i) overjet: No significant difference was observed in the means of overjet between canine protection and group function. However a significant difference (\( p < 0.05 \)) was observed for overjet between the means of group function and balanced occlusion and also between canine protection and balanced occlusion.

ii) Overbite: The difference in the means of overbite between canine protection and group function was not significant. However a significant difference (\( p < 0.001 \)) was observed between the means of group function and balanced occlusion and also between canine protection and balanced occlusion (\( p < 0.01 \)).

(b) Mesiodistal molar relationship
i) Right: The difference in the means between canine protection vs group function and between balanced occlusion vs. groups function were statistically significant (\( p < 0.001 \)). However no statistically significant difference was observed between canine protection vs. balanced occlusion.

ii) Left: The difference in the means between canine protection vs. group function (\( p < 0.01 \)) and between balanced occlusion vs group function (\( p < 0.001 \)) were statistically significant. However, there was no statistically significant difference observed between canine protection and balanced occlusion.

c) Intercanine width
i) Maxillary: No statistically significant difference was observed for maxillary intercanine width between the three groups.

ii) Mandibular: Similarly, no statistically significant difference was observed for mandibular intercanine width among the three groups.
Fig. 1. Marking on the maxillary central incisor

Fig. 2. A silicone bite registration material

Fig. 3. Occlusal registration

Fig. 5. Perforation or translucent areas in occlusal registration

Fig. 5. Measurement of arch width
d) Inter molar width  

i) Maxillary: No statistically significant difference was observed amongst the three groups studied for the maxillary intermolar width.  

ii) Mandibular: A statistically significant difference was observed between canine protection and group function (p<0.01) and also between canine protection and balanced occlusion (p<0.001). However, there was no statistically significant difference between group function and balanced occlusion group.

(3) Comparison between groups for masticatory efficiency  

No statistically significant difference was observed between canine protection and group function group for masticatory efficiency. However, balanced occlusion group presented, with statistical significant (p<.05) higher masticatory efficiency than group function and canine protected occlusion group.

Discussion:  
Mastication is one of the main functions of the stomatognathic system. Masticatory movements and masticatory efficiency of individuals are certainly influenced by lateral tooth contact patterns and existing dental morphological variables such as overjet, overbite, mesiodistal molar relationships, intercanine width and intermolar width.

This study evaluated the prevalence of three lateral tooth contact patterns: canine protection, group function and balanced occlusion. Different variables such as age, overjet, overbite, mesiodistal molar relationship(R&L), intercanine width, intermolar width and masticatory efficiency were studied for each group and comparisons were made between three lateral tooth contact patterns and subsequently masticatory efficiency was correlated with age and dental morphology.

Masticatory efficiency can be tested by fractional sieving (Edlund, 1980)\(^7\), computer assisted image processing (Mahmood, 1992)\(^8\) and colorimetry (Dahlberg, 1942\(^9\)and Keyser, 1977\(^6\)).

In this study carrots, containing β-carotene (a natural dye, having characteristic wavelength, not absorbed or stain oral mucosa and remain unaffected by saliva and water) were used as a test material to estimate masticatory efficiency and subsequently correlated with lateral tooth contact patterns because lateral motion of chewing is frequently associated with chewing carrots.

Mandibular position: Lateral tooth contact patterns: In order to evaluate the influence of lateral tooth contact patterns on masticatory efficiency it is necessary to evaluate lateral tooth contact patterns in the functional range of mandibular position or/close to the maximum intercuspation as has been mentioned by several authors\(^10,11\). According to them the functional range of mandibular movement is usually present within the range of 2mm from maximum intercuspation while recording of the lateral tooth contact patterns in the edge to edge position of canines does not include the occlusal events that take place from the intercuspal position to the edge to edge position. Thus in the present study all lateral tooth contact patterns were evaluated in the functional range of mandibular position.

Relationship between lateral tooth contact patterns and dental morphology: We found that individuals with minimal horizontal and vertical overlap tended to have balanced occlusion. Eriksson (1982)\(^12\) found a positive correlation between non functional side interferences and anterior open bite but a negative correlation with increased extent of overbite.

In this study individuals with increased mesiodistal molar relationship (mesial occlusion) tend to have balanced occlusion and individuals with decreased mesiodistal molar relationship (distal occlusion) tended to have group function occlusion. Madone and Ingervall (1984)\(^13\) concluded that group function was related to distal occlusion where as canine protection was related to neutral molar relationship.

The current findings show that there was no significant difference in intercanine width, as regards the three lateral tooth contact patterns for both arches and there was no significant difference between sagittal relationship of canine protection and group function. This shows that dimensions of anterior region of both arch play minor role in lateral tooth contact patterns. It appears that horizontal overlap of canine did not dictate the various lateral tooth contact patterns.

No significant difference was observed for maxillary intermolar width in relation to different lateral tooth contact patterns. Individuals with increased mandibular intermolar width had a tendency to have group function. No significant
difference in mandibular intermolar width was present between canine protection and balanced occlusion.

In this study, individuals with balanced occlusion showed higher masticatory efficiency when compared to subjects with group function and canine protection. This may be due to increased number of contacts and biting force. The canine protection group presented with least masticatory efficiency which may be due to immediate disocclusion of all posterior teeth and fewer number of occlusal contacts and lesser EMG activity in lateral excursions.

Role of balancing contacts

All subjects included in this study were clinically asymptomatic, had no temporomandibular disorders or bruxism and still they presented with high prevalence of balanced tooth contacts (30%). In the present study all balancing contacts were observed in the functional range of mandibular movement during lateral excursions. This explains the fact that non working side contacts may not be responsible for TMJ dysfunction. This observation is similar to that found in previous studies. Agerberg (1988) found that there was no relationship between non working side contacts and TMD.

The role of balancing contacts (not interference) in masticatory efficiency was found to be an important observation, as the present study revealed that balanced occlusion group presented with increased masticatory efficiency. However, balanced occlusion showed less intermaxillary and intermolar width and decreased overjet and overbite. This shows the importance of wide distribution of contacts rather than area of non functional occlusal surfaces for increasing masticatory efficiency. This may be true because in our study the intermaxillary and intermandibular molar width for canine protection group were greater but this group revealed less masticatory efficiency out of three.

It has been reported that increased masticatory efficiency is associated with increased lateral component of the mandibular movement. This might be true in case in the balanced occlusion because of less posterior disocclusion due to less horizontal and vertical overlap and subsequently increased lateral movement of mandible with wide distribution of contacts. Further there was no significant difference in the masticatory efficiency observed between canine protection and group function. This is because number of contacts did not significantly increase from canine protection to group function.

Woda (1979) stated that during unilateral mastication the chewing of the food was performed by working as well as non working side contacts. This imposes the distinction between the chewing and non chewing sides and the working and non working sides (kinematic). He stated that sliding during jaw closure occurred on working cusp surfaces and that sliding during jaw opening occurred on non working cusp surfaces, thereby demonstrating that cusp guiding occurs on non working as well as working cusp surfaces. This means that during chewing on the left side, mandible makes a lateral movement to the left, causing working contacts. Later the mandible crosses the median sagittal plane and, due to a slight lateral movement on the right, permits the teeth on the left side to establish non working side contacts, whereas by the position of bolus, the left side can still be defined as the working side. In fact, all the cusp surfaces on the side of the bolus participate in the mastication of food regardless of their kinematic situation (working or non working). Thus, during a functional left lateral mandibular movement, from a kinematic point of view there is a working relationship of the cusps on the left side and a non working relationship on the right side, whereas from functional point of view the side where the bolus is found should be called the chewing side and the other side should be non chewing. These findings indicate that non working side contacts play some role in masticatory efficiency even in unilateral chewing pattern. This maybe the possible reason that in our study balanced occlusion showed higher masticatory efficiency when compared to other lateral tooth contact patterns.

CONCLUSION

The following conclusions were arrived at from this study:

1. A variety of functional tooth contact patterns exist in the population of young adult patients. In this study 15% of the subjects exhibited canine protection, 55% group function and 30% balanced occlusion.

2. Different lateral tooth contact patterns may be the result of variation in dental morphology. Balanced occlusion exhibited minimum
horizontal and vertical overlap of incisors in the present study.

3. Canine protection occlusion had significantly lower mean masticatory efficiency than group function and balanced occlusion group. This signifies that the masticatory efficiency is dependent on lateral tooth contact patterns.

4. Masticatory efficiency is influenced by dental morphology. Individuals with large overjet tend to have decreased masticatory efficiency and with reduced overbite tend to have higher masticatory efficiency. Individuals with mesial occlusion had a tendency to have high masticatory efficiency when compared to distal occlusion. Hence it may be of significance while taking up cases for restoring lost occlusion.

5. The masticatory efficiency significantly had correlation with age and overjet, implying that individuals with larger overjet had low masticatory efficiency, but it increased with advancing age.

6. The present study showed 85% variation in the masticatory efficiency. It might be because of unexplained variables such as gender, biting force and masticatory muscle activity.

References:


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