Effect of Occlusal Scheme on the Pressure Distribution of Complete Denture Supporting Tissues: An In Vitro Study

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Introduction

The search for ideal tooth arrangement that maximizes the denture stability, comfort, esthetics, and function have occupied dental literature for many years and still continuing to do so. The occlusal contacts between the teeth during centric and eccentric movement of the mandible is very important and is directly related to the amount and the direction of the stresses that are to the remaining residual ridges. So, the choice of occlusal scheme is one of the major factors in the fabrication of complete dentures. Of the many occlusal schemes, bilateral balanced occlusion, monoplane occlusion, and lingualized occlusion are routinely incorporated in the dentures. This as an individual scheme represents a different concept of occlusion.

Masticatory forces encountered during chewing are transmitted through the occluding surfaces of the artificial teeth in denture to the supporting residual ridge tissues. The transmission of masticatory forces to the underlying ridge may be influenced by the size, form of the posterior teeth and the type of occlusal scheme incorporated in the complete denture. The way these masticatory forces are distributed along the underlying ridge may play an important role in maintaining the health of the supporting tissues under complete denture. There are several studies which have investigated the distribution of stresses under the dentures. A few studies have been reported in the literature which dealt with comparison of stress distribution in bilateral balanced occlusion, monoplane occlusion, and lingualized occlusion. This study provides an attempt at understanding the parameters of stress distribution on the ridge in three different occlusal schemes incorporated in the artificial denture. This was an in vitro study to investigate the pressure values on the supporting tissues under simulated dentures using different posterior occlusal schemes.

Materials and Methods

The simulators used in this study composed of the maxillary and mandibular clear heat cure acrylic resin edentulous models. Pressures on the supporting structure under the complete denture were measured using eight strain gauges placed on the model surface on the buccal and lingual slopes of the ridges on the molar and pre-molar region. Pressure on the supporting structure was measured and signals from the sensors were amplified and recorded by the multi-channel electronic strain indicator.

Results:
The mean pressure which was obtained at each measurement point was compared by one-way ANOVA test.

Conclusion: Overall monoplane occlusion had lesser pressure values compared to completely balanced and lingualized occlusal scheme. Lingualized occlusal scheme was found to transfer stresses from working side to non-working side to stabilize the mandibular denture.

Key Words: Balanced occlusion, complete denture, lingualized occlusion, monoplane occlusion
of the articulator, and the opposing ridges were in angles Class I relationship. The articulator was set with the sagittal and lateral path inclinations at 30° and 15°, respectively and with the sagittal and lateral inclination of the incisal guide table at 10° and 0°, respectively.

The residual ridge simulations were duplicated. These duplicated ridges were used to fabricate experimental dentures with interchangeable posterior teeth. A set of common complete denture base with the anterior teeth set (Vivodent DCL-A2; A56 and A4) was used to arrange the anteriors. Balancing was done in all eccentric movements on the articulator and these dentures with anterior teeth arrangement were processed using heat cure acrylic resin material (Heat Cure Acryln H – Denture Base Polymer). Then, they were finished and polished.

Over this common base with anterior teeth which were retrieved in heat cure acrylic resin material, reference grooves were made to reorient the interchangeable posterior set. The posterior occlusal form used in the study were (Ivoclar Vivadent): (1) The 30° anatomic teeth set (Postaris DCL-A2; PU3 and PL3) for conventional bilateral balanced occlusion, (2) ortholingual teeth set (Ortholingual DCL-A2; LU3 and LL3) for lingualized occlusion, and (3) the zero-degree teeth set (Orthoplane DCL-A2; MU3 and ML3) for monoplane occlusion.

These posterior interchangeable segments of the experimental dentures which were set in the three different schemes: Completely balanced occlusion, lingualized occlusion and monoplane occlusion, attained bilateral contact from the centric relation to all eccentric occlusal positions. They were then heat processed individually using heat cure acrylic resin material (Heat Cure Acryln H – Denture Base polymer). These posterior interchangeable segments were then finished and polished (Figure 1). Final balanced occlusion of posterior teeth was established by selective grinding in a semi-adjustable articulator.

**Method of attaching the strain gauge**

Pressures on the supporting structure under the complete denture were measured using 8 strain gauges placed on the model surface on the buccal and lingual slopes of the ridges on the molar, and pre-molar region (Figures 2 and 3). These strain gauges (FLA-SIL-II Tokyo Sokki Kenkyujo Co. Ltd., Tokyo, Japan) were 5.0 mm² in size and 0.5 mm thick. The strain gauges were bonded with adhesive material recommended by manufacture which was applied to their undersurface.

**Recording the pressure readings**

Pressure on the supporting structure was measured: (1) With teeth in centric occlusion, (2) with a 3 mm thick piece of rubber placed between the right posterior teeth while the condylar balls of the articulator were locked, and (3) with a 3 mm thick...
piece of rubber placed between the right posterior teeth in the eccentric position when the incisal guide pin of the articulator was 5 mm left latero to centric occlusion. A vertical static load of 100 N was applied to the center of the articulator, using a load application device (unconfined compression testing machine). The signals from the sensors were amplified and recorded by the multichannel electronic strain indicator (SI-33MS) (Figure 4). This load was based on the chewing force of the edentulous patient with complete dentures.

The recordings were repeated 5 times for each situation, and the mean pressure was calculated. The mean pressure which was obtained at each measurement point was compared by one-way ANOVA test. The comparison of the three different occlusal schemes was done using pairwise comparison of the three groups by Tukeys multiple post-hoc procedure tests.

**Results**

In the present study, the \( P < 0.05 \) were obtained by one-way ANOVA analysis and Tukeys multiple post-hoc procedure tests (Graphs 1-3) showed significant differences in the pressure distribution in various areas in centric, unilateral chewing and eccentric relation.

Graph 1a and b shows the pressure values on the supporting structure under the denture in centric occlusion. The pressure values at the buccal and palatal slope of the maxillary ridge ranged from 25.45 to 38.84 kPa and from 74.04 to 143.13 kPa, respectively. Regardless of the scheme of occlusion the pressure values at the palatal area were greater than those at the buccal area. The pressure values at the buccal and lingual slopes of the mandible ranged from 63.27 to 167.42 kPa and 73.02 to 91.64 kPa respectively. In the molar region, the pressure values at the buccal slope were twice those at the lingual slope regardless of the scheme of occlusion.

There was no significant difference in the pressure values under the maxillary and mandibular denture between completely balanced occlusion and lingualized occlusion. There was significant overall less pressure distribution in monoplane occlusion compared to completely balanced and lingualized occlusion.

**Graphs 1 and 2:**

Graph 1: (a) Comparison of three groups with pressure values on the upper buccal and palatal slopes in centric relation by one-way ANOVA, (b) comparison of three groups with pressure values on the lower buccal and lingual slopes in centric relation by one-way ANOVA.

Graph 2: (a) Comparison of three groups with pressure values on the upper buccal and palatal slopes in unilateral chewing by one-way ANOVA, (b) comparison of three groups with pressure values on the lower buccal and palatal slopes in unilateral chewing by one-way ANOVA.
Graph 2a and b shows the pressure distributions on the supporting structure when the rubber was placed in the right molar region. As compared with the pressure values in the centric occlusion the pressure values at all the measuring points were changed. The pressure at the buccal slope and the palatal slope of the maxillae on the working side ranged from 90.76 to 114.62 kpa and 174.84 to 196.95 kpa, respectively. Lower pressure values were observed in the maxillae on the non-working side ranging from 67.35 to 81.89 kpa at the palatal slope and 0 at the buccal slope. Mandibular working side pressure ranged from 51.93 to 179.49 kpa and non-working side values ranged from 8.58 to 131.64 kpa. Greater pressure values were found at the buccal area from pre-molar to molar on the working side.

The pressure values in completely balanced occlusion and monoplane occlusion were greater at the buccal slope on the working side. In contrast, there was significantly less pressure on the palatal slope of the molars on the non-working side. Beneath the mandibular denture, the pressure with completely balanced occlusion and monoplane occlusion was greater at the buccal slope on the working side and less at the lingual slope on the working side.

Graph 3a and b shows the pressure distributions on the supporting area when the rubber was placed on the right molar region during eccentric occlusion. The pressure values at the buccal slope and at the palatal slope ranged from 00.0 to 59.93 kpa and 77.53 to 175.56 kpa, respectively. On the non-working side the values in the palatal region ranged from 77.53 to 101.38 kpa. Only small pressure values were recorded on the buccal side values ranged from 8.29 to 114.62 kpa and 77.53 to 175.56 kpa, respectively. Lower pressure values at the buccal area ranged from 30.69 to 102.84 kpa and from 62.55 to 138.47 kpa on the lingual areas. On the non-working side greatest pressure values at buccal slope of the molar region than lingual slope of the pre-molar region.

A comparison was made between completely balanced, monoplane occlusion, and lingualized occlusion for pressure distribution. The pressure values in completely balanced and monoplane occlusion were greater at the buccal slope on the working side. Less pressure was found with completely balanced and monoplane occlusion at all non-working side.

**Discussion**

Masticatory stresses applied on the occlusal surface of an artificial denture are transmitted to the functional tissues. Previously numerous studies have demonstrated that different types of artificial posterior teeth are required depending on the architecture of the residual ridge. The basic concept of different occlusal schemes studied is to give importance to the preservation of the remaining residual ridge integrity and preventing it from undergoing further deterioration over time.

The topography and architecture of the remaining residual ridge tissue influences and dictates the type of occlusal scheme of the artificial teeth to be selected in a given clinical situation. The fundamental basis for selecting the type of occlusal scheme is the preservation of the existing foundational structure and providing factors favorable to enhance the stability of the artificial denture. The occlusal surface of the artificial denture encounters the masticatory forces. These forces are transmitted through the artificial denture base which is in close contact with the foundational tissue consisting of the bone and soft tissue covering. Depending on the type and shape of occlusal surface, masticatory forces are transmitted to the basal tissues differently. Furthermore, the bucco-lingual dimension and type of cusp of the artificial posterior teeth have an influence on stability of the denture. There are different occlusal scheme proponents such as bilateral balanced occlusion, lingualized occlusion, neurocentric occlusion, and monoplane occlusion. The basic guidelines for all of these occlusal schemes are centered around preservation of the remaining foundational ridge tissue and overcoming different destabilizing forces. This increases stability and support qualities in the artificial denture, controlling the amount and direction of forces reaching the underlying residual ridge tissue. Although there are several types of posterior teeth available to be selected in artificial denture, there are no tangible studies done which propagates any one type of posterior teeth as superior over the other form in terms of preserving the remaining residual ridge. There is a void in the clear guidelines as to which type of occlusal scheme is suitable in comparison to the other type of posterior teeth. This gap is the stimulus to undertake this study wherein an
attempt is being made to analyze the pressure values on the
tissue under simulated dentures using different posterior
occlusal schemes.

In this study, a single base with anterior teeth that were
common for all the three detachable posterior occlusal schemes
was used. By having a single base, any changes which might be
made on the base would produce the same change throughout
the investigation. Construction of the base was such that the
entire occlusal pattern could be placed in position or removed
from the base with ease and replaced with accuracy. For the
investigation to be valid, the posterior occlusal pattern being
tested could be the only variable. In order to accomplish this
result, a single mounting was used, so the vertical dimension, centric, and eccentric recording were identical. A single
common denture base with anterior teeth arranged was used
for all three detachable posterior schemes. For testing of
posterior occlusal patterns, this arrangement was satisfactory
which provided no change in the incisal guide angle. This is
necessary for testing of balanced occlusion.3

Pressure on the supporting structures under the complete
denture was measured using eight flexible strain gauges placed
on the model surface. Each strain gauge was 5.0 mm² in size
and 0.5 mm thick and, therefore, could fit the surface of the
residual ridge easily.

Pressure on the supporting structure was measured: (1) With
teeth in centric occlusion, (2) with a 3 mm thick piece of rubber
placed between the right posterior teeth while the condylar
balls of the articulator were locked, and (3) with a 3 mm thick
piece of rubber placed between the right posterior teeth in the
eccentric position.

The pressure recorded with the simulated dentures in centric
showed maximum pressure on the palatal slopes of upper
denture and buccal slopes of the molar region of the lower
denture in all the three types of occlusal schemes. The simulator
used in this study supported the hypotheses that stress bearing
area in the maxilla was residual ridge crest and the palatal rugae.
The mandibular stress bearing area being the external oblique
ridge or buccal shelf area.4,5

When the completely balanced occlusion was compared with
the lingu alized scheme of occlusion, there was no significant
difference in the recorded pressures during centric occlusion.
This may have been because the positions of the mandibular
posterior teeth of the two experimental dentures and the
point of occlusal force application were much the same. There
was significant overall less pressure distribution difference in
monoplane occlusion compared to completely balanced and
lingualized occlusion. These results supported the previous
study done by Swoope and Kydd6 where denture base
deformation was related to the different cusp form and occlusal
surface area of the artificial teeth. Reduction of the angle of the
cusp of artificial posterior teeth resulted in significant decrease
in pressure values of the complete denture base. Sharry et al.7
and associates demonstrated on dry skulls that more stresses
were placed on the bone with dentures of cusps teeth than with
zero-degree teeth.

When unilateral mastication was simulated, a very low pressure
was recorded on the maxillary buccal slopes of the non-working
side in all the three types of occlusal scheme. This indicated
that the denture moved from ridge crest. These results were
supported by the study done by Frechette et al.8 where, it was
studied that with each denture, pressures on the residual ridge
of the working side increased 30-80% in unilateral chewing.
And also there was decrease in the number of positive pressure
strokes on the balancing side during unilateral chewing.
Another study by Frechette et al.9 compared balanced and non-
balanced occlusion of artificial dentures based on distribution
of masticatory forces. This study showed that there was an
almost complete lack of positive pressure at the non-working
buccal flange. However, this did not happen in the mandibular
denture, as some pressure was observed at all measuring points.
This indicated that the mandibular denture had functional
lever balance.10

When the three occlusal schemes were compared with
unilateral chewing, there were no significant difference in
the upper denture, but the lower denture showed significant
differences. There were higher pressure values on the
mandibular buccal and lingual slopes of the non-working side
in lingu alized occlusion when compared with completely
balanced and monoplane occlusion. These results indicated
that lingu alized occlusion allowed the occlusal force to be
exerted forward to the lingual side and to spread to the non-
working side in the mandibular lower denture. These results
were supported by a similar study done by Inoue et al.10 where
lingualized occlusion was found to transfer stresses from the
occluding side to the opposite non-working side to stabilize
the mandibular denture.

When the three occlusal schemes were compared with
unilateral eccentric chewing, there were significant differences
in the upper buccal slopes, and lower buccal and lingual slopes
of non-working side between completely balanced, lingu alized,
and monoplane occlusion. The pressure values recorded on
the buccal slope of the molar region on working side were
highest, followed by lingual slopes of the non-working side.
The lingual slopes of working and buccal slopes on the non-
working side at molar region were significantly decreased
with lingu alized occlusion. These results indicated that the
lingualized occlusion provided a resultant force lingual to
the ridge crest to increase lever stability for the mandibular
denture.10 Kimoto et al. did a study to compare the lingu alized
and bilateral balanced occlusion on 28 patients, and the study
concluded that lingu alized occlusion patients experienced
greater satisfaction with retention of their denture than bilateral
balanced occlusion patients. However, the study was done by Sutton and McCord in a randomized cross-over controlled trial where subject satisfaction was evaluated with three different occlusal scheme dentures and did not find much significant difference between conventional and lingualized occlusion. Clough et al. reported the preference of the complete denture with lingualized occlusion over monoplane occlusion on patient perception with superior masticatory ability.

Some of studies describe the functional superiority of conventional balancing to that of lingualized occlusion. Most of the edentulous patients present with different alveolar bone resorption patterns, atrophic mucosa and abnormalities of the maxillomandibular relation where fabrication of conventional balanced occlusion becomes difficult. Lingualized occlusion allows easier teeth arrangement and equilibration, so lingualized occlusion is more suitable in these cases than full balanced occlusion, which needs a strict occlusal relationship.

The findings of this study tend to support Parr and Ivanhoe's lingualized occlusion review. The lingualized occlusion concept is simple, adaptable to many different clinical situations and easy to obtain contact between the maxillary lingual cusp and the opposing fossa on the working and non-working side.

**Conclusion**

Pressure distribution in completely balanced, lingualized and monoplane occlusal schemes were compared. Within the limitations of this study the following conclusions can be drawn:

1. In centric occlusion, the maxillary pressure values were greater on the palatal slopes than on the buccal slopes. The greatest pressure values were found on palatal slopes of pre-molar. In the mandibular molar region, the pressure values were greater at the buccal slopes as compared to that of lingual, regardless of the scheme of occlusion. Overall monoplane occlusion had lesser pressure values compared to completely balanced, and lingualized occlusal scheme.

2. With simulated unilateral mastication, the pressure was increased on the maxillary working side and decreased on the non-working side. A very minimum or no pressure was observed on the buccal slopes of the non-working side. In the mandible, increased pressure was recorded at the lingual slope on the working side and at the buccal slope on the non-working side. Decreased pressure were found at the buccal slope on the working and non-working side when using the lingualized occlusal scheme as compared to completely balanced and monoplane occlusion.

3. With simulated unilateral mastication in eccentric occlusion, the pressure on the maxillary side was increased. A small amount of pressure was observed at the buccal slope on the non-working side. In the mandible, maximum pressure was observed at the buccal slope of the molar region. On the non-working side, the maximum pressure was observed at the lingual slopes when using the lingualized occlusal scheme as compared to completely balanced and monoplane occlusion.

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