A Clinico-radiographic Evaluation of Relation between Neutral Zone and Crest of Mandibular Residual Alveolar Ridge with Different Duration of Edentulousness

Jitendra J Mete¹, Santosh Y Dixit², Sumit J Deshpande³, Harshad Wagaj⁴, Pravin Gaikwad⁵

Introduction
Complete denture prosthesis is a primarily mechanical artificial device used to rehabilitate the handicapped edentulous jaws, i.e., a mechanical device is used to function in biological environment. For prosthesis to function properly in the oral cavity, it must be in harmonious relation with orofacial neuromusculature. Speech, mastication, swallowing, smiling, and laughing involve the synergistic actions of the tongue, lips, cheeks, and floor of the mouth which are very complex and highly individual. Improper tooth position, flange form and contour not in harmony with orofacial musculature often results in dentures which are unstable and unsatisfactory, even though they were skillfully designed and expertly constructed. Harmony between complete denture and neuromuscular function is the foundation of successful, stable denture.¹

Continuous resorption of the residual alveolar ridge and the forces from perioral musculature impose challenges in determining the tooth position.² Sir E. Wil – Ford Fish introduced the concept of neutral zone in complete denture in the year 1931. According to him, the natural teeth occupy a “zone of equilibrium” with each natural tooth assuming a position that is the resultant of various forces acting on it.³⁴ Russel and Robert termed it as “Reciprocal space” and “Potential space,” respectively. It has been variously termed as “Dead space,” “Zone of minimal conflict,” “Denture space,” “Reciprocal zone,” and “Zone of neutral muscular function.”⁶⁻⁹

However, this thought evoked controversial opinions and arguments. While many authorities said that the artificial teeth should be positioned where the natural teeth grew,¹⁰,¹¹ Lawrence stated that the buccal cusps and fossae of the posterior teeth should be directly over the crest of the alveolar ridge. This is said to result in more stability and less lateral forces since the occlusal pressure on the tooth falls close to the fulcrum and creates little or no torque.¹²

Conclusion: With increase in duration of edentulousness, there is a more lingual positioning of neutral zone in relation to crest of residual alveolar ridge in mandibular molar regions, more labial positioning of the neutral zone with respect to crest of the residual alveolar ridge in mandibular anterior region.

Key Words: Duration of edentulousness, mandibular denture, neutral zone, teeth arrangement

Materials and Methods: A total of 60 completely edentulous subjects were selected as subject for the study and were divided into three groups (20 in each group), depending on their duration of edentulousness - Group I: Edentulous for 6 months to 2 years, Group II: Edentulous for 2-5 years, and Group III: Edentulous for more than 5 years. Neutral zone was functionally recorded using impression compound at the predetermined vertical dimension of occlusion. Two different gauge wires were adapted and stabilized on the crest of residual alveolar ridge of mandibular cast and the center of neutral zone record rim. Occlusal radiographs were taken of each cast with the neutral zone record rim. Radiographs were studied for the buccolingual relation of the neutral zone and the crest of residual alveolar ridge with different duration of edentulousness.

Results: Mean lingual shift of neutral zone with respect to center of crest of the alveolar ridge in mandibular right molar region is −0.8, −2.05, and −3.60 mm for Groups I, II, and III, respectively. The mean lingual shift of neutral zone with respect to center of crest of the alveolar ridge in mandibular left molar region is −0.9, −1.90 mm, and −3.30 mm for Groups I, II, and III, respectively. Mean labial shift of neutral zone with respect to center of crest of the alveolar ridge in mandibular anterior region is 1.95, 2.95, and 4.65 mm for Groups I, II, and III, respectively.

Background: The location of neutral zone in relation to crest of ridge varies from individual to individual depending on the duration of edentulousness. The aim of this study was to determine and to compare the position of neutral zone in relation to crest of mandibular residual alveolar ridge with different duration of edentulousness. J Int Oral Health 2016;8(9):916-921.

Abstract
Background: The location of neutral zone in relation to crest of ridge varies from individual to individual depending on the duration of edentulousness. The aim of this study was to determine and to compare the position of neutral zone in relation to crest of mandibular residual alveolar ridge with different duration of edentulousness. J Int Oral Health 2016;8(9):916-921.

Materials and Methods: A total of 60 completely edentulous subjects were selected as subject for the study and were divided into three groups (20 in each group), depending on their duration of edentulousness - Group I: Edentulous for 6 months to 2 years, Group II: Edentulous for 2-5 years, and Group III: Edentulous for more than 5 years. Neutral zone was functionally recorded using impression compound at the predetermined vertical dimension of occlusion. Two different gauge wires were adapted and stabilized on the crest of residual alveolar ridge of mandibular cast and the center of neutral zone record rim. Occlusal radiographs were taken of each cast with the neutral zone record rim. Radiographs were studied for the buccolingual relation of the neutral zone and the crest of residual alveolar ridge, depicted by different gauge wires, in anterior, premolar and molar region. The data obtained was subjected to statistical analysis using the Kruskal–Wallis H-test.
Supporters of neutral zone concept stated that invariably arranging the teeth over the crest of the residual ridge condemned patients by accentuating facial deformity, provoking phonetic problems, making food manipulation difficult during deglutition and because of instability of the mandibular denture. They were of the opinion that contraction of muscles developed forces directed against denture which will either help to stabilize it or tend to dislodge it.

The extraction of teeth causes loss from the buccal side of maxillary alveolar ridge and from the lingual side of mandibular alveolar ridge, leading to smaller maxillary and larger mandibular residual ridges. Thus, the residual alveolar ridge crest changes its location in a buccolingual direction after resorption. In addition, tongue has tendency to enlarge in edentulous mouth, together influencing the buccolingual position of the neutral zone.

Hence, the study was planned to determine and to compare the position of neutral zone in relation to crest of mandibular residual alveolar ridge with different duration of edentulousness to develop the guidance for proper positioning of artificial denture teeth.

Materials and Methods

Protocol of the study was presented before and approved by the ethical review board of the institute. Completely edentulous healthy patients, visiting to Department of Prosthodontics, with the history of edentulousness from 6 months to 12 years were selected as study participants. After case history and clinical examination, detailed procedure was explained to the patients and consent was obtained. These subjects were divided into three groups:

- **Group I:** 20 subjects edentulous for 6 months to 2 years
- **Group II:** 20 subjects edentulous for 2 to 5 years
- **Group III:** 20 subjects edentulous for more than 5 years.

The exclusion criteria were as follows:

- Subjects with major osseous surgery or any congenital or acquired osseous abnormality of orofacial region
- Subjects with flabby ridges
- Subjects with any pathology of tongue leading to enlargement of tongue
- Subjects exhibiting disorders or enlargement of orbicularis oris
- Subjects with oral submucous fibrosis
- Subjects with a history of rapid attrition of artificial teeth.

The neutral zone was recorded using impression compound (MDM Corporation, India) softened in water bath at 55-60°C by instructing the patient to do following actions till the compound hardened.

- Protrude the tongue, and touch the corners of mouth with the tongue.
- Swallow.
- Pronounce vigorously “DE, TE, ME, PE, SE, SIS, SO.”

The height of compound rim was reduced to the height 2/3rd of retromolar pads and the corners of the mouth with the help of sharp knife and sand paper (size: 400 fine, 3M ESPE). The crest of the residual alveolar ridge of the final casts was then trimmed about 1 mm using a sharp knife. A 30-gauge stainless steel wire was adapted and stabilized along the crest of the residual alveolar ridge (Figure 1). The center of the buccolingual width of each compound rim was marked along its length and a 28-gauge stainless steel wire was adapted and stabilized over the center of each rim (Figure 2). The wires were stabilized using adhesive cello tape.

Recording bases were repositioned on the master cast and occlusal view radiographs were obtained of each record base and its cast using ultra speed films (57 mm × 76 mm, Kodak Insight, India). The object to source distance was 8 inch and the central was directed at the center of the cast.
parameters used were 70 kV voltage, 8 mA current and 2.5 s impulse. All the films were developed in X-ray processor. Films were studied for the relationship between the images of two wires in a buccolingual direction with 30-gauge wire representing crest of alveolar ridge and 28-gauge wire representing center of neutral zone (Figure 3). Measurements were made at five regions right molar, right premolar, anterior, left premolar, and left molar with a millimeter ruler. Where the images of two wires coincided, a zero score was assigned. Buccal/labial location of neutral zone with respect to ridge was assigned positive value and lingual location was assigned negative value.

Data collected from 60 subjects was statistically analyzed using Kruskal–Wallis $H$ test and Chi-square test. All the statistical analyses were performed using statistical software (Graph Pad Prism 5 for windows) and Microsoft excel. A value of $P < 0.05$ was considered statistically significant.

**Results**

It is observed that as the duration of edentulousness increases, there is a significant lingual shift of neutral zone with respect to center of crest of the alveolar ridge in both mandibular right and left molar region (Tables 1 and 2). The mean lingual shift of neutral zone with respect to center of crest of the alveolar ridge in mandibular right molar region is $-0.8$, $-2.05$, and $-3.60$ mm for Groups I, II, and III, respectively (Table 1). Mean lingual shift of neutral zone with respect to center of crest of the alveolar ridge in mandibular left molar region is $-0.9$, $-1.90$, and $-3.30$ mm for Groups I, II, and III, respectively (Table 2).

In premolar region, there is no significant shift of neutral zone with respect to center of crest of the alveolar ridge with increase in duration of edentulousness (Tables 3 and 4). At right premolar region, it is observed that the neutral zone in 23.33% locations is lingual to center of crest of residual alveolar ridge, 21.26% locations is buccal to center of crest of residual alveolar ridge and located and 55% locations is coinciding with center of crest of residual alveolar ridge (Table 3). At left premolar region, it is observed that the neutral zone in 20% locations is lingual to center of crest of residual alveolar ridge, 16.66% locations is buccal to center of crest of residual alveolar ridge, and 63.33% locations is coinciding with center of crest of residual alveolar ridge (Table 4).

In mandibular anterior region, there is significant labial positioning of the neutral zone with respect to crest of the alveolar ridge with increase in duration of edentulousness. The mean labial shift of neutral zone with respect to center of crest of the alveolar ridge in mandibular anterior region is

![Figure 3: Occlusal radiograph showing relation between two wires.](image-url)
Table 4: Percentage count of neutral zone locations with different duration of edentulousness at left premolar region.

<table>
<thead>
<tr>
<th>Duration of edentulousness (years)</th>
<th>Lingual (% count)</th>
<th>Buccal (% count)</th>
<th>Coinciding (% count)</th>
<th>Total (% count)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>4 (20)</td>
<td>3 (15)</td>
<td>13 (65)</td>
<td>20 (100)</td>
</tr>
<tr>
<td>2.5</td>
<td>4 (20)</td>
<td>3 (15)</td>
<td>13 (65)</td>
<td>20 (100)</td>
</tr>
<tr>
<td>More than 5</td>
<td>4 (20)</td>
<td>4 (20)</td>
<td>12 (60)</td>
<td>20 (100)</td>
</tr>
<tr>
<td>Total (% count)</td>
<td>12 (20)</td>
<td>10 (16.66)</td>
<td>38 (63.33)</td>
<td>60 (100)</td>
</tr>
</tbody>
</table>

χ²=0.25, P=0.99, not significant

Table 5: Mean, standard deviation, maximum and minimum value of neutral zone with different duration of edentulousness in anterior region.

<table>
<thead>
<tr>
<th>Duration of edentulousness (years)</th>
<th>N</th>
<th>Mean ± Standard deviation</th>
<th>Minimum value (mm)</th>
<th>Maximum value (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>20</td>
<td>1.95±2.064</td>
<td>-2</td>
<td>5</td>
</tr>
<tr>
<td>2.5</td>
<td>20</td>
<td>2.95±2.460</td>
<td>-2</td>
<td>5</td>
</tr>
<tr>
<td>More than 5</td>
<td>20</td>
<td>4.65±0.933</td>
<td>2</td>
<td>6</td>
</tr>
</tbody>
</table>

H=20.62, P=0.0001, highly significant

1.95, 2.95, and 4.65 mm for Groups I, II, and III, respectively (Table 5).

Discussion

This study evaluated changes in neutral zone position in buccolingual direction in relation to crest of mandibular residual alveolar ridge in three groups with different duration of edentulousness at right and left molar, premolar, and anterior region. An effort was made to generalize a pattern of shift to form a basis for positioning of teeth in reference to duration of edentulism.

On analyzing the results, the position of neutral zone with different durations of edentulousness in mandibular molar region showed trend of lingual shift with increasing duration of edentulousness. This result is in agreement with Martone and Demirel and Oktemer. Lingual positioning of neutral zone may result because of aging facial changes, and the mandibular posterior residual alveolar ridges resorption pattern, i.e., resorption primarily from vertical and lingual side with resultant buccal shift of crest of residual alveolar ridge in molar region. Prolonged periods of edentulism may result in sagging of the facial musculature. In mandibular molar area, adjacent buccinator fibers run horizontally downward and forward. Edentulism eliminates the tooth and alveolar bone support of the buccinator fibers. McGregor suggested shortening of buccinator fibers in the absence of dental bulge. This may result in distortion of facial curtain. On contraction buccinators direct the forces further lingually. Consequently, neutral zone may be placed more lingually in posterior segment. Fahmi concluded that in mandibular posterior region, neutral zone was located more buccally by 1.05 mm to 2.388 mm in prolonged edentulous periods. Fahmi’s study found different results from this study. This may be due to the differences in methods. Sample size for longer edentulous periods was relatively small (N = 9) in Fahmy’s study. This study had the larger sample size (N = 20) for each group.

8 subjects (40%) in the study Group I, where the period of edentulousness is within 6 months and 7 subjects (35%), where period of edentulousness is within 1 year. In total, 15 subjects (75%) are within 1 year of period of edentulousness, period of edentulousness could be one of the reasons that 55% shown lingual position of the neutral zone. The results have shown a trend of lingual positioning of neutral zone increasing to 75% in Group II and 92.5% in Group III. Small percentage of buccal positioning of neutral zone may be attributed to increased muscular forces from the tongue muscles and decreased muscular forces from cheek muscles.

Statistical analysis by Chi-square test (χ² = 0.47, P = 0.97) showed the buccal and lingual positioning of the neutral zone in premolar region has no significant trend. This is in agreement with the Lawrence, and reflects the mandibular residual alveolar ridges resorption pattern, i.e. resorption primarily from vertical side in premolar region.

The position of neutral zone with different duration of edentulousness in mandibular anterior region showed a trend of labial shift in relation to crest of residual alveolar ridge with increasing duration of edentulousness. This finding is in agreement with the Lawrence, and reflects the mandibular residual alveolar ridges resorption pattern, i.e., resorption primarily from vertical and labial side with resultant lingual shift of crest of residual alveolar ridge in anterior region.

It is a well-established fact that the mandible usually exhibits atrophy to a much greater extent than the maxillae, mainly due to change in blood supply that occurs with the increasing age following the process of bone resorption. The advanced resorption not only decreases the denture bearing area but also moves mandibular ridge buccally. However, residual ridge resorption being multifactorial, the amount of ridge resorption and shift of residual ridge varies from patient to patient.

Limitations

Limitations of this study are as follows:

- Study involved only healthy subjects with normal neuromuscular function, without any congenital or
acquired intraoral and facial osseous abnormalities. Hence, the results and inferences drawn from these results are not applicable to subjects with congenital or acquired osseous abnormalities, abnormal neuromuscular functions, pathologies of tongue, restricted mouth opening, oral submucous fibrosis, and facial asymmetry.

- Impression compound is used in the present study for recording of neutral zone. Other materials like soft wax, a polymer of dimethyl siloxane filled with calcium silicate, silicone, and tissue conditioners and resilient lining materials have been suggested for recording of neutral zone. Makzoumé has showed that neutral zone varies morphologically with different materials and techniques used in his study. Hence, the furthore studies comparing position of neutral zone in relation to crest of mandibular residual alveolar ridge with different duration of edentulousness using other materials and techniques will be helpful.

Conclusions
Within the limitations of this study the following conclusions can be drawn:

- With increasing duration of edentulousness, there is more lingual positioning of neutral zone in relation to crest of residual alveolar ridge in mandibular molar regions
- Neutral zone locations with different duration of edentulousness in mandibular premolar region have no significant shift in buccal-lingual directions in relation to crest of residual alveolar ridge as the duration of edentulousness increases
- With increase in duration of edentulousness, there is more labial positioning of the neutral zone with respect to crest of the residual alveolar ridge in mandibular anterior region
- The location of neutral zone varies from individual to individual depending on their musculature. One need not necessarily follow the pattern of teeth arrangement relating to the crest of the ridge only but also should follow pattern dictated by the musculature that not only help in achieving more favorable forces exerted by musculature for denture retention and stability, but will also prevent the teeth from interfering with normal muscle function.

References