Original Article

To determine and compare the position of neutral zone in relation to crest of mandibular alveolar ridge with different duration of edentulousness: A clinico–radiographic study

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INTRODUCTION

Complete denture prosthesis is a primarily biomechanical artificial device that is fit in the edentulous mouth to rehabilitate the handicapped edentulous jaws and to function with good retention and stability. This prosthesis functions in the oral cavity; hence, it must be fashioned such that it is in harmony with normal neuromuscular function.[1] Successful treatment of patients with complete denture depends on the proper positioning of artificial teeth in relation to the basal seat and surrounding tissue.[2]

It was Sir E. Wilfred Fish who introduced the concept of neutral zone in complete denture as early as in the year 1931. He argued that the natural teeth occupy a “zone of equilibrium,” with each tooth assuming a position that is the resultant of various forces acting on it.[3,4] Since then, many others have helped to advance and develop both the theoretical basis and the practical problems. Russel termed it as “Reciprocal space,”[5] Robert called it the “Potential space,”[6] while others named it as “Dead space,” “Zone of minimal conflict,” “Denture space,” “Reciprocal zone”[7] and “Zone of neutral muscular function.”[8]

This study was undertaken to establish a relation between the crest of alveolar ridge and functionally obtained neutral zone and to determine the effect of duration of edentulousness on the location of neutral zone in relation to the crest of residual alveolar ridge.

Abstract

Purpose: The purpose of this study was to establish a relation between the crest of alveolar ridge and functionally obtained neutral zone and to determine the effect of duration of edentulousness on the location of neutral zone in relation to the crest of residual alveolar ridge. Materials and Methods: The study included three groups: Group I–15 subjects edentulous for 0 months to 2 years; Group 2–15 subjects edentulous for 2–5 years; and Group 3–15 subjects edentulous for more than 5 years. Neutral zone recording was performed for each subject and the buccolingual relationship of the crest of the mandibular alveolar ridge and position of the neutral zone was examined. The results were analyzed by the Kruskal–Wallis H test and the Chi-square test. Results: The results suggested that the location of the neutral zone varies from individual to individual depending on their musculature and that there is a significant relation to the duration of edentulousness. As edentulousness increases, there is more lingual positioning of the neutral zone at the molar region of both sides of the arch. At the premolar region, there is no change in position of the neutral zone; it remains constant as resorption of the alveolar ridge is directly under the buttress. In the anterior region, there is more labial positioning of the neutral zone as edentulousness increases. Conclusions: This technique proves itself to be an easy and inexpensive way to determine the relationship between the crest of alveolar ridge and neutral zone. Incorporating this technique into practice will be a great aid that can be exploited by the clinicians for functional and psychological comfort of the patients.

Key words: Completely edentulous, neutral zone, perioral musculature
duration of edentulousness on the location of neutral zone in relation to the crest of the mandibular residual alveolar ridge.

**MATERIALS AND METHODS**

Included in this study were 45 completely edentulous healthy subjects treated in the A.B. Shetty Memorial Institute of Dental Sciences, Deralakatte, Mangalore, Karnataka, India.

These subjects were divided into three groups:
- Group 1: 15 subjects edentulous for 0 months to 2 years
- Group 2: 15 subjects edentulous for 2–5 years
- Group 3: 15 subjects edentulous for more than 5 years.

The mandibular master casts are obtained and duplicated with reversible hydrocolloid impression material (Agar-agar) (Castogel, Bego, Germany) and poured with type III dental stone (Kalstone, Kalabhai Karson Pvt. Ltd., Mumbai, India) to obtain a pair of master casts. These casts are modified at the crest of the ridge for adaptation of wire and blocked out with modeling wax (Hindustan Dental Products, Hyderabad, India) to obtain a pair of master casts. These casts are modified at the crest of the ridge for adaptation of wire and blocked out with modeling wax (Hindustan Dental Products, Hyderabad, India), followed by record base made using autopolymerizing acrylic resin (DPI-RR Cold Cure, Mumbai, India) using the sprinkle-on method. Following this, the record bases are tried in the patient’s mouth and checked for extensions, retention, stability and comfort.

The neutral zone was recorded using low fusing impression compound [Figure 1] (DPI PINNACLE, Mumbai, India). The height of the compound rim was leveled with height 2/3rd of the retromolar pads and the corners of the mouth with the help of a sharp knife and sand paper (size: 400 fine). The crest of the alveolar ridge of the final casts was then trimmed about 1 mm using a sharp knife.

A 36-gauge stainless steel wire (Sendent S.S. wire soft) was adapted and stabilized along the center of the alveolar ridge [Figure 2]. The center of the buccal-lingual width of each compound rim was marked along its length and a 26-gauge stainless steel (Sendent S.S. wire soft) was adapted and stabilized over the center of each rim [Figure 3]. The wires were stabilized using cyano-acrylate resin. Two different gauge wires are used for radiographic interpretation.

The recording base was repositioned on the master cast and occlusal view radiographs (X-Mind, Satelec Z.I., France) were obtained [Figure 4] of each record base and its cast using ultraspeed films (57 mm × 76 mm). The object to source distance was 8 inches and the central was directed at the center of the cast. Exposure parameters used were 70 kV voltage, 8 mA current and 2.5 s impulse. All the films were developed in an X-ray processor.

The films were viewed in a viewing box to determine the relationship between the images of two wires in a buccal-lingual direction, with the thinner wire representing the crest of the alveolar ridge and the thicker wire denoting the center of the neutral zone [Figure 5]. Where the two images coincided, a zero score was assigned. Buccal/labial location of the neutral zone with respect to the ridge was assigned a positive value and the lingual location was assigned a negative value. Measurements were made with a millimeter ruler to an accuracy of 0.5 mm.

The basic data collected from 45 subjects were subjected to statistical analysis by using the
Kruskal–Wallis H test and the Chi-square test. All the statistical analyses were performed using SPSS version 15 and Microsoft Excel software. A value of $P < 0.05$ was considered to be statistically significant.

**RESULTS**

The study involved estimate the position of the neutral zone and its relation to the crest of the mandibular alveolar ridge in completely edentulous subjects at different periods of edentulousness for three age groups: Group I (0 months to 2 years), Group II (2–5 years) and Group III (>5 years) at five locations – left molar, left premolar, anterior region, right premolar and right molar.

Table 1 shows the position of the neutral zone in relation to the alveolar crest ridge for Group I. At the left molar region, left premolar region, anterior region, right premolar region and right molar region, the mean values of the neutral zone in relation to the crest of the mandibular alveolar ridge are -0.83 mm, 0.00 mm, 1.46 mm, -0.06 mm and -0.63 mm, respectively, with mean duration of edentulousness of 0.93 years.

Table 2 shows the position of the neutral zone in relation to the alveolar crest ridge for Group II. At the left molar region, left premolar region, anterior region, right premolar region and right molar region, the mean values of the neutral zone in relation to the crest of the mandibular alveolar ridge are -2.26 mm, -0.06 mm, 1.8 mm, -0.06 mm and -2.06 mm, respectively, with mean duration of edentulousness of 3.23 years.

Table 3 shows the position of the neutral zone in relation to the alveolar crest ridge for Group III. At the left molar region, left premolar region, anterior region, right premolar region and right molar region, the mean values of the neutral zone in relation to the crest of the mandibular alveolar ridge are -3.6 mm, 0.00 mm, 3.3 mm, 0.00 mm and -3.8 mm, respectively, with mean duration of edentulousness of 8.5 years.

At the left molar region, 60% of the subjects showed lingual positioning of the neutral zone in Group I, and the percentage increased to 80% in Group II and 93.3% in Group III, which is highly significant ($P = 0.002$) [Table 4]. At the right molar region, 53.3% of subjects showed lingual positioning of neural zone in Group I, and the percentage increased to 80% in Group II and 93.3% in Group III, which is highly significant ($P = 0.001$) [Table 5]. The correlation of percentage count of neutral zone locations with different durations of edentulousness at the right and left molar regions is shown in Graph 1.

At the left premolar region, 73.3% of subjects showed position of neutral zone coinciding with
Table 1: Position of neutral zone in relation to the alveolar ridge crest in different locations for 0 months to 2 years of edentulousness

| No. of subjects | Period of edentulousness (years) | Left molar region (mm) | Left premolar region (mm) | Anterior region (mm) | Right premolar region (mm) | Right molar region (mm) |
|-----------------|---------------------------------|------------------------|--------------------------|---------------------|--------------------------|------------------------|
| 1               | 0.5                             | -3.5                   | 0                        | 2.5                 | 0                        | -3                     |
| 2               | 0.5                             | -2                     | 1                        | 2                   | 0                        | -2.5                   |
| 3               | 1                               | -3                     | 0                        | 3                   | 0                        | -2                     |
| 4               | 1.5                             | -2.5                   | 0                        | 1                   | 1                        | -1                     |
| 5               | 1                               | 1                      | 0                        | 2                   | -1                       | 0                      |
| 6               | 0.5                             | 1                      | -1                       | 1                   | 0                        | -2                     |
| 7               | 0.5                             | -1                     | 0                        | 3                   | -1                       | 1                      |
| 8               | 1.5                             | 2                      | 0                        | 1                   | 0                        | 2                      |
| 9               | 1.5                             | 2                      | 0                        | 2                   | 0                        | 2                     |
| 10              | 0.5                             | -2                     | 0                        | 2                   | 0                        | -3                     |
| 11              | 1                               | -3                     | 1                        | 3                   | 1                        | -2                     |
| 12              | 1.5                             | -2                     | 1                        | -2                  | 0                        | -2                     |
| 13              | 0.5                             | -3.5                   | 0                        | -3                  | -1                       | 2                     |
| 14              | 1                               | 2                      | 0                        | 1                   | 0                        | 1                     |
| 15              | 1                               | 2                      | 0                        | 3                   | 0                        | 2                     |
| Total           | 14                              | -12.5                  | 0                        | 21.5                | -1                       | 9                     |
| Mean            | 0.93                            | -0.83                  | 0.00                     | 1.46                | -0.06                    | -0.63                  |

Table 2: Position of neutral zone in relation to the alveolar ridge crest in different locations for 2-5 years of edentulousness

| No. of subjects | Period of edentulousness (years) | Left molar region (mm) | Left premolar region (mm) | Anterior region (mm) | Right premolar region (mm) | Right molar region (mm) |
|-----------------|---------------------------------|------------------------|--------------------------|---------------------|--------------------------|------------------------|
| 1               | 2                               | -2                     | 0                        | 3                   | 0                        | -4                     |
| 2               | 3                               | -4                     | 1                        | 3                   | 0                        | -3                     |
| 3               | 4                               | -3                     | 0                        | 3                   | 0                        | -2                     |
| 4               | 4.5                             | 2                      | 0                        | 1                   | -1                       | 2                     |
| 5               | 2.5                             | -3                     | -1                       | 2                   | 1                        | -3                     |
| 6               | 4.5                             | -4                     | 0                        | 1                   | 0                        | -2                     |
| 7               | 3                               | -5                     | 0                        | -2                  | 0                        | -3                     |
| 8               | 3                               | -2                     | 0                        | 1                   | 0                        | -4                     |
| 9               | 3                               | -3                     | -1                       | 2                   | 0                        | -3                     |
| 10              | 2.5                             | 1                      | 0                        | 4                   | -1                       | 2                     |
| 11              | 2.5                             | -5                     | 0                        | 3                   | 0                        | -3                     |
| 12              | 4                               | -3                     | 1                        | 1                   | 0                        | -4                     |
| 13              | 4.5                             | -2                     | -1                       | 2                   | 1                        | -3                     |
| 14              | 3                               | 2                      | 0                        | 1                   | -1                       | -2                    |
| 15              | 2.5                             | -3                     | 0                        | 2                   | 0                        | 1                     |
| Total           | 48.5                            | -32                    | -1                       | 27                  | -1                       | -31                    |
| Mean            | 3.23                            | -2.26                  | -0.06                    | 1.8                 | -0.06                    | -2.06                  |

Table 3: Position of neutral zone in relation to the alveolar ridge crest in different locations for more than 5 years of edentulousness

| No. of subjects | Years of edentulousness (years) | Left molar region (mm) | Left premolar region (mm) | Anterior region (mm) | Right premolar region (mm) | Right molar region (mm) |
|-----------------|---------------------------------|------------------------|--------------------------|---------------------|--------------------------|------------------------|
| 1               | 5.5                             | -4                     | -1                       | 3                   | -1                       | -4                     |
| 2               | 7                               | -5                     | 0                        | 4                   | 0                        | -6                     |
| 3               | 8                               | -3                     | 1                        | 2                   | 0                        | -4                     |
| 4               | 9                               | -3                     | 0                        | 5                   | 0                        | -5                     |
| 5               | 6                               | -6                     | 0                        | 3                   | 0                        | -3                     |
| 6               | 10                              | 3                      | 0                        | 6                   | 1                        | 2                     |
| 7               | 12                              | -5                     | 0                        | 3                   | 0                        | -4                     |
| 8               | 7                               | -4                     | -1                       | 3                   | 0                        | -6                     |
| 9               | 8.5                             | -5                     | 0                        | 4                   | 0                        | -3                     |
| 10              | 8                               | -4                     | 0                        | 4                   | 0                        | -3                     |
| 11              | 9                               | -3                     | 1                        | 3                   | -1                       | -5                     |
| 12              | 10                              | -2                     | 0                        | 2                   | 0                        | -3                     |
| 13              | 11                              | -5                     | 0                        | 5                   | 0                        | -4                     |
| 14              | 7                               | -6                     | 0                        | 1                   | 1                        | -5                     |
| 15              | 10                              | -3                     | 0                        | 2                   | 0                        | -4                     |
| Total           | 128                             | -55                    | 0                        | 50                  | 0                        | -57                    |
| Mean            | 8.5                             | -3.6                   | 0.0                      | 3.3                 | 0.0                      | -3.8                   |
the crest of the ridge in Group I, 66.7% in Group II and 73.3% in Group III. 15.6% of subjects showed lingual positioning and 13.3% showed buccal positioning. On statistical analysis by the Chi-square test \((\chi^2 = 0.348, P = 0.986)\), it was shown that the buccal and lingual positioning of the neutral zone had no trend [Table 6]. At the right premolar region, 66.7% of subjects showed position of neutral zone coinciding with the crest of the ridge in Group I, 66.7% in Group II and 73.3% in Group III. 17.8% of subjects showed lingual positioning and 13.3% of subjects showed buccal positioning. On statistical analysis by the Chi-square test \((\chi^2 = 0.315, P = 0.989)\), it was shown that the buccal and lingual positioning of the neutral zone had no trend [Table 7]. The correlation of percentage count of neutral zone locations with different durations of edentulousness at the right and left premolar regions is shown in Graph 2.

On analyzing the results, the position of the neutral zone with different periods of edentulousness in the anterior region [Table 8] showed a trend of normal physiological process where the mandibular anterior alveolar ridges are resorbed centrifugally.

On statistical analysis by the Kruskal–Wallis H test, a standard deviation of 1.79749 at 0–2 years of edentulousness, 1.42428 at 2–5 years of edentulousness and 1.34519 for more than 5 years of edentulousness were shown, which is highly significant \((P = 0.005)\).

### DISCUSSION

Artificial complete denture prosthesis is the conventional treatment option for all edentulous patients. Establishing support, harmonious occlusion with good retention, stability, esthetics and phonetics are the prime objectives and goals for all prosthodontists. In order to construct dentures that function properly not only in chewing but also in speaking and swallowing, prosthodontists must develop the fit and contour of the external surface just as accurately and meticulously as the fit and contour of the impression surface and occlusal surface.

| Duration of edentulousness (in years) | Lingual (% count) | Buccal (% count) | Total (% count) | Mean | Standard deviation | Minimum value (in mm) | Maximum value (in mm) |
|--------------------------------------|-------------------|------------------|-----------------|-------|--------------------|----------------------|----------------------|
| 0-2                                  | 9 (60)            | 6 (40)           | 15 (100)        | -0.8333 | 2.22539          | -3.50                | 2.00                 |
| 2-5                                  | 12 (80)           | 3 (20)           | 15 (100)        | -2.2667 | 2.25093          | -5.00                | 2.00                 |
| More than 5                          | 14 (93.3)         | 1 (6.7)          | 15 (100)        | -3.6667 | 2.19306          | -6.00                | 3.00                 |

\[H = 12.205, P = 0.002, \text{highly significant}\]

| Duration of edentulousness (in years) | Lingual (% count) | Buccal (% count) | Total (% count) | Mean | std | Minimum value (in mm) | Maximum value (in mm) |
|--------------------------------------|-------------------|------------------|-----------------|-------|-----|----------------------|----------------------|
| 0-2                                  | 8 (53.3)          | 7 (46.7)         | 15 (100)        | -0.6333 | 2.02190 | -3.00                | 2.00                 |
| 2-5                                  | 12 (80)           | 3 (20)           | 15 (100)        | -2.0667 | 2.05171 | -4.00                | 2.00                 |
| More than 5                          | 14 (93.3)         | 1 (6.7)          | 15 (100)        | -3.8000 | 1.89737 | -6.00                | 2.00                 |

\[H = 19.578, P = 0.001, \text{very highly significant. std: Standard deviation}\]
Natural teeth are the most movable parts of the masticatory system. If outward horizontal forces from the tongue are greater than inward forces exerted by the buccinator muscle bands and the lips, the teeth will move horizontally until the opposing forces are equal. This is the neutral zone. As teeth erupt into the mouth, they are guided into a specific zone of neutrality that determines the horizontal position of each tooth in the arch.

Generally, muscular activity and habits that develop during childhood continue through life. After the teeth have been lost, muscle function and activity remain highly individual and greatly influence any complete denture that is placed in the mouth.\(^{[1,9]}\)

In this study, position of NZ with different durations of edentulousness at the right and left molar regions showed a trend of normal physiological process where mandibular posterior ridges resorb centripetally and neutral zone was positioned lingually, which is highly significant. However, a small percentage of subjects have shown buccal positioning of the neutral zone.

At right and left premolar regions, a trend of normal physiological process where mandibular posterior ridges resorbed directly under the buttress and position of NZ was directly over the crest of the ridge was seen, which is highly significant. However, a small percentage of subjects have shown buccal and lingual positioning of the neutral zone.

In the anterior region, position of NZ with different periods of edentulousness showed a trend of normal physiological process, where the anterior mandibular ridges resorbed centrifugally and the position of NZ located labially, which is highly significant.

In Group I, six subjects (40%) had period of edentulousness of within 6 months and five subjects (33.3%) had period of edentulousness of within 1 year [Table 1]. In total, 11 subjects (73.3%) were within the 1-year period of edentulousness; the period of edentulousness could be one of the reasons to show the cumulative result of 56.6% subjects in the lingual position of the neutral zone. The results have shown a trend of lingual positioning of neutral zone increasing to 80% in Group II and 93.3% in Group III. This small percentage of buccal positioning of the neutral zone may be reasoned for increase in muscular forces from the tongue muscle and decreased muscular forces from cheek muscles, which is a resultant neutral zone in the molar region.

The observations suggested that the location of the neutral zone varies from individual to individual, depending on their musculature, and there is significant relation to the duration of edentulousness. As edentulousness increases, there is more lingual positioning of the neutral zone at the molar region of both sides of the arch. At the premolar region, there is no change in position of the neutral zone; it remains constant as resorption of the alveolar ridge is directly under the buttress. In the anterior region, there is more labial positioning of the neutral zone as the edentulousness increases.

### REFERENCES

1. Beresin VE, Schiesser FJ. The neutral zone in complete dentures. J Prosth Dent 1976;36:356-65.
2. Fahmi FM. The position of the neutral zone in relation to the alveolar ridge. J Prosth Dent 1992;67:805-9.
3. Khamis M, Razek A, Abdalla F. Two dimensional study of...
the neutral zone at different occlusal heights. J Prosthet Dent 1981;46:484-9.

4. Starcke EN. The contours of polished surfaces of dentures- A review of literature. J Am Dent Assoc 1970;81:155-60.

5. Russell AF. The reciprocal lower complete denture. J Prosthet Dent 1959;9:180-90.

6. Roberts AL. The effects of outline and form upon denture stability and retention. Dent Clin North Am 1960;4:293-303.

7. Makzoumé JE. Morphologic comparison of two neutral zone impression techniques: A pilot study. J Prosthet Dent 2004;92:563-8.

8. Fenn HR, Liddelow KP, Gimson AP, MacGregor AR. Fenn, Liddelow and Gimson's Clinical Dental Prosthetics. 3rd ed. London: Wright; 1989.

9. Beresin VE, Schiesser FJ. The neutral zone in complete dentures. J Prosthet Dent 2006;95:93-101.