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## **An evaluation of neutral zone position in relation to mandibular alveolar ridge with different edentulous periods**

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### **Abstract**

Successful treatment of patients with complete dentures depends upon the stability of denture which is greatly affected by the positioning of the artificial teeth. The teeth should be arranged in the position where the forces of tongue and cheeks are neutralized i.e. the Neutral Zone. The position of neutral zone changes with the duration of edentulism and is dependent on the residual ridge resorption pattern.

**Keywords:** Edentulous, neutral zone, residual ridge resorption, retention, residual alveolar ridge

### **Introduction**

Complete denture treatment method remains an integral and important part of dental education and practice. Successful complete dentures should replace the lost tissues in approximately the same amount and in the same positions from which the tissues were lost. After loss of teeth, ridge resorption occurs mostly in the alveolar process sparing the basal portion leading to qualitative and quantitative reduction in the denture bearing area, loss of sulcus depth, reduced ridge height, reduced load bearing capacity of denture bearing area and reduced denture stability and retention (Beresin & Schiesser 1976). All oral functions such as speech, mastication, swallowing, smiling and laughing involve the combined actions of the tongue, lips, cheeks and the floor of the mouth which are very complex and highly individualistic (Beresin & Schiesser 1976). Keeping these factors in mind, the mandibular complete dentures must be constructed in complete co-ordination with the neuromuscular function, which is the foundation of a successful, stable denture. This can be accomplished by utilizing the zone of minimum conflict, Neutral Zone, a concept given by Fish in 1931. Neutral zone philosophy is based on the concept that for each individual, there exists within the denture space a specific area where the function of the musculature will not unseat the denture and where forces generated by the tongue will be neutralized by the forces generated by the lips and cheeks. The term neutral zone concept was coined by Beresin and Schiesser in 1976. Neutral Zone has also been referred to as dead zone, stable zone, zone of equilibrium, zone of least interference, biometric denture space, potential denture space, reciprocal zone, zone of neutral muscular function. As the review of literature revealed few studies and varied opinions regarding the relationship of neutral zone and residual alveolar ridge, a study was conducted to evaluate the position and relationship of neutral zone to the crest of mandibular residual alveolar ridge and the duration of edentulism.

### **Materials and Methods**

The study was conducted on 40 completely edentulous patients selected from the Outpatient Department of Prosthodontics at Govt. Dental College and Hospital, Patiala, Punjab to radiographically evaluate the position of neutral zone and its relation to the crest of mandibular residual alveolar ridge. The patients were divided into 4 groups of 10 each according to the period of edentulism as Group A (0 to 2 years), Group B (2 to 4 years) Group C (4 to 8 years), Group D (8 to 12 years).

Neutral zone was recorded using low fusing green stick impression material and red cake impression compound in 7:3 ratio. The patient was asked to perform all the functional

movements which helped in the molding of the material by the muscular actions. The relationship between residual alveolar ridge crest and neutral zone was measured by adapting a 25 gauge wire at the crest of the mandibular residual alveolar ridge of the duplicated mandibular master cast and a 22 gauge wire at the centre of the recorded neutral zone (Fig 1). The difference in position of the two wires in a labio/bucco-lingual direction was measured on an occlusal radiograph using a digital vernier caliper at the anterior midline, premolar and molar regions bilaterally.

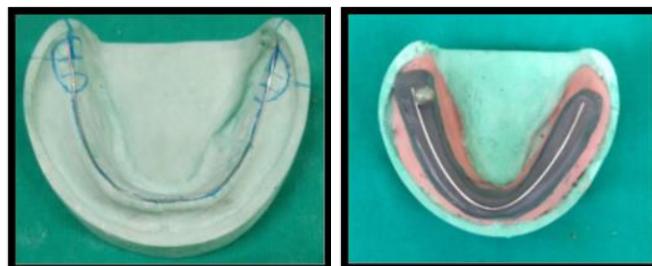
Positive sign indicate the labial/ buccal shift, negative sign indicated lingual shift and 0 indicated the coinciding of neutral zone with respect to the crest of the residual alveolar ridge. The position of first premolar and first molar were measured approximately 34% and 53% from the anterior midline for standardization.

Since magnification of radiographic image is a common error in dental radiography, the formula applied to evaluate the image magnification was

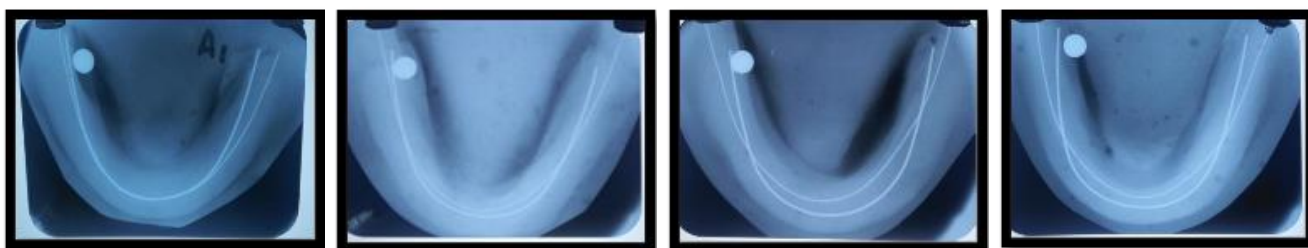
$d \times l / D$ , where  $d$  = source to object distance,  $l$  = image length,  $D$  = source to film distance.

A stainless steel ball of diameter 5.52mm was used for standardizing the magnification (Fig1). Percentage of magnification was calculated as 3.09% and in order to eliminate magnification error, 3.09% of each reading was

calculated and was subtracted from the radiographic reading. The data so obtained was statistically analysed by applying Kruskal Wallis H test and Mann Whitney U test. Kruskal-Wallis H test analysed the labio/bucco, lingual positioning of neutral zone in relation to the centre of the crest of the mandibular residual alveolar ridge and Mann Whitney U test compared the effect of duration of edentulism on change in position of neutral zone in relation to the centre of the crest of the mandibular residual alveolar ridge (Fig 2).



**Fig 1:** 25 gauge stainless steel wire adapted over the center of the crest, 22 gauge stainless steel wire adapted over the center of the recorded neutral zone (note the 5.52mm diameter ball placed on the lingual aspect for standardization of magnification)



**Fig 2:** Occlusal radiographs showing relation between neutral zone and the crest of residual alveolar ridge for Groups A, B C & D (Prototypes) respectively

## Results

The mean distance between the position of neutral zone with respect to the crest of the mandibular residual alveolar ridge in the right molar region was -0.76mm in Group A, -1.46mm in Group B, -2.4mm in Group C, -3.32mm in Group D and in the left molar region the mean distance between the position of neutral zone with respect to the crest of the mandibular residual alveolar ridge was -0.035mm in Group A, -1.07mm in Group B, -2.8mm in Group C, -4.1mm in Group D.

The mean distance between the position of neutral zone with respect to the crest of mandibular residual alveolar ridge in the left premolar region was 0.105mm in Group A, -0.23mm in Group B, 0.26mm in Group C, 0.129mm in Group D and in the right premolar region, the mean distance between the position of neutral zone with respect to the crest of mandibular residual alveolar ridge was 0.21mm in Group A, -0.054mm in Group B, 0.014mm in Group C, no shift in neutral zone position in Group D

The mean distance between the position of neutral zone with respect to the crest of mandibular residual alveolar ridge in the anterior region was found to be 0.37mm in Group A, 0.38mm in Group B, 2.22mm in Group C, 2.7 mm in Group D. At the left molar region, neutral zone was located lingually in 50% of the subjects in Group A, 70% in Group B and 100% in Groups C and D. 40% of the subjects in Group A and 30% of the subjects in Group B showed a buccal positioning of neutral zone with the crest of the residual alveolar ridge and a small percentage of subjects (10%) showed neutral zone

coinciding with the crest of the residual alveolar ridge

- At the right molar region, the neutral zone was located lingually in 80% of the subjects with respect to the crest of the residual alveolar ridge in Group A, 90% in Group B, and 100% in Groups C and D. The neutral zone was found to be buccally located in 10% of the subjects in Groups A and B while 10% of subjects in Group A showed neutral zone coinciding with the crest of the residual alveolar ridge.
- At the left premolar region, neutral zone was found to be coinciding with the crest of residual alveolar ridge in 60% of cases in Groups A & B; 70% in Group C and 90% in Group D. It showed 10% of lingual shift in Groups A & C and 30% in Group B. Buccal shift was found to be 30% in Group A; 20% in Group C and 10% in Groups B and D.
- At the right premolar region, neutral zone was found to be coinciding with the crest of residual alveolar ridge in 80% of cases in Groups A ;70% in Groups B & C and 100% in Group D. It showed 20% of lingual shift in Groups B & C. Buccal shift was found to be 20% in Groups A & B and 10% in Group C. There was a more lingual positioning of neutral zone with increased duration of edentulism at the right and left molar regions with respect to the crest of the residual alveolar ridge.

**Table 1:** Mean & standard deviation showing distance between neutral zone and the crest of the residual alveolar ridge at the left molar region

Groups	N	Mean	S.D	P value	Significance
A	10	-.0350	.83239	<0.05]	S
B	10	-1.0774	1.36886		
C	10	-2.8640	.35387		
D	10	-4.0100	.80808		

(SD= Standard deviation,  $P>0.05$ = Non Significant,  $P<0.05$  = Significant  $P<0.01$  = Highly Significant)

**Table 2:** Mean & standard deviation showing distance between neutral zone and the crest of the residual alveolar ridge at the left premolar region

Groups	N	Mean	S.D	P value	Significance
A	10	.1051	.56451	0.393	NS
B	10	-.2336	.63498		
C	10	.2674	.79405		
D	10	.1298	.41046		

(SD= Standard deviation,  $P>0.05$ = Non Significant,  $P <0.05$  = Significant  $P<0.01$  = Highly Significant)

**Table 3:** Mean & standard deviation showing distance between neutral zone and the crest of the residual alveolar ridge at the anterior region

Groups	N	Mean	S.D	P value	Significance
A	10	.3780	.49114	<0.05	S
B	10	.3820	1.43919		
C	10	2.2060	1.27381		
D	10	2.7430	.90059		

(SD= Standard deviation,  $P>0.05$ = Non Significant,  $P<0.05$  = Significant  $P<0.01$  = Highly Significant)

**Table 4:** Mean & standard deviation showing distance between neutral zone and the crest of the residual alveolar ridge at the right premolar region

Groups	N	Mean	S.D	P value	Significance
A	10	.2100	.51305	0.431	NS
B	10	-.0540	.50138		
C	10	.0220	.92157		
D	10	.0000	.00000		

SD= Standard deviation,  $P>0.05$ = Non Significant,  $P<0.05$  = Significant  $P<0.01$  = Highly Significant)

**Table 5:** Mean & standard deviation showing distance between neutral zone and the crest of the residual alveolar ridge at the right molar region

Groups	N	Mean	S.D	P value	Significance
A	10	-.7390	.58328	<0.05	S
B	10	-1.4580	1.18308		
C	10	-2.3910	.57928		
D	10	-3.3110	.74173		

(SD= Standard deviation,  $P>0.05$ = Non Significant,  $P<0.05$  = Significant  $P<0.01$  = Highly Significant)

Comparison of change in position of neutral zone with crest of mandibular residual alveolar ridge between different groups at the:

**Table 6:** Left molar region

Groups	N	Mean	S.D	P value	Significance
Group A	10	-.0350	.83239	0.035	S
Group B	10	-1.0774	1.36886		
Group A	10	-.0350	.83239	<0.05	S
Group C	10	-2.8640	.35387		
Group A	10	-.0350	.83239	<0.05	S
Group D	10	-4.0100	.80808		
Group B	10	-1.0774	1.36886	<0.05	S
Group C	10	-2.8640	.35387		
Group B	10	-1.0774	1.36886	<0.05	S
Group D	10	-4.0100	.80808		
Group C	10	-2.8640	.35387	<0.05	S
Group D	10	-4.0100	.80808		

**Table 7:** Left premolar region

Groups	N	Mean	S.D	P value	Significance
Group A	10	.1051	.56451	0.247	NS
Group B	10	-.2336	.63498		
Group A	10	.1051	.56451	0.853	NS
Group C	10	.2674	.79405		
Group A	10	.1051	.56451	0.796	NS
Group D	10	.1298	.41046		
Group B	10	-.2336	.63498	0.315	NS
Group C	10	.2674	.79405		
Group B	10	-.2336	.63498	0.316	NS
Group D	10	.1298	.41046		
Group C	10	.2674	.79405	0.971	NS
Group D	10	.1298	.41046		

Comparison of change in position of neutral zone with crest of mandibular residual alveolar ridge between different groups at the

**Table 8:** Anterior region

Groups	N	Mean	S.D	P value	Significance
Group A	10	.3780	.49114	0.579	NS
Group B	10	.3820	1.43919		
Group A	10	.3780	.49114	0.05	S
Group C	10	2.2060	1.27381		
Group A	10	.3780	.49114	<0.05	S
Group D	10	2.7430	.90059		
Group B	10	.3820	1.43919	0.05	S
Group C	10	2.2060	1.27381		
Group B	10	.3820	1.43919	<0.05	S
Group D	10	2.7430	.90059		
Group C	10	2.2060	1.27381	0.190	NS
Group D	10	2.7430	.90059		

**Table 9:** Right premolar region

Groups	N	Mean	S.D	P value	Significance
Group A	10	.2100	.51305	0.353	NS
Group B	10	-.0540	.50138		
Group A	10	.2100	.51305	0.393	NS
Group C	10	.0220	.92157		
Group A	10	.2100	.51305	0.481	NS
Group D	10	.0000	.00000		
Group B	10	-.0540	.50138	0.998	NS
Group C	10	.0220	.92157		
Group B	10	-.0540	.50138	0.739	NS
Group D	10	.0000	.00000		
Group C	10	.0220	.92157	0.738	NS
Group D	10	.0000	.00000		

Relation between change in position of neutral zone with crest of mandibular residual alveolar ridge between different groups at the

**Table 10:** Right molar region

Groups	N	Mean	S.D	P value	Significance
Group A	10	-.7390	.58328	0.052	NS
Group B	10	-1.4580	1.18308		
Group A	10	-.7390	.58328	<0.05	S
Group C	10	-2.3910	.57928		
Group A	10	-.7390	.58328	<0.05	S
Group D	10	-3.3110	.74173		
Group B	10	-1.4580	1.18308	0.123	NS
Group C	10	-2.3910	.57928		
Group B	10	-1.4580	1.18308	<0.05	S
Group D	10	-3.3110	.74173		
Group C	10	-2.3910	.57928	<0.05	S
Group D	10	-3.3110	.74173		

**Table 11:** Percentage count of the neutral zone with different period of edentulism at the left molar region

Duration of edentulism (years)	Lingual (%count)	Buccal (% count)	Coinciding (% count)	Total (% count)
A (0-2)	5(50)	4(40)	1(10)	10(100)
B (2-4)	7(70)	3(30)	-	10(100)
C (4-8)	10(100)	-	-	10(100)
D (8-12)	10(100)	-	-	10(100)

**Table 12:** Percentage count of the neutral zone with different period of edentulism at the right molar region

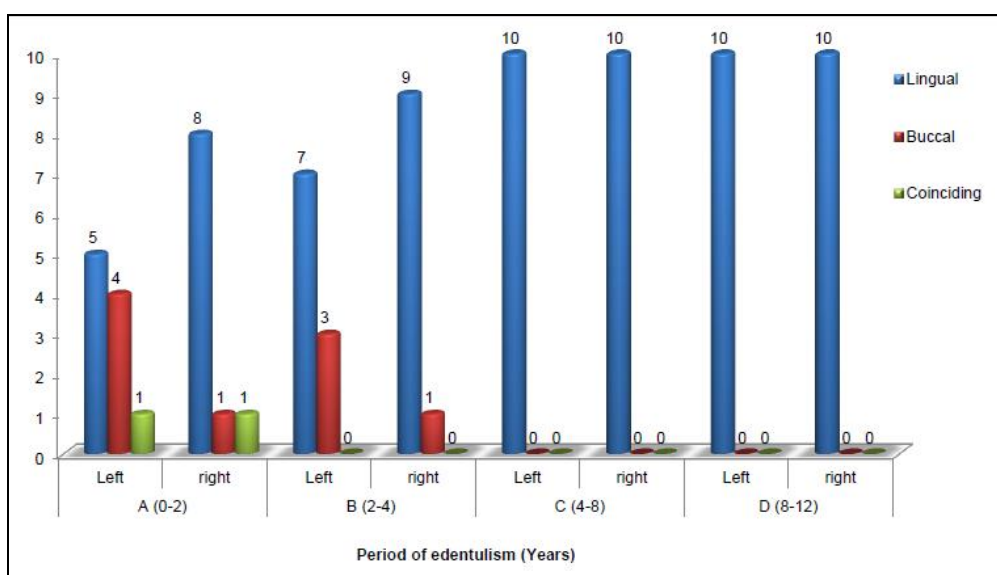
Duration of edentulism (years)	Lingual (%count)	Buccal (% count)	Coinciding (% count)	Total (% count)
A (0-2)	8(80)	1(10)	1 (10)	10(100)
B (2-4)	9(90)	1(10)	-	10(100)
C (4-8)	10(100)	-	-	10(100)
D (8-12)	10(100)	-	-	10(100)

**Table 13:** Percentage count of the neutral zone with different period of edentulism at the left pre molar region

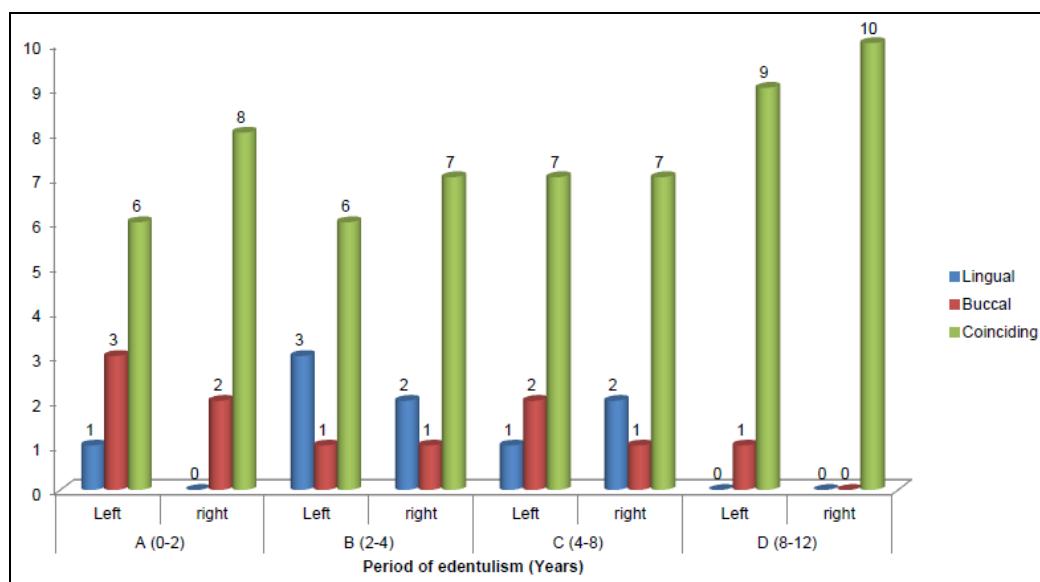
Duration of edentulism (years)	Lingual (% count)	Buccal (% count)	Coinciding (% count)	Total (% count)
A (0-2)	1(10)	3(30)	6 (60)	10(100)
B (2-4)	3(30)	1(10)	6(60)	10(100)
C (4-8)	1(10)	2(20)	7(70)	10(100)
D (8-12)	-	1(10)	9(90)	10(100)

**Table 14:** Percentage count of the neutral zone with different period of edentulism at the right pre molar region

Duration of edentulism (years)	Lingual (%count)	Buccal (% count)	Coinciding (% count)	Total (% count)
A (0-2)	-	2(20)	8 (80)	10(100)
B (2-4)	2(20)	1(20)	7(70)	10(100)
C (4-8)	2(20)	1(10)	7(70)	10(100)
D (8-12)	-	-	10(100)	10(100)



Bar diagram showing co-relation of percentage count of neutral zone at the left and right molar regions.



Bar diagram showing co- relation of percentage count of neutral zone at the left and right premolar regions

## Discussion

The position of neutral zone is specific and it varies from individual to individual. The change in position of the neutral zone depends upon the duration of edentulism and the residual ridge resorption pattern. Failure to recognize the cardinal importance of tooth position will reduce the stability and retention of the complete dentures. But there is a common practice of arranging artificial teeth over the crest of the residual alveolar ridge which will accentuate facial deformity, provoke phonetic problems and affects mastication (Weinberg 1958). The alveolar ridge crest does not remain in the same antero-posterior and mediolateral position and changes its location in a buccolingual direction after resorption in an edentulous mandible. The buccolingual positioning of the residual alveolar ridge after resorption along with the enlarged tongue in an edentulous mouth together influenced the buccolingual positioning of the neutral zone.

When the residual alveolar ridge has resorbed significantly, denture stability and retention are more dependent on correct position of the teeth and contour of the external surfaces of the dentures. Edentulous mandible exhibits atrophy to a much greater extent than the maxillae due to change in blood supply that occurs with the increasing age following resorption. In certain cases, the crest of the ridge falls below the origin of the mentalis muscle resulting in folding of the muscle attachments over the alveolar ridge and on the superior surface of the crest. Advanced resorption decreases the denture bearing area and moves the mandibular ridge buccally and neutral zone either bucco-lingually in different patients. (Fahmy & Lammie 1992) [3] The mandibular region showed a trend of lingual shift of neutral zone with increasing edentulous periods. Lingual positioning of the neutral zone may result because of aging facial changes and due to resorption primarily from the vertical and lingual side with resultant buccal shift of the crest of residual alveolar ridge. The position of neutral zone with different edentulous periods in the mandibular anterior region showed a trend of labial shift in relation to the crest of residual alveolar ridge. This reflects the mandibular anterior residual alveolar ridge resorption pattern i.e. resorption primarily from vertical and labial side with resultant lingual shift of the crest of residual alveolar ridge. Lammie observed a labial shift in the position of neutral zone in the mandibular anterior region. The change in position of neutral zone with respect to the crest of residual

alveolar ridge depends also on the order of teeth loss. Early loss of posteriors might accentuate the residual ridge resorption in the posterior regions which might shift the neutral zone lingually.

The results of the present study exhibiting lingual positioning of neutral zone with respect to the crest of residual alveolar ridge at the molar regions are in accordance with the observations of Jain, Bhorgonde, Mete J J, Martone, Demirel, Oktemer. According to them, prolonged period of edentulism resulted in sagging of the facial musculature which might be the reason for lingual positioning of the neutral zone. Martone was of the view that mandibular posterior ridges resorbed centripetally positioning neutral zone lingually. The findings of our study exhibited a small percentage of buccal positioning of neutral zone in Groups A (10%) and B (10%) of shorter edentulous periods. The shift of neutral zone to buccal side in these patients might have been due to increased muscular forces from the tongue muscles and decreased muscular forces from the cheek muscles. Also these muscular forces are highly individualistic and may vary from patient to patient.

In contrast with results of the present study, Fahmy observed neutral zone to be located more buccally than lingually within a range of 1.5 to 2.38mm in the posterior regions. Subjects with short period of edentulism might be the reason for the buccal positioning of neutral zone with respect to the centre of the crest of the residual alveolar ridge at the posterior regions. He also stated that loss of teeth led to bone loss from the buccal side of the maxillary alveolar ridge and from the lingual side of the mandibular alveolar ridge, resulted in smaller maxillary and larger mandibular residual ridges. The buccolingual positioning of the residual alveolar ridge after resorption along with enlarged tongue in an edentulous mouth together influenced the buccolingual positioning of the neutral zone. Pawah also observed a tremendous buccal shift of 52% and lingual shift of 29.3% in position of neutral zone with respect to the crest of the residual alveolar ridge in Group 2.

As per results of this study, it can be suggested that the artificial teeth should not always be arranged on the crest of the residual alveolar ridge as the location of neutral zone varies in different individual, particularly taking into consideration the period of edentulism. With increase in period of edentulism, the teeth should be placed more lingually in the molar regions, on the ridge in premolar area,

more labially in the anterior region but not ignoring the esthetics and phonetics criteria. Consideration of all these factors shall provide a more stable, comfortable and successful prosthesis to an edentulous patient.

### Conclusion

On the basis of results and conditions of this study, following conclusions were drawn:

- As the period of edentulism increases, the position of neutral zone changes more lingually in the molar region and labially in the anterior region, with respect to crest of the residual alveolar ridge.
- The position of neutral zone remains more or less constant in the premolar region with respect to the crest of the residual alveolar ridge.
- The position of neutral zone in relation to the residual alveolar ridge was found to be highly affected by the period of edentulism and the residual ridge resorption pattern.

Within the limitations of the study, the neutral zone changes its position with respect to the crest of the mandibular residual alveolar ridge, lingually and labially in the molar and anterior regions respectively with nearly no change in the premolar region according to the increased edentulous periods. Arrangement of artificial teeth in relation to the change in position of neutral zone, with period of edentulism may be recommended for enhanced retention and stability of the mandibular complete dentures.

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