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Evaluation of the effect of duration of edentulousness on the position of neutral zone in relation to residual alveolar ridge using Computed Tomography (CT) – An In-vivo Study

Dental Science

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ABSTRACT

Purpose: To evaluate the effect of duration of edentulousness on the position of neutral zone in relation to the crest of the residual alveolar ridge in the molar, premolar and anterior region in mandibular complete denture using Computed Tomography (CT).

Materials and Method: Thirty edentulous patients were categorized into three groups based on their period of edentulousness- Group 1: 0 to 6 months of edentulousness, Group 2: 7 months to 2 years of edentulousness and Group 3: 3 years to 10 years of edentulousness. The neutral zone position in relation to the crest of the alveolar ridge was evaluated by adapting TMA wires on the center of the compound rim and on the ridge crest on the master cast. CT images of the casts and the rims were obtained and the results were compared in the right and left premolar, molar and anterior region. When the images of the rims and cast coincided, a zero score was assigned and buccal or labial locations of the neutral zone with respect to the ridge are given a positive value. Lingual locations of the neutral zone with respect to the ridge were given a negative value. The results were statistically analyzed using one way ANOVA followed by Tukey's Post Hoc test.

Results: In the premolar and molar regions, neutral zone was positioned lingual to the crest in group 1 patients and there was a gradual shift to the buccal side in group 2 and 3 patients. Highly statistical significant difference was found between group 1 and 3 in the left premolar and molar region (p=.000). No statistical significant difference was seen between the groups in the anterior region.

Conclusion: It was concluded that the neutral zone was found to be located lingual to crest of the ridge during the early period of edentulousness i.e., between 0-6 months. After that it starts shifting buccally and labially in relation to the crest. This shifting of neutral zone is more pronounced after 3 years of extraction.

KEYWORDS:

neutral zone,zone of minimum conflict,stability, resorbed mandibular ridges

Introduction:

Complete denture stability is the quality of a removable dental prosthesis to be firm, steady, or constant, to resist displacement by functional horizontal or rotational forces 17. Stability is affected by various factors such as fit of the denture, muscular factors, position of occlusal plane, contours of the polished surface and occlusion.All oral functions, such as 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 individualistic1. The coordination of complete dentures with neuromuscular function is the foundation of successful, stable dentures1,2,3.

When all of the natural teeth have been lost, there exists within the oral cavity a void which is the potential denture space. Neutral Zone or Zone of minimum conflict is that area in the potential denture space where the forces of the tongue pressing outward are neutralized by forces of the cheeks and lips pressing inward. The primary tenet of the neutral-zone approach to complete dentures is to locate that area in the edentulous mouth where the teeth should be positioned so that the forcesexerted by muscles will tend to stabilize the denture rather than unseat it1,2,3. Fish proposed that the position for teeth is not necessarily on the ridge, inside the ridge or outside the ridge, but at a point where tongue and cheek pressure balance4. Since the forces are developed through muscular contraction during the various functions of chewing, speaking and swallowing, they vary in magnitude and direction in different individuals and in different periods of life2. Joseph et al 5 believed that the neutral zone concept may be advantageous when fabricating complete dentures. And also incorrect tooth placement and arbitrary shaping of the polished surfaces may have an adverse effect on the success of the prosthesis.

Earl 6stated that the positions of the residual ridges are not constant and should not be used as controls for the bucco-lingual position of the teeth and the teeth are placed in a comfortable relation to the musculature rather the "tooth over the ridge concept". David7proposed that the lower posterior teeth should be set directly over the lower ridge. Brien and Michael8stated that the central fossae of the mandibular posterior teeth are positioned over the crest of the residual ridge.Rapp9stated that to increase the stability of the lower denture the lower teeth should be placed lingual to the lower ridge and or tilted so that force is directed lingually. Ben10 compared between the physiological and anatomic method for posterior tooth positioning and concluded that the positioning mandibular posterior teeth according to the physiological method resulted in a more buccal position of the teeth.

Fahmi11found that the position of the neutral zone in relation to the alveolar ridge was highly affected by the period of edentulousness. The longer the period of edentulousness, the more buccally/labially located was the neutral zone.

Therefore an in-vivo study was conducted to evaluate the effect of duration of edentulousness on the position of neutral zone in relation to residual alveolar ridge. The objectives of the study are to determine the position of center of the crest of alveolar ridge with respect to the neutral zone in the right and left molar, premolar and anterior region. To also emphasize that the fact that position of the neutral zone is getting altered continuously with respect to the period of edentulousness.

Materials and methods:

Patient selection:

Thirty Completely edentulous patients were selected for this study who reported to the Department of Prosthodontics, Tamil Nadu Government Dental College and Hospital after approval from the institutional ethical committee. These thirty edentulous individuals were selected with the following inclusion and exclusion criteria. Inclusion criteria includes patients with clinically completely healed extraction sockets and patients with class I tongue position. Exclusion criteria include i) Patients with neuromuscular disturbances, ii)Patients with infections of the oral cavity, iii) Patients with abnormal ridge relationship and iv) Patients with syndromes of the oral cavity with features of complete anodontia. Out of these thirty patients, 18 were men and 12 were women with the age group between 40 and 70 years.

The selected subjects are grouped into three categories as follows; Group 1: 0-6 months of edentulousness, Group 2: 7 Months -2 years of edentulousness and Group 3: 3 Years – 10 Years of edentulousness.

The Null hypothesis was that there was no significant difference between the groups according to the period of edentulism on the position of the neutral zone in relation to the crest of the ridge.

Clinical procedure:

Primary impressions were made using impression compound (Aslate, India) and primary casts were made with Type II dental plaster (Asian Chemicals, India) (Fig. 1a, 1b) and custom trays were fabricated using auto-polymerizing acrylic resin (DPI, India).

Fig.1a Primary impression

Fig. 1b Primary cast

Using green stick compound (Samit, India) and light body impression material (Coltene Whaledent, Switzerland), secondary impressions were made using selective pressure impression technique and master casts were made using Type III dental stone (Kalabhai, India). (Fig. 2a, 2b)

Fig. 2a Secondary impression

Fig. 2b Secondary cast

Record bases were fabricated using auto-polymerizing acrylic resin and checked intra orally for extensions. If the record base moved during these functional movements, or if the patient was aware of the movement, then the record base was unstable. Now the record base was removed from the patient's mouth and adjusted for over extensions until the record base was stable. After the correct extensions of the record bases were determined, multiple grooves are made on the surface of the record base for retention of the impression compound.

Establishing neutral zone:

The neutral zone was recorded by using the swallowing method, where the impression compound was softened in the hot water bath maintained at 65 degree Celsius. The impression compound was kneaded and worked until it was uniformly soft and shaped in to a form of a bite block. To locate the neutral zone the patients are lubricated with petrolatum jelly. The patient was asked to swallow and purse the lips as in sucking repeatedly. After the compound rim was set, it was taken out and evaluated for the symmetry of the arch. (Fig.3a, 3b)

Fig 3a.Initial moulding of the neutral zone - Occlusal view and 3b. Lateral view

Any excess material was removed with bard parker blade. After the symmetry was achieved, the occlusal plane adjustment of the compound rim was done using three soft tissue landmarks: Corner of the lips, lateral border of the tongue and two-thirds the height of the retro-molar pad.A Bard Parker blade was used initially and final finishing was done with 150 grit sandpaper to establish the occlusal plane. (Fig.4)

The lower compound rim was inserted into patient's mouth and checked for stability. The patient was asked to open the mouth wide, wet the lips with the tongue and count from one to ten. If these movements raise the rim, the lack of stability was caused by an improper molding of the compound rim. The procedure was repeated and tested until a stable rim was achieved. (Fig. 5)

Fig. 4 Final moulding of Neutral zone - Lateral view

Fig. 5 Intra oral view of recorded Neutral zone

Adaptation of wire on the cast and compound rims:

The crest of the alveolar ridge on the master cast was trimmed about 1 mm using a Bard Parker knife and the midline of the crest of the ridge on the cast was marked using a graphite marker. A 0.017 x 0.025 Titanium Molybdenum Alloy preformed arch wire (Ormco, Italy) was adapted along the crest of the alveolar ridge on the master cast and kept 2 mm short of the retro-molar pad. The wire was secured on the cast using commercial glue. The compound rim was placed over the master cast and the midline of the compound rim were marked using a graphite marker and a 0.017 x 0.025 Titanium Molybdenum Alloy preformed arch wire was adapted along the center of compound rim. (Fig. 6)

Fig. 6 TMA Wires adapted on the crest of the ridge on the master cast and midline of the recorded Neutral zone

Evaluation of neutral zone by computed tomography:

All the casts with the compound rims were placed on the gantry of the CT machine (GE, USA) and coronal sections of the casts with compound rims were obtained with a slice thickness of 2 mm. (Fig.7)

Fig. 7 Preparation of the casts for CT scanning

The deviation of the wires in the computed tomographic image were then assessed by the computer and when the two images of the wire coincided, a zero score was assigned and buccal or labial locations of

the neutral zone with respect to the ridge were given a positive value. Lingual locations of the neutral zone with respect to the ridge were given a negative value. These values were measured in relation to the right and left molars (RM, LM), premolars (RP, LP) and the lower incisor region.The measured points of the molar area were defined using the anterior borders of the retro-molar pad as reference points. The points were 10 mm (RM2, LM2), 15 mm (RM1, LM1) and 20 mm (RP, LP) forward from the reference points on both the left and right sides. In addition, the reference of the midline was determined by a perpendicular line from the incisive papilla toward the occlusal plane as proposed byK. Ikebe12. (Fig. 8a, 8b)

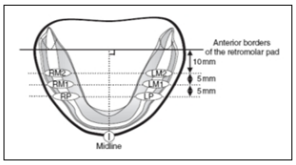

Fig. 8a Reference markings

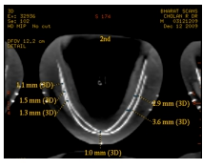

Fig. 8b CT Scan of the Cast and the Recorded Neutral zone with wires adapted

Statastical analysis:
The overall group comparison was done using one way ANOVA followed by Tukey's Post Hoc test.

Results:
The Null hypothesis was rejected. There was statistical difference between the groups according to the edentulous period on the position of the neutral zone. During the initial period of edentulism, in majority of the patients, the neutral zone is located lingually. As the duration increases, there is a shift in the position of the neutral zone buccal to the crest of the ridge. The deviation of neutral zone position in relation to the crest of the ridge was measured in the right and left premolar and molar and anterior regions, and comparison was done to find the significance between the three groups. The percentage of individuals in each group showing the corresponding values of neutral zone position in relation to the crest of the ridge is also mentioned in the table. (Table. 1)

Table 1: Variation of NZ with respect to crest of residual alveolar ridge in Computed Tomography in relation to the right and Left Molar, premolar and anterior region between Group 1, Group 2 and group 3

Region	Deviation from the Crest of the Ridge (mm)	Groups (with % of individuals)		Mean Difference	P value
Left molar		Group 1	Group 2		
	< 0 (Lingual) 0 (Crest) >0 (Buccal)	9(90%) 1(10%) 0(0%)	1(10%) 1(0%) 8(80%)	-2.79	0.002**
Left molar		Group 1	Group 3		
	< 0 (Lingual) 0 (Crest) >0 (Buccal)	9(90%) 1(10%) 0(0%)	1(10%) 0(0%) 9(90%)	-3.19	.000**
Left molar		Group 2	Group 3		
	< 0 (Lingual) 0 (Crest) >0 (Buccal)	1(10%) 1(10%) 8(80%)	1(10%) 0(0%) 9(90%)	-0.400	0.848a
Left premolar		Group 1	Group 2		
	< 0 (Lingual) 0 (Crest) >0 (Buccal)	5(50%) 0(0%) 5(50%)	2(20%) 1(10%) 7(70%)	-1.12	.121a
Left premolar		Group 1	Group 3		
	< 0 (Lingual) 0 (Crest) >0 (Buccal)	5(50%) 0(0%) 5(50%)	0(0%) 0(0%) 10(100%)	-2.44	0.000**
Left premolar		Group 2	Group 3		
	< 0 (Lingual) 0 (Crest) >0 (Buccal)	2(20%) 1(10%) 7(70%)	0(0%) 0(0%) 10(100%)	-1.32	0.058*
Anterior		Group 1	Group 2		
	< 0 (Lingual) 0 (Crest) >0 (Buccal)	0(0%) 0(0%) 10(100%)	1(10%) 1(10%) 8(80%)	2.27	0.097a
Anterior		Group 1	Group 3		
	< 0 (Lingual) 0 (Crest) >0 (Buccal)	0(0%) 0(0%) 10(100%)	0(0%) 0(0%) 10(100%)	0.52	0.870a
Anterior		Group 2	Group 3		
	< 0 (Lingual) 0 (Crest) >0 (Buccal)	1(10%) 1(10%) 8(80%)	0(0%) 0(0%) 10(100%)	-1.74	0.241a
Right premolar		Group 1	Group 2		
	< 0 (Lingual) 0 (Crest) >0 (Buccal)	6(60%) 0(0%) 4(40%)	3(30%) 0(0%) 7(70%)	-0.99	0.347a
Right premolar		Group 1	Group 3		
	< 0 (Lingual) 0 (Crest) >0 (Buccal)	6(60%) 0(0%) 4(40%)	0(0%) 0(0%) 10(100%)	-2.58	0.003**
Right premolar		Group 2	Group 3		
	< 0 (Lingual) 0 (Crest) >0 (Buccal)	3(30%) 0(0%) 7(70%)	0(0%) 0(0%) 10(100%)	-1.59	0.077a
Right molar		Group 1	Group 2		
	< 0 (Lingual) 0 (Crest) >0 (Buccal)	7(70%) 0(0%) 3(30%)	2(20%) 0(0%) 8(80%)	-2.02	0.026*
Right molar		Group 1	Group 3		
	< 0 (Lingual) 0 (Crest) >0 (Buccal)	7(70%) 0(0%) 3(30%)	2(20%) 2(20%) 6(60%)	-2.28	0.011*
Right molar		Group 2	Group 3		
	< 0 (Lingual) 0 (Crest) >0 (Buccal)	2(20%) 0(0%) 8(80%)	2(20%) 2(20%) 6(60%)	-0.261	0.932a

a - p – Not Significant, ** - p – Highly Significant, * - p –Significant

Discussion:
Residual ridge resorption is a lifelong pathophysiologic condition which leads to alteration in the available denture bearing area. This leads to a compromised situation in the mandible leading to flat mandibular ridges. The potential denture spaces decreases as the muscles of the lip and cheek tend to fall in and the tongue expands as the period of edentulousness increase. Finding the ideal position of the teeth is important to obtain retention and stability in resorbed ridges.

The need for neutral zone was stressed as early as 1931 by Fish13. The neutral zone is that area in the potential denture space where the forces of the tongue pressing outward are neutralized by forces of the cheeks and lips pressing inward. Neutral zone technique is used not only in resorbed mandibular ridges but also has been used in cases with mandibular resection, glossectomy, and implant prosthesis and also in neurological disorder patients.

Many authors have tried locating the neutral zone position in relation to the ridges but numerous controversies exist. Some have claimed the location to be on the crest of the ridge, buccal as well as lingual. It was seen that neutral zone is affected by factors like muscle activity and period of edentulousness.

With this background, the present study was conducted to evaluate the effect of duration of edentulousness on the position of neutral zone in relation to the residual alveolar ridge using computed tomography (CT). Previously studies have been conducted using conventional occlusal radiographs14,15. The use of CT in this study eliminated the chances of magnification errors with occlusal radiographs. The neutral zone was recorded intra orally using low fusing tracing compound impression material, which permits the patient to mold the material

into the neutral zone with the least amount of time and effort and also the possibility of adjustability.

In this study, the neutral zone was positioned lingual to alveolar ridge crest in 90% of group 1 which is in accordance with the study done by Fahmiet al 11wherethe position of the neutral zone was present lingual to the crest, in 93.5% of cases of recent extraction in the lower left molar region. He concluded that the neutral Zone was located more buccally than lingually as the period of edentulousness increases which is also proved by the results in group 3.

Ikebe12also concluded that bucco-lingual center of the occlusal table was located slightly buccal to the residual alveolar ridge. In this study, the NZ was positioned buccal to crest of alveolar ridge in 80% of subjects in group 2 and 90% in group 3. This shifting is more pronounced after 3 years of extraction. This buccal positioning of the neutral zone may be due to increased muscular forces from the tongue than the from cheek muscles.Wright's findings showed that if the buccolingual size of the mandibular teeth are too large or if set by even 1 mm lingually, the tongue will be deprived of approximately 1000 mm3 of its functionalspace. The size of the tongue enlarges as the patient becomes edentulous resulting in more tongue pressure. Cramping of the tongue can result in dislodging force which can affect the stability of a mandibular denture.

In the anterior region, the NZ was positioned labial to the crest in 100% of the subjects with an edentulous period of 0-6 months and 100% of the subjects with an edentulous period of 3 -10 years, the p value being 0.870 which is statistically not significant.This is in accordance with the studies done by Charles EW16, Fahmi FM11.They concluded that it would be safe to assume that in all patients having a relatively normal ridge relationship, regardless of the amount of resorption the labial surfaces of the central incisors should be anterior to the borders of the denture.

But this is in contradictory to Lammie17, where he has shown that as the ridge resorbs the ridge crest falls below the origin of the mentalis muscle, when such resorption occurs, the muscle attachment folds over the alveolar ridge and comes to rest on the superior surface of the crest
In this study, patients were selected randomly in each group; further studies in the future can be done by doing a prospective study following the patients from pre-extraction period to atleast 3 years to get more accurate results.

Conclusion:

Within the limitations of this study, it can be concluded that the neutral zone was found to be located lingual to crest of the ridge during the early edentulousness i.e., between 0-6 months in the premolar and molar region. After that it starts slowly moving towards buccal and labial side of crest. This shifting of neutral zone is more pronounced after 3 years of extraction. There is no change in the anterior region. It lies buccal to the crest in the anterior region.

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