

Patient Satisfaction With Complete Dentures Fabricated Using Two Neutral Zone Techniques: A Within-Subject Cross-Over Pilot Study

Komal Ladha · Rekha Gupta ·
Shubhra Gill · Mahesh Verma

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Abstract Several studies have compared complete dentures fabricated using conventional and neutral zone (NZ) techniques. However, studies comparing patient satisfaction with complete dentures fabricated using swallowing and phonetic NZ techniques are lacking in literature. To compare patient satisfaction with the complete dentures fabricated using the two NZ techniques. To compare the bucco-lingual dimensions of the NZ records obtained with these techniques. Ten completely edentulous subjects dissatisfied with their existing mandibular complete dentures participated in the study. Five subjects first received the swallowing neutral zone (SNZ) dentures and five the phonetic neutral zone (PNZ) dentures. Tissue conditioner was used as the recording material in both the techniques. After having worn the prosthesis for a minimum of 2 months, subjects responded to a questionnaire that measured their perceptions of various factors associated with the prosthesis. The prostheses were then changed and the procedures repeated. Student *t* test and non-parametric Mann–Whitney tests were used for statistical analysis. Level of statistical significance was set $p < 0.05$. There was no statistical significant difference in patient satisfaction with the SNZ and PNZ complete dentures for all the variables assessed. Statistical significant difference was observed for majority of the variables when the two NZ dentures were compared with patients' old dentures. The difference in the mean dimensions of the two NZ records

was also found to be statistically insignificant except in the maxillary left premolar region. The study indicated that patient satisfaction with the complete dentures fabricated using SNZ technique did not significantly differ from that of the PNZ technique. Data gathered at the final appointment showed that SNZ dentures were preferred by the patients with regards to esthetics, stability, comfort and ability to chew. For ability to speak, mixed preferences were found.

Keywords Patient satisfaction · Swallowing neutral zone · Phonetic neutral zone

Introduction

The arrangement of teeth in complete dentures has been predominantly based on certain mechanical principles without much consideration for the biology and physiology of the orofacial muscles surrounding the prosthetic appliance [1, 2]. This has an adverse influence on the success of the complete denture prosthesis, particularly in patients with severely atrophic mandibular ridges [3].

To take the physiology of muscles into account, the neutral zone (NZ) concept was introduced. It is an old concept, but is extremely valuable till date and, yet not often practiced. Knowledge and practical application of this technique may be advantageous in complete denture fabrication.

The NZ is defined as “the potential space between the lips and cheeks on one side, and the tongue on the other; that area or position where the forces between the tongue and cheeks or lips are equal” [4]. It is also referred to as the dead space [5] and the zone of minimal conflict [6]. This concept considers the actions of the tongue, lips, cheeks

K. Ladha (✉)
Department of Prosthodontics, ESIC Dental College & Hospital,
New Delhi, India
e-mail: komalladha@yahoo.co.in

R. Gupta · S. Gill · M. Verma
Department of Prosthodontics, Maulana Azad Institute of Dental
Sciences, New Delhi, India

and floor of the mouth on a recording material during a specific oral function [1, 7–14]. Various movements including sucking [15], grinning [1], whistling [1] and pursing the lips [16] push the material into a position where the bucco-lingual forces are neutralized.

Swallowing is used as the principle modeling function in the traditional ‘modeling compound-swallowing impression technique’, for obtaining the NZ [7]. Speech is another important part of the routine oral activities. It is utilized as the principle modeling function in a technique called piezography. Piezography records the mandibular denture space by means of pressure developed during oral functions, mainly speech [17, 18]. This technique customizes the contours of the lingual surface and precludes over-extension. The term ‘phonetic neutral zone technique’ will be used in the present study [8].

Many studies have analyzed NZ dentures [16, 19, 20] as compared with dentures made using conventional techniques in the edentulous patient. [8, 15, 21, 22] However, no study could be identified in the literature that compared patient satisfaction with complete dentures fabricated using the swallowing neutral zone (SNZ) and phonetic neutral zone (PNZ) techniques for the same patients.

NZ technique is principally used to record the mandibular denture space as mandibular dentures are less stable than the maxillary [8, 23]. However, in a study by Fahmy and Kharat [15], NZ technique was used to record both the maxillary and the mandibular denture space. Considering the actions of lips and cheeks during various oral functions on the polished surfaces of maxillary denture as well, it was decided in the present study to record both the maxillary and the mandibular denture spaces.

This study aimed to compare the levels of patient satisfaction with complete dentures fabricated using the two NZ techniques. Satisfaction of the subjects with their existing complete dentures was also established. A comparison of the bucco-lingual dimensions of the SNZ and PNZ records obtained was done.

Because of the limitations in time and the lack of patient compliance due to long treatment durations, it was proposed to carry out this study with a minimum sample size of 10 patients. The null hypothesis under the study was that there is no significant difference in patient satisfaction with the two types of NZ complete dentures.

Materials and Methods

Selection of Patients

Ten healthy completely edentulous subjects (male; $n = 9$ and female; $n = 1$) who were dissatisfied with their existing conventional mandibular complete dentures were selected

for this cross-over clinical trial in Maulana Azad Institute of Dental Sciences, New Delhi, India. The subjects were selected for participation in the study based on the inclusion and exclusion criteria's (see Boxes 1, 2). Informed written consent was obtained from all the subjects and the protocol was approved by the Institutional Ethical Committee of the Maulana Azad Institute of Dental Sciences.

Methodology

All participants rated their satisfaction with their existing complete dentures prior to the treatment by responding to a closed-ended questionnaire. On the basis of their participation in the study, first five subjects received SNZ complete dentures and the last five received PNZ dentures. After 2 months of adaptation, subjects rated their satisfaction with the dentures by responding to the questionnaire. Subsequently, the dentures were changed and response was noted after the adaptation period.

Material

In the present study, tissue conditioner was used as a recording material for both the NZ techniques to nullify the effect of use of different recording materials.

Treatment

All treatment procedures were performed by a single clinician. For all the patients, conventional complete denture fabrication procedures were followed till the jaw relation step. Face–bow transfer was made and jaw relation was mounted on a semi-adjustable articulator (Hanau H2). In order to reduce the number of clinical steps and the errors associated with duplication of master casts, try-in of both the dentures were prepared on the same master casts mounted on the articulator. At the try-in appointment of the first set of dentures, wash impressions was taken using zinc-oxide eugenol impression paste (DPI Impression paste, Dental Products of India, Mumbai) on the intaglio surface of the maxillary and mandibular trial dentures while in occlusion. Dental stone (Kalstone, Kalabhai Dental Pvt. Ltd., Mumbai) was poured in the wash impressions and the first trial dentures were flaked. The second sets of dentures were constructed on the original master casts. Therefore, additional step of jaw registration was eliminated and the vertical relation of occlusion was kept same for both the dentures.

Fabrication of Neutral Zone Record Bases

Maxillary and mandibular occlusal rims were removed from the mounted master casts and new record bases were

Box 1 Inclusion criteria

1. 60–80 years of age.
2. Conventional complete denture wearers using dentures for a minimum of 1 to 10 years and dissatisfied with their existing mandibular denture.
3. Advanced mandibular ridge resorption (Atwood's class V and VI).
4. Possessing an adequate understanding of written and spoken Hindi.
5. Able to understand and respond to the questionnaire used in the study

Box 2 Exclusion criteria

1. Acute/chronic symptoms of temporomandibular disorders.
2. Uncontrolled systemic diseases.
3. Psychological conditions that could influence the patients reaction to the treatment.
4. Pendulous residual ridges.
5. Smokers and tobacco users

constructed using auto-polymerizing acrylic resin (DPI-RR Cold Cure, Dental Products of India, Mumbai) for recording the NZ. An acrylic keel, 2.0–3.0 mm in width was constructed vertically along the centre of these record bases. The keel was sectional having two posterior and one anterior segment. It touched the opposing occlusal rim; acted as a vertical stop and supported the tissue conditioner material used to record the NZ (Fig. 1)

When recording the mandibular NZ, the maxillary record base was left outside the mouth and vice versa.

Recording the NZ

The patient was seated comfortably in an upright position with the head supported. The record bases were checked in patients' mouth for comfort and proper extensions. The NZ was recorded using the following two techniques.

Fig. 1 Shows maxillary and mandibular NZ record bases with acrylic keel



The Phonetic Technique The phonetic NZ was developed segmentally [3]. Right lateral segment was molded first followed by the left, and, finally the anterior segment was molded. 3 ml of tissue-conditioning material was mixed in the ratio recommended by the manufacturer (Visco-gel, Denstply International Ltd., UK). The mix was loaded using a spatula on the right lateral segment and the record base was carefully inserted in the patient's mouth. The patient was asked to pronounce a sentence, "Papa Ne Shor Machete Baby Ko Cheese Khilakar Khush Kiya, Aur, Kavita Se Kaha Sadak Par Mat Chal, Jakar Shishe Ke Thermos Main Coffee La", which included bilabial (m, p, b), labiodental (f, v), alveolar (s, sh) and, dental (th) sounds. In order to induce sufficient muscle contraction, all the sounds had to be pronounced clearly, loudly, and vigorously. The patient repeated the sentence until the material polymerized. The whole sequence had to be completed quickly to ensure pure phonetics and no swallowing. The segment was remolded if the patient accidentally swallowed during the pronunciation. Excess tissue conditioning material anterior to the premolar area was removed. Same procedure was repeated to mold the left lateral and the anterior segment. Phonetic NZ of the maxillary denture space was recorded similarly. Tissue conditioner in excess of the height of keel was trimmed.

The Swallowing Technique The swallowing NZ was also developed segmentally in a manner similar to the phonetic technique. Same volume of tissue-conditioning material was used to mold each segment. While molding each segment, the patient was instructed to perform a series of actions until the material was set: smiling, pursing the lips, sucking, swallowing and wetting the lips with the tongue. To facilitate swallowing, patient was provided with a cup of warm water which he/she could sip. The base was removed once the material was set and any excess material that had flown in the other segment was removed. Upon completion, the record was inspected for accuracy. NZ of the maxillary denture space was recorded similarly.

Laboratory Stage

V-shaped notches were prepared in the land area of the maxillary and mandibular cast. Polyvinyl silicone putty (Affinis, Coltene/Whaledent Pvt. Ltd., Mumbai, India) was adapted buccally and lingually/palatally around the records to prepare indices. Tissue conditioner was removed from the record bases, and the keels were trimmed. The record bases were placed back on the casts and the indices were reseat around them. Wax was poured into the space between the indices; this provided an exact representation of the NZ.

Measurement of NZ Dimensions

The indices were removed and dimensions of the NZ occlusal rims were measured bucco-lingually using a vernier caliper and a scale in millimeters. For both the arches measurements were taken in the molar (MR, ML) and premolar (PR, PL) areas on both the right (R) and the left sides (L). Dimension in the anterior midline (AM) area was also recorded.

The NZ wax rims were made to uniformly contact each other. The teeth were arranged (Cosmo HXL teeth set, Dentsply International Ltd.) and their position was verified by placing the indices together around the wax try-in. Balanced occlusion was achieved on the articulator.

Try-in and Recording of Polished Surfaces

After the wax try-in was found satisfactory, polished surfaces of the trial dentures were recorded using ZOE impression paste. During recording, the patient either performed the respective physiologic movements used for SNZ recording or pronounced the sentence used for PNZ recording. For the first set of dentures, wash impressions were also made at this step.

Completion of Dentures

The trial dentures were invested, processed, finished, and lightly polished to prevent alteration of contours (Trevalon, Dentsply India Pvt. Ltd., Mumbai). The dentures were inserted, carefully evaluated, and checked for occlusal errors.

Psychometric Measures

Questionnaire Design and Scoring Patient satisfaction was assessed using a closed-ended questionnaire. The questionnaire consisted of 16 items. Responses to items were given by the patient on a 5-point likert scale i.e., for each given item patient had to choose one out of the five

responses. The likert scale values for the five responses ranged from 0 to 4; where 0 was given when the patient was not at all satisfied; (1) when not very satisfied; (2) when reasonably satisfied; (3) when very satisfied and (4) when totally satisfied. The response values of all the 16 items was added up to give the total score.

The questionnaire was completed unaided by the subject. All queries were dealt with by the research worker. Primary outcome variables assessed for the maxillary and mandibular dentures were: (1) general satisfaction, (2) retention, (3) stability, and (4) the ability to speak. Secondary outcome variables were (5) comfort, (6) ability to chew sliced bread, apples, carrots, lettuce, and nuts, (7) appearance, (8) part of you, (9) soreness of the gums, and (10) food under the dentures.

Choice of Prosthesis

At the final appointment, all the participants were asked to compare the two dentures directly. Prior to this appointment patients had rated only the prostheses that they were wearing, and did not directly compare the two dentures for each variable. A separate questionnaire was provided for the patients to indicate which of the two sets of dentures they preferred with regard to esthetics, stability, comfort, ability to speak and chew. Final choice of prosthesis was determined by the patient as first and second preference.

Statistical Analysis

Statistical analysis was carried out using SPSS version 17.0 (Chicago, IL, USA). The comparison of age and mean dimensions between the SNZ and PNZ groups was performed using Student's *t* test. Sex was compared using Fisher's exact test between the two groups. Non-normal distributed variables were compared using Kruskal–Wallis test with further paired comparisons performed using Mann–Whitney *U* test. The level of statistical significance was set at $p < 0.05$.

Results

Mean age ($p = 0.551$) and sex ($p = 1.000$) were comparable between the SNZ and PNZ groups with no significant difference observed.

Comparison of NZ Dimensions

The difference in the mean dimensions of the two NZ records was statistically insignificant for all the areas except the maxillary PL region ($p < 0.05$) (see Table 1).

Psychometric Measurements

Table 2 shows the median scores of all the variables assessed under the present study with respect to patients' old dentures (Group A), the SNZ (Group B) and the PNZ (Group C) dentures. Variables were assessed for both maxillary and mandibular dentures. All the three groups exist within same subjects.

Primary Outcome Variables

Comparison of median scores among the three groups within the subjects, for the variables of general satisfaction, retention (maxillary and mandibular), stability (mandibular) and speech were found as statistically significant. A statistically significant difference in the median scores was found between groups A and B and groups A and C but the difference was insignificant between the two NZ dentures i.e., groups B and C for these variables.

No significant difference was found among the groups for the variable of stability (maxillary).

Secondary Outcome Variables

Comfort, appearance, feeling of part of body and chewing ability Statistical significance was observed on comparison between groups A and B and groups A and C but the result was insignificant between groups B and C, except for the ability to chew bread, where the result was found to be statistically insignificant among all the groups.

Soreness under dentures The result was found to be statistically insignificant among the groups for this variable.

Food entrapment The result was statistically insignificant among the groups for this variable with respect to maxillary dentures. Statistical significance was observed on

comparison of the median scores of groups A and B with respect to the mandibular dentures but was insignificant between groups A & C and groups B & C.

Total score The result was found to be statistically significant among the three groups when the medians of the total score were compared.

Final Appointment: Choice of Prosthesis

At the final appointment, subjects directly compared the two prostheses with regard to esthetics, stability, comfort, ability to speak and chew. Final choice of prosthesis was determined by the patients as first preference and second preference for the two dentures (see table 3).

For esthetics, SNZ dentures were preferred by six patients and PNZ dentures by three patients. one patient indicated no preference.

For stability, five patients preferred both the dentures and five patients preferred SNZ dentures.

For comfort, seven patients preferred SNZ dentures, two patient's preferred PNZ dentures and one patient found both the dentures comfortable.

For ability to speak, three patients chose SNZ and four patients PNZ dentures respectively, three patients preferred both the dentures.

For chewing ability, SNZ dentures were preferred by six patients, PNZ dentures by two patients and two patients preferred both the dentures.

Regarding the final choice, SNZ dentures were the first preference of five patients, PNZ dentures were the first preference of three patients, and two patients preferred both the dentures.

Discussion

The objective of this cross-over pilot study was to compare patient satisfaction with complete dentures fabricated using the swallowing and phonetic NZ techniques. The buccolingual dimensions of the NZ records obtained with these techniques were compared in three areas; anterior, premolar and molar to note the differences.

In the present study, subjects rated their satisfaction with their old and the two sets of NZ complete dentures by responding to a questionnaire which assessed various factors associated with the function of the prosthesis. Responses were recorded on a 5-point likert scale. The results of the psychometric evaluation confirm the hypothesis under the study that there is no statistical significant difference in patient satisfaction with the two types of NZ dentures.

The results, however, indicate that both SNZ and PNZ dentures led to significant improvements in patient satisfaction

Table 1 Mean bucco-lingual dimensions (in mm) of the SNZ and PNZ records

	PNZ (<i>n</i> = 10) Mean ± SD	SNZ (<i>n</i> = 10) Mean ± SD	<i>p</i> value
Max AM	4.35 ± 1.18	4.90 ± 1.39	0.353
Max PR	3.8 ± 1.23	3.95 ± 1.19	0.785
Max PL	3.15 ± 0.69	4.15 ± 1.31	0.046
Max MR	3.70 ± 0.63	4.55 ± 1.30	0.086
Max ML	3.65 ± 0.91	4.35 ± 0.67	0.066
Man AM	4.1 ± 1.22	4.75 ± 2.31	0.445
Man PR	3.65 ± 1.36	4.0 ± 1.41	0.579
Man PL	3.60 ± 1.29	3.60 ± 1.26	1.000
Man MR	4.20 ± 1.75	4.05 ± 0.86	0.812
Man ML	4.20 ± 1.56	3.95 ± 1.34	0.706

Table 2 Median scores of the old, SNZ and PNZ dentures

Variables	<i>n</i> = 10			Significance of difference (<i>p</i> < 0.05)			
	Group A (old) Median (min–max)	Group B (SNZ) Median (min–max)	Group C (PNZ) Median (min–max)	Among the groups	Between A & B	Between A & C	Between B & C
Gen. satisfaction	1 (0–1)	4 (2–4)	3 (2–4)	0.000	0.000	0.000	0.619
Retention (Max.)	2.5 (1–4)	4 (2–4)	4 (3–4)	0.015	0.014	0.016	0.786
Retention (Mand.)	0 (0–1)	4 (2–4)	3 (2–4)	0.000	0.000	0.000	0.510
Stability (Max.)	3 (1–4)	3 (3–4)	3 (3–4)	0.099	0.071	0.071	1.000
Stability (Mand.)	0.5 (0–1)	3 (2–4)	3 (2–4)	0.000	0.000	0.000	0.490
Comfort	1 (1–2)	3 (2–4)	3 (2–3)	0.000	0.000	0.000	0.543
Speech	1.5 (0–4)	4 (2–4)	3.5 (2–4)	0.017	0.012	0.021	0.640
Chew bread	3 (0–4)	4 (2–4)	4 (2–4)	0.062	0.136	0.077	0.654
Chew apple	1.5 (0–3)	3 (2–4)	4 (1–4)	0.002	0.002	0.003	0.400
Chew carrot	1 (0–3)	3 (1–4)	3 (1–4)	0.002	0.002	0.002	1.000
Chew sweetmeat	1 (0–2)	2.5 (2–4)	3 (0–4)	0.000	0.000	0.002	0.749
Chew nuts	1 (0–2)	3 (1–4)	2 (0–4)	0.003	0.001	0.024	0.260
Appearance	2 (1–3)	4 (1–4)	4 (2–4)	0.002	0.006	0.002	0.656
Part of the body	3 (0–3)	4 (3–4)	4 (3–4)	0.001	0.002	0.002	1.000
Soreness (Max.)	4 (2–4)	4 (3–4)	4 (4–4)	0.595	0.942	0.317	0.317
Soreness (Mand.)	2 (0–4)	3.5 (0–4)	3 (2–4)	0.064	0.086	0.222	0.936
Food entrapment (Max.)	4 (2–4)	4 (2–4)	4 (3–4)	0.814	0.542	0.829	0.626
Food entrapment (Mand.)	1 (0–2)	2.5 (0–4)	2.5 (0–4)	0.046	0.023	0.051	0.587
Total score	32 (24–38)	61 (44–70)	58.5 (47–71)	0.000	0.000	0.000	0.495

Shading implies that the results were found to be statistically significant for the variables assessed

with majority of the primary and secondary outcome variables when compared with their old dentures. Similar results have been reported by various studies which have compared NZ complete dentures with dentures made using conventional techniques [8, 15, 21, 22]. However, no study could be identified in literature which compared patient satisfaction with the complete dentures fabricated using the PNZ technique and the conventional technique.

The results of the present study indicate that patients found NZ complete dentures more comfortable and esthetic than their old dentures. While recording maxillary NZ, we noticed formation of convex bulges in the tissue-conditioning material unilaterally or bilaterally on the buccal surface in many patients (Fig. 2). Correct positioning of the teeth, optimal contouring of the polished surfaces and the convex bulges reproduced in the maxillary dentures provided improved facial support and better esthetics. It is therefore suggested that NZ can be

recorded for the maxillary denture space to provide optimum facial support.

The patients' ability to chew bread and their satisfaction with the stability of maxillary dentures did not significantly differ between their old and the two sets of NZ dentures. This would be possibly because of fact that maxillary dentures are usually more stable than the mandibular. Similar results were found for the variables of soreness of gums and food entrapment under the maxillary denture.

Patients in the present study did not find significant improvement in speech with their PNZ dentures when compared with the SNZ dentures. It is suggested that customization of palatal contours of maxillary dentures by recording palatograms when using PNZ technique would possibly result in improvements in speech. Further studies can be conducted which will evaluate the function of speech subsequent to the recording of palatogram and phonetic NZ.

Table 3 Preference for SNZ or PNZ denture with regards to esthetics, stability, comfort, ability to speak and chew and final choice of prosthesis

Variable	<i>n</i>	Percentage (%)
Esthetics		
SNZ	6	60.0
PNZ	3	30.0
No preference	1	10.0
Stability		
SNZ	5	50.0
PNZ	–	–
Both	5	50.0
Comfort		
SNZ	7	70.0
PNZ	2	20.0
Both	1	10.0
Ability to speak		
SNZ	3	30.0
PNZ	4	40.0
Both	3	30.0
Ability to chew		
SNZ	6	60.0
PNZ	2	20.0
Both	2	20.0
Final Choice		
SNZ	5	50.0
PNZ	3	30.0
Both	2	20.0

**Fig. 2** Shows convex bulges developed on the buccal surface of the maxillary NZ record

It was also observed that the mean dimensions of the NZ records in the molar areas were narrower than the bucco-lingual widths of the commercially available acrylic resin teeth. This required grinding of the teeth lingually in both

the PNZ and SNZ dentures in order not to disturb their function. Ikebe et al. [24] and Gahan et al. [10], reported a similar need of grinding the teeth lingually. It is suggested that artificial teeth with narrow bucco-lingual widths should be readily available commercially or the teeth should be customized when constructing NZ dentures.

Conclusion

A cross-over pilot study was conducted to test the hypothesis that there is no difference in patient satisfaction with the complete dentures fabricated using the SNZ and PNZ techniques. The findings of this study validate the hypothesis and also show that there is no significant difference in the mean dimensions of the two NZ records. The results of the choice of prosthesis showed that with regards to esthetics, comfort, stability and ability to chew SNZ dentures were preferred by the patients. For ability to speak, mixed preferences were found for both the dentures. It can therefore be suggested that dentures fabricated using SNZ techniques led to better overall patient satisfaction. However, these findings must be interpreted with caution because of the limited sample size of the study. It is suggested that a further study with an increased sample size should be carried out to validate the findings of this study.

Conflict of Interest None.

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