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Clinical outcomes of incorporating neutral zone and CAD/CAM technology into complete denture workflow (Crossover Randomized Clinical Trial)

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Aim: The purpose of this study was to evaluate and compare neutral-zone CAD/CAM dentures and conventionally fabricated heat-polymerized dentures; by assessing patient satisfaction, dentist satisfaction, and upper denture peak retention force.

Materials and methods: This research employed a within-subject comparison of two distinct denture kinds in a randomized clinical trial design as follows; group I: CAD/CAM neutral-zone dentures, and group II: heat-polymerized conventional dentures. Twelve completely edentulous patients exhibiting marked ridge resorption were recruited, and each patient received two denture sets in a random sequence. Dentures were clinically evaluated on the insertion day by a non-operating dentist then, patients used their dentures for eight weeks before further assessments. Dentures' clinical adequacy was rated by the dentist via the visual analog scale (VAS), also a digital force gauge was used to measure the dentures' peak retention force. Patient satisfaction was evaluated according to the patient denture assessment questionnaire (PDA). The obtained scores were used to compare the two denture types using the Independent-samples t-test and the Pearson's correlation coefficient test was used to assess the degree of association between patient and dentist-reported outcomes.

Results: The Independent t-test revealed significantly higher values for patient and dentist satisfaction with neutral-zone dentures compared to conventional dentures, and also a higher mean value for CAD/CAM dentures' peak retention force ($P < 0.001$). Pearson's correlation coefficient test revealed a non-significant correlation between patient and dentist satisfaction scores ($p > 0.05$).

Conclusion: Milled neutral-zone dentures demonstrated better retention and better impact on patient and dentist acceptance than conventional heat-polymerized dentures.

Keywords: CAD/CAM complete dentures; Neutral zone; Denture retention; Patient satisfaction; Dentist satisfaction.

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Introduction

The ideal placement for prosthetic teeth in full dentures has been the subject of numerous hypotheses and notions over time.[1,2] However, the introduced dogmatic approaches have been contested and proven inadequate not only by rigid research but also by failure to restore function, aesthetics, and comfort in many patients particularly those with severely atrophic mandibular ridges. [3] To overcome such a problem, the neutral zone technique was advocated to locate the position of teeth and the shape of the polished surface of denture flanges so that the forces exerted by muscles will tend to stabilize the denture rather than unseat it. [4]

The field of digital dentistry is expanding significantly, and CAD/CAM complete denture construction has been proven to provide more adapted, retentive, and stable dentures than conventional techniques, as it eliminates the effect of polymerization shrinkage. [5,6] Faty et al, [7] examined the retention and adaptation of milled and 3D-printed denture bases and compared them to conventional ones. The findings indicated notable distinctions between the three groups; 3D-printed denture bases demonstrated better retention, but their adaptation was comparable to that of traditional heat-polymerized denture bases, while milled denture bases demonstrated better adaptation and retention than both of the other groups.

To fully digitize the denture restoration process, including clinical and laboratory procedures, there is still much work to be done. Intraoral scanning and mandibular movement devices are feasible techniques, but they require further methodological exploration and the maturity of the technology. Thus, in clinical operations; impressions and jaw relation records are yet needed and these contemporary techniques are adaptable in how they can be integrated with the steps of conventional protocols. [8] In this way the neutral-zone record, the definitive impressions, and the interocclusal records could be all digitized to physiologically locate prosthetic teeth positions and to functionally define the contour of the cameo surfaces for those digital dentures. [8-10]

When patients' anatomical and physiological needs are taken into account along with appropriate prosthetic techniques, a dentist can create an ideal denture. However, the question of whether patients are satisfied or not with their dentures will never end. It is not appropriate to evaluate the success of a patient's rehabilitation with a denture just based on the prosthodontist's clinical standards; patient satisfaction should also be taken into account because the patients' evaluation approach is based on everyday life aspects rather than clinical ones. [11,12] A clinical study was conducted to evaluate the patient's priority in the fabrication of complete dentures and the denture satisfaction factors from both the dentist and patient perspectives, although the majority of patients were concerned about better chewing function, congruence between dentist and patient satisfaction scores was evident. [13]

Clinical evidence is lacking on whether dentures fabricated by computer-aided-design/ computer-aided-manufacturing along with incorporating the neutral-zone impression technique in the digital workflow can afford superior clinical outcomes when compared with those fabricated conventionally, particularly in patients suffering from ridge resorption. Thus, the current work aims at comparing and correlating the patient and dentist-reported outcomes and testing the retention force for; milled neutral-zone and conventional heat-polymerized dentures restoring patients with advanced ridge resorption. The null hypotheses were that; there would be no differences between the

two denture kinds regarding retention, patient, or dentist satisfaction, and there would be no differences between the patients' and dentists' perception of denture competence.

Materials and methods

The study employed a within-subject comparison between CAD/CAM neutral-zone dentures (group I) and heat-polymerized conventional dentures (group II). The protocol of the research was approved by the ethical committee of the Faculty of Dentistry Beni-Suef University on 1/2024 (no. of approval: # REC-FDBSU/01022024-01/AM). Sample size calculation was performed using G*Power version 3.1.9.7 [14] A power analysis was designed to have adequate power to apply a two-sided statistical test to reject the null hypothesis that there is no difference between groups. By adopting an alpha level of (0.05) and a beta of (0.2), i.e. power = 80% and an effect size (d) of (0.95) calculated based on the results of a previous study. [15] The predicted sample size (n) was 11 and was increased to 12 to appropriately detect differences between the treatment dentures.

Patient selection

The following criteria were used to choose the patients: they had to be completely edentulous and have been so for more than five years; they also had to exhibit resorbed mandibular ridges (Class V Atwood's) [3], class I maxilla-mandibular relationship; U-shaped palatal vault; free of TMJ and any osseous disorders. Exclusion criteria included xerostomia, maxillofacial surgery-related defects, any congenital abnormality, patients with flabby ridges, neuro-muscular disorders, and any soft or hard tissue pathology. After receiving their ethical approval, the twelve participants from the outpatient department clinic who were 50 years of age or older became eligible for the study.

Conventional complete denture fabrication

Primary and definitive impressions were made following the two-step impression technique, stone casts were poured, and the centric occluding relation record was obtained according to the wax wafer technique. Before the clinical try-in session, the bite records with their corresponding master casts were digitalized using a desktop scanner (Medit T300, Seoul, South Korea) having the station sequence of scanning upper cast, lower cast then bite registration, and were stored as standard triangulation language (STL) files. Trial placement of the waxed-up denture was performed to verify the accuracy of the obtained records before going through the next steps of heat-processing or digital workflow. Before processing, a sphere of wax was added to the outer surface of the waxed-up denture base to smudge the calculated marked geometric center of each maxillary cast. [7] After processing, a metallic ring was attached to the palatal surface of each denture at the smudged position by auto-polymerizing acrylic resin (Acrostone cold cure denture base material, Acrostone, Egypt), and the conventional dentures were kept until the fabrication of the neutral-zone dentures.

Designing and fabrication of the neutral-zone tray

A well-adapted, 2mm-short border mandibular base plate was designed with established occlusal contact at the proper occlusal vertical dimension (VDO) against a maxillary bite-block through narrow posterior occlusal rims set at the proper level and inclination for the occlusal planes as reproduced from the scanned bite record. (fig.1a&b) Based on the generated CAM file, a 3D printer (Microdent 1Pro 3D printer,

Mogassam, Egypt)was used to fabricate the tray in photo-curable resin (HEX MODEL gray resin, Cairo, Egypt). To enable proper interlocking with the impression material, the tray design was created with multiple indentations. Additionally, a stainless-steel orthodontic wire was bent and attached over the anterior ridge crest using auto-polymerizing resin (fig.1c).

Neutral zone impression

A tissue conditioning material (COE-COMFORT™ tissue Conditioner, GC AMERICA) was mixed and applied to the tray exterior, the patient was asked to repeat distinctly pronounced sounds and to perform smiling, whistling, sucking, extending tongue and moving it from left to right licking the upper and the lower lips, and also given a straw and glass of water to sip and swallow repeatedly to mold the impression material through the action of the cheek and lip muscles moving inward, and the muscles of the tongue moving outward pushing the impression material into the position of muscle neutrality. The patient's ability to speak, swallow, and open wide without impression movement or being dislodged was finally confirmed. **(fig.1d)**

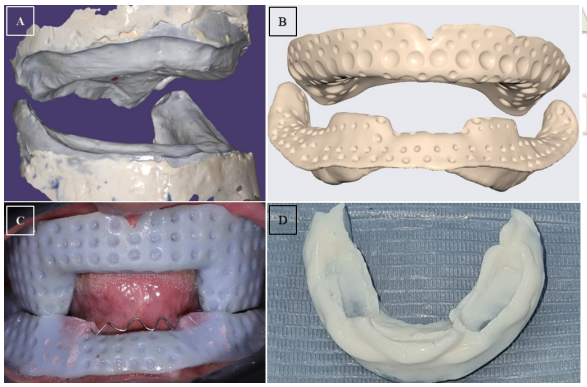

Fig. 1. Neutral-zone tray designing(A&B), construction (C), and the obtained neutral-zone registration(D).

Digital denture designing and fabrication

The formed neutral-zone impression was scanned and scan data were superimposed on the previously obtained records, thus the virtual lower cast with a well-defined neutral-zone space was aligned in the software to the opposing maxillary cast based on the patient's inter-arch relations. After virtual trimming of the neutral-zone impression to the level of the formed tongue depression, a flat occlusal platform was formed representing the lower occlusal plane functional level and the faciolingual location of the neutral zone, thus providing a physiological guide for teeth positioning. First, virtual teeth were automatically positioned in the average locations based on the software algorithms relative to certain anatomical landmarks, then teeth were rearranged and denture flanges were remolded based on the digitized confines of obtained neutral-zone registration; the software was used to create a newly polished surface then the gingiva free-forming tools were used to trim the external contours until uniform matching between the software-generated base forms and the exterior impression surfaces (fig.2).

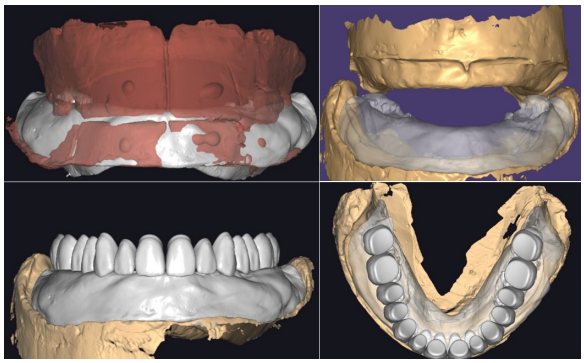

Fig. 2. Dataset alignment and neutral-zone teeth arrangement.

Based on the CAM file generated, trial neutral-zone prototype dentures were 3D-printed in tooth-colored resin and reevaluated for occlusal and esthetic aspects before final denture fabrication. After a successful try-in, the maxillary arch geometrical center was calculated for each master cast before the denture fabrication; a midpoint marked on the midline drawn from

the center of the incisive papilla to a point midway between the two hamular notches represented the center of the arch. [16] In the position of the marked center, a cylindrical body was virtually attached to the outer surface of the designed maxillary denture base. Finalized denture data were transferred as STL files to the milling machine (ED5X EMAR DENTAL MILLS, C2, Industrial Complex, 10th of Ramadan City, Egypt) and dentures were milled from reinforced monolithic polymethylmethacrylate resin blocks. (two-color PMMA multilayer open system, Chongqing Zotion Dentistry Technology Co., Ltd. China)**.** The metallic ring was attached to the palatal surface at the smudged geometric center (fig.3a-e).

Dentures insertion

Patients were randomly assigned to receive one of the two dentures first. Six patients received the conventional denture first and the other six received the neutral-zone denture first. The selected denture was delivered to the patient after performing the needed adjustments for the fitting and occlusal surfaces (fig.3f). Before patients were given instructions on how to take care of their prosthesis and arrange for regular recall appointments, the dentist's satisfaction with various clinical aspects of denture standards and the maxillary denture peak retention force were evaluated. Patients were not told about the nature of the disparity between the two dentures and were blind to the type of worn denture. Patients were allowed to use the denture for eight weeks before assessment of their satisfaction, and the second denture was delivered and evaluated in the same way only after a two-week washout period. upon delivery of the second set, the first set was always withheld.

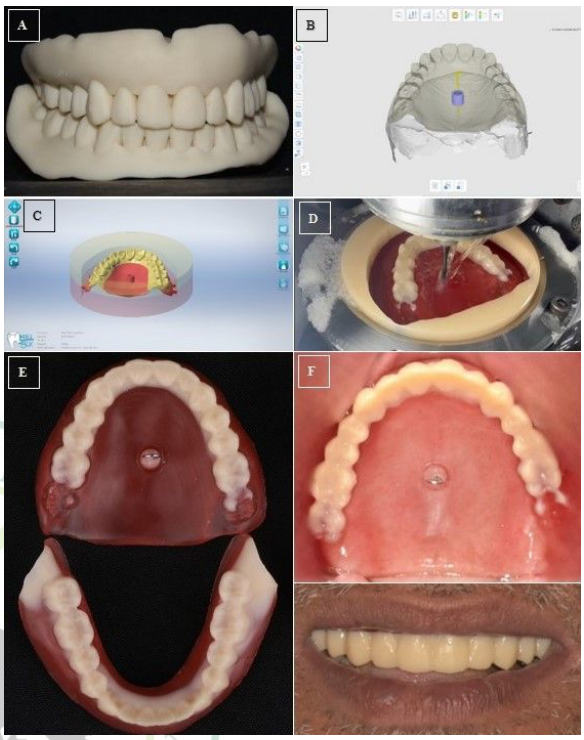

Fig. 3. Steps involved in digital denture processes; 3D-printed neutral-zone trial denture (A), marking the geometric center of the maxillary denture (B), preparation of CAM file for milling process (C&D), milled upper and lower dentures extraoral view (E), and intraoral view of final prosthesis (F).

Dentures evaluation

a.Evaluation of the maxillary denture retention

Dentures were immersed in water for 24 hours and were allowed to remain for 5 minutes in the patient's mouth to ensure adaptation to tissues before the evaluation of retention. A digital force gauge (HF-100 Digital Force Gauge, Jinan Hensgrand Instrumentation Co., Ltd., Jinan, China) was used to measure denture retention. The display before each measurement was adjusted to zero via the zero button. In the upright position, the patient was instructed to tilt the head backward till the palate was almost 45 degrees to the floor, this posture allowed the administered dislodging force to be almost perpendicular to the denture. The metallic ring was engaged by the device hook and dislodging force was applied to the denture until it was forced out of its position,

the maximum force required to remove the denture was considered as the peak retention value. The measurement procedures were repeated 5 times at intervals of 5 minutes to calculate the average result. [16]

b.Evaluation of dentist satisfaction:

To assess the level of dentist satisfaction with different aspects of denture clinical standards, a VAS-based survey form was developed along the lines of a previous study.[12] Another blinded prosthodontist was assigned to fill in the formulated template and score each denture based on specific criteria set for clinical evaluation of denture retention, stability, margin extensions, and the extent of needed adjustments for fitting and occlusal surfaces. Every item has a maximum score of 10 points and a minimum value of 0 points for quantitative assessment of denture quality ranging from 0–10. Table 1 displays the criteria for ranking dentist satisfaction.

Table (1): Dentists' satisfaction ranking criteria.

Items	Content	8 - 10		6 – 7		< 6	
		CV	NZ	CV	NZ	CV	NZ
1-Fitting surface adaptation	Duration and quantity of needed adjustments to eliminate pressure on tissues.	Minimal		A few		Excess	
2-Retention	Resistance to dislocation when the dentures are pulled in a vertical direction.	Obvious resistance		Some resistance, readily dislocated		No resistance, easily dislocated	
3-Stability	Maintaining stability with; Applying alternate pressure to the first molar simultaneously, and with tongue motions.	Stable without movement		Some movement		Shifting, tipping, and rising.	
4-Border extension of denture base	-Denture base border morphology fit with soft tissue morphology -Labial, buccal, and lingual borders reached the sulcus -Posterior borders reached the vibrating line and covered the retromolar pad.	All consistent		Consistent with three criteria		Consistent with two or fewer criteria	
5- Occlusal equilibration	Amount of grinding, and grinding time.	Little		Some		Excess	

NZ; neutral-zone denture (group I), CV; conventional denture (group II)

c.Evaluation of patient satisfaction

Retention, stability, masticatory efficiency, comfort, speech efficacy, and esthetics were evaluated by the patients based on a customized PDA questionnaire with 22 questions answerable by a five-point Likert scale. The scale of 1 to 5 represents never, rarely, sometimes, often, and always depending on the question's positivity or negativity, patients were asked to rate their dentures on each aspect, this allowed the levels of patient satisfaction to be explained as follows: unsatisfactory, hardly satisfactory, moderately satisfactory, very satisfactory, and excellent satisfaction. [11, 17] The same examiner explained the questions thoroughly to the participants so that they could easily comprehend how to complete the questionnaire.

Statistical analysis

There were no dropouts among the participants. Six criteria were used to evaluate patient satisfaction, and five clinical criteria were used by the dentist to determine the dentures' appropriateness, in addition to the assessment of the peak retention force values for the twenty-four maxillary dentures. data were collected and tabulated for statistical analysis; they were analyzed using the statistical package for social sciences, version 23.0 (SPSS Inc., Chicago, Illinois, USA), and explored for normality using the Kolmogorov-Smirnov and Shapiro-Wilk test. Data were presented as mean± standard deviation and ranges. The Independent-sample t-test of significance was used when comparing between two means and Pearson's correlation coefficient test was used to assess the degree of association between two sets of variables. The confidence interval was set to 95% and the margin of error accepted was set to 5%.

Results

The main metrics used to compare the two treatments were the calculated mean values of; denture peak retention force, dentist, and patient satisfaction scores. Compared to traditional dentures, neutral-zone dentures achieved significantly higher values for most of the assessed criteria. The denture ranking scores acquired by patients and dentists showed a weak statistical association (negative in group I and positive

in group II). Descriptive statistics are illustrated in Table (2,3).

Table (2): Comparison between conventional and neutral-zone dentures according to denture peak retention force, dentist satisfaction scores, and patient satisfaction scores.

Outcome	Mean±SD & ranges	CV denture group	NZ denture group	t-test	p-value
Retention force	Mean±SD	23.58±5.18	43.63±3.64	-10.962	<0.001**
	Range	17.35-32.82	37.06-48.02		
Dentist satisfaction scores	**Tissue surface adaptation**				
	Mean±SD	7.08±0.67	9.17±0.72	-7.358	<0.001**
	Range	6-8	8-10		
	Retention				
	Mean±SD	6.75±0.62	9.50±0.52	-11.734	<0.001**
	Range	6-8	9-10		
	Stability				
	Mean±SD	8.50±0.52	9.50±0.52	-4.690	<0.001**
	Range	8-9	9-10		
	Border extension of denture base				
	Mean±SD	6.67±0.49	9.58±0.51	-14.182	<0.001**
	Range	6-7	9-10		
	Occlusal equilibration				
	Mean±SD	6.00±0.74	9.58±0.51	-13.787	<0.001**
	Range	5-7	9-10		
	Total				
	Mean±SD	35.00±1.81	47.33±1.37	-18.824	<0.001**
	Range	31-38	45-49		
Patient satisfaction scores	**Function & comfort**				
	Mean±SD	16.83±0.94	17.33±0.65	-1.517	0.143
	Range	15-18	16-18		
	Aesthetics & speech				
	Mean±SD	11.50±1.31	12.67±1.30	-2.184	0.040*
	Range	10-14	10-14		
	Lower denture retention, stability & comfort				
	Mean±SD	10.67±1.23	16.00±1.04	-11.445	<0.001**
	Range	9-13	14-18		
	Expectation				
	Mean±SD	5.50±1.38	12.50±0.90	-14.683	<0.001**
	Range	4-8	11-14		
	Upper denture retention & stability				
	Mean±SD	12.08±0.79	15.08±1.73	-5.461	<0.001**
	Range	11-13	12-17		
	Importance & comfort				
	Mean±SD	15.42±2.39	16.08±2.07	-0.731	0.473
	Range	11-19	12-19		
	Total				
	Mean±SD	72.00±2.98	89.67±4.05	-12.159	<0.001**
	Range	68-75	82-94		

Using: t-Independent Sample t-test for Mean±SD; p-value >0.05 is insignificant; *p-value <0.05 is significant; **p-value <0.001 is highly significant

Intergroup comparisons of; denture peak retention force, dentist-reported outcomes, and patient-reported outcomes:

Statistical analysis using the independent t-test showed a significantly higher mean value of retention force in the neutral-zone group compared to the conventional denture group (P<0.001). By implementing the VAS for quantitative assessment of complete denture quality, the clinical efficiency of dentures produced by digital and conventional techniques was also compared using the independent t-test; there was a statistically significant higher mean value of dentist satisfaction with; tissue surface adaptation, retention, stability, border extension, and occlusal equilibration in neutral-zone group compared to conventional denture group (p<0.001). The highest mean dentist satisfaction scores were for the neutral-zone dentures concerned with the extension of denture borders and occlusal acuity (9.58±0.51), while the lowest mean scores were calculated for occlusion correctness of conventional dentures (6.00±0.74). The t-test revealed also that patient satisfaction was significantly higher with neutral-zone dentures compared to the traditional ones, because of improved speech and aesthetics (p<0.05), closer matching to patient expectations, and improved stability and retention of the dentures (P <0.001). The highest mean patient satisfaction scores were recorded for the feeling of comfort when eating and swallowing with neutral-zone dentures (17.33±0.65), Conventional dentures showed the lowest mean scores (5.50±1.38) for meeting patients' expectations (Table 2).

Table (3): Correlation between patient and dentist satisfaction scores using Pearson's correlation coefficient (r).

Groups	Total patient satisfaction scores and total dentist satisfaction scores	
	r-value	p-value
CV denture group	0.236	0.461
NZ denture group	-0.044	0.893
	Total score of patient satisfaction and total score of dentist satisfaction about dentures' retention and stability	
CV denture group	0.141	0.662
NZ denture group	-0.151	0.640

Using: Pearson's correlation coefficient (r); p-value >0.05 NS; *p-value <0.05 S; **p-value <0.001 HS

Correlation between dentist and patient-reported outcomes

Pearson's correlation coefficient test revealed overall congruence between the total patient and dentist satisfaction scores in the conventional denture group, however, the correlation was weak (p>0.05). Also, the correlation between total scores of patient satisfaction and total scores of dentist satisfaction calculated for denture retention and stability in the conventional group was positive but non-significant (p>0.05). For the neutral-zone denture group, Pearson's correlation coefficient test revealed a non-significant negative correlation (p>0.05) for

both total satisfaction scores and retention and stability scores (Table 3).

Discussion

The present study intended to add further proof to support the clinical application of digital dentures when compared to conventional dentures by considering the dentist and patient-reported outcomes and evaluating denture retention. We also aimed to offer a precise and workable method of integrating the neutral-zone recordings with the CAD/CAM complete denture workflow, which raises important clinical implications, particularly among patients who are candidates for such physiological technique. [18-20] The first postulated null hypothesis was rejected since the data showed a substantial difference between the two types of dentures in every way. The second null hypothesis, however, was accepted due to the congruence between the patient's and dentist's cumulative scores for quantitative evaluation of the conventional dentures' efficiency.

Although it is strongly advised to functionally delineate the exterior denture contours and the prosthetic teeth positions in patients with advanced ridge resorption, the applicability of the neutral-zone technique is affected by various factors including; different impression materials, tray designs, functional movements, and whether open-mouth or closed-mouth technique is employed. [21,22] That's why we customized a peculiar neutral-zone tray design and used an easily moldable material with a long working time to allow the patient to perform a combination of multiple functions involving; swallowing, tongue movements, and speech, thus, getting the benefits of all functions, [9,10] and by having the patient close gently at the proper VDO and swallow, we were able to better control the impression material and prevent its displacement everywhere and guaranteed more accurate molding and more even distribution of pressure on impression material. [23] The technique is also not widely practiced and the quality of neutral-zone dentures produced by the conventional techniques can be significantly impacted by lack of technical support and experience; thus, we favored integrating it with the digital workflow which was more standardized. [8-10] To further ensure accurate reproduction of the software-created design without any change in the patient-determined teeth positions or base contours, dentures were milled from pre-polymerized monolithic pucks as a single piece. This eliminated the need for additional steps of bonding the teeth to milled or printed bases which occasionally cause the prosthetic teeth to become misaligned. [24]

In agreement with other research, [25,26] there is a consensus that CAD/CAM dentures show a more precise base fit, better clinical retention, and a minimized occurrence of denture-related traumatic lesions. we also can refer to Al Helal et al. [16] who concluded that the retention offered by milled bases can be higher than that offered by conventional heat-polymerized denture bases. Those findings were further supported by other studies [27-29] that reported that digital dentures demonstrated a significant improvement in quality of life, muscle activity, retention, fitting, extension, stability, and higher dimensional accuracy compared to conventionally fabricated dentures. This could account for the milled denture's superior results in this study, but still for the manufacturing of digital dentures, extreme residual ridge resorption is a difficult clinical scenario with not many reported outcomes, and only a few CAD/CAM processes endure to handle this complex scenario. [12,29] Thus, Measuring the maxillary denture retention was valuable to rule out the potential impact of unretentive conventional upper denture on subsequent evaluations of patients' perceptions of their dentures that might affect

the results of this study. This study, therefore, builds upon previous studies that sought to elucidate the importance of the neutral-zone approach. It has been shown that the physiologically inadequate volume of the denture base, as well as the functionally inappropriate setting of the denture teeth, are linked to compromised retention, poor stability, phonetic issues, inadequate facial support, inefficient tongue posture/function, and increased gagging. [19,30]

Successful rehabilitation with a complete denture does not only depend on factors modulated by dentist and lab fabrication, patient-dependent factors are also a major concern. For patients, neutral-zone digital dentures were more pleasant. Feeling easy and comfortable during eating and swallowing earned the highest rating by patients, which makes sense because the artificial teeth were positioned in the zone of muscle balance. [19-21] The three primary structures involved in mastication are the tongue, teeth, and the medial roll of the buccinator muscle, the premolar buccal surface serves as a point of fixation for the medial roll of the buccinator keeping food and saliva inside the mouth and giving the muscle enough leverage, this works in tandem with the tongue-generated peristaltic movement essential to mastication and swallowing. [32] The achieved harmonious relationship with muscles and the greater stability and retention of those digital dentures would account for the patient's increased capacity to use their dentures. [33]

Despite aesthetic concerns of some patients regarding the unpleasant transition between artificial teeth and denture base in group I, the difference in patients' perception of appearance between neutral-zone and conventional dentures was non-significant, this can be interpreted by the fact that; the main concern for most patients, particularly the elderly is to have a stable, retentive, comfortable denture with which they can masticate well, this is likely more vital for them than esthetic appeal, and also, as per an earlier research report, [34] participants were able to talk more effectively and adjust more quickly with their neutral-zone dentures since it represents the most physiological posture, which explains the statistically significant higher mean value of cumulative aesthetics and speech satisfaction scores for neutral-zone dentures.

On the other hand, the conventional dentures stumbled to meet the patient's expectations and got the lowest scores in this perspective. Subjects in this group have reported more tissue irritation which mostly is related to polymerization shrinkage of the dentures which distorts the palatal area of the maxillary denture resulting in an inaccurate fit to the tissues and also affects teeth position and final occlusion. [35] This was correlated to the lowest scores reported by the dentist for conventional denture border and occlusal correctness; conventional dentures formed by compression-molding technique exhibit greater errors and inaccuracies, to correct these flaws excessive adjustments for borders, fitting surface, and occlusal contacts are occasionally required, this consumes much more time and represents an unpleasant experience for both patient and dentist and even in its best ways is subjective, not standardized, and highly error-susceptible, thus can accentuate rather than correct the errors and further impacts the patient's psychological acceptance of the prescribed treatment, and this is the first aspect that can alter the outcomes of the treatment. [12]

The results of this study for the conventional denture group align with those of previous investigations that correlated dentist and patient outcomes; patient satisfaction and denture quality were found to positively correlate by prior research where patient satisfaction was linked to the denture's proper extensions and retention.[36-38] Conversely, for the neutral-zone group in our

study, the statistical analysis depicted a nevertheless weak but negative correlation; the improved denture clinical aspects judged by the dentist were not every time validated by the greater patient satisfaction with the parameters of the function. Berg [39] also revealed that the prediction of patient satisfaction does not correlate with the quality of the denture.

The subjectivity in the assessment of patient and dentist satisfaction may be one of this study's limitations. however, it is worth mentioning that the employed questionnaires demonstrated good reliability by assessing their internal consistency and test-retest reliability. [11]Also, customizing the questionnaires using valid psychometric response scales [17] helped to measure such subjective characteristics and to obtain a detailed quantitative computation of the patient's perceptions of using their dentures, and the dentist's perception of denture quality. Furthermore, the cross-over study design excluded the impact of patient-related factors and variables that could impact the tested outcomes. [(40)] Another limitation of this study is the increased number of clinical sessions needed for the fabrication of the digital neutral-zone dentures compared to traditional workflow; an extra visit to obtain the neutral-zone impression and another one for CAD/CAM try-in. However, in such a situation of ridge atrophy; it was more reliable to combine conventional impression techniques that enabled accurate capture of both features of denture foundation and denture space with the novel CAD/CAM manufacture that offered improved denture materials and enhanced fit, retention, and stability. Also, further research is recommended to explore the differences between CAD/CAM neutral-zone; CAD/CAM standard; conventional heat-polymerized; and neutral-zone heat-polymerized dentures in a compromised clinical setting.

Conclusions

Within the limitations of this study, the current research concludes the following:

- Compared to traditional heat-polymerized dentures, CAD/milled neutral-zone dentures showed superior retention and an improved effect on patient and dentist acceptance.
- The patient's demands and priorities are not necessarily addressed by the clinical assessment criteria of dentists.

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