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Comparison of Electromyographic Muscle Activity and Occlusal Accuracy Between the Conventional and CAD/CAM Neutral Zone Complete Dentures (Randomized Controlled Clinical Trial)

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Aim: This study aimed to evaluate and compare the occlusal force distribution, measured with the T-Scan system, and electromyographic activity, assessed during static and dynamic tests with the Myowise device, between conventional and CAD/CAM neutral zone (NZ) complete dentures.

Materials and Methods: This within-subject randomized controlled clinical trial involved eight completely edentulous patients, each receiving two types of NZ complete dentures: Conventionally (Group I) and CAD/CAM (Group II). The patients were randomly assigned to use one of the dentures first before switching to the other. At the time of denture insertion, occlusal force distribution was assessed using a T-scan. After two months, electromyographic activity was measured with a Myowise device. The independent t-test was used for intergroup comparisons.

Results: Group II showed higher occlusal force distribution and greater mean muscle activity of the temporalis (TA) and masseter (MM) muscles during the static test (clenching) compared to Group I; however, these differences were not statistically significant. Group II also exhibited less asymmetry in TA and MM muscle activity between the right and left sides during the static test, without statistical significance difference. During the dynamic test (chewing), no significant differences in muscle activity were observed between the two groups on the "working side" and "balancing side" ($p > 0.05$).

Conclusion: The NZ technique ensures balanced occlusal forces and optimal muscle coordination in complete dentures, whether created with CAD/CAM or conventional methods. Both approaches are equally successful in producing stable and functional dentures.

Keywords: Electromyography, CAD/CAM, Dental impression technique, Complete denture.

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Introduction

Through persistent efforts to enhance oral hygiene, edentulous patients have been globally reduced.[1] Nevertheless, the demand for complete denture (CD) treatment remains significant. Several patients may choose not to undergo implant therapy because of financial constraints, an existing medical condition, or an unwillingness for surgical procedures.[2] However, CD wearers often struggle with proper eating due to the instability of their mandibular dentures. The success of mandibular CD relies heavily on adequate stability and retention.[3] Studies have shown that more than 50% of mandibular CDs encounter issues with retention and stability.[4]

The correlation between dentures' cameo surface and the teeth' positioning to the surrounding musculature is essential for maintaining proper retention and stability in CD. The Glossary of Prosthodontic Terms-9 defines the NZ as the potential space between the lips and cheeks on one side and the tongue on the other. It refers to the zone or location where the forces between the tongue and cheeks or lips are balanced.[5] has been demonstrated to improve the function of the muscles involved in chewing, specifically the masseter (MM) and temporalis (TA) muscles, more efficiently than conventional CDs.[6] This is because the NZ facilitates the physiological adaptation of dentures to the surrounding oral musculature, thereby improving their competence during function.[7] Beresin et al. suggested against placing prosthetic teeth directly on the crest of the ridge, whether buccally or lingually. Instead, they suggested positioning the teeth according to the muscle activity of each patient.[8] Dentures constructed utilizing the NZ method result in lower CDs that are more stable and have better retention for individuals with severely resorbed ridges. Proper alignment of posterior teeth also ensures adequate room for the tongue and minimizes the accumulation of food.[9]

Muscle activity differs significantly when a patient wears a satisfactorily fabricated CD using the NZ technique compared to the conventional technique.[10] Electromyography (EMG) is an effective technique for investigating muscle function and activity, rendering it a vital instrument in dental research. EMG is a technique used to examine muscle function by analyzing the electrical signals produced during muscular contractions. Surface electromyography is a noninvasive method of measuring muscular activity. It involves placing surface electrodes on the skin just above the muscle.[11,12] Myowise is a recent medical device designed for the acquisition of EMG data from the TA and MM muscles (right and left). It provides valuable information related to the patient's occlusal condition. Myowise performs both static and dynamic tests. the static test (Clenching), assesses the peak muscle activity and symmetry between the left and right TA and MM muscles. The dynamic test (chewing), evaluates muscle activity during functional movements, comparing the "working side" and "balancing side" muscles.[13]

Understanding the role of muscle activity is crucial, but ensuring proper occlusion in achieving a stable mandibular complete denture is equally important. The maximum biting force of CD wearers is reduced to approximately 20% of that of dentulous patients. This diminished biting force adversely affects masticatory function, leading to poor chewing ability in CD wearers.[14] A static balanced occlusion, characterized by symmetrical contact between the posterior teeth in a mandibular centric relation position, is the minimum prerequisite for CD occlusion.[15] Occlusal disharmony can lead to physical injury and decrease the stability and retention of dentures. Consequently, evaluating and

correcting the occlusion when providing complete dentures is a standard procedure. Regardless of whether an intraoral approach or a clinical remount procedure is selected, occlusal-indicating material is employed to visualize occlusal contacts.[16] When utilizing articulating paper, the identification of premature contact is determined by the subjective perception of the intensity, shape, and size of the markings.[17] Recently, the T-Scan devices have been implemented for digital occlusal analysis to assess several occlusion parameters, such as the distribution patterns of occlusal force in CDs. The T-Scan provides crucial data on the distribution of occlusal force, which is essential for generating a balanced and measurable occlusal force. Ideally, the occlusal force should be evenly distributed, roughly 50% on the right and 50% on the left sides. This equitable distribution of force enhances the CDs' ability to adapt to the surrounding tissue while chewing.[18-20]

Computer-aided design and computer-aided manufacturing (CAD/CAM) technologies have significantly transformed the process of manufacturing CDs. Studies have shown that integrating CAD/CAM technology in CD fabrication reduces polymerization shrinkage and improves denture adaptation.[21] Furthermore, CAD/CAM technology has been successfully applied in previous case reports for implementing the NZ concept, using 3D-printed record bases and wax trial dentures to capture NZ impressions.[22] This study aimed to evaluate and compare the occlusal force distribution, measured with the T-Scan system, and electromyographic activity, assessed during static and dynamic tests with the Myowise device, between conventional and CAD/CAM NZ CDs. The null hypothesis for this clinical trial posited that there would be no differences between conventional and CAD/CAM NZ CDs regarding the occlusal force distribution and electromyographic activity.

Materials and Methods

Patient selection and randomization procedure

This within-subject randomized control clinical trial received approval from the Faculty of Dentistry, Ain Shams University (approval number: FDASU-ReclR012317). It was registered and published on https://clinicaltrials.gov/ under the NCT number NCT05990088, with a registration date of July 22, 2023.

Based on the findings of a previous study,[12] a power analysis was conducted to ensure sufficient statistical power for applying a two-sided null hypothesis test, which assumes no difference between various tested groups in terms of both the occlusal force distribution and electromyographic activity of TA and MM muscles. Using an alpha (α) level of 0.05 (5%) and a beta (β) level of 0.2 (80% power), along with an effect size (d) of 1.55, the calculated sample size (n) was determined to be 8 cases per group. The calculation of the sample size was conducted using G*Power version 3.1.9.7.[23]

Eight completely edentulous patients were assigned from the outpatient clinic of the Oral and Maxillofacial Prosthodontics department at a dental institution. This randomized controlled clinical trial was following CONSORT 2010 guidelines. The journey of those participating in the study is depicted in the CONSORT 2010 flow diagram (Figure 1). Patients were recruited according to the following inclusion criteria: males and females aged 65-75 who had been completely edentulous for more than five years, and with Angle class I maxillo-mandibular relationships. Patients with systemic diseases affecting neuromuscular function, xerostomia, temporomandibular joint (TMJ) disorders, congenital or acquired abnormalities, flabby tissue ridges, tongue

pathology, or psychological conditions influencing their reaction to treatment were excluded.

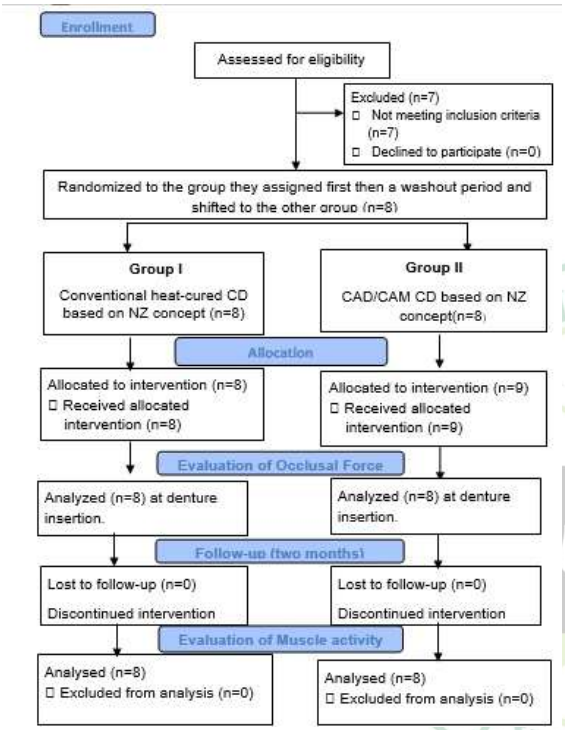

Figure 1: Participant CONSORT Flowchart Detailing Patient Progression Through Each Stage of the Randomized Controlled Trial.

A total of eight patients participated in this study. Each patient received two CDs based on the NZ concept: one constructed using the conventional heat-curing polymerization technique (Group I) and the other using the CAD/CAM milling technique (Group II). Before commencing the trial, the patients were provided with a clear explanation of the study's objectives and methodology, and each participant provided their informed consent by signing the necessary documentation.

Sixteen sets of randomization sequences were generated, each containing two unique numbers to determine the sequence of denture insertion for each patient. An impartial practitioner, who was not engaged in the process of selecting or treating patients, randomly allocated individuals to either Group I or Group II. The practitioner had access to the randomization sequence and could access the randomization lists, which were securely saved on a laptop protected by a password. The randomly generated codes were enclosed in sequentially arranged, opaque, and sealed envelopes using a research randomizer (https://www.randomizer.org/). Patients chose an envelope, and the practitioner established their group allocation. Patients were blinded to the type of denture they received. They used the provided dentures for two months before the assessment. Afterward, the dentures were withdrawn, and following a two-week washout period, the other denture was delivered and assessed in the same manner. Participants remained blinded throughout the study.

Study Procedures

The initial steps were identical for both groups, following standard clinical and laboratory procedures.[24,25] Primary impressions were performed using hydrocolloid impression material (Cavex CA37, Cavex Holland BV, Haarlem, The Netherlands). Final impressions were taken with zinc oxide and eugenol impression material (Cavex Outline, Cavex Holland BV, Haarlem, The Netherlands) after border molding with green stick compound (Kerr, Kerr Corporation, *Chicago,* USA). These impressions were then boxed and poured with type 3 dental stone (Elite Model, Zhermack, Polesine (RO), Italy). Maxillary casts were mounted on a semi-adjustable articulator using a maxillary face bow (Bio-Art Elite Face Bow, Bio-Art, São Carlos, Brazil), and mandibular casts were mounted using the centric jaw relation record taken from the patient using the wax wafer technique, Additionally a protrusive record was taken to adjust the condylar guidance of the articulator and setting of artificial teeth was preformed and intraoral try-in was done. Afterward, the steps differed for both groups.

For Group I, a mandibular denture base was created using cold cure acrylic resin (Acrostone Acrylic Material, Acrostone, Cairo, Egypt) on the mandibular mounted cast. This base included two uniform acrylic occlusal stops set at the correct occlusal vertical dimension, paired with a maxillary denture base containing two posterior bite blocks. Additionally, 25-gauge wrought wire loops were affixed along the crest of the ridge to hold the NZ recording material in place. (Figure 2A) Before taking the NZ impression, the maxillary denture base with the two-bite blocks was inserted to support the facial muscles and allow the tongue to be positioned correctly on the teeth and palatal contours during function.[26,27] The NZ impression was made using tissue conditioning material (COE COMFORT™ Tissue conditioner, GC, America) placed along the cameo surface of the base plate. Patients were instructed to perform functional movements until the NZ core was molded. These movements included smiling, grinning, pursing lips, counting from 60 to 70, speaking aloud, pronouncing vowels, drinking water, swallowing, slightly protruding the tongue, and wiping the lips. The actions were iterated for 10 minutes until the material was set.[28] (Figure 2B)

The NZ impression was positioned on the cast and lubricated with a separating medium. Putty was applied in two matrices: on the lingual portion of the model to form an artificial tongue, and on the labial and buccal sides of the NZ impression, fully encasing the occlusion rim. These matrices were performed at the exact level of the lower occlusal plane established in the mouth.[27] The impression material and occlusal stops were removed, and the index was repositioned to preserve the area of the NZ. Wax (Cavex Set Up regular, Cavex, The Netherlands, Holland) was then poured into this space, accurately representing the NZ. Cross-linked shallow cusped acrylic teeth (CROSS LINKED 2, Polident, Slovenia, Europe) were set up precisely according to the index in the mandibular arch (Figure 2C), followed by the maxillary artificial teeth to establish a balanced lingualized occlusion.

An intraoral try-in was performed afterward, followed by external impressions of the dentures' labial, buccal, and lingual surfaces. These impressions determined the thickness, contours, and shape of the polished surfaces of the CD. The adhesive (3M ESPE VPS Tray Adhesive, 3M Canada, USA) was applied to the external surface of the trial denture base, and regular-body impression silicone (3M™ Imprint™ 4 Penta™ regular VPS Impression Material Refill, 3M Canada, USA) was dispensed over the cameo surface of the trial dentures. Only one arch was registered at a time, starting with the buccal and labial surfaces and ending with the lingual/palatal surfaces. The patient was instructed to perform appropriate movements for the physiological molding of these surfaces until the material polymerized. The trial dentures were removed from the mouth, and the gross excess was removed.[29,30] Investing, packing, and processing of the CD were generally the same as conventional dentures.[28] (Figure 2D)

Regarding Group II, after the try-in of the set-up denture, all records were scanned by a laboratory scanner (Medit T300, Seoul, South Korea), then digitized and saved. Based on each patient's scan data, a custom tray design was generated. This included a well-adapted mandibular base with two narrow posterior occlusal stops set at the appropriate level and inclination of the occlusal planes, which bites against a maxillary base with two narrow posterior occlusal stops at the proper vertical dimension. The tray was printed (Microdent 1Pro 3D printer, Mogassam, Egypt) in photo-curable resin (HEX MODEL gray resin, Cairo, Egypt). A bent orthodontic wire was attached across the anterior part using cold-

cure resin to augment the tray's multiple dents in interlocking the impression. (Figure 3A) Afterward, the following steps of the impression procedure were the same as in group I.[22]

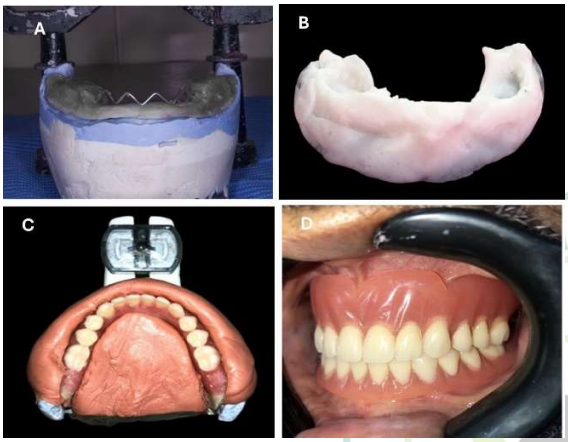

Figure 2: A: Neutral zone impression tray made from cold cure acrylic B: A neutral zone impression was made using tissue conditioning material at the proper vertical dimension of occlusion. C: Artificial teeth set in the neutral zone space defined by the putty index. D: Conventional neutral zone complete denture.

The neutral zone impression was scanned using an intraoral scanner (MEDIT I700, Seoul, Korea). The obtained impression was then superimposed on the original denture design. A flat occlusal platform, representing the appropriate functional height of the occlusal plane and the actual faciolingual location of the NZ, was created by virtually trimming the impression to the level of the formed tongue depression. This process produced a physiological guide for teeth realignment within the scanned space.
The previously scanned protrusive record was utilized to adjust the lateral condylar guidance settings on the virtual articulator. Maxillary and mandibular teeth were then selected from the library, with the maxillary teeth featuring steeper cusps and the mandibular teeth having shallower cusps. The maxillary teeth were positioned so that their lingual cusps were aligned over the central fossae of the mandibular teeth, ensuring that the lingual cusps served as the primary occlusal contacts. The mandibular teeth were arranged to minimize buccal cusp contact in centric occlusion, reducing potential interferences during lateral and protrusive movements. Using digital articulator tools within the design software, bilateral and simultaneous contacts were established during excursive movements, with the maxillary lingual cusps engaging the mandibular occlusal surfaces. (Figure 3B). The modified design was fabricated as an NZ prototype denture try-in base using a 3D printer, and the subsequent impression procedure for the cameo surface followed the same steps as in Group I.[29,30] (Figure 3 C&D)

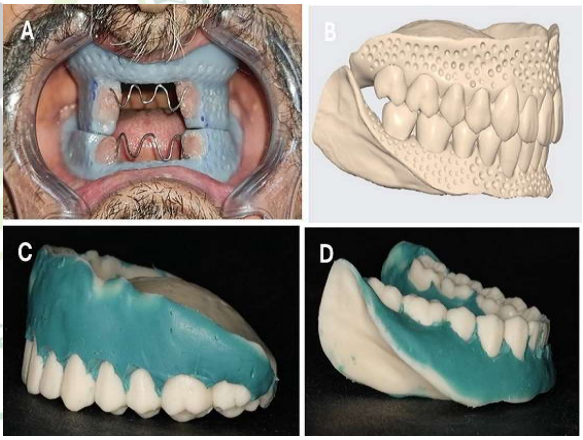

Figure 3: A: 3D-printed neutral zone impression tray featuring two occlusal stops and a wrought wire loop on the crest of the ridge. B: Electronic try-in bases for the maxilla and mandible. C: Maxillary impression of the polished surface of the try-in base. D: Mandibular impression of the polished surface of the try-in base.

The impression was scanned and trimmed using the gingiva free-forming tools until there was a uniform match between the new base forms and the exterior impression surfaces. The CAM file of the CDs was transferred to a 5-axis milling machine (ED5X EMAR DENTAL MILLS, C2, Industrial Complex, 10th of Ramadan City, Egypt) to mill the CD from reinforced monolithic polymethylmethacrylate resin blocks (two-color PMMA multilayer open

system, Chongqing Zotion Dentistry Technology Co., Ltd., China).

The CDs were assigned to groups based on a randomization sequence and were used by the patients for two months. Following this period, patients underwent a two-week washout phase before using the alternate denture.

Evaluation of Occlusal Force Equilibration

The distribution of occlusal force was evaluated during the delivery of the CD using the T-Scan III (T-Scan III - 7.0 Software, Tekscan Inc., South Boston, MA, USA). A sensor of suitable size was chosen depending on the shape and size of the dentures' arch. Patients were directed to assume an upright sitting position, and the sensor was placed parallel to the maxillary occlusal plane, with the midline indicated between the central incisors. Patients performed 2–4 trial bites before recording to adjust sensor sensitivity. They were after that directed to bite down with maximum intercuspation, with the sensor placed between maxillary and mandibular CDs. They were directed to hold this bite for 1-3 seconds, as per the guidelines provided by the manufacturer. [31-33] The procedure was repeated three times, and the collected data was stored on a computer for analysis. The occlusal force distribution percentage on both sides was documented. The mean values were derived from the recordings of each side, and differences in occlusal forces between the sides were observed. (Figure 4A)

After evaluating the occlusal force distribution, the occlusions of CDs in both groups were adjusted. The dentures were then delivered to the patients, who were scheduled for EMG evaluation after two months.

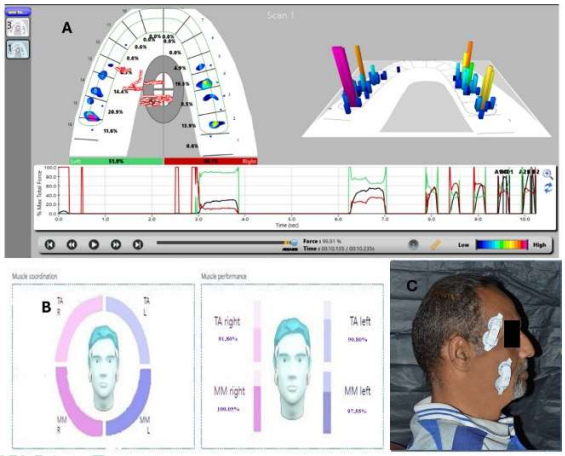

Figure 4: A: A report was generated by the T-Scan device to evaluate the occlusal force distribution of the CAD/CAM neutral zone complete denture. B: A report generated by the Myowise device to evaluate muscle activity for the CAD/CAM neutral zone complete denture during static testing. C: Electrodes of the Myowise device placed on the patient's face, positioned parallel to the masseter and temporalis muscle bellies

Temporalis and Masseter Muscle Activity

Two months after CD insertion, TA and MM muscle activity were assessed using a computerized instrument (Easymyo, 3 Technology S.r.l., Udine, Italy). The electromyographic procedures followed the methodology described by Ferrario et al.[34,35] The Myowise surface electrodes were placed following the detailed instructions supplied in the software. The electrodes were positioned on the muscle bellies, aligned with the direction of the muscle fibers. For the masseter muscles, the electrodes were placed parallel to the exo-canthion-gonion line, with the upper pole of the electrode aligned with the tragus–labial commissure line. The electrodes for the temporalis muscles were placed vertically, corresponding to the frontoparietal suture.[36]

After confirming the correct positioning of the electrodes, a calibration phase was conducted for subsequent data normalization. This involved placing two cotton rolls between the arches of the 5th and 6th teeth (second premolars and molars) for 5

seconds, during which the patient maintained maximum clenching. Following calibration, a static test (Clenching) was conducted in which the patient performed continuous clenching for 15 seconds. This test recorded the electrical signals of muscle activity as a percentage, as well as the percentage of asymmetry between both sides. (Figure 3B&C) Subsequently, a dynamic test (chewing) was conducted to measure muscle activity during mastication, recording the working and balancing percentages. For the dynamic test, the patient performed chewing cycles for 15 seconds on the cotton roll on the right side, and then the test was repeated by chewing the cotton roll on the left side. Data were recorded as percentages for each muscle activity (TA Right, TA Left, MM Right, MM Left), the asymmetry percentage between both sides during the static test, and the percentages for the working and balancing sides during the dynamic test.

Statistical analysis

The data acquired were analyzed using SPSS version 26.0, a statistical software package developed by SPSS Inc. in Chicago, Illinois, USA. The normality of the numerical data was assessed using the Kolmogorov-Smirnov and Shapiro-Wilk tests. The data were provided as mean, standard deviation, and range values. Intergroup comparisons were conducted using an independent t-test. A 95% confidence interval was employed, with a 5% margin of error, and a significance level of $p < 0.05$ was established for all tests.

Results

Table 1 shows the comparison of occlusal force distribution between Group I and Group II.Group II exhibited a higher occlusal force distribution, with 49.82±1.55% on the right side and 50.18±1.55% on the left side, resulting in a right-left difference of -0.36±3.10%. In contrast, Group I had 49.95±1.79% on the right side and 50.05±1.79% on the left side, with a right-left difference of -0.11±3.59%. Although there were differences between the groups, these variations were not statistically significant.

Table 1: Comparison of Occlusal Force Distribution Between Group I and Group II on the Right and Left Sides, Including Differences.

Evaluation of occlusal force distribution	Group I *(n=8)*	Group II *(n=8)*	Test value	*P*-value
Right side%				
Mean±SD	49.95±1.79	49.82±1.55	-0.158	0.874
Range	46.58-51.85	47.12-51.52		
Left side%				
Mean±SD	50.05±1.79	50.18±1.55	-0.158	0.874
Range	48.15-53.42	48.48-52.88		
#Difference (Rt.-Lt.)				
Mean±SD	-0.11±3.59	-0.36±3.10	-0.158	0.874
Range	-6.84_3.7	-5.76_3.04		

Table 2 shows the comparison of mean muscle activity and asymmetry during the static test for Group I and Group II. Group II showed higher muscle activity in the temporalis (TA) and masseter (MM) muscles compared to Group I (Group II: TA Right: 99.26±2.88, TA Left: 98.94±4.93, MM Right: 101.69±6.51, MM Left: 104.30±9.21; Group I: TA Right: 97.78±5.65, TA Left: 96.71±4.52, MM Right: 99.85±10.42, MM Left: 99.39±11.57), although these differences were not statistically significant. Similarly, the asymmetry in muscle activity was less in Group II (0.43±3.36) than in Group I (0.73±3.64), but without statistical significance (p-value > 0.05).

Table 2: Comparison of Muscle Activity and Asymmetry During Static Test (Clenching) Between Group I and Group II.

During static test	Group I (n=8)	Group II (n=8)	Test value	*P*-value
TA Right%				
Mean±SD	97.78±5.65	99.26±2.88	-0.951	0.342
Range	91.8-109.7	96.5-105		
TA left%				
Mean±SD	96.71±4.52	98.94±4.93	-0.791	0.429
Range	90.8-105.5	92.8-105.6		
MM right%				
Mean±SD	99.85±10.42	101.69±6.51	-0.263	0.792
Range	82.8-116.6	92.7-110.5		
MM left%				
Mean±SD	99.39±11.57	104.30±9.21	1.052	0.293
Range	82.8-117.5	92.5-117.5		
#Asymmetry%				
Mean±SD	0.73±3.64	0.43±3.36	-0.106	0.916
Range	-4.3_5.2	-4.9_4.3		

Table 3 presents the comparison of muscular activity evaluation ("working side" and "balancing side") during the dynamic test between Group I and Group II. There was no significant difference between Group I (Right Working side: 79.79±6.00%, Left Working side: 76.30±5.37%, Right Balancing side: 23.70±5.37%, Left Balancing side: 20.21±6.00%) and Group II (Right Working side: 79.59±5.28%, Left Working side: 78.43±5.46%, Right Balancing side: 20.41±5.28%) with a *p*-value > 0.05.

Table 3: Comparison of Muscle Activity ('Working and Balancing') Between Group I and Group II During Dynamic Test.

During Mastication	Group I (n=8)	Group II (n=8)	Test value	*P*-value
Rt. Working side%				
Mean±SD	79.79±6.00	79.59±5.28	-0.369	0.712
Range	70.7-85.7	70.7-85.7		
Lt. Working side%				
Mean±SD	76.30±5.37	78.43±5.46	-0.844	0.399
Range	69.9-85.7	70.7-85.7		
#Rt. Balancing side%				
Mean±SD	23.70±5.37	21.58±5.46	-0.844	0.399
Range	14.3-30.1	14.3-29.3		
#Lt. Balancing side%				
Mean±SD	20.21±6.00	20.41±5.28	-0.369	0.712
Range	14.3-29.3	14.3-29.3		

Discussion

NZ CDs are designed to enhance the ability of the oral and perioral muscles to stabilize and retain the dentures. These dentures have been designed to withstand the forces exerted by the surrounding muscles, rather than being displaced by them.[27,28,37] As digital technology has advanced, CAD/CAM denture systems have gained popularity for their precision and efficiency. Despite this technological advancement, there is a lack of studies examining the performance of CAD/CAM dentures designed based on the NZ concept regarding muscle activity and occlusal force distribution compared to conventional dentures. Thus, this study aimed to evaluate the electromyographic activity of the temporalis and masseter muscles and the occlusal force distribution between conventional and CAD/CAM NZ CDs. The null hypothesis of this study was accepted, indicating that there were no differences between conventional and CAD/CAM NZ CDs regarding the occlusal force distribution and electromyographic activity.

A mandibular denture base with two uniform acrylic occlusal stops set at the correct occlusal vertical dimension was used. Additionally, 25-gauge wrought wire loops were affixed along the crest of the ridge to record the impression of the NZ at the occlusal vertical dimension determined at the previous appointment using the occlusion rim. The impression material was slow-setting to mold it into the desired contour and dimension.[38]

Shallow-cusped artificial teeth with lingualized balanced occlusion were used in this study to reduce eccentric tipping forces affecting the prosthesis.[38]

There was no statistically significant difference in the mean values of occlusal force distribution between Group I and Group II. This can be attributed to the NZ technique, which ensures balanced occlusal forces and proper positioning of artificial teeth in the NZ. This alignment with the natural muscle dynamics enhances denture

stability, reduces premature occlusal contacts, and results in a more even distribution of occlusal forces across both sides of the dentures.[7]

Our study's findings, which show nearly equal occlusal force distribution in conventional and CAD/CAM neutral zone complete dentures, agree with Abdel Aal A's study that claimed the neutral zone concept achieves uniform occlusal force distribution.[7] The mean range of muscle activity for the TA and MM muscles during the static test for both groups ranged from 96.71±4.52% to 104.30±9.21%. These values fall within the normal range of muscle activity, defined as 80% to 120%. According to the Myowise device manual,[13] patients whose dental occlusion does not necessitate significant muscular adaptations typically exhibit 80% to 120% of the activity recorded on clenching on a cotton roll during the static test. Furthermore, the mean asymmetry values for Group I and Group II were 0.73±3.64 and 0.43±3.36, respectively. A positive asymmetry index signifies a predominance of right-side muscle activity, whereas a negative index denotes greater activity on the left antimere. The Myowise device manual [13] indicates that 95% of healthy individuals have asymmetry values between 10% and -10%, with 0% indicating perfect symmetry.

The results for mean muscle activity and asymmetry during the static test, as well as the mean activity on the working and balancing sides during the dynamic test for Group I and Group II, showed no statistically significant differences. This lack of significance can be attributed to both types of dentures being designed based on the neutral zone concept. This design principle ensures that complete dentures achieve a "muscle balance," harmonizing with the surrounding tissues and normal neuromuscular function. Furthermore, the teeth are positioned disrupting the regular functioning of the muscles. Moreover, the forces exerted by the muscles on the dentures enhance their stability and capacity to stay in place.[12,27] The electromyographic results of our study, which concluded that both conventional and CAD/CAM neutral zone complete dentures produce less asymmetry between right and left muscle activity, are consistent with previous studies. These studies have shown that the neutral zone concept achieves balanced muscular activity, leading to improved stability and retention.[7,29]

The results for the mean values of Group I and Group II, according to the muscle activity evaluation of "working side%" and "balancing side%" during the dynamic test, showed no statistically significant difference this is because the NZ concept distributes the load evenly across the denture, reducing the need for balancing muscle activity and allowing the working muscles to perform more effectively. Additionally, the NZ approach respects the natural contours and dynamics of the oral cavity, creating a more comfortable and functional denture.[12,27,39]

This study provides valuable insights into the effectiveness of CAD/CAM and conventional neutral zone complete dentures. Clinicians can therefore base their choice on factors such as patient needs, technique sensitivity, cost, and available technology, without compromising functional outcomes. The study faced certain limitations, particularly the small sample size and the relatively short duration of the follow-up period. To mitigate the impact of variations in muscle activity, a within-subject study design was chosen, facilitating more precise and reliable comparisons between individual participants. However, the T-Scan system, while useful, may not fully capture occlusal forces due to the potential instability of complete dentures on soft tissue surfaces. Despite this limitation, the T-Scan provided valuable insights into occlusal force distribution and detected premature contacts

that the articulating paper could not identify. Future research should involve larger sample sizes and extended follow-up periods to thoroughly evaluate CAD/CAM dentures.

Conclusion

The neutral zone approach ensures balanced occlusal forces and optimal muscle coordination, regardless of whether CAD/CAM or conventional methods are used for fabricating complete dentures. Consequently, both techniques are equally effective in producing functional and stable complete dentures.

Competing interests

The authors declare no conflict of interest.

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Ethics Approval:
This in vivo study was approved by the Faculty of Dentistry, Ain Shams University (number of approvals: FDASU-ReclR012317))

Availability of Data
All data included in this study are available from the corresponding author upon request.

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