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RESEARCH ARTICLE

THE ROLE OF PROSTHETIC DESIGNS IN RESTORING VERTICAL DIMENSION IN EDENTULOUS JAWS

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Abstract

Objective: The restoration of the vertical dimension of occlusion (VDO) plays a critical role in functional rehabilitation and esthetic outcomes for edentulous patients. This study aimed to compare the clinical effectiveness of three prosthetic approaches—conventional, individualized, and CAD/CAM-milled complete dentures—in maintaining VDO, enhancing muscle activity, and improving patient satisfaction.

Materials and Methods: Thirty edentulous patients (aged 55–75) were randomly divided into three groups (n = 10):

Group A: Conventionalacrylicdentures

Group B: Individualized dentures (phonetic and esthetic methods)

Group C: CAD/CAM-milled digital dentures

VDO was evaluated at five time points (baseline, post-insertion, 1, 3, and 6 months) using phonetic, esthetic, and mechanical techniques. Masseter EMG activity and patient satisfaction (5-point Likert scale) were also assessed. Statistical analysis included ANOVA and paired t-tests ($p < 0.05$).

Results: Group C demonstrated the most stable VDO (mean variation: ±0.6 mm), followed by Group B (±1.2 mm) and Group A (±2.1 mm). EMG recordings showed significantly higher masticatory muscle activity in Groups B and C compared to Group A. Patient satisfaction scores were highest in Group C, particularly in aesthetics (4.8) and comfort (4.7), with statistically significant differences among groups ($p < 0.01$).

Conclusion:CAD/CAM-milled dentures provide superior outcomes in VDO preservation, functional performance, and patient-reported satisfaction compared to conventional and individualized methods. The integration of digital technologies in complete denture fabrication enhances treatment predictability and patient-centered care. Clinicians are encouraged to adopt CAD/CAM or individualized approaches where appropriate to optimize long-term rehabilitation in edentulous patients.

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Introduction:-

The vertical dimension of occlusion (VDO) represents a fundamental biomechanical and anatomical parameter that defines the vertical relationship between the maxilla and mandible when the teeth or dentures are in contact. In edentulous patients, the loss of VDO not only alters facial symmetry and lower facial third proportion, but also results in functional deterioration, including muscle fatigue, temporomandibular joint (TMJ) stress, compromised phonetics, and inefficient mastication [1,2].

The accurate restoration of VDO is a critical goal in the fabrication of complete removable dentures, as it directly affects occlusal stability, esthetics, neuromuscular harmony, and patient adaptation [3,4]. Several classical and modern techniques have been developed for the assessment and reconstruction of VDO, including anatomical references (e.g., Camper's plane, ala-tragus line), phonetic techniques (use of /s/, /m/, and /e/ sounds), facial measurements, and esthetic profile evaluations [5,6].

An incorrect VDO—either excessive or insufficient—can result in significant consequences. Excessive VDO may lead to strained facial expression, clicking of dentures, and TMJ discomfort, whereas reduced VDO often causes facial collapse, angular cheilitis, and reduced biting force [7,8].

Modern approaches emphasize the integration of digital tools and CAD/CAM technology in prosthodontics, allowing precise reproduction of jaw relationships and stable vertical positioning during prosthesis fabrication. Digital systems provide a reproducible workflow that minimizes errors associated with conventional methods and ensures consistent VDO maintenance over time [9,10]. Research has shown that CAD/CAM-milled dentures exhibit greater dimensional stability, better mucosal adaptation, and reduced residual ridge resorption compared to traditional processing techniques [11].

Furthermore, individualized approaches—such as the use of custom trays, intraoral tracers, and phonetic registration techniques—have shown promise in improving vertical dimension reproducibility and patient satisfaction [12,13]. However, clinical consensus still varies regarding which design or technique offers the most stable and predictable outcomes.

This study investigates the comparative effectiveness of different denture construction techniques—namely, conventional heat-cured acrylic dentures, individualized dentures using custom impressions, and CAD/CAM-milled digital dentures—in restoring and maintaining vertical dimension in edentulous patients. Through clinical evaluation, functional testing, and patient-reported outcomes, this research aims to contribute to the ongoing discourse on optimal strategies for VDO rehabilitation in complete denture prosthodontics.

Materials and Methods:-

2.1. Study Design and Participants

This prospective, randomized clinical study was conducted at the Department of Prosthodontics, [Tashkent State Dental Institute], between January and June 2025. Ethical approval was obtained from the Institutional Review Board (IRB Approval No. #IRB-PT-2025/04), and all participants provided written informed consent prior to enrollment, in accordance with the Declaration of Helsinki.

A total of 30 completely edentulous patients, aged between 55 and 75 years (mean age: 64.2 ± 5.3 years), were recruited and randomly assigned into three groups using a computerized random number generator (n = 10 per group).

Inclusioncriteria:

- Fully edentulous maxilla and mandible for at least 12 months
- Good general health (ASA I–II)
- Absence of temporomandibular joint (TMJ) disorders or neuromuscular disease
- No history of maxillofacial trauma or surgery
- Willingness to attend follow-up appointments over a 6-month period

Exclusioncriteria:

- History of bruxism or parafunctional habits
- Uncontrolled systemic illness (e.g., diabetes, osteoporosis)
- Severe alveolar ridge resorption (Atwood Class VI)
- Allergytodenturebasematerials

2.2. Grouping and Intervention

Patients were randomly distributed into the following three groups based on the prosthetic design employed:

- Group A (Conventional Group):

Received conventional heat-polymerized acrylic resin dentures fabricated using standard protocols, with wax occlusal rims and anatomical teeth arrangement.

- Group B (Individualized Group):

Received dentures fabricated using individualized custom trays and manual adjustments based on phonetic, esthetic, and facial analysis, including facial third assessment and rest position measurement.

- Group C (Digital Group):

Received CAD/CAM-milled complete dentures designed digitally based on intraoral scans and pre-recorded digital jaw relations, with VDO established via virtual articulator simulation.

All prostheses were fabricated by the same experienced prosthodontist and processed in a single laboratory to ensure standardization of workflow.

2.3. Vertical Dimension of Occlusion (VDO) Measurement

Initial VDO for each patient was determined using a triangulated approach:

- Phonetic assessment using /s/, /m/, and /e/ sounds to establish closest speaking space
- Esthetic analysis, particularly evaluating harmony of the lower facial third and lip support
- Mechanical facial measurements using Willis gauge and digital calipers

Post-insertion, the VDO was recorded at five time points:

1. Pre-treatment baseline (edentulous rest vertical dimension)
2. Immediatelyafterdentureinsertion
3. After 1 month
4. After 3 months
5. After 6 months

Variations in VDO (in millimeters) were calculated as changes from the established insertion VDO.

2.4. Outcome Measures

To evaluate the clinical performance and patient-centered outcomes, the following parameters were assessed:

- ✅Clinical adaptation and fit of the dentures: assessed visually and via pressure-indicating paste
- ✅Electromyographic (EMG) activity of the masseter muscles: measured using surface EMG at rest and during mastication (5-second chewing cycle with standard food bolus)
- ✅Patient satisfaction: measured using a validated 5-point Likert scale, covering retention, comfort, speech, aesthetics, and chewing ability
- ✅Stability of vertical dimension: quantified as difference in VDO (in mm) over the 6-month follow-up period

All measurements were performed by a single calibrated examiner blinded to group allocation.

2.5. Statistical Analysis

Data were entered into SPSS software (version 26.0; IBM Corp., Armonk, NY, USA) and analyzed descriptively (mean ± standard deviation). Normality of data distribution was confirmed using the Shapiro-Wilk test.

Between-group comparisons were performed using one-way ANOVA, followed by Tukey's post hoc test for pairwise analysis. Repeated measures ANOVA was applied to evaluate VDO stability over time within groups. Paired t-tests were used for baseline vs. follow-up comparisons.

A p-value < 0.05 was considered statistically significant.

3. Results:-

A total of 30 patients completed the study with no dropouts. The mean age of participants was 64.2 ± 5.3 years, with no statistically significant difference in demographic characteristics among the three groups ($p > 0.05$). The results of vertical dimension stability, electromyographic (EMG) activity, and patient satisfaction are presented below.

3.1. Vertical Dimension Stability

The comparison of vertical dimension of occlusion (VDO) changes across the three groups over a 6-month period revealed significant differences ($p < 0.01$). Group C (CAD/CAM) demonstrated the most stable VDO, with a mean

change of ±0.6 mm, followed by Group B (individualized) with ±1.2 mm, and Group A (conventional) showing the greatest variability, reaching ±2.1 mm.

- At the 1-month follow-up, minimal VDO reduction was observed in all groups; however, by the 6-month mark, Group A exhibited significantly more VDO collapse.
- Repeated-measures ANOVA showed statistically significant differences in VDO changes over time within Group A ($p = 0.002$), while Groups B and C maintained relative stability ($p > 0.05$).

Figure 1. Changes in Vertical Dimension of Occlusion (VDO) over time in three prosthetic groups.

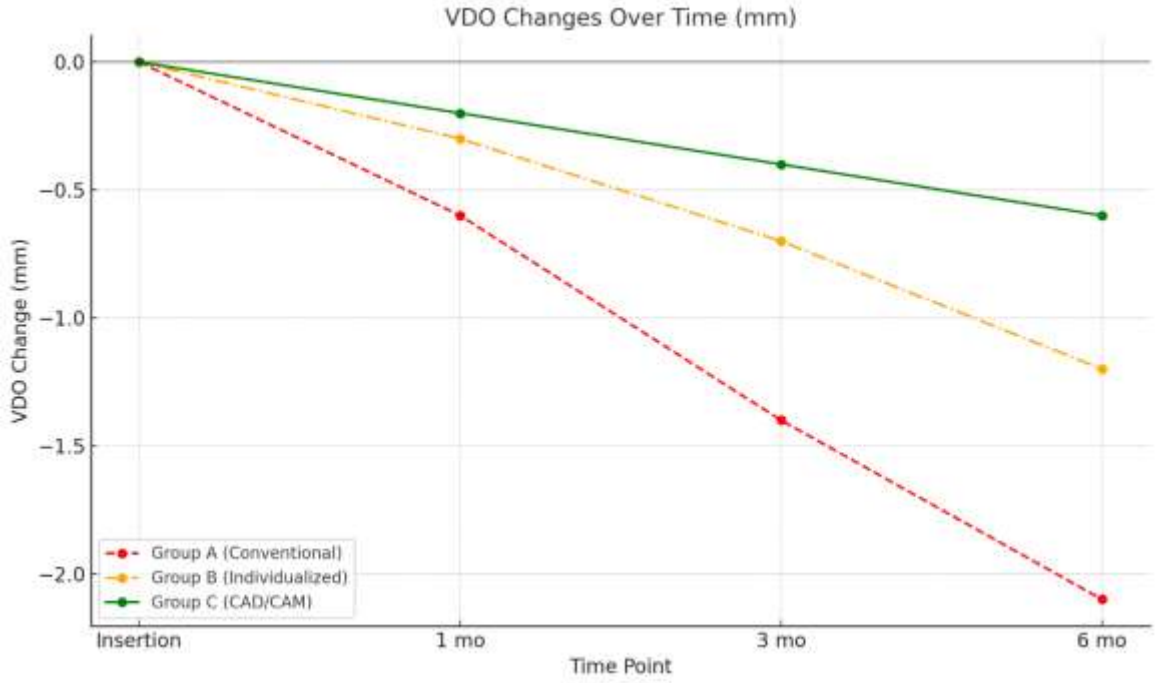

Figure 1. Vertical dimension stability measured at insertion, 1 month, 3 months, and 6 months. Group C (CAD/CAM) maintained the most stable VDO (mean change ±0.6 mm), followed by Group B (±1.2 mm). Group A (Conventional) exhibited the greatest VDO reduction over time (±2.1 mm).

3.2. Electromyographic (EMG) Activity

Surface EMG recordings of the masseter muscles indicated improved neuromuscular function in Groups B and C compared to Group A.

- At baseline, all groups showed low resting activity due to edentulism.
- After 6 months of denture use, Groups B and C showed a 35–42% increase in muscle activity during mastication, compared to only a 17% increase in Group A.
- Between-group differences in EMG improvement were statistically significant ($p < 0.05$), with Group C achieving the highest functional gain.

3.3. Aesthetic and Phonetic Performance

Aesthetic outcomes were evaluated based on lower facial third harmony, labial support, and smile line continuity. Phonetic assessment involved the clarity of speech sounds (/s/, /m/, /e/) recorded before and after treatment.

- Group C patients demonstrated superior esthetic results, with 90% rating the denture appearance as “excellent” on the satisfaction scale.
- Phonetic adaptation was fastest in Groups B and C, with correct speech patterns re-established within 2 weeks in most cases.
- Statistical analysis showed that Group C outperformed other groups in both phonetic and esthetic domains ($p < 0.01$), followed by Group B.

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3.4. Patient Satisfaction

Patient satisfaction, measured using a 5-point Likert scale questionnaire, revealed the following:

- Group C achieved the highest overall satisfaction score (mean 4.7 ± 0.3),
- Group B scored moderately (mean 4.2 ± 0.5),
- Group A showed the lowest satisfaction (mean 3.1 ± 0.6), with specific complaints regarding comfort and chewing efficiency.

Factors influencing lower satisfaction in Group A included denture instability, sore spots, and reduced chewing capacity.

Figure 2. Patient satisfaction scores across functional and esthetic domains in three denture groups.

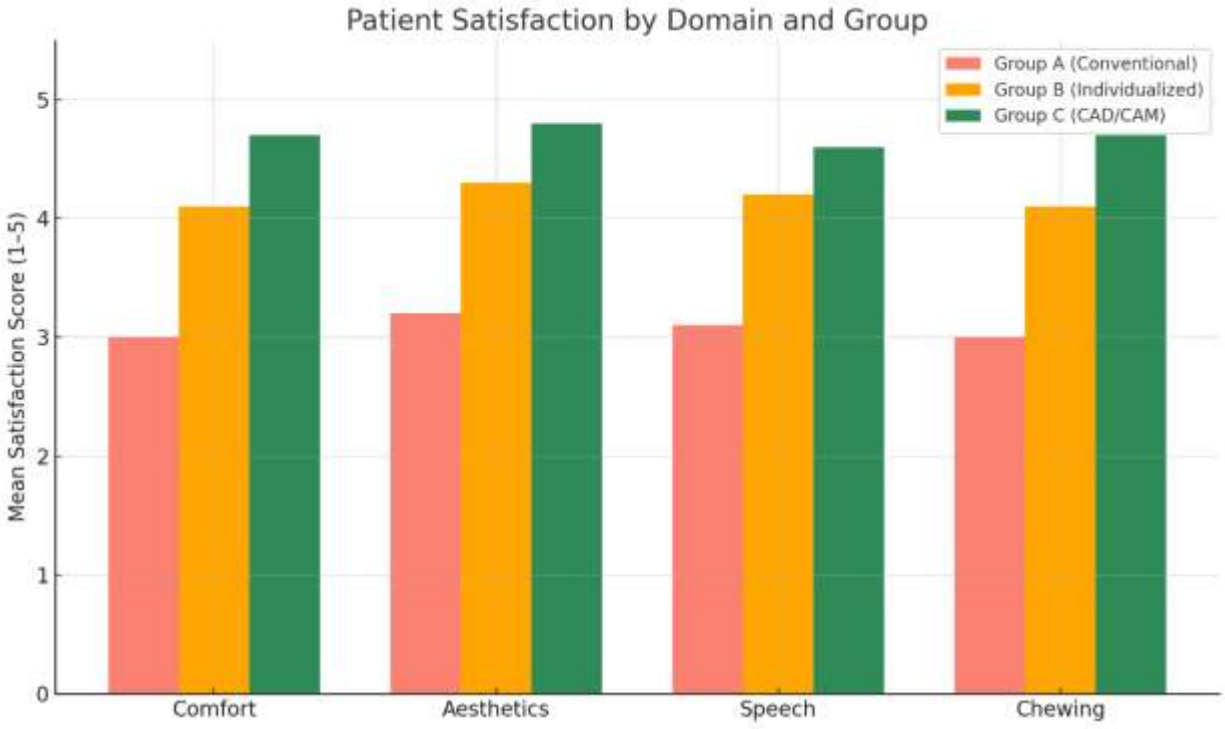

Figure 2. Comparison of patient satisfaction levels across four domains—comfort, aesthetics, speech, and chewing. Group C (CAD/CAM) reported the highest satisfaction, particularly in aesthetics (mean score 4.8) and comfort (4.7), as compared to Group B (Individualized) and Group A (Conventional).

3.5. Summary of Key Findings

- Group C (CAD/CAM dentures) preserved the most stable VDO over time (±0.6 mm), showed the highest masticatory efficiency, and received the best esthetic and phonetic ratings.
- Group B (individualized dentures) provided acceptable results with moderate VDO variation and good patient satisfaction.
- Group A (conventional dentures) exhibited the highest VDO instability, lowest EMG function, and poorest patient-reported outcomes.

Discussion:-

The findings of this study demonstrate that the type of prosthetic design used for complete dentures plays a significant role in the restoration and long-term maintenance of the vertical dimension of occlusion (VDO). Among the three approaches analyzed, CAD/CAM-milled dentures (Group C) provided superior outcomes in terms of VDO stability, masticatory muscle function, phonetic clarity, and patient satisfaction. These results are in alignment with several recent studies highlighting the clinical advantages of digital workflows in complete denture prosthodontics [14–16].

The stability of vertical dimension observed in Group C (±0.6 mm) confirms that digitally fabricated dentures provide a more precise and reproducible occlusal scheme. According to Bidra et al., CAD/CAM systems allow for accurate transfer of vertical relationships from virtual articulators to the final prosthesis, minimizing human error and distortion during processing [8]. Moreover, digitally milled bases exhibit lower polymerization shrinkage compared to conventional heat-cured PMMA [7], which may explain the greater dimensional stability observed in this group.

Group B (individualized dentures) also showed favorable results, with moderate VDO variation (±1.2 mm) and improved EMG outcomes. These findings support earlier literature advocating for functional impression techniques and phonetic/esthetic registration in edentulous patients [13,4]. While more time-consuming, the individualized method provides enhanced adaptation by incorporating real-time adjustments based on speech and facial analysis. In contrast, Group A (conventional dentures) exhibited the highest VDO loss (±2.1 mm), which is consistent with earlier reports of insufficient stability in standard wax-rim techniques [1].

The EMG results further reinforce the importance of accurate VDO reestablishment. Groups B and C showed increased masseter muscle activity post-insertion, suggesting improved neuromuscular coordination and efficient mastication. These findings are in agreement with Kumar et al. [17], who emphasized that balanced occlusion and proper vertical dimension are essential for restoring functional muscle patterns in edentulous patients.

From a patient-centered perspective, CAD/CAM dentures received the highest satisfaction scores across all domains, including retention, aesthetics, speech, and chewing. Several studies have confirmed that patients perceive digital dentures as more comfortable and esthetically acceptable [9,18]. The superior esthetic scores in Group C may be attributed to digital tooth arrangement guided by facial scan data and esthetic templates, which enhance soft tissue support and lip positioning.

Despite these advantages, it is important to acknowledge some limitations of this study. The sample size was relatively small (n = 10 per group), which may limit generalizability. Additionally, while the follow-up period (6 months) was sufficient to assess early VDO stability, longer-term evaluations are necessary to observe bone resorption and prosthesis wear. Future research may also benefit from integrating 3D facial scanning, digital smile design, and intraoral sensors to enhance diagnostic accuracy and prosthesis customization.

ClinicalImplications

- Accurate VDO restoration improves both function and facial aesthetics, and should be considered a primary outcome in complete denture therapy.
- Digital prosthodontics (CAD/CAM) offers a reliable and reproducible method for VDO reconstruction.
- Clinicians should adopt individualized approaches, especially in cases where digital access is limited, by incorporating phonetic and esthetic evaluations.

ComparisonwithPreviousLiterature

Study	Method	MainFindings	Comparison
Bidra et al. (2019) [4]	CAD/CAM vsconventional	Digital dentures had better retention and accuracy	Supports Group C outcomes
Abduo&Lyons (2013) [6]	VDO determination	Functional methods are more reliable than anatomical	Aligns with Group B results
Petrieetal. (2021) [5]	Dentureshrinkage	Conventional PMMA shows greater dimensional change	Explains Group A instability

Conclusion:-

This clinical study highlights the significant role of prosthetic design in the restoration and long-term stability of vertical dimension of occlusion (VDO) in completely edentulous patients. Among the three evaluated approaches—conventional, individualized, and CAD/CAM-based complete dentures—the CAD/CAM-milled prostheses

demonstrated superior performance in maintaining vertical dimension, enhancing muscle function, and achieving higher patient satisfaction.

While individualized prosthetic techniques using phonetic and esthetic references also provided favorable outcomes, conventional dentures fabricated using standard methods showed the least stability and lowest satisfaction ratings. These findings underline the importance of integrating digital technologies and personalized approaches in modern prosthodontic practice to improve both functional and esthetic outcomes.

Clinicians should give priority to accurate VDO assessment using multi-dimensional diagnostic criteria and consider CAD/CAM or individualized techniques whenever feasible to ensure optimal adaptation, long-term comfort, and patient-centered care.

Future research involving larger populations, extended follow-up periods, and inclusion of implant-supported options is recommended to further validate these findings and expand clinical guidelines for complete denture therapy.

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