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REVIEW

Occlusal scheme in complete denture for knife-edge ridge: What works best?

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ABSTRACT

Fabrication of complete dentures for atrophic and knife-edge mandibular ridges poses challenges due to uneven stress distribution, which affects support, stability, and comfort. The selection of an occlusal scheme plays an important role in optimizing load transmission to the denture-supporting tissues. This systematic review aims to evaluate stress and strain distribution as well as denture displacement across various occlusal schemes in patients with atrophic or knife-edge ridges. A structured literature search was conducted through PubMed, Scopus, ScienceDirect, SpringerLink, and Google Scholar for studies published between 2015 and 2025. Seven studies met the inclusion criteria, encompassing in vitro experiments, finite element analysis (FEA), photoelastic models, and clinical evaluations. From 407 screened articles, seven studies were analyzed. Lingualized occlusion (LO) demonstrated the most even stress distribution centered along the ridge crest, while bilateral balanced occlusion (BBO) improved stability under functional loading. Monoplane occlusion (MO) reduced vertical strain but exhibited higher localized stress under specific conditions. No single occlusal scheme was universally superior. LO and MO provided favorable biomechanical outcomes in specific conditions, whereas occlusal scheme selection should be adapted to ridge morphology and patient functional needs. (IJP 2025;7(1):8-13)

Introduction

Complete tooth loss is recognized as a key indicator of the overall burden of oral diseases, and it remains a major oral health concern worldwide. This condition is often the final consequence of chronic oral diseases, particularly advanced dental caries and severe periodontal disease, although trauma and other contributing factors may also lead to complete tooth loss.[1,2] According to the World Health Organization, the global average prevalence of complete tooth loss in 2025 is approximately 7% among individuals aged 20 years and older, with this figure increasing sharply to 23% in those aged 60 years and above.[2]

Edentulism leads to significant alveolar bone remodeling, affecting both the vertical and horizontal dimensions of the residual ridge.[3] This process is known as residual ridge resorption and occurs up to four times more frequently in the mandible than in the maxilla.[4] It is primarily caused by functional stresses transmitted by removable complete dentures, which have limited contact areas and suboptimal design features that contribute to uneven load distribution and further alter the morphology of the mandibular residual ridge.[4,5] Residual ridge resorption over time results in a severe form of ridge atrophy known as knife-edge ridge in the mandible, which compromises denture support and long-term comfort.[6]

Despite advances in implant-supported prostheses, conventional complete denture (CD) therapy remains a widely utilized and realistic treatment option for many edentulous patients worldwide, particularly among the elderly or those with systemic or financial limitations.[7,8] CD are designed to restore essential oral functions, yet their effectiveness can be challenged in patients with advanced ridge resorption. This knife-edge shaped ridge may act as a fulcrum during mastication, leading to denture instability, pressure point pain, and compromised treatment outcomes with complete dentures.[9]

The occlusal scheme defines the arrangement of occlusal contacts during mandibular movements and directly influences how occlusal forces are transmitted to the denture-bearing tissues.[10] Proper occlusal contact helps distribute masticatory forces uniformly across the residual ridge, potentially minimizing tissue overload and preventing further bone resorption.[11,12] These complications can be further minimized by ensuring optimal distribution of occlusal forces through careful selection of the occlusal scheme. The transmission of masticatory forces is strongly influenced by the size, shape, and occlusal design of posterior denture teeth.[13] Studies have shown that modifying cusp inclination and choosing appropriate occlusal schemes, such as monoplane or lingualized occlusion, can reduce pressure on the supporting tissues, enhance patient comfort, and decrease the risk of soft tissue trauma.[13,14]

Despite the variety of occlusal schemes proposed for atrophic ridges, including bilateral balanced occlusion (BBO), monoplane occlusion (MO), and lingualized occlusion (LO), no clear consensus has been established regarding which occlusal scheme offers the most favorable biomechanical outcomes, particularly in

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cases involving knife-edge residual ridges. This uncertainty highlights the need for a systematic evaluation of the existing literature to better understand the biomechanical implications of occlusal scheme selection in complete denture rehabilitation.

Therefore, this systematic review aims to synthesize current biomechanical evidence on the influence of occlusal schemes in complete dentures for knife-edge residual ridges, with particular focus on stress distribution, load transmission, and overall denture performance.

Methods

Search Strategy

This systematic review was conducted in accordance with the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. A protocol outlining the research objectives, eligibility criteria, search strategy, and data extraction method was developed a priori; however, it was not registered in any public registry.

A comprehensive literature search was performed in PubMed, Scopus, ScienceDirect, SpringerLink, and Google Scholar for studies published between January 2015 and June 2025. The search was designed to identify studies evaluating the biomechanical impact of different occlusal schemes in complete dentures, particularly in cases involving atrophic or knife-edge mandibular ridges. Search terms included both Medical Subject Headings (MeSH) and free-text keywords combined with Boolean operators (AND, OR). Typical search strings included combinations such as: ("complete denture" OR "full denture") AND ("occlusal scheme" OR "occlusal pattern") AND ("atrophic ridge" OR "knife-edge ridge" OR "resorbed ridge") AND ("stress distribution" OR "strain" OR "biomechanical"). Search queries were customized for each database. Duplicates were removed before screening.

Eligibility Criteria

This review followed the PICO framework: Population (P): Edentulous patients or models with atrophic or knife-edge mandibular ridges; Intervention (I): Complete dentures fabricated with various occlusal schemes; Comparison (C): Bilateral balanced occlusion (BBO), monoplane occlusion (MO), and lingualized occlusion (LO); Outcomes (O): Biomechanical parameters such as stress/strain distribution, load transmission, and indicators of denture stability.

Inclusion criteria: In vitro or simulation-based biomechanical studies; In vivo clinical studies evaluating complete dentures with different occlusal schemes in patients with atrophic or knife-edge ridges; Studies reporting relevant biomechanical outcomes directly (e.g., stress, strain) or indirectly (e.g., retention, tissue pressure, patient-reported stability).Articles published between 2015–2025 in English, in peer-reviewed journals.

Exclusion criteria: Case reports, review articles, expert opinions, animal studies; Studies not involving atrophic or knife-edge ridges; Studies evaluating implant-supported or implant-retained prostheses; Non-English or non-peer-reviewed publications; Studies lacking methodological transparency or sufficient data; Grey literature (conference abstracts, theses, dissertations).

Selection Process

Titles and abstracts were initially screened by a single reviewer according to predefined criteria. Full-text articles were subsequently assessed for eligibility. Final inclusion decisions were discussed and confirmed with co-authors to ensure reliability. The PRISMA 2020' flow diagram figure 1 illustrates the number of studies identified, screened, excluded, and included.

Data Extraction and Synthesis Method

Data extraction was carried out using a standardized Microsoft Excel form table 1. Extracted data included author(s), year, study design, occlusal scheme, ridge condition (atrophic or knife-edge), biomechanical testing method, main outcomes, and key findings. No automation tools were used. Extracted data were reviewed for accuracy and completeness before synthesis.

Data Synthesis

Due to heterogeneity in study design, ridge condition, and biomechanical evaluation methods, a narrative synthesis was conducted. Key biomechanical outcomes, including stress or strain distribution, load transmission, and occlusal force balance, were analyzed in relation to occlusal scheme and ridge resorption level. Most studies reported that LO distributed stress more evenly and reduced mucosal loading compared to MO, particularly in atrophic ridges. BBO contributed to denture stability under oblique forces. MO showed mixed results, enhancing stability in certain occlusal plane configurations but often associated with increased ridge stress. The variety of measurement techniques (T-scan, strain gauges, finite element analysis [FEA], photoelastic analysis) led to differences in reported units and data formats, which limited quantitative synthesis. Therefore, trends and clinical implications were interpreted descriptively..

Risk of Bias Assessment

Risk of bias was assessed using the Joanna Briggs Institute (JBI) checklist, adapted for in vitro and simulation-based biomechanical studies. Key criteria included clarity of objectives, study design, sample preparation, measurement validity, consistency of reporting, and methodological transparency.

Most of the seven included studies demonstrated low to moderate risk of bias. Common limitations involved the absence of sample size justification, lack of calibration details, and unreported blinding procedures. The single in vivo clinical study (El-Agamy et al., 2023) used an appropriate design but lacked details on participant allocation and assessor blinding. Risk of bias

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Table 1. Data extraction results.

Author(s)	Title	Study Design	Occlusal Scheme	Ridge Condition	Biomechanical Method	Outcome Measured	Key Findings
Hafezeqoran A, et al. (2018)	Evaluation of strain in mandibular denture-supporting area in three different occlusal schemes during jaw movements	In Vitro with Strain Gauge	BBO, LO, MO	Atrophic Mandibular Ridge	Strain Gauge	Strain in specific mandibular areas	MO occlusal scheme produced lower strain on the denture-supporting area, with the buccal shelf bearing the highest pressure. Across all occlusal schemes, the working side experienced more strain than the non-working side during eccentric movements.
Fatola, et al. (2024)	Pain-related analysis on a resorbed ridge with various denture occlusal schemes using finite element method	Finite Element Analysis	BBO, LO, MO	Atrophic Mandibular Ridge (Class III)	3D Finite Element Method	von Mises Stress	MO showed the lowest overall stress, while LO exceeded the pressure pain threshold in only one small area.. The researchers concluded that the LO is the ideal occlusal scheme for fabricating denture with resorbed alveolar ridge conditions.
Fatiallah & Faraj (2016)	Comparing Maximum Stresses and Displacements in A Lower Complete Denture with Different Occlusal Plane Levels and Schemes: A Three Dimensional Finite Element Stress Analysis Study	Finite Element Analysis	BBO, LO, MO	Mandibular edentulous ridge	3D Finite Element Analysis	Stress and Displacement	LO showed the lowest stress on supporting tissues. MO improved denture stability and reduced rotational movement across all occlusal plane levels.
Chandrathara, et al. (2020)	Analysis of the Stress Distribution Pattern of Anatomic and Non-Anatomic Tooth Forms on Maxillary and Mandibular Edentulous Ridges—A Photoelastic Study	Photoel-astic In Vitro Study	Anatomic, Non Anatomic	Medium Ridge Height	Polariscope	Stress Distribution	Stress of greater magnitude was observed with cuspal teeth whereas non-anatomic (0º) showed slightly less magnitude of stress.
Chaturvedi, et al. (2021)	Clinical analysis of CAD-CAM milled and printed complete dentures using computerized occlusal force analyser	Clinical In Vivo Study	BBO, LO, MO	General Edentulous	T-Scan III Occlusal Force Analysis	Force Distribution, Centralization	LO scheme and subtractive method yielded optimal force distribution
El-Agamy, et al. (2023)	The Effect of Different Occlusal Schemes on Masticatory Performance for Conventional and Digital Complete Dentures	Clinical In Vivo Study	BBO, LO	General Edentulous	Masticatory Performance Testing	Chewing Time and Swallowing	BBO and LO similarly effective; 3D BBO slightly superior
Madalli P, et al. (2015)	Effect of Occlusal Scheme on the Pressure Distribution of Complete Denture Supporting Tissues: An In Vitro Study	In Vitro with Strain Gauge	BBO, LO, MO	General Edentulous	Strain Gauge Measurement	Pressure on supporting tissues	Overall monoplane occlusion had lesser pressure values compared to completely balanced and lingualized occlusal scheme. Lingualized occlusal scheme was found to transfer stresses from working side to non-working side to stabilize the mandibular denture.

Table 2. Risk of Bias Assessment for Included Study (Based on JBI Checklist).

Author(s)	Study Design	Tool Used	Risk of Bias	Notes
Hafezeqoran et al. (2018)	In Vitro	JBI In Vitro	Low	Clear objectives and valid; minor sample size concern
Chaturvedi et al. (2021)	Clinical (RCT)	JBI Clinical Trials	Moderate	No randomization/blinding, unclear allocation
El-Agamy et al. (2023)	Clinical (Crossover)	JBI Clinical Trials	Moderate	Limited washout info; small sample size
Fatiallah & Faraj. (2022)	FEA Simulation	JBI In Vitro	Low	Defined load and ridge levels; methodologically sound
Chandrathara, et al. (2020)	In Vitro (Photoelastic)	JBI In Vitro	Low	Clear objectives and valid; minor sample size concern
Madalli P, et al. (2015)	In Vitro	JBI In Vitro	Low	Clear objectives and valid; minor sample size concern
Fatola et al. (2025)	FEA Simulation	JBI In Vitro	Low	Accurate ridge modeling, appropriate FEA

assessment informed interpretation but was not used as an exclusion criterion. A summary of the assessment is presented in table 2.

Results

Out of 407 records initially identified, 7 studies met the inclusion criteria and were included in the final synthesis. These comprised three in vitro experiments, two finite element FEA simulations, and two clinical in vivo studies, all investigating the biomechanical effects of different occlusal schemes in complete dentures for atrophic or severely resorbed mandibular ridges. The included studies compared at least two of the following occlusal schemes: bilateral BBO, LO, and MO. Outcomes of interest included stress or strain distribution, tissue pressure, and occlusal force balance, measured using techniques such as strain gauges, T-scan digital analysis, pressure sensors, photoelastic models, and finite element analysis (FEA).

Thematic findings are summarized as follows: Lingualized Occlusion (LO); LO consistently demonstrated a more uniform stress distribution across the residual ridge compared with other schemes. Stress concentration was primarily centralized along the ridge crest, with reduced loading on the mucosal slopes. This scheme also enhanced masticatory efficiency and load transmission balance, particularly in patients with atrophic ridges. Bilateral Balanced Occlusion (BBO): BBO showed advantages in maintaining denture stability under oblique and eccentric loading. It effectively minimized denture tipping during functional movements but was associated with slightly higher localized stresses on posterior ridges in some in vitro and FEA studies.

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Monoplane Occlusion (MO): MO yielded variable results. While several studies reported reduced vertical strain and simplified occlusal adjustments, others noted increased localized stress on residual ridges and less effective load distribution compared to LO. The absence of cusp interdigitation contributed to decreased shear forces but compromised overall stability in knife-edge ridges.

Across all studies, the variety of biomechanical assessment methods and ridge morphologies limited direct comparison and meta-analysis. However, the general trend suggests that LO offers superior stress distribution, BBO provides functional stability, and MO serves as a simplified option for severely resorbed ridges where minimal lateral stress is desired. Detailed study characteristics are presented in table 1, while risk of bias assessment using the Joanna Briggs Institute (JBI) tools is summarized in table 2.

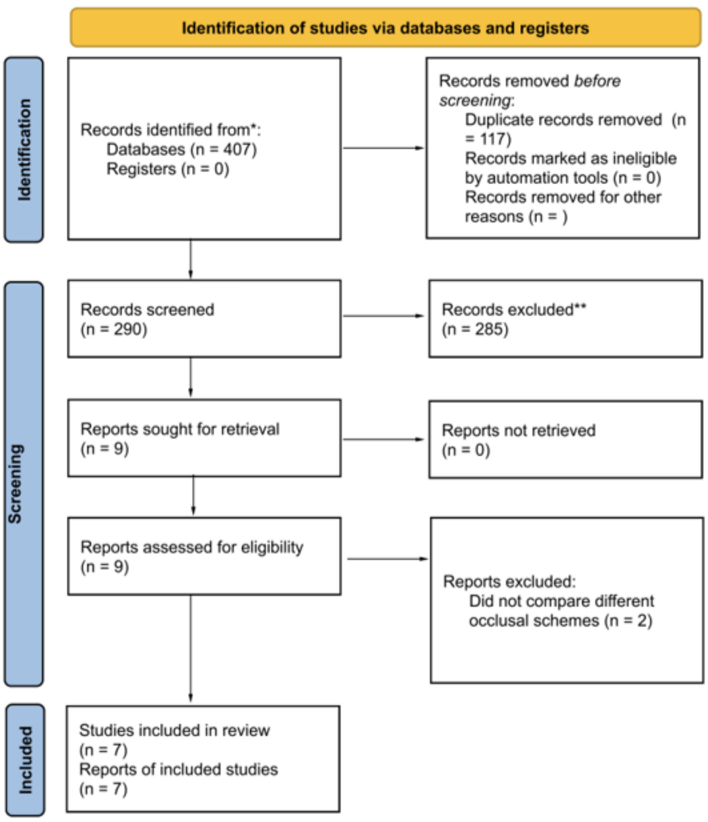

Figure 1. PRISMA flow diagram of study selection.

Discussion

This systematic review aimed to critically evaluate biomechanical evidence on the influence of occlusal schemes in complete denture prostheses for patients with atrophic or knife-edge residual ridges. As residual ridge resorption progresses, the supporting area for dentures becomes narrower and less favorable for stress distribution, compromising denture retention, stability, and patient comfort.[15,16] Therefore, selecting an occlusal scheme that can optimize load transmission while minimizing strain on the compromised mucosa is critical in edentulous prosthodontic rehabilitation.

This review synthesized findings from seven studies, including in vitro experiments, FEA, photoelastic simulations, and clinical assessments. These studies compared three main occlusal schemes: BBO, LO, and monoplane occlusion MO. The primary outcomes measured were stress or strain on the mucosa, pressure on denture-bearing areas, occlusal force distribution, and denture stability.

Several studies reported consistent biomechanical advantages of the LO scheme in atrophic ridges. Fatola et al. and Fatiallah & Faraj found that LO resulted in lower von Mises stress values compared to BBO and MO, particularly under oblique loading conditions.[17,18] These findings suggest that LO can concentrate occlusal forces more centrally and reduce lateral interferences, thus lowering the risk of mucosal trauma.

Interestingly, Hafezeqoran et al. reported a different outcome. Using strain gauge analysis, they found that MO produced the lowest strain on the denture-supporting tissues, especially in the buccal shelf region.[12] This apparent contradiction may be due to differences in biomechanical models and loading directions. While LO may be superior under dynamic or oblique forces, MO could be more advantageous under controlled vertical loads or in specific anatomical contexts.

Further insights were provided by clinical studies using occlusal force measurement systems. Chaturvedi et al. and El-Agamy et al. observed that LO and BBO produced better occlusal force balance and more symmetrical left–right distribution compared to MO.[19,20] These findings reinforce the clinical relevance of occlusal scheme selection in optimizing masticatory efficiency and patient satisfaction.

Studies using photoelastic and pressure sensor methods also supported the superiority of LO and BBO over MO in terms of stress distribution. These schemes spread occlusal forces across a wider area, minimizing localized pressure points, especially in the posterior regions.[13,21] However, MO showed improved stability when the occlusal plane was leveled with the ridge crest or aligned with the middle third of the retromolar pad, as reported by Fatiallah & Faraj.[18]

In the context of knife-edge mandibular ridges, the biomechanical implications of these occlusal schemes become particularly relevant. The sharp and narrow crest provides a limited denture-bearing area and tends to concentrate functional loads along the ridge peak, predisposing to mucosal soreness and accelerated resorption. In such cases, LO appears most

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beneficial because it directs occlusal contacts more centrally and transfers forces toward the middle of the ridge, minimizing shear stress on the crest. BBO may further enhance stability during lateral or oblique movements, which helps prevent tipping of the denture on the knife-edge ridge. Conversely, MO can reduce vertical load but may still generate localized pressure on the sharp ridge crest if the occlusal plane is not carefully aligned. Therefore, these findings underscore the importance of adapting the occlusal scheme to ridge morphology to achieve optimal comfort, stability, and long-term tissue preservation in patients with knife-edge mandibular ridges.

Overall, while the findings across studies were not entirely uniform, several consistent patterns emerged. LO generally reduced stress on the mucosa and provided more centralized occlusal force distribution. MO, while effective in reducing vertical strain in some controlled scenarios, often resulted in higher stress concentrations under non-ideal occlusal plane configurations or lateral loading. These findings suggest that no single occlusal scheme is universally superior in all biomechanical contexts. Instead, the selection of an appropriate occlusal scheme should be guided by individual patient factors, including residual ridge morphology, occlusal plane orientation, and anticipated functional load. Furthermore, the heterogeneity in study design, ridge modeling, and loading protocols likely contributed to variations in outcomes and should be taken into account when interpreting the evidence.

Conclusion

This systematic review evaluated the biomechanical effects of different occlusal schemes in complete dentures for patients with atrophic or knife-edge mandibular ridges. Across seven included studies—comprising in vitro, finite element analysis, and clinical evaluations—consistent trends emerged regarding stress distribution and denture stability.

LO generally demonstrated more uniform stress distribution on the denture-bearing mucosa and better balance of occlusal forces, contributing to enhanced comfort and load control. BBO improved denture stability, particularly under functional and oblique loading conditions. MO tended to reduce vertical strain in some configurations but often produced higher localized stresses, especially during lateral or uneven loading.

No single occlusal scheme exhibited universal superiority under all biomechanical conditions. Therefore, occlusal scheme selection should be individualized, taking into account the patient's ridge morphology, occlusal plane orientation, and functional requirements.

Variations in study design, ridge modeling, and biomechanical testing methods among existing research emphasize the need for standardized, high-quality experimental and clinical studies. Future investigations integrating in vivo load measurements with digital simulation models are recommended to strengthen the evidence base and refine clinical decision-making for edentulous patients with resorbed ridges.

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