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REVIEW ARTICLE

EFFECTIVENESS OF IMPLANT-SUPPORTED REMOVABLE COMPLETE DENTURES RETAINED BY BALL, BAR, AND RAIL ATTACHMENT SYSTEMS ON FOUR ANTERIOR MANDIBULAR IMPLANTS: A SCOPING REVIEW

Liana Papayan[1], Anna Hakobyan[2]
[1]PhD, Head of the Department of Stomatology, Armenian Medical Institute, Yerevan, Armenia
[2]PhD, Associate Professor, Department Prosthodontic, Yerevan State Medical University after M. Heratsi, Yerevan, Armenia
Corresponding author: Anna Hakobyan, Yerevan State Medical University after M. Heratsi,Yerevan, Armenia
e-mail: anushik-76@mail.ru
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ABSTRACT

Background: Implant-supported removable overdentures are an established treatment option for completely edentulous patients, particularly those experiencing inadequate retention and stability with conventional complete dentures. The clinical performance of these prostheses depends on implant number, distribution, attachment design, and biomechanical characteristics.
Objective: To map the available scientific evidence regarding the effectiveness of ball, bar, and rail attachment systems used for mandibular implant-supported removable complete dentures, with particular emphasis on configurations supported by four anterior implants.
Methods: This review is structured according to the Joanna Briggs Institute (JBI) methodology and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR). The Population–Concept–Context framework was applied. PubMed/MEDLINE, Scopus, Web of Science, and Cochrane Library are proposed as information sources. Clinical trials, observational studies, case reports, in vitro investigations, finite element analyses, and systematic reviews are considered relevant. Evidence is categorized according to attachment design, implant number, clinical outcomes, complications, and follow-up.
Results: The mapped literature demonstrates a substantial evidence base concerning ball and bar attachment systems for mandibular overdentures. Clinical case reports describe mandibular rehabilitation using ball and prefabricated bar attachments. Finite element investigations have compared two- and four-implant configurations and different attachment mechanisms. However, direct comparative clinical evidence specifically involving four anterior mandibular implants and all three attachment systems remains insufficient. Evidence regarding rail attachments is particularly limited.
Conclusion: Ball and bar attachments are established options for mandibular implant-supported overdentures. Four-implant configurations have biomechanical and clinical relevance, but their outcomes should be distinguished from evidence derived from two-implant studies. Further clinical research is necessary to determine the comparative effectiveness of ball, bar, and rail systems.

Keywords: Mandibular overdenture; dental implants; four implants; ball attachment; bar attachment; rail attachment; complete edentulism; prosthetic retention; scoping review.

INTRODUCTION

Complete edentulism is associated with considerable functional, anatomical, and psychosocial consequences, particularly when conventional complete dentures fail to provide adequate retention and stability. The mandibular residual ridge is frequently affected by progressive alveolar bone resorption, which may compromise denture support, masticatory efficiency, speech, and patient comfort.

Longitudinal investigations have demonstrated the continuing reduction of residual alveolar ridges following tooth loss, highlighting the limitations of conventional complete denture rehabilitation in certain edentulous patients. Implant-supported removable overdentures have therefore become an important treatment alternative for improving prosthetic retention, stability, and functional

rehabilitation. [1,2]

The McGill Consensus Statement established the mandibular two-implant overdenture as the first-choice standard of care for edentulous patients, emphasizing its clinical relevance compared with conventional complete dentures. This recommendation was subsequently reinforced by the York Consensus Statement. Clinical investigations and systematic reviews have demonstrated favorable outcomes associated with implant-supported mandibular overdentures, including improved patient satisfaction, functional rehabilitation, and oral health-related quality of life. Nevertheless, implant number and attachment configuration should be selected according to anatomical conditions, prosthetic requirements, and individual patient characteristics. [3–6]

The effectiveness of implant-supported overdentures is influenced not only by the number of implants but also by their spatial distribution and the mechanical characteristics of the attachment system. Different attachment designs may affect prosthetic retention, stability, load transfer, maintenance requirements, and peri-implant tissue responses. Systematic reviews have demonstrated that attachment selection represents an important factor in the clinical performance of mandibular implant overdentures. Among the commonly investigated configurations, ball and bar attachments have received substantial attention in clinical and biomechanical research. [6–8]

Ball attachments consist of individual spherical abutments connected to the implants and corresponding matrices incorporated into the fitting surface of the removable prosthesis. Their principal advantages include relatively simple clinical procedures, individual implant engagement, and comparatively straightforward maintenance. However, attachment wear, loss of retention, implant angulation, and replacement of retentive components may influence their long-term performance. Comparative clinical investigations have evaluated ball and bar attachment systems in mandibular implant overdentures, providing information regarding their retention characteristics and prosthetic outcomes. 7–9

Bar attachment systems connect multiple implants through a common supporting framework, providing a splinted prosthetic configuration. The framework may contribute to prosthetic stability and modify the distribution of functional forces among supporting implants. Nevertheless, bar systems require adequate interarch space, accurate framework adaptation, and sufficient access for cleaning beneath the connecting structure. Prosthetic complications may include clip wear, loss of retention, component loosening, and difficulties associated with plaque control. Clinical investigations comparing splinted and unsplinted implant configurations have demonstrated the importance of evaluating both peri-implant tissue responses and prosthetic maintenance requirements. [7,10,12]

Four anterior mandibular implants represent an alternative configuration that may be considered when additional implant support or a particular prosthetic design is required. Compared with conventional two-implant overdentures, a four-implant arrangement introduces additional possibilities for attachment distribution and prosthetic stabilization. Comparative clinical investigations involving two- and four-implant mandibular overdentures have contributed to the understanding of implant number and its influence on treatment outcomes. Nevertheless, an increased implant number does not automatically guarantee improved clinical effectiveness. Implant positioning, bone availability, interimplant distance, occlusal loading, and attachment geometry must be considered during treatment planning. [13–15]

The biomechanical behavior of different implant configurations is another important consideration. Finite element investigations comparing one-, two-, and four-implant overdentures have demonstrated differences in stress distribution within the prosthesis and supporting structures. These findings indicate that implant number and attachment configuration may influence biomechanical behavior under functional loading conditions. However, experimental biomechanical results should be interpreted together with clinical evidence and should not be considered independent proof of clinical superiority. [13]

Rail-type attachment systems represent another mechanical approach, characterized by guided engagement between the supporting and removable prosthetic components. Their potential application in mandibular overdentures may be related to controlled insertion pathways and resistance to selected directions of prosthetic displacement. However, the available literature does not provide sufficient direct comparative clinical evidence concerning rail attachments in four-implant mandibular overdentures. Consequently, their effectiveness should be considered an important area for future investigation rather than an established clinical advantage.

Although previous systematic reviews have evaluated different attachment systems for mandibular implant-supported overdentures, the available literature demonstrates heterogeneity in implant number, attachment design, outcome assessment, and follow-up duration. Furthermore, many investigations focus on two-implant configurations, limiting the direct applicability of their findings to four-implant-supported prostheses. A scoping review is therefore appropriate to map the available clinical and biomechanical evidence, identify differences among attachment systems, and establish research gaps concerning four-implant mandibular rehabilitation. [6–8,13–15]

2. Aim and Research Questions

2.1. Aim

The primary aim of this scoping review is to map the scientific evidence concerning the clinical, biological, biomechanical, and prosthetic effectiveness of removable mandibular complete overdentures retained by ball, bar, and rail attachment systems, with emphasis on four anterior implants.

2.2. Specific objectives

To identify studies investigating ball, bar, and rail attachments in mandibular overdentures.

To describe the influence of attachment design on prosthetic retention and stability.

To map evidence concerning implant survival and marginal bone changes.

To identify biological and mechanical complications.

To assess reported outcomes concerning mastication and patient satisfaction.

To identify gaps in the evidence concerning four-implant-supported configurations.

2.3. Research questions

What scientific evidence is available regarding ball, bar, and rail attachments in mandibular overdentures? How does implant number influence biomechanical outcomes? What differences in retention and stability have been reported between attachment systems?

What biological and technical complications have been documented? What evidence is available regarding four anterior mandibular implants? What additional research is required to establish the clinical effectiveness of rail attachments?

3. MATERIALS AND METHODS

3.1. Study design

This manuscript follows the methodological structure of a scoping review based on the JBI framework.

Reporting is planned according to PRISMA-ScR.

The review aims to identify and characterize the available literature rather than calculate a pooled treatment effect.

The methodology should be finalized after the actual database searches, duplicate removal, and independent screening have been completed.

3.2. PCC framework

Table 1. Population–Concept–Context framework

Component	Definition
Population	Completely edentulous adult patients
Concept	Ball, bar, and rail attachment systems
Context	Implant-supported removable mandibular complete overdentures
Main configuration	Four implants in the anterior mandibular region
Supplementary evidence	Studies involving two or other numbers of implants

Studies involving two implants will be analyzed separately and will not be presented as direct evidence for four-implant rehabilitation.

3.3. Information sources

The following databases are proposed:

PubMed/MEDLINE.

Scopus.

Web of Science.

Cochrane Library.

Supplementary searching should include Google Scholar, reference lists of relevant publications, and clinical trial registries.

3.4. Search strategy

The following search strategy is proposed for PubMed:

text

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( "Dental Prosthesis, Implant-Supported"[Mesh]
  OR "implant-supported overdenture"
  OR "implant-retained overdenture"
  OR "mandibular overdenture")
AND
("ball attachment"
  OR "bar attachment"
  OR "rail attachment"
  OR "sliding attachment"
  OR "precision attachment"
  OR "attachment system")
AND
( mandible
  OR mandibular
  OR edentulous
  OR "complete edentulism")
```

A supplementary search will identify four-implant configurations:

text

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("four implants"
  OR "four-implant"
  OR "4 implants"
  OR "four implant-supported")
AND
( "mandibular overdenture"
  OR "implant-supported overdenture")
AND
(ball OR bar OR rail OR attachment)
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The terminology for rail attachments will require additional searching because different manufacturers and research groups may use different descriptions for guided mechanical attachment systems.

3.5. Inclusion and exclusion criteria

Table 2. Eligibility criteria

Inclusion criteria	Exclusion criteria
Completely edentulous mandible	Partially edentulous patients without relevant overdenture data
Implant-supported removable prostheses	Fixed implant-supported restorations
Ball, bar, or rail attachment systems	Unspecified attachment systems
Two- or four-implant configurations	Studies without relevant implant data
Randomized controlled trials	Editorials without research data
Prospective and retrospective studies	Irrelevant case reports
In vitro and finite element studies	Studies unrelated to overdenture biomechanics
Systematic and scoping reviews	Duplicate publications

3.6. Study selection

The study selection process should consist of four stages:
Identification of records.
Removal of duplicates.
Title and abstract screening.
Full-text eligibility assessment.
Two independent reviewers should perform screening, with disagreements resolved through discussion or a third reviewer.

3.7. Data extraction

The following information should be extracted:
Author and year.
Country.
Study design.
Number of patients.
Number of implants.
Implant distribution.
Attachment type.
Follow-up period.
Implant survival.
Marginal bone changes.
Prosthetic retention and stability.
Mechanical complications.
Patient satisfaction.

3.8. Data synthesis

The evidence will be mapped descriptively according to:
Ball attachment systems.
Bar attachment systems.
Rail attachment systems.
Biomechanical investigations.
Biological outcomes.
Prosthetic maintenance.
Patient-reported outcomes.
No meta-analysis is planned because of anticipated methodological and clinical heterogeneity.

4. Results

4.1. Overview of the available evidence

The preliminary evidence mapping identified clinical reports, biomechanical investigations, and systematic reviews addressing mandibular implant-supported overdentures.
The available literature can be classified into five main categories:
Clinical studies of ball attachment systems.
Clinical studies of bar attachment systems.
Biomechanical investigations comparing attachment configurations.
Studies investigating the influence of implant number.
Reviews of prosthetic complications and maintenance.
The evidence is more extensive for ball and bar attachments than for rail systems.
An important distinction is that some mandibular clinical reports describe two implants, whereas biomechanical investigations have evaluated four-implant configurations. These two evidence categories must be interpreted separately.

4.2. Ball attachment systems

Ball attachments consist of a spherical male component connected to the implant and a corresponding female matrix incorporated into the fitting surface of the overdenture.
They provide individual retention at each implant site and are frequently used in mandibular implant-supported prostheses.



Figure 1. Ball attachment components in mandibular implant-supported overdenture rehabilitation.

The spherical abutments engage the corresponding matrices incorporated into the denture base. This mechanical connection improves resistance to vertical displacement and contributes to prosthetic retention.

A clinical report by Park (2009) described rehabilitation of an edentulous mandible using ball attachments and additional posterior healing abutments. The authors reported satisfactory prosthetic function during 18 months of follow-up.

The study is relevant because it illustrates mandibular clinical management and prosthetic incorporation of ball attachments. However, it does not represent a direct comparison of four ball attachments.

Clinical reference: Park JB. Rehabilitation of the edentulous mandible with implant-supported overdenture using ball attachments and healing abutments: A case report.

4.2.1. Retention and maintenance

The principal advantages of ball attachments include relatively simple construction, independent engagement, and accessibility for maintenance.

Potential complications include:

Wear of the retention matrices.

Loss of retention.

Deformation of plastic inserts.

Loosening of attachment components.

Denture base fracture around the housings.

The clinical performance of ball attachments depends on implant parallelism, attachment height, available prosthetic space, and the mechanical characteristics of the retention inserts.

4.3. Bar attachment systems

Bar attachment systems connect two or more implants through a common framework.

In mandibular overdenture rehabilitation, a bar can provide implant splinting and a common retention structure for the removable prosthesis.

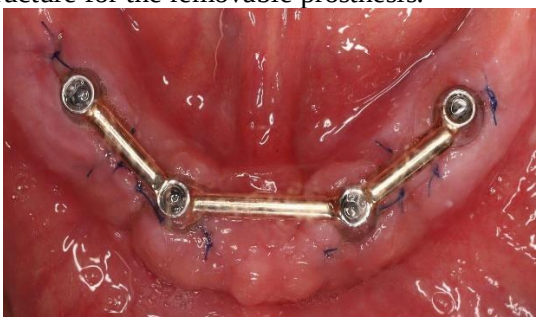


Figure 2. Prefabricated bar attachment system in mandibular implant-supported overdenture rehabilitation.

Ha et al. (2012) described the use of a prefabricated SFI-Bar system in an edentulous mandibular patient.

The clinical procedure included implant adapters, ball joints, a connecting tube bar, and incorporation of the corresponding female retention component into the denture.

The authors demonstrated the clinical feasibility of this system and described its chairside adjustment and prosthetic maintenance.

Importantly, the reported clinical case involved two implants, not four. Therefore, it provides evidence about mandibular bar attachment techniques rather than direct clinical evidence for a four-implant bar configuration.

Original clinical publication: Ha SR, Kim SH, Song SI, Hong ST, Kim GY. Implant-supported overdenture with prefabricated bar attachment system in mandibular edentulous patient. Journal of Advanced Prosthodontics. 2012;4(4):254–258.

4.3.1. Biomechanical characteristics

The connecting bar modifies the relationship between individual implants and the removable prosthesis.

The mechanical behavior depends on:

Bar rigidity.

Implant distribution.

Framework adaptation.

Clip design.

Occlusal loading.

Prosthetic space.

Cantilever length, where present.

Splinting may alter force distribution between implants, but it does not necessarily reduce every form of peri-implant stress.

4.3.2. Maintenance requirements

Bar systems require particular attention to hygiene beneath the framework.

The patient must be able to clean the space between the bar and underlying soft tissues. Retention clips also require periodic assessment.



Figure 3. Female retention component incorporated into the fitting surface of a mandibular bar-supported overdenture.

The female component engages the connecting bar and provides mechanical retention. Accurate positioning is important for passive seating of the prosthesis and prevention of excessive stress on the denture base.

4.4. Four-implant configurations and biomechanical evidence

Four anterior mandibular implants may provide multiple retention points and allow different attachment configurations.

However, the clinical choice between two and four implants should consider bone availability, anatomical limitations, prosthetic space, and patient-specific factors.



Figure 4. Schematic representation of four implants distributed in the anterior mandible.

This illustration demonstrates a possible four-implant configuration in the mandibular interforaminal region. It is a schematic representation and not a clinical radiograph.

The position of the implants should be determined according to anatomical conditions, including the mental foramina and mandibular canal.

A finite element investigation published in 2017 compared two- and four-implant mandibular overdentures retained by ball and Locator attachments.

Four three-dimensional models were developed:

Two implants with ball attachments.

Four implants with ball attachments.

Two implants with Locator attachments.

Four implants with Locator attachments.

The investigation demonstrated differences in stress distribution according to attachment type and implant number. Ball attachments produced higher stresses in certain modeled components than Locator attachments.

These findings provide biomechanical information but cannot establish clinical superiority or long-term implant survival.

Reference: Influence of Number of Implants and Attachment Type on Stress Distribution in Mandibular Implant-Retained Overdentures: Finite Element Analysis. 2017.

PubMed Central (PMC)

4.5. Rail attachment systems

Rail attachment systems are characterized by a guided mechanical engagement between the prosthetic and supporting components.

The concept differs from conventional ball attachments and may also differ from conventional bar-and-clip systems, depending on the geometry and retention mechanism.

The proposed mechanical principle involves controlled engagement along a defined insertion pathway.

Potential design considerations include:

Direction of prosthesis insertion.

Retention characteristics.

Resistance to lateral displacement.

Friction and component wear.

Prosthetic space.

Accessibility for cleaning.

The literature identified in this preliminary mapping did not establish sufficient direct clinical evidence for a four-implant mandibular rail attachment system.

Therefore, this system should be considered an evidence gap rather than an attachment with demonstrated clinical superiority.

4.6. Radiographic evaluation

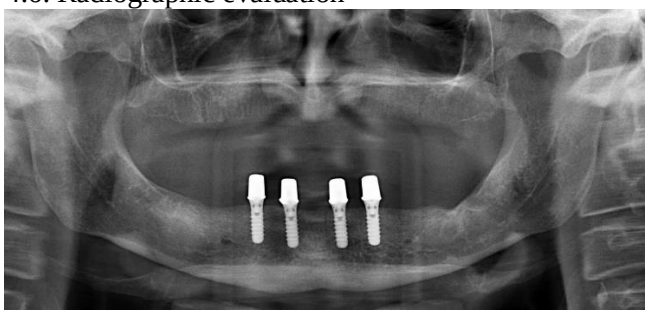


Figure 5. Panoramic radiographic assessment of implant distribution in the edentulous mandible.

Radiographic examination is necessary to evaluate implant positioning, marginal bone levels, and the relationship of implants to surrounding anatomical structures.

In the mandible, special attention should be given to:

Mental foramina.

Mandibular canal.

Residual bone height.

Interimplant distance.

Marginal peri-implant bone levels.

Periapical radiographs may provide additional information during long-term follow-up.

4.7. Comparison of attachment systems

A. Ball



Figure 6. Individual engagement

B. Bar



Figure 7 Implant splinting

C. Rail

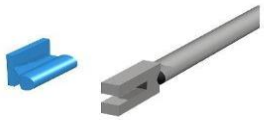


Figure 8. Guided engagement

Table 3. Comparative characteristics of attachment systems

Characteristic	Ball	Bar	Rail
Implant splinting	No	Yes	Design-dependent
Retention	Individual	Clip or framework	Guided engagement
Prosthetic stability	Attachment-dependent	Framework-dependent	Design-dependent
Hygiene	Generally accessible	Requires cleaning beneath bar	Design-dependent
Maintenance	Insert replacement	Clip maintenance	Component inspection
Clinical evidence	Established	Established	Limited
Four-implant clinical evidence	Limited specific data	Limited specific data	Insufficient

The table represents general mechanical characteristics and does not imply a validated ranking of clinical effectiveness.

4.8. Biological and technical complications

Complications associated with mandibular implant-supported overdentures may be divided into biological and technical categories.

Table 4. Complications and clinical management

Complication	Potential cause	Clinical management
Loss of retention	Insert or clip wear	Replacement or activation
Denture fracture	Insufficient resin thickness	Repair or reinforcement
Peri-implant mucositis	Plaque accumulation	Hygiene and periodontal management
Marginal bone loss	Inflammation or overload	Clinical and radiographic evaluation
Attachment loosening	Mechanical instability	Component assessment
Bar-related hygiene problems	Restricted access	Hygiene instruction and design review
Rail component wear	Repeated mechanical engagement	System-specific maintenance

4.9. Patient satisfaction and functional outcomes

The clinical effectiveness of implant-supported mandibular overdentures should also be evaluated using patient-reported outcomes.

Relevant parameters include:

Chewing comfort.

Denture retention.

Speech.

Oral comfort.

Ease of insertion and removal.

Satisfaction with treatment.

Oral health-related quality of life.

The Oral Health Impact Profile for edentulous patients (OHIP-EDENT) and Visual Analogue Scale (VAS) are appropriate instruments for assessing these outcomes.

5. DISCUSSION

The interpretation of the available evidence suggests that the clinical effectiveness of implant-supported overdentures is determined by the interaction between implant number, implant distribution, attachment design, prosthetic material, and functional loading. Although ball and bar attachment systems have been investigated extensively, differences in study methodology and follow-up duration make it difficult to establish a universally superior attachment configuration. Long-term clinical investigations have demonstrated favorable implant survival with both ball and bar systems, although the frequency and type of prosthetic maintenance may differ. [16,17]

One important consideration is the long-term mechanical performance of ball and bar attachments. Walton's randomized clinical trial compared two-implant mandibular overdentures retained by ball and bar-clip systems over three years. The study reported different

patterns of prosthetic maintenance, with the bar-clip group demonstrating fewer extensive repairs in the specific attachment designs investigated. These findings indicate that attachment selection should consider not only initial retention but also the expected maintenance burden throughout the functional life of the prosthesis. [16]

Long-term findings were also reported by Naert and colleagues, who evaluated mandibular overdentures retained by different attachment systems. Their five-year investigation demonstrated favorable implant survival and relatively high retention with bar attachments, although soft-tissue complications were more frequent in the bar group. In a subsequent ten-year investigation, ball attachments demonstrated high retention forces, while different mechanical complications were observed among the ball, bar, and magnetic groups. These findings emphasize that retention, biological response, and prosthetic maintenance should be considered as separate clinical outcomes. [17,18]

The influence of implant number is particularly relevant to the present review. Finite element investigations comparing one, two, and four ball attachments have demonstrated that increasing the number of implants changes stress distribution within the prosthesis, attachment components, and supporting structures. El-Zawahry et al. reported that four-implant models showed different deformation and stress patterns compared with one- and two-implant configurations. Importantly, their findings did not establish that four implants were clinically superior to two implants. Rather, they demonstrated that implant number influences biomechanical behavior under the modeled loading conditions. [19,20]

Clinical investigations involving different implant numbers provide additional information. A randomized clinical study comparing two and four mini-implants demonstrated favorable short-term clinical outcomes for both configurations. The results suggest that four implants may provide an alternative retention arrangement in selected edentulous patients; however, implant diameter, primary stability, and loading protocol must be considered when interpreting these findings. [21]

A five-year randomized clinical investigation comparing three and four mini-implants further demonstrated the importance of evaluating long-term outcomes rather than relying exclusively on early retention measurements. Both groups demonstrated relatively small marginal bone-level changes, without a significant difference between the configurations. Although this study involved mini-implants, its findings are relevant to the broader discussion of implant number and should not be directly extrapolated to four conventional-diameter implants. [22]

The relationship between implant distribution and patient satisfaction is also important. A randomized clinical investigation evaluating two versus four interforaminal and posteriorly distributed implants reported improvements in oral health-related quality of life and patient satisfaction following overdenture treatment. These results indicate that the anteroposterior distribution of implants may influence functional rehabilitation. However, implant position and prosthetic design should be considered together rather than attributing the outcomes exclusively to implant number. [23]

A particularly relevant recent randomized clinical trial evaluated four-implant mandibular overdentures retained by two different bar configurations: quadrilateral and bilateral linear bars. The study included implants positioned in the canine and first molar regions. The quadrilateral bar configuration was associated with higher patient satisfaction regarding denture stability, retention, and chewing, whereas the bilateral linear configuration offered advantages in comfort and hygiene accessibility. These findings provide direct clinical evidence concerning four-implant mandibular bar-supported overdentures, although the short follow-up period limits conclusions regarding long-term effectiveness. [24]

Patient-reported outcomes should be regarded as essential components of treatment effectiveness. Naguib et al. demonstrated improvements in oral health-related quality of life following mandibular overdenture rehabilitation with different attachment systems. Their randomized clinical trial showed that both ball and Locator attachments contributed to improved quality-of-life scores. Although the investigation involved a single-implant configuration, it supports the importance of assessing functional and psychosocial outcomes alongside technical performance. [25]

The influence of attachment selection on patient satisfaction was also investigated in a randomized crossover clinical trial comparing self-aligning and conventional ball attachments. The results demonstrated improvements in selected oral health-related quality-of-life domains with the self-aligning attachment, particularly among patients with limited prosthetic space. This finding highlights the importance of attachment geometry and the available vertical space during prosthetic planning. [26]

Another important aspect is the influence of retention force and mechanical wear. An in vitro investigation comparing three attachment systems for mandibular implant-retained overdentures demonstrated differences in retention loss and wear after repeated insertion-removal cycles. The ball system showed relatively limited retention loss, whereas other systems demonstrated different patterns of wear. Such findings are relevant to long-term maintenance planning, although laboratory aging cannot fully reproduce intraoral clinical conditions. [27]

The comparison of different bar designs also requires consideration of material properties. Framework rigidity, clip characteristics, and the distribution of functional forces may influence prosthetic performance. A recent randomized investigation comparing cobalt-chromium and PEEK bars examined clip wear and patient satisfaction. The results suggest that framework material may influence surface characteristics and patient-reported outcomes. Nevertheless, additional long-term research is necessary before drawing conclusions about the superiority of one material. [28]

Four-implant configurations using alternative attachment mechanisms have also been investigated in relation to marginal bone preservation. A randomized clinical study comparing two- and four-implant telescopic overdentures reported differences in radiographic bone-height changes. However, the small sample size and specific telescopic attachment design limit the generalizability of these findings to ball and bar systems. [29]

Long-term evidence involving four narrow implants is provided by a nine-year randomized clinical investigation of mandibular overdentures retained with Locator attachments. The study reported high implant survival and manageable prosthetic complications during follow-up. These results demonstrate that four-implant mandibular rehabilitation can provide favorable long-term outcomes in selected patients, although narrow implants and Locator attachments represent a different configuration from four conventional implants with ball, bar, or rail attachments. [30]

Regarding rail attachment systems, the present evidence mapping indicates that further research is required to establish their clinical effectiveness in four-implant mandibular overdentures.

Their theoretical mechanical advantages should not be interpreted as demonstrated clinical benefits. Future comparative investigations should define rail geometry, retention force, insertion pathway, wear characteristics, and hygiene accessibility.

Direct comparisons with ball and bar systems should use standardized implant positions, prosthetic materials, loading conditions, and follow-up periods.

Overall, the additional clinical and biomechanical evidence supports the need for individualized attachment selection. Ball and bar systems have established clinical applications, whereas rail systems require further validation.

Future prospective randomized clinical trials involving four conventional-diameter mandibular implants should evaluate implant survival, marginal bone changes, prosthetic retention, mechanical complications, maintenance frequency, masticatory performance, and patient satisfaction over extended follow-up periods.

6. LIMITATIONS OF THE REVIEW

The present review has several limitations that should be considered when interpreting its findings. First, the available literature demonstrates considerable heterogeneity in study design, implant number, implant diameter, attachment configuration, prosthetic materials, loading protocols, and follow-up periods. This variability makes direct comparisons between different attachment systems difficult and limits the possibility of establishing definitive conclusions regarding their relative clinical effectiveness.

Second, a substantial proportion of the available clinical evidence concerns two-implant mandibular overdentures rather than four-implant configurations. Although these studies provide valuable information regarding attachment performance, retention, prosthetic maintenance, and patient satisfaction, their findings cannot be directly generalized to four conventional-diameter implant-supported overdentures.

Third, several investigations included in the evidence base evaluated mini-implants, narrow-diameter implants, or alternative attachment mechanisms, such as Locator and telescopic systems. These configurations differ biomechanically from conventional-diameter implants retained by ball, bar, or rail attachments. Therefore, their clinical outcomes should be interpreted as indirect evidence rather than direct comparative evidence.

Fourth, the available studies frequently used different outcome measures. Implant survival, marginal bone-level changes, attachment retention, prosthetic complications, maintenance frequency, masticatory performance, and oral health-related quality of life were not consistently evaluated across all investigations. This methodological inconsistency limits the comparability of reported results.

Another limitation concerns the relatively limited duration of follow-up in several clinical investigations. Short-term improvements in retention and patient satisfaction do not necessarily predict long-term mechanical stability or biological success. Attachment wear, clip deformation, framework complications, and peri-implant tissue changes may become more apparent after several years of functional loading.

Furthermore, biomechanical and in vitro investigations provide important information regarding stress distribution, retention loss, and material properties; however, these experimental findings cannot fully reproduce the complex clinical environment. Consequently, laboratory results should not be interpreted as definitive evidence of clinical superiority.

Finally, the evidence concerning rail attachment systems in four-implant mandibular overdentures remains particularly limited. The absence of sufficient high-quality comparative clinical studies prevents reliable conclusions regarding their long-term effectiveness relative to established ball and bar attachment systems.

Despite these limitations, the present review provides an overview of the available clinical and biomechanical

evidence and identifies important research gaps relevant to the selection of attachment systems for four-implant mandibular overdentures.

7. FUTURE PERSPECTIVES

Future research should focus on well-designed prospective randomized clinical trials directly comparing ball, bar, and rail attachment systems in mandibular overdentures supported by four conventional-diameter implants. Such investigations are necessary to establish whether differences in attachment geometry and implant distribution result in clinically meaningful improvements in prosthetic stability, functional performance, and long-term patient satisfaction.

Future studies should incorporate standardized implant positioning, preferably including both anterior and posterior implant locations, to allow reliable comparisons between different attachment configurations. Particular attention should be given to the influence of anteroposterior implant distribution on biomechanical behavior, rotational movement, and stress transfer to the supporting structures.

Long-term clinical investigations with follow-up periods of at least five years, preferably extending to ten years, are also required. These studies should evaluate implant survival, marginal bone-level changes, peri-implant soft-tissue health, attachment retention, prosthetic fractures, clip wear, framework deformation, and maintenance frequency.

Another important direction involves the development and evaluation of advanced prosthetic materials. Comparative studies of cobalt-chromium, titanium, and polyetheretherketone frameworks may provide further information regarding rigidity, fatigue resistance, surface wear, and long-term mechanical performance. The interaction between framework material and attachment components should also be investigated under standardized functional loading conditions.

Digital technologies may provide additional opportunities for improving the design and fabrication of implant-supported overdentures. Computer-aided design and computer-aided manufacturing (CAD/CAM), digital implant planning, and three-dimensional biomechanical modeling may contribute to more accurate framework adaptation, optimized attachment positioning, and improved prosthetic reproducibility.

Particular research attention should be directed toward rail attachment systems. Future investigations should establish standardized definitions of rail geometry, attachment dimensions, retention characteristics, insertion pathways, and mechanical properties. Direct clinical comparisons with ball and bar systems are required to determine whether the theoretical advantages of rail attachments translate into measurable improvements in retention, stability, patient comfort, and maintenance requirements.

Patient-centered outcomes should also receive greater attention in future clinical research. Standardized assessment instruments should be used to evaluate oral health-related quality of life, chewing efficiency, speech, comfort, hygiene accessibility, and overall patient satisfaction. Economic evaluations comparing initial treatment costs and long-term maintenance expenses would further support evidence-based clinical decision-making.

Ultimately, multicenter randomized clinical trials incorporating standardized clinical, radiographic, biomechanical, and patient-reported outcomes are needed to establish evidence-based recommendations for the selection of attachment systems in four-implant mandibular overdenture rehabilitation.

8. CONCLUSION

The available clinical and biomechanical evidence indicates that implant-supported mandibular overdentures represent an effective treatment option for the rehabilitation of edentulous patients. However, their long-term clinical performance depends on the interaction between implant number, implant distribution, attachment design, prosthetic material, and functional loading.

Ball and bar attachment systems demonstrate established clinical applications and generally favorable outcomes in terms of implant survival, prosthetic retention, and patient satisfaction. Nevertheless, differences in maintenance requirements, mechanical complications, hygiene accessibility, and peri-implant tissue responses should be considered when selecting an appropriate attachment configuration.

Four-implant configurations may provide additional opportunities for improving prosthetic support and stability, particularly when implants are distributed appropriately in the anterior and posterior regions. However, the available evidence does not establish that four implants are universally superior to two implants in all clinical situations.

The evidence concerning rail attachment systems remains insufficient to demonstrate their long-term clinical superiority over conventional ball and bar systems. Further comparative clinical investigations are therefore necessary before specific recommendations regarding their routine use can be established.

Within the limitations of the available literature, attachment selection should be individualized according to anatomical conditions, prosthetic space, functional requirements, hygiene accessibility, and anticipated maintenance needs. Future high-quality randomized clinical trials with extended follow-up are essential to establish the most predictable and clinically effective attachment configuration for four-implant mandibular overdentures.

DECLARATIONS

Ethical Approval

Not applicable.

Competing Interests

The authors declare no conflict of interest.

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REFERENCES

1. Atwood DA, Coy WA. Clinical, cephalometric, and densitometric study of reduction of residual ridges. J Prosthet Dent. 1971;26(3):280–295. doi:10.1016/0022-3913(71)90070-9.

2. Tallgren A. The continuing reduction of the residual alveolar ridges in complete denture wearers: a mixed-longitudinal study covering 25 years. J Prosthet Dent. 1972;27(2):120–132.doi:10.1016/0022-3913(72)90188-6.

3. Feine JS, Carlsson GE, Awad MA, Chehade A, Duncan WJ, Gizani S, et al. The McGill consensus statement on overdentures. Mandibular two-implant overdentures as first choice standard of care for edentulous patients. Gerodontology. 2002;19(1):3–4.

4. Thomason JM, Feine J, Exley C, Moynihan P, Müller F, Naert I, et al. Mandibular two implant-supported overdentures as the first choice standard of care for edentulous patients—The York Consensus Statement. Br Dent J. 2009;207(4):185–186. doi:10.1038/sj.bdj.2009.728.

5. Batenburg RH, Meijer HJ, Raghoebar GM, Vissink A. Treatment concept for mandibular overdentures supported by endosseous implants: a literature review. Int J Oral Maxillofac Implants. 1998;13(4):539–545.

6. Sutariya PV, Shah HM, Patel SD, Upadhyay HH, Pathan MR, Shah RP. Mandibular implant-supported overdenture: A systematic review and meta-analysis for optimum selection of attachment system. J Indian Prosthodont Soc. 2021;21(4):319–327. doi:10.4103/jips.jips_158_21.

7. Gotfredsen K, Holm B. Implant-supported mandibular overdentures retained with ball or bar attachments: a randomized prospective 5-year study. Int J Prosthodont. 2000;13(2):125–130.

8. Walton JN. A randomized clinical trial comparing two mandibular implant overdenture designs: 3-year prosthetic outcomes using a six-field protocol. Int J Prosthodont. 2003;16(3):255–260.

9. Naert I, Alsaadi G, Quirynen M. Prosthetic aspects and patient satisfaction with two-implant-retained mandibular overdentures: a 10-year randomized clinical study. Int J Prosthodont. 2004;17(4):401–410.

10. Naert I, Gizani S, Vuylsteke M, van Steenberghe D. A 5-year randomized clinical trial on the influence of splinted and unsplinted oral implants in the mandibular overdenture therapy. Part I: Peri-implant outcome. Clin Oral Implants Res. 1998;9(3):170–177. doi:10.1034/j.1600-0501.1998.090304.x.

11. Naert I, Gizani S, Vuylsteke M, van Steenberghe D. A 5-year prospective randomized clinical trial on the influence of splinted and unsplinted oral implants retaining a mandibular overdenture: prosthetic aspects and patient satisfaction. J Oral Rehabil. 1999;26(3):195–202. doi:10.1046/j.1365-2842.1999.00369.x.

12. Prasad S, Faverani LP, Santiago Junior JF, Sukotjo C, Yuan JC. Attachment systems for mandibular implant-supported overdentures: a systematic review and meta-analysis of randomized controlled trials. J Prosthet Dent. 2024;132(2):354–368. doi:10.1016/j.prosdent.2022.08.004.

13. El-Anwar MI, El-Taftazany EA, Hamed HA, Abd ElHay MA. Influence of number of implants and attachment type on stress distribution in mandibular implant-retained overdentures: finite element analysis. Open Access Maced J Med Sci. 2017;5(2):244–249. doi:10.3889/oamjms.2017.047.

14. Batenburg RH, Raghoebar GM, van Oort RP, Heijdenrijk K, Boering G. Mandibular overdentures supported by two or four endosteal implants: a prospective, comparative study. Int J Oral Maxillofac Surg. 1998;27(6):435–439. doi:10.1016/S0901-5027(98)80032-5.

15. Meijer HJA, Raghoebar GM, Batenburg RHK, Visser A, Vissink A. Mandibular overdentures supported by two or four endosseous implants: a 10-year clinical trial. Clin Oral Implants Res. 2009;20(7):722–728. doi:10.1111/j.1600-0501.2009.01710.x.

16. Walton JN. A randomized clinical trial comparing two mandibular implant overdenture designs: 3-year prosthetic outcomes using a six-field protocol. Int J Prosthodont. 2003;16(3):255–260.

17. Naert I, Gizani S, Vuylsteke M, van Steenberghe D. A 5-year randomized clinical trial on the influence of splinted and unsplinted oral implants in the mandibular overdenture therapy. Part I: Peri-implant outcome. Clin Oral Implants Res. 1998;9(3):170–177. doi:10.1034/j.1600-0501.1998.090304.x.

18. Naert I, Alsaadi G, Quirynen M. Prosthetic aspects and patient satisfaction with two-implant-retained mandibular overdentures: a 10-year randomized clinical study. Int J Prosthodont. 2004.

19. El-Zawahry MM, Ibraheem EM, Nassani MZ, Ghorab SA, El-Anwar MI. Stress analysis of mandibular implant overdentures retained with one, two, or four ball attachments: A finite element study. Dent Res J (Isfahan). 2018;15(6):437–443.

20. Wakam R, Benoit A, Mawussi KB, Gorin C. Evaluation of retention, wear, and maintenance of attachment systems for single- or two-implant-retained mandibular overdentures: A systematic review. Materials (Basel). 2022;15(5):1933. doi:10.3390/ma15051933.

21. Aunmeungtong W, Kumchai T, Strietzel FP, Reichart PA, Khongkhunthian P. Comparative clinical study of conventional dental implants and mini dental implants for mandibular overdentures: A randomized clinical trial.

Clin Implant Dent Relat Res. 2017;19(2):328–340. doi:10.1111/cid.12461.
22. Celebic A, Kovacic I, Petricevic N, Alhajj MN, Topic J, Junakovic L, et al. Clinical outcomes of three versus four mini-implants retaining mandibular overdenture: A 5-year randomized clinical trial. Medicina(Kaunas).2024;60(1):17. doi:10.3390/medicina60010017.
23. Impact of the extension of the anterior-posterior spread on quality of life and satisfaction of patients treated with implant-retained mandibular overdentures – a randomized clinical trial..
24. Abozaed HW. Patient satisfaction and oral health-related quality of life of quadrilateral bar versus bilateral linear bar for mandibular implant overdenture: Randomized controlled clinical trial. Eur J Dent. 2026;20(2):630–637. doi:10.1055/s-0045-1809912.
25. Naguib AA, Nassouhy N, El Khourazaty N, Salah A, Fouda K, Nabi NA. Quality of life of edentulous patients with single mandibular implants and mandibular overdentures using two different attachments: A randomized clinical trial. Int J Prosthodont.2022;35(5):616–626. doi:10.11607/ijp.7942..
26. A quality-of-life comparison between self-aligning and ball attachment systems for 2-implant-retained mandibular overdentures. PubMed.
27. Retention loss and wear assessment of three attachment systems for implant retained-mandibular overdentures: An in vitro study.
28. Mohamed SM, Rostom DAH. Nylon clip wear and patient satisfaction in implant-retained mandibular overdenture using PEEK bar versus metal bar: A one-year randomized clinical study. BMC Oral Health. 2026;26(1). doi:10.1186/s12903-026-08020-3.
29. Awaad NM, Eladl NM, Abbass NA. Assessments of bone height loss in telescopic mandibular implant-retained overdentures retained by two and four end-osseous implants: A randomized clinical trial. Open Access Maced J Med Sci. 2019;7(4):623–637. doi:10.3889/oamjms.2019.108.
30. Two- versus four-narrow-implant-retained dentures with immediate-loaded anterior implants: 9 years randomized clinical trial.

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