UNIVERSIDADE DE SÃO PAULO
FACULDADE DE ODONTOLOGIA DE BAURU

CAMILA ALVES CARNEIRO

What is the best attachment system used in Kennedy classes I and II removable partial dentures? A systematic review with meta-analysis

Qual o melhor sistema de encaixes utilizado em próteses parciais removíveis em classe I e II de Kennedy? Uma Revisão sistemática com metanálise

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Orientador: Prof. Dr. Vinicius Carvalho Porto

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DEDICATÓRIA

Dedico este trabalho, assim como todo meu mestrado à minha mãe e à minha versão de 2015. Enquanto para a segunda, estar aqui significava um sonho, porém, um que acreditava impossível realizar-se; a primeira a incentivou e acreditou pelas duas.

Fez o impossível tornar-se possível.

Conseguimos.

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*"O que me fez, de **meu ninho** sair,*
Foi para a vida construir,
Voando em meu próprio caminho".

E eu perguntei ao passarinho,
"Pois então, conseguistes enfim?"
"Ah sim, mas o que reflito aqui,
*É que não conseguiria **sozinho**".*

*"**Meu berço** me moldou ao mundo,*
E em sua voz, comigo trago,
O que tenho em mim, fecundo".

"O que tenho de mais sagrado,
A essência de um amor profundo,
*O que me faz um **abençoado**".*

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“Por vezes sentimos que aquilo que fazemos não é senão uma gota de água no mar. Mas o mar seria menor se lhe faltasse uma gota”

Madre Teresa de Calcutá

RESUMO

Indivíduos parcialmente desdentados requerem bastante atenção durante o planejamento reabilitador e o cirurgião-dentista deve usar seu conhecimento e habilidade para fornecer uma prótese estética e funcional, utilizando o suporte dos dentes remanescentes e do rebordo. A utilização de próteses parciais removíveis (PPRs) conjugada a prótese Parcial fixa (PPF), por meio de sistemas de encaixes (*attachments*) pode ser considerada benéfica para o paciente, pois confere um aspecto mais estético e funcional à prótese finalizada. Assim, o uso de encaixes ampliou os quesitos de retenção, função e estética quando comparadas às PPRs convencionais. Porém, há dúvidas em sua correta indicação e previsibilidade ao longo dos anos, uma vez que há diversidade de opções para o uso. O objetivo desta revisão sistemática foi avaliar a literatura publicada sobre próteses dentomucosuportadas, avaliando qual sistema de encaixe pode apresentar os melhores resultados biomecânicos e estéticos em PPRs. Uma busca abrangente de estudos publicados até Novembro de 2021 foi realizada nas bases de dados PubMed/MEDLINE, Web of Science, Cochrane Library de acordo com os critérios Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) e foi aprovada e registrada no International Prospective Register of Systematic Reviews (PROSPERO: CRD42021268449). A pergunta PICO (população, intervenção, comparação e desfecho) formulada foi: “Qual é o melhor sistema de encaixe usado nas próteses parciais removíveis classe I e II de Kennedy?”. Com base nos critérios de inclusão estipulados, um total de 21 de 871 artigos foram selecionados. O período de avaliação dos estudos variou de 3 a 282 meses. No total, foram encontrados 1.357 pacientes, dos quais foram listados 526 usuários de próteses com encaixe, não sendo identificadas diferenças significativas na taxa de sobrevida entre os sistemas ($p>0,05$). O encaixe Mini SG (extracoronal) foi o mais utilizado entres os estudos. A taxa de sobrevida variou de 37% a 98,1% em 10 estudos. Nos 10 estudos selecionados para análise quantitativa, a metanálise indicou uma taxa de falha total de 16,6% (intervalo de confiança de 95%IC:10,4-25,4%), valor Q: 26,258, P = 0,002 e heterogeneidade de I^2=65,725. Constatou-se a escassez de estudos clínicos avaliando e comparando diferentes sistemas de encaixe. No entanto, os dados obtidos indicaram que os tipos extracoronários são a escolha mais viável de tratamento em casos de extremidade livre. Em geral, a PPR

retida por encaixe tem boa retenção e melhor estética em comparação com a PPR convencional, assim como as complicações e falhas podem ser controladas com adequado planejamento. Portanto, representa uma opção viável e segura para o tratamento reabilitador oral.
Palavras-chave: Prótese Parcial Removível; Prótese Parcial Fixa; Encaixe de Precisão de Dentadura; Revisão sistemática; Metanálise.

ABSTRACT

What is the best attachment system used in Kennedy classes I and II removable partial dentures? A systematic review with meta-analysis

Partially edentulous individuals require a lot of attention during rehabilitation planning and the dentist must use his knowledge and skill to provide an esthetic and functional prosthesis, using the support of the remaining teeth and the ridge. The use of removable partial dentures (RPDs) in conjunction with fixed partial dentures (FPD), through attachment systems can be considered beneficial for the patient, as it gives a more aesthetic and functional aspect to the finished denture. Thus, the use of attachments increased the requirements of retention, function and aesthetics when compared to conventional RPDs. However, there are doubts about its correct indication and predictability over the years, since there is a diversity of options for its use. The aim of this systematic review was to evaluate the published literature on dentalmucossupported prostheses, evaluating which attachment system can present the best biomechanical and esthetic results in RPDs. A comprehensive search of studies published up to November 2021 was performed in PubMed/MEDLINE, Web of Science, Cochrane Library databases according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) criteria and was approved and registered in the International Prospective Register of Systematic Reviews (PROSPERO: CRD42021268449). The PICO question (population, intervention, comparison, and outcome) formulated was: “What is the best attachment system used in Kennedy class I and II removable partial dentures?”. Based on the stipulated inclusion criteria, a total of 21 out of 871 articles were selected. The evaluation period of the studies ranged from 3 to 282 months. In total, 1,357 patients were found, of which 526 users of RPDs retained by attachments were listed, and no significant differences were identified in the survival rate between the systems ($p>0.05$). The Mini SG (extracoronal) attachment was the most used among the studies. The survival rate ranged from 37% to 98.1% in 10 studies. In the 10 studies selected for quantitative analysis, the meta-analysis indicated a total failure rate of 16.6% (95% confidence interval CI: 10.4-25.4%), Q value: 26.258, $P = 0.002$

and heterogeneity of I^2=65.725. There was a scarcity of clinical studies evaluating and comparing different attachment systems. However, the data obtained indicated that extracoronary types are the most viable treatment choice in cases of free end. In general, attachment-retained RPD has good retention and better esthetics compared to conventional RPD, as complications and failures can be controlled with proper planning. Therefore, it represents a viable and safe option for oral rehabilitation treatment.

Keywords: Partial Removable Prosthesis; Fixed Partial Prosthesis; Denture Precision Attachment; Systematic review; Meta-analysis.

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LISTA DE ABREVIATURAS E SIGLAS

FPD	Fixed partial denture
RPD	Removable partial denture
NHMRC	National Health and Medical Research Council
PPR	Prótese parcial removível
PPF	Prótese parcial fixa
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
IC	Intervalo de Confiança
PICO	Population, Intervention, Comparison, Outcome
RoB	Risk of Bias

SUMÁRIO

1. INTRODUCTION

With the ease of access to information and ever-higher beauty standards, society has developed a constant search for esthetics. It is increasingly common to see people in body and facial aesthetic clinics and this would be no different in the dentistry area. In fact, most individuals seek dental care mainly for two reasons: discomfort (pain) or an esthetic complaint. Thus, the dentist must be able to integrate the patient's physical and psychological concerns with the properly proposed treatment (KAMANTHILA, 2018; SWELEN, 2014).

Therefore, tooth loss configures, besides the absence of function, an esthetic damage. In this context, the area of oral rehabilitation involves the reinstatement and conservation of oral functions, as well as appearance and oral health and these treatments are made by a result of the comparative review between the biofunctional and esthetic indications, advantages and disadvantages that involves each case (MAGDA-ECATERINA et al., 2018).

The significant number of rehabilitations techniques the clinical peculiarities, as also all the factors that influence the treatment plan, must be considered when choosing a specific therapeutic approach. And for partially edentulous patients, the treatment options include removable partial dentures (RPD), fixed partial dentures (FPD) and the implant prosthesis (JAIN, 2013; MUENINOFF AND JOHNSON, 1982).

Implantology can often satisfactorily meet the functional and esthetic needs in cases of tooth loss, making it a prevalent treatment modality among professionals and patients. However, it is necessary to consider that the use of implants is not always feasible and has its limitations. Many factors contraindicate/limit its use, including age, smoking, uncontrolled systemic diseases, in addition to low bone quality and high financial cost (Goiato et al. 2014). In addition, in some rehabilitation plans, where the soft tissue conditions, bone ridge, are not favorable, dental implants may not present better esthetic and functional results, leading to the failure of rehabilitation treatment. Considering such limitations, the isolated use of RPD still has its importance in the face of oral rehabilitation treatments (CHEATHAM, 1984; PAPI et al. 2015).

Another reason for the use of the RPDs that there has been a steady decline in the prevalence of tooth loss and edentulism in the population. In addition to restoring the patient's function and esthetics, one treatment goal is to restore the patient's function and esthetics to prevent further damage to the remained teeth. Data observed in the study of Douglas and Watson (2002) estimates that, in the U.S.A, the search for RPD treatments increased by 2020, due to the population's growth and its life expectancy. Besides, RPD treatment is more feasible, and today it's still considered the most common and versatile form of treatment for partially edentulism (KIM, 2019).

A conventional RPD uses claps positioned on the abutment teeth as the main means of direct retention. However, the use of traditional claps as direct retainers can generate an esthetic disadvantage, especially when positioned on abutments of a RPD in the anterior region. Thus, clinical circumstances demand more complex planning, where the indication of a conventional RPD may present unsatisfactory results. The association between RPD and FPD can fulfill these shortcomings in these cases. Moreover, all the biomechanical principles that are applied in the planning of a conventional RPD are also considered for RPD associated with FPD, in that way, it becomes a beneficial association, helping to preserve structures and providing esthetics and comfort. And this association can occurs using a retention clip over the milled crown on the abutment tooth or using RPD retained by attachment (JAIN, 2013; MOLDOVAN, RUDOLPH and LUTHARDT, 2018; MUNOT, 2020).

According to the ninth edition of the Glossary of Prosthetic Terms (2017), attachment can be defined as a mechanical device responsible for the main fixation, retention, and stabilization of a removable prosthesis. It basically consists of two metal parts, a receptacle, and a closely fitting part. The former, the female component (matrix) is usually contained within the normal or expanded contours of the crown of the abutment tooth and the latter, the male component (patrix), is attached to a pontic or the denture framework.

In their study, Burns and Ward (1990) explain that as the main retainer of a prothesis, the attachment must provide a resistance to movement of the prosthesis toward and away from the tissue as the resistance to its horizontal movement. Furthermore, it ought to provide a resistance to movement of the prosthesis away from the tooth as the contrary. However, according to a finite elements study of El

Charkawi and El Wakad (1996), to avoid excessive torque applied to the most distal abutment, it may necessitate splinting of the abutments, splitting allowed to reduce the tensions that are transmitted to the support elements.

This principle is applied in the significant number of attachment systems available. It can be classified in different ways and conform to the clinical situation. The literature agrees that no single type of attachment is applicable to all clinical circumstances and requires adequate reverse planning for its correct use. Therefore, the selection must be made considering the planning of the prostheses and the anatomical morphology of the arch, as well as the location and position of the abutment tooth (BURNS and WARD, 1990; TANASIC et al., 2012).

If it considers its relationship with the abutment tooth, it can be divided into intracoronary and extracoronary; first, the female component is located inside the crown of the abutment tooth and the male component is in the frame of the RPD. This type of attachment is necessarily rigid and has the advantage of maintaining forces closer to the long axis of the tooth. The extracoronary, mostly resilient, is attached externally to the milled crown, leading to the application of forces further away from the long axis of the tooth, transferring the forces resulting from mastication to the support area. From another point of view, resilient attachments reduce stress on the periodontal ligament of the abutment tooth by providing a more uniform distribution of occlusal forces (BECERRA, 1987; BURNS and WARD, 1990; FALCÓN-ANTENUCCI, 2009).

The planning of a RPD retained by attachments must be done carefully and obeying all the biomechanical principles, which can generate disagreements among professionals about which attachment system to use, especially in cases of free end where it must be taken into account the effect of masticatory forces not only on the abutment tooth, but also on the fibromucosa and associated alveolar bone.

From what was discussed, there is a need to establish guidelines for clinical practice that can facilitate the correct indication, advantages, and disadvantages of using attachment systems in oral rehabilitation. And since there is no systematic review in the literature on the subject, this systematic review with meta-analysis aimed to evaluate the differences between attachment systems in freed end removable prostheses and establish recommendations for the correct use to provide better functional, esthetic and biomechanical results.

2. ARTICLE

The article presented in this Dissertation was written according to the International Journal of Prosthodontics instructions and guidelines for submission.

What is the best attachment system used in Kennedy classes I and II removable partial dentures? A systematic review with meta-analysis

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ABSTRACT

Purpose*.** Evaluate the published literature on dentomucosupported prostheses, in which the attachment system can present the best clinical outcome in removable partial denturesStudy Selection*.** A comprehensive search of studies published up to November 2021 was performed in the PubMed/MEDLINE, Web of Science and Cochrane Library databases according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) criteria and was approved and registered in the International Prospective Register of Systematic Reviews (PROSPERO: CRD42021268449). The PICO question was "What is the best attachment system used in Kennedy class I and II removable partial dentures?"

***Results*.** A total of 21 out of 871 articles were selected. The evaluation period of the studies ranged from 3 to 282 months. In total, 1,357 patients were found, of which 526 users of prostheses with attachment were listed, and no significant differences in survival rate between the systems was identified. The Mini SG attachment (extracoronal) was the most commonly used attachment beyond the study. The survival rate ranged from 37% to 98.1% in 10 studies. In the 10 studies selected for quantitative analysis, the meta-analysis indicated a total failure rate of 16.6% (95% confidence interval, (CI): 10.4–25.4%), Q-value: 26.258, *P*=.002, and heterogeneity of I^2=65.725.

***Conclusion*.** Clinical studies evaluating and comparing different attachment systems during rehabilitation are lacking. However, the data obtained indicate that the extracoronary attachment system is the most viable choice of treatment in free end. In general attachment retained RPD has good retention and better esthetics compared to conventional RPD.

1. INTRODUCTION

Removable partial dentures (RPDs) use clasps positioned on the abutment teeth for direct retention. However, the use of traditional clasps as direct retainers can create an esthetic disadvantage, especially when placed on the pillars of an RPD in the anterior region. In such situations, other options should be considered.[1] Implant treatment and mini-implants have been considered a favorable treatment option for rehabilitating edentulous patients and often satisfy functional and esthetic needs in many situations. However, the use of implants is not always feasible and has limitations.[2,3]

Options such as retaining clips on the crown of the abutment tooth or using RPD retained by attachment systems, which, when well planned, fulfill the functional objectives of rehabilitation, in addition to the patient's esthetic demands.[4,5]

Attachments are devices responsible for the retention and stabilization of dental prostheses, and several types of attachment systems are available on the market. Attachments can be classified according to the clinical situation. The literature agrees that no type of attachment fits all clinical circumstances and requires adequate planning for correct use.[6,7] Therefore, selection must be made according to the prosthesis planning and the anatomical morphology of the arch, as well as the location and position of the abutment tooth.

According to the relationship with the abutment tooth, the attachment can be classified as intracoronary, which is necessarily rigid and has the advantage of maintaining the forces more in line with the long axis of the tooth, and extracoronary, mostly resilient, leading to the application of forces further away from the long axis of the tooth, transferring the forces resulting from chewing to the support area. They also contribute to the reduction of stress in the periodontal ligament of the abutment tooth by providing a more uniform distribution of occlusal forces.[6,8,9]

Establishing guidelines for clinical practice that can facilitate the correct indication, advantages, and disadvantages of attachment systems in oral rehabilitation are necessary. Therefore, this systematic review and meta-analysis aimed to evaluate which attachment system offers the best results in terms of predictability, force distribution, comfort, and quality of life for the patient in Kennedy class I and II cases. The null hypothesis is that there is no difference between the assessed attachment systems.

2. MATERIALS AND METHODS

This project was conducted according to the criteria established by the Cochrane Collaboration (Cochrane Handbook for Systematic Reviews of Interventions–Handbook 5.1.0) and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses recommendations for the development and elaboration of systematic reviews with meta-analysis. This systematic review was approved and registered in the International Prospective Register of Systematic Reviews (PROSPERO) database (registration: CRD42021268449) to allow the evaluation of the proposed methodological design.[2,10]

The analyses were based on the population, intervention, comparison, and outcome (PICO) index: Kennedy classes I and II individuals in need of prosthetic rehabilitation (population), use of attachments integrated with RPD (intervention), possible different viable attachment systems for fixed partial dentures combined with removable partial dentures (comparison), and clinical survival, biomechanical analysis, patient comfort, retention, quality of life, and prosthesis stability (outcome). Studies were selected according to the following inclusion criteria: using the English language, clinical follow-up studies of at least 6 months of the type: case series, retrospective, prospective, controlled, and randomized clinical trials. Participants considered for each study will be adults with Kennedy classes I or II who were undergoing rehabilitative treatment using RPD conjugated with fixed partial denture (FPD) using

attachments. Studies related to in vitro methodology, systematic reviews or literature reviews, and clinical cases with incomplete data that did not allow the collection of the necessary information were excluded. Several databases, including MEDLINE, PubMed, Cochrane Library, SciELO, and Web of Science, were searched for articles published until November 1, 2021. In addition, a search was performed on platforms such as Scholar Google, references from selected articles and in the gray literature (OpenGray). The following Boolean operators based on MeSH/PubMed were used: fixed-removable partial dentures," "denture precision attachment," "removable partial denture," "clinical," and removable partial dentures. The PubMed search used the following terms: ("fixed-removable partial denture" [All Fields]) AND ("denture precision attachment" [All Fields]); ("removable partial denture" [All Fields]) AND ("denture precision attachment" [All Fields]); ("removable partial denture" [MeSH Terms]) AND ("denture precision attachment" [MeSH Terms]) AND ("clinical study" [All Fields]). We conducted a manual search of specific journals and related studies in the field of dental prostheses.

The included studies were evaluated in relation to the classification of clinical study types, retrospective, clinical case series, prospective, or randomized controlled trials (RCT), as indicated by the National Health and Medical Research Council (NHMRC).

Data collection was performed by two previously calibrated reviewers (C.A.C. and J. F. S. Jr.). To resolve any disagreement, consensus meetings were held to evaluate the selected titles and abstracts. Subsequently, a definitive consensus meeting was held to evaluate the selected articles, data collection, and risk of bias. Finally, further clarification of doubts and technical support were offered by an additional advisers (V.C.P. and K.H.N.). Studies were evaluated and classified according to the type of study performed. All data in the tables were extracted by two investigators (C. A. C. and J. F. S. Jr.) and checked by a third investigator (V. C. P.). Due to the profile of different types of clinical studies, the National

Health and Medical Research Council (NHMRC) study hierarchy scale was used.[11] In addition to this assessment, we applied the Cochrane Risk of Bias scale for randomized trials, and the New-Castle Ottawa scale for prospective studies and clinical case-control series (C.A.C; L. C. F. P; J.F.S.Jr).

2.1 Summary measures

Quantitative data were grouped for some variables: prevalence of failure of removable partial dentures associated with attachment and number of technical and biological complications in RPDs associated with attachment divided into general (every evaluated attachment) and extracoronary attachments. The number of RPD was considered in the data analysis. This information was evaluated for the event rate, considering a 95% confidence interval (CI). The contribution of each study was assessed. Comprehensive Meta-Analysis software (version 3.0; Biostat, Englewood, NJ, USA) was used to construct the forest.[12]

2.2 Risk of bias in the evaluated studies

Heterogeneity was assessed using the Q method and the value of I^2 was analyzed,[13,14] a heterogeneity above 75 (0–100) may reflect greater significance,[14,15] and randomized analysis was adopted for all meta-analyses to reduce the potential for heterogeneity.[16]

3. RESULTS

A total of 871 articles were found, 58 of which were selected based on their titles. After reading the abstracts, 25 clinical studies that used RPDs retained by attachment were selected for full-text reading. Finally, 21 articles were selected (Fig. 1).

The 21 clinical studies were classified as nine RCTs, eight prospective, two retrospective, one case-control, and one longitudinal.[17-37] The main information for each study is shown in Table 1. The evaluation period of the studies ranged from 3 to 282 months. In

total, 1,357 patients were found, of which 526 users of prostheses with attachment were listed. Three studies did not specify the number of patients rehabilitated with attachment.[17-19] From the patient sample, 1,612 removable dentures were analyzed, 711 of which were retained with attachment. One study did not specify the number of prostheses retained by the attachment.[19]

Regarding the type of attachment, the Mini SG attachment (extracoronal) was the most used among the 711 prostheses (190). According to Kennedy's classification, most RPDs were class I (391), while only 113 were class II. According to the arch, there were 334 rehabilitations retained by attachment in the upper arch and 374 in the lower arch. Seven studies did not specify the arch in which they were performed.[19-25]

The survival rate ranged from 37% to 98.1% in the 10 studies. Among biological complications, abutment extraction was the most frequent (n=83), followed by abutment fractures (n=52). Regarding technical complications, loss of retention or insufficient activation of the attachment was the most common complication (n=2), followed by debonding (n=29), fracture of the infrastructure (metal frame) (n=19), and fracture of the attachment (n=18) (Table 1).Considering prospective studies, Owall[26] evaluated 57 prostheses with attachment for 2 years, made by several different dentists and different laboratories and reported a failure rate of 63%, which differs from the results found in eight other prospective studies, which reported a failure rate of 8.3% and 25.7% in both technical and biological parameters in RPDs retained by attachment (Table 1).

Specifically, on chewing, Afify et al[27] evaluated the occlusal force between 16 patients treated with conventional and attachment RPDs in an RCT study. Group II (attachment) presented results with statistically significant differences from Group I (conventional RPD) in the periods 3, 6, and 12 months after insertion. The occlusal force of Group II was close to that of natural teeth. From the results of this study, it was concluded that it is preferable to use a new extracoronal attachment design (unilateral OT) because it is

simpler, more comfortable for patients, and offers higher masticatory efficiency in the form of occlusal force than conventional RPD. Furthermore, a retrospective study by Shala et al[18] evaluated retention, chewing quality, and esthetics in patients with conventional and retention-by-attachment (Ceka) rehabilitation. Among the RPDs retained by attachment, 50% of the patients reported excellent retention. Outros estudos destacaram elevado índice de satisfação (Zajc et al[28]) e indicação pertinente para casos estéticos (Vanzeverem et al[19])

In a retrospective study, Studer et al[29] evaluated the survival rate and the reasons for the failure of 130 RPDs attached to different types of attachments, incorporated in 112 patients, and the recommendation to avoid rigid attachments in free-end situations was concluded. However, according to some studies,[30-32] which also evaluated survival and failure rates in rehabilitation with different types of attachment, all showed a high survival rate, ranging from 60% to 91.7%.

Kern et al[33] when comparing the interdental space between rehabilitation with attachment and shortened dental arch and proved that changes in the interdental space were observed in 74% of cases of RPD with attachment, an increase of 54% over the years.

Some authors published five RCTs in which they evaluated different aspects of two types of rehabilitation, with reduced dental arch and using RPDs retained by attachment. Two of these studies[20,22] evaluated tooth loss caused by these rehabilitations over 5 and 10 years, respectively, in both studies, and no statistically significant differences were found. In other studies, periodontal health was assessed by plaque index, bleeding index, probing depth, and clinical attachment, as in the study published by Walter et al[21] prostheses retained by attachment resulted in small harmful effects on the abutment teeth, according to the mentioned indices, and after 5 years of evaluation, the reduced dental arch group showed better results. However, at 10 years of follow-up,[23] the two groups did not show statistical differences in probing depth, similar to the 15 years of follow-up.[24]

Two other studies compared periodontal indices (probing depth, plaque, and bleeding index). A prospective one,[34] also compared the survival rate in 23 patients with uni-or bilateral shortened dental arches. They concluded that attachment-retained RPDs contribute less to the formation of dental plaques than clasp-retained RPDs do. In an RCT study, Reslan et al[35] evaluated the same periodontal indices in two types of rehabilitation with the same attachment, but with different designs, evaluated at 3, 6, and 9 months. The plaque and bleeding index decreased with time, but the probing depth and clinical insertion increased.

Finally, in quality-of-life analysis, some authors researched the patient's perception of chewing, comfort, manipulation, quality of life, and esthetics in rehabilitation using attachment. Persic et al[36] compared them with clasp-retained RPDs and obtained better results for all parameters evaluated. Radovic et al[37] evaluated rehabilitation retained by attachment over 60 months and concluded that parameters related to patient perception improved significantly.

According to a previous simple analysis, on average, the survival rate of attachment-retained RPDs in all evaluated studies was high, even when technical and biological complications were involved.

3.1 Meta-analysis

The meta-analysis was performed due to the total failure event rate and the technical and biological complications provided by the evaluated studies. Regarding the event rate of failure in RPD associated with attachment, in 10 studies involving a total of 414 removable prostheses associated with attachment, 65 failures were identified. The event rate ranged from 10.4% to 25.4%. The overall pooled event rate was 16.6% (random; 95% CI, 10.4–25.4%; Fig. 2). The heterogeneity of the failure rate was considered a Q-value of 26.258; P=.002; I^2=65.725.

The event rate for technical complications in RPD associated with attachment was determined in six studies involving 280 removable prostheses associated with attachment and 54 technical complications were identified. The event rate ranged from 7.8% to 44.8%. The overall pooled event rate was 20.7% (random; 95% CI, 7.8–44.8%; Fig. 3). The heterogeneity for the failure rate was considered a Q-value of 47.479; P=.000; I^2=89.469.

In the event rate of biological complications in RPDs associated with attachment, five studies involved a total of 145 removable prostheses associated with attachment, then 27 biological complications were identified. The event rate ranged from 7.8% to 30.2%. The overall pooled event rate was 16.1% (random; 95% CI, 7.8–30.2%; Fig. 4). The heterogeneity for the failure rate was considered a Q-value of 9.608; P=.048; I^2=58.369.

Additional analyses of the event rate for total failure and technical and biological complications were performed only in RPDs associated with extracoronal attachment as a subgroup. Regarding the event rate of failure, in eight studies involving a total of 337 removable prostheses associated with extracoronary attachments, 53 failures were identified. The event rate ranged from 9.4% to 28.7%. The overall pooled event rate was 16.9% (random; 95% CI, 9.4–28.7%; Fig. 5). The heterogeneity of the failure rate was considered to have a Q-value of 24.870; P=.001; I^2=71.853.

Regarding the technical event rate in four studies involving 203 removable prostheses associated with extracoronary attachments, 16 technical complications were identified. The event rate ranged from 4.3% to 23.0%. The overall pooled event rate was 10.4% (random; 95% CI, 4.3–23.0%; Fig. 6). The heterogeneity for the failure rate was considered a Q-value of 8.708; P=.033; I^2=65.548.

Finally, regarding the event rate for biological complications, in three studies involving 68 removable prostheses associated with extracoronary attachments, seven biological complications were identified. The event rate data ranged from 4.2% to 26.4%. The

overall pooled event rate was 11.2% (random; 95% CI, 4.2–26.4%; Fig. 7). The heterogeneity of the failure rate was considered to have a Q-value of 2.731; P=.255; I^2=26.773.

3.2 Risk of Bias

Other scales were used to better analyze the quality of articles and risk of bias. The Newcastle-Ottawa scale was used in clinical cohort and case-control studies, evaluating three dimensions of quality: selection, comparability and outcome. (Tables 2 and 3). The Cochrane RoB 0.2 scale was used in cases of randomized clinical trials (Fig 8), evaluating the studies in five major dimensions. The scales showed a low risk of bias, with unlikely serious alteration of the results. For the randomized studies, the main limitations were related to the D2 and D4 domains, with bias due to deviations from intended intervention and bias in measurement of the outcome. On the other hand, for cohort studies and case series, it was shown to be a deficiency, but in general, all studies had a high score on this scale (>6).

4. DISCUSSION

The results observed in this systematic review and meta-analysis supported the null hypothesis, which states that there is no specific attachment system to use in Kennedy classes I and II. Among the 21 studies evaluated, the survival rate was high, even when considering different systems of attachment and different methodological types of clinical studies.

Considering the results of the evaluated studies, in general, no attachment system was shown to be superior. However, Studer et al[29] concluded that RPD reconstruction with a rigid type of attachment should be avoided by preferring alternatives such as clasp-retained RPDs or semi-rigid attachments. It ends by specifying that the use of these attachments should be observed even more strictly in free-end situations. These results differ from those obtained by

Owall[31] in a prospective study that evaluated a rigid intracoronary attachment system in 53 free-end rehabilitations and obtained a survival rate of 83.3% at 5 years of follow-up.

Regarding the Kennedy class situation, in an RCT assessing only unilateral cases, Afify et al[27] concluded that unilateral attachment showed better results than conventional prostheses, which can be attributed to the special design of the OT unilateral attachment and its resilience, which helps to distribute the load more favorably under masticatory force, which differs from the prospective study by Schmitt et al[34] which compared unilateral and bilateral free-end rehabilitations with a significant difference between the two groups. The authors concluded that a unilaterally retained RPD without cross-arc stabilization and extended cantilever length created significant stress on the fixed denture. However, there are limitations to the reduced number of patients in the group of unilaterally retained removable dental prostheses, which can be inadequate to draw definitive conclusions about attachment performance.

Three of the 21 included studies compared the conventional RPDs with the attachment-retained RPD[19,27,36]. Evaluating effects of these treatments taking into consideration esthetics, chewing, and oral health-related quality of life. The attachment-retained RPD results proved to be better in the assessed studies. When compared to implant-supported removable partial dentures (ISRPD), in a systematic review by Lemos et al[3], showed that the survival rate ranged from 90 to 100%, which shows higher values than those shown in this study in rehabilitations with an attachment system. The authors also reported that among the ISRPD with attachment, the one that presented the best results was an extracoronary one, as it presented greater resilience and better stress distribution.

Among the 10 studies included in this meta-analysis, a total failure event rate of 16.6% was observed. Regarding technical and biological complications, carried out with five studies, they had an event rate of 20.7% and 16.1%, respectively, which may seem high compared to

the survival rate in implant-supported removable prostheses made by a systematic review, with the same number of selected studies, where the result was 3%.[3] A meta-analysis performed only on studies that evaluated rehabilitation with extracoronary attachment found a total failure event rate of 16.9%, slightly higher than in the general group. Regarding technical and biological complications, there was a decrease in both parameters compared with the general analysis. The technical rate was 10.4%, and the biological complication event rate was 11.2%. This led us to consider that intracoronary attachments were responsible for most of the technical and biological complications observed in this study. However, it must be taken into consideration that the follow-up in both studies with rigid intracoronary attachment was much longer than in the other, leading to a greater chance of complications.

Regarding the limitations, several articles,[20,21,30,35-37] have issues with the number of patients, considering the small sample size. Assertion that longer observation periods will be required in a substantially greater number of patients before definitive statements can be made regarding RPDs retained by attachments. However, Persic et al[36] describe limitations, such as differences in the number and position of the remaining teeth and patient income. In a prospective study by Owall,[26] discrepancy between the dentist's early satisfaction and the results after 2 years was very high, and many technical or biotechnical failures were found, classified as a limitation once they could not be controlled. These findings suggest the need for further studies on the results of general practitioners using technically advanced prosthodontics.

Although not mentioned in the evaluated studies, because the survival rate (98,1%) remained high and the complication rate (8,3%) low in studies that evaluated extracoronary attachments until five years of follow-up, it can be assumed that its resilience function remained effective. Wolfart et al[25] reinforce a maintenance rate in resilient components of 7.4% at five years of follow-up. Therefore, the need for effective follow-up of patients is

highlighted. Regarding to biological failures, some studies correlate tooth extraction with periodontal disease, endodontic reasons, untreated carious lesion, and abutment fracture[20,22,29,31]. Another aspect refers to the forces' distribution, lateral and oblique force impact may have been the primary reason for technical failures, which consequently led to biological failure[34].

Among the RCTs, there were randomization methods in blocks, stratified, and simple methods by tossing a coin. Most of the sample size calculations were based on the mean difference of the patients with a power of 90% and a two-sided significance level of 5% with equal allocation to the two arms. Regarding the sample size, among the 21 selected studies, the sample varied between eight and 135 prostheses evaluated in the same study. In 13 of these studies, there was a dropout due to death, movement, or withdrawal. Regarding the quality and risk of bias of these studies, the main limitations identified were related to the composition of the sample, analysis of results and comparability between groups, which reinforces the need for clinical follow-up studies in the area.

One limitation of this study was the absence of data from some articles. Data related to survival rate, failures, dental arch, and type of Kennedy classification were mainly from RCT studies. In addition, most studies did not compare two different types of attachment systems but compared them to conventional prostheses, making it difficult to compare two or more attachment systems used in free-end situations. However, most studies that evaluated technical complications and aspects related to patients' perceptions of rehabilitation using an attachment system showed significantly better results than conventional RPDs. Therefore, the use of attachments in current rehabilitation is a viable alternative.

Another factor is related to the risk of bias of the selected studies. For RCTs, analyzed using the Cochrane RoB 0.2 scale, dimensions D2 and D5 were the most affected, which may be due to the lack of blinding of research participants during the interventions, as well as the

lack of a specific predetermined comparative analysis of the results obtained. For the cohort and case-control studies analyzed by Newcastle-Ottawa, all papers showed a good bias score, since a maximum of nine stars can be assigned to the study, more than half of the selected cohorts had 8 stars, and the only case-control with 6 stars. On this scale, five or fewer stars represent a high risk of bias, while six or more stars are considered low risk of bias[38].

Finally, based on the evaluated studies, it is possible to affirm that, as suggested by Jain,[4] the choice of an attachment must be done rigorously, being difficult to select the best one,, being the professional responsibility knowing the characteristics and indications of each one, besides the biomechanics principles involved in any case of rehabilitation with RPDs. In addition, more randomized and prospective studies should be performed in this area to allow better clinical selection of RPD attachment.

5. CONCLUSIONS

Based on the findings of this systematic review and meta-analysis, the following conclusions were drawn.

1. The use of extracoronary attachments is effective and superior when compared to intracoronary attachments, the same have acceptable rates of biological and technical complications.

Studies have shown the use of retention systems associated with PPR presented better rates of satisfaction, quality of life and aesthetics, when compared to conventional techniques for obtaining PPR. Therefore, the use of RPD-retained attachment should be considered as a favorable rehabilitation treatment for partially edentulous patients.

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Conflict of Interest

None of the authors has a relevant financial relationship(s) with a commercial interest.

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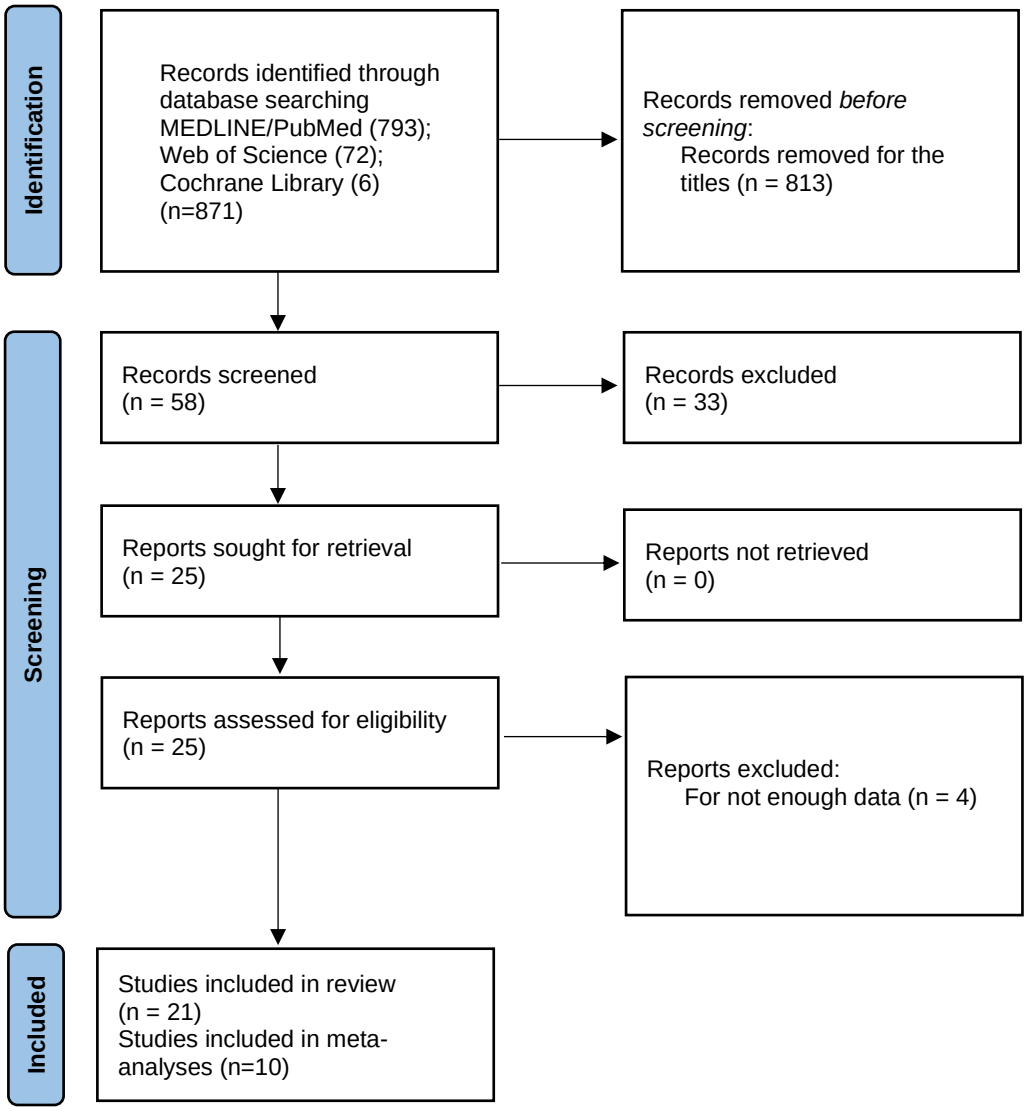

Figure 1. Data of article selection according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses diagram.

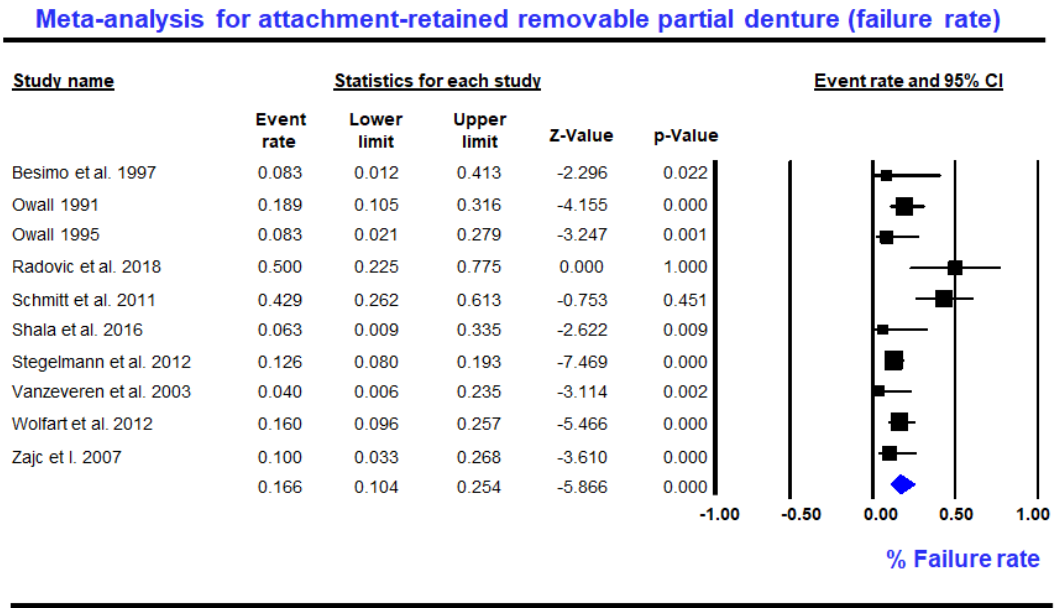

Figure 2. Meta-analysis forest plot showing the total failure rate of removable partial dentures attachment retained

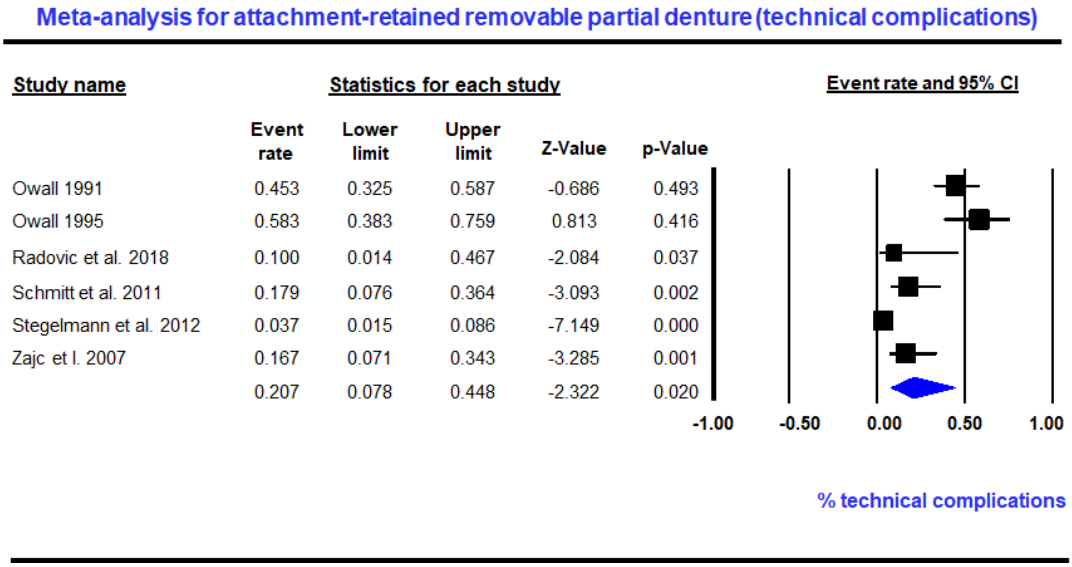

Figure 3. Meta-analysis forest plot showing technical complication rate in removable partial dentures attachment retained.

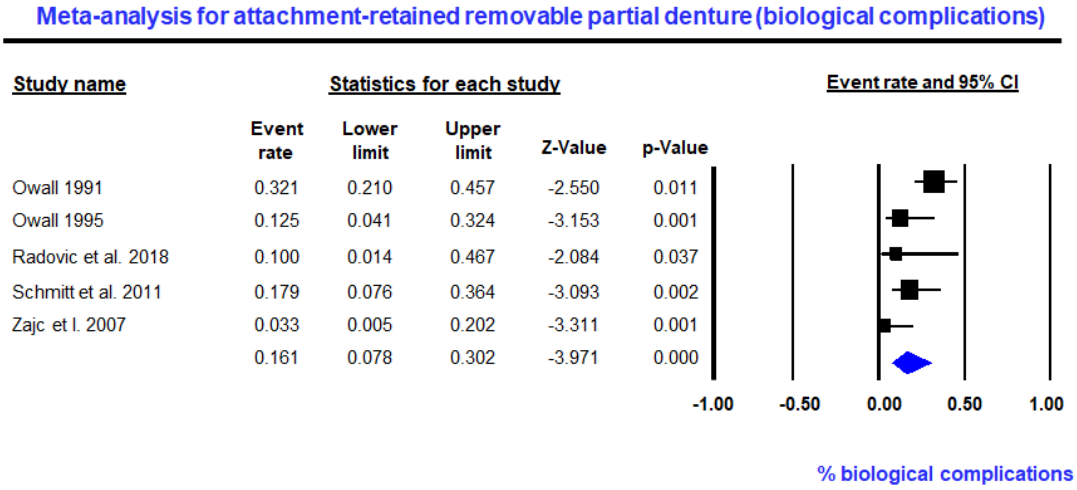

Figure 4. Meta-analysis forest plot showing biological complication rate in removable partial dentures attachment retained.

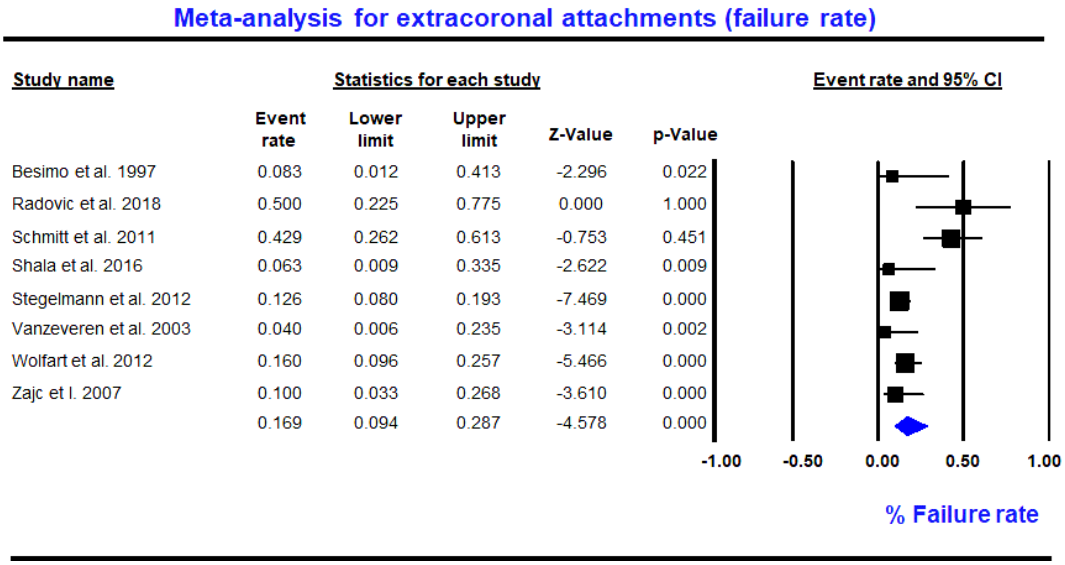

Figure 5. Meta-analysis forest plot showing the failure rate of removable partial dentures with extracoronal attachment.

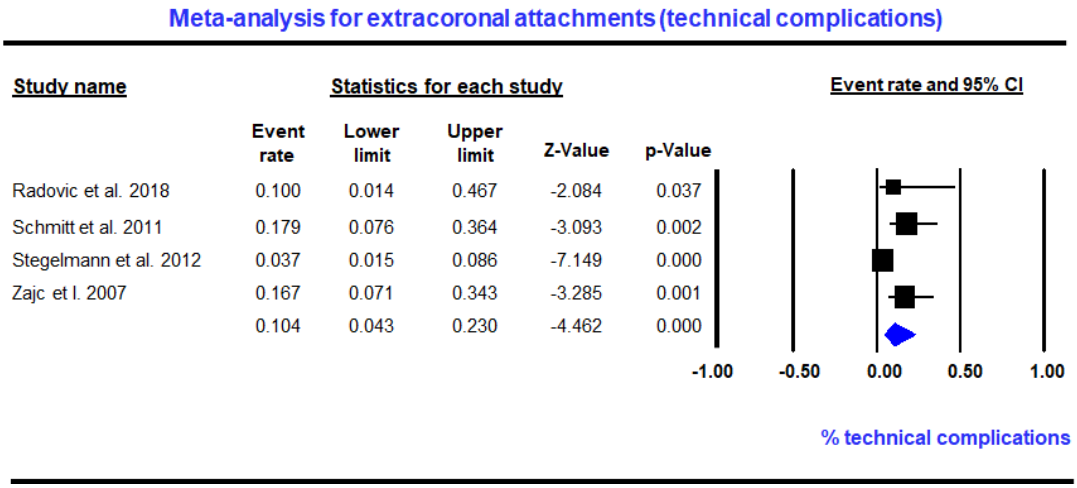

Figure 6. Meta-analysis forest plot showing technical complications in removable partial dentures with extracoronal attachment.

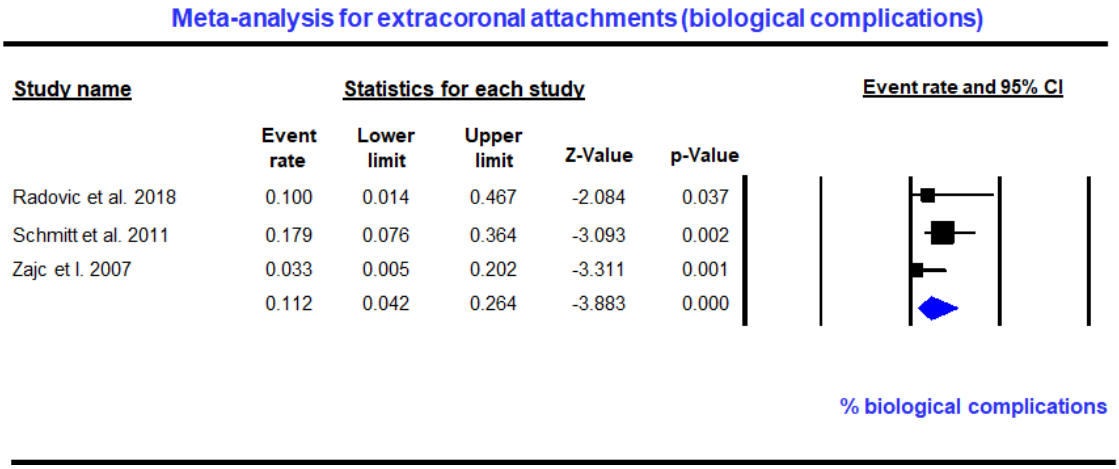

Figure 7. Meta-analysis forest plot showing biological complications in removable partial dentures with extracoronal attachment.

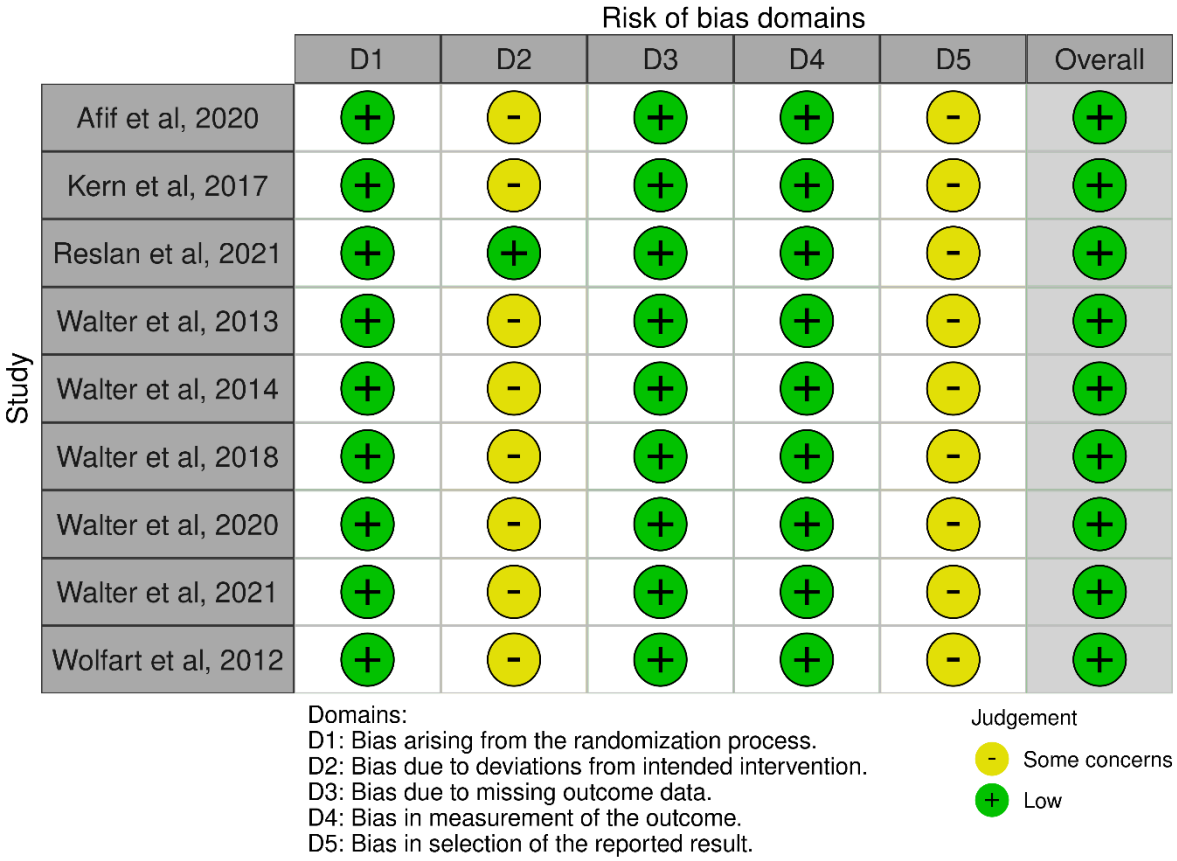

Figure 8. RoB 0.2 scale of RCT studies, especifying the domains.

Table 1. Characteristics of included studies (n=21).

Author/ Year	Study type/(NHMRC)	Number of Patients	Number of RPDs	Attachment System	Kennedy Class (n)	Follow-up (months)	Survival rate (%)	Main complications (n)
Afify, Helmy e Abbas 2020	RCT (II)	8	8	OT unilateral	II	3, 6 e 12	NR	NR
Besimo et al 1997	Prospective (III-2)	10	12	SG*	I (8) II (4)	12 e 24	91,7%	Attachment detached from de framework (1)
Kern et al 2017	RCT (II)	51	51	Mini SG	I	6 a 60	NR	NR
Owall 1991	Prospective (III-2)	49	53	McCollum**	I (49) II (4)	60 120 180	83,3% 68,6% 67,3%	Debonding (4); Loosening of the precision system (3); fracture of the CoCr infrastructure (2); additional retention in clasps (3), fixed denture repair (5), patrician fracture (8), RPD refabrication (3), tooth extraction and fixed extension modification (7), extraction for complete denture (7).
Owall 1995	Prospective (III-2)	21	24	Ball*	I (20) II (2)	14 a 282	70%	Failures in the RPD framework (2);
Owall 1998	Prospective (III-2)	57	57	McCollum**; Duolock**; CEKA Revax; Roach; Povoromo; Regulex; Unor 10803	I (39) II (18)	24	37%	Attachment fracture (7); Insufficient activation (8); RPD loose attachment (5); unused RPD (1); Implant retreatment (3); Debonding (4); Tooth fracture (2)
Persic et al 2015	Prospective (III-2)	62	62	ASC 52*	I	3	NR	NR
Radovic et al 2018	Prospective (III-2)	10	10	SD Snap in Latch*	II	12 e 60	NR	Tooth fracture (1); Attachment fracture (1)
Reslan et al 2021	RCT (II)	14	14	Vario-Stud-Snap	I	3, 6 e 9	NR	NR
Schmitt et al 2011	Prospective (III-2)	23	28	Mini SG*	I (20) II (8)	60	Class I: 70% Class II: 25%	Attachment wear - Class II (4); Attachment screw activation - Class I (20) and Class II (3); Debonding - Class I (1) and Class II (1); Ceramic fracture - Class II (3). Abutment fracture - Class I (4); Class II (1)

Shala et al. 2016	Retrospective (III-2)	NR	16	Ceka	I (34) II (10)	NI	93,8%	NR
Stegelmann et al. 2012	Case-control (III-2)	NR	135	Preci-vertix	I e II (58)	4 a 141	94%	Abutment tooth extraction (8); Coating (5); Fracture of the base (6); fracture of the metallic infrastructure (3)
Studer et al.1998	Retrospective (III-2)	112	130	Conex; SG; Ipsoclip Plastic Roach; Gerber RZ; Unor RZ; Unor AG	I (82) II (31)	60 a 96	Rigid: 30,1% Semi-rigid: 93,1%	Tooth fracture (29), tooth extraction (18), loss of retention in fixed prosthesis (4), core fracture (4), FPD infrastructure fracture (4), ceramic fracture (1), major connector fracture (1), attachment fracture (1).
Vanzeverem et al 2003	Longitudinal	NR	25	Friction-Slide Bona	NR	1 a 133	NR	Attachment fracture (1)
Walter et al. 2013	RCT (II)	71	71	Mini SG	NR	60	NR	Tooth loss (22)
Walter et al. 2014	RCT (II)	56	56	Mini SG	NR	60	NR	NR
Walter et al. 2018	RCT (II)	51	51	Mini SG	NR	120	NR	NR
Walter et al. 2020	RCT (II)	79	79	Mini SG	NR	120	NR	NR
Walter et al. 2021	RCT (II)	81	81	Mini SG	NR	180	NR	NR
Wolfart et al. 2012	RCT (II)	81	81	Mini SG	NR	60	NR	Tooth extraction (18); Tooth fracture (15); Debonding (19); Infrastructure fracture (1); Repair of the denture base (2)
Zajc et al. 2007	Prospective (III-2)	28	30	Mini SG*	I (12) II (18)	36	100%	Partial replacement of the restoration (3); total restoration replacement (3); ceramic fracture (1);

RPD: Removable Partial Denture; RCT: Randomized Controlled Trial; NR: Not reported; * extracoronal attachment; ** intracoronal attachment, NHMRC Classification.

Table 2. Newcastle -Ottawa scale for cohort studies.

Article	Cohort Star Template			
	Selection	**Comparability**	**Outcome**	**Overall**
Besimo et al, 1997	★★★	★★	★★★	★★★★★★★★
Owall, 1991	★★★	★	★★★	★★★★★★★
Owall, 1995	★★★	★	★★★	★★★★★★★
Owall, 1998	★★★	★★	★★★	★★★★★★★★
Persic et al., 2015	★★★	★★	★★	★★★★★★★
Radovic et al, 2018	★★★	★★	★★★	★★★★★★★★
Schmitt et al, 2011	★★★	★	★★★	★★★★★★★★
Shala et al., 2016	★★★	★★	★★★	★★★★★★★★
Studer et al, 1998	★★★	★★	★★★	★★★★★★★★
Zajc et al, 2007	★★★	★★	★★★	★★★★★★★★

Table 3. Newcastle-Ottawa scale for case-control study.

Article	Cohort Star Template			
	Selection	**Comparability**	**Outcome**	**Overall**
Stegelman et al., 2012	★★	★	★★★	★★★★★★

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