A Systematic Review of Mechanical Properties of Polymeric Attachments used for Retain Overdentures: A Comparison Between Traditional and Newly Models

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ABSTRACT

Purpose: The main problem related to conventional attachments for overdentures is the loss of retention. The purpose of this review was to analyze the mechanical properties of different polymeric attachments presented in the literature to consider their clinical use viability. Materials and Methods: This work was registered in Open Science Framework (osf.io/7j9vz) and followed the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA). A search of two independent reviewers of articles was performed on Embase, Pubmed, Science Direct, and Scopus databases. Results: The databases found a total of 1803 references and 1226 articles titles. A total of 21 articles were included in this scoping review. The polymers used for manufacturing attachments were polyacetal, polylactic acid, poly(ether-ether-ketone), polytetrafluoroethylene, polyethylene, and poly(ethylene terephthalate). Conclusion: Polyamide Locators demonstrated highest initial and final retention, indicating superior long-term stability. Among emerging materials, polyacetal and polylactic acid attachments also showed excellent retention, supporting clinical applicability.

INTRODUCTION

Implant-supported overdentures (IOD) improve the stability, retention, chewing, and quality of life compared to conventional total prostheses.[1,2] For patients with cognitive or motor problems are the best choice against fixed prostheses due to the opportunity to remove the prosthetic device for cleaning by other people.[3]

The attachments and prosthetic components used for retention overdentures are characterized by splinted and non-splinted.[1,4] Splinted systems include bar and clip attachments, while non-splinted systems comprise ball, magnetic, locator, and double crown attachments.[4-6] The splinted attachments present good stability and retention, can correct the non-parallelism between implants, and resist lateral and rotational forces.[5-7] The non-splinted present advantages like the lowest cost, simple manufacturing technique, less space between arches, and easy maintenance and cleaning.[8]

One of the principal problems related to attachments is retention loss.[9-12] This is due to insertion and removal cycles needed for cleaning, chewing forces, functional and parafunctional habits,[13-15] leading to periodic maintenance to exchange components that are part of the attachment, which makes the cost of treatment high.[16,17]

Different materials and models are introduced for manufacturing attachments, including polymeric materials, to make the retention more stable.[8,9,13] These are characterized as high molar mass chemical substances, consisting of repeating units, and which can be combined with additives such as fillers, dyes, and stabilizers and, depending on this interaction, different properties can be obtained, which does this class of material very interesting to be used in dentistry.[18]

Among the polymers used are polyacetal,[9,13] polyamide,[19] polylactic acid - PLA,[20] poly(ethylene terephthalate) – PET,[13] polytetrafluoroethylene – PTFE,[9,13] polyethylene,[13] and poly(ether-ether-ketone) – PEEK.[8] Polyacetal is derived from the synthesis of formaldehyde and is characterized as a depolymerizable polymer with crystallinity and rigidity, stable molecular structure, high chemical resistance, thermal stability, good fatigue resistance, low friction coefficient, high abrasion resistance, and dimensional stability.[21-23] PLA is derived from the bacterial fermentation of corn dextrose, has high rigidity, low toxicity, is biodegradable and has high resistance and high modulus.[20,24] PET is a semi-crystalline thermoplastic with an aromatic structure.[13] It is formed by intermediates such as terephthalic acid (TPA) and ethylene glycol (EG), derived from crude oil.[25] It has high chemical resistance, high hydrophilic stability due to the presence of aromatic rings, low roughness, low density, high hardness, good resistance to compression and fatigue, and low cost.[13,26] Polyethylene is polymerized from monomeric ethylene and characterized as partially crystalline. They have a symmetrical molecular structure and do not have polar groups, forming polymeric materials with excellent mechanical properties such as corrosion resistance and electrical isolation, in addition to low cost.[27,28] PEEK is a high-performance, aromatic, semi-crystalline, chemically inert biopolymer, in addition to good mechanical properties, high resistance to elevated temperatures, good wear resistance, and low affinity for biofilm adhesion.[29,30] PTFE has high chemical resistance, biological tolerance, thermal stability, anti-friction, and anti-adhesive properties.[31]

The manufacturing attachments from polymeric materials can improve the retention and durability of current systems and decrease treatment costs and time. In view of this, the aim of this review was to analyze and compare the mechanical properties of different polymeric attachments, including newly models and traditional presented in the literature.

MATERIAL AND METHODS

This systematic review was carried out and structured according to the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA).[32] Following their protocols was registered in Open Science Framework (osf.io/7j9vz).

The inclusion criteria were selected articles that presented attachments for overdentures manufactured with polymers and had mechanical properties analysis and *in vitro* studies. Only English articles and journal with selective political editorial and Journal Impact Factor (JCR) was selected. With exclusion criteria, was adopt all articles that do not have polymers with attachment material and book chapters, abstracts, letters, and conferences.

The search was performed in the databases Pubmed, Science Direct, Embase, and Scopus. The search terms were attachments AND polymers AND "mechanical properties" AND overdentures, abutments AND polymers AND "mechanical properties" AND overdentures, "Prosthetic components" AND polymers AND "mechanical properties" AND overdentures, locator AND overdenture, attachment AND polymers AND "mechanical properties" AND overdentures, abutments AND polymers AND "mechanical properties" AND overdentures, prosthetic components AND polymers AND "mechanical properties" AND overdentures, Compound terms were used with double quotes, except for the embase database, which used single quotes. The Rayyan Reference Management Program (Qatar Foundation - 2024) was used to check duplicates and facilitate the selection of articles for full reading and final selection.

The article selection was performed in two phases. In the first, two independent reviewers (M.R.C and J.A.M.A) performed the reading of titles and abstracts to identify possible studies to be included. In the second phase, the references that did not enter the included criteria were excluded and the articles that entered were integral read by two reviewers (M.R.C and J.A.M.A). For the final selection of references, was performed one discussion about the articles with our coordinator (A.C.R) before the final decision which included the author, objective, the polymer utilized, analysis performed, number of specimens (n), and results. Word software (Microsoft, WA, USA) was used to create the table with the results.

The main objective of this scoping review was to answer the following question that was formulated based on PICO (population, intervention, comparison, and outcomes): "New models of polymeric attachments have better mechanical properties and retention than traditional ones"?

The articles were qualitatively assessed for risk of bias to have greater reliability in the results according to the Joanna Briggs Institute.[33] This assessment has three values, low risk when the article is easy to interpret and understand, so there is no risk of bias. "Unclear" when the article does not present some point where it needs to be justified by the author of this review and high risk when the results are not fully understood.

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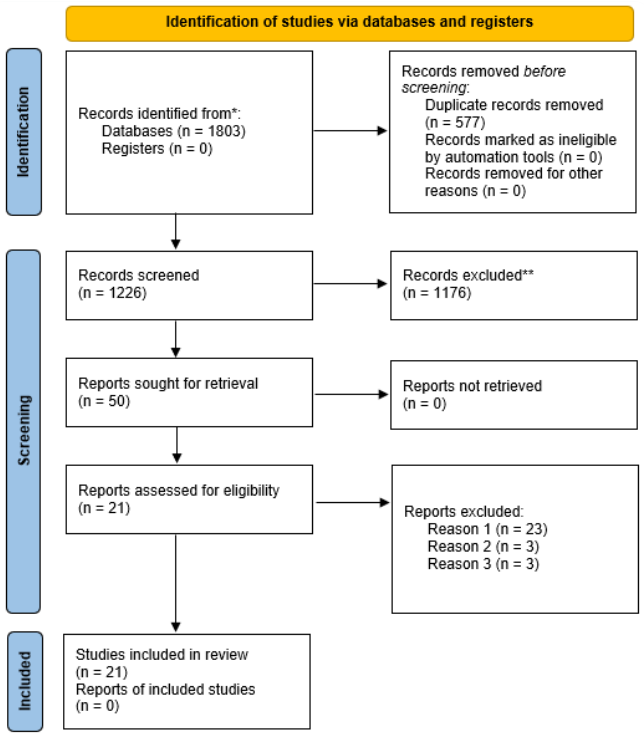
The questions used to evaluate the articles were adapted from the Joanna Briggs Institute: 1) Do the articles have attachments made of polymers?; 2) Did the study show a similar comparison between attachments?; 3) Did the study present mechanical analysis?; 4) Does the study have laboratory analysis?; 5) Was appropriate statistical analysis used?

RESULTS

The search was detailed using the PRISMA diagram *(Figure 1)*. The databases found a total of 1803 references. After excluding duplicates, 1226 remained. After reading the titles and abstracts of these references and applying the inclusion criteria, 50 articles remained. Of these, all were fully read for the final selection. A total of 21 articles were included in this systematic review. The studies included are from 2004-2023.

Among the analyses performed in the included studies, the most used was retention force with 19 studies,[9,13,34-50] followed by roughness[13,34,35,42,51] and hardness[13,34,35,52] with three studies, compression with two studies,[13,34,52] measuring deformation under the microscope with two specimens,[9,47] tensile strength[34] and finite elements[48] with only one study each.



Reason 1: Doesn't meet the inclusion criteria.

Reason 2: Without access to the manuscript.

Reason 3: Didn't have the JCR.

Figure 1: The Prisma Flow Diagram of the search, inclusion and exclusion data.

The polymers evaluated in the studies were Polyamide with 12 studies[34-45], polyacetal with five studies,[9,13,33,35,51] PEEK with five studies,[31-33,35,51] PTFE with four studies,[9,13,35,51] PET with two examples,[13,35] silicone reliners with two studies,[33,34] polyvinylsiloxane with two studies,[35,49] and Polyethylene,[13] Thermoplastic resin,[33] with one example.

The attachments used to compose the overdenture attachment system are the locator with 11 studies[34-39,44] *(Table 1)*; new models of attachments[9,13,20,50,51], ball with two studies,[48,49] followed by the double crown[47] and bar/clip[45] with one specimen, and equator,[38] Novaloc,[35] ERA,[37] and Titach with one.[41]

For new model attachments *(Table 2)*, the polymer that showed the greater values of the initial retention was PLA and additively manufactured.[20] For the final retention simulated 2 years of use, Polyacetal showed more stable retention with higher values.[9,13,20,51] Following the stud attachments, the traditional Locator made from polyamide *(Table 3)* showed greater values compared to new models, with the ring transparent presented higher values than PLA in the initial and final retention.[34,36,38,39] For double crown and bar/clip, PEEK showed better values,[45,47] however for the double crown the best choice is the zirconia-peek with higher initial and final values than peek-peek[47] *(Table 4)*.

The main objective of this review was to analyze the mechanical behavior of polymers as attachments for overdentures. With the results found it was possible to observe a positive relationship of these materials about the retention force. In general, the materials that presented the highest values for retention were PET[13,50] and polyacetal.[9,13] PEEK showed stability[46] of retention or increase[47] at the end of the cycles. For hardness[13,50] and compression,[13] the polyacetal had the highest values, and for roughness the lowest.[13,50]

When the tension generated was evaluated under vertical and oblique loads under the matrix, polyacetal and silicone, respectively, presented the lowest values.[48] When compared under different retention force silicones with the conventional metallic o-ring, the silicone RelineII presented higher initial values.[49]

When analyzing the deformation of the attachment after retention tests, PEEK (BioHPP) presented the lowest values compared to Cobalt-Chromium and Zirconia Oxide,[46] and PTFE the highest compared to metal and polyacetal.[9]

The risk of bias analysis was performed according to the qualitative assessment of the Joanna Briggs Institute *(Figure 2)*.[33] Only one study[48] had a high risk of bias. This fact is due to the lack of description of the statistical analysis.

DISCUSSION

The present systematic review aimed to compare the mechanical properties and retention of new polymeric models of attachments for overdentures with models already used. Among the most used polymers for new models are polyacetal, PEEK, PLA and PET[9,20,50,51], together with new designs with the aim of mainly improving retention stability with increased prosthesis insertion/removal cycles.

One of the main limitations of this systematic review was the heterogeneity of the data, in relation to the sample number, type of analyzes performed, different models and materials used, which made meta-analysis of the data impossible. However, these differences are beneficial as they demonstrate a broad field of study with a variety of polymers and geometric shapes of the attachments under development.

Table 1. The characteristics of the included studies and their results found.

Author	Objective	Polymer	Attachment	Analysis	n	Results
Abdelrehim., 2021[46]	To assess the retentive behavior of implant overdentures and the loss of retention from clip wear When used with different bar attachment materials.	Polyetheretherketone (PEEK), with 20% ceramic fillers (BioHPP)	Female part (Clip) of the bar/ clip attachment	Retention analysis and microscope measurement of the wear of female clips	12	The initial retention force of the female clips inserted in the bar demonstrated that the BioHPP bar presents the lowest values compared with Co-Cr and ZrO_2. However, the BioHPP bar presents the least percentage decrease with only 15.7% against 70.2% for ZrO_2 and 33.5% for the Co-Cr bar. For the measurements of deformation of the clips, clips used with BioHPP showed the least degradation.
Abdelaziz., 2023[40]	To evaluate initial retention along with the gradual loss of retention at the different time intervals	Polyetheretherketone (PEEK)	Locator F-TX	Retention tests (5475 cycles)	12	The Locator F-TX showed loss of retention by 91.93% after 2 years and 92.91% after 3 years of simulation. However, the mean initial retention values are highest than other groups like ball and socket group and Locator R-TX. These initial values for Locator F-TX are 30.95 for low retention and 29.42 for medium retention.
Chindarungruangrat., 2022[35]	To examine the retentive properties of materials and thermocycling on attachments for overdentures	Polyamide, polyetheretherketone (PEEK), and polyvinylsiloxane (PVS)	Novaloc and Locator	Retentive tests	10	The majority of the attachments and materials showed a decrease in the retention after thermocycling. Only group with locator and polyamide material showed an initial decrease at the time 3 and 6 months, however at the time 12 the retention showed a raise of the retention, higher than timer 3 and 16, but lower than timer 0 (initial). The group locator and PEEK material showed the higher initial retention, however the retention loss by 57.83% at the time 12. The group Novaloc with PVS showed the most stable retention between all groups, with loss of the values at 12 months only 4.82%.
Chung., 2004[37]	To compare the retention of various overdenture attachments systems	Polyamide	Locator and ERA	Retention with tensile dislodging force	5	Era gray attachment showed high retention values. Locator white showed medium and locator pink showed low retention values.
Dhamodaran., 2022[45]	To compare the retentive capacity of two attachment systems after thermocycling	Polyamide	Locator	Retention tests	4	The cumulative retention values for the Locator group were 18.85 N ± 2.50N.
Elkabbany., 2020[47]	Evaluate the change in retention of novel metallic and non-metallic double-crown attachments	Polyetheretherketone (PEEK)	Double crown	Retention force	8	The median retention values are greater for the Zirconia abutment and PEEK framework compared to the pure PEEK system (abutment and framework). The pure PEEK system also showed an increase in retention over the cycles.
ELsyad., 2016[39]	To evaluate and compare the retention and stability of mandibular implant overdentures with different attachments systems	Polyamide	Locator	Retention tests (vertical movement with 540 cycles)	5	The locator group with medium retention classification showed the highest initial values with 65.20N and the highest final values too, with 39.80N.
Ionescu., 2012[44]	To investigate the retentive force of three different attachment systems	Polyamide	Locator	Retention	11	The white color had the highest medium retention values (51.61N)
Galo Silva., 2019[13]	Evaluate physical-mechanical properties of different polymers used for attachments	Polyethylene terephthalate (PET), Polyacetal, Polytetrafluorethylene (PTFE), and Polyethylene.	New model (capsule) of female part of the ball attachment	Roughness, compressive, hardness, and retention force.	20	Polyacetal demonstrated the lowest values for roughness and PTFE was the greater. For superficial hardness and compressive strength, polyacetal showed the highest values and PTFE the lowest. For the retention force, PET and Polyacetal presented higher retention, and PTFE was the lowest.
Galo Silva., 2022[51]	To evaluate a newly developed attachment made of polyetheretherketone (PEEK) for overdenture	Polyetheretherketone (PEEK), Teflon, and polyacetal	Newly model	Fatigue resistance (2880 cycles), surface roughness, compressive strength, and surface hardness	20	PEEK present the greater values for compression resistance, followed by polyacetal and Teflon. For surface roughness, polyacetal showed the lowers, and Teflon the highest. For hardness, PEEK showed no difference between the groups. For retention force among the time, polyacetal showed the greater values, followed by o'ring, PEEK and Teflon, respectively.
Gibreel., 2021[48]	Analysis evaluates the effect of specific retention biomaterials	Polyetheretherketone (PEEK), Polyacetal, thermoplastic resin and silicone resilient liner.	Female part of the ball attachment	Finite Element Analysis	1	Under posterior loading at the matrix area, Polyacetal showed the lowest values. The stress on the matrix is close to Polyacetal, Thermoplastic resin, and PEEK. Under oblique Silicone showed the lowest values about the stress on the attachment and the other three polymers had similar results with 119 MPa for PEEK, 121 MPa for thermoplastic resin, and 120 MPa for the Polyacetal.
Kubo., 2018[49]	Investigate mechanical properties of silicone resilient denture liners on retention force over time	Nine types of silicone resilient dentures liners with Polyvinyl siloxane	Female part of the ball attachment	Retention force, hardness, compression, tensile strength, and roughness.	5	The initial retention was greater for GC RelineII soft than conventional o'ring. Greater reduction in retention was correlated with low strain compression. No correlation was observed between initial retention force and surface roughness.
Mariotto., 2020[50]	Evaluate the effects of different cleansing solutions on the physical-mechanical properties of three polymeric materials	Polyacetal, Polytetrafluoroethylene (PTFE), and Polyethylene terephthalate (PET)	New model (capsule) of female part of the ball attachment	Retention force, Roughness, and Hardness.	60	For roughness, PTFE presented the highest values before the immersion. Polyacetal showed reduction when immersion in NaOCl. For the other solutions, PET and PTFE are not influenced. For hardness, before immersion Polyacetal showed the highest values and PTFE lowest. Water caused a reduction in all polymers. For retention, PET showed the highest values and PTFE the lowest.
Perlis., 2022[42]	To estimate the effect of temperature changes on surface and retention loss of attachments	Polyamide	Locator	Surface roughness and retention tests	25	Thermal changes in the water temperature promote retention loss and corrosion of the metal surface on the locator attachment.
Ramadan., 2020[41]	To measure the retention of two different materials attachment systems	Polyamide	Locator	Retention tests with tensile dislodging force (1000 insertion and removal cycles)	8	When comparing the new model Titach attachment with locator R-tx, the metal-to-metal attachment Titach showed higher initial and final retention values with 63.25N median for the initial and 46.10N median for the final, against 40.60N median for the initial and 34.35N median for final retention for Locator. The locator group showed less loss of the retention values than titach group.
Sassi., 2022[38]	To investigate the drop in retention of low-profile attachments systems	Polyamide	Locator and Equator	Retention with simulated 1,200,000 masticatory cycles	10	The equator group had more constant retention values than locator, even for pink or clear matrices. However, locator had greater initial retention values.
Shastry., 2016[43]	To evaluate retention loss of locator, bar-clip and ball attachment	Polyamide	Locator	Retention tests (100 pull out)		The bar-clip with nylon (polyamide) showed the higher mean retentive force of 70.66N and 65.18N before and after thermocycling, respectively. The Locator group showed lower values among the groups.
Tehini., 2019[36]	The effect of simulated mastication on the retentive properties of Locator attachments	Polyamide	Locator	Retention tests (T0 initial; T1 100,000 cycles and T2 200,000 cycles, and microscopic measurement	10	At the initial time the group of transparent color Locator showed the highest retention values, followed by Pink and Blue. For the time T2, the order of the retention did not change comparing the three groups. However, for group transparent and pink the retention values increase, and for the group blue decrease. For the measurement the internal diameters of the locator groups, the group T showed smaller dimensions at the time 0 and 2, for XY measurement. For the AB measurement the group B showed smaller values.
Tehini., 2020[34]	To compare the effect of simulated mastication on the three types of locator attachments	Polyamide	Locator	Retention tests (100,000 loads cycles)	10	The highest mean retention values are for clear, followed by pink and last blue. All groups showed loss of the retention after de cycles, but the blue group showed highest values with 37%, followed by pink with 9% and clear with 7%.
Valente., 2019[9]	Develop a new attachments system for overdentures and compares its retention and deformation	Polyacetal and Polytetrafluorethylene (PTFE)	New model (capsule) of female part of the ball attachment	Retention force and stereomicroscopy	20	Polyacetal showed greater retention compared to PTFE and metal. For the deformation measurement, PTFE showed greater deformation, and metal the small.

Table 2. Retention values for initial and final retention of new models of polymeric attachments.

Authors	Material	Time (month)	Initial Retention	Final Retention
Campos., 2023[20]	Acrylonitryle-butadyene-styrene (ABS), Polylactic acid (PLA), and Polyacetal	24	ABS = 27.20N PLA = 39.36N Polyacetal = 30.95N	ABS = 1.29N PLA = 14.24N Polyacetal = 21.83N
Galo Silva., 2019[13]	PET, Polyacetal, Polyethylene, and PTFE	24	*	PET = 17.64N Polyacetal = 20.24N Polyethylene = 9.44N PTFE = 4.65N
Galo Silva., 2022[51]	PEEK, Teflon, and polyacetal	24	PEEK = 10.83N Teflon = 6.63N Polyacetal = 18.23N	PEEK = 14.19N Teflon = 5.41N Polyacetal = 23.58N
Mariotto., 2019[50]	PET, Polyacetal, and PTFE	24	PET = 16.16N Polyacetal = 15.34N PTFE = 5.30N	PET = 17.28N Polyacetal = 22.46N PTFE = 4.71N
Valente., 2019[9]	Polyacetal, and PTFE	24	Polyacetal = 18.23N PTFE = 6.63N	Polyacetal = 23.58N PTFE = 5.42N

Table 3. Initial and final values for locator attachments.

Authors	Material	Time (month)	Initial retention	Final retention
Dhamodaran., 2022[45]	Polyamide - Locator transparent and bar-clip	*100 pull out tests	-	Locator: 18.85N Bar-clip: 27.87N
ELsyad., 2016[39]	Telescopic crown and Locator transparent, pink, and blue	6	Telescopic: 19.01N Blue: 19.64N Pink: 51.20N Transparent: 65.20N	Telescopic: 4.94N Blue: 14.80N Pink: 33.60N Transparent: 39.80N
Ionescu., 2012[44]	Polyamide Locator blue, white, pink and magnect	12	Blue: 19.48N White: 53.34N Pink: 30.25N Magnetic: 3.41N	Blue: 17.88N White: 49.88N Pink: 28.99N Magnetic: 2.88N
Ramandan., 2020[41]	Titach and Locator transparent	12	Titach: 63.25N Locator: 40.60N	Titach: 46.10N Locator: 34.35N
Sassi., 2022[38]	Polyamide – Locator and Equator For both clear and pink	36	Equator Pink: 24.17N Locator Pink: 31.46N Equator Clear: 34.85N Locator Clear: 48.27N	Equator Pink: 23.22N Locator Pink: 21N Equator Clear: 27.6N Locator Clear: 21.17N
Tehini., 2019[36]	Polyamide – Locator transparent, pink and blue	18	Transparent: 41.73N Pink: 15.43N Blue: 9.90N	Transparent: 44.63N Pink: 16.7N Blue: 6.23N
Tehini., 2020[34]	Polyamide – Locator transparent, pink and blue	4	Transparent: 41.73N Pink: 14N Blue: 9.95N	Transparent: 38.20N Pink: 14N Blue: 6.37N

Table 4. Initial and final retention values for different attachment systems.

Authors	Material	Time (month)	Maximum Retention – Initial	Maximum Retention – Final
Abdelrehim., 2021[46]	Bar: Co-Cr; ZrO_2; BioHPP Clip: Nylon	12	Co-Cr = 62.68N ZrO_2 = 62.51N BioHPP = 34.14N	Co-Cr = 41.34N ZrO_2 = 18.53N BioHPP = 28.69N
Elkabbany., 2020[47]	Double crown: ZP (Zirconia-PEEK); PP (PEEK-PEEK); TP (Ti alloy-PEEL); TC (Ti alloy-Co-Cr), and TG (Ti alloy-gold)	120	ZP = 33.3N PP = 20.8N TP = 14.6N TC = 23.5N TG = 10.0N	ZP = 35.0N PP = 27.3N TP = 23.8N TC = 17.2N TG = 10.3N
Kubo., 2018[49]	Different silicone resilient denture liners as matrix of ball attachments. GC RelineII (soft) (GS); GC RelineII (extra soft) (GES); GC RelineII (extra extra soft) (GEES); Sofreliner (soft) (SS); Sofreliner (medium soft) (SM); Sofreliner Tough (soft) (STS); Sofreliner Tough (medium) (STM); Evatouch Super (ES); Mollosil Plus (MP).	36	GS = 5.39N GES = 1.40N GEES = 1.34N SS = 1.31N SM = 2.12N STS = 1.77N STM = 4.03N ES = 4.01N MP = 2.59N	GS = 3.01N GES = 1.18N GEES = 1.21N SS = 1.15N SM = 1.65N STS = 1.28N STM = 3.65N ES = 3.17N MP = 2.01N

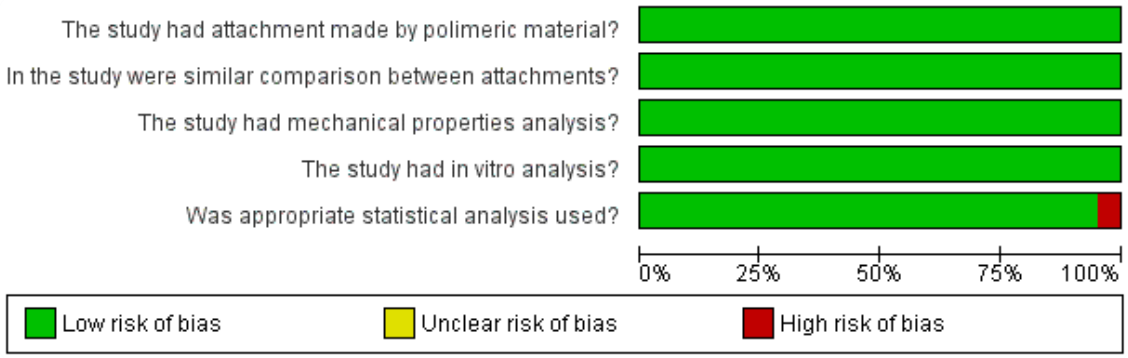


Figure 2: Risk of bias graph of the included studies.

Among the conventional non-splinted models, the locator is the most used, composed of polyamide and present in 11 studies.[34-39,41-44] It was possible to observe that the female portion that shows the greatest retention is the transparent one, followed by the pink and blue. In all, the final retention is greater than that reported in the literature to retain and stabilize an overdenture for a long period, which is between 8 and 10N.[42,50]

Among the new non-splinted models under development, the change occurs in the female part, which was previously composed of an o'ring and now of a single-body capsule, which does not require the union of the metal and the o'ring, therefore, it remains only in a single body, as demonstrated by different studies.[9,13,20,50,51] These studies used polyacetal, PLA, ABS, PET, PEEK, Teflon, and PTFE as polymers.[9,13,20,50,51] The material that presented the best initial retention was PLA and the final one was polyacetal.[20] However, the PLA capsule manufactured through additive manufacturing, as demonstrated by Campos *et al*., 202320, may have influenced the initial result due to greater roughness and consequently greater friction during the simulated insertion and removal cycles.

When comparing the non-splinted attachments already on the market with the new ones under development, it is observed that the Locator, associated with transparent rubber, presents greater initial and final retention than any model and polymer used in the new studies. The main difference between the studies is that the new models had a simulation time of 24 months, that is, 2 years of use, while the locator studies simulated 4,[36] 6,[39] 12,[34,41,44] except the study by Sassi *et al*., 2022,[38] which simulated 36 months, that is, 3 years of use.

Regarding the comparison between polymeric and metallic attachments, in general, polymeric attachments have higher retention values. Comparing the new models under development

with conventional non-splinted polymeric models, these models being mainly composed of polyamide, capsule-shaped attachments, used as the female portion of the ball, in association with polyacetal and PET showed the best retention stability compared to other polymers and models. This is due, in addition to the new geometric shape that can contribute positively, but mainly the characteristics of the polyacetal, which is characterized by having high crystallinity, high resistance to corrosion, dimensional stability, low coefficient of friction and being self-lubricating, which contributes to less wear and internal friction, deformation and consequent loss of retention.[13,18-20] While PET is semi-crystalline, chemically inert, has high corrosion resistance and high thermal stability.[53,54]

PEEK, when used for non-splinted attachments, presents high initial retention, however, at the end of the cycles its retention is drastically lost.[40,51] This may occur due to the chemical composition of PEEK, as well as the type and presence or absence of loads on pure PEEK. Materials made with unfilled PEEK, present deformation and early loss of retention, compared to PEEK with micro and nano fillers.[55] However, the PEEK used in double crown and bar presented opposite results.

For the double crown attachments, PEEK showed the best results. For double crowns, PEEK demonstrated good results used such as primary and secondary crowns or in combination with metallic materials.[47] After 10.000 insertion and separation cycles double PEEK crown, Zirconium-PEEK combined crown, and Titanium and PEEK combined showed an increase in the retention values. The degree of deformation or adaptation between copings determines whether retention will decrease, remain stable, or increase during cycles. In the case of using PEEK, there is a decrease in abrasion wear and a mechanical adaptation between the copings, which causes this increase in retention. This mechanism offers advantages compared to the use of metals, which suffer abrasion and wear, which reduce the contact between the copings and consequently the retention. Furthermore, the intrinsic properties of PEEK contribute to these results.[56]

For the bar attachments, PEEK was used as the bar of the system.[46] The PEEK bar presented the lowest initial values of retention compared to Co-Cr and ZrO_2. This difference is due to their elastic module. Co-Cr and ZrO_2 have similar values while PEEK has lower values.[57-59] However, in terms of durability, PEEK bars showed the least percentage decrease of retention with only 15.7%, compared to 70.2% for ZrO_2 and 33.5% for Co-Cr bar. For measurements of deformation of the clips, when it's used for PEEK bars these showed an insignificant increase for the upper and lower projections.[46] This is mainly because PEEK has abrasion resistance against metallic alloys, which gives retentive stability, a positive factor because these systems have metallic alloys in their composition.[60] Thus, using it as part of the system where there are metallic materials can be a viable alternative for retention stability over time. However, it is important to emphasize that the PEEK used in one of the studies[46] was BioHPP, characterized by the addition of 20% of ceramic filaments, which has better mechanical properties compared to pure PEEK. Anyway, these results are positive because the stability of loss retention and loss wear of clips used with PEEK bars induce loss costs of treatment due to less need for clip replacement.

Polyacetal was the polymer that presented the lowest values for the roughness of the female part of the ball attachment.[13,50] The surface roughness is an important factor to be evaluated, due to the properties and chemical composition of the materials interfering with the adhesion and maintenance of microorganisms. These characteristics can affect peri-implant health or cause serious illnesses such as chronic obstructive pneumonia, generalized respiratory tract infections, or bacterial endocarditis.[61,62]

Another factor to be considered is the values for hardness and compression, which influence the retention mechanism of the attachments. For hardness and compression, presented in studies with capsule, a new model of the female part of the ball attachments, polyacetal had the highest values, while PTFE had the lowest.[13,50] These results indicated that the polyacetal capsules can be used in clinical cases while PTFE didn't have adequate mechanical properties.

In another study, the finite element analysis of the female part of ball attachments made from polyacetal, and silicone was investigated when subjected to vertical and oblique forces. These polymers had the lowest values of stress generated compared to PEEK and titanium.[48] It is worth noting that, unlike the other polymers mentioned, silicone presented this value mainly due to its viscoelastic properties and low modulus of elasticity.[63] These data are important because, under chewing forces, vibration and micromovements occur between the system components, which can lead to loss of structure and failure of the attachment.[64]

Based on the critical analysis of the studies included in this review, the polyacetal showed the best results for the newly model of the female part of the attachment ball, and PEEK was the best for the bar of the bar/clip system and double crown. However, considering traditional models, the locator with transparent rubber still presents better initial and final retention than other attachments. However, visualizing the patient's cognitive capacity so that the IOD can be removed and inserted safely and easily must be taken into consideration, and, if applicable, use attachments with less retention.

The results point to the feasibility of using polymers as attachments for overdentures, which can reduce treatment costs due to increased retention stability and durability, in addition to the fact that these materials can be recyclable, reducing the environmental impact compared to metallic materials.

In addition to the great importance of the topic, innovative potential, environmental impact, cost reduction, technical facilitation, the number of articles found, and the heterogeneity of the data obtained, demonstrate the vast field for studies in this area, one time that literature, as presented in databases, does not allow direct comparison between results.

Thus, the present review demonstrates the feasibility to use polymers for application in attachments for overdentures, which highlights the requirement for clinical studies to corroborate the results found, verify the wear pattern, and decrease or increase in retention or fracture of the components under conditions of the oral cavity.

CONCLUSIONS

It was possible to conclude based on the data found in the studies included in this review that:

1. Using polymers to retain attachments is a possible option and should be based on the mechanical and physical-chemical properties of each polymer;
2. Composed of polyamide, Locator is still the attachment that presents the greatest initial and final retention;
3. New models associated with polyacetal, PLA and PET show good initial and final retention, which indicates their clinical use;
4. PEEK demonstrated favorable outcomes in attachment systems such as bar/clip and double crown, underscoring its suitability for clinical implementation.

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