

The effect of ball versus locator attachment system on the performance of implant supported overdenture: A systematic review

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ABSTRACT

Objective: This systematic review was aimed to compare ball and locator attachment system on the basis of clinical and biomechanical performance of implant supported overdenture as well as biological and patient related outcomes.

Material and methods: Open and free electronic and manual searches were performed in digital databases including MEDLINE via PubMed, the Cochrane Database of Clinical Trials, and Scopus along with some other reliable sources. From the 667 retrieved records, 11 full-text controlled trials were included in this study. Risk of bias was assessed according to RoB 2.0 except for one RCT (economic evaluation), only assessed by CASP checklist.

Results: From the 11 retrieved studies, total 183 locator and 219 ball attachments were identified in 452 subjects of 30 yrs–95 yrs of age. Studies provided data about prosthodontic complications or maintenance (replacement or the activation of matrix and patrix part, loss of retention, fracture and relining of the prosthesis, fracture of the attachment and the survival probability), oral health impact profile, soft tissue parameters and periodontal complications, marginal bone loss, patient related outcome and cost of the attachment systems. Only 5 studies were assessed at low risk bias, while other 6 at moderate to high risk of bias.

Conclusion: Locator attachment system show lesser complications including loss of retention and lower maintenance appointments, lesser soft tissue, and periodontal complications than the ball attachment. Ball is better in terms of cost effectiveness. In other related outcomes, no significant differences were noted between ball and locator attachment.

1. Introduction

The residual ridge resorption is a continuous process to occur once the teeth are lost. Individual variation in the resorption rate has been observed with conventional complete dentures. Rehabilitation of severely resorbed ridges with conventional complete dentures is a serious prosthodontic challenge.¹ Implant retained overdentures are popular, simple, and economical treatment modality for the rehabilitation of edentulous jaws. This treatment modality also increases patient satisfaction and quality of life.^{2,3} The Implant retained overdenture results in decreased bone loss or even a slight bone gain in some clinical situations.⁴ The implant-retained overdentures requires less number of implants, provides better hygiene maintenance and is less time consuming treatment option in comparison to the fixed prosthesis.⁵ Apart from its high clinical survival rate, frequent relining, fracture of

denture and wear of attachments are the few disadvantages and complications. Two implant retained mandibular overdenture is marked as the 'standard' treatment choice in rehabilitation of a completely edentulous patient.⁶ Recent studies have reported a more conservative approach to support mandibular overdenture with the use of even a single implant but it is not recommended as there is high chances of failure.⁷

Several attachment systems are available for the implant-supported overdentures includes ball stud/O-ring (Dal-Ro, TG-O ring), locator (self-aligning, CM-LOC), bar, magnet, and telescopic attachments.⁸ The selection of a suitable attachment system depends on retention, durability, ease of maintenance, amount of inter-arch space available, the individual clinical situation and needs.⁹ The clinical problems observed are more during the first year of service, due to the recurrent need for activation and replacement of the attachment components.¹⁰ The ball

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Table 1
Eligibility criteria (PICOS).

Domains	Inclusion criteria	Exclusion criteria
Participants	Subjects with complete/partial edentulism, Male/female; Any race or ethnicity; Mandible/ maxilla; Implant-retained overdenture (Single or multiple implants).	Subjects with systemic diseases, infections, radiation history, neoplastic lesions, smoking habits, and patient cooperation appeared questionable.
Intervention	Locator attachment (CM-LOC, or Equator type)	Studies without a control group.
Comparison	Ball attachment (Dal-Ro system, TG-O ring etc.)	Articles involving other attachment systems like bar, magnet and telescope.
Outcome	Outcomes i.e. Clinical, biomechanical, prosthetic, and biological performance, patient satisfaction, quality of life and preference. No restrictions were made to analyse other possible outcomes reported in included studies.	Successful outcomes of implant system but not related to ball or locator attachment on clinical, prosthetic and patient related factors.
Study design	Randomized clinical trials, cross-over, prospective controlled trials with at least three months of observation period after the intervention	Review articles, retrospective studies, studies without control groups, animal studies, systematic reviews, meta-analyses, case reports, and case series.

and the locator attachments are widely used attachment systems because of their convenient handling and requirement of less chair-side time. Decreased denture mobility and stress on the implants were seen in case of ball attachments.¹¹ Complications of ball attachment were described in previous studies as frequent loosening, wear of the attachment and fracture of the denture that leads to its frequent replacement.¹² The advanced locator attachment system provides dual-retention and self-aligning features. The low profile feature is said to be very useful when the inter-occlusal space is limited.¹³ Few of the complications with the locator attachment were described previously are plaque accumulation, difficulty in cleaning and frequent need to replace the nylon inserts.¹⁴

The purpose of this systematic review is to compare the ball stud and locator attachments in terms of clinical and biomechanical performance, oral tissue response, patient satisfaction, and maintenance issues for better understanding of the patient’s perceptions and clarification of the clinical controversies for the selection of the appropriate attachment systems in various clinical situations with an aim of improving the quality of life of the patient.

2. Materials and methods

We followed PRISMA (preferred reporting items for systematic reviews and meta-analysis) guidelines (www.prisma-statement.org) and the Cochrane Handbook for Systematic Reviews of Interventions (www.cochrane-handbook.org) for the proper conduction and reporting of the analysis.^{15,16} A prior protocol registration was made on publicly accessible database (PROSPERO: crd.york.ac.uk/prospero/CRD42020209537).

2.1. Information sources and search strategy

Unrestricted electronic and manual searches were performed up to October 2021. Published literature and abstracts were retrieved by digital databases including MEDLINE via PubMed (www.ncbi.nlm.nih.gov), the Cochrane Collaboration Oral Health Group Database of Clinical Trials (www.cochrane.org), and Scopus (<http://www.scopus.com>), along with other sources like Clinical trial registry (ISRCTN registry) and Clinicaltrials.gov. Database specific terms and free text keywords were used to identify published literature.

Table 2
Search strategies in different databases.

Databases searched	Articles identified
<p>MEDLINE via PubMed http://www.ncbi.nlm.nih.gov/pmc</p> <p>PMC Advanced Search Builder: ((((((((((((((edentulous) AND dental implant) AND overdenture) AND complications) OR retention) OR bone loss) OR satisfaction) OR oral health) OR cost) AND ball) OR O ring) AND locator) OR CM LOC) AND attachment)</p> <p>Search details (((((((((((((((“mouth, edentulous”[MeSH Terms] OR (“mouth”[All Fields] AND “edentulous”[All Fields]) OR “edentulous mouth”[All Fields] OR “edentulous”[All Fields]) AND (“dental implants”[MeSH Terms] OR (“dental”[All Fields] AND “implants”[All Fields]) OR “dental implants”[All Fields] OR (“dental”[All Fields] AND “implant”[All Fields]) OR “dental implant”[All Fields]) AND (“denture, overlay”[MeSH Terms] OR (“denture”[All Fields] AND “overlay”[All Fields]) OR “overlay denture”[All Fields] OR “overdenture”[All Fields]) AND (“complications”[Subheading] OR “complications”[All Fields]) OR (“retention, psychology”[MeSH Terms] OR (“retention”[All Fields] AND “psychology”[All Fields]) OR “psychology retention”[All Fields] OR “retention”[All Fields]) OR (“bone diseases, metabolic”[MeSH Terms] OR (“bone”[All Fields] AND “diseases”[All Fields] AND “metabolic”[All Fields]) OR “metabolic bone diseases”[All Fields] OR (“bone”[All Fields] AND “loss”[All Fields]) OR “bone loss”[All Fields]) OR (“personal satisfaction”[MeSH Terms] OR (“personal”[All Fields] AND “satisfaction”[All Fields]) OR “personal satisfaction”[All Fields] OR “satisfaction”[All Fields]) OR (“oral health”[MeSH Terms] OR (“oral”[All Fields] AND “health”[All Fields]) OR “oral health”[All Fields]) OR (“economics”[Subheading] OR “economics”[All Fields] OR “cost”[All Fields] OR “costs and cost analysis”[MeSH Terms] OR “costs”[All Fields] AND “cost”[All Fields] AND “analysis”[All Fields]) OR “costs and cost analysis”[All Fields]) AND ball[All Fields] OR O[All Fields] AND ring[All Fields]) AND locator[All Fields]) OR (“CM”[All Fields] AND LOC[All Fields]) AND “attachment”[All Fields]</p>	455
<p>Cochrane Central Register of Controlled Trials https://www.cochranelibrary.com/central</p> <p>and</p> <p>Cochrane Database of Systematic Reviews https://www.cochranelibrary.com/cdsr/reviews</p> <p>#1 MeSH descriptor: [maxilla] explode all trees</p> <p>#2 (maxilla OR maxillary OR “upper jaw”)</p> <p>#3 MeSH descriptor: [mandible] explode all trees</p> <p>#4 (“mandible” OR “mandibular” OR “lower jaw” OR “jaw” OR “arch”)</p> <p>#5 MeSH descriptor: [edentulous] explode all trees</p> <p>#6 (“edentulism” OR “edentulous jaw” OR edentulous arch OR “edentulous maxilla” OR “edentulous mandible” OR “edentulous maxillary” OR “edentulous mandibular” OR “edentulous maxillary arch” OR “edentulous mandibular arch”)</p> <p>#7 MeSH descriptor: [implant] explode all trees</p> <p>#8 (“implant” OR “dental implant” OR implant retained overdenture)</p> <p>#9 MeSH descriptor: [attachment] explode all trees</p> <p>#10 (“ball attachment” OR “O ring attachment” OR “locator attachment” OR “self aligning attachment”)</p> <p>#11 (#1 OR #2 OR #3 OR #4 OR #5 OR #6) AND (#7 OR #8) AND (#9 OR #10)</p>	90
<p>Scopus http://www.scopus.com</p> <p>(TITLE-ABS-KEY (edentulous*) TITLE-ABS-KEY (edentulous arch*) TITLE-ABS-KEY (edentulism) OR TITLE-ABS-KEY (maxilla*) TITLE-ABS-KEY (maxill*) OR TITLE-ABS-KEY (mandible*) TITLE-ABS-KEY (mandib*) TITLE-ABS-KEY (“implant*”) OR TITLE-ABS-KEY (“dental implant”) OR TITLE-ABS-KEY (“overdenture”) TITLE-ABS-KEY (“implant retained overdenture”) TITLE-ABS-KEY (denture*) TITLE-ABS-KEY (“prosthesis”) OR TITLE-ABS-KEY (“attachment”) OR TITLE-ABS-KEY (ball) OR TITLE-ABS-KEY (“locator”) OR TITLE-ABS-KEY (“o-ring”) OR TITLE-ABS-KEY (“dal-ro”) OR TITLE-ABS-KEY (“self-aligning”) OR TITLE-ABS-KEY (“stud”) OR TITLE-ABS-KEY (“equator”) TITLE-ABS-KEY (“clinical trial”))</p>	104

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Table 2 (continued)

Databases searched	Articles identified
Other sources- ISRCTN registry, Clinicaltrials.gov, and manual searches	18
Total	667

2.2. Eligibility criteria

PICOS (populations, interventions, comparisons, outcomes, and study designs) was used to describe the eligibility criteria (Table 1). All articles abstracts those appeared to meet the inclusion criteria were independently evaluated by each one of the three authors. Differences in opinion to select the articles were resolved by thorough discussion.

2.3. Study selection, data collection and analyses

The titles and abstracts of electronically identified records were first screened by two reviewers (NG and RB) for inclusion. Subsequently, the

literature that met the eligibility criteria were studied fully and again judged against inclusion and exclusion criteria. Any conflicts among reviewers were resolved by consultation with the third author (NKS). Data extraction obtained independently by the same two reviewers and any conflicts were again resolved by discussion with the third author. The following information was extracted: authors, year of publications, interventions and comparator, mean age of participants, number of participants, implants, attachments, and dropouts, duration of follow-up, time of loading, additional information like priori sample calculation, baseline comparability, and measurement accuracy consideration along with objectives, and outcomes. Each author independently assessed the methodological soundness and quality of included literature.

2.4. Risk of bias and additional analyses

Assessment of the risk of bias across studies were done by two authors (NG and NKS) using the RoB 2.0 (recent modified Risk of Bias assessment tool) for randomized clinical trials. (<https://www.riskofbias.info/welcome/rob-2-0-tool> accessed October 30, 2021; current

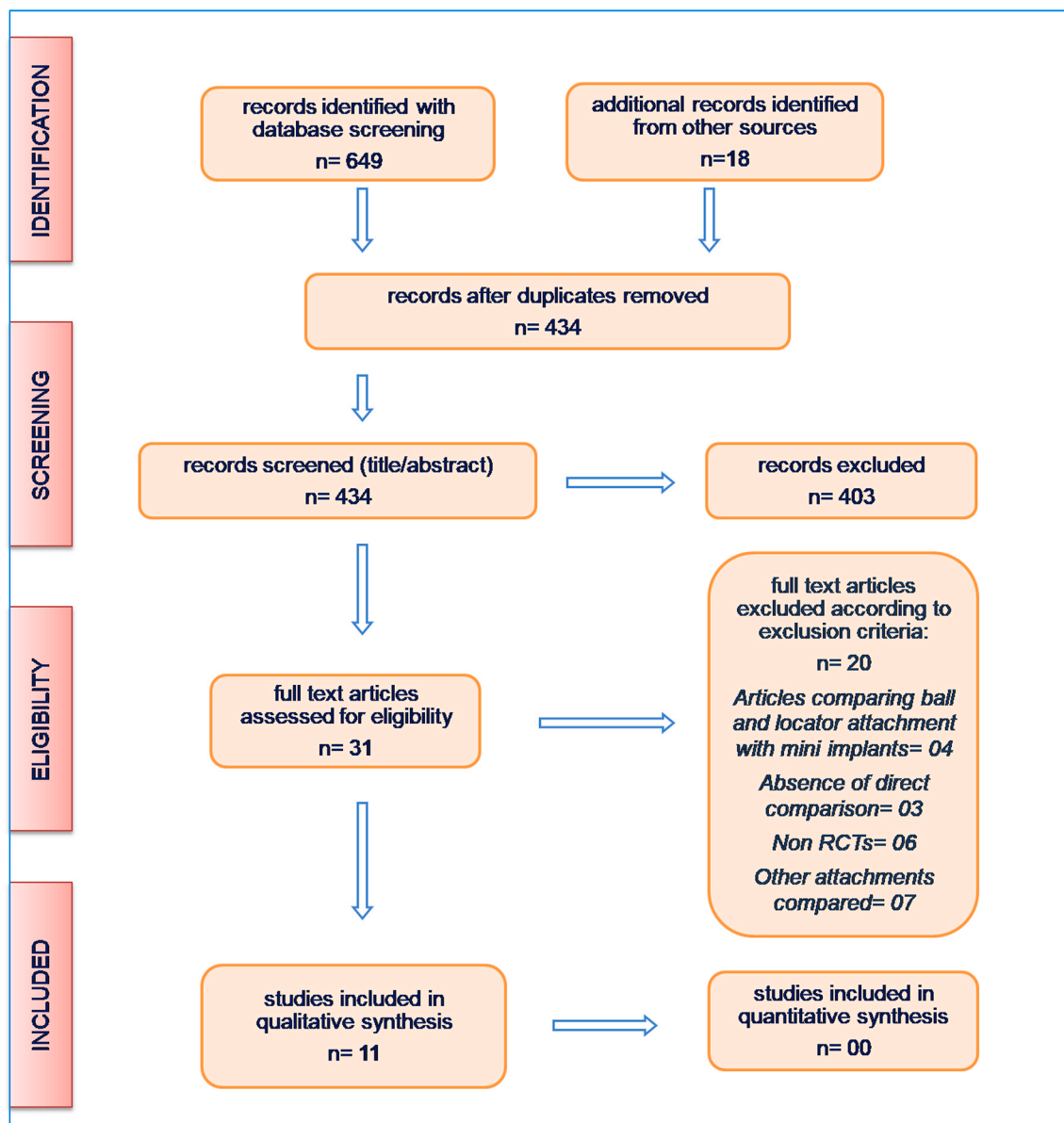


Fig. 1. PRISMA flow diagram for screening and inclusion of the studies.

Table 3
Characteristics and outcome of included studies.

Author; year of publication and setting	Study design	Intervention and comparator	Objective	No. of patients (m/f)	Mean age	No. of implants	No. of Attachment Locator Vs ball	Dropouts and follow-up	Single/bi/Multiple	Immediate/early/delayed loading	Additional information	Outcomes
1. Wilfried K. Kleis et al. ¹⁰ ; 2010; Germany	RCT	SA locator attachment Vs Traditional ball attachment (Dal-Ro system and TG-O-Ring)	Prosthetic maintenance of the attachment systems; Stability, condition of soft tissue, and patient perception	60 (15 m + 45f)	64 years (46–95 years)	120 (mandible)	Locator- 23 Ball- 33	Locator-6 Ball –7 and 12 month	2 Standard implants (Osseotite TG) of 4.0 mm diameter and 11, 11.5, or 13 mm length with a mucosal passage of 2.8 mm were inserted in the of the canine area (infraforaminal mandible).	Average 3.5 months after implantation,	<i>Priori sample calculation- NI Baseline comparability- NI Measurement accuracy considered- NI</i>	More maintenance appointment for locator than ball attachments. Not enough evidences for one better than other attachment system.
2. Hakan Bilhan et al. ²⁰ ; 2011; Istanbul	RCT (within subject crossover trial)	SA Locator and then ball attachment	OHRQL via OHIP-14	27 (16 m + 9f)	57.3 years (44 to 74)	(54 mandible)	Locator – 13 Ball- 12	2 subjects and 6 months	4.5 × 13 mm endosseous dental implants (Osseospeed, Astra Tech AB, Mölndal, Sweden)	Early loading with in 6 week duration	<i>Priori sample calculation- NI Baseline comparability- NI Measurement accuracy considered- NI</i>	OHIP– NS but Locator is better than ball attachment in patients with reduced vertical dimension.
3. Sirmahan Cakarer et al. ²¹ ; 2011; Istanbul	RCT	Ball, bar, and locator attachments	complications associated with the overdentures, attachments and implants	36 patients (16 male, 20 female)	mean age of 66.3 years (43–89)	95 implants (24 maxilla, 71 mandible)	Ball-19 Locator-8 Bar- 9	3, 6, 12 months and, annually. ≥ 5 years (mean 41.17 months)	Different implant systems such as Astra Tech, BioHorizons, Bio-Lok, Endopore, Frialit, ITI and Swiss Plus	2–3 months	<i>Priori sample calculation- NI Baseline comparability- NI Measurement accuracy considered- NI</i>	Statistically insignificant difference for attachment systems regarding the implant failure, replacement of the parts and fractured overdentures. Locator attachment was found superior to ball with respect to the number of complications.
4. Nabeel H. M. Alsabeeha et al. ²² ; 2011; New Zealand	RCT	Wider DM implant with large ball and regular DM implant with the Locator attachment system Vs Regular DM implant and the standard ball attachment system	Surgical and prosthetic outcomes	36 (m = 12, f = 24)	Mean age 68 years (range 53–85)	36 implants (mandible)	Regular ball- 10 Large ball- 12 and regular Locator – 12	1 subject and one implant in control group and 12 months	One implant with three different sizes- 3.75 mm (Southern Implants, Irene, South Africa), 8 mm Southern Implants and 4 mm (Neoss International, Harrogate, UK).	Six weeks	<i>Priori sample calculation- NI Baseline comparability- NI Measurement accuracy considered- NI</i>	Less maintenance appointments were needed for larger attachment systems on wide diameter implants.
5. Kivanc Akca et al. ²³ ; 2013; Turkey	RCT	Two unsplinted implants	biologic and prosthetic outcomes	29 (21f + 8 m)	Mean age 67.8	58 (mandible)	Ball = 19 Locator = 10	10 subjects (2 ball + 8)	Two implant 4.1 × 12 (SLA surface, institutStraumann)	Early loading (5–6 weeks)	<i>Priori sample calculation- NI Baseline</i>	Locator attachments associated with

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Table 3 (continued)

Author; year of publication and setting	Study design	Intervention and comparator	Objective	No. of patients (m/f)	Mean age	No. of implants	No. of Attachment Locator Vs ball	Dropouts and follow-up	Single/bi/Multiple	Immediate/early/delayed loading	Additional information	Outcomes
		supporting a mandibular overdenture retained with ball attachments Vs locator attachment			(f) 64.3 (m)			locator) and 5 years			comparability- NI Measurement accuracy considered- NI	fewer complications. Ball attachment group experienced slightly more marginal bone loss and frequent need for reactivation or replacement of the matrix part along with denture relining procedures.
6. Corina Marilena Cristache et al. ²⁴ ; 2014	RCT	Retentive anchor (ball stud), Locator and magnet attachment	focusing on costs, maintenance requirements and complications	69(no. of male and female not specified)	42–84	69 (mandible)	Ball 23, locator 23, and magnet 23	NI and 5 years	Two implant screw-type Straumann (Switzerland) standard soft tissue level implants 4.1 mm diameter and length 10 mm or 12 mm.	6 weeks I.e. Early loading	Priori sample calculation- yes Baseline comparability- yes Measurement accuracy considered- NI	Economically retentive anchor with titanium matrix and locator systems are better (due to initial low cost of the components and fewer complications associated). Ball attachment and golden matrix demands continuous after care.
7. Marina Pisani et al. ¹⁴ ; 2017; Canada	RCT (crossover)	Ball and then locator attachment	patient's perceptions- retention and stability, oral function, hygiene, aesthetic, pain	24(11 m + 11f)	68–81 years; mean 73.2	48 (Mandible)	Ball = locator = 12	2 subjects and 12 months	Two implant overdenture	NI	Priori sample calculation- NI Baseline comparability- NI Measurement accuracy considered- NI	The ball attachment retain less debris and found easier to clean when compared to the locator attachment. An adequate retention level needed to adjust according to individual preference and satisfaction.
8. Marwa Abdel Aal et al. ²⁵ ; 2019; faculty of Dentistry-Cairo university.	RCT	CM-LOC (locator) Vs Ball attachment	OHRQL based on functional limitation, physical pain, psychological disorders, physical disability, Psychological disability, social	80(45 m + 20f)	50–69 year	71 (mandible)	34 ball and 37 CM-LOC (locator)	15 (initially 6 implant failure + 3 dropout, 3 dropout in ball and locator each after 1 year) and 12 months	One (Zimmer Dental (Implants ZDI, Tapered screw vent Indiana America) of diameter 3.7 mm, and length 10 mm)	3 months	Priori sample calculation- yes Baseline comparability- NI Measurement accuracy considered- NI	Both CM LOC and Ball attachments are good alternatives. CM-LOC seemed to offer promising results, but care should be given to the frequency of

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Table 3 (continued)

Author; year of publication and setting	Study design	Intervention and comparator	Objective	No. of patients (m/f)	Mean age	No. of implants	No. of Attachment Locator Vs ball	Dropouts and follow-up	Single/bi/Multiple	Immediate/early/delayed loading	Additional information	Outcomes
9.Nahla Eid KamelSelimTaha et al. ²⁶ ;2019; School of Dentistry of the Federal University of Goias, Brazil	Randomised crossover clinical trial	Ball attachment Vs Stud type equator (locator) attachment	disability, handicap Clinical and patient reported outcomes according to six items: comfort, chewing efficiency, speech, retention, stability and satisfaction.	19(11 m+8f)	Mean age from 51.6 to 84.1 years old (mean = 66.1	19 (mandible)	9 ball and 9 equator	2 dropouts 1 after the implant placement and 1 lost follow up and 1 week and 3 month	One cylindrical morse taper implant of 3.75 mm DM, implant length was defined according to availability of bone height	3 months	<i>Priori sample calculation- yes Baseline comparability- yes Measurement accuracy considered- NI</i>	matrix changing and maintenance. Satisfaction occurred irrespective of the type of the attachment used and preference may be biased by the sequence of attachment use, which suggests the presence of a learning effect. Locator system concluded as less cost-effective in terms of the initial as well as after cost.
10.Amr Ahmed Naguib et al. ²⁷ ;2019; Faculty of Dentistry, Cairo University.	RCT	Ball attachment Vs CM-LOC (locator attachment)	cost-effectiveness	52 (no.of male n female not specified)	50–69 years	52 (mandible)	Total 52 26 each	1 year	Single implant	3 month i.e. delayed loading	<i>Priori sample calculation- NI Baseline comparability- NI Measurement accuracy considered- NI</i>	Clinical pocket depth lower for locator and Gingival index values in the locator group comparable to the BS group but insignificant.
11.Hisham A Mously ²⁸ ;2020; Saudi Arabia	RCT	Locator attachment Vs Ball stud (BS) attachment	Gingival index and clinical pocket depth in cases of reduced vertical space.	20	30–60 yrs	NI (mandible) Kennedy class1	10 each	6,12,18 months	Pitt Easy V-TPS implant-3.75and 10 mm	3months	<i>Priori sample calculation- NI Baseline comparability- yes Measurement accuracy considered- NI</i>	Clinical pocket depth lower for locator and Gingival index values in the locator group comparable to the BS group but insignificant.

SA: self aligning; m: male; f: female; OHRQL: oral health related quality of life; OHIP: oral health impact profile; NS: not significant; NI: no information.

version).¹⁷ An online web-app [robvis](https://www.riskofbias.info/welcome/robvis-visualization-tool) was used to visualizing the risk of bias assessments as “traffic-light” and “weighted-bar” plots (<https://www.riskofbias.info/welcome/robvis-visualization-tool>).¹⁸ Moreover, quality of articles those conducted only economic evaluation regarding the attachment systems, were evaluated under the CASP checklist (Critical Appraisal Skills Programme (2018) www.casp-uk.net Accessed: November 04, 2021).¹⁹

2.5. Summary measures and synthesis of result

Quantitative analysis was planned if selected studies were presented with sufficient homogenous data with respect to intervention and outcomes. Otherwise, qualitative assessment of the specifics would have been attempted. Data on the comparison of ball and locator attachment systems used in implant retained overdentures and other possible factors were planned to express as risk ratios (RR) for dichotomous and standardized mean difference (SMD) for continuous data, together with the 95% confidence intervals (CI). In order to have a measure of the absolute risk, data were also planned to express as risk difference (RD) together with 95% CI. If the studies differ in terms of factors like participant groups, settings, procedures, follow-ups, and study design the random-effects-model for meta-analysis was planned to combine the data otherwise fixed effect model would have been selected. Between-study heterogeneity was planned to evaluate clinically as well as quantified using I^2 statistic. The level of significance was set at 0.05, except for the 0.10 used for the heterogeneity tests.

3. Result

3.1. Study selection

Table 2 reports search strategy applied in different databases to collect articles. Fig. 1 shows Prisma flow diagram that narrates steps taken during the reviewing process to identification and selection of studies. We initially identified 667 records, in which 233 were excluded

as duplicates. 403 more articles were rejected on the basis of titles and abstracts. Subsequently, full text assessments were done on remaining 31 records for eligibility, 20 studies were excluded according to exclusion criteria and reasons summarized in Fig. 1. Finally, 11 full-text controlled trials (11 RCTs)^{10,20–29} were included in the systematic review.

3.2. Study characteristics

Table 3 compiles Information extracted from the included studies. The articles were published between 2010 and 2020. Total 183 locator attachment and 219 ball attachments were identified in 452 subjects of minimum 30 yrs to maximum 95 yrs of age. Total 662 implants were placed in which only 24 were reported in maxilla and all other used in mandible. Total dropouts reported were 45 in 7 studies while no information was gain in other 4. Follow-up period reported was minimum 3 months to maximum of 5 yrs. Statistically significant difference was found with regard to gender and age in baseline data. No information was found in most of the studies regarding prior sample calculation, baseline comparability, and inspecting the accuracy of the measurements.

3.3. Results of individual studies and qualitative syntheses

Because of the heterogeneity in study designs, intervention, participant groups (number, age, and gender), implant number, follow-up period, loading protocols along with presence of low quality studies, a quantitative analysis was not conducted. For the descriptive purpose, outcomes presented into following paragraphs.

After final screening, 11 studies were selected for the descriptive analysis. Of these, 5 studies^{10,21–24} provided data about prosthodontic complications and the maintenance. After reviewing the studies complication observed are replacement or the activation of matrix and patrix part, preterm loss of retention, fracture and relining of the prosthesis, fracture of the attachment and the survival probability of

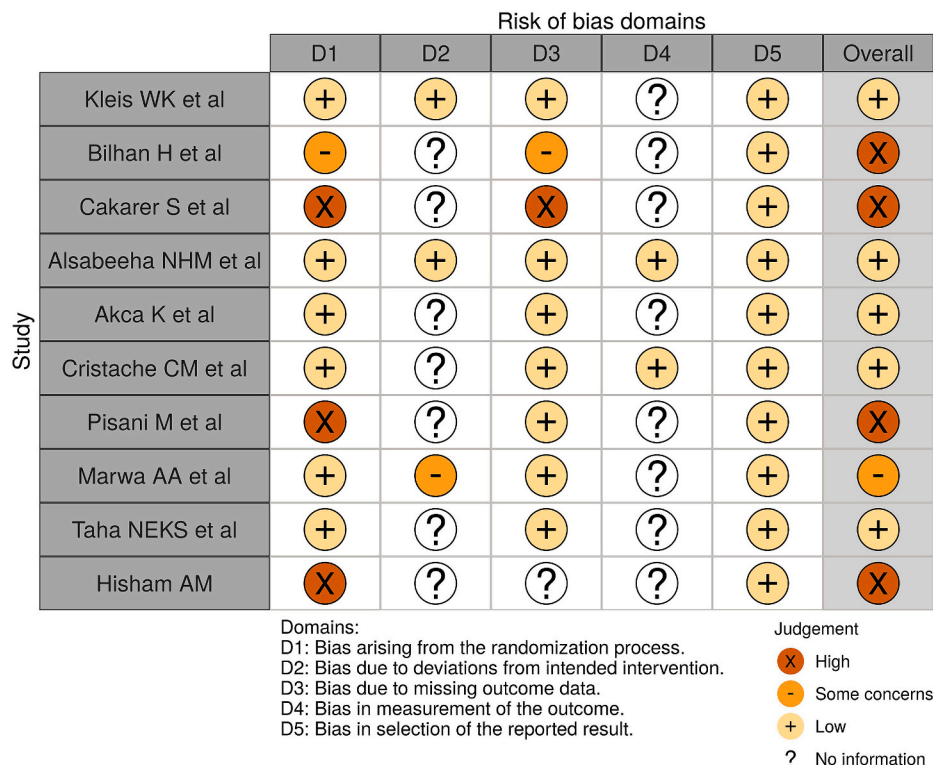


Fig. 2. Risk of bias summary (traffic light plot).

Table 4
Risk of bias assessment.

Author and year of publication	Random sequence generation and allocation concealment;	Blinding of participants and personnel (Bias due to deviations from intended interventions);	Incomplete outcome data (Bias due to missing outcome data);	Blinding of outcome assessment (Bias in measurement of the outcome);	Selective outcome reporting (Bias in selection of the reported result).	Overall
Kleis WK et al. ¹⁰ ; 2010; Germany	Low Sufficient information about randomization and allocation concealment. (The patients were randomized ... systems. Each patient's ... random ... supply)	Low Sufficient information gained (Nondisclosure was guaranteed ... obtained system.)	Low Dropouts recorded, described and adequately explained (Patient (Dal-Ro®) was not willing ... could not be traced for follow-up ... (Locator®:n = 4, ... could not be included in follow-up examination ...)	NI No information about blinding of outcome assessors; however reviewers discussed and agreed that results are not likely to be affected by lack of blinding	Low All possible and important outcomes are adequately reported	Low risk
2. Bilhan H et al. ²⁰ ; 2011; Istanbul	SC Allocation concealment was not described properly. (The final 25 edentulous ... were randomly ... lottery method.)	NI (unclear bias)	SC Dropouts recorded, described but not adequately explained	NI (unclear bias)	Low All possible and important outcomes are adequately reported	High risk
3. Cakarar S et al. ²¹ ; 2011; Istanbul	High Insufficient information about sequence generation and allocation concealment process. (The individuals ... randomly assigned to the ... groups.)	NI (unclear bias)	High Dropouts were neither disclosed nor described	NI (unclear bias)	Low All possible and important outcomes are adequately reported	High risk
4. Alsabeeha NHM et al. ²² ; 2011; New Zealand	Low Sufficient information about randomization and allocation concealment. (the randomization and allocation ... using 36 sequentially numbered opaque sealed ... maximum concealment.)	Low Sufficient information gained (A dental assistant not involved ... procedures ... study.)	Low Dropouts recorded, described and adequately explained	Low reviewers discussed and agreed that results are not likely to be affected by lack of blinding. (blinding of outcome assessors to the interventions was not possible in this study.)	Low All possible and important outcomes are adequately reported.	Low risk
5. Akca K et al. ²³ ; 2013; Turkey	Low Sufficient information about sequence generation and allocation concealment process	NI (unclear bias)	Low Dropouts recorded, described and adequately explained	NI No information about blinding of outcome assessors; however reviewers discussed and agreed that results are not likely to be affected by lack of blinding	Low All possible and important outcomes are adequately reported.	Low risk
6. Cristache CM et al. ²⁴ ; 2014	Low Sufficient information about randomization and allocation concealment. (A dental assistant, not involved in this Soft-enter replaced as Paramark ... sequentially numbered opaque sealed envelopes ... protocol proposed by)	NI (unclear bias)	Low No dropout reported	Low Sufficient information gained. (Data collection ... by two independent ... assessment)	Low All possible and important outcomes are adequately reported.	Low risk
7. Pisani M et al. ¹⁴ ; 2017; Canada	High Insufficient information about sequence generation and allocation concealment process	NI (unclear bias)	Low Dropouts recorded, described and adequately explained	NI (unclear bias)	Low All possible and important outcomes are adequately reported.	High risk
8. Marwa AA et al. ²⁵ ; 2019; faculty of Dentistry-Cairo university	Low Sufficient information about randomization and allocation concealment. (patients were assigned to ... using non transparent sealed ... randomization.)	SC Blinding was impossible due to the difference in the attachment shape	Low Dropouts recorded, described and adequately explained	NI (unclear bias)	Low All possible and important outcomes are adequately reported.	SC (moderate risk)
9. Taha NEKS et al. ²⁶ ; 2019; School of Dentistry of the Federal University of Goias, Brazil	Low Sufficient information about randomization and allocation concealment. (Participants were assigned randomly ... using a web-based platform (https://www.randomizer.org/) ... allocation and	NI (unclear bias)	Low Dropouts recorded, described and adequately explained	NI No information about blinding of outcome assessors; however reviewers discussed and agreed that results are not likely to be affected by lack of blinding	Low All possible and important outcomes are adequately reported.	Low risk

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Table 4 (continued)

Author and year of publication	Random sequence generation and allocation concealment;	Blinding of participants and personnel (Bias due to deviations from intended interventions);	Incomplete outcome data (Bias due to missing outcome data);	Blinding of outcome assessment (Bias in measurement of the outcome);	Selective outcome reporting (Bias in selection of the reported result).	Overall
11.Hisham AM ²⁸ ;2020; Saudi Arabia	<i>informed individually to blind allocation.)</i> High Insufficient information about sequence generation and allocation concealment process. (The study participants were then randomlysystem use.)	NI (unclear bias)	High No disclosure and description of missing outcome data gained	NI (unclear bias)	Low All possible and important outcomes are adequately reported.	High risk

NI: no information; SC: some concerns.

attachment parts. Out of 5, 3 studies^{21,23,24} unequivocally concluded that locator attachment system experienced lesser complications than ball attachment, while only one study¹⁰ gave contrast conclusion to the above result. In addition, one study²² concluded that the prosthodontic success, while better with the large ball attachment systems, was statistically insignificant.

4 articles provided data for oral health impact profile (OHIP).^{10,20,25,26} After reviewing the studies the parameters observed are physical handicap, functional limitation, physical pain and discomfort, psychical Indisposition, and social, psychical and physical impairment. All 4 studies, unequivocally concluded that self-aligning attachments are comparable to ball attachments in OHRQL and may be better in case of less inter-arch space for attachment. Also CM-LOC gives better results than ball attachment except in removal and insertion where it causes psychological discomfort.

4 literature evaluated soft tissue parameters and periodontal complications.^{10,21,23,28} After reviewing the studies the parameters observed are, mucosal enlargement, soft tissue recession, pocket depth of periodontal pocket, and plaque, gingival, and bleeding index. Out of 4, 2 studies^{23,28} compared depth, plaque, bleeding and gingival index related to ball and locator attachments and the results were not statistically significant. However 2 studies^{10,21} gave contrast result and concluded that ball attachment suffered these problems greater than locator attachment in terms of mucosal enlargement, hygiene problem and soft tissue recession.

2 Study^{22,23} included in this systematic review evaluated marginal bone loss in which 1 study²³ observed bone loss around ball attachment to be greater than locator attachment. In another study²² mean marginal bone loss was less around wider implant than regular one although it was not statistically significant.

One trial¹⁴ observed patient’s perception of ball and Locator attachments systems. After reviewing the study the parameters observed mainly are retention and stability apart from improvement in oral function, previous experience with the attachment, confidence in the dentist’s work, pain, hygiene problem and aesthetics. The results obtained were not statistically significant. Furthermore, one study²⁶ evaluated patient’s satisfaction In which six parameters were included to compare speech, chewing ability, comfort ability, retention, stability and overall satisfaction in ball and equator attachment. Results showed no significant difference in outcome was found between attachments.

Two articles^{24,27} evaluated cost effectiveness, in which the result obtained from one RCT²⁷ was that the initial as well as total cost of the CM-LOC attachment was around 2.2 times more than the ball attachment. In contrarily to above, another study²⁴ reported statistical insignificant differences between the ball and locator attachment group, after the 5-year evaluation. In addition, ball attachment with golden matrix registered more expensive aftercare and complications comparing with

the other groups due to the higher number of events that cost around 5 to 6 times more than ball with titanium matrix and locator attachment.

Other reported outcomes. In 5 studies Implant failure occurred during healing, in which one study reported that implant failure was more in case of ball attachment but was not statistically significant. Furthermore another study concluded that *peri-implantitis* observed around ball attachment was more than locator. In 1 study ISQ (implant stability quotient) was found lower for regular diameter implant than wider but it was not statistically significant.

4. Discussion

Various attachments systems are available for implant supported overdentures. The ball (O-ring, Dal-Ro, TG-O ring system) and locator (self aligning, CM-LOC, equator type) attachments have been the most accepted, widely used and popular attachment systems. In addition, other systems such as bar and clip, extra-coronal resilient attachment (ERA), and magnet attachments have been developed so far. With the advancement in the attachment systems, stress distribution and clinical success rate have been improved. We have planned this systematic review to compare the clinical, biomechanical, biological as well patient related outcomes in relation to implant retained overdentures with traditional ball/O-ring attachment and relatively advanced locator attachment system.

Five studies^{10,21–24} included in this systematic review compared prosthodontic complications/maintenance in which 3 studies^{21,23,24} showed similar result and concluded that locator attachment system experienced lesser complications than ball attachment while only one study¹⁰ gave contrast results to above and another one²² study provides insignificant results. Similar to above findings, Clinical studies have discussed that overdentures retained by ball attachments had more complications and needed more maintenance than locator attachments. This is because of the frequent activation and replacement of matrix component to maintain retention.²⁹ Furthermore, the locator attachment can be used with minimal inter-arch space and low risk of denture base fracture occurs when compared with other attachment systems.^{30,31} Christophe Guédat et al.³² in a retrospective study investigated the maintenance of locator and reported that most common complication associated with locator attachment was loss of retention over time. It was concluded that modification of attachment design could reduce the wear.³² Sajji Upinder et al.³³ in an in vitro study compared the retentive force and wear patterns of ball and locator attachment upon cyclic loading. Locator overdenture attachment showed greater retention and longer function. Similar results were obtained in an in-vitro study by Tae-Yun-Kang³⁴ for the comparison of the changes in the retentive force of commonly used attachments. The initial retentive forces revealed the highest value for Locator. In contrast to

Table 5
Quality assessment according to CASP checklist (articles evaluating cost).

Questions	Cristache CM et al. ²⁴ ; 2014	Amr AN et al. ²⁷ ;2019
Was a well-defined problem constituted?	Yes (low)	Yes (low)
Was a comprehensive explanation of the competing substitute given?	Yes (low)	Yes (low)
Does the paper provide enough proof that the scheme would be productive?	Yes (low)	Yes (low)
Were the identification, measurement and valuation of the effects of the intervention done appropriately?	Yes (low)	Yes (low)
Were all relevant resources needed, and health outcome costs for each alternative identified, measured in appropriate units and valued credibly?	Can't tell (unclear)	Can't tell (unclear)
Were expenses and outcomes adjusted for different times at which they occurred?	Can't tell (unclear)	Can't tell (unclear)
What were the results of the evaluation?	Yes (low)	Yes (low)
Was an incremental analysis of the consequences and cost of alternatives performed?	No (high)	No (high)
Was an adequate sensitivity analysis performed?	No (high)	No (high)
Is the programme likely to be equally effective in your context or setting?	Yes (low)	Yes (low)
Are the costs translatable to your setting?	Can't tell (Unclear)	Can't tell (Unclear)
Is it worth doing in your setting?	Yes (low)	Yes (low)

above result Tejomaya Shastry et al.³⁵ in an in vitro study concluded that higher retentive force was found for the ball/o-ring and bar attachments compared to the locator attachment. Furthermore, Marco Tallarico et al.³⁶ in a multicentre retrospective study with a mean follow up period of 5 years found that locator attachments showed higher number of complications when compared to ball and equator attachment. Several finite element analysis^{37–39} showed that locator attachment required less repair/maintenance in comparison to ball attachments. Apart from the conventional retention the locator attachment provides extended range of retention based on the colour of nylon inserts (Extralight retention: blue, light retention: pink, and medium retention: transparent). These were used with the implant inclination of 0, 5, 10 and 20°. Extended range inserts (Extralight retention: red, and medium retention: green) are used only with the 20° implant inclination.

One clinical trial included in this systematic review evaluated patient's satisfaction in which six parameters were included to compare comfort ability, speech, chewing ability, stability, retention, and overall satisfaction in ball and equator attachment.¹⁴ Results showed no significant difference in the outcome between attachments. Similar results were found by Krennmair et al.⁴⁰ in a cross over clinical trial where results showed insignificant difference between ball or Locator attachment in terms of satisfaction assessed and neither attachment had a superior patient preference. In a systematic review by Chaware et al.⁴¹ where survival rate, tissue response, and patient satisfaction of different attachments were evaluated. In this study both the ball and locator attachments showed efficient patient satisfaction for mandibular overdentures.

4 studies^{10,20,25,26} included in this systematic review provided data for oral health impact profile (OHIP). All 4 studies, unequivocally concluded that self-aligning attachments are comparable to ball attachments in OHRQL and may be a better choice only in cases of minimal inter-occlusal space for attachment insertion. Also CM-LOC gives better results than ball attachment except in removal and insertion where it causes psychological discomfort. Similar results were obtained by Fayadd MI⁴² where no significant difference in patient oral health and quality of life was observed between locator and ball attachments. Contrarily to the above results, Swarup S et al.⁴³ in a cross-over study concluded that there is a significant improvement in the subjects OHRQL with the use of a ball attachment.

2 RCTs^{24,27} included in this systematic review evaluated cost effectiveness, after reviewing the studies the result obtained from one study shows that the total cost (initial as well as after cost) of the CM-LOC locator attachment was higher than the ball attachment while other one showed non significant difference between the two groups, after the 5-year evaluation. Contrarily to the above result Carine Matthys et al.⁴⁴ in a 5 year clinical follow up, analysed the cost-effectiveness of 2 different well-known attachment systems Dalbo (ball) and locator for mandibular 2IOD. The 2IOD on Locator (Legacy) was found to be more cost-effective.

4 clinical trial^{10,21,23,28} included in this study evaluated soft tissue parameters and periodontal complications. Out of 4, 2 studies compared pocket depth, plaque, bleeding and gingival index related to ball and locator attachments and the results were found to be statistically insignificant but overall, locator attachment showed less peri-implant tissue changes. Similar results were obtained by Shady et al.⁴⁵ where clinical parameters showed no significant differences between the two type of attachments with respect to gingival recession and pocket depth. In a systematic review done by Chaware and Thakkar⁴¹ where survival rate, tissue response, and patient satisfaction of different attachments were compared in which ball and locator attachments showed favourable soft tissue response (plaque and bleeding index) for mandibular overdentures. However 2 studies gave contrast result and reported that ball attachment suffered these problems greater than locator attachment in terms of mucosal enlargement, hygiene problem and soft tissue recession. Zakaria E. Radwan⁴³ concluded that locator attachment showed lowest plaque index score and probing depth than ball and magnet. However gingival bleeding scores showed no significant difference in between the groups. Overall locator attachment showed less peri-implant tissue changes.

One study²³ included in this systematic review observed bone loss around ball attachment to be greater than locator attachment. Similar results⁴⁶ were obtained in a study where bone loss around locator attachment was found least when compared with ball and magnet attachment. In contrast to the results of the present study no significant differences in bone loss were observed between both the ball and locator attachment group by Shady et al.⁴⁵ where clinical and radiographic parameters were compared between ball and locator attachment systems for mandibular implant-retained single overdenture. In another included study²² mean marginal bone loss was less around wider implant than regular one although it was not statistically significant.

4.1. Strength, limitations and future recommendations

We applied the predefined guidelines for conduction and reporting of this systematic review. This review focuses to cater the evidence regarding clinically relevant issues in implant prosthesis practice. In addition, sincere effort was made to perform transparent and unrestricted searches for all likely and worthy studies, were undertaken with thorough data on the review outcomes. Patient's satisfaction with the use of overdenture is high,⁴⁷ especially if the patient has had a past experience with complete dentures. However, other factors like chewing efficiency, bone loss and retention, also can influence patient preference and overall well-being. These factors must be considered by the dentist while deciding the treatment plan and for the selection of attachment system. Maintenance is a major problem for mandibular IODs, ranges from repair to replacement to fabrication of new the prosthesis.⁴⁸ Although, a similarity in the performance was observed for both the Locator and ball systems, the attachment selection is completely based

on particularity of each patient. There are some limitations to the present review mainly due to some RCTs presented with high to moderate risk of bias (Fig. 2) and methodological shortcomings (see Table 4 and 5). Furthermore, less number of studies were retrieved for the variables like marginal bone loss, patient perception, patient satisfaction towards the treatment, and cost effectiveness regarding the type of attachment system so that the results of this study regarding these variables have to be evaluated carefully. In addition, only one study was identified considering maxillary edentulous space for implant overdenture prosthesis, so that these results must not be generalized and contemplate carefully if maxillary arch is considered for prostheses. Results of this systematic review should not be generalized for a particular population, age, time of loading, single/bi/multiple implant overdentures, or follow-up period because there was presence of heterogeneity regarding these variables among included studies, therefore, high-quality randomized clinical trials to investigate the same issue involving different parameters and variables are necessary to be conducted in near future.

5. Conclusion

Based on the findings of this systematic review, the following conclusions were drawn:

1. Locator attachment system experienced lesser complications/maintenance than ball attachment. In addition, locator attachment can be used with reduced inter-occlusal space, having low risk of fracture than ball attachment.
2. Loss of retention was less observed during treatment with locator attachment while insignificant difference was noted between attachments regarding patient perception and overall satisfaction towards retention and stability.
3. Lesser soft tissue and periodontal complications along with less marginal bone loss were observed with locator attachment than ball attachment.
4. Ball attachment is cost-effective than locator attachment primarily depends upon number of complications arises and maintenance appointment taken to correct the same.
5. No significant difference was noted between locator and ball attachment system regarding OHIP, patient's perception, and overall satisfaction towards the treatment.
6. Still, result of this study should be generalized carefully; more number of low risk bias randomized clinical trials with sound methodological quality is needed to be conducted in near future to strengthen the evidence.

Author contributions

Neeteesh K. Shukla (NKS), Nimmi Gupta (NG) performed electronic and manual searches for the retrieval of the studies. NG and Rajesh Bansal (RB) screened articles for eligibility and performed data extraction from the selected studies. NG along with NKS assessed risk of bias in individual studies. NKS prepared the manuscript according to guidelines and finally all authors read and approved the final manuscript before submission.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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