The Influence of Patient-Related Factors and Material Selection on the Clinical Outcomes of Fixed and Removable Complete Implant Prostheses: An Overview on Systematic Reviews

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Purpose: To analyze the influence of material selection, attachment type, interarch space, and opposing dentition on the prosthetic outcomes of fixed and removable implant complete prostheses (FCIPs and RCIPs, respectively). ***Materials and Methods:*** This review was designed as an overview of systematic reviews. An electronic database search was performed to identify scientific literature that reported on FCIPs and RCIPs. The last search was performed in January 2020. The final inclusion of systematic reviews for data extraction was decided by consensus of the authors. The included studies were analyzed qualitatively. ***Results:*** A total of 21 systematic reviews (FCIP: n = 11, RCIP: n = 10) out of 5,733 articles initially identified were included for data extraction and interpretation. High overall 5-year and 10-year prosthesis survival rates were shown for FCIPs and RCIPs (93.3% to 100% and 96.9% to 100%, respectively). Chipping/fracture of the veneering material was the most frequent technical complication for FCIPs, and attachment-related complications were the main technical problems for RCIPs. For FCIPs, the effect of prosthetic material was not significant on the technical complications nor the survival rates. No studies were identified that provided direct information on the effect of interarch space in FCIPs and RCIPs. ***Conclusions:*** Both FCIPs and RCIPs obtained high overall survival rates, but technical complications cannot be avoided with either prosthesis type. No prosthetic material can be considered as the material of choice over another. Attachment type has no influence on the overall clinical outcomes of RCIPs. The influence of opposing dentition and the required prosthetic space were not investigated sufficiently. *Int J Prosthodont 2021;34(suppl):s46–s62. doi: 10.11607/ijp.7070*

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Complete dentures served as the primary treatment modality for rehabilitation of edentulism before the introduction of dental implants.[1] However, numerous disadvantages of complete dentures have been reported in the literature. Patient dissatisfaction due to discomfort during speech and impaired ability to chew were the main patient-reported limitations.[2] A decreased maximum bite force in individuals with complete dentures compared to dentate individuals has been objectively measured,[3–5] and increased residual ridge resorption was noted[6] in complete denture–wearing patients. These limitations were first counteracted with the use of fixed complete implant prostheses (FCIPs), and then with removable complete implant prostheses (RCIPs).[1] Implant-borne prostheses significantly improved patient comfort,[7] patient satisfaction, and oral health–related quality of life (OHRQoL),[8] as

reported in several reviews of the literature. Moreover, bone preservation[9] and biting forces[10] were reported to be significantly higher for edentulous patients rehabilitated with implant prostheses.

Regarding clinical performance, FCIPs and RCIPs have both elicited high prosthesis survival rates in edentulous patients. The 5-year prosthesis survival rates were reported to be 93.3% to 100%[11–15] for FCIPs and 96.9% to 100%[16,17] for RCIPs. Additionally, both types of prosthesis have shown similar results regarding preference during prosthesis selection and masticatory efficiency.[18–20] Accordingly, both FCIPs and RCIPs can be considered as favorable solutions for the prosthetic rehabilitation of edentulous patients based on survival rates and patient preference.

When deciding between a fixed or removable prosthesis for the rehabilitation of completely edentulous patients, there are numerous parameters to consider, such as patient-based esthetic requirements, hard and/or soft tissue status, and intermaxillary relationship. The most relevant esthetic factor is whether or not facial tissues, such as the lips and cheeks, need support. Furthermore, advanced hard and/or soft tissue resorption related to edentulism might lead to a need for complex augmentation procedures for fixed implant prostheses, which can potentially be avoided with RCIPs. Last, RCIPs are less favorable than fixed solutions for cases with limited prosthetic space.

Despite the high survival rates, prosthesis-related complications are reportedly inevitable for both FCIPs and RCIPs. However, a difference has been noted between the two types of restorations with regard to the incidence of prosthetic complications and maintenance needs. The complication rate and maintenance need for RCIPs were reported to be 4 to 10 times higher than for FCIPs.[21] Moreover, the likelihood of prosthetic complications for FCIPs was reported to be 70.7% after 5 years and 91.4% after 10 years.[22] Although avoiding prosthetic complications is unlikely,[22] complications can be minimized by identifying possible risk factors with careful clinical evaluation prior to treatment, comprehensive treatment planning, and, finally, appropriate execution.[22,23]

Once a fixed or removable option is selected, the next treatment planning decision is the specific features of the prosthesis, such as prosthetic material, fixation method between the implant and restoration for FICPs, and attachment type for RICPs. With the introduction of new manufacturing methods and technologies (such as CAD/CAM), treatment protocols and prosthetic materials have evolved significantly.[12,15] However, the influences of these new developments and materials have not been sufficiently reported in a comprehensive manner. Furthermore, the intermaxillary relationship and existing prosthetic space play important roles when deciding on a fixed vs removable prosthesis and other associated parameters, like prosthetic material or attachment system. Yet, not much information can be retrieved from the literature about the influence of these clinical patient-based factors on the clinical outcomes of complete implant prostheses. Hence, an in-depth analysis of these factors—namely, the necessary interarch space, the optimal prosthetic material, and the influence of opposing dentition—is needed for decision-making.

Therefore, this review aimed to evaluate the existing literature on the influences of material selection, attachment type, existing prosthetic space, and opposing dentition on the long-term clinical outcomes of FCIPs and RCIPs. In order to provide the highest level of evidence, this review was designed as an overview of systematic reviews, including the relevant literature on the topic of interest.

MATERIALS AND METHODS

This overview of systematic reviews aimed to analyze patient-related factors, such as prosthetic space and opposing dentition, as well as material-related factors. The Cochrane recommendations were followed for its design (https://methods.cochrane.org/cmi/overviews-of-reviews).

Focus Question

The focus question was structured by using the PICO (population, intervention, comparison, outcome) strategy:

- Population: Completely edentulous patients
- Intervention: Implant-supported full-arch fixed prosthesis
- Comparison: Implant-supported complete overdentures
- Outcome: Long-term prosthetic survival and complication rates, with outcome measures material selection, fixation type, attachment type, opposing dentition, and prosthetic space

Accordingly, the focus question of this present overview was: What are the influences of intermaxillary space, opposing dentition, and material selection on the long-term outcomes (ie, survival and complication rates) of FCIPs and RCIPs?

Search Strategy

An electronic database (MEDLINE/PubMed, Cochrane Library) search was performed to identify the scientific literature that reported on full-arch implant prostheses. The extracted data were divided into two groups: data related to FCIPs and data related to RCIPs. No search filters were applied, and the last search was performed in January 2020.

Search Terms

The following keywords were selected: edentulous mandible; edentulous maxilla; implant; full-arch; full arch; overdenture; fixed; removable; implant complete prosthesis; fixed complete prosthesis; and removable complete prosthesis. The combinations of the keywords were used as follows:

- (overdenture) AND implant
- (removable complete prosthesis) AND implant
- (fixed complete prosthesis) AND implant
- ((((removable) OR overdenture))) AND implant complete prosthesis
- (implant complete prosthesis) AND fixed
- ((((full-arch) OR full arch))) AND (((edentulous mandible) OR edentulous maxilla))
- ((((edentulous mandible) OR edentulous maxilla))) AND implant

Furthermore, a hand search was performed based on the included reviews' reference lists.

Eligibility Criteria

Systematic reviews (SRs) with or without meta-analyses were considered for inclusion if they involved information in the following categories with respect to FCIPs and RCIPs:

- Long-term prosthesis survival rates, as well as maintenance and/or technical complication rates
- Effect of prosthetic material on clinical outcomes of FCIPs
- Effect of attachment type (ie, free standing, bar) on clinical outcomes of RCIPs
- Required prosthetic space for different fixation (cement- or screw-retained) and attachment types
- Effect of opposing dentition on prosthetic clinical outcomes

Clinical prospective and retrospective studies, laboratory studies, and preclinical studies were excluded, as well as SRs in which the prosthetic clinical outcomes (survival and/or technical and mechanical complication rates) were not directly related to the outcome measures of the focus question (ie, the prosthetic material, attachment type for RCIPs, fixation type for FCIPs, opposing dentition, and prosthetic space).

Study Selection

A two-phase selection process was performed. In phase one, one reviewer (D.K.) screened the titles and abstracts in order to identify eligible SRs. The outcomes of this initial screening were reviewed and discussed by the reviewing team (D.K.; V.F.; M.L.; and I.S.).

In phase two, three reviewers (D.K.; V.F.; and I.S.) evaluated the eligible full-text articles. The final inclusion of an SR for data extraction was done by the consensus of these three reviewers.

Data Extraction

Data extraction was performed by two reviewers (D.K. and I.S.). The included reviews were divided into two categories: FCIPs and RCIPs.

Subsequently, subcategorization was done as follows:

- Reviews on FCIPs: prosthetic material, fixation type, opposing dentition
- Reviews on RCIPs: attachment type, opposing dentition, and prosthetic space

The data extracted also included information on authors, year of publication, number of included primary studies, patient and prosthesis characteristics, follow-up period, survival rates of the prostheses, main technical complication outcomes, and main conclusions of the SRs.

RESULTS

SR Selection

A total of 10,029 references were identified in the electronic database search, and 5,733 remained after removal of duplicates. After screening of titles and abstracts, 76 articles were eligible for full-text assessment. SRs in which the prosthetic clinical outcome was not relevant to the assessed parameters were excluded (n = 55); therefore, 21 SRs in total (11 reviews for FCIPs and 10 reviews for RCIPs) were included in the qualitative synthesis. The complete workflow for identification and selection is provided in Fig 1.

SR Characteristics

Overall, 11 SRs investigated the clinical outcomes of FCIPs associated with material (n = 7),[11–15,22,24] fixation type (screw- vs cement-retained; n = 3),[25–27] and opposing dentition (n = 1).[28] The FCIP SRs were published between 2011 and 2020 (Table 1). Ten SRs evaluated the clinical outcomes of RCIPs associated with attachment type (n = 9)[16,17,23,29–34] and opposing dentition (n = 1)[35] and were published between 2010 and 2018 (Table 2). No SR reporting on prosthetic space requirements for FCIPs or RCIPs was identified. Meta-analyses were performed in 9 of the 11 SRs investigating FCIPs[11,14,15,22,24–28] and in 6 of the 10 SRs investigating RCIPs.[16,17,31–34]

Fixed Complete Implant Prostheses

Eight reviews[11–15,26–28] reported on FCIP survival rate, and eight reviews[11–13,15,22,24–26] on technical complication rates (Table 1).

Prosthesis survival and technical complication rates

Prosthesis survival was defined if the prosthesis was still in situ with or without modification after the follow-up

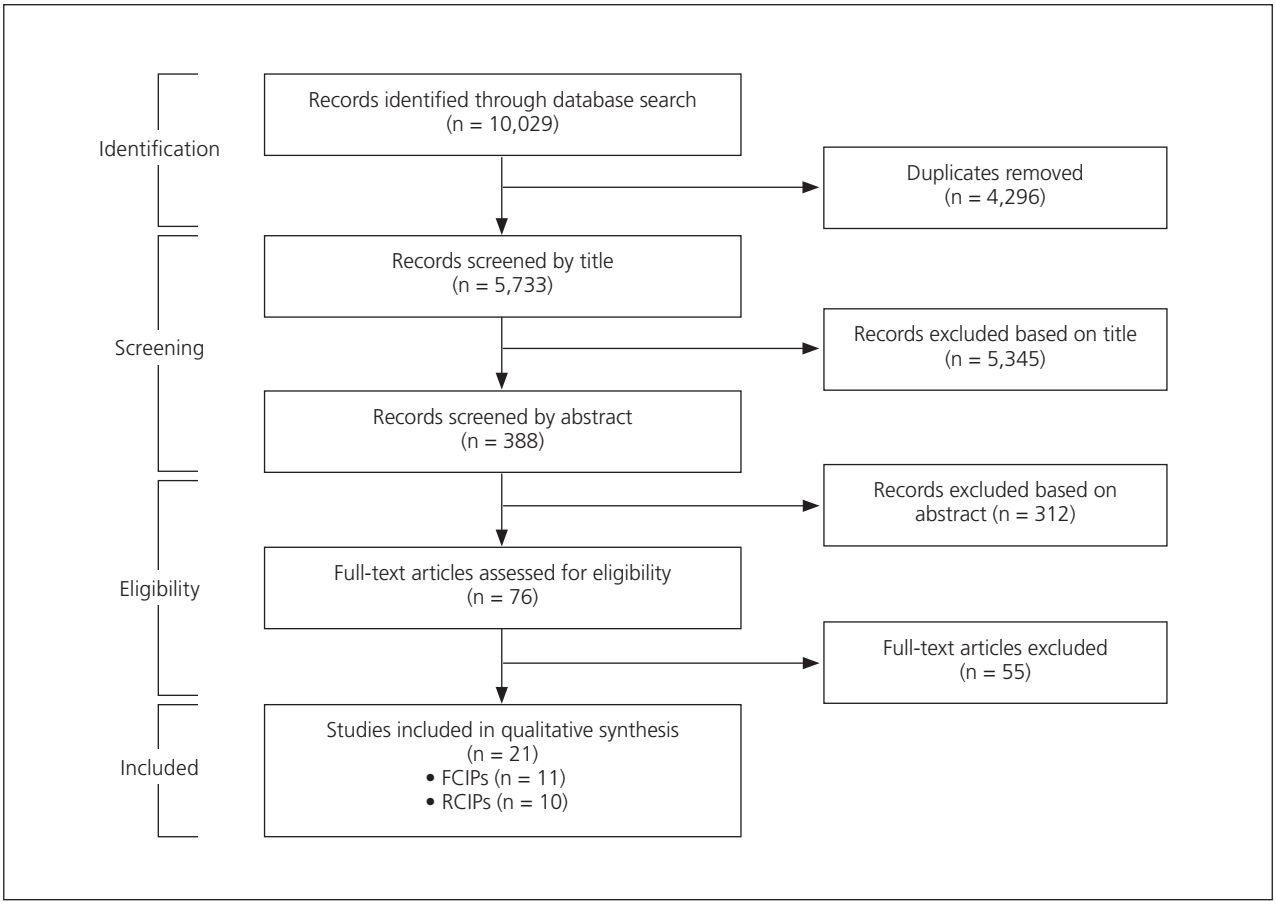

Fig 1 Flowchart according to the PRISMA guidelines.

period. High overall survival rates were reported for FCIPs. Metal-acrylic resin FCIPs have a longer focus in the literature and acquired high survival rates: Papaspyridakos et al[14] reported survival rates of 98.61% after an observation period of 5 years and 97.2% after an observation period of 10 years. Bagegni et al[11] reported a 98% survival rate for precious metal-acrylic resin FCIPs after 9.3 years and a 96% survival rate for nonprecious metal-acrylic resin FCIPs after 6.06 years. Kwon et al[13] reported survival rates of FCIPs as 93.3% to 100% between a period of 5 and 10 years and 82% to 100% over 10 years. Since the use of zirconium dioxide (ZrO_2) as a prosthetic material for FCIPs is relatively new, the follow-up periods and number of clinical studies are limited. Pieralli et al[15] reported an estimated 5-year survival rate of 97.7%, and Bidra et al[12] reported a 98.6% survival rate (4 failures out of 285 FCIPs). For metal-ceramic FCIPs, Papaspyridakos et al[14] reported an FCIP survival rate of 100% after 5 years and 100% after 10 years. Bagegni et al[11] reported a 96% survival rate for nonprecious metal-ceramic FCIPs after a mean follow-up period of 5.15 years.

Technical complications were reported as comprising both implant component–related complications (screw loosening, screw fracture, abutment fracture, implant fracture) and prosthesis-related complications (wear, decementation, veneering material chipping/fracture, framework fracture). While implant component–related complications were scarce,[12,15,22,24] prosthesis-related complications, particularly chipping of the veneering material, were reported to be the predominant technical complication for FCIPs,[12,13,15,22,24] occurring with an incidence rate between 8% and 34.8% over 5 years.[12,15,22] Furthermore, this problem was reported with an incidence rate of 66.6%[22] after 10 years and 70% after 15 years[24] for metal-acrylic resin FCIPs.

Material selection

The review by Bagegni et al[11] analyzed whether prosthetic material had an influence on the clinical outcomes of FICPs, and five types of prosthetic materials were identified: porcelain-fused-to–nonprecious alloys; porcelain-fused-to-ZrO_2; precious metal-acrylic resin; nonprecious metal-acrylic resin; and PMMA. The follow-up period of the 41 included studies ranged from 3 to 20

Table 1 Included Systematic Reviews on FCIPs

Study, y	No. and type of studies included	Publication period of included studies	Meta-analysis performed	No. of patients/ prostheses included	Arch	Follow-up period of included studies	Prosthetic material	Material characteristics
Prosthesis material								
Bozini et al,[24] 2011	19: 14 prospective, 5 retrospective	1990–2008	Yes	994/998	Both	5 y	Metal-acrylic resin	N/A
Papaspyridakos et al,[22] 2012	7: 6 prospective, 1 RCT	1996–2009	Yes	278/281 (1,957 implants)	Both	5–15 y (mean: 9.5 y)	Metal-acrylic resin	N/A
Papaspyridakos et al,[14] 2014	17 prospective	1997–2012	Yes	501/501 (2,827 implants)	Mandible	5 y	Metal-acrylic resin (93.6%), metal-ceramic (6.4%)	N/A
Kwon et al,[13] 2014	18: 10 prospective, 6 retrospective cohort	1995–2013	No	N/A	Both	5 y	Metal-acrylic resin	N/A
Bidra et al,[12] 2017	12: 3 prospective, 9 retrospective	2012–2016	No	223/285	Both	2 mo–8 y	Monolithic zirconia (1 study) Conventionally veneered zirconia (6 studies) Minimally veneered zirconia (veneering was restricted to the facial surfaces of anterior teeth and/or gingival region only) (5 studies)	NobelProcera Zirconia, Nobel Biocare (4 studies) Prettau Zirconia, Zirkonzahn (4 studies) Zirite, Kéramo Spa (1 study) Sagemax zirconia, Sagemax Bioceramics (1 study) Cercon, DeguDent (1 study) CeraCrown System, Oral Iceberg (1 study)
Pieralli et al,[15] 2018	7: 1 prospective, 6 retrospective	2012–2016	Yes	218/273	Both	1.7–5.6 y (mean: 3.1 y)	Veneered zirconia	NobelProcera Zirconia, Nobel Biocare (3 studies) ICE Zirkon Translucent, Zirkonzahn (1 study) Zirite, Kéramo Spa (1 study) Sagemax zirconia, Sagemax Bioceramics (1 study) CeraCrown System, Oral Iceberg (1 study)

N/A = not available; CR = complication rate.

Fixation type	Main outcomes: Technical complications	Main outcomes: Prosthesis survival	Main conclusions
Screw-retained	Veneer chipping/fracture: 5-y CR = 30.6%; 10-y CR = 51.9%; 15-y CR = 66.6% Material wear: 5-y CR = 17.3%; 10-y CR = 31.6%; 15-y CR = 43.5% Abutment screw loosening: 5-y CR = 4.7%; 10-y CR = 9.2%; 15-y CR = 9.2% Prosthetic screw loosening: 5-y CR = 5.3%; 10-y CR =10.3%; 15-y CR = 10.3% Prosthetic screw fracture: 5-y CR = 4.1%; 10-y CR = 8.0%; 15-y CR = 11.7% Abutment screw fracture: 5-y CR = 2.1%; 10-y CR = 4.3%; 15-y CR = 6.3%	N/A	The most frequent complication was veneer chipping/fracture. Almost half of the prostheses demonstrated material wear after 15 y. The abutment- or screw-related complications (screw loosening/fracture) were lower than prosthesis-related complications, still above 10% after 15-y follow-up.
Screw-retained	Veneer chipping/fracture: 5-y CR = 33.3%; 10-y CR = 66.6% Screw fracture: 5-y CR = 10.4%; 10-y CR = 20.8% Wear of acrylic resin teeth: 5-y CR = 10.0%; 10-y CR = 20.0% Screw loosening: 5-y CR = 9.3%; 10-y CR = 18.5%	N/A	The veneer fracture/chipping was the most frequent prosthetic complication. It was attributed to materials failure (accumulated fatigue, plastic deformation), prosthetic design issues (framework misfit, inadequate prosthetic space, excessive cantilevers), patient characteristics (parafunctional activity) and laboratory errors (casting errors, firing failures). Yet no correlation analysis performed.
94.4% screw-retained; 5.6% cement-retained	N/A	98.61% 5-y and 97.2% 10-y metal-acrylic resin; 100% 5-y and 100% for 10-y for metal-ceramic	The prosthetic design, the veneering materials and the retention type had no influence on the prosthetic survival rate. Even the prosthetic materials (metal-acrylic resin vs metal ceramic) had no statistical signifincant influence on FCIP survival, the number of included metal-ceramic FCIPs (469 metal-resin vs 32 metal-ceramic FCIPs) were too low to draw an accurate conclusion
N/A	The most common prosthetic complications 5 to10 y: fracture or loosening of abutments or prosthesis screws, fracture of acrylic resin suprastructures and fracture of acrylic resin teeth >10-y: fracture or loosening of abutment or prosthesis screws, fracture of acrylic resin suprastructure and fracture of acrylic resin teeth	93.3 to 100% 5-10y 82-100% > 10 y	Metal-acrylic resin FCIPs demonstrated high survival rates after 5 to 10 y, but long-term follow-up (> 10 y) could not be performed due to limited available literature.
N/A	16.1% of the total number of FCIPs (n = 49 out of 285) prosthetic complication, 14.7% chipping or fracture of the veneering porcelain (n = 42 out of 285), 0.7% fractured abutment, 0.7% abutment loosening	98.6%	One-piece zirconia fixed complete dentures had a very low failure rate in the short term, but a substantial rate of chipping of porcelain veneer. Reduced prosthetic space was associated with all fractures.
Screw-retained	Estimated chipping rate after 5 y: 34.8%. Other technical complications (screw loosening, de-cementations) were scarcely reported.	97.7% 5-y	Literature on all-ceramic FCIPs is limited to veneered zirconia restorations. The 5-y survival estimates of zirconia-based FCIPs are high. However, chipping of the ceramic veneer was observed frequently. Clinical recommendations on alternative monolithic ZrO2 FCIPs cannot yet be made due to lack of data.

Table 1 Included Systematic Reviews on FCIPs *(continued)*

Study, y	No. and type of studies included	Publication period of included studies	Meta-analysis performed	No. of patients/ prostheses included	Arch	Follow-up period of included studies	Prosthetic material	Material characteristics
Bagegni et al,[11] 2019	41: 2 RCTs; 22 prospective, 17 retrospective	1994–2016	Yes	1,722/1,656 (4 studies did not report the number of prostheses)	Both	3–20 y Porcelain-fused-to zirconia mean: 3.6 y Metal-acrylic resin mean: 9.3 y Nonprecious acrylic resin mean: 6.06 y Nonprecious metal-ceramic mean: 5.15 y PMMA mean: 3 y	Porcelain-fused-to–non-precious alloy, porcelain-fused-to-zirconia, precious metal-acrylic resin, nonprecious metal-acrylic resin, PMMA	N/A
Fixation type								
Sailer et al,[26] 2012	15: 2 RCTs, 10 prospective, 3 retrospective	2000–2011	Yes	681 FCIPs (patients NR)	Both	Cement-retained mean: 1.4 y Screw-retained mean: 6.1 y	Various	N/A
Wittneben et al,[27] 2014	22: NR	–	Yes	928 FCIPs	Both	Mean: 7.46 y	Various	N/A
Millen et al,[25] 2015	16 studies: NR	–	Yes	928 FCIPs	Both	Mean: 6.5 y	Various	N/A
Opposing dentition								
Carneiro-Campos et al,[28] 2020	6: 2 prospective, 4 retrospective	2004–2017	Yes	404 FCIPs	Mandible	12–84 mo	Metal-acrylic resin	Framework characteristics: Novum titanium (50) CAD/CAM titanium (237) Cast titanium (45) Prefabricated titanium milled bar (51) Cobalt-chromium (16) Cast in gold alloy (5)

N/A = not available; CR = complication rate; NR = not reported; PMMA = polymethyl methacrylate.

years.[11] Prosthetic survival rates were 98% for porcelain-fused-to-ZrO_2 (observation period of 3.6 years); 98% for precious metal-acrylic resin (gold; observation period of 9.3 years); 96% for nonprecious metal-acrylic resin (observation period of 6.06 years); 96% for nonprecious metal-ceramic (observation period of 5.15 years), and 98% for the all-resin group (observation period of 3 years). No statistically significant difference was found between the groups.[11] The most common technical complication for all prosthetic material groups was chipping.[11] Metal-resin demonstrated a 22% chipping rate, which was the highest chipping rate among all prosthetic materials. The chipping rate for metal-ceramic was 8%, and for all-ceramic was 15%. There was a trend for higher chipping rates for metal-acrylic resin FCIPs compared to metal-ceramic FCIPs, but this trend was not significant.[11]

Two included reviews investigated solely metal-resin FCIPs.[13,24] The survival rates were reported by Kwon et al as ranging between 93.3% and 100% for FCIPs based on 18 studies with a follow-up period of 5 to 10 years.[13] Bozini et al[24] included 19 studies and reported only technical complication rates for FCIPs. All restorations were screw-retained. Resin tooth fracture/wear was the

Fixation type	Main outcomes: Technical complications	Main outcomes: Prosthesis survival	Main conclusions
N/A	Chipping: 8% for metal-ceramic, 15% for all-ceramic, 22% for metal-acrylic decementation: 11% for metal-ceramic, 2% for all-ceramic; screw loosening: 3% for metal-ceramic, 4% for all-ceramic, 7% for metal-acrylic	96% nonprecious metal-ceramic, 98% for porcelain fused to zirconia, 98% for precious metal-acrylic resin, 96% for non-precious metal-acrylic resin, 98% for PMMA	No statistically significant difference in prosthesis survival was found between the different prosthetic materials. The CRs (screw loosening, decementation, chipping) showed no statistically significant difference between the different prosthetic material groups.
Screw-retained (631 FCIPs) vs cement-retained (50 FCIPs)	Estimated 5-y total complication rate: screw-retained 54.1%; cement-retained 62.9%, estimated 5-year screw loosening rate: screw-retained 9.4%; cement-retained 3.1%, estimated 5-year screw fracture rate: screw-retained 6.6 %; cement-retained 0%, estimated 5-y chipping rate: screw-retained 23.3%; cement-retained 67.4%	5-y: 100% (88.9% to 100%) cement-retained FCIPs; 95.8% (91.9% to 97.9%) screw-retained FCIPs	No retention type can be considered superior over another. Screw retention is recommended for FCIPs since the retrievability is an important advantage when the reparation of any technical complication is required.
Screw-retained (922 FCIPs) vs. cement-retained (6 FCIPs)	N/A	5-y: 96.71%	Due to a low number of studies with cement-retained FCIPs, no comparison with screw-retained FCIPs was possible.
Screw-retained	Estimated overall prosthetic complication rate per 100 years is 19.44. Resin chipping/or fracture rate per 100 years is 10.04. Fracture and/or chipping rate is 8.95	N/A	The rate of veneer chipping was notably high for screw-retained FCIPs. The prosthesis and retention type had more effect than prosthesis material on technical complication rates.
N/A	N/A	The prevalence of FCIP failures when in opposition to natural dentition was 5.4%, 4.9% for the removable partial dentures, and 14.0% for FCIPs. When removable partial dentures and RCIP maxillary dentitions were individually compared with natural dentitions, the results showed no differences in relation to the survival rate.	With a moderate certainty of evidence, FCIPs opposed by natural maxillary dentitions do not have different survival rates than with other opposing prosthetic designs.

major complication with a rate of 70% after 15 years, followed by 15% for prosthetic screw loosening, 13.4% for abutment screw loosening, 11.7% for prosthetic screw fracture, 8.8% for framework fracture, and 6.3% for abutment screw fracture.[24] Evaluating potentially relevant factors that might influence complication rates, such as fixation type and opposing dentition, was not possible due to poor reporting, and no cement-retained restorations were investigated in the included primary studies.[24]

Two included SRs investigated both metal-ceramic and metal-resin FCIPs. In 2012, Papaspyridakos et al[22] conducted a review focusing on biologic and technical complications of FCIPs, including 7 studies (1 metal-ceramic and 6 metal-acrylic resin) with a mean follow-up time of 9.5 years. The difference in complication rates between the two different restorative materials was not reported.[22] Chipping or fracture of the veneering material was 33.3% after 5 years and 66.6% after 10 years. It was reported that the percentage of prostheses free of complications was only 29.3% after 5 years and 8.6% after 10 years.[22] An overall complication rate of 24.6% was estimated per 100 restorations/year. Another frequent technical complication was screw

Table 2 Included Systematic Reviews on RCIPs

Study, y	No. and type of included studies	Publication period of included studies	Meta-analysis performed	No. of patients/ prostheses included	Follow-up period of included studies	Attachment type	Arch	No. of supporting Implants per arch
Attachment type								
Slot et al,[17] 2010	31: 2 RCTs, 11 prospective, 18 restrospective	1992–2009	Yes	796 patients	12–180 mo	Bar attachment (29 studies) Ball attachment (10 studies)	Maxilla	2–8
Andreiotelli et al,[29] 2010	18: 4 RCTs, 14 prospective	1994–2008	No	957 patients	5–19 y	Bar attachment (15 studies) Telescopic attachment (1 study) Magnet attachment (3 studies) Ball attachment (5 studies)	Maxilla (3 studies) Mandible (15 studies)	1–6
Cehreli et al,[31] 2010	49: NR	1997–2008	Yes	2,583 patients	1–20 y	Ball attachment (10 studies/1-y follow-up; 14 studies/1–5-y follow-up; 2 studies > 5-y follow-up) Bar attachment (8 studies/< 1 y; 20 studies/1–5 y; 5 studies/> 5 y) Magnet attachment (1 study/< 1 y; 6 studies/1–5 y) Other attachments (ie, bar with Ceka Revax, milled gold bar with 4 Ceka attachments, cast gold cylinder and cementable copings, cast gold bar with ball attachments and no extension) (1 study/< 1 y; 4 studies/1–5 y; 3 studies/> 5 y)	Maxilla (5 studies) Mandible (36 studies) Both (5 studies) N/A (1 study)	1–8
Osman et al,[23] 2012	18: 8 prospective, 10 retrospective	1991–2010	No	498 patients	3 mo–10 y	Bar attachment (18 studies) Telescopic attachment (1 study) Magnet attachment (2 studies) Ball attachment (5 studies)	Maxilla	2–10
Raghoebar et al,[16] 2014	24: 4 RCTs, 20 prospective	1992–2014	Yes	406 patients	1–12 y	Bar attachment (25 studies) Ball attachment (2 studies) Telescopic attachment (1 study) Locator attachment (1 study)	Maxilla	2–8
Assaf et al,[30] 2017	29: 14 RCTs, 8 prospective, 3 retrospective, 4 systematic reviews	2004–2015	No	1,567 patients	1–15 y	Bar attachment (8 studies) Ball attachment (12 studies) Magnet attachment (2 studies) Locator attachment (5 studies)	Mandible	2–6

N/A = not available; ND = natural dentition; IS/TS = implant-supported/tooth-supported FPD.

Opposing dentition	Main outcomes: Technical complications	Main outcomes: Prosthesis survival	Main conclusions
N/A (13 studies) All kinds of opposing dentition (18 studies) RCIPs (1 study)	N/A	≥ 6 implants and bar attachment: 97.4% per y ≤ 4 implants and bar attachment: 96.5% per y	6-implant–supported maxillary RCIPs with a bar attachment showed the highest survival rates, followed by RCIPs with 4 implants and a bar attachment, and 4 or fewer implants with ball attachment.
N/A	Bar attachments with distal extensions are more prone to fracture. Rigid bars demonstrated lower complication rates than resilient bars. Maxillary RCIPs without palatal coverage had higher incidence of mechanical problems compared to mandibular RCIPs. Regardless of the anchorage system, the major complication in maxillary RCIPs was matrix loosening or fracture.	N/A	A higher frequency of prosthetic complications exists for maxillary RCIPs compared to mandibular RCIPs.
N/A	Technical complications in mandible/maxilla/both arches showed no significant change in the time intervals studied. More matrix replacements after 5 y vs the first year in the both-arches group. More matrix replacements and patrix fractures between 1 and 5 y and at > 5 y vs the first year in the mandible group. Comparative evaluations of the arches treated showed that time-dependent prosthetic outcomes for the mandible, maxilla, and both arches were similar. The technical complications for all types of attachments were comparable. Among the attachment systems evaluated, the only detected difference was that a dislodged, worn, or loose matrix or its respective housing was more common after the first year with ball retainers. The frequencies of fractures, relines, and renewal of RCIPs were similar in the time intervals studied.	N/A	Technical complication rates are similar for maxillary and mandibular RCIPs during the first y, 1 to 5 y, and after 5 y of function. The type of attachment system used has no effect on the prosthetic outcome of RCIPs during the first y, 1 to 5 y, and after 5 y of function.
N/A (10 studies) ND (7 studies) RPD (5 studies) FCIP (2 studies) ND + TSFPD (5 studies) ND + ISFPD (3 studies) RCIP (7 studies) RCTP (1 study) CD (3 studies)	Adjustment or repair of loosened/fractured matrices of attachment systems dominated the identified studies. RCIPs with cantilevered bars showed higher failure rates. Reduced palatal coverage and absence of metal reinforcement was a contributing factor for higher denture base complications.	N/A	Maintenance need of attachment systems and denture adjustments were the most frequently encountered postoperative maintenance requirements. Prosthodontic maintenance requirements of maxillary overdentures are a direct consequence of the attachment system, together with number and distribution of implants.
N/A	N/A	≥ 6 implants and bar attachment: 99.5% per y ≤ 4 implants and bar attachment: 96.9% per y ≤ 4 implants and free-standing attachment: 98.8% per y	Maxillary RCIPs (≥ 4 implants in all studies) with a bar attachment have high implant and prosthesis survival rates.
N/A (3 studies) ND (1 study) RPD (4 studies) FCIP (1 study) ND + TSFPD or ISFPDs (3 studies) RCIP (2 studies) CD (18 studies)	Adjustments to the RCIP attachment complications (regardless of the attachment system) were the most common problem. Higher rate of RCIP fracture was observed when the denture base was not reinforced. Bar-retained mandibular RCIPs possess a high success rate, estimated to be up to 100% for periods over 10 years. Rigid bars showed a significantly lower incidence rate of technical complication rates than resilient bars. Systems with round bars suffered 3 times more complications than systems with milled bars.	N/A	Attachment type seemed to have no clear effect on the clinical outcomes of RCIPs.

Table 2 Included Systematic Reviews on RCIPs *(continued)*

Study, y	No. and type of included studies	Publication period of included studies	Meta-analysis performed	No. of patients/ prostheses included	Follow-up period of included studies	Attachment type	Arch	No. of supporting implants per arch
Keshk et al,[32] 2017	4 RCTs (2 RCTs reported on same patient group and were considered as one)	2006–2016	Yes	126 patients	3–5 y	Telescopic attachment (3 studies) Ball attachment (2 studies) Bar attachment (1 study)	Mandible	2–4
Leão et al,[33] 2018	9: 5 RCTs, 3 prospective, 1 crossover	2000–2016	Yes	380 patients	9–120 mo	Bar attachment (191 RCIPs) Free-standing attachment (196 RCIPs) Ball attachment (162 RCIPs) Telescopic crown (22 RCIPs) Magnet attachment (12 RCIPs)	Mandible	2–4
Payne et al,[34] 2018	6 RCTs	1999–2017	Yes	294 RCIPs	2–10 y	Locator attachment (1 study) Telescopic attachment (1 study) Ball attachment (5 studies) Bar attachment (3 studies) Magnet attachment (3 studies)	Mandible	2
Opposing dentition								
Ohkubo and Baek,[35] 2010	20 studies: NR	1994–2009	No	868 mandibular RCIPs, 259 maxillary RCIPs	2–10 y	N/R	Maxilla (10 studies) Mandible (10 studies)	2–4 implants per mandible, 2–7 implants per maxilla

N/A = not available; ND = natural dentition; IS/TS = implant-supported/tooth-supported FPD; NR = not reported.

loosening, with a reported complication rate of 10.4% after 5 years and 20.8% after 10 years.[22] Screw fracture occurred at an annual rate of 1.9% (6 studies reported 37 out of 1,713 implants), which translated to a 5-year complication rate of 9.3% and a 10-year complication rate of 18.5%.[22] Prosthesis-related complication rates, namely chipping/fracture, were reported to be 6.7% for 1 year, 33.3% for 5 years, and 66.6% for 10 years. Moreover, in 3 studies, 16 out of 153 prostheses were reported to have framework fracture, with a 5-year rate of 4.9% and a 10-year rate of 9.8%.[22] The other review reporting the survival rates of metal-ceramic and metal-resin prostheses included 17 studies with 501 prostheses/patients.[14] The cumulative survival rates were 98.61% for 5 years and 97.25% for 10 years. The authors suggested that the prosthetic design, veneering material, and retention type had no influence on the prosthodontic survival rates.[14]

Two recent SRs assessed the clinical outcomes of ZrO_2 FCIPs.[12,15] Pieralli et al included 7 studies investigating veneered ZrO_2 FCIPs with a follow-up period of 1.7 to 5.6 years, reporting a 5-year estimated survival rate of 97.7%. The most common complication was chipping at a rate of 34.8%.[15] Bidra et al[12] reported comparable survival rates for all-ceramic FCIPs. The survival rate was reported as 98.6%, and the overall technical

Opposing dentition	Main outcomes: Technical complications	Main outcomes: Prosthesis survival	Main conclusions
N/A	Prosthetic maintenance (ie, fracture/remake, reline/rebase) and attachment system maintenance (ie, retention loss, fracture, matrix activation, matrix replacement, patrix activation, patrix replacement) needs were similar based on a meta-analysis (comparing telescopic and ball attachments only). Based on one included RCT, the bar and telescopic attachments had similar maintenance need outcomes. However, telescopic attachment problems were reported to be more difficult to handle.	N/A	The meta-analysis revealed no significant differences regarding prosthodontic maintenance when comparing telescopic attachments to ball attachments.
N/A	The most frequent complications in the splinted group included clip fracture and rebasing of the denture. In the free-standing group, the main complication was fracture of the teeth of the prosthesis. The meta-analysis revealed no statistically significant difference between the splinted and free-standing groups.	N/A	The splinted and free-standing RCIP attachment systems achieved similar results with regard to marginal bone loss, implant survival rate, and technical complication rate.
N/A	No meta-analysis was performed to compare ball and bar attachments due to substantial heterogeneity. The need for repair of attachment system was higher with ball attachments in the short term, and there was no difference in the need for replacement of the attachment system. It is uncertain whether there is a difference in short-term prosthodontic outcomes when ball and bar attachments are compared. One trial provided data for ball vs telescopic attachments and reported no difference in prosthodontic maintenance between the two systems for short-term patrix replacement, matrix activation, matrix replacement, or in relining of the RCIP. It is uncertain whether there is a difference in short-term prosthodontic maintenance when ball and telescopic attachments are compared.	N/A	In the short term, it was not possible to determine any preferred attachment system for mandibular over dentures, whereas in the long term, the evidence was insufficient for analysis. For maxillary overdentures, there is no evidence to determine the relative effect of different attachment systems on prosthodontic success or prosthodontic maintenance.
ND (20 studies) RPD (6 studies) FCIP (8 studies) ND + TSFPD or ISFPDs (5 studies) RCIP (9 studies) RCTPs (1 study) CD (17 studies)	Even though the included studies that investigated the maxillary and mandibular RCIPs reported detailed information of the opposing dentition, the relationship between the opposing dentition and clinical outcome was not analyzed. Except for one study in which the existing mandibular ND negatively influenced the implant and prosthetic survival rates for maxillary RCIPs, no study directly compared different dentitions opposing the RCIPs.	N/A	The existing literature is insufficient to report any correlation between the clinical outcome (ie, implant survival, RCIP survival, complication rate) and the opposing dentition.

complication rate as 16.1%[12] based on 12 included studies. Moreover, it was stated that 3 of the studies reporting chipping stated that the complication was related to the limited prosthetic space.[12] Furthermore, both SRs stated that there is a need for long-term clinical studies for all-ceramic FCIPs before they can be seen as a reliable prosthetic material for rehabilitation of the edentulous jaw.[12,15]

Fixation type

In a comprehensive SR comparing screw-retained and cement-retained FCIPs, Sailer et al[26] included 59 studies, 16 of which reported data on FCIPs. Out of 681 FCIPs, 50 were cemented and 631 were screw-retained; the follow-up periods were 1.4 years and 6.1 years, respectively. The 5-year survival rates were estimated to be 88.9% to 100% for cement-retained FCIPs and 91.9% to 97.9% for screw-retained FCIPs. No statistical difference in survival rate was reported between the two fixation types.[26] However, a trend of fewer total technical complications was observed for the cement-retained prostheses compared to the screw-retained ones.[26]

The 5-year survival rate of screw-retained FCIPs was reported as 96.71% in an SR by Wittneben et al[27] in which screw-retained prostheses exhibited fewer technical and biologic complications compared to cement-retained

prostheses overall. Moreover, the prosthesis type (single crown, FDPs, or FCIPs) did not play a significant role regarding survival rate. In an SR by Millen et al[25] on 16 studies and 928 screw-retained FCIPs, the overall prosthetic complication rate per 100 years was estimated to be 19.44%. The rate for resin chipping and/or fracture was 10.04%, and for prosthesis fracture and/or chipping was 8.95%.[25] The chipping rate was notably high, but due to lack of eligible studies on cement-retained FCIPs for inclusion, no data on cement-retained FCIPs were presented, and therefore no comparison was performed between screw- and cement-retained FCIPs.[25]

Opposing dentition and prosthetic space

Only one SR reporting on the effect of opposing dentition on the clinical outcomes of FCIPs was identified.[28] The analysis was done for a total of 404 mandibular FCIPs, for which the opposing dentition was reported for only 385 FCIPs: 112 FCIPs opposed to a maxillary natural dentition, 204 FCIPs opposing maxillary RPDs, and 69 FCIPs opposing maxillary RCIPs. The failure rate for FCIPs opposing natural dentition was 5.4%, 4.9% for opposing RPDs, and 13.99% for opposing RCIPs.[28] No statistical differences were detected among the failure rates.[28] With a moderate certainty of evidence, opposing natural maxillary dentitions do not affect the long-term survival of FCIPs compared to other maxillary prosthetic designs, such as RPDs or RCIPs.[28]

No SR was identified that assessed the required prosthetic space. However, in the SR by Bidra et al,[12] the reason for failure of 4 out of 285 ZrO_2 FCIPs (1.4%) was restricted to 3 out of 12 studies in which the authors suggested that the failures were due to limited prosthetic space.

Removable Complete Implant Prostheses

Prosthesis survival and overall prosthetic maintenance/technical complication rates

The survival rates of maxillary RCIPs were reported in two of the included SRs. Slot et al[17] analyzed 31 studies including a total of 796 patients. In cases with six or more implants with a bar attachment, RCIPs demonstrated an annual survival rate of 97.4%. The survival rate was 96.5% per year for RCIPs supported by four or fewer implants with bar attachments.[17] In a more recent SR by Raghoebar et al,[16] 24 studies were included, and a 99.5% survival rate for maxillary RCIPs supported by six or more implants and a bar attachment was reported. For RCIPs with four or fewer implants and a bar attachment, the survival rate was 96.9%, and for RCIPs with four or less implants with nonsplinted attachments, the survival rate was 98.8% per year.[16]

Several authors attempted to suggest a standardized approach for reporting the prosthetic outcomes of RCIPs.[30] As a result, the need for follow-up care of RCIPs was defined as either complication or maintenance. Complications were considered as unexpected events (Table 3), whereas maintenance was defined as regular follow-up care (Table 4).[30] Nevertheless, a lack of standardized reporting was detected among the included SRs; accordingly, prosthetic events were addressed as technical complications in the present overview.

Attachment-related complications and need for repair, namely need for activation, replacement, or repositioning, were the most frequently encountered events for RCIPs in either the maxilla or mandible.[23,29–31] Cehreli et al,[31] who included 49 studies and 2,585 patients, reported technical complication rates for the time intervals of < 1 year, 1 to 5 years, and > 5 years for mandibular RCIPs with various attachment types. Matrix activation (< 1 year: 14.10%; 1 to 5 years: 20.85%; > 5 years: 46.50%); matrix replacement (< 1 year: 14.10%; 1 to 5 years: 20.87%; > 5 years: 57.50%); matrix loss, wear, or displacement (< 1 year: 7.50%; 1 to 5 years: 20.43%, > 5 years: 12%); and need for rebase (< 1 year: 10.64%; 1 to 5 years: 11.44%; > 5 years: 14.80%) were the most frequent technical complications.[31] Matrix replacement need for both arches was more common for > 5 years compared to < 5 years of function. The frequency of matrix replacement for both arches was significantly different between the < 1 year (14.10%) and > 5 year (57.50%) intervals.[31]

Four of the included SRs reported on the technical outcomes of mandibular RCIPs,[30,32–34] one reported on maxillary RCIPs,[23] and two reported both arches.[29,31,35] Andreiotelli et al[29] reported a higher incidence of technical complications with RCIPs in the maxilla compared to those in the mandible. The difference was attributed to a number of factors. Complete edentulism has been shown to occur earlier and more frequently in the maxilla than in the mandible (40% vs 27%, respectively)[36]; hence, maxillary RCIPs are opposed by a fixed dentition more often than mandibular RCIPs.[36] Moreover, maxillary implants are usually angulated more facially, and the teeth are arranged anterior and inferior to the residual ridge. This less-than-ideal implant positioning and the anatomical differences may make maxillary overdentures subject to more unfavorable loads.[29] Finally, it was suggested that vertical prosthetic space can be more limited in cases of maxillary edentulism. However, no meta-analysis was performed,[29] and the results contradicted a meta-analysis from the SR by Cehreli et al,[31] which showed that maxillary and mandibular RCIPs demonstrated similar overall complication rates and complication rates for the different follow-up intervals (< 1 year, 1 to 5 years, > 5 years).[31]

Attachment type

Various attachment types from numerous manufacturers are available for RCIPs. They can be classified into two main groups: free-standing attachments and splinted attachments. The free-standing attachments are stud

Table 3 Possible Prosthetic Complications of RCIPs

Complication type	Component definition
Patrix loosening	The "patrix" refers to bars/superstructures, free-standing attachments, and/or their components, such as screws.
Patrix activation	
Patrix replacement	
Patrix fracture	
Matrix dislodging, wear, or loosening	The "matrix" refers to O-ring, resilient cap, and magnet attachments, as well as all types of metal alloy or plastic bar clips (single sleeve or multiple sleeve) and the permanent resilient lining material connecting the inner abutment and cantilevered bars/superstructures.
Matrix activation	
Matrix replacement	
Matrix fracture	
RCIP fracture	Fracture of acrylic resin or fractured denture teeth.
Reline of RCIPs	–

Table 4 Examples of Prosthetic Maintenance of RCIPs

Prophylaxis, minor occlusal or anatomical corrections, polishing
Prosthesis screw tightening or replacement not more than once a year after the first year
Activation, repair, and/or replacement of either the matrix or patrix not more than two times in the first year and a maximum of five times in 5 years
Denture relining not more than once in 5 years

attachments—such as ball, Locator, or telescopic—and magnets. Splinted attachments are also known as bar attachments and are mainly classified as flexible or rigid bars.

The effect of attachment type on the clinical outcomes of RCIPs has been studied in various SRs.[16,17,23,29,30,32–34] In regard to the survival rates of maxillary RCIPs, Slot et al[17] reported significantly better results with four-implant–supported RCIPs with bar attachments compared to four-implant–supported RCIPs with ball attachments. Also, Raghoebar et al[16] stated that maxillary RCIPs supported by four or more implants with splinted attachments are accompanied by higher implant and RCIP survival rates compared to RCIPs supported by 4 or fewer implants and free-standing anchorage.

In a recent SR and meta-analysis on mandibular RCIPs, Leão et al[33] reported that splinted and free-standing attachments showed no statistical difference regarding prosthetic complications. Nonetheless, the observed complication types were different. Clip and RCIP fracture were more common with bar attachments, whereas free-standing attachments and ball attachments demonstrated more need for matrix change and deformation of the plastic components.[33] Moreover, the complications were different between resilient (Dolder) and rigid (milled) bar designs.[33] Fewer interventions were needed when using rigid anchorage with milled bars and metal-reinforced four-implant–supported RCIPs compared to resilient stabilization provided from round bars for RCIPs, but no difference was detected for two-implant–supported RCIPs.[29,30] This event is related to the capability of the rigid anchors to limit the movement and rotation of the RCIPs, therefore reducing the wear of the attachments. Moreover, a higher need for relines was observed with free-rotation designs.[30] Cantilever extensions of bar attachments were also addressed as a contributing factor for increased technical complications.[23]

Keshk et al[32] investigated the technical complication rates of telescopic attachments compared to ball and bar attachments. Based on their meta-analysis, no statistical difference was reported between telescopic and ball attachments with respect to the technical complication rates for matrix activation, matrix replacement, patrix replacement, overdenture relining, and overdenture remake.[32] Moreover, only one of the included studies investigated a comparison between telescopic attachments and bar attachments. Telescopic attachments demonstrated a smaller number of complications compared to milled bars[32]; however, it was stated that

the process is highly technique sensitive for telescopic attachments compared to any other attachment type.[32]

The findings of the comprehensive review by Cehreli et al[31] evaluated the complications of both maxillary and mandibular RCIPs based on 49 studies, and attachment system had no effect on the incidence of technical complications. Similarly, a recent Cochrane review by Payne et al[37] based on 294 mandibular RCIPs reported no influence of different attachment systems on prosthodontic success or prosthodontic maintenance. Ball attachments showed higher short-term need for repair requirement compared to bar attachments; however, it was stated that the quality of the evidence was low.[37] Hence, it was not possible to identify any preferred attachment system for mandibular RCIPs.

Opposing dentition and prosthetic space

In general, more vertical and horizontal prosthetic space is needed for components supporting RCIPs than for fixed restorations. In cases when RCIPs are considered as a treatment option, the arches should accommodate enough space for the attachment, the housings/bar clips, and the prosthesis thickness.[38] Lack of sufficient prosthetic space will lead to inadequate dimensions of both the attachments and the prosthesis. However, an evidence-based definition of sufficient prosthetic space, or a direct correlation between insufficient interarch space and clinical outcomes of RCIPs, are not possible at present. Nonetheless, there were efforts to calculate the required minimum vertical prosthetic space. Andreiotelli et al[29] suggested a minimum vertical distance from the implant platform level to the incisal edge of the RCIP of 13 to 14 mm for bar attachments and 10 to 11 mm for free-standing attachments. Moreover, the vertical space requirement was reported to be highest for bar attachments, followed by telescopic attachments and then ball and magnet attachments.[29]

The relationship between technical complications and opposing arch characteristics was investigated by only one SR[35] including 20 clinical studies (10 on maxillary RCIPs and 10 on mandibular RCIPs). Although information on opposing dentition was included, no attempts were made to correlate it with technical complications. Standardized reporting of opposing dentition is lacking in the literature, but possible antagonists include natural dentition, complete denture, RPD, FCIP, RCIP, natural dentition + implant-supported FPD, and natural dentition + tooth-supported FPD. Also, Osman et al[23] reported that denture base fracture of maxillary prostheses increased when the natural dentition was present as a counterpart, especially in cases of reduced palatal coverage and absence of metal reinforcement.

DISCUSSION

This overview aimed to investigate the clinical outcomes of FCIPs and RCIPs with respect to prosthetic survival rates and technical complication rates. An in-depth analysis of SRs was performed to identify the factors that can cause or increase the rate of failure/technical complications. There is a consensus in the existing literature focusing on complete implant prostheses, either fixed or removable, that while prosthesis survival rates are high for short-term[11,17] and long-term[11,13,14] follow-up periods, technical complications are unavoidable for both types of prosthesis.[12–15,22–24,29,31–33] Accordingly, it was widely recommended that there should be a focus on reducing and minimizing complication rates.[22] In this context, analyzing the existing evidence on the probable causes of technical complications is highly important. These factors can be related to the prosthetic material, the attachment/fixation type, the interarch space, and, finally, the opposing dentition. Despite SRs reporting extensively on survival and complication rates, multivariate analysis of prosthetic characteristics is mostly lacking due to multiple interacting factors and differences in reporting.

Although the use of metal-based prosthetic materials for FCIPs has a longer history in the literature, high-strength ceramics are becoming widely used. Although clinical outcomes have proven to be similar for all types of prosthetic materials,[11] it should be kept in mind that the follow-up periods for ZrO_2 FCIPs are limited (up to 8 years) compared to conventional FCIP prosthetic materials (ie, metal-acrylic resin).[11] Furthermore, reports on the clinical requirements for different prosthetic materials namely identify prosthetic space, and information on the influence of the opposing dentition is lacking. Better quantification and documentation of all possible parameters are therefore required to improve treatment and objective guidelines for a follow-up protocol.

Screw-retained FCIPs have a tendency to show more technical complications than cement-retained FCIPs.[26] However, because FCIPs are more prone to technical complications compared to FDPs and single crowns,[26] screw retention is recommended for FCIPs due to the retrievability.[26] Moreover, all-ceramic materials showed higher complication rates[26] when used with screw retention, especially when the material thickness was insufficient.

One included SR focused on the influence of the opposing dentition on FCIP survival and found no significant differences between the survival rates of FCIPs opposing the natural dentition, an RPD, or an RCIP.[28] However, FCIPs were pooled for different types of prosthetic material as well as for fixation type. Moreover, the possible influence on technical complication rates of opposing natural dentition was not analyzed.[28]

Clinical outcomes of RCIPs retained by different attachment systems have been widely reported. Similar survival rates were reported for splinted and free-standing attachment systems;[33] however, the technical complication types differed. Each attachment system comes with clinical prerequisites and different indications. Existing prosthetic space, interimplant distance, implant position and angulation, and number of implants can be considered as factors that dictate the implant attachment of preference.[39,40] When ill-positioned implants are combined with free-standing attachments, the insertion path and fit will not be optimal, which may result in a higher incidence of need for matrix change or patrix wear. In cases of misangulated implants, bar attachments are preferred to correct the axis deviations and achieve better insertion.[41] Rather interestingly, the factors affecting the clinician's preference regarding attachment type can be quite variant. A survey showed that clinicians often select attachments based on subjective criteria, such as their expertise, personal comfort, dental technician's preference, or by influence of marketing strategies.[42] Incorrect selection of an attachment type may result in higher maintenance need and complication rates.

Only one SR focusing on the effect of opposing dentition on clinical outcomes of RCIPs was identified.[35] The authors reported that the influence of the opposing dentition could not be investigated due to lack of evidence. Even though no agreement exists in the literature regarding the effect of opposing dentition on complication rates of RCIPs, in a number of clinical studies on maxillary RCIPs, the opposing dentition was addressed as a factor causing increased complication or failure rates.[43–47] A fixed dentition (either a fixed prosthetic reconstruction or natural dentition) as antagonist can presumably create higher forces and may lead to increased complication rates. Moreover, limitations in vertical space for the prosthetic components and matrix are suggested to be more common in the maxilla, which may lead to higher complication and failure rates.[36] Yet, amid the statements indicating that interarch space and opposing dentition can be accounting factors, no evidence-based results can be obtained from the current literature.

Future clinical trials designed to evaluate the clinical outcomes of FCIPs or RCIPs should be more standardized with regard to the attachment system used, prosthetic materials selected, interarch space, and status of the opposing arch to enable more definite conclusions to be drawn. Consensus is needed among investigators when it comes to using the same terminology. The influences of opposing arch and interarch space on technical complication rates of RCIPs and FCIPs should also be evaluated within RCTs.

CONCLUSIONS

Both FCIPs and RCIPs can be considered eligible treatment options for the rehabilitation of complete edentulism due to their high overall survival rates. Technical complications are frequent events that cannot be avoided but can be minimized. However, there is a void in the literature regarding possible contributing factors (eg, opposing dentition, prosthetic space requirement) and their influences on technical complication rates. Although screw retention is recommended for FCIPs, no prosthetic material can be considered as the material of choice over another, since the clinical outcomes were similar. Similarly, attachment type has no influence on the overall clinical outcomes of RCIPs, and the influences of opposing dentition and required prosthetic space were not investigated sufficiently. A need for well-designed clinical trials evaluating the effect of interarch space requirement and opposing dentition on prosthodontic survival and complication rates is warranted.

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