



Review article

Does replacement of missing dental units with resin-retained bridges improve oral health-related quality of life?: A systematic review

P. Hoyle^{a,*}, K. Patel^a, P.E. Benson^b^a Charles Clifford Dental Hospital, 76 Wellesley Road, Sheffield, S10 2SZ, United Kingdom^b University of Sheffield School of Clinical Dentistry, Sheffield, S10 2TA, United Kingdom

ARTICLE INFO

Keywords:

Quality of life
Oral health-related quality of life
Resin-retained bridge
Tooth replacement
Adhesive bridge

ABSTRACT

Objectives: To assess the current literature in regard to two research questions:

- Does placement of a 2-unit cantilever RRB to replace a missing dental unit improve oral health-related quality of life (OHRQoL) in patients over 18 years old?
- Are there any differences in OHRQoL between different methods of replacing missing teeth?

Methods: Systematic review following the Preferred Reporting Items for Systemic Reviews and Meta-Analysis statement (PRISMA) statement.

Data/sources: MEDLINE via Ovid, Scopus, PsycINFO via Ovid, Cochrane Library, Web of Science and clinicaltrials.gov were searched (Jan 1980 to Nov 2018) using high-level MeSH terms for studies published in English, investigating OHRQoL, using valid indices.

Risk of bias (RoB): Determined using Cochrane RoB tool and ROBINS-I.

Evidence certainty: Grading of Recommendations, Assessment, Development and Evaluation (GRADE) Working Group tool.

Results: *Study Selection:* 280 articles were identified; 270 were excluded after abstract review, 7 after examining full text, leaving 3 articles (3 studies, 188 participants, 172 analysed) included in this review; one RCT and two observational studies.

Synthesis of results: There was significant heterogeneity and no meta-analysis was possible.

Description of effect: One pre-post study design found provision of 2-unit RRBs significantly reduced the total OHIP-49 score (effect size 0.67), compared with an untreated control. One case-control study found no differences in total OHIP-49 between individuals treated with RRB or implant-supported crown. Major complications related to a worse OHRQoL.

Discussion: Quality of evidence: The overall RoB assessments were one study “some concerns” and two studies “serious”. The GRADE assessment was “moderate” for one comparison and “low” for two comparisons.

Clinical significance: A 2-unit cantilever RRB to replace one missing tooth probably results in a large improvement in oral health-related quality of life. Clinicians should ensure that the correct investigations and design of prosthesis are prescribed to help reduce any failures that may impact on OHRQoL.

1. Introduction

Tooth loss can be either acquired or developmental. Although populations are retaining their teeth for longer, it has been shown that up to 14% of Europeans lose one or more teeth annually [1]. Developmental agenesis of teeth also accounts for between 2.5–6.9% of the population [2].

Although tooth loss - either acquired or developmental - is not life threatening, some studies have shown that it can have a negative

impact on quality of life [3]. Oral health-related quality of life (OHRQoL) is an inclusive, multifactorial term given to estimate the level to which oral conditions impact on the normal functioning of an individual [4]. Change in OHRQoL before and after a dental procedure is increasingly being used to assess the effectiveness of treatment.

There are a number of factors associated with tooth loss that affect OHRQoL, including the number and distribution of missing teeth [5]. Aesthetics and masticatory function can also be impacted by tooth loss, which also results in diminished quality of life [6].

* Corresponding author.

E-mail address: p.j.hoyle@sheffield.ac.uk (P. Hoyle).

Table 1
Summary of MeSH search terms.

Patients	Adults; Hypodontia; Dental Agenesis; Congenital Developmental Missing Teeth; Congenital Developmental absent teeth
Intervention	2 unit cantilever; Resin Retained Bridges; Resin-bonded bridges; Adhesive bridges; RBBs; RRBs
Comparisons	Implant retained crown; Removable partial denture; Conventional bridge; No treatment.
Outcomes	Quality of life, Patient satisfaction, Oral Health Related Quality of Life; Quality of Life; Oral function; Aesthetics; OHIP; Patient satisfaction
Studies	RCTs; Cohort; Cross-sectional; Case-control; Review; Letter

The treatment modalities for tooth replacement include removable partial dentures, conventional fixed-fixed or resin-retained bridges (RRBs) and the more costly dental implant-retained prostheses. Clinical outcomes in terms of longevity, survival and success rates of dental prostheses, including those of RRBs have been extensively researched [7–9]. Despite this, looking at the provision of restorations from the patient’s perspective, without professional clinical input, has been investigated less frequently, but is now gaining traction over the last few years [10]. Understanding the implications of a restoration from a patient’s perspective via patient-related outcome measures (PROMs) (which includes OHRQoL), will allow clinicians to better inform their patients as to what effect a certain dental prosthesis will have on their quality of life. This in turn allows the patient’s expectations to be managed and enhances the informed consent process.

Reissman [11] looked at the OHRQoL when providing implant-retained prostheses in dentate and edentulous cases. They found eight studies showing an improvement in OHRQoL following treatments with an implant-supported fixed dental prosthesis with effect sizes ranging from 0.49 in patients with short implants in the posterior region to 1.26 and 2.38 in patients with missing anterior teeth. There has been no comparable research undertaken to a similar level of evidence looking at the impact of RRBs on the OHRQoL.

Therefore, the aim of this systematic review was to assess the current literature relating to changes in OHRQoL in patients who had received 2-unit cantilevered RRBs to replace single unit teeth that are absent for either developmental or acquired reasons.

The specific research questions were:

- Does placement of a 2-unit cantilever RRB to replace a missing dental unit improve OHRQoL in patients over 18 years old?
- Are there any differences in OHRQoL between different methods of replacing missing teeth?

2. Methods

This systematic review methodology was reviewed and registered with PROSPERO [ID:CRD42019114427]. It was designed following the Preferred Reporting Items for Systemic Reviews and Meta-Analysis statement (PRISMA) statement [12].

2.1. Criteria for considering studies for this review

2.1.1. Types of participants

Inclusion of studies including adult male and female participants in their permanent dentition (18 years and older) who had at least one appropriately sized space either in their maxillary or mandibular dental arch, which could be prosthodontically rehabilitated with a RRB. There was no minimum number of participants within studies for them to be included in the review.

Table 2

Example of search terms for Scopus database.

Example Search Terms (Scopus Database)	(TITLE-ABS-KEY (adult OR anodontia OR hypodontia OR dental OR agenesis OR congenital OR "developmentally absent") AND TITLE-ABS-KEY ("resin retained bridge*" OR "resin bonded bridge*" OR "adhesive bridge*" OR rrb* OR rbb*) AND TITLE-ABS-KEY ("quality of life" OR "patient satisfaction" OR "oral health related quality of life" OR ohrqol OR "oral function" OR aesthetics OR ohip))
--	---

2.1.2. Types of interventions

2.1.2.1. Intervention. Any study where participants, or at least a subgroup of participants, had received 2-unit cantilever RRBs were included. Studies with participants who received concurrent treatments were excluded.

2.1.2.2. Comparator(s)/control. Studies that compared treatment with 2-unit cantilever RRBs to a comparison of no treatment or alternative prosthodontic replacements such as alternative designs of resin-bonded bridges, conventional bridges, implants or removable partial dentures.

2.1.3. Types of outcome measures

Only studies using validated outcome measures for OHRQoL, including, but not limited to the OHIP [13], the Geriatric Oral Health Assessment Index (GOHAI) [14], Dental Impact on Daily Living (DIDL) [15] and the UK Oral Health-related Quality of Life measure (OHQoL-UK) [16].

2.1.4. Type of studies

Cross-sectional, retrospective and prospective studies, of either an observational or randomised-controlled trial (RCT) design were included. Studies were not excluded based on their methodological type (Table 1).

2.2. Search strategy

Electronic literature searches were performed on the following databases, encompassing much of the available published literature: MEDLINE via Ovid, Scopus, PsycINFO via Ovid, Cochrane library, Web of Science and clinicaltrials.gov. MeSH terms were used and adapted for each database as necessary. Grey literature was also assessed, however none were identified that were suitable for inclusion. MeSH terms were selected as per the PICO framework and can be seen in Table 1. Searches were limited to those published in English from January 1980 to November 2018. An example of search criteria for the Scopus database can be found in Table 2.

2.3. Data collection and analysis

2.3.1. Selection of studies

Titles and abstracts were independently screened by two review authors (PH, KP). Initially, inter-reviewer reliability of inclusion was assessed in 10% of articles identified through MeSH terms in relevant databases to establish a baseline for further inclusion of studies within the review. Any further papers of contention following the initial 10% were discussed, and a unanimous agreement was sought as to whether it should be included or not. Agreed full texts to be considered were once again reviewed independently by the same review authors. Disagreement was settled with a discussion with a third review author (PB) (Fig. 1).

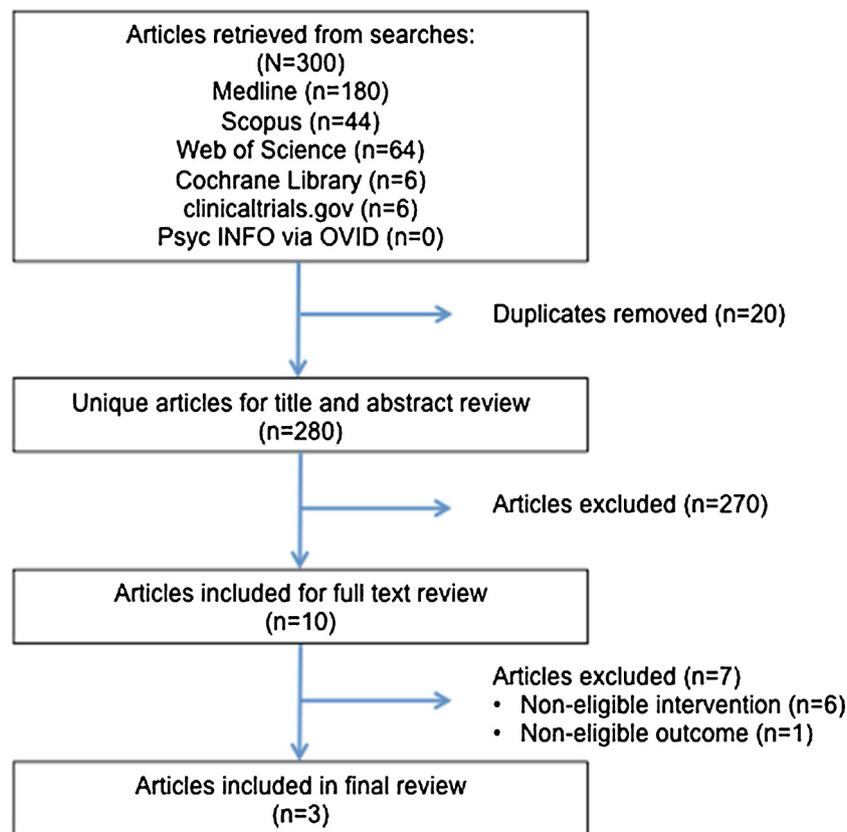


Fig. 1. Flow diagram demonstrating literature search and screening process.

2.3.2. Data extraction and management

Data were extracted and assimilated on a piloted, standardised data collection sheet by two review authors (PH, KP). The reviewers were not blinded to any of the studies. Data on the following parameters were collected:

- Year of publication, authors and country of origin
- Primary, and where appropriate, secondary aims
- Study design
- Participants
- Intervention
- Control/comparison
- Outcomes as related to aims of study

Disagreement was resolved through discussion and consultation with a third reviewer (PB).

2.3.3. Assessment of risk of bias in included studies

Risk of bias was determined for all included studies using an appropriate, validated tool, suited to the study design. For randomised controlled trials (RCTs), risk of bias was assessed according to the recently updated Cochrane's Risk of Bias tool for RCTs V2 [17]. Non-RCT design studies were assessed using the Risk Of Bias In Non-randomised Studies-of Interventions (ROBINS-I) tool [18]. All three authors filled in the tool appropriate for each included study and differences were discussed. A consensus agreement was achieved as to the risk of bias for each category the relevant tool included. The overall risk of bias of the paper was categorised into low, high or some concerns, where the Cochrane risk of bias tool was used. When the ROBINS-I tool was used, the risk of bias for the paper was categorised using the following descriptors: low, moderate, serious, critical or no information.

2.3.4. Assessment of evidence certainty

The certainty of the retrieved evidence was assessed using the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) Working Group tool [19].

2.3.5. Data synthesis

Due to methodological and observational differences between included studies, it was concluded by all three review authors, that there was sufficient significant heterogeneity that conducting a meta-analysis would not be appropriate. Descriptive analysis of the findings of the studies was undertaken to identify core themes relating to the aims of this review.

Due to this marked heterogeneity, standardised effect sizes (ES) were used to determine the benefit of an intervention within a study. This allows for direct comparison between studies, despite differences in methodological or outcome variables. ES aim to quantify the effectiveness of a particular intervention. In plain terms, it is the ratio of a difference in means between the experimental and control groups, to its standard deviation [20]. An ES of 0.2 is considered small, that of 0.5 is considered medium, and 0.8 considered large [21]. A minimum ES of 0.5 is required when assessing the importance of an intervention relating to Patient Reported Outcome Measures [22].

3. Results

3.1. Description of studies

A total of 280 unique articles were identified for review after duplicates were removed. The titles and abstracts of these articles were subsequently independently reviewed by two authors (PH, KP) resulting in 10 articles being identified for full text review. Full text review identified 3 articles (3 studies, 188 participants, 172 analysed) suitable for inclusion in the final review [23–25] (Fig. 1).

Table 3
Summary of studies included in review.

Study	Objectives	Methods	Participants	Summary findings	Relevant Effect Sizes
Anweigi et al. [23]	Determine the impact of hypodontia on the QoL of adolescent and young adult patients with congenital absence of teeth. Assess the impact of restoring tooth spaces with resin-bonded bridgework on QoL of patients with hypodontia.	Design: Prospective cohort Intervention: 2-unit cantilever RRBs Comparison: "Control". Patients who had not commenced or were in the early stages of orthodontic treatment. Patients had unrestored spaces due to congenital absence. Assessments: Baseline and 6 month's after receiving RRBs for the test group Outcomes: OHRQoL OHRQoL Measure: OHIP-49	N = 82 Intervention group - n = 40 (completed orthodontics and spaces restored with RRBs). Control group- n = 42 (still in active phase of orthodontics). Mean age- 16-34 years Median = 19 F:M- F = 43 M = 39 All non-syndromic hypodontia	Hypodontia had a negative impact on OHRQoL with primary concern being that of aesthetics. RRB placement improved the OHRQoL after orthodontic treatment. In control group- orthodontic treatment resulted in poorer OHRQoL prior to restorative treatment as the gaps increased in size allowing for prosthodontic rehabilitation.	Intervention group effect size: 0.67; Comparison group Effect size: -0.54; p < 0.001
Botelho et al. [24]	Compare the long-term longevity of two-unit cantilevered and three-unit fixed-fixed resin-bonded fixed partial dentures for the replacement of a maxillary permanent incisor. Investigate PROMs of CL2 and FF3 design over RRBs over the long-term.	Design: RCT Intervention: 2-unit cantilever RRBs (CL2) Comparison: 3-unit F-F design RRBs (FF3) Assessments: Follow up to 18 years Outcomes: Longevity Subject satisfaction OHRQoL Measures: Subject satisfaction (VAS scale) OHRQoL (OHIP-49)	N = 22/28 subjects reviewed CL2 = 13/15, FF3 = 10/14 Mean age- Mean age = 50.8 +/- 11.5 No Stat Sig difference between groups (p > 0.05) F:M- CL2:M = 6, F = 9. FF3:M = 8, F = 6 No Stat Sig difference between groups (p > 0.05) Only maxillary incisors	CL2 RRB designed prostheses were more likely to be successful and survive than FF3 (P = 0.000 and P = 0.009). Both in terms of survival and maintenance it is easier No significant difference in OHIP-49 scores between the 2 groups (p > 0.05). Sub-analysis revealed a significant finding in that CL2 prostheses were easier to clean.	Effect size between intervention group and comparison group OHIP score: 0.51 (p > 0.05). Not enough participants to reject null hypothesis on OHRQoL.
Lam et al. [25]	Compare OHRQoL amongst subjects treated with implant-supported crowns and 2-unit cantilevered resin bonded bridges. Investigate factors associated with OHRQoL amongst those who experience complications, specifically to determine association between OHRQoL and treatment modality, nature of complications and number of complications.	Design: Case-control study Intervention: 2-unit Cantilever RRBs (cRRB) Comparison: Implant supported crown (ISC) Assessments: At least 5 years post fit Outcome: OHRQoL OHRQoL Measure: OHIP-49	N = 78 ISC = 39 cRRB = 39 Mean age- 52.4 ISC Mean age- 56.3 RRB Mean age- 48.5 F:M- ISC M % = 56.4 and F% = 43.6 RRB M% = 35.8 and F% = 64.2 Only bounded saddles	Similar primary OHIP scores for both treatment modalities Higher summary OHIP score if suffered major complications as opposed to minor ones; in RRB group no significant difference in OHIP scores for minor and major complications however was a significant difference for ISCs.	Standardised effect size between intervention group and comparison group: +0.02 (P = 0.53); Standardised effect size between minor and major complications for both ISC and cRRBs: -0.64 (P = 0.02); Standardised effect size between minor and major complications for intervention only (cRRB): -0.41 (P = 0.07).

The studies included in the final review were a prospective cohort study (82 participants, 77 analysed) [23] a RCT (28 participants, 17 analysed) [24] and a case controlled study (78 participants analysed) [25]. Although two of the studies were described as prospective, only one reported data from the same individuals before and after treatment [23]; therefore, the results would assist the answer to the first research question – does placement of a RRB improve OHRQoL? The other two studies collected cross-sectional OHRQoL data following treatment; therefore would assist the answer to second research question – are there any differences in OHRQoL between alternative methods of replacing teeth. A summary of the studies can be found in Table 3.

3.2. Assessment of risk of bias

For all three studies, the outcome measure assessed for risk of bias was OHRQoL. No included study had a low risk of bias. One study was found to have “some concerns” relating to risk of bias and 2 studies were found to have “serious” risk of bias.

It was decided that the direction of the potential bias was unpredictable, making it difficult to assess its impact of potential bias on the outcome variable.

3.2.1. Risk of bias of included RCTs

One RCT [24] was included. The use of the Cochrane’s Risk of Bias Tool highlighted the overall risk of bias within this study to be categorised as having “some concerns”. The domains as assessed to have “some concerns” can be seen in Table 4.

3.2.2. Risk of bias of included non-RCTs

The ROBINS-I tool was used to assess risk of bias for the 2 observational studies included [23,25]. A “serious” overall risk of bias was found for both studies. The domains contributing towards this risk category are indicated in Table 4.

3.2.3. Assessment of evidence certainty

The certainty of the evidence collated through the RCT and two observational studies was assessed using the GRADEpro tool. One observational study [23] demonstrated with moderate certainty that the use of a 2-unit cantilever resin-retained bridge (RRB) to replace one missing tooth likely results in a significant improvement in OHRQoL (effect size 0.67). This study had a large range of outcomes, compounded by the fact that the control group were still undergoing orthodontic treatment, could have led to a worsened OHRQoL, and thereby impacting on the study’s true effect size.

Table 4
Summary of risk of bias assessment.

Paper	Risk of bias tool utilised	Overall risk of bias result	Domains in which anything but low risk of bias was identified
Anweigi et al. [23]	ROBINS-I Tool (Sterne et al., 2016)	SERIOUS	Bias due to confounding: SERIOUS Bias in selection of participants into the study: LOW Bias in classification of interventions: LOW Bias due to deviations from intended interventions: LOW Bias due to missing data: MODERATE Bias in measurement of outcomes: MODERATE
Lam et al. [25]	ROBINS-I Tool (Sterne et al., 2016)	SERIOUS	Bias in selection of the reported result: LOW Bias due to confounding: SERIOUS Bias in selection of participants into the study: MODERATE Bias in classification of interventions: SERIOUS Bias due to deviations from intended interventions: MODERATE Bias due to missing data: LOW Bias in measurement of outcomes: MODERATE
Botelho et al. [24]	Cochrane risk of bias Tool V2 (Higgins et al., 2016)	SOME CONCERNS	Bias in selection of the reported result: LOW Risk of bias arising from the randomization process: SOME CONCERNS Risk of bias due to deviations from the intended interventions: SOME CONCERNS Missing outcome data: LOW Risk of Bias in measurement of the outcome: SOME CONCERNS Risk of bias in selection of the reported result: SOME CONCERNS

There was weak evidence suggesting that when replacing a single missing tooth the OHRQoL is better after 18 years with a 2-unit cantilevered RRB than a 3-unit fixed-fixed RRB. This might be because there are more complications (such as failure) with a 3-unit fixed-fixed RRB compared with a 2-unit cantilevered RRB [24]. There were only a small number of participants followed up in the control group (3-unit fixed-fixed RRBs), potentially accounting for the wide confidence intervals.

Furthermore, there was weak evidence suggesting that there is no difference in OHRQoL when a 2-unit cantilever RRB is used to replace a single missing tooth compared with an implant-retained crown [25]. This study had large confidence intervals and didn’t provide information about the techniques used and who undertook the procedures. [For full summary tables, please see Appendix 1]

3.3. 2-unit cantilever resin-retained bridges and OHRQoL

Two of the three included studies had the impact of restorations with RRBs on OHRQoL as their primary outcome measure [23,25]. Botelho et al. [24], reported ‘survival’ as the primary outcome and patient reported outcomes (satisfaction and OHRQoL) were secondary outcomes. All three studies used OHIP-49 as a measure of OHRQoL. Botelho et al. [24], used an additional Visual Analogue Scale (VAS) questionnaire to assess their subject’s general satisfaction with their RRBs.

The context and follow up times in which OHIP-49 was used within the studies varied considerably. Anweigi et al., [23] found that at 6 months follow up, there was a statistically significant difference in the median total OHIP-49 scores between the test and control groups following the provision of RRBs in the test group (test 15.5, IQR 5.0–39.0; control 54.0, IQR 21.0–76.0: p < 0.001 Mann-Whitney U). There were also significant differences in the change scores between the two groups, with the test group demonstrating a reduction in the median total OHIP-49 score (-12.0, IQR 2.0–39.5) compared with an increase in the median total OHIP-49 score in the control group (+9.0, IQR -1.0–29.0). The authors reported a “moderately large” improvement in OHRQoL following the provision of a RRB (effect size 0.67), whereas the control group demonstrated a “moderately large” deterioration in OHRQoL (effect size -0.54). This was attributed to their continued orthodontic treatment and the opening of spaces in preparation for prosthodontic restoration in aesthetic zones. They concluded that the “provision of RRBs has a clinically meaningful and positive impact on oral health related quality of life of adolescents and young adult patients with hypodontia”.

Botelho et al., [24] used OHIP-49 and VAS questionnaires to assess patient-reported outcomes in participants receiving 2-unit cantilever (CL2) compared with participants receiving 3-unit fixed-fixed (FF3) RRBs to replace missing maxillary incisors. The mean total OHIP-49 score was 14.0 (sd 12.5) for the participants in the CL2 group and 29.5 (sd 30.1) for the participants in the FF3 group. The effect size between the two groups (mean difference in score divided by the standard deviation of the score) was quite large (0.51); however, the authors were unable to detect a significant difference, as the study was underpowered for this outcome. The effect sizes were much smaller for the satisfaction questionnaire, except for questions related to ease of cleaning (ES 0.85) and firmness of the prosthesis (ES 0.66) where participants receiving CL2 RRBs reported higher satisfaction to those receiving the FF3.

Lam et al., [25] primarily looked at the impact of complications on OHRQoL in patients receiving ISCs (intervention) and 2-unit cantilever RRBs (control). They found that patients had similar median total OHIP scores (ISC 74.0, IQR 63.0–96.0; cRBB 68.0, IQR 54.0–100.0: $p = 0.53$, Mann-Whitney U; ES 0.02).

3.3.1. OHRQoL linked to longevity

The study by Botelho et al., [24] as discussed in the previous section, was underpowered for all the outcomes, in particular OHRQoL. Despite its low number of participants (at review CL2 $n = 13$ and FF3 $n = 10$, but only 4 with OHIP-49 scores), the study does have some notable findings associated with the longevity of CL2 in comparison to FF3 RRBs. The study defined success as an “absence of complications requiring intervention beyond routine periodontal maintenance” and survival as “retention of the original prosthesis”.

At 18 years, 100% of the CL2 RRBs had survived and were successful compared to 10% of the FF3 RRBs categorised successful with a further 50% surviving for both outcomes ($p < 0.001$, chi-sq). Debonding was the only mode of failure within the FF3 RRBs, with 71 months being the average time to first debond (range = 3–176 mths) after insertion of the prosthesis. The mean success time (210.5, sd 21.4 mths) for CL2 RRBs was significantly longer than FF3 RRBs (109.2, sd 87.2 mths; $p = 0.008$, unpaired t test). The mean survival time for CL2 RRBs (212.2, sd 22.5 mths) was also greater than FF3 RRBs (195.7, sd 51.3 mths) but this was not found to be statistically significant ($p > 0.05$, unpaired t test).

The low sample size means that links between longevity and OHRQoL cannot be reliably drawn and the results and should be interpreted with caution. It can be seen in previous systematic reviews investigating OHRQoL and tooth replacement in partially dentate patients that OHRQoL can change over time by varying amounts with different prosthetic replacements. It is difficult to say how much of the change in OHRQoL over time is attributable to response shift, or the impact of prosthesis longevity on the patient’s satisfaction [26].

3.3.2. OHRQoL linked to complications

As mentioned previously the mean total OHIP scores in the study by Lam et al., [25] were high. All the domain scores were increased, but principally in the domains of Functional limitation, Physical pain and Physical disability. The authors suggest that those participants who experience complications with their restorations were particularly liable to report poor OHRQoL. The authors defined “minor complications” as those requiring repair of the original “survived” restorations. They classified “major complications” as “failed” restorations requiring replacement with a new one. Out of the 39 ISCs that were placed 14 experienced minor complications and 7 experienced major complications. Within the control group ($n = 39$), 7 of the RRBs experienced minor complications and 7 experienced major complications. Both ISCs and RRBs experience similar single complications however ISCs experienced 3 times as many multiple complications within the review period.

Significantly higher median total OHIP-49 scores (representing

poorer OHRQoL) were reported by patients experiencing major complications (median 81.0, IQR 61.8–99.8) in comparison to minor complications (median 61.0, IQR 54.5–75.5: $p = 0.02$, Mann-Whitney U; ES 0.64). Significant differences in the median total OHIP-49 scores were also demonstrated in the ISC group between those participants experiencing minor complications (median 68.5, IQR 56.8–76.3) and major complications (median 96.0, IQR 74.0–107.0: $p = 0.02$, Mann-Whitney U; ES -1.04), as well as single complications (median 61.0, IQR 54.0–82.0) and multiple complications (median 75.5, IQR 64.8–92.0: $p = 0.04$, Mann-Whitney U; ES -0.45). No differences were shown for these groups in the RRB group.

Regression analysis of subjects with complications showed that the nature of the complication ($p < 0.01$), treatment modality ($p = 0.04$) and gender ($p = 0.02$) were significant factors in affecting OHIP scores of these patients with major complications, ISCs and women all having increased OHIP scores.

4. Discussion

This systematic review revealed paucity in the established literature investigating the impact of 2-unit cantilever RRBs on OHRQoL, with many of the studies examining their survival or success, as opposed to patient-related outcome measures.

There were considerably fewer papers considered for final inclusion within this systematic review than with other similar reviews. For example, Reissmann et al., [11], included 63 articles in the final review looking at the impact of implant-supported prostheses on OHRQoL. One reason for this might be that implants can be used in a larger variety of clinical scenarios compared with RRBs. This allows authors to include studies with both partially dentate and edentulous participants.

In regard to the two research questions presented at the start of the review, one study [23], judged to be at serious risk of bias, concluded that the provision of 2-unit cantilever RRBs to restore single bound saddles gave a moderately large improvement in OHRQoL. This was seen in hypodontia patients with RRBs being placed both in the aesthetic zone and posteriorly. The reason this study was judged to be at a serious risk of bias was because the test group, who all received a RRB, were compared with a control group comprised of participants preceding orthodontic treatment or within their active phase of orthodontic treatment prior to receiving prosthodontic rehabilitation for their congenitally missing teeth. Orthodontic treatment with fixed appliances has been shown to worsen OHRQoL at least in the short term [27], but also in such a group of patients, gaps may be present and increasing in size within the aesthetic zone, in preparation for a RRB. Such spaces may appear unsightly and may compromise OHRQoL. The use of this comparison group might potentially over-estimate the impact of the RRB; however, examining the longitudinal data in the RRB participants only before and after placement of the restoration demonstrated a significant improvement.

The other studies included [24,25] did not provide longitudinal data before and after treatment and therefore can only offer information to answer the second research question, which investigates whether one restoration is superior to any other. Botelho et al. [24], provides some evidence that the 2-unit cantilever RRB is superior to a 3-unit fixed-fixed design RRB with regard to its success and survival and also in its positive impact on OHRQoL. This may be linked to superior survival rates in the former group. The results presented by Lam et al. [25], suggest that although the OHRQoL is similar when individuals are treated with RRBs or implants, those subjects who have been rehabilitated with implant retained prostheses and subsequently experience complications with their restoration both in terms of severity and number of problems, may exhibit a poorer OHRQoL.

The heterogeneity in the included studies’ methodologies meant that conducting a meta-analysis was not deemed appropriate. Even though OHIP-49 was used to account for OHRQoL, the method for which it was used differed in all the studies. Despite this, the outcome

measure for OHRQoL used in all the studies was OHIP-49, even if it wasn't the primary outcome measure.

The respective risk of bias assessment and the GRADEpro assessment for the included studies highlighted issues with all of the studies to differing extents. There appeared to be common issues with potential confounding and outcome measurements. However, it is acknowledged that blinding patients, operators and assessors in these types of studies, where the prostheses are visibly and physically different is challenging and impossible. This can make it very difficult to achieve a "low" risk of bias status when using such formalised risk of bias tools, and is not necessarily a fault of the study design, but rather the intervention being assessed.

Control of baseline variables has been attempted in all the studies to a varying degree. All have reported no variation in baseline characteristics for both intervention and comparison groups. Despite this, key attributes in terms of baseline characteristics have not been investigated. Such characteristics include personality states and socio-economic status (SES) of subjects recruited into studies. Those subjects considered to have high levels of neuroticism may exhibit scores indicating a poorer OHRQoL [28]. Botelho et al. [24], and Lam et al. [25], attempted to account for SES via measuring education status and level of their subjects.

There was an attempt by some authors of articles included in this review to standardise the local dental factors that may predispose a restoration to success or failure. These included taking into account the occlusion and abutment tooth status. Anweigi et al., [23] and Botelho et al. [24], gave a limited consideration to occlusal status in patients recruited into their studies by the way of ensuring that subjects didn't suffer from bruxism. Botelho et al. [24], went further and calculated functional occlusal pairs in both treatment groups. Lam et al. [25], only described the site of prosthesis placement within the arch. Further consideration could have been given to favourable occlusal factors, including recording guidance on excursive movements of the mandible, which may impact on the longevity of any RRB placed, or if there was sufficient inter-occlusal space for the bridge retainer allowing for a minimal or no abutment tooth preparation.

Anweigi et al., [23] and Botelho et al. [24], attempted to investigate the restorative status of RRB abutment teeth. Their inclusion criteria stipulated that they had to be either unrestored or minimally restored and caries free. However, there was no recording as to what the restorative material was on the abutment tooth, or its location- both of which can affect the subsequent bond strengths of resin cements. Lam et al. [25], did not include any information as to the prerequisite abutment tooth criteria. Heavily restored abutment teeth may decrease the bonding strength of the RRB, which may increase rates of complications and thereby potentially decrease OHRQoL. Furthermore, bonding onto an existing restoration introduces another interface of restorative failure.

Complications had an impact on the OHRQoL reported by patients, with severity of the complication and the number of complications being determinants as to the impact. Patients experiencing major complications or multiple complications were seen to have worse OHRQoL. A merit of some of the studies included was the time that participants were followed up. Botelho et al., [24] reviewed their participants for up to 18 years, whilst Lam et al. [25], reviewed participants for 10 years. Such a great time frame allows for most complications of their interventions to be accounted for. It captures late complications such as periodontal disease formation, caries formation and progression in abutment teeth, and debond rates. Ideally, this would translate to an either increased or reduced OHRQoL.

There was no significant difference in the impact upon OHRQoL when different designs of RRBs, for example, 2-unit cantilever RRBs or 3-unit fixed-fixed design, were used within the maxillary incisor region. This was despite the statistically significant difference in mean success times. However, these findings do need to be interpreted with caution due to the fact the study was significantly underpowered.

A major concern with the data presented in some of the studies included [23,24] was that they were underpowered for the outcome measure of interest, OHRQoL. The sample size within the study by Lam et al. [25], was sufficient to provide 80% power and 0.05 significance level for a moderate magnitude of difference ($ES = 0.5$), accounting for an approximate 20% non-response. Botelho et al. [24], found limitations to their inclusion criteria of subjects with "a single permanent maxillary central or lateral incisor missing and its edentulous space present or minimally lost". They reported difficulty in recruiting sufficient participants with these criteria, resulting in their study being underpowered for their PROMs. It was calculated that a sample size of 84 would be required to show a moderate magnitude of difference ($ES = 0.5$), using 80% power and a 0.05 significance level. In reality, only 12 intervention subjects (CL2) and 9 comparison subjects (FF3) were included for their subjects' satisfaction analysis (using the VAS) and 13 intervention subjects (CL2) and 4 comparison subjects (FF3) were included for OHIP analysis. The study by Anweigi et al. [23], was one participant short in its control group of its anticipated number of between 38–44 participants per group required for 90% power to detect significant differences ($\alpha = 5\%$ corresponding to 95% confidence interval).

The results of this systematic review are encouraging regarding the use of 2-unit cantilever RRBs to restore single-bounded saddles in both the anterior and posterior dentition. The studies indicate a positive impact on OHRQoL, regardless of the reason for teeth being absent. They also give us an insight into other determinants of OHRQoL such as the number and type of complications. However, further well designed, prospective longitudinal studies that are adequately powered are needed to assess the impact of RRBs upon OHRQoL as well as the impact that factors, such as bridge design and RRBs has in comparison to other treatment modalities. Patient satisfaction is an important factor to consider when analysing different treatment modalities, but it is important for studies focussing on satisfaction to utilise validated measures, so robust data analysis can be undertaken. Studies with similar designs and outcome measures will facilitate meta-analysis for further data processing.

Despite the relative limitations of the studies included within this review, the results relating to the OHRQoL of 2-unit cantilever RRBs mimic clinical studies investigating prostheses of a similar design. Clinical evidence suggests that 2-unit cantilevered designed RRBs have superior longevity when appropriately treatment planned [7]. Clinicians can now be more confident in informing their patients that not only do 2-unit cantilevered RRBs have a good survival and success rates, but also whilst it is functioning, it will improve their OHRQoL considerably.

RRBs are typically a porcelain-fused to metal prostheses, which are bonded to abutment teeth with resin cement. There are differing procedural factors that need to be considered when providing RRBs including prosthesis design and abutment tooth preparation. Advantages of using this as treatment modality include relative ease of clinical steps and laboratory work. This translates to more efficient use of clinical resources and minimal cost to the patient and clinician alike, both temporally and financially.

In conclusion, this review has found some evidence that the provision of a 2-unit RRB significantly improves OHRQoL, regardless of the reason for the loss of the tooth and that the improvement is similar between different types of fixed restorations. However, the levels of certainty for these findings are low, as the number of studies is so small. Further, well-designed prospective studies are required to make more definite conclusions, and to quantify any potential improvements in OHRQoL from provision of such restorations.

Funding

None.

Registration

This systematic review methodology was reviewed and registered with PROSPERO [ID: CRD42019114427].

Declaration of interest

None.

Acknowledgments

No acknowledgements.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.jdent.2019.103209>.

References

- [1] F. Müller, F.M. Naharro, G.E. Carlsson, What are the prevalence and incidence of tooth loss in the adult and elderly population in Europe? *Clin. Oral Implants Res.* 18 (2007) 2–7, <https://doi.org/10.1111/j.1600-0501.2007.01459.x>.
- [2] B.J. Polder, M.A. Van't Hof, F.P. Van der Linder, et al., A meta-analysis of the prevalence of dental agenesis of permanent teeth, *Community Dent. Oral Epidemiol.* 32 (2004) 217–226, <https://doi.org/10.1111/j.1600-0528.2004.00158.x>.
- [3] J.G. Steele, A.E. Sanders, G.D. Slade, P.F. Allen, S. Lahti, N. Nuttall, A.J. Spencer, How do age and tooth loss affect oral health impacts and quality of life? A study comparing two national samples, *Community Dent. Oral Epidemiol.* 32 (2004) 107–114, <https://doi.org/10.1111/j.0301-5661.2004.00131.x>.
- [4] A. Preciado, J. Del Rio, M.J. Suárez-García, J. Monetero, C.D. Lynch, R. Castillo-Oyagüe, Differences in impact of patient and prosthetic characteristics on oral health-related quality of life among implant-retained overdenture wearers, *J. Dent.* 41 (2012) 493–503, <https://doi.org/10.1016/j.jdent.2012.07.006>.
- [5] A.E. Gerritsen, P.F. Allen, D.J. Witter, E.M. Bronkhorst, N.H.J. Creugers, Tooth loss and oral health-related quality of life: a systematic review and meta-analysis, *Health Qual. Life Outcomes* 8 (2010) 126, <https://doi.org/10.1186/1477-7525-8-126>.
- [6] G. Boretti, M. Bickel, A.H. Geering, A review of masticatory ability and efficiency, *J. Prosthet. Dent.* 74 (1995) 400–403, [https://doi.org/10.1016/S0022-3913\(05\)80381-6](https://doi.org/10.1016/S0022-3913(05)80381-6).
- [7] P.A. King, L.V. Foster, R.J. Yates, R.G. Newcombe, M.J. Garrett, Survival characteristics of 771 resin-retained bridges provided at a UK dental teaching hospital, *Br. Dent. J.* 218 (2015) 423–428, <https://doi.org/10.1038/sj.bdj.2015.250>.
- [8] S. Djemal, D. Setchell, P. King, J. Wickens, Long-term survival characteristics of 832 resin-retained bridges and splints provided in a post-graduate teaching hospital between 1978–1993, *J. Oral Rehabil.* 26 (1999) 302–320, <https://doi.org/10.1046/j.1365-2842.1999.00374.x>.
- [9] B.E. Pjetursson, W.C. Tan, K. Tan, U. Bragger, M. Zwahlen, N.P. Lang, A systematic review of the survival and complication rates of resin bonded bridges after an observation of at least 5 years, *Clin. Oral Implants Res.* 19 (2008) 131–141, <https://doi.org/10.1111/j.1600-0501.2007.01527.x>.
- [10] D.L. Patrick, G.H. Guyatt, C. Acquadro, Chapter 17 patient-reported outcomes, in: J.P.T. Higgins, S. Green (Eds.), *Cochrane Handbook for Systematic Reviews of Interventions*, Wiley-Blackwell, Chichester, England, 2009, pp. 531–546.
- [11] D.R. Reissman, M. Dard, R. Lamprecht, J. Struppek, G. Heydecke, Oral health-related quality of life in subjects with implant-supported prostheses: a systematic review, *J. Dent.* 65 (2017) 22–40, <https://doi.org/10.1016/j.jdent.2017.08.003>.
- [12] D. Moher, A. Liberati, J. Tetzlaff, D.G. Altman, The PRISMA group, preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement, *Ann. Intern. Med.* 151 (2009) 264–269, <https://doi.org/10.7326/0003-4819-151-4-200908180-00135 W64>.
- [13] G.D. Slade, A.J. Spencer, Development and evaluation of the oral health impact profile, *Community Dent. Health* 11 (1994) 3–11 PMID: 8193981.
- [14] K.A. Atchison, T.A. Dolan, Development of the geriatric oral health assessment index, *J. Dent. Educ.* 54 (1990) 680–687 PMID: 2229624.
- [15] A. Leao, A. Sheiham, The development of a socio-dental of dental impacts on daily living, *Commun. Dent. Health.* 13 (1996) 22–26 PMID: 8634892.
- [16] C. McGrath, R. Bedi, An evaluation of a new measure of oral health related quality of life-OHQoL-UK(W), *Commun. Dent. Health* 18 (2001) 138–143 PMID: 11580088.
- [17] J.P.T. Higgins, J.A.C. Sterne, J. Savović, M.J. Page, A. Hróbjartsson, I. Boutron, B. Reeves, S. Eldridge, A revised tool for assess risk of bias in randomised controlled trials, in: J. Chandler, L. McKenzie, I. Boutron, V. Welch (Eds.), *Cochrane Methods, Cochrane Database of Systematic Reviews*, 10 2016 Supple.1.
- [18] J.A.C. Sterne, et al., ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions, *BMJ* 335 (2016) i4919, <https://doi.org/10.1136/bmj.i4919>.
- [19] GRADEpro GDT, GRADEpro Guideline Development Tool [Software] (developed by Evidence Prime, Inc.). Available from, McMaster University, 2015, [grade.pro.org](http://www.gradepro.org).
- [20] R. Coe, It's effect size, stupid: what effect size is and why it is important, Annual Conference of the British Educational Research Association (2002) (Accessed 07 May 2019), <http://www.cem.org/attachments/ebe/ESguide.pdf>.
- [21] J. Cohen, *Statistical Power Analysis for the Behavioural Sciences*, second ed., Lawrence Erlbaum Associates, Hillsdale, NJ, 1988.
- [22] G.R. Norman, J.A. Sloan, K.W. Wyrwich, Interpretation of changes in health-related quality of life: the remarkable universality of half a standard deviation, *Med. Care* 41 (2003) 582–592, <https://doi.org/10.1097/01.MLR.0000062554.74615.4C>.
- [23] L. Anweigi, F. Allen, H. Ziada, Impact of resin bonded bridgework on quality of life of patients with hypodontia, *J. Dent.* 41 (2013) 683–688, <https://doi.org/10.1016/j.jdent.2013.05.010>.
- [24] M. Botelho, A. Chan, N. Leung, W. Lam, Long-term evaluation of cantilevered versus fixed–fixed resin-bonded fixed partial dentures for missing maxillary incisors, *J. Dent.* 45 (2016) 59–66, <https://doi.org/10.1016/j.jdent.2015.12.006>.
- [25] W. Lam, C. McGrath, M. Botelho, Impact of complications of single tooth restorations on oral health-related quality of life, *Clin. Oral Impl. Res.* 25 (2014) 67–73, <https://doi.org/10.1111/clr.12166>.
- [26] Z. Ali, S.R. Baker, S. Shahrbaf, N. Martin, M.V. Vettore, Oral health-related quality of life after prosthodontic treatment for patients with partial edentulism: a systematic review and meta-analysis, *J. Prosthet. Dent.* 121 (2019) 59–68.e3, <https://doi.org/10.1016/j.prosdent.2018.03.003>.
- [27] M. Chen, D.W. Wang, L.P. Wu, Fixed orthodontic appliance therapy and its impact on oral health-related quality of life in Chinese patients, *Angle Orthod.* 80 (2010) 49–53, <https://doi.org/10.2319/010509-9.1>.
- [28] G. Matthews, I.J. Deary, M.C. Whiteman, *Personality Traits*, third ed., Cambridge University Press, Cambridge, UK, 2009.