

Survival and Success Rates of Endodontically Treated Teeth Restored with Full Veneer Crowns or Full Cuspal Coverage onlays: A Systematic Review

Keywords

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ABSTRACT

Introduction: The aim of this paper is to compare the survival and success rates of endodontically treated posterior teeth restored with full veneer crowns or full cuspal coverage onlays in vivo. Methods: A literature search using PubMed, Medline and Embase via Ovid, and The Cochrane Library retrieved English and non-English language articles from 1946 to April 2022. Electronic searches were supplemented with the use of forward citation chaining via Google Scholar. Results: A total of eleven studies met all predetermined search criteria. Data were extracted and tabulated. Survival rates for onlays ranged from 95% to 100% at two years and 90.7% to 100% at three years with success rates ranging from 86.6% - 96.6% at two years and 86.6% to 96% at three years. Survival results for full veneer crowns were reported at 87.8% at over two years, 95.1% at three years, and 84% - 97.73% at five to ten years. Success rates have been reported at 91.11% - 92.64% at five years and 60% at six years. Conclusions: The data suggest that the use of onlays instead of full veneer crowns in the restoration of endodontically treated posterior teeth is favourable in the short to midterm.

INTRODUCTION

After endodontic treatment of posterior teeth, a final restoration is placed to restore the tooth structure lost from previous pathology and endodontic access.¹ The choice of restoration will have a direct impact on tooth survival with research showing that preservation of sound tooth structure, provision of cuspal coverage and the maintenance of a coronal seal all have a direct impact on survival rate.²⁻⁵ In total there are five methods of restoring an endodontically treated tooth. These are: direct restorations, crowns, post-core crowns, onlays and endocrowns.

When there is adequate remaining tooth structure, full veneer crowns are routinely chosen for the restoration of the posterior root filled tooth. However, when assessing root filled treated teeth, it is often the case that

the remaining sound tooth structure is located around the periphery, with large proportions of the central dentine being removed by placement of previous restorations and endodontic access. The axial wall reduction required for the provision of a full veneer crown can lead to the removal of the remaining tooth structure in the periphery, which could be preserved.

With the quantity of remaining tooth structure having a direct impact on tooth survival⁵ it seems beneficial to look at other options that offer the same benefits whilst preserving what little tooth structure remains. Onlays reduce the need for excessive axial reduction⁶ with 26% less tooth reduction compared to full veneer crowns.⁷ This preservation of tooth structure, combined with full cuspal coverage and good aesthetic results suggests that the use of full coverage onlays may be favourable when compared to conventional full veneer crowns.

It is the intention of this systematic review to collate the success and survival rates of posterior root canal treated teeth restored with full cuspal coverage onlays and compare this to full veneer crowns. The null hypothesis is that onlays provide a poor success and survival rate when compared to full veneer crowns in the restoration of endodontically treated posterior teeth. Success will be determined by the retention of the tooth and restoration without need for intervention, whilst survival will be determined by the retention of the tooth irrespective of the need for intervention. This in turn will confirm if onlays are a better alternative for the restoration of the posterior root filled tooth when compared to full veneer crowns, helping to direct the clinician in their choice of final restoration after root canal treatment.

MATERIALS AND METHODS

The systematic review has been conducted using the PRISMA statement.⁸ To help guide study design and facilitate a specific search strategy initially a PICOS was developed (*Table 1*). After completion of the PICOS the study design was finalised and registered with PROSPERO under the reference CRD42022287217.

Table 1. PICOS.	
Population	Endodontically treated posterior permanent teeth in a population aged between 13 – 99 years
Intervention	Full cuspal coverage onlays
Comparison	Full veneer crowns
Outcome	Survival, defined as the retention of the tooth in the mouth OR success, defined as retention of the tooth and restoration without any need for repair or replacement
Studies	Randomised control trials, prospective cohort studies, and retrospective cohort studies

SEARCH STRATEGY

The search strategy was created combining all possible search terms. This was then reviewed by two separate authors and a librarian from the University of Edinburgh with use of PRESS peer reviewed guidelines.⁹ Searches were carried out via MEDLINE and EMBASE via OVID, PubMed and Cochrane Central Register of Controlled Trials (CENTRAL) using the pre-determined search criteria on 8th April 2022 (*Table 2*).

Studies were selected and pooled using two independent reviewers. Initially, titles and abstracts were reviewed. Authors were contacted and the interlibrary loan service at the University of Edinburgh was used to request any unavailable articles. If the articles were unable to be retrieved, they were removed from the study. The remaining articles were read in full and assessed against the pre-determined inclusion criteria (*Table 3*). Further articles were sought using citation reference searches via Google Scholar. All references identified were collated and stored in the reference manager EndNote 20 (Endnote 20, Clarivate Analytics, Philadelphia, USA).¹⁰ All included and excluded papers were collated and discussed using the Cohen kappa coefficient to measure interrater reliability ($\kappa=1$).¹¹

Data extraction for all articles matching the inclusion criteria was carried out by a single reviewer. All information that was relevant to the primary outcome and met the inclusion criteria

Table 2. Search terms.

General search terms used in search. Full search terms available in Appendix 1.
Root trea* OR Root canal OR endodon* OR non-vital OR pulpless AND Premolar OR molar OR posterior AND Onlay OR overlay OR crown OR veneer OR zirconia OR gold OR lithium OR ceramic OR composite OR resin AND Failure OR loss OR survival OR success OR retention

Table 3. Inclusion and Exclusion criteria.

Inclusion criteria	Exclusion criteria
In vivo Human Endodontically treated teeth Posterior teeth A full English translation if written in another language	In vitro Animal Anterior teeth Inadequate English translation Inadequate methodology Case reports Opinion pieces Letters to the editor

was collected irrespective of whether other results within the same study were excluded. All included studies were assessed for risk of bias by using ROBINS-1 tool¹² for non-randomised cohort studies and RoB-2 tool¹³ for randomised control trials, the studies were then critically appraised using the CASP critical appraisal tool for cohort studies¹⁴ and randomised control trials.¹⁵ Information regarding tooth type, intervention and survival was collated in an Excel spreadsheet (Microsoft Excel for Mac, Microsoft Corporation, Redmond, USA)¹⁶ for analysis and tabulation.

All studies not written in English with potentially relevant information have been collated and reported on. These have not been included in the results to avoid mistranslation however they have been included in the discussion.

RESULTS

The electronic searches on 8th April 2022 provided 1707 possible studies as shown in the below PRISMA flow diagram¹⁷ (Figure 1). After removal of duplicates and assessment of the remaining studies' titles and abstracts, nineteen studies were sought for retrieval. Citation reference searching did not provide any further related studies.

A total of eleven studies were included in the systematic review with descriptions of each intervention provided in Table 4. Table 5 collates the results from all included studies showing reported survival rates for two, three, five, six, eight, and twelve years; and success rates for three, five and six years.

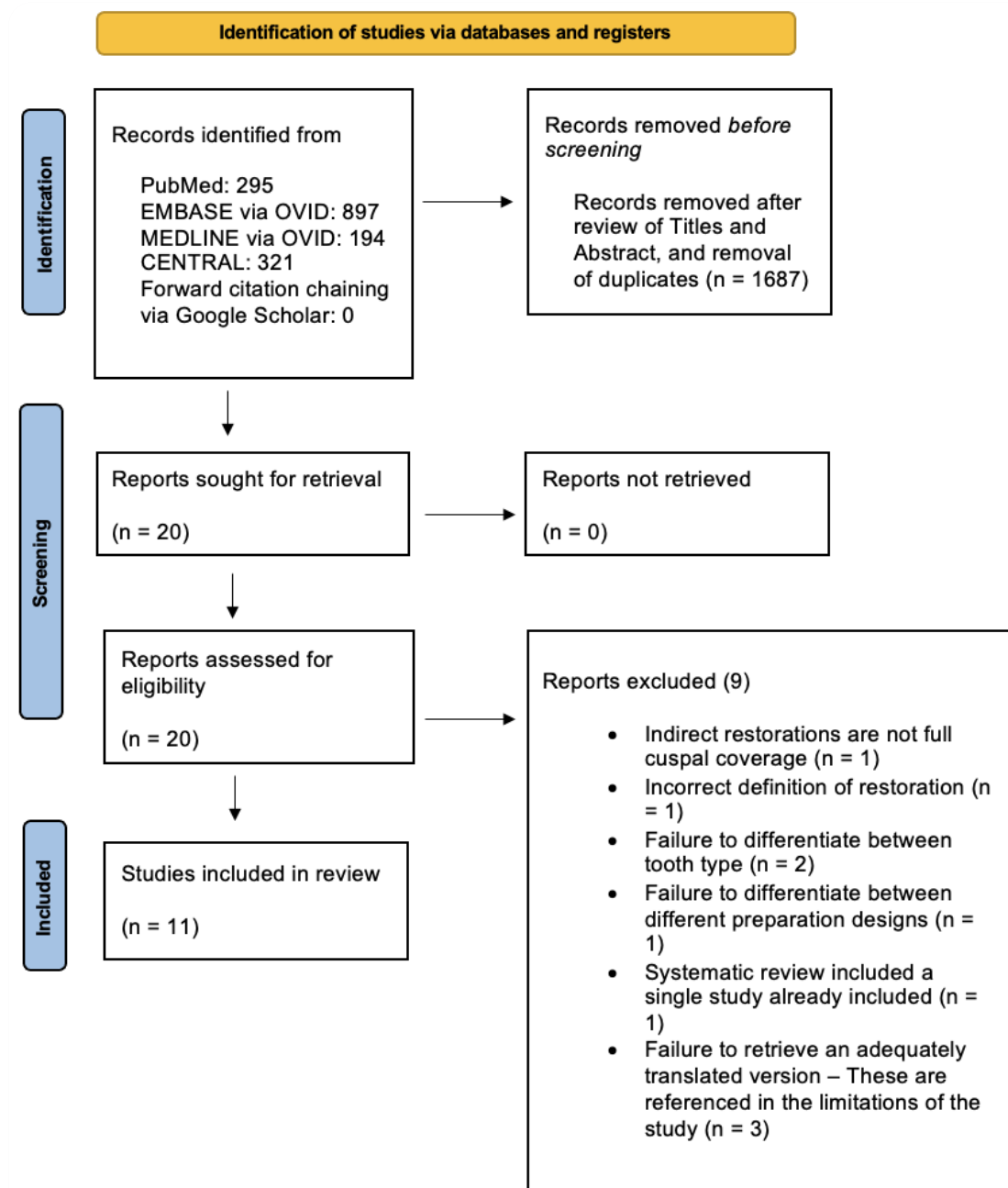


Figure 1: Identification of studies via databases and registers.

Table 4. Studies retrieved for data collection and the intervention provided.

Study	Description of intervention
Xiao. W et al. 2020 ⁷	The pulp chambers of posterior endodontically treated teeth were sealed with 1 mm of glass Ionomer cement before the pulp chamber was filled to 1.5 – 2.0 mm from the occlusal margin with composite resin. Each tooth was then restored with a lithium disilicate onlay. Preparations were prepared with a flat bevel of 20 – 30 degrees or a 1 mm deep round shoulder margin. Restorations were cemented with a dual curing resin cement.
Lu. T et al. 2019 ¹⁸	The pulp chamber was covered with 2.0 – 3.0 mm of glass-ionomer cement. An internal bevel of 8 – 10 degrees was incorporated into the remaining chamber space before an occlusal reduction of 1.0 – 1.2 mm for polymer-infiltrated ceramic network material (PICN) onlays and 2 mm for feldspar ceramic onlays. Onlays were cemented with resin cement.
Dammaschke. T et al. 2013 ¹⁹	Posterior endodontically treated teeth were restored with post and crowns by the school of dental science. Clinical protocols were not available.
Ferrari. M et al. 2019 ²⁰	Posterior teeth with more than 50% remaining coronal tooth tissue were endodontically treated. The access cavities were restored with a single fibre post or composite resin before restoration with a lithium disilicate partial crown. After analysis of the methodology the preparation for the partial crown is the same as that of an onlay and so the study has been included within this category. The partial crowns were full cuspal coverage restorations with 1.0 – 1.5 mm occlusal reduction with interproximal box extensions. Margins were on enamel except in cases where aproximal boxes were too deep. Restorations were bonded in place with resin cement.
Pratt. I et al. 2016 ²¹	Posterior teeth were endodontically treated by postgraduates under a microscope. The teeth were then restored with a full coverage restoration in the form of either a full coverage crown, composite resin, dental amalgam, or provisional restoration.
Chotvorrarak. K et al. 2021 ²²	Molar teeth were root canal treated and restored with single unit full coverage crowns by undergraduates, graduates, and specialists. The teeth were restored with a mixture of cast and fibre posts or direct resin composite before crowns were placed.
Jirathanyanatt. T et al. 2019 ²³	Root treated posterior teeth restored with cast or fibre posts and full coverage single unit crowns in a post graduate clinic.
Monaco. C et al. 2017 ²⁴	Root canal treated posterior teeth were randomly selected and restored with either full coverage zirconia crowns or metal ceramic crowns. Fibre posts were used in the restoration of several teeth.
Suksaphar. W et al. 2018 ²⁵	Root canal treated premolar teeth were restored with or without posts before subsequent restoration with a full coverage crown.
Mannocci. F et al. 2002 ²⁶	Premolar teeth with class II defects were endodontically treated and restored with fibre posts and metal ceramic crowns.
Ferrari. M et al. 2012 ²⁷	Root treated first and second molars were restored with full coverage crowns. Cast metal or fibre posts were used in teeth without enough coronal tissue for a core build up to be provided.

EXCLUDED STUDIES

A total of eight studies were excluded from the study. These have been listed with their reason for exclusion in Table 6.

RISK OF BIAS

A risk of bias assessment was carried out for each included study using the ROBINS-1¹² tool for non-randomised cohort studies and RoB-2¹³ for randomised control trials. A summary of both tools have been depicted in Figure 2 created using ROAVIS.³⁷ Of the eleven studies assessed nine showed a moderate risk of bias and three showed a serious risk of bias. The higher risk of bias was due to: a significant change in preparation design depending on remaining dentine^{7,23} or exclusion of patients with a recall of less than twelve months, and exclusions due to missing data and multiple analysis of the intervention mixing outcomes and subgroups.²²

QUALITY ASSESSMENT

A CASP quality assessment for both cohort studies and randomised control trials was used to help evaluate the reliability and relevance of each study, determining the overall quality of each study included in the systematic review. Summaries of both assessments are depicted in Table 7 and Table 8.^{14,15}

DISCUSSION

The aims of the study were to collate the success and survival rates for full veneer crowns and onlays for the restoration of endodontically treated posterior teeth and compare them to help determine which restoration performs better. A meta-analysis was not possible due to the differences in protocol and material used. Due to this a narrative assessment was required.

Table 5. Results

Study	Study Type	Age range (Years)	Tooth type	Restoration type	Survival Rates %						Success Rates %			
					2 years	3 years	5 years	6 years	8 years	12 years	2 years	3 years	5 years	6 years
Xiao. W et al. 2020 ⁷ China	Prospective cohort study	13 – 68 (Mean: 25)	Premolars: 30 Molars: 70	Lithium disilicate onlay	100%	N/A	N/A	N/A	N/A	N/A	95.8% (P<0.05)	N/A	N/A	N/A
Lu. T et al. 2019 ¹⁸ China	Prospective cohort study	17 - 71	Premolars: 21 Molars: 80	Feldspar ceramic onlay PICN onlay	N/A	N/A	N/A	N/A	N/A	N/A	N/A	90.7% (95% CI, 85.6%- 95.8%) 97.0% (95% CI, 94.9%-99.1%)	N/A	N/A
Dammaschke. T et al. 2013 ¹⁹ Germany	Retrospective cohort study	18.1 - 76	241 restorations (undefined)	Full coverage crown (Undefined0	N/A	87.8% - 100%	96.9%	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ferrari. M et al. 2019 ²⁰	Randomised control trial	18 - 69	Premolars: 30 Molars: 30	Lithium disilicate onlay (Partial crown)	Premolars: 100% (P < 0.005) Molars: 100% (P < 0.005)	Premolars: 93.3% (P < 0.005) Molars: 100% (P < 0.005)	N/A	N/A	N/A	N/A	Premolars: 86.6% (P < 0.005) Molars: 96.6% (P < 0.005)	Premolars: 86.6% (P < 0.005) Molars: 96.6% (P < 0.005)	N/A	N/A
Pratt. I et al. 2016 ²¹ U.S.A	Retrospective cohort study	N/A	N/A	Full coverage crown (Undefined0	N/A	N/A	N/A	N/A	84%	N/A	N/A	N/A	N/A	N/A
Chotvorrarak. K et al. 2021 ²² Thailand	Retrospective cohort study	18 – 78	Molars: 76	Full coverage crown (Undefined0	97.6%	87.8% (>24 months)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Jirathanyanatt. T et al. 2019 ²³ Thailand	Retrospective cohort study	16 - 81	Premolars: 61 Molars: 41	Full coverage crown (Undefined0	N/A	N/A	92.6%	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Monaco. C et al. 2017 ²⁴ Italy	Randomised control trial	18 - 70	Premolars: 44 Molars: 46	Zirconia full coverage crowns Metal ceramic full coverage crowns	N/A	N/A	97.73% 97.44%	N/A	N/A	N/A	N/A	N/A	91.11% 92.64%	N/A
Suksaphar. W et al. 2018 ²⁵	Retrospective cohort study	N/A	Premolars: 61	Full coverage crowns	N/A	N/A	95.1%	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Mannocci . F et al. 2002 ²⁶	Randomised control trial	35 - 55	Premolars: 57	Metal ceramic full coverage crowns	N/A	100%	N/A	N/A	N/A	N/A	94.73%	N/A	N/A	N/A
Ferrari. M et al. 2012 ²⁷ Italy	Randomised control trial	N/A	Premolars: 360	Metal ceramic full coverage crowns	N/A	N/A	N/A	94.1%	N/A	N/A	N/A	N/A	N/A	60%

Survival: Retention of the tooth; Success: Retention of the restoration without the need for intervention.

Table 6. Excluded studies.

Studies	Reasons for exclusion
Aquilino. SA et al. 2002, ²⁸ Sarkis-Onofre et al. 2014 ²⁹	No differentiation between types of teeth. Study includes anterior teeth.
Chrepa. V et al. 2014 ³⁰	Restorations were a mix of full and partial coverage onlays.
Dias. MCR et al. 2018 ³¹	A buccal veneer was added to the preparation of some of the onlays included in the cohort altering the restoration.
Li Z et al. 2015, ³² Di Lorio. E et al. 2016, ³³ Qiang. WL et al. 2018 ³⁴	An accurate translation was not retrieved.
Ozyoney. G et al. 2013 ³⁵	Teeth included were extensively damaged with little to no coronal tissue, Preparation was that of an endocrown, with the access cavity used for retention of the restoration.
Sequeira-Byron. P et al. 2015 ³⁶	The systematic review comments on a single study already reviewed ²⁶ .

Survival rates for posterior teeth restored with onlays were reported as 100% at two years^{7,20} and 96.6% at three years.²⁰ These survival rates confirm that the use of minimally invasive indirect adhesive restorations offer better tooth survival rates at two years when compared to full veneer crowns reported as 97.6% and similar rates at three years, which were reported as 87.8% - 100%.^{22,26} Success rates for premolars and molars restored with onlays were reported as 86.6% - 96.6% at 2 years^{7,20} and 90.7% - 97% at three years.^{18,20} In comparison, full veneer crowns were reported as 94.73% at two years²⁶ and up to 92.64% at five years²⁴ showing comparative survival rates between the two types of restoration. There are no studies reporting on the success and survival of onlays after three years and so a comparison between the two cannot be made for long term survival and success however, for full veneer crowns survival has been reported as 94% - 97.73% at five years,^{24,28} 94.1% at six years,²⁷ 84% at eight years²¹ and 89% at 10 years.²⁸ Success rates have been reported as 91.11% - 92.64% at five years²⁴ and 60% at six years.²⁷

Within the majority of the studies, teeth restored with and without posts have been pooled together. Post-core crowns are deemed to be a separate type of restoration required when the remaining tooth structure is insufficient to retain a restoration alone. The combination of restoration techniques may reduce the reliability of the information as it is not possible to compare the survival rates of onlays to full veneer crowns alone. Ferrari, et al. 2012 reported survival rates of premolars without posts, with prefabricated fibre posts and with custom fibre posts. The results show that full veneer crowns without posts perform well when there are three or four coronal walls, and the survival rate reduces as the amount of coronal tissue declines. The study shows that when coronal tissue is minimal, inclusion of a post improved the survival rates, highlighting how inclusion of these restorations may have introduced a level of inaccuracy.²⁷ These findings are contradictory to the findings by Pratt, et al. and Ferrari, et al. 2019 who both state that the presence of a post did not influence the survival of

the tooth.^{20,21} A comparison of onlays to full veneer crowns would be beneficial to ascertain which restoration performs better when there is no need for core retention. Equally, more studies defining the amount of residual tooth tissue for both restorations would guide the clinician as to which restoration performs better as the remaining tooth structure declines.

The retrievability is important in the selection of a final restoration. Whilst a restoration may perform well, if each failure results in the need for tooth removal, a less predictable but overall more retrievable restoration may be preferential. Xiao et al. reported five failures for onlays, of which all were retrievable. The failures were due to material fracture on teeth prepared with a 1 mm shoulder.⁷ There were no failures in the group prepared with a flat butt joint. In a study by Lu et al. there was a total of five failures, three were due to debonding, one was due to ceramic fracture, and one was due to tooth fracture. Ferrari et al. 2019 reported four failures in relation to premolars and one for molars restored with lithium disilicate onlays.²⁰ These occurred at one and two years for premolars and two years for molars. Out of five failures, two premolars were irretrievably damaged resulting in removal of the tooth, an explanation for these was not provided. Failures of teeth restored with crowns was limited to fracture alone in four of the studies included.^{19,22,23,25} Pratt et al. provided reasons for failure but did not define which restoration type each was associated with, whilst Monaco et al. reported two unrestorable failures, one due to core fracture, and one due to root fracture. Chipping of the ceramic veneer was the reason for five other restorable failures.²⁴ Ferrari et al. 2012 reported a total of nineteen failures due to root fracture, eighteen due to fracture of the post or core, sixteen due to debonding of the post, 34 due periradicular pathology, and 46 due to crown dislodgement. Whilst data are limited it appears that the use of an onlay restoration may be more retrievable and provide a better coronal seal, however further studies are needed to determine this.²⁷

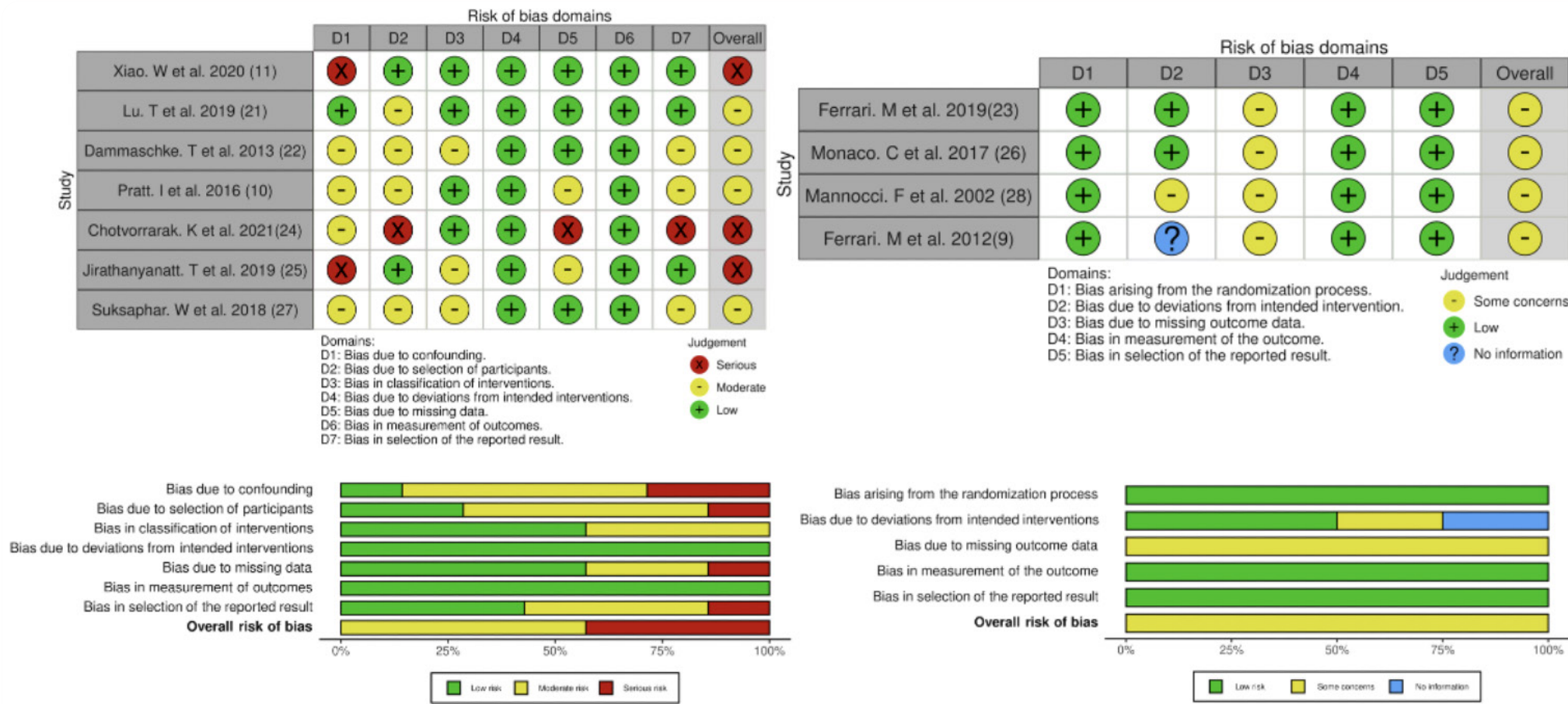


Table 7. CASP tool for cohort studies.

	CASP Questions														Quality assessment
Study	1	2	3	4	5a	5b	6a	6b	7	8	9	10	11	12	
Xiao. W et al. 2020 ⁷	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Lithium disilicate onlay 100% survival rate at two years 95.8% success rate at two years	Results are adequately precise	Yes	Yes	Can't tell	Lithium disilicate onlays are an adequate restoration	Good
Lu. T et al. 2019 ¹⁸	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Feldspathic ceramic onlay 90.70% success rate at three years. PICN onlay 97.00% success rate at three years.	Results are adequately precise.	Yes	Yes	Can't tell	Lithium disilicate onlays are an adequate restoration	Good
Dammaschke. T et al. 2013 ¹⁹	Yes	Can't tell	Yes	Yes	No	No	Yes	Yes	Full coverage crown survival rate of 96.9% at 5 years	Results are adequately precise	Yes	Yes	Can't tell	Full coverage crowns are an adequate restoration	Moderate
Pratt. I et al. 2016 ²¹	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Full coverage crowns survival of 84% at 8 years	Results are adequately precise	Yes	Yes	Can't tell	Full coverage crowns are an adequate restoration	Moderate
Chotvorarak. K et al. 2021 ²²	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Full coverage crowns survival of 97.6% at 2 years and 87.8% > 2years	Results are adequately precise	Yes	Yes	Can't tell	Full coverage crowns are an adequate restoration	Moderate
Jirathanyanatt. T et al. 2019 ²³	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Full coverage crowns survival of 92.6% at 2 years	Results are adequately precise	Yes	Yes	Can't tell	Full coverage crowns are an adequate restoration choice	Moderate
Suksaphar. W et al. 2018 ²⁵	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Full coverage crowns survival of 95.1% at 5 years	Results are adequately precise	Yes	Yes	Can't tell	Full coverage crowns are an adequate restoration choice	Moderate

Key:
1. Did the study address a clearly focused issue?
2. Was the cohort recruited in an acceptable way?
3. Was the exposure accurately measured to minimise bias?
4. Was the outcome accurately measured to minimise bias?
5a. Have the authors identified all important confounding factors?
5b. Have they taken account of the confounding factors in the design and/or analysis?
6a. Was the follow up of subjects complete enough?
6b. Was the follow up of the subject long enough?
7. What are the results of the study?
8. How precise are the results?
9. Do you believe the results?
10. Can the results be applied to the local population?
Key taken from CASP quality assessment tool.¹⁴

Table 8. CASP tool for randomised control trials.

Article	CASP Questions													Quality assessment
	1	2	3	4a	4b	4c	5	6	7	8	9	10	11	
Ferrari. M et al. 2019 ²⁰	Yes	Yes	Yes	Yes	No	No	Can't tell	Yes	Yes	N/A	Yes	Yes	Can't tell	Good
Monaco. C et al. 2017 ²⁴	Yes	Yes	No	Yes	No	No	Can't tell	Yes	Yes	N/A	Yes	Yes	Can't tell	Moderate
Mannocci. F et al. 2002 ²⁶	Yes	Yes	No	Yes	No	No	Can't tell	Yes	Yes	N/A	Yes	Yes	Can't tell	Moderate
Ferrari. M et al. 2012 ²⁷	Yes	Can't tell	Yes	Yes	No	No	Can't tell	Yes	Yes	N/A	Yes	Yes	Can't tell	Moderate

Key:

1. Did the study address a clearly focused research question?

2. Was the assignment of participants to interventions randomised?

3. Were all participants who entered the study accounted for at its conclusion?

4a. Were the participants blind to the intervention they were given?

4b. Were the investigators blind to the intervention they were giving the participants?

4c. Were the people assessing/analysing outcomes blinded?

5. Were study groups similar at the start of the randomised controlled trial?

6. Apart from the experimental intervention, did each study group receive the same level of care?

7. Were the effects of intervention reported comprehensively?

8. Was the precision of the estimate of the intervention or treatment effect reported?

9. Do the benefits of the experimental intervention outweigh the harms and costs?

10. Can the results be applied to your local population/ in your context?

11. Would the experimental intervention provide greater value to the people in your care than any of the existing interventions?

Key taken from CASP quality assessment tool.¹⁵

Regarding the retrievable failures exhibited by the onlay restorations, changes to the restoration protocol may have helped to minimise the risk. The failures of the restorative material could be due to the internal stresses introduced by the shoulder preparation, suggesting that when providing ceramic onlays it may be favourable to opt for a flat butt joint finish over shoulder margins⁷ Lu *et al.* also states that rubber dam was used “when possible” and restorations were adjusted immediately after seating with diamond burs and a high-speed handpiece.¹⁸ Whilst the study does not identify which restorations were not cemented under rubber dam, the poor moisture control, and the possibility of cement lute damage due to adjustment before full curing of the cement, may have all contributed to the bond failure, suggesting a level of technique sensitivity. There was also no mention of immediate dentine sealing (IDS) in either study. A recent systematic review reports how the use of IDS can increase bond strength and fracture resistance of ceramic restorations. As these are the two main failures seen, the use of IDS when restoring posterior endodontically treated teeth with an adhesive restoration may be beneficial.³⁸

The studies reporting on restoration with indirect onlays have reported success rates for four different restorative materials: Lithium disilicate (89.6% - 96.6% at three years),²⁰ feldspathic ceramic (90.7% at three years)¹⁸ and polymer-infiltrated ceramic material (PICN) (97% at three years),¹⁸ Both feldspathic ceramic and PICN were included in the same study

by Lu. *et al.*, however no statistical significance was noted between the two materials (chi-square=1.645; P=.20).¹⁸ There was no significant difference between restorative materials when restoring with full veneer crowns.²⁴

A further three studies were excluded from the systematic review due to an inability to obtain an adequate translation. The studies were not used as the methods and results could not be assessed. Di Lorio *et al.*³³ reported a survival rate of 100% of thirteen lithium disilicate onlays at three years. Li *et al.*³² reported a success rate of 96.6% for premolars with mild defects restored with lithium disilicate onlays and 92.1% for molars with severe defects. This was compared to teeth restored with post and full coverage crowns which reported success rates of 96.3% and 88.5% respectively. Onlay survival rates were reported at 96% and 100% respectively compared to 98.1% and 96.2% for teeth restored with crowns which suggests that onlay restoration failure may be more retrievable than full veneer crowns. Similarly, Qiang *et al.*³⁴ reported three year success rates of ceramic onlays on endodontically treated teeth with a mild defect at 100% for a flat butt joint preparation, 100% for a bevelled butt joint preparation and 94% for a shoulder margin. This again suggests that whilst ceramic onlays may be a good alternative to conventional crown preparations in the restoration of posterior endodontically treated teeth, the preparation itself and management of stress concentrations will have a direct impact on how long

the restoration lasts. The study reports 100% survival of the teeth with mild defects suggesting that the use of a minimally invasive restoration could mean that failures are more retrievable. As the size of the defect increases the success and survival rates decrease with teeth exhibiting severe defects showing success rates of 95.2%, 73.7% and 73.3% respectively. Survival rates for teeth with severe defects were reported at 100%, 89.5% and 80% respectively suggesting that in teeth with larger defects a flat butt joint performs to a higher standard, however this was not deemed to be of significance with $P>0.05$ for the success rates of each preparation type. The results of this study whilst promising should not be used to inform clinical practice until adequate translation of the literature can be provided and an analysis of the materials and methods can be completed.

CONCLUSION

From the information available, when comparing full cuspal coverage onlays to the survival rates of full veneer crowns, survival rates between two and three years are similar and so the null hypothesis can be rejected. Similar survival rates over a three-year period combined with minimal loss of tooth structure suggest that the use of onlays instead of full veneer crowns is favourable, supporting the use of onlays over full coverage crowns when restoring posterior endodontically treated teeth. Further long-term studies evaluating success and survival for onlays for more than three years would be beneficial to provide insight into the performance of onlay restorations after this timeframe. A deeper understanding of full veneer crowns and their survival would also be beneficial through the differentiation of crowns with and without post core crowns in current and future research.

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