Effectiveness of prosthodontic interventions and survival of remaining teeth in adult patients with shortened dental arches - a systematic review Journal of Dentistry

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Title page

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Abstract (242/ 250 words)

Objectives: A systematic review of randomised and non-randomised controlled trials was conducted to evaluate studies of the effectiveness of different tooth replacement strategies in adult patients with shortened dental arches. The objectives of the review were to determine the survival rates of different prosthodontic interventions, the risk of tooth loss with and without prosthodontic interventions, and the impact of different tooth replacement strategies on oral-health related quality of life (OHRQoL).

Methods: The protocol was registered with the International Prospective Register of Systematic Reviews (PROSPERO CRD42017064851), and the review was conducted in accordance with the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA).

Results: The search strategy identified 112 potentially relevant publications; 22 from Medline (OVID), 54 from EMBASE (OVID), 35 from CENTRAL, one from the authors' knowledge of the subject area, and none from OpenSIGLE. Ten articles were included in this systematic review. Of these, four were analyses of different outcomes from a multicentre randomized controlled trial in Germany, whilst one study was the pilot phase for this trial. Two further randomized controlled trials were included from the United Kingdom and Republic of Ireland. The remaining articles were reports of prospective cohort studies from Denmark and the Netherlands.

Conclusions: there is currently insufficient evidence to recommend one tooth replacement strategy over another in adult patients with reduced dentitions.

Clinical significance: (44/ 50 words) There is a need for further research as there are insufficient numbers of good quality randomised controlled trials currently available. Authors should be encouraged to adhere to CONSORT guidelines for randomized controlled trials, and report findings in such a way that facilitates future meta-analysis.

Introduction

The population of the world is ageing. The United Nations has estimated that globally, the percentage of older persons (60 years and over) increased from 9.9% in 2000 to 12.3% in 2015. It is expected that this percentage will rise to over 20% by 2050, with an elderly population of nearly 2.1 billion (Fig. 1).[1] As significant transformations are occurring in populations, changes have also been noted in oral health. More and more adults are retaining their natural teeth into old age (Fig. 2). The 2009 UK Adult Dental Health Survey (ADHS) reported that only 6% of those surveyed were missing all their teeth, a significant decrease from 37% in 1968.[2]

With increased tooth retention, population growth and ageing, the global burden of oral conditions has increased by approximately 20.8% since 1990. Collectively, oral conditions affected 3.9 billion people worldwide in 2010, with untreated caries and severe periodontal disease causing an increased burden, especially in less developed regions. These oral conditions often lead to becoming partially dentate. [4]

Potential consequences of tooth loss include impaired mastication, altered food choices, psychosocial problems and reduced oral health related quality of life.[5,6] However, depending on the pattern of tooth loss, it may not be necessary to replace all missing teeth, especially in older patients. Kayser first described the shortened dental arch (SDA) concept, suggesting that patients with at least four occlusal units (one unit = pair of occluding premolars; two units = pair of occluding molars) had sufficient adaptive capacity to constitute a functional dentition.[7] The concept has been suggested as an oral health goal for adults until the end of life by the World Health Organisation,[8] and is considered to have a useful role in contemporary clinical practice.[9]

Where tooth replacement is required to restore partially dentate patients to at least a

reduced functional dentition, there are various fixed and removable prosthetic options. Traditionally these have included removable partial dentures, and resin bonded or conventional bridgework. In the last number of decades these options have grown in scope with the demonstrated predictability of dental implants. However, decision making for different patterns of tooth loss and patient groups is often not evidence based.[10] In addition, the financial cost of tooth loss disproportionately affects older age groups[11], and there is a need to achieve better clinical outcomes, which are cost-effective and require less maintenance.

A recent systematic review concluded that the shortened dental arch concept appears to be as feasible as tooth replacement with removable partial dentures in partially dentate patients.[12] However, outcome measures were restricted to the impact on oral health related quality of life. Thus, a more comprehensive systematic review of randomised and non-randomised controlled trials was conducted to evaluate studies of the effectiveness of different tooth replacement strategies in adult patients with shortened dental arches. Specifically, the objectives of the review were to determine the survival rates of different prosthodontic interventions, the risk of tooth loss with and without prosthodontic interventions, and the impact of different tooth replacement strategies on oral-health related quality of life (OHRQoL).

Material and Methods

Methods of analysis and inclusion criteria for this systematic review were specified in advance and published as a protocol.[13] The protocol was registered with the International Prospective Register of Systematic Reviews (PROSPERO CRD42017064851), and the review was conducted in accordance with the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA)[14].

Eligibility criteria included experimental or observational study designs investigating partially dentate adult (18 years or older) patients with between 4 and 10 functional teeth in occlusion with a natural dentition or prosthesis. Functional teeth in the maxilla, mandible or both arches were eligible for inclusion. Eligible prosthodontic interventions were removable partial dentures, conventional or resin bonded bridgework, implant supported crown or bridgework, and the comparator was no intervention or different interventions ('head-to-head'). Primary outcomes included survival of prosthodontic interventions (mean follow-up of 5 years or more), survival of remaining teeth (mean follow-up of 5 years or more) and change in OHRQoL using validated self-reported measures (mean follow-up of 1 year or more). Secondary outcomes included any biological or technical complications.

The electronic databases of MEDLINE, CENTRAL, Embase and the grey literature database of OpenSIGLE were searched for primary studies conducted in the period from 1980 to and including 1st November 2017. The OVID interface (MEDLINE, Embase) search strategy is available in Appendix 1, and this was adapted for CENTRAL as appropriate. The trial registries of the World Health Organisation (ICTRP) and US National Institutes of Health (ClinicalTrials.gov) were also searched. Reference lists of included studies or reviews identified through the search were reviewed for any further eligible studies. All searches were restricted to articles published in the English language.

Two review authors (CML and CM) extracted data from each included study independently and in duplicate using a data collection sheet developed for the review. Any differences were resolved by discussion and, where necessary, arbitration by a

third person (GMK). For each study the following data was recorded: year of publication, country of origin, funding; participants; study design; outcomes.

Results

Study selection

Two independent review authors (CML and CM) screened all titles and abstracts identified by the electronic searches. Full reports were obtained for all titles that appeared to meet the inclusion criteria or where there was uncertainty. Disagreements between reviewers were resolved by discussion, and a third reviewer (GMK) was available for resolution of any differences. As described in the PRISMA flow diagram (Fig. 3), the search strategy identified 112 potentially relevant publications; 22 from Medline (OVID), 54 from EMBASE (OVID), 35 from CENTRAL, one from the authors' knowledge of the subject area, and none from OpenSIGLE. After 32 duplicates were identified, 80 titles and abstracts were screened by both reviewers independently. Inter-rater reliability was assessed using the Kappa statistic, with substantial agreement between the reviewers – K = 0.68 (95% CI 0.51, 0.85). Following discussion, and arbitration by the third reviewer, 60 of these citations were excluded. Subsequently, twenty full text articles were retrieved and screened. From this, ten studies were eligible for inclusion in this systematic review. The main characteristics of each included study are presented in Table 1. Full reports that were excluded are presented in Table 2.

An initial evaluation of the included papers showed considerable heterogeneity in study populations, interventions and outcome measures. Despite clinical heterogeneity, a meta-analysis was undertaken for the outcome 'survival of prosthodontic interventions'.

This was not considered appropriate for other outcomes, and therefore a descriptive manner of data presentation was used.

Study populations

Budtz-Jorgensen and Isidor[15] followed 53 patients at the Royal Dental College, Aarhaus, Denmark, who had complete maxillary dentures opposed by partially dentate mandibles. Twenty-five of these were male and twenty-eight were female. Mean ages in the study groups were 69.7 years (range 61 – 83) and 68.3 years (range 61 – 81), whilst the mean number of mandibular teeth in each group was 6.9 (SD 1.7) and 7.5 (1.7). In the Netherlands, Gerritsen et al.[18,19], analysed the records of 59 patients participating in a prospective observational cohort study at the Nijmegen Dental School. Of these patients, twenty-one were male and thirty-eight were female. The study cohort comprised patients with shortened dental arches in at least one jaw (intact anterior dentitions and 3-4 posterior occluding pairs), shortened dental arches extended by removable partial dentures and a control group with complete dental arches. The average ages at baseline in the respective groups were 37.8 years (SD 11.2), 31.7 years (SD 8.0) and 40.0 years (SD 9.7).

Thomason et al.[17] recruited 60 patients at Newcastle Dental Hospital, United Kingdom, who had a maximum of eight remaining mandibular teeth, excluding molars. Twenty-five of these patients were male and thirty-five female, with a median age of 67 years (range 39 – 81). In a pilot study, Wolfart et al.[16] recruited 30 patients at a German dental school who were also missing molars in one jaw, and at least one canine and one premolar present bilaterally. There was equal recruitment of males and females, with a mean age of 62 years. In the subsequent multi-centre randomized controlled trial, Wolfart et al.[21,22] and Walter et al.[20,23] studied 152 patients from fourteen dental schools

in Germany. Inclusion criteria for remaining teeth was as for the pilot phase of the study.[16] Allocated study groups had mean ages of 60.4 years (SD 10.6) and 59.6 years (SD 10.4), with 70 males and 82 females participating. Most recently McKenna et al.[24] recruited 132 patients from a university dental hospital and a geriatric day hospital in the Republic of Ireland. Recruitment was restricted to patients over 65 years seeking tooth replacement, who had a minimum of 6 remaining natural teeth in both arches of good prognosis. Neither the specific age profile or gender of the participants was reported.

Interventions

All of the included studies investigated removable partial dentures as an intervention in a study arm.[15-24] Conventional cobalt chrome metal frameworks were provided for patients in three of the studies[15,17,24], whilst removable partial dentures in the pilot phase and subsequent multicentre randomized controlled trial in Germany were retained by precision attachments.[16,20-23] Specific design features of removable partial dentures were not reported by Gerritsen et al.[18,19] All of the studies also investigated fixed tooth replacement to at least a shortened dental arch, if not already present. Cantilever fixed partial dentures were used to restore patients in one arm of the German study.[16,20-23] Budtz-Jorgensen investigated fixed partial dentures retained by pins and boxes, with single and double abutment and pontic designs up to ten units.[14] In the studies by McKenna et al. and Thomason et al.[17,24], more minimally invasive resin bonded bridges were investigated, whilst Gerritsen et al.[18,19] included a third control group of patients with complete dental arches for comparison. Intervention with implant supported crown or bridgework was not analyzed by any of the included studies.

Outcome measures

Two studies assessed survival of prosthodontic interventions after 5 years. Budtz-Jorgensen and Isidor[15] reported number of prosthesis failures whilst Thomason et al.[17] reported survival probability and compared interventions using hazard ratios. Survival of remaining teeth was analyzed in four studies but outcome measures varied. Budtz-Jorgensen and Isidor[15] reported the number of tooth extractions in each study group over a 5-year follow-up period. Gerritsen et al. reported cumulative survival and hazard ratios for tooth loss with a mean follow up of 27.4 – 35 years[18], whilst a separate analysis reported the rate of tooth loss[19]. Walter et al. reported survival probability for tooth loss in both jaws, the study jaw and in relation to most posterior teeth at 5 years[20]. Three studies provided data on changes in oral health related quality of life (OHRQoL). Wolfart et al. measured changes using the OHIP-49 questionnaire in a pilot study over 12 months[16], and subsequently used the same measure in a multi-centre trial with 5-year follow-up[21]. More recently, Mc Kenna at al. used OHIP-14 questionnaires to assess the impact of treatments over a 12-month period[24]. Several studies reported different secondary outcomes over a minimum follow-up period of 5 years. Outcome measures included cumulative survival and hazard ratios for first restorative interventions, rate of restorative interventions, changes in periodontal indices, incidence of caries and number of treatments for biological and technical reasons.[15,18,19,22,23]

Quality assessment

Cochrane risk of bias[35] assessments were undertaken of each randomized controlled trial report included. These are presented in Table 3, and a summary of the overall quality of these studies is shown in Fig. 4. The quality of three included non-randomized, non-interventional studies was assessed using the Newcastle Ottawa

Scale[36] protocol. Of these, the study by Budtz-Jorgensen[15] was assessed as being of the best quality, earning 8 out of 9 stars for cohort studies. The cohort studies by Gerritsen et al. earned 6[19] and 7[18] stars respectively, across the domains of selection, comparability and outcome.

Conclusions of included studies

Survival of prosthodontic interventions

Thomason et. al[17] reported survival probabilities of approximately 25% for removable partial dentures and 70% for resin bonded bridges at 5 years. Resin bonded bridges had a slightly lower hazard rate, but the difference was not statistically significant (Hazard ratio = 0.59; 95% CI 0.27, 1.29). Significantly, patients in the resin bonded bridge group also required less treatment intervention at follow-up appointments (39/175) compared with the removable partial denture group (78/175). Accepting a loss of power in the study, the authors concluded that the greater need for maintenance in the RPD group, the reported advantages of resin bonded bridges[29,37] and the absence of significant difference in survival, offers positive support for the use of resin bonded bridges in restoring shortened lower dental arches of elderly persons. Previously, Budtz-Jorgensen at el.[15] also concluded that treatment with distally extending cantilevered fixed partial dentures is a favourable alternative to treatment with RPDs in elderly patients. There were relatively more failures in the removable partial denture group (10/26) than in the fixed partial denture group (8/41) over the 5 year period, but no statistical analysis was undertaken.

Survival of remaining teeth

In their prospective cohort study, Budtz-Jorgensen and Isidor[15] reported more extractions in the RPD study group (11) than in the fixed partial denture group (1) during 5 year follow-up. However, as with prostheses survival, no statistical analysis was undertaken. When comparing shortened dental arches with and without removable partial dentures, Gerritsen et al.[19] found no significant difference in cumulative survival of remaining anterior or premolar teeth. However, the authors concluded that patients with a shortened dental arch had an increased risk of losing premolar teeth, as the hazard ratio was statistically significant when compared to the complete dental arch group. In a further analysis, Gerritsen et al.[18] reported no statistically significant difference in the per year risk of tooth loss between the shortened dental arch groups with or without removable partial dentures. However, they concluded that replacement of absent posterior teeth by free end removable partial dentures cannot be recommended as it seems to be associated with a less favourable clinical course. Walter et al.[20] also found no significant differences in survival probability at 5 years for first tooth loss in both jaws, the study jaw or in relation to most posterior teeth, with or without removable partial dentures.

Changes in Oral Health Related Quality of Life

In Germany, Wolfart et al.[16,21] compared the impact on OHRQoL for patients with and without removable partial dentures. Both a pilot study[16] and subsequent multicentre randomized controlled trial[21], concluded that both treatment concepts showed a similar improvement in OHRQoL, with no significant differences between the treatment groups. The multicentre study did note a slightly longer adaptation period in the removable partial denture group, with improvements in OHRQoL continuing until 1 year post-insertion. In contrast, McKenna et al.[24] concluded that treatment based on the SDA concept achieved significantly better results than that based on RPDs, in terms of impact

on OHRQoL. These results were seen in both a dental hospital and geriatric day hospital setting, 12 months after treatment intervention.

Biological and Technical Complications

Budtz-Jorgensen and Isidor[15], when comparing FPDs to RPDs, concluded that generally the need for dental and prosthetic follow-up treatment was more pronounced in the RPD group than in the FPD group. Fifty-seven carious lesions were observed in the RPD group compared with 10 lesions in the FPD group, although again statistical analysis was not undertaken. They also noted no progression of periodontal disease adjacent to the abutment teeth in any of the groups. Walter et al.[23] did find statistically significant although minor detrimental effects of RPDs on periodontal health, when compared to patients restored to a fixed premolar occlusion. Overall, small significant differences were noted in plaque indices, bleeding indices, clinical attachment loss and probing pocket depths in distal sites of the posterior most teeth associated with prostheses. However, the authors concluded that these small negative effects do not justify a rejection of RPDs when they are indicated. From the same German study, Wolfart et al.[22] found statistically significant differences in treatment for technical reasons over the 5-year follow-up. 24% of patients in the RDP group needed treatment compared with 8% in the SDA group (p=0.01). In the analysis by Gerritsen et al.[19], the authors concluded that wearing a RPD in SDA subjects did not increase the risk of receiving a first-time restoration. However, SDA subjects did have an increased risk of receiving a first-time restoration in anterior and premolar teeth compared to complete dental arch subjects. In a separate analysis[18], they also found no statistically significant difference in the per year risk of direct, indirect restorations or endodontic treatments, between the shortened dental arch groups with or without removable partial dentures.

Discussion

Ten articles were included in this systematic review. Of these, four were analyses of different outcomes from a multicentre randomized controlled trial in Germany, whilst one study was the pilot phase for this trial. Two further randomized controlled trials were included from the United Kingdom and Republic of Ireland. The remaining articles were reports of prospective cohort studies from Denmark and the Netherlands.

Only two studies considered the survival of prosthodontic interventions in adult patients with shortened dental arches after a minimum follow-up period of 5 years. This time period was chosen as it has been used in other systematic reviews investigating indirect prostheses.[38-40] However, it is accepted some clinicians may argue that such a period is too short to obtain reliable information on survival and complication rates.[41] Both studies compared cantilever bridgework to removable partial dentures. Meta-analysis (Figure 5) showed statistically significant better survival for cantilever bridgework. However this should be interpreted with caution, due to the noted clinical heterogeneity between these studies. All patients in the study by Budtz-Jorgensen and Isidor had maxillary complete dentures and more invasive bridge designs were used in the mandible. Restorations were also cemented with a luting cement (Zinc Phosphate) and therefore, the data may not reflect the performance of more contemporary resin bonded materials. Thomason et al. did use more contemporary resin bonding techniques and single abutments wherever possible. Such techniques for cantilever resin bonded bridges are associated with relatively high survival rates[42], in comparison with removable partial dentures at 5 and 10 years.[43] This study failed to detect a statistically significant difference in time to survival between the two treatment groups, although the RPD group required significantly more treatment interventions and maintenance at follow-up appointments. Again these

findings should be interpreted with caution, as the small sample size and relatively high drop-out (15 patients) is likely to have resulted in loss of power and ability to show any true difference between the interventions. The German multicentre study also reported more maintenance for technical reasons in the RPD group, although they were retained by precision attachments, which would not be standard practice in the United Kingdom. In addition, they reported significant but minor detrimental effects of RPDs on periodontal health. Previous studies have shown increased plaque and gingivitis, particularly at abutment teeth, and these results may reflect the less hygienic, more complex design used. However, there is no clear evidence that RPDs increase the risk of periodontitis.[44]

Tooth loss was considered in four of the included studies. Budtz-Jorgensen and Isidor reported more extractions in the RPD group than the FPD group. However, it was suggested that several of these teeth could have been retained if patients had been willing to accept more costly further treatment. This highlights how cost, amongst other factors, can be a barrier to treatment and cause inequality in dental service utilisation[12,45]. Gerritsen et al., in separate analyses of a prospective cohort study, reported that for patients with shortened dental arches, wearing removable partial dentures had no significant impact on cumulative survival of remaining teeth or risk of tooth loss. However, when compared to a third group of patients with complete dental arches, cumulative survival of premolar teeth in patients with shortened dental arches was significantly lower. Again, these results must be interpreted with caution due to the small sample size, and no detail of possible confounding variables such as previous caries status, smoking, diet or oral hygiene. The multicentre RCT in Germany also found no significant difference in cumulative survival at 5 years for tooth loss in each study group. In general, these findings are consistent with the understanding of tooth loss as a multifactorial outcome that is difficult to predict.[46,47]

It is recognised that purely clinical indicators are insufficient when assessing treatment outcomes. For treatment plans to meet patient preferences and needs, the gap between the clinican's and patient's view of clinical reality must be narrowed. Many subjective patient reported outcome measures (PROMS) have been developed, but few are used routinely at the point of care.[48] Wolfart et al. and McKenna et al. used different versions of the oral health impact profile (OHIP) to assess changes in oral health related quality of life (OHRQoL) in their randomized controlled trials. This is a widely reported and validated tool[49-51], with versions including 49 item (OHIP-49) and 14 item (OHIP-14) questionnaires. There is strong evidence that tooth loss is associated with impairment in OHRQoL, however, the prevalence of negative impacts increases significantly when the number of occluding pairs of teeth drops below ten.[6] McKenna et al.[24] found that treatment according to the SDA concept resulted in significantly better mean OHIP-14 scores compared with RPD treatment, in both a dental hospital and geriatric day hospital setting. Contemporary standardised protocols were used for provision of resin bonded bridges in the SDA group and cobalt chrome frameworks were provided in the RPD group. In contrast, Walter et al.[16,21] used median OHIP-49 scores in both studies, and found no significant differences between the SDA and RPD groups at 12 months or at 5 years. These findings were similar to a previous UK pilot study, comparing the SDA concept with RPDs. Summary satisfaction scores improved in both groups, but significant differences were not established.[29]

A major limitation of this review is that it was only possible to conduct a meta-analysis using two studies for one outcome, and the overall estimate of treatment effect is therefore limited. This reflects the considerable heterogeneity in interventions and outcomes across only ten included studies. Heterogeneity makes it difficult to compare inconsistency, indirectness and imprecision across studies. In general, the quality of

studies varied. This is consistent with a previous review of restorative approaches in shortened dental arch patients, which graded the overall body of evidence as low.[52] In our review, randomization was judged to be adequate in all trials. However, for indirect prostheses it is almost impossible to blind the clinician or patient from the intervention, whilst blinding of the assessor is challenging due to marked differences in the appearance of prostheses. All but one of the included randomized trials were assessed as at high risk of performance bias, but lack of blinding was considered unlikely to affect outcomes in the majority of studies. Both the United Kingdom and German multicentre trials experienced significant numbers of patients lost to follow-up, and loss of power, whilst the cohort studies also had small sample sizes. Another limitation is that the review was mainly based on studies that were conducted in an institutional environment, such as university or hospital based clinics, and therefore lacks external validity. It is important to note that not all possible prosthodontic interventions were considered, with no studies on dental implants included. Furthermore, some of the prosthodontic interventions provided, particularly in the Danish and German studies, are much more invasive than would be considered standard practice in the United Kingdom. All searches included only English-language publications, and this may have excluded several additional studies published in other languages. However, the scoping exercise suggested this was unlikely and previous studies[53] have found little effect in excluding trials published in languages other than English, on combined effect estimates in meta-analyses of RCTs.

Conclusion

In conclusion there is currently insufficient evidence to recommend one tooth replacement strategy over another in adult patients with reduced dentitions. There is limited evidence that removable partial dentures are associated with more maintenance

and impact less on oral health related quality of life, in comparison with restoration to a shortened dental arch using resin bonded bridges. However, there is a need for further research as there are insufficient numbers of good quality randomised controlled trials currently available. Authors should be encouraged to adhere to CONSORT guidelines for randomized controlled trials, and report findings in such a way that facilitates future meta-analysis. In particular, future studies should focus on contemporary prosthodontic interventions, including dental implants, and provide more standardised core outcomes with longer term follow-up. These should include subjective qualitative outcomes so that future treatment strategies can be based on evidence that is 'patient centred'. Finally, with an aging population, and evidence of income related barriers to oral healthcare for many older adults[11], there is a need to ascertain which treatment strategies are most cost-effective.

Acknowledgements

Conflicts of interest: none. Funding by the Royal College of Surgeons Edinburgh, Small Research Grant.

Tables

Table 1:

Characteristics of included studies

	Setting	Participants	Age	Country	Interventions	Outcomes	Follow-up
Budzt-Jorgensen et al. (1990)[15]	DS	53	61-83	Denmark	SDA / FPD RPD	Intervention Survival Biological / technical complications	5 years
Wolfart et al. (2005)[16]	DS	30	>35	Germany	SDA / FPD RPD	OHRQoL	1 year
Thomason et al. (2007)[17]	DH	60	39-81	UK	SDA / RBB RPD	Intervention Survival	5 years
Gerritsen et al. (2013)[18]	DS	59	Mean ages: 37.8 (11.2), 31.7 (8.0), 40.0 (9.7)	Netherlands	SDA / FPD CDA RPD	Tooth Survival Biological / technical complications	27 – 35 years
Gerritsen et al. (2013)[19]	DS	59	Mean ages: 37.8	Netherlands	SDA / FPD CDA RPD	Tooth Survival Biological /	27 - 35 years

			(11.2), 31.7 (8.0), 40.0 (9.7)			technical complications	
Walter et al. (2013)[20]	DS / DH	152	>35	Germany	SDA / FPD RPD	Tooth Survival	5 years
Wolfart et al. (2014)[21]	DS / DH	152	>35	Germany	SDA / FPD RPD	OHRQoL	5 years
Wolfart et al. (2012)[22]	DS / DH	152	>35	Germany	SDA / FPD RPD	Biological / technical complications	5 years
Walter et al. (2014)[23]	DS / DH	152	>35	Germany	SDA / FPD RPD	Biological complications	5 years
McKenna et al. (2015)[24]	DS / DH	132	>65	Ireland	SDA / RBB RPD	OHRQoL	1 year

Table 2

Characteristics of excluded studies

Study	Reason for exclusion
Baba et al. (2008)[25]	Study of cross sectional design with no intervention comparison and follow-up
Degidi et al. (2003)[26]	Study did not define number of missing teeth and there was no shortened dental arch subgroup for survival results
Fueki et al. (2015)[27]	Included participants with greater than 10 teeth in study

	arch (2 – 12 missing occlusal units)
Goshima et al. (2009)[28]	Study only presented results with 1 month follow-up
Jepson et al. (2003)[29]	Study did not present a validated oral health related quality of life outcome
Mc Kenna et al. (2014)[30]	Study presented data on oral health related quality of life contained in included study
McKenna et al. (2013)[31]	Study only presented results with 1 month follow-up
Sasse et al. (2014)[32]	Mean observation period of study was less than 5 years
Schmitt et al. (2011)[33]	Study did not define number of missing teeth or age of participants
Weibrich et al. (2001)[34]	Maximum observation period of study less than 5 years and there was no shortened dental arch subgroup for survival results

Table 3

Assessment of risk of bias (randomized controlled trials)

	Thomasson et. al (2007)	***Walter et. al (2013)***	***Walter et. al (2014)***	***Wolfart et. al (2005)***	***Wolfart et. al (2014)***	***Wolfart et. al (2012)***	***McKenna et. al (2015)***
Sequence generation	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Allocation sequence concealment	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Blinding of personnel	Low risk	High risk	High risk	High risk	High risk	High risk	High risk
Blinding of outcome assessment	Low risk	Low risk	High risk	Low risk	Low risk	High risk	Low risk
Incomplete outcome data	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Selective reporting	Unclear risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk

Table 4

<u>Survival of remaining teeth</u>

		SDA + RPD	*SDA*	*CDA*
Walter et al. (2013)	**Cumulative Survival**	First tooth loss 0.74 (0.64, 0.84)	First tooth loss 0.74 (0.63, 0.85)	-

	Probability at 5 years (95% CI)			
Gerritsen et al. (2013)	**Hazard Ratio (95% CI)**	Anterior teeth 1.62 (0.29, 9.06); Premolar teeth 1.21 (0.61, 2.43)	Reference group	Anterior teeth 0.22 (0.03, 1.47); Premolar teeth 0.13 (0.05, 0.32)
Gerritsen et al. (2013)	**Extractions per year (Mean (SD))**	Upper jaw 0.12 (0.12); Lower jaw 0.06 (0.10)	Upper jaw 0.06 (0.08); Lower jaw 0.05 (0.10)	Upper jaw 0.03 (0.03); Lower jaw 0.03 (0.03)

Table 5

Changes in Oral Health Related Quality of Life

		Pre-treatment / Baseline		*12 months*	
		SDA + RPD	**SDA**	**SDA + RPD**	**SDA**
Wolfart et al. (2005)	**OHIP-49 score (Median (IQ range))**	43.5 (18 - 112)	31.8 (26 - 66)	14.7 (9 - 20)	8.3 (5 - 43)
Wolfart et al. (2014)		38.0 (14.0 - 67.0)	40.0 (18.0 - 69.0)	13.0 (6.0 - 35.0)	15.5 (6.0 - 39.0)
McKenna et al. (2015)	**OHIP-14 score (Mean (SD))**	11.5 (4.7)	12.0 (5.5)	5.8 (3.5)	4.0 (2.6)

Figure legends

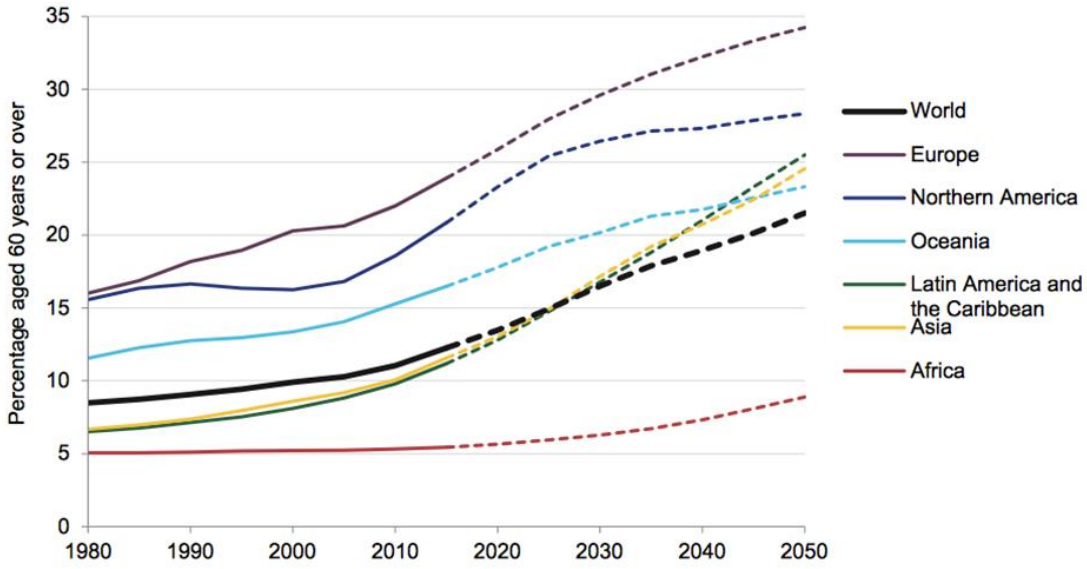
Figure 1: Percentage of the population aged 60 years or over for the world and regions, 1980-2050[1]

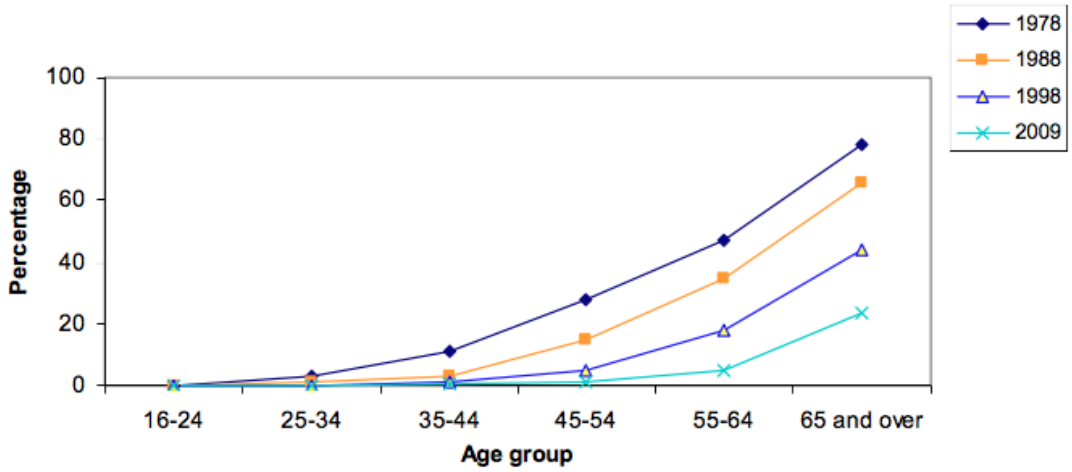
Figure 2: Trends in percentage edentate by age: England, 1978-2009[3]

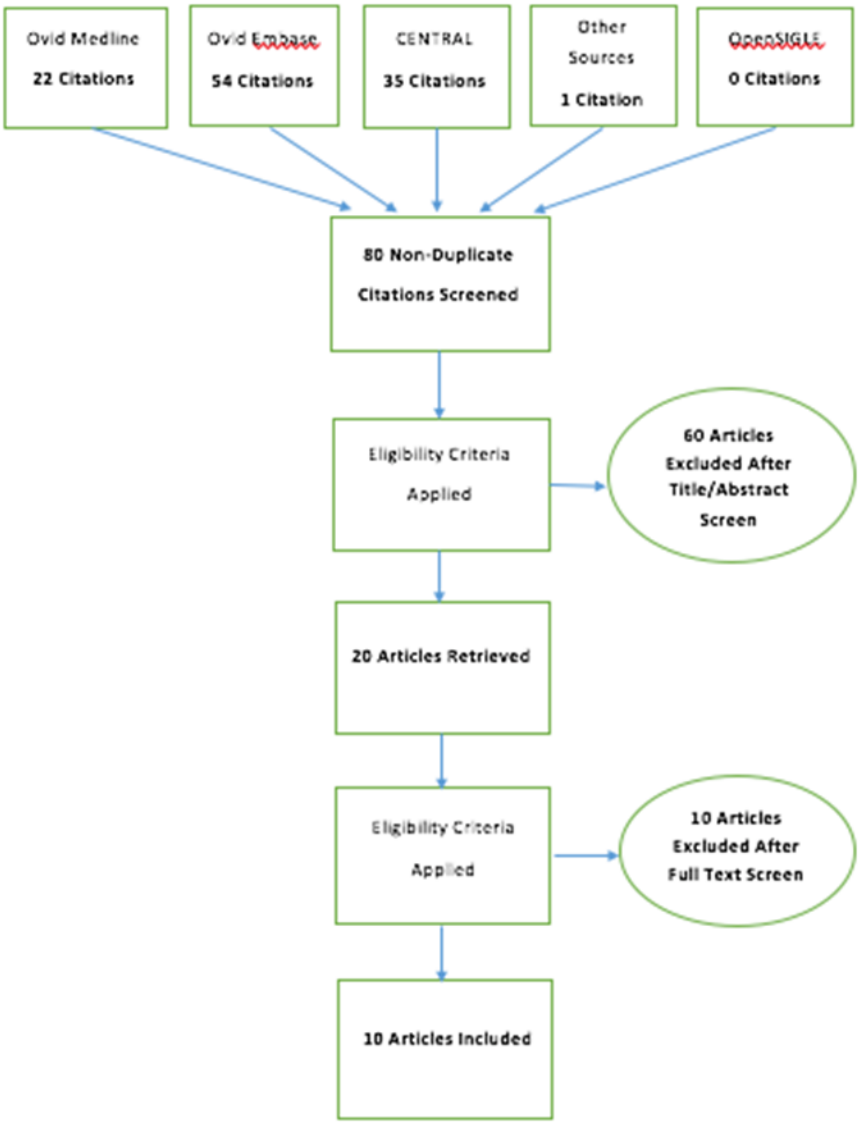
Figure 3**:** PRISMA flow diagram for studies retrieved through search and selection

Figure 4: Summary of risk of bias (randomized controlled trials)

Figure 5 Meta-analysis of survival of prosthodontic interventions


Percentage aged 60 years or over
35
30
25
20
15
10
5
0
1980
1990
2000
2010
2020
2030
2040
2050
World
Europe
Northern America
Oceania
Latin America and the Caribbean
Asia
Africa


1978
1988
1998
2009
100
80
60
40
20
0
Percentage
16-24
25-34
35-44
45-54
55-64
65 and over
Age group


Ovid Medline
22 Citations
Ovid Embase
54 Citations
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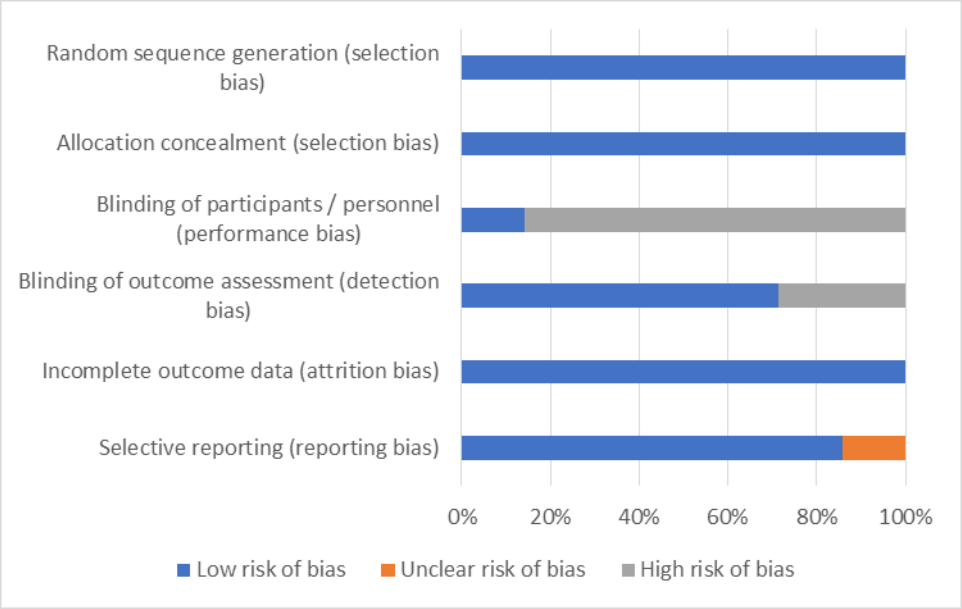
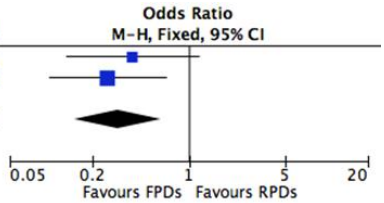
35 Citations
Other Sources
1 Citation
OpenSIGLE
0 Citations
80 Non-Duplicate Citations Screened
Eligibility Criteria Applied
60 Articles Excluded After Title/Abstract Screen
20 Articles Retrieved
Eligibility Criteria Applied
10 Articles Excluded After Full Text Screen
10 Articles Included


Random sequence generation (selection bias)
Allocation concealment (selection bias)
Blinding of participants / personnel (performance bias)
Blinding of outcome assessment (detection bias)
Incomplete outcome data (attrition bias)
Selective reporting (reporting bias)
0%
20%
40%
60%
80%
100%
Low risk of bias
Unclear risk of bias
High risk of bias

Study or Subgroup	FPDs Events	FPDs Total	RPDs Events	RPDs Total	Weight	Odds Ratio M-H, Fixed, 95% CI
Budtz-Jorgensen et al (1990)	8	41	10	26	39.1%	0.39 [0.13, 1.17]
Thomason et al. (2007)	11	54	15	30	60.9%	0.26 [0.10, 0.68]
Total (95% CI)		**95**		**56**	**100.0%**	**0.31 [0.15, 0.64]**
Total events	19		25			

Heterogeneity: $Chi^2 = 0.31$, df = 1 (P = 0.58); $I^2 = 0\%$

Test for overall effect: Z = 3.17 (P = 0.002)



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Appendix 1: OVID MEDLINE / Embase Search Strategy

1. (t##th* adj6 replac*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier]
2. Dental Prosthesis, Implant-Supported/ or Dental Implantation, Endosseous/ or Dental Implants/ or oral implant*.mp.
3. bridge*.mp.
4. Dental Prosthesis, Implant-Supported/ or Denture, Partial/ or Jaw, Edentulous, Partially/ or Denture, Partial, Removable/ or partial denture*.mp. or Denture, Partial, Fixed/
5. 1 or 2 or 3 or 4
6. (short* adj6 dental arch*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier]
7. (functional* adj6 dentition*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier]
8. 6 or 7
9. t##th loss.mp
10. surviv*.mp.
11. fail*.mp.
12. "quality of life".mp. or "Quality of Life"/
13. Health Status Indicators/ or Health Status/ or health stat*.mp
14. 9 or 10 or 11 or 12 or 13
15. 5 and 8 and 14
16. limit 15 to (english language and clinical trial, all)