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Authors	McKenna, Gerald;Tada, Sayaka;McLister, Conor;DaMata, Cristiane;Hayes, Martina;Cronin, Michael;Moore, Ciaran;Allen, Finbarr
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UCC
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

Abstract (250/250 words)

Tooth replacement options for partially dentate older adults: a survival analysis

Objectives: To compare the success of two different tooth replacement strategies for partially dentate older adults; namely resin bonded bridgework (RBB) provided to restore patients according to the principles of the shortened dental arch concept (SDA) and conventional full-arch rehabilitation with removable dental prostheses (RDPs).

Methods: A randomised controlled clinical trial (RCT) was conducted with partially dentate adults aged 65 years or older. Each patient from the RDP group had all missing natural teeth replaced with cobalt–chromium framework RDPs. Each patient from the SDA group was restored to 10 occluding pairs of natural and replacement teeth using RBB. Patients were followed-up at 6, 12, 24, 36 months. Success rates were generated according to defined success criteria. Log-rank tests and Cox's proportional hazard models were used to compare the success of the two treatment strategies.

Results: After 36 months, 89 patients completed the RCT; n=45 in the RDP group and n=44 in the SDA group. The overall success rate of the SDA treatment was 90.4% compared to 73.0% for RDPs (p=0.005). In the upper arch SDA treatment was 100% successful compared to 86.4% for RDPs (p=0.019). In the lower arch, lower success rates were reported for both the SDA treatment (80.0%) and RDPs (60.0%) (p=0.054). Further analyses with cox's proportional hazard models demonstrated that SDA treatment was significantly more successful than RDPs (Hazard Ratio: 2.47, p=0.04).

Conclusions: After 36 months SDA treatment using RBB was significantly more successful than RDPs used for conventional full-arch rehabilitation in partially dentate older adults.

Clinical significance: (37/ 50 words) Functionally orientated treatment according to the principles of the SDA is a feasible alternative to RDPs for partially dentate older

patients. SDA treatment using RBB can achieve higher success rates compared to RDPs in this patient group.

Introduction

Global population projections indicate that the proportion of people over 65 years of age is increasing and will continue to do for the foreseeable future. Oral health professionals have observed that in addition to simply an ageing population, there have been significant changes in the oral health of older adults in recent years[1,2]. As the numbers of edentulous older adults has declined, there has been a significant increase in the number of partially dentate elderly. Changing attitudes, improved access to dental care and more effective preventative programmes have meant that large numbers of patients are now retaining natural teeth into old age. However, despite these improvements to dental health, many of these partially dentate older patients still require treatment to replace missing teeth.

As older patients retain natural teeth for longer the dental profession is charged with controlling chronic dental diseases in an increasingly challenging oral environment. Many older patients suffer from a variety of conditions which make mechanical tooth cleaning and denture cleansing very difficult. By their nature, older patients also suffer most from chronic systemic diseases. Loss of manual dexterity due to conditions such as Parkinson's Disease or Arthritis can make keeping teeth and dentures clean almost impossible. In addition, many older patients consume food rich in complex carbohydrates which can promote the development of coronal and root caries[3,4]. As these patients get older, their mouths and teeth undergo a number of age related changes. One of the most marked changes is a reduction in the amount of saliva in their mouths with large numbers complaining of xerostomia. Physiological changes can contribute to xerostomia but dry mouth is a common side effect of many drugs taken by to control systemic medical conditions. A lack of saliva can have a devastating effect on the remaining dentition, directly contributing to an increased risk of caries, periodontal disease and subsequent tooth loss[5]. Removable dental prostheses (RDPs) can themselves present a significant maintenance challenge for

patients[6,7]. This can have further negative effects on dental disease progression and subsequent tooth loss.

Future dental practitioners will spend an increasing proportion of their time providing treatment for older patient[1]. With increasingly available sources of information and a more dentally aware population, clinicians will be tasked with replacing teeth in a conservative, cost effective and patient centred approach. Despite the large numbers of RDPs produced there are alternative treatments available to replace missing teeth. These include fixed prosthodontic options attached to natural teeth or dental implants. Less complex, functionally orientated treatment solutions are very applicable to partially dentally older patients. One of these is the Shortened Dental Arch (SDA) concept which aims to provide patients with a functional dentition of 10 occluding pairs of teeth without the need for a RDP[8]. By preserving mainly anterior teeth the SDA concept can offer patients an aesthetic result which they can easily maintain. Studies have shown that by providing 10 occluding pairs of teeth patients have suboptimal but acceptable levels of function for older patients[9]. Although the SDA concept has been shown to be acceptable to both patients and clinicians there is also evidence to suggest that it is currently an underutilised treatment approach[10]. Whilst a small number of patients will retain the 20 natural teeth necessary to achieve a natural SDA, a more realistic situation is that patients can be restored to a SDA. This can be done using a variety of fixed prosthodontic options including fibre reinforced composite resin, conventional bridgework and adhesive resin bonded bridgework (RBB). RBB has been shown to be an effective and simple way of replacing missing teeth to provide patients with a SDA[11].

The aim of this study was to compare the success of two different tooth replacement strategies for partially dentate older patients. These strategies were conventional full-arch

rehabilitation with RDPs and functionally orientated treatment according to the principles of the SDA with RBB used to replace missing teeth.

Material and Methods

As illustrated in Figure 1, a randomised controlled clinical trial (RCT) was conducted (Trial registration: ISRCTN26302774). The in-depth methodology of the RCT has been described in a number of previous publications and so a short summary is provided here[12]. Partially dentate patients aged 65 years and older were recruited from two centres: Cork University Dental Hospital and St Finbarr's Geriatric Day Hospital in Cork, Ireland. Those patients in St Finbarr's Geriatric Day Hospital represented a more systemically unwell and older cohort as they attended the Day Hospital to receive a range of medical treatments.

Patients were included in the study if they were 65 years or older and seeking replacement of missing natural teeth. Participants had a minimum of six remaining natural teeth in both arches of good prognosis, could accept routine dental care in a dental chair, could communicate in English and had no medical conditions which precluded routine dental treatment. Full ethical approval was granted for the study (ref: ECM 5 (9) 05/02/08). Each patient was provided with written information detailing the proposed treatment involved and each patient completed a written consent form prior to treatment. A power calculation was made based on summary OHIP-14 score data from the United Kingdom Adult Dental Health Survey[13]. The calculation was based on an equivalence study. The power calculation indicated that 44 patients per group was required to give power of 80% with a one sided 5% level of significance. The attrition rate was set at 30% to allow for drop outs during the study, so the targeted baseline recruitment was 130 participants. Patients were recruited and treated in both a dental hospital and a geriatric day hospital with a mobile dental unit.

Randomisation was performed using a computer generated schedule in SAS®. All patients were randomly allocated to two different treatment groups: the RDP group and

the SDA group. Randomisation was conducted in blocks of varying length and was stratified according to age and gender with separate randomisation sequences in the two recruitment centres. There was no difference in randomisation according to dental status or number of missing teeth. Patient randomisation was conducted by a research assistant and the allocation was concealed from the clinical operator. Initially, all patients received standardised dental care to render them dentally fit including extraction of hopeless teeth, restoration of caries and non surgical management of periodontal disease.

Patients from each treatment group received standardised care according to a treatment protocol. Each patient from the RDP group had all missing natural teeth replaced with RDPs fabricated with cobalt–chromium frameworks. Each patient from the SDA group was restored to a premolar occlusion of 10 occluding pairs of natural and replacement teeth using RBB throughout the arch. The number and position of RBBs provided was tailored to the clinical needs of each patient. Posterior teeth distal to the SDA were left unopposed. The RBB was provided using a standardised protocol in each case with each unit of bridgework designed with a nickel chromium wing which was sand blasted chairside prior to cementation using a resin cement. Cantilever designs were utilised for each item of RBB. Each item of fixed and removable prosthodontics was constructed by the same dental laboratory. All operative treatment was conducted by a single operator with postgraduate training in clinical prosthodontics during a 24 month period. Patients were followed up for 36 months with review appointments at 6, 12, 24 and 36 months. In addition, patients attended without appointments if they required further treatment associated with either tooth replacement strategy. At each appointment both the SDA and the RDP patients were assessed for success according to the criteria in Table 1.

The success of tooth replacement (RDP or SDA) in each arch was measured from the entry-point into the study, defined as the date of treatment provision (RDP or SDA), until the end-point, defined as the date when decementation, the need for repair, or non usage were observed. The observation period was censored when 36 months had passed since the date of treatment provision. A Kaplan–Meier survival analysis was performed to illustrate the success probability of the two treatments and the distribution was compared with a log-rank test. Further survival analysis was undertaken using a Cox proportional hazards model with age, gender, arch (upper vs lower) and pattern of tooth loss (Kennedy Classification) used as covariates. To compare the characteristics of the two treatment groups, Mann-Whitney U and Chi-squared tests were used. P-values of less than 0.05 were considered to be statistically significant and data were analyzed using IBM SPSS Statistics 24 (IBM Company, Tokyo, Japan).

Results

After 36 months, 89 participants completed the RCT. As part of the study a total of 89 RDPs were constructed and 73 arches were restored to SDAs using RBBs. For the arches restored to a SDA, 66 (90.4%) were judged as successful with a further 7 (9.5%) having survived after one episode of recementing. In comparison, 65 RDPs were judged to have been successful (73.0%) with a further 10 (11.2%) having survived. A total of 14 RDPs (15.7%) were no longer in use and were considered as unsuccessful (Table 1).

The profiles of the patients treated as part of the trial are summarised in Table 2. Forty patients did not complete the trial (30.3%), 15 from Cork University Dental Hospital and 25 from St Finbarr's Geriatric Day Hospital. The high dropout rate in St Finbarr's Geriatric Day Hospital was due to a variety of reasons including death (10 patients) and admission to long - term care facilities due to illness (eight patients), which represented this older and more systemically unwell group. During the trial, 20 patients (30.8%) were lost from the RDP group and 20 were lost from the SDA group (29.9%). This indicated that patients did not leave the study simply because they were randomly allocated to the more experimental treatment group (SDA group). Analysis of the non-responders did not indicate any systemic differences between them and those who completed the trial.

The success rates for the treatment groups according to pattern of tooth loss (Kennedy classification) and arch is illustrated in Table 3. This data illustrates that the majority of cases treated in the upper arch for both groups were Kennedy Class III: RDP Group n=17, SDA Group n=23; and Kennedy Class I in the lower arch: RDP Group n=23, SDA

Group n=14. This data illustrates the high success rates for SDA treatment in the upper arch (100%) across all Kennedy Classifications but low success rates for RDPs placed in Kennedy Class I cases (34.8%).

Kaplan-Meier survival curves for the two treatment groups are illustrated in Figure 2 with the data broken down by arch in Figures 3 and 4. A log-rank test demonstrated that the overall success rate for the SDA Group was significantly better than the RDP Group (p=0.005). This finding was consistent when the upper (p=0.019) and lower (0=0.054) arches were analysed separately (Table 4). Further survival analysis for the two treatment groups using a Cox proportional hazards model with age, gender, arch and Kennedy Classification as covariates is illustrated in Table 5. This analysis demonstrated that SDA treatment was almost 2.5 times more successful that RDP treatment (HR 2.47; p=0.04). Treatment provided in the upper arch was also significantly more successful than the lower arch (HR: 3.9, p<0.05).

Discussion

This study represents one of a very small number of randomised clinical trials within clinical prosthodontics with a long-term follow up period (3 years). This study illustrates that oral rehabilitation according to the principles of the SDA utilising RBBs can be a very successful form of treatment with overall success rates of 90.4%. This compared very favourably to conventional full-arch rehabilitation using RDPs which had an overall success rate of 73.0% (p=0.005). This trend continued when the upper and lower arches were analysed separately. In the upper arch SDA treatment was 100% successful compared to 86.4% (p=0.019) for RDPs. In the lower arch, lower success rates were reported for both the SDA (80.0%) and the RDP (60.0%) groups (p=0.054). When the lower arch was analysed according to Kennedy Classification it was demonstrated that Class I RDPs were successful in only 34.8% of cases compared to 80% success for Class II, 87.5% for Class III and 100% for Class IV cases.

Given patients' dislike of removable dentures, their biological cost and high levels of non-compliance, other treatment options should be considered when planning tooth replacement for older, partially dentate patients[14]. This study provides high quality evidence to advance this discussion in the form of an appropriately powered randomised controlled clinical trial with a significant follow up period. Despite these strengths of the study a number of limitations should be noted including the assessment of the prostheses. Whilst patient randomisation and allocation was conducted by a research assistant the assessment of the prostheses was undertaken by the same operator who provided the initial treatment. Given the clear difference between the two forms of treatment provided, blinding was impossible but an independent assessor could have been used to assess survival and success criteria. One operator provided all

of the treatment during this study. Whilst this means that the standard of treatment provided was consistent throughout, the external validity of study could be questioned as the operator had postgraduate training in prosthodontics. Further research is required to determine if similar results could be obtained in other centres or in primary care.

The results of this study can be interpreted in relation to previous work in this area. Using a similar study deign, researchers from the University of Newcastle concluded after a 5 year follow-up RBB used to provide patients with a SDA had similar survival characteristics as RDPs[15]. In contrast to the results present in this paper all of the RBBs placed in the previous study were in the lower arch and all were placed as distal extension prostheses. Further evidence is available from another study carried out at the University of Geneva. In this study, which also compared functionally orientated treatment with RDPs, a 19% failure rate was reported for the fixed prostheses used[16]. Further evidence on the long term success of the SDA concept is available from a multicentre German trial which has reported results over a 5 year period[17]. Whilst this study also reports very positive survival rates for treatment according to the principles of the SDA, patients in the German study were provided with RDPs retained using precision attachments and conventional fixed bridgework in the SDA group. Therefore the results are not directly comparable. The low success rates reported for Kennedy Class 1 dentures in the lower arch do mirror other classic studies which have shown that unsuccessful partial dentures are more likely to replace posterior teeth only, particularly in the lower arch[18].

This study provides further evidence of the advantages of functionally orientated treatment compared to conventional tooth replacement strategies such as RDPs. In addition to the high success rates demonstrated in this study, previous work has

illustrated that functionally orientated treatment has positive impacts on oral health related quality life, masticatory performance and patient satisfaction[19-22]. Especially in partially reduced dentitions with (almost) sound remaining teeth RBB offers a good treatment alternative to RDPs. They are relative easy to place and well accepted by the patient. The biological price is low compared to conventional bridges and RDPs. Evidence also suggests that maintenance of a functionally orientated dentition is more achievable for the patient and ultimately more cost effective[23-25]. The combination of these factors should encourage both policymakers and clinicians to utilise this treatment concept more widely in appropriate cases. One criticism often levelled at the use of RBBs is the reduced success rate found in primary care[26,27]. This study illustrates that high success rates can be achieved in older patients when the operative treatment is undertaken in both a dental hospital and non-hospital setting.

Conclusion

After 36 months the cumulative survival rate for RBBs used as part of functionally orientated treatment (SDA group) was significantly better than conventional full-arch rehabilitation using RDPs for partially dentate older adults (p=0.005).

Tables

Treatment Group	**Criteria**	**Description**	**Arches Restored (n(%))**
SDA			Total Number: 73
	Successful	・RBB all retained ・No episodes of decementation	66 (90.4%)
	Survived	・RBB recemented on one occasion	7 (9.5%)
	Unsuccessful	・RBB recemented on 2 or more occasions ・RBB remade ・RBB lost	0 (0%)
RDP			Total Number: 89
	Successful	・RDP in function	65 (73.0%)
	Survived	・RDP in function but repaired or altered	10 (11.2%)
	Unsuccessful	・RDP not in use	14 (15.7%)

Table 1 Success criteria for tooth replacement strategies

	SDA Group (n=44)	RDP Group (n=45)	p-value[1]
Age (years)	71.5 (IQR: 69.0-78.0)	74.0 (IQR: 69.0 - 78.0)	0.739
Gender	M=20, F=24	M=21, F=24	0.909
Number of residual natural teeth (n)	18.0 (IQR: 17.0-20.5)	19.0 (IQR: 17.0-20.0)	0.325
Occlusal Units (n) (baseline)	8.0 (IQR: 6.0-8.0)	7.0 (IQR: 6.0-8.0)	0.034

Table 2 Characteristics of treatment groups ([1]Analyses using Mann-Whitney U and Chi-squared tests)

Kennedy Classification	SDA Group				RDP Group			
	Upper Arch (n=38)		Lower Arch (n=35)		Upper Arch (n=44)		Lower Arch (n=45)	
	n	Success Rate (%)	n	Success Rate (%)	n	Success Rate (%)	n	Success Rate (%)
I	4	100	14	85.7	4	100	23	34.8
II	1	100	1	100	15	86.7	10	80
III	23	100	11	90.9	17	76.5	8	87.5
IV	10	100	9	88.9	8	100	4	100

Table 3 Three year success rates according to treatment group, Kennedy Classification and arch

Arch Restored	Treatment Group	Time Point (months)	Success Rate (%)	95% CI	*p*-value (log rank test)
Total (upper and lower arch)	SDA (n=73)	6	98.6	90.7-99.8	0.005
		12	94.5	86.1-97.9	
		24	90.4	80.9-95.3	
		36	90.4	80.9-95.3	
	RDP (n=89)	6	92.1	84.2 - 96.2	
		12	84.3	74.9 - 90.4	
		24	77.5	67.4 - 84.9	
		36	73.0	62.5 - 81.0	
Upper	SDA (n=38)	6	100	N/A	0.019
		12	100	N/A	
		24	100	N/A	
		36	100	N/A	
	RDP (n=44)	6	97.7	84.9-99.7	
		12	93.2	80.3-97.7	
		24	90.9	77.6-96.5	
		36	86.4	72.1-93.6	
Lower	SDA (n=35)	6	97.1	81.4-99.6	0.054
		12	88.6	72.4-95.5	
		24	80.0	62.6-89.9	
		36	80.0	62.6-89.9	
	RDP (n=45)	6	86.7	72.7-93.8	
		12	75.6	60.2-85.6	

		24	64.4	48.7-76.5
		36	60.0	44.3-72.6

Table 4 Summary of success rates for treatment groups after 3 years including breakdown by arch

	Reference	Hazard Ratio	95% CI	P-value
Treatment Group	SDA RDP	1 2.47	 1.04 – 5.86	 0.040
Age	N/A	0.98	0.92 – 1.05	0.392
Gender	Female Male	1 1.36	 0.67 – 2.76	 0.546
Arch Restored	Upper Lower	1 3.91	 1.56 – 9.83	 0.004
Kennedy Classification	III & IV I & II	1 2.29	 0.98 – 5.37	 0.056

Table 5 Survival analysis using Cox proportional hazards model

Figure legends

Figure 1 Patient flow diagram

Figure 2 Kaplan-Meier survival analysis, RDP Group vs SDA Group

Figure 3 Kaplan-Meier survival analysis, RDP Group vs SDA Group in upper arch

Figure 4 Kaplan-Meier survival analysis, RDP Group vs SDA Group in lower arch

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