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Research Article

Impact of the Removable Partial Denture Components on the Prognosis of the Abutment Teeth: An Exploratory Clinical Study

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Abstract

Introduction

Partial edentulism is considered one of the challenging topics in dentistry. The main objectives of the patient are to restore function and esthetics. However, the dentist's main goals are preserving the remaining teeth supporting structures and restoring the patient's quality of life. A Removable Partial Denture (RPD) design should be considered carefully for each case, as there are clinical and personal variables for each patient that will impact the prognosis of the denture. With the growing need for RPD, design principles require more research to improve the preservation of abutment teeth. This study aims to clinically evaluate the abutment teeth and supporting tissues before and after RPD placement and to correlate these clinical findings with the RPD components.

Methods: Patients were recruited from the dental clinic at Schulich Dentistry, Western University in London, Ontario, Canada. Abutment teeth were evaluated for the following clinical parameters: Tooth Mobility (TM), caries, defective restorations, tooth fracture, Probing Depth (PD), Gingival Recession (GR), bleeding on probing (BOP) and Plaque Index (PI). These clinical measurements were collected at the time of RPD insertion and at least two years after. Clinical parameters were analyzed using Kruskal Wallis H, Mann-Whitney U and Chi-Squared tests.

Results: 34 participants were recruited, and 40 cast metal RPDs were evaluated. The mean age of participants was 73.8 years, and the mean duration of denture use was 37.6 months. Most frameworks assessed were Kennedy Class III RPDs. Caries were significantly associated with rest type, wherein occlusal rests showed an increased incidence of caries compared to cingulum rests. The retentive clasp arm type was associated with a mean difference in PD, wherein cast circumferential and wrought wire clasp arms had deeper PD after RPD insertion than Infra gingival clasps (I-bars).

Conclusion: The results of this study suggest clasp arms and occlusal rests influence dental disease. Larger samples and more clinical studies are needed to confirm the role of specific RPD components on the abutment teeth prognosis.

Introduction

As the number of individuals experiencing partial edentulism increases, the need for removable prosthodontic treatment continues to grow [1,2]. Patient expectations for treating partial edentulism include restoring masticatory function, esthetics and comfort. The ideal treatment modalities for partial edentulism are fixed dental or implant-supported restorations [3]. Although the success of these restorations is high, they may not be feasible for all patients due to high costs, general health concerns, and anatomical issues [3,4]. Thus, a removable partial denture (RPD) represents a viable alternative.

RPDs are economical, conservative, and minimally invasive [5]. Additionally, they are used in all age cohorts [6]. However, in a study investigating the quality of RPDs, 65% of prostheses had defects with respect to integrity, tooth wear, presence of temporary reline material, stability, and retention [6]. The most prevalent defect was a lack of stability [6]. After five years of use, 25% of RPDs required replacement or were no longer used by patients [6]. After ten years of use, this value doubled to 50% [7]. Esthetics was also a major source of dissatisfaction for patients [6]. Thus, RPD design should be planned carefully by the clinician to fulfill patients' expectations.

One of the principal functions of RPDs is preserving the remaining soft and hard tissues [3]. However, several studies have found that RPDs increased plaque accumulation and decreased salivary flow on oral surfaces in contact with the RPD, which increases the risk for caries and periodontal disease [8-12]. Forces of mastication are transmitted from the RPD's components to the natural teeth and residual ridges [13]; if these forces are not transmitted along the long axis of the abutment teeth, they can cause bone loss and gingival recession around the abutment teeth [13-16]. Many studies showed that RPDs increased the incidence of gingival inflammation, pathological probing depths, alveolar bone loss, mobility, and carious lesions on abutment teeth [17-21].

However, these studies investigated the effects of the RPD as a whole and not the specific design components more likely to cause these effects. A carefully designed RPD combined with proper oral hygiene instruction and follow-up has been shown to have no significant deterioration of the periodontal status of the remaining teeth [22]. This study aims to clinically evaluate the abutment teeth and supporting tissues before and after RPD placement and to correlate these clinical findings with the RPD design components.

Materials and Methods

This study was approved by the Western University Health Science Research Ethics Board in London, Ontario, Canada (Project ID: 120646). The study was carried out with the latest version of the Declaration of Helsinki. Informed consent from the participants was obtained after the nature of the procedures had been fully explained. Individuals who received an RPD from Schulich Dentistry at Western University were contacted to participate in the study. The inclusion criteria were as follows: individuals who were at least eighteen years of age, able to read and communicate in English, have used their RPDs for at least two years, use their dentures throughout the day and during eating, and follow oral hygiene instructions related to their dentures. Individuals were excluded if they wore their dentures continuously for twenty-four hours a day, only used their dentures for esthetics, or did not use their dentures.

The age and sex of each participant were collected. Additionally, the duration of denture use, smoking status, oral hygiene habits, and medical history of diabetes, anxiety, depression, or xerostomia were noted. Each participant's RPD was examined to determine the Kennedy classification and check the RPD components. Major connector type was identified, and the specific denture components in contact with the tooth were inspected and evaluated as either intact, malformed or broken. The denture components were categorized as retentive clasp arm (cast circumferential, wrought wire, or gingival approach clasp/I-bar), reciprocal component (clasp arm or plate) and rest (occlusal, cingulum, marginal ridge, or incisal rest).

All abutment teeth were assessed for categorical and continuous clinical parameters. The categorical clinical parameters were Tooth Mobility (TM), caries, defective restorations, and tooth fracture. TM was recorded according to Miller's Mobility Index [23]. The continuous clinical parameters were Probing Depth (PD), gingival Recession (GR), Bleeding on Probing (BOP), and Plaque Index (PI). PD and GR were measured using a University of North Carolina probe. PD was measured as the distance from the gingival margin to the base of the pocket. GR was calculated as the distance between the gingival margin and the cementoenamel junction. PI was measured according to O'Leary et al. 1972 [24]. All parameters were measured at six sites (buccal, distobuccal, mesiobuccal, lingual, distolingual, and mesiolingual) on each abutment tooth. The mean of all six sites was calculated for each clinical parameter in all abutment teeth.

Categorical and continuous clinical parameters were assessed at two-time points:

1. Before RPD treatment. Data collected before RPD insertion were obtained from the patient's electronic or paper dental records stored at Schulich Dentistry at Western University.
2. After RPD insertion. Values collected after RPD insertion refer to values collected at least two years post-insertion. Data collected after RPD insertion were obtained by clinical evaluation or from the patient's most recent electronic or paper dental records (within 6 months).

For nominal clinical parameters, the primary outcome variable was the mean difference before and after RPD insertion. The mean difference was calculated using the following equation: [(mean after RPD insertion) – (mean before RPD insertion)].

All analyses were performed on IBM SPSS Statistics 29.0.0 and R Statistics 4.2.2. For nominal clinical parameters (PD, GR, BOP, and PI), normality was assessed using the Shapiro-Wilk Test, and equal variances were assessed using Levene's Test of Equal Variances. The outcome variable was analyzed using ANOVA (analysis of variance) for normally distributed clinical parameters. If the clinical parameter was non-parametric, the outcome variable was analyzed using Kruskal Wallis H Tests and Mann-Whitney U Tests. If the Kruskal Wallis H Test was significant, the groups were assessed independently using the Mann-Whitney U Test. Categorical clinical parameters (TM, caries, defective restorations and tooth fracture) were evaluated using chi-square tests for associations with the denture component group. The statistical analyses were performed at a 5% level of significance. All p-values reported are unadjusted.

Results

182 patients received an RPD from the dental clinics at Western University. 67 patients were excluded due to incomplete data during RPD insertion. The remaining 115 patients were contacted. 77 patients could not be contacted, declined to participate in the study, or did not meet the inclusion criteria (Figure 1). This resulted in a final study sample size of 34 participants. Of the 34 participants, data points were obtained via clinical evaluation for 53% of individuals and via dental records for 47%.

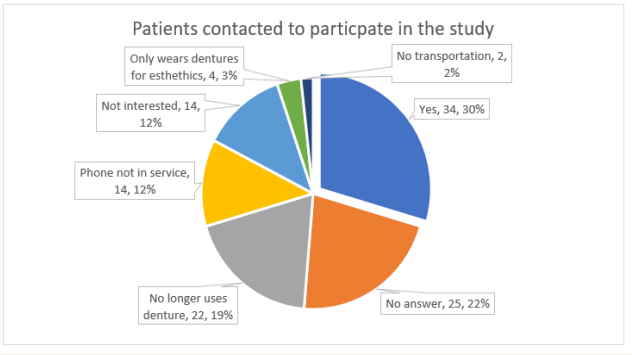

Figure 1: Patients contacted to participate in the study divided by those who consented or declined to participate. The chart shows specific reasons why patients declined to participate.

The participants ranged from 54 to 89 years of age, with a mean age of 73.8 ± 8.2 years. 53% of participants were male. Most of the participants were non-smokers (91%). The average duration of denture use was 37.6 months. Regarding oral hygiene habits, participants brushed their teeth an average of 2 times daily and cleaned their dentures 1.5 times daily. 32% of participants had xerostomia, 20% had type 2 diabetes, and 14% had anxiety or depression, as shown in Table 1.

Table 1: Participant's demographics and clinical information.

Categorical variables		N (%)
Gender	Male	18 (53)
	Female	16 (47)
Smokers	Yes	3 (9)
	No	31 (91)
Medical history	Xerostomia	11 (32)
	Diabetes	7 (20)
	Anxiety	1 (3)
	Depression	4 (11)
Continuous variables	Age (Years)	73.8 ± 8.2
	Average duration of denture use (Months)	37.6
	Average times brushing teeth/day	2
	Average times cleaning denture/day	1.5

Of the 34 participants, 6 participants had both a maxillary and mandibular RPD. Therefore, a total of 40 RPD frameworks were evaluated. All RPDs had cast metal frameworks (Table 2). Regarding the Kennedy Classification, 33% of RPDs were Class I, 25% were Class II, and 42% were Class III (25). 53% of participants had mandibular

RPDs; mandibular RPD major connectors consisted of lingual palates (76%) and lingual bars (24%). 47% of participants had maxillary RPDs; maxillary RPD major connectors consisted of anterior-posterior plates (79%), palatal plates (5%), and palatal straps (16%). Each denture components, including retentive clasps, reciprocal clasps and plates and rests, were assessed and examined (Table 3).

Table 2: Participant's RPD variables.

Sample RPD variables		N (%)
Dental arch with RPD	Maxillary	19 (47)
	Mandibular	21 (53)
Maxillary major connectors	Anterior-posterior plate	15 (79)
	Palatal plate	1 (5)
	Palatal strap	3 (16)
Mandibular major connectors	Lingual bar	5 (24)
	Lingual plate	16 (76)
PRD Kennedy classification	Class I	13 (33)
	Class II	10 (25)
	Class III	17 (42)

Table 3: Abutment teeth divided by RPD design element group.

Denture component group		N
Retentive clasp arm type (N=112)	Cast circumferential	70
	Wrought wire	32
	I-bar	10
Reciprocal and plating component type (N=222)	Reciprocal clasp arm	55
	Reciprocal plate	167
Rest type (N=158)	Occlusal rest	107
	Cingulum rest	51

235 abutment teeth were evaluated and divided into the denture component groups. Only one abutment tooth analyzed had a broken RPD denture component, which was excluded from the analyses. Retentive clasp arm type was associated with a mean difference in PD (Kruskal-Wallis x2(2) =5.680, p=0.050) (Figure 2). Post-hoc analysis revealed a significant difference between cast circumferential clasp arms and I-bars (Mann-Whitney U=213.0, p=0.045), wherein cast circumferential clasp arms (mean rank=42.46) had deeper PD after RPD insertion in comparison to I-bars (mean rank=26.80). There was also a significant difference between wrought wire clasp arms and I-bars (Mann-Whitney U=81.0, p=0.019), wherein wrought wire clasp arms (mean rank=23.97) had deeper PD after RPD insertion in comparison to I-bars (mean rank=13.60).

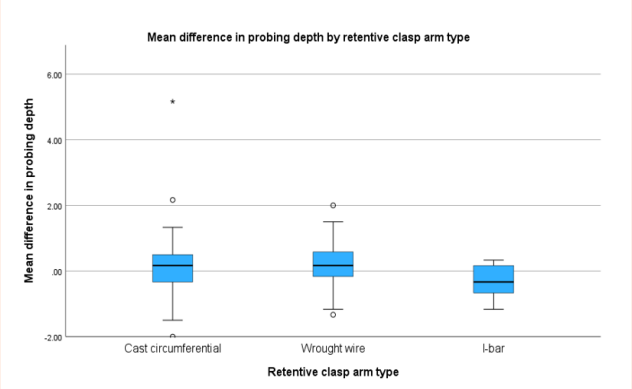

Figure 2: Mean difference in probing depth related to retentive clasps arm type.

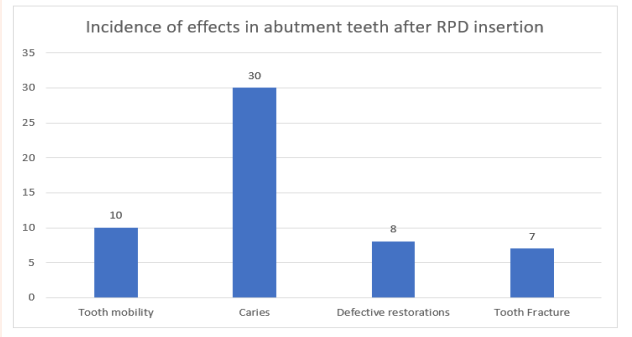

Figure 3: Incidence TM, caries, defective restoration and tooth fracture after RPD insertion.

Figure 3 shows the incidence of TM, caries, defective restorations, and tooth fractures after RPD insertion, which were absent before RPD insertion. After RPD insertion, 25% of patients had TM, 75% had caries, 20% had defective restorations, and 17% had tooth fractures. Table 4 shows the results of the analyses between the RPD denture components and categorical clinical parameters. Caries were significantly associated with the rests, especially occlusal rests, as compared to cingulum rests, as shown in Figure 4 (Chi-Square x2(1) =7.616, p=0.006).

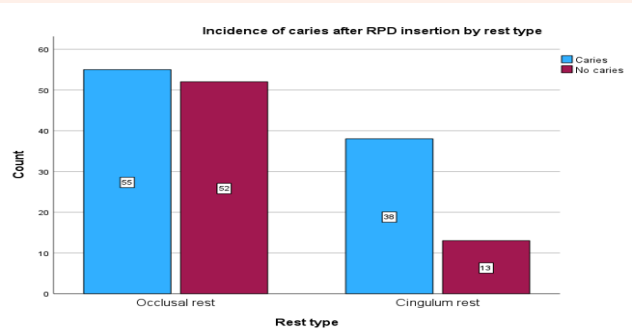

Figure 4: Incidence of caries after RPD insertion related to rest type.

Table 4: Chi-square test results between the RPD components and categorical clinical parameters (tooth mobility, caries, defective restoration and tooth fracture).

Retentive clasp arms (N=113)		
Tooth mobility	x2(2) =2.999	p=0.223
Caries	x2(2) =1.534	p=0.465
Defective restorations	x2(2) =0.965	p=0.617
Tooth fracture	x2(2) =0.675	p=0.714
Reciprocal component (N=223)		
Tooth mobility	x2(1) =1.510	p=0.219
Caries	x2(1) =0.423	p=0.515
Defective restorations	x2(1) =0.019	p=0.891
Tooth fracture	x2(1) =0.001	p=0.982
Rest type (N=158)		
Tooth mobility	x2(1) =1.085	p=0.298
Caries	x2(1) =7.616	p=0.006*
Defective restorations	x2(1) =0.248	p=0.619
Tooth fracture	x2(1) =0.695	p=0.404

Discussion

The purpose of this study was to collect clinical information from a sample of individuals who have been using their RPDs for at least two years. The current study aimed to assess abutment teeth and their supporting tissues before and after RPD placement and to correlate these findings to RPD design elements. The study cohort was primarily non-smokers with excellent oral hygiene habits; this may have contributed to the lack of significant findings in the analyses for GR, BOP, PI, TM, defective restorations, or tooth fracture. This correlates to several studies that showed a lack of periodontal breakdown if the RPDs were well-designed and well-maintained [20,22,26,27]. The majority of participants had RPDs with a Kennedy Class III Classification, which was also a common finding in other clinical studies [20,27]. The high incidence of Class III RPDs may indicate a lack of progression towards controlled dental disease or a decreased ability of patients to afford fixed prostheses and dental implants.

The analysis showcased an association between retentive class arm type and mean difference in PD, wherein cast circumferential and wrought wire clasp arms resulted in deeper PD compared to I-bars, although in the current study, only 10 I-bar clasps were This may be due to the combined effect of tooth contact and the stress applied to abutment teeth [21,22,28]. Firstly, clasp arms alter the natural tooth contour, interfering with the natural cleaning actions of saliva and potentially increasing plaque formation on the tooth surface [8,12]. This can lead to gingivitis, periodontitis, tooth mobility and alveolar bone loss [8,17,21]. The I-bar alters the natural tooth contour the least, as the area of contact of the clasp with the tooth is minimal [29]. Second, the design of the clasp directly influences the transmission of forces to the abutment tooth [30,31]. When placed at the height of the contour of the tooth and with a mesial occlusal rest, the I-bar will exert minimal oblique forces on the abutment tooth [29]. Forces should be transmitted along the long axis of the tooth, which are then transmitted to the alveolar bone [21]. However, when oblique forces are present via cast circumferential or wrought wire clasp arms, there is a disturbance in blood flow and damage to the periodontium, leading to a reduction in bone density [21]. The load on abutment teeth is strongly influenced by the number and location of the rests, the major connectors' rigidity, and the denture base's extension [29]. Therefore, the findings suggest that I-bars be used more frequently if applicable and reinforce the importance of ensuring that all clasp arms are passive.

The analyses displayed a relationship between occlusal rest and caries. Studies have shown an increased risk of caries on tooth surfaces covered by RPDs [17,22,28,32]. As discussed above, this may be the effect of increased tooth contact. In addition, frictional and mechanical wear serve as additional contributing factors; wear can originate from the small movements of the RPD against the teeth and periodontium during functioning [33]. Repeated movements can cause abrasion to the tooth structure and damage the periodontium, increasing the risk of carious lesions [34,35]. Studies have shown improved patient cooperation with oral hygiene instructions and frequent follow-ups decreased decayed and filled tooth surfaces [22].

This pilot study has some limitations. The current study had a small sample size, which may not have had sufficient power to detect associations. Additionally, there were great inter- and intra-individual differences within the collected sample, inclusive of type of RPD, number of abutment teeth, condition of abutment teeth at the time of RPD insertion and recall interval these confounders were not controlled and may have affected the association between RPD design components and the various clinical parameters.

Conclusion

In conclusion, this study suggests that the type of retentive clasp arm may contribute towards deeper PD and that the rest type may influence the development of caries. With the growing aging population and the high need for RPD, continued research is required to confirm these findings

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