Evaluation of periodontal parameters on Removable Partial Denture abutment teeth with direct and indirect retainers: A 48-month follow-up

A 48-month periodontal evaluation of RPD abutment

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Abstract

Objectives: To evaluate periodontal parameters of abutment teeth and interproximal sites, in patients with mandibular class I Kennedy Removable Partial Dentures (RPD), after 4 years of periodontal treatment.

Methods: Fourteen patients with periodontal disease were treated and evaluated for the following parameters: plaque index (PI), bleeding on probing (BOP), probing depth (PD), gingival recession (GR), clinical attachment loss (CAL) and keratinized mucosa (KM). Parameters were compared between abutment teeth with direct and indirect retainers at all time-points. Periodontal maintenance was recorded at 6, 18 and 48 months. Data were analyzed using the Friedman and Wilcoxon Tests.

Results: Most patients (n=11; 78.6%) included were female and had a mean age of 66 years (± 7.8). After 48 months, a significant reduction was only observed in PI for both abutment teeth; in contrast, PD, GR, CAL and KM all increased by the end of the study. BOP increased at 48 months for the abutment teeth with direct retainers. The distal site of the abutment teeth with direct retainers presented higher values for GR and CAL.

Conclusion: Non-surgical periodontal therapy was effective during the first 18 months, but periodontal conditions were worse at 48 months after therapy. The distal sites of abutment teeth with direct retainers presented the worst periodontal conditions.

Keywords: Periodontal therapy; Oral hygiene; Chronic periodontitis

Introduction

Removable partial dentures (RPD) are considered an alternative, conservative and affordable method of treatment for the rehabilitation of edentulous areas (Amaral *et al*., 2010; Dias *et al*., 2016). However, the use of RPD can lead to changes in the dental biofilm accumulation, which, if not properly removed, can damage the remaining teeth and periodontal tissues, causing caries and periodontal disease (Bergman, 1987; Mine *et al*., 2009; Amaral *et al*., 2010; Preshaw *et al*., 2011). Non-surgical therapy is necessary to reduce the inflammation present around teeth affected by periodontal disease, with progression of the disease controlled by a maintenance program (Renvert and Persson, 2004; Lang *et al*., 2008). Importantly, patients who use RPD may have poor knowledge regarding the prevention, aetiology and development of periodontal disease, and the maintenance of natural dentition should be a constant concern for clinicians (Ribeiro *et al*., 2012).

As such, the follow-up of rehabilitated patients is crucial and patients should also be motivated to maintain optimal oral hygiene and receive periodontal treatment

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to improve periodontal clinical parameters (Oruba *et al.* 2014; Tada *et al*., 2015; Dula *et al*., 2015). Adequate prosthesis planning is also critical for the success of prosthetic treatment as RPD design can affect the distribution of the masticatory forces on the residual alveolar ridge and abutment teeth (Hussain *et al*., 2015). Kennedy's class I RPD are removable prostheses that are used by patients with bilateral distally extended edentulous areas. These RPD can incur degenerative changes on the alveolar ridge due to the masticatory force redistribution (Alkatan and Kaynak, 2005). Abutment teeth with direct retainers are adjacent to the edentulous space; the axis of rotation of the prosthesis occurs at this site and the tooth receives a greater load due to masticatory forces, especially when there is no posterior abutment (Amaral *et al*., 2010; Carr *et al*., 2010). Additionally, teeth involved in RPD placement (direct and indirect abutments) are most affected by periodontal diseases in comparison to non-abutment teeth (Amaral *et al*., 2010; Aquino *et al*., 2011). Futhermore, sites closer to the edentulous space may be associated with more negative consequences, due to previous bone loss (Jahangiri, 1998) and to the prosthesis design (Ercoli and Caton, 2018). Some studies have recommended a program of control and periodic maintenance of RPD treatment, in association with motivation, to maintain the success of the prosthetic treatment over the long term (Hussain *et al*., 2015; Ercoli and Caton, 2018; Almeida *et al*., 2019). A previous study (Almeida *et al*., 2019) showed that the use of RPDs does not aggravate periodontal conditions after 18 months of follow-up, and that the maintenance of periodontal follow up is beneficial for such patients.

However, longitudinal evaluation of more than 30 months of the periodontal parameters and conditions of abutment teeth are lacking, particularly for cases in which periodontal treatment has been performed (Alkatan and Kaynak, 2005; Tada *et al*., 2015). Thus, the aim of this study was to evaluate the effect of periodontal therapy on the clinical parameters of abutment teeth with direct and indirect retainers, of patients using Kennedy's class I removable partial dentures, during 48 months of follow-up. Additionally, the effects of this therapy on mesial and distal site-specific responses were assessed.

Materials and Methods

Subject Population

This study was conducted at the Federal University of Rio Grande do Norte (located in Natal, Brazil) and presents 48 months of data from a previously published 18-month study (Almeida *et al*., 2019) of patients wearing maxillary complete dentures and mandibular Kennedy Class I RPD for at least 6 months before initiation of the study. All subjects who fulfilled the inclusion/exclusion criteria were invited to participate in the study. The eligible subjects were informed of the nature, risks and benefits of their participation in the study and signed an informed consent form, which was registered with the Brazilian Registry of Clinical Trials as Registration Number: RBR-97v6f5. The study protocol was previously approved by Ethics Committee in Clinical Research of the Federal University of Rio Grande do Norte (Protocol number: 650.568).

Inclusion and exclusion criteria

To be included in the study, patients had to be over 18 years of age, had to use maxillary complete dentures and mandibular Kennedy Class I RPDs and present a diagnosis of chronic periodontitis. After at least 6 months of denture insertion, patients who presented probing depth (PD) ≥ 4mm or clinical attachment level (CAL) ≥ 3mm in at least one site in abutment teeth with direct or indirect retainers were diagnosed for chronic periodontitis (Armitage, 1999). Exclusion criteria were pregnancy, breast-feeding, current smoking and smoking within the past 5 years, and systemic conditions that could affect the progression of periodontitis (e.g. diabetes, immunological disorders, osteoporosis).

Experimental design, clinical examination, compliance monitoring

A single prothesis specialist made all the prostheses before the initiation of the study protocol and these were fitted as described by Carreiro *et al.* (2017). The abutment teeth with direct retainers were always premolars or canines closer to the distal extension areas, and the retainers were designed with T-bar clasps with occlusal rets placed on the mesial surfaces. Major connectors were designed as plate or lingual bars. When a lingual plate was used, indirect retainers were the terminal rests at the end of major connectors that were in contact with the cingulum rest at each abutment teeth. All teeth involved in this design were considered as abutment teeth with indirect retainers, although, technically, a lingual plate was not an indirect retainer as it rested on unprepared lingual inclines of anterior teeth. If a lingual bar was used, the indirect retainers were considered minor connectors, and a rest in the chosen abutment teeth were located on the cingulum. The indirect retainer components were often placed on canine or incisor teeth and as far as possible from the distal extension base, to provide the best leverage against dislodgment (Carr *et al*., 2010). After denture insertion, some adjustments were performed, such as further finishing and polishing of the surface of the prosthesis to make it as smooth as possible.

At least 6 months after prosthesis insertion, the patients were invited to participate in the study. A periodontal examination was performed to assess whether the patient would full-fill the inclusion criteria. If the

participant had at least one site in abutment teeth with PD ≥ 4 mm or CAL ≥ 3 mm, they were diagnosed with localized and moderate periodontitis. This examination was considered baseline time point. The following periodontal parameters were assessed at six sites per tooth (buccal, disto-buccal, mesio-buccal, lingual, mesio-lingual, disto-lingual), using a manual periodontal probe; BOP (presence/absence) (Muhlemann and Son, 1971), PD (mm), GR (mm) and CAL (mm; the sum of PD and GR), and keratinized mucosa (KM; the smallest distance from the gingival margin of the mucogingival junction in mm). All parameters were registered with a William's periodontal probe. PI was assessed as presence or absence at the main four surfaces of the teeth (Ainamo and Bay, 1975). Abutment teeth with direct retainers were defined as teeth adjacent to the edentulous areas on each side of the mouth, while teeth with indirect retainers in the prosthetic design were as far as possible from the distal extension bases. A trained and calibrated examiner performed the intra-oral physical assessment of the lower arch for PD (Kappa = 0.89) and KM (Kappa = 1.00).

After the periodontal examination (baseline), all patients attended one session of non-surgical periodontal treatment. First, ultrasonic supragingival scaling was performed, then hand curettes were used for subgingival scaling and root planing, removing biofilm/calculus in the periodontal pockets, and a prophylaxis was done. Oral hygiene instructions were given at the end of the session, guidance on how to clean the prosthesis was provided and interproximal brushes were recommended when necessary. Clinical monitoring was performed at baseline, and at 6, 18 and 48 months post-therapies, additional periodontal maintenance was done at 3 months and 12 months. Between 18 and 48 months, no periodontal maintenance was performed. Periodontal parameters were collected, and periodontal treatment was carried out in those patients with remaining PD ≥ 4mm with BOP and biofilm/calculus.

Data analysis

Data were analysed using SPSS® statistics software (Statistical Package for Social Science, free version) for Windows (SPSS Inc., Chicago, Illinois, United States). In this study, patients were considered as their own controls. For all sites of abutment teeth, the mean values were calculated for clinical parameters, and means for each abutment tooth were recorded. A mean of the interproximal sites was considered at the two points of each face (mesio-buccal with mesio-lingual, and disto-buccal with disto-lingual) for the clinical results evaluated. The normality distribution and variability assessment were obtained after descriptive analyses. Normal distributions were not detected, thus, non-parametric tests were used for analysing clinical parameters, such as PI, BOP, PD, GR, CAL and KM. The Friedman test was used for intragroup analyses and, when significance was found, the Wilcoxon test was used to recognize the differences between times. For intergroup analyses, the differences between abutment teeth with different types of retainers were analysed by the Wilcoxon test for all times. All analyses were conducted at a 5% level of significance.

Results

Sixty-seven (67) patients were invited to participate in this study. Of this these, 38 patients met all inclusion criteria at baseline and were evaluated. Subsequently, thirty patients were analysed at the 6- and 18-month time points, but only 14 attended the 48-month post-treatment appointment. The main reasons for patient loss during the study period were loss of contact, patient avoidance/withdrawal, tooth extraction, dental implant placement, and fracture of the prosthesis. A greater proportion of females took part in the study; 11 females (78.6%) and 3 males (21.4%), and patients presented with a mean age of 66 years (± 7.8). With regard to the major prosthesis connectors, 85.71% (n = 11) used a lingual plate connector, and 14.29% (n = 3) used a lingual bar connector. Additionally, 61.5% (n = 8) of patients did not use the same prosthesis at the end of the study (only 38.5%, n = 6, maintained the same prosthesis). The major reasons for discontinuing use of the prosthesis were breakage, poor adaptation of prosthesis or pain.

Table 1 presents the intragroup and intergroup analyses of the periodontal clinical parameters of abutment teeth with direct and indirect retainers at baseline, and at 6, 18 and 48 months after therapy. In the intragroup analysis, there was no statistical difference for BOP and KM over time (p_2>0.05). However, PI presented a statistically significant reduction over time, with differences principally found between baseline and 18 months post-treatment for abutment teeth with direct and indirect retainers (p_3>0.05). PD presented statistical differences over time, presenting a decrease at 6 months, and remaining the same at 18 months, followed by an increase at 48 months after treatment; however, statistical difference was only observed between 18 and 48 months for abutment teeth with indirect retainers (p_3>0.05). For GR and CAL, the values increased significantly over time (p_2<0.05), except for the GR of abutment teeth with indirect retainers. According to the intergroup analysis presented in Table 1, the direct abutments presented higher values for GR and CAL for all the evaluated time points (p_1>0.05). In addition, the PD for direct abutments was also statistically higher at baseline and at 18 months than for indirect abutments (p_1>0.05). Figure 1 shows the median values of the abutment teeth with direct and indirect retainers over time for PI and BOP, while Figure 2 shows PD, GR and CAL.

Table 1. Intragroup and intergroup analyses of periodontal clinical parameters of abutment teeth with direct and indirect retainers [median (Q25-Q75)] at baseline, and at 6, 18 and 48 months post-therapy.

Parameter	Period	Direct Abutment (n=14)		Indirect Abutment (n=14)		P1
BOP (%)	Baseline	29.16	(14.58-43.75)	23.62	(11.46-44.83)	0.638
	6 Months	12.50	(06.25-16.67)	09.72	(05.21-28.33)	0.582
	18 Months	12.50	(08.33-25.00)	08.33	(06.04-33.36)	0.638
	48 Months	24.99	(07.29-45.83)	03.54	(00.00-50.00)	0.582
	P2		*0.063*		*0.176*	
PI (%)	Baseline	87.50	(71.88-100)*+	79.17	(59.37-90.63)*	0.073
	6 Months	68.75	(34.37-100)*	52.09	(32.81-66.65)	0.059
	18 Months	75.00	(25.00-87.50) +	39.58	(25.00-52.50)*	0.271
	48 Months	56.25	(34.38-90.62)	53.13	(32.80-67.71)	0.463
	P2		***0.022***		***0.030***	
PD (mm)	Baseline	1.87	(1.40-2.27)	1.68	(1.30-1.97)	**0.026**
	6 Months	1.63	(1.08-2.04)	1.44	(1.18-1.89)	0.753
	18 Months	1.67	(1.41-1.81)	1.40	(1.16-1.60)*	**0.023**
	48 Months	2.00	(1.68-2.08)	1.98	(1.59-2.18)*	0.972
	P2		***0.036***		***0.024***	
GR (mm)	Baseline	1.46	(0.95-2.33)	0.56	(0.43-0.92)	**0.019**
	6 Months	1.08	(0.73-2.20)	0.53	(0.32-1.12)	**0.013**
	18 Months	0.92	(0.58-2.02)*	0.50	(0.26-0.95)	**0.009**
	48 Months	1.75	(1.23-2.33)*	0.94	(0.47-1.19)	**0.009**
	P2		***0.005***		*0.126*	
CAL (mm)	Baseline	3.54	(2.83-3.89)	2.22	(1.88-2.72)	**0.009**
	6 Months	3.04	(2.33-3.68)*	2.27	(1.54-2.68)*	**0.009**
	18 Months	2.58	(2.31-3.62)*+	1.96	(1.55-2.51)*+	**0.004**
	48 Months	3.79	(3.08-4.71)+	2.85	(2.43-3.33)+	**0.011**
	P2		***0.002***		***0.002***	
KM (mm)	Baseline	2.50	(2.00-3.50)	3.00	(2.46-3.55)	0.327
	6 Months	3.00	(2.00-3.50)	3.13	(2.45-3.75)	0.363
	18 Months	3.00	(2.50-3.50)	3.13	(2.51-4.00)	0.278
	48 Months	2.75	(2.00-3.00)	2.83	(2.38-3.17)	0.196
	P2		*0.284*		*0.259*	

Equal symbols mean statistically significant differences within the group at the time points evaluated, by the Friedman (P2) and Wilcoxon ($p<0.05$) tests (P3). P1 indicates the P value between the groups in the periods evaluated by the Wilcoxon test.

Table 2 presents the periodontal parameters of interproximal sites (specific sites) of abutment teeth with direct and indirect retainers at baseline, and at 6, 18 and 48 months after periodontal treatment. When comparing the mesial and distal sites for abutment teeth with direct retainers, there were no differences for BOP and PI ($p_1>0.05$), but there were significant differences for PD at baseline and 48 months, and for GR and CAL at all time points ($p_1<0.05$), with the exception of CAL at 48 months ($p_1>0.05$). For the analysis of abutment teeth with direct retainers over time, there were no significant differences for distal sites ($p_3>0.05$); for mesial sites, CAL decreased from baseline to 18 months, but increased at 48 months, and statistical difference was observed between 6 and 48 months, and between 18 and 48 months ($p_3<0.05$).

For abutment teeth with indirect retainers, no differences were found for any of the clinical parameters evaluated, when comparing the mesial and distal sites (Table 2). There were no differences over time for BOP and PI over time for either of the interproximal sites ($p_3>0.05$). For PD and CAL, significant differences were observed over time, with increases at 18 and 48 months post-treatment in PD for mesial and distal sites, respectively ($p_3<0.05$), and an increase in CAL from 6 to 48 months at mesial sites of abutment teeth with indirect retainers ($p_3<0.05$). When the distal sites of the two types of retainers were compared, no statistically significant differences were found for BOP and PI ($p_4>0.05$); however, significant differences were seen at 48 months for PD, and for GR and CAL at all time points ($p_4<0.05$). With regard to the mesial sites of the abutment teeth with direct and indirect retainers, no statistically significant differences were found for BOP, PI and GR ($p_5>0.05$), but there were significant differences at baseline for PD and CAL ($p_5<0.05$).

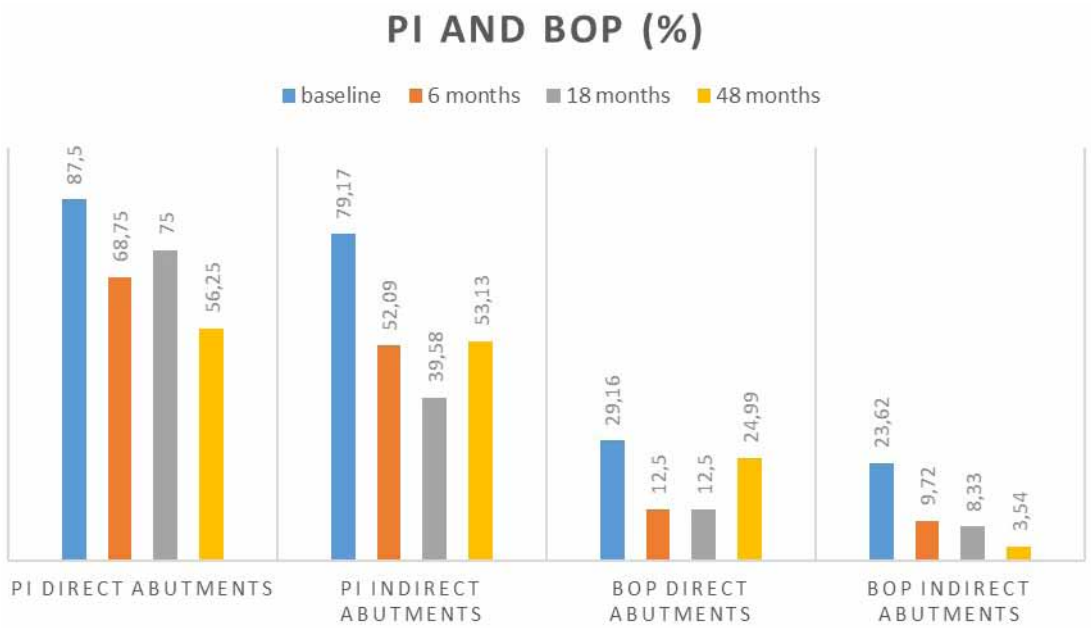

Figure 1. Plaque index (PI) and bleeding on probing (BOP) of abutment teeth with direct and indirect retainers (median) at baseline, and at 6, 18 and 48 months post-therapy.

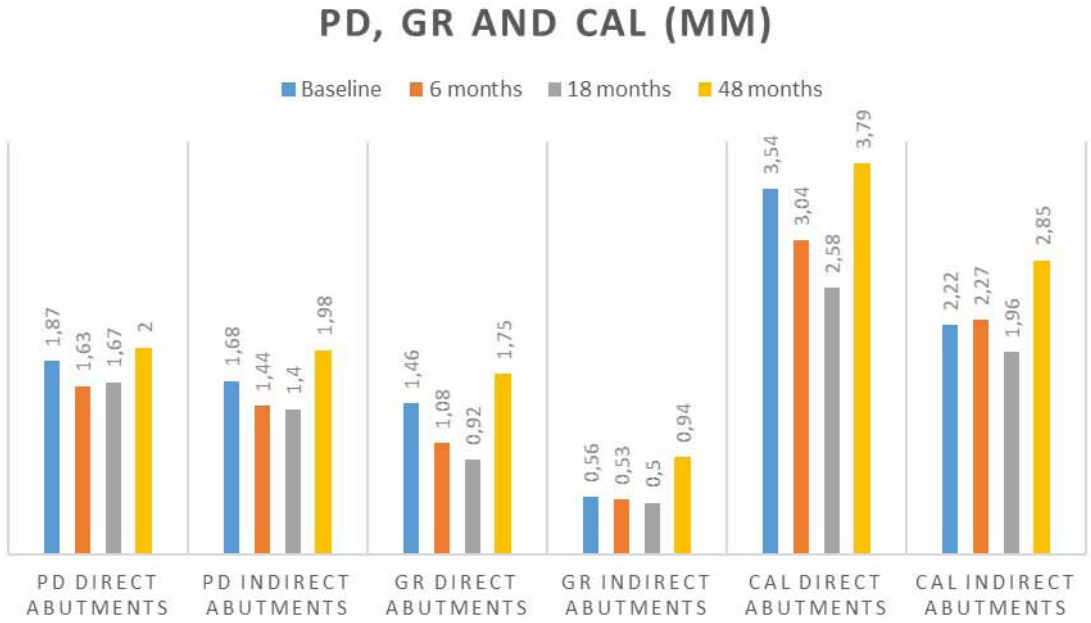

Figure 2. ***Probing depth (PD), gingival recession (GR) and clinical attachment level (CAL) of abutment teeth with direct and indirect retainers (median) at baseline, and at 6, 18 and 48 months post-therapy.***

Discussion

The present study followed patients with chronic periodontitis to analyse the influence of the use of prostheses on clinical parameters for 48 months after periodontal treatment, in 14 patients that used Kennedy's removable class I partial dentures. Periodontal treatment was seen to be effective, especially during the first 18 months of follow-up, since it improved most of the periodontal clinical parameters analysed, in relation to baseline, although an increase in parameters was observed at 48 months post treatment. This was also observed for interproximal sites, although the distal sites exhibited the worst periodontal conditions.

The increases observed in PD, GR and CAL in the abutment teeth with direct retainers at 48-months post treatment might have occurred as a result of a longer intervals between maintenance visits as the follow up progressed, even when the patient was aware and motivated regarding their oral hygiene. This observation highlights the importance of regular return visits, as well as the constant orientation and motivation that the patient needs to receive in order to maintain an adequate level of oral hygiene and prevent the recurrence of periodontal disease. Several studies emphasize, not only the importance of carefully planned prosthetic treatment, but also the need for patients to make periodic return

Table 2. Evaluation of the periodontal parameters of interproximal sites of abutment teeth with direct and indirect retainers [median (Q25-Q75)] at baseline, and at 6, 18 and 48 months after periodontal treatment.

Parameter	Period	Mesial of Direct Abutment (n=14)	Distal of Direct Abutment (n=14)	*p-value 1*	Mesial of Indirect Abutment (n=14)	Distal of Indirect Abutment (n=14)	*p-value 2*
BOP (%)	Baseline	37.5(0.0-50.0)	37.5(0.0-56.3)	0.608	25.0(0.00-75.0)	25.0(0.00-50.0)	0.250
	6 Months	0.0(0.0-31.3)	25.0(0.0-25.0)	1.000	0.00(0.00-25.0)	25.0(0.00-25.0)	0.132
	18 Months	0.0(0.0-2500)	12.5(0.0-25.0)	0.558	0.00(0.00-25.0)	0.00(0.00-25.0)	0.589
	48 Months	12.5(0.0-50.0)	25.0(0.0-31.3)	0.589	25.0(0.00-50.0)	25.0(0.00-53.1)	0.551
PI (%)	Baseline	100(87.5-100)	100(100-100)	0.564	100(87.5-100)	100(87.5-100)	1.000
	6 Months	100(50.0-100)	100(50.0-100)	0.480	100(50.0-100)	100(50.0-100)	0.783
	18 Months	100(50.0-100)	100(37.5-100)	0.317	75.0(0.00-100)	50.0(0.00-100)	0.748
	48 Months	100(37.5-100)	100(50.0-100)	0.157	62.5(25.0-100)	75.0(46.3-100)	0.236
PD (mm)	Baseline	2.25(1.69-2.75)[a]	2.00(1.19-2.00)	**0.005**	2.00(1.44-2.06)[b]	1.75(1.38-2.13)	0.227
	6 Months	1.65(1.25-2.15)	1.50(1.00-2.00)	0.057	1.75(1.19-2.00)	1.75(1.19-2.00)	0.739
	18 Months	1.50(1.44-2.00)	1.75(1.19-2.00)	0.473	1.63(1.25-2.00)*	1.38(1.25-2.00)	0.565
	48 Months	2.00(1.94-2.56)	2.00(1.44-2.13)[A]	**0.040**	2.16(1.72-2.00)*	2.23(1.66-2.69)[B]	0.182
GR (mm)	Baseline	0.00(0.0-0.81)	1.88(1.18-2.75)[A]	**0.005**	0.00(0.00-0.44)	0.13(0.00-0.50)[B]	0.858
	6 Months	0.13(0.0-0.75)	1.63(1.00-2.88)[A]	**0.005**	0.00(0.00-0.75)	0.25(0.00-0.50)[B]	0.855
	18 Months	0.13(0.0-0.81)	1.50(0.69-2.56)[A]	**0.002**	0.25(0.00-0.63)	0.25(0.00-0.56)[B]	0.250
	48 Months	0.88(0.0-1.38)	1.75(1.23-2.81)[A]	**0.007**	0.69(0.19-1.02)	0.44(0.08-0.75)[B]	0.139
CAL (mm)	Baseline	2.75(2.19-3.00)[a]	3.25(3.00-4.31)[A]	**0.050**	2.00(1.69-2.56)[b]	1.88(1.50-2.50)[B]	0.512
	6 Months	2.25(1.69-2.75)*	3.25(2.44-4.25)[A]	**0.018**	2.00(1.69-2.31)*	2.00(1.50-2.25)[B]	0.837
	18 Months	2.00(1.88-2.31)[+]	3.38(2.44-3.94)[A]	**0.005**	1.88(1.25-2.75)[+]	1.88(1.50-2.06)*[B]	0.325
	48 Months	3.00(2.44-4.31)*[+]	3.75(2.88-4.88)[A]	0.065	2.75(2.36-3.35)*[+]	2.79(2.22-3.12)*[B]	0.240

p-value 1 indicates difference between mesial and distal of abutment teeth with direct retainers (Wilcoxon Test)
p-value 2 indicates difference between mesial and distal of abutment teeth with indirect retainers (Wilcoxon Test)
Equal symbols mean statistically significant differences within the group at the time points evaluated, by the Friedman (p-value 3) and Wilcoxon ($p<0.05$) tests.
Different uppercase letters indicate differences between distal sites for abutment teeth direct and indirect retainers at each time point (Wilcoxon test; p-value 4)
Different lowercase letters indicate differences between mesial sites for abutment teeth direct and indirect retainers at each time point (Wilcoxon test; p-value 5)

appointments to reassess their periodontal condition, to avoid harmful changes to the abutment teeth over time (Qudah and Nassrawin, 2004; Alkantan and Bay, 2005; Almeida *et al*., 2019).

The frequency of return appointments after periodontal treatment or prosthesis installation has been evaluated previously (Tada *et al*., 2015; Ercoli and Caton, 2018), and have emphasized the importance of regular maintenance appointments for a good periodontal prognosis in the remaining teeth of subjects who use RPD. In the present study, there were significant improvements in the clinical parameters, PI, BOP, PD, GR and CAL, between baseline and 6 months post treatment, which were maintained at 18 months post-treatment. Subsequently, between 18 and 48 months, there was a significant increase in the CAL in abutment teeth with direct and indirect retainers, and these values were higher than at baseline. It is important to note that this increase, even if statistically significant, appears to be clinically irrelevant since differences were of approximately 0.5 mm and not detectable with the aid of conventional periodontal probes. It is also necessary to highlight that there was no change in KM over time and no difference between the groups; furthermore, the thickness of this tissue has been associated with better results for some clinical parameters after treatment (Chang *et al*., 2019). In addition, another longitudinal study (Carreiro *et al*., 2017) observed that abutment and non-abutment teeth presented increases in GR, PD and BOP after 7 years of using prostheses.

Furthermore, Carreiro *et al.* (2017) observed that even though all biomechanical principles were considered at the time of the construction of the prostheses, this was not enough to avoid damage to the remaining teeth, since the worst conditions were found in abutment teeth, even when the prosthesis was adequately made. However, it should be noted that, in the aforementioned study (Carreiro *et al*., 2017), periodontal maintenance therapy was not performed during the follow-up period; moreover, the authors observed an inadequate quality of the prosthesis

after 7 years, which probably contributed to the worsening of clinical parameters. In the present study, it was not possible to compare the abutment teeth and non-abutment teeth, as most of the RPD employed a lingual plate as the major connector. However, different types of retainers were compared, and abutment teeth with direct retainers exhibited worse periodontal conditions, especially for GR and CAL, consistent with other reports (Qudah and Nassrawin, 200; Mine *et al*., 2009; Amaral *et al*., 2010; Dula *et al*., 2015; Carreiro *et al*., 2017; Almeida *et al*., 2019).

We, therefore, performed a second analysis to understand why abutment teeth with direct retainers presented these alterations; for this, the periodontal conditions of the interproximal sites were evaluated. All sites evaluated demonstrated positive changes at 18 months after treatment, but these clinical parameters increased between 18 and 48 months. Interestingly, PI did not change in the abutment teeth with direct retainers, suggesting that the prosthesis retains biofilm. These abutment teeth have the closest contact with the metallic structure, preventing the self-cleaning function of saliva, possibly facilitating the settlement of the biofilm in the region and consequent development of the disease (Carreiro *et al*., 2017; Larsen and Fiehn, 2017).

When comparing different sites of the same tooth, or the same site for different abutment teeth, the distal sites of abutment teeth with direct retainers always presented the worst attachment loss. This condition may be associated with bone remodelling following tooth extraction, which would have been present from baseline (Jahangiri *et al*., 1998). In addition, it is important to highlight that all patients who participated in the present study were mandibular Kennedy Class I patients. This type of prosthesis has been associated with a higher occurrence of periodontal diseases than other types of classification (Dhingra *et al*., 2012). Moreover, the adaptation of this type of prosthesis is made difficult by continuous bone resorption throughout life, which is faster in the mandible than in the maxilla (Jahangiri *et al*., 1998).

As such, the choice of the abutment teeth should be made to ensure that teeth can support the prosthesis during use and remain viable for a long period. In the present study, more than 50% of subjects were not using the same class I RPD by the end of the study, but the reasons for this were not related to the choice of abutment teeth. Rather they may be related to poor support, as the free-end mandibular RPD presents deficient distal dental support, associated with a difference between the mucosa and the periodontal ligament due to their different resiliency and viscoelastic responses (Cunha *et al*., 2011; De Freitas *et al*., 2012). The dual-support system generates compressive forces that may jeopardize the supporting tissues and increase displacement of the denture base and generation of more forces on the direct retainers (Cunha *et al*., 2011; De Freitas *et al*., 2012). Together these factors may lead to the need for RPD replacement.

The main strength of this study is the follow-up time period. However, the results should be interpreted with caution due to the high loss of patients compared to a previous study (Almeida *et al*., 2019). Accordingly, longitudinal studies with larger samples are needed to acquire additional data and to establish an ideal interval between return visits for a better long-term outcome for these patients. Nonetheless, removable partial dentures represent a less invasive solution for the treatment of patients with partially edentulous mandibles and bilateral free extremities, even if the support of this type of prosthesis can generate higher overload on the teeth involved, especially if there is reduced remaining support (Carr *et al*., 2010). For these reasons, periodontal treatment and maintenance therapy with minimum periodicity should form part of the rehabilitation treatment plan to prevent the progression of periodontal disease and ensure the long-term success of the prosthesis (Ercoli *et al*., 2018).

Conclusion

Non-surgical periodontal therapy was effective during the first 18 months, but periodontal conditions worsened by 48 months after therapy. Therefore, minimal periodicity of recall is required during maintenance therapy to maintain adequate long-term periodontal health. The distal sites of abutment teeth with direct retainers presented the worst periodontal conditions.

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