Evaluation of Clinical Periodontal Parameters of Abutment Teeth Supporting Distal-Extension Base Removable Partial Dentures: A Cross-sectional Study

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ABSTRACT

To assess the clinical periodontal status of abutment teeth in regards of different design components of distal-extension removable partial dentures. Subjects (N=100) with acrylic or cobalt-chromium distal-extension removable partial dentures were enrolled and their periodontal parameters plaque and gingival indices [PI, GI], probing depths [PD], clinical attachment loss [CAL] and a mobility index [MI] evaluated. Denture base type, major connector, occlusal rests position, design of direct retainers, retention, stability and denture wearing habits were further evaluated. Acrylic RPDs were associated with higher mean±SE PI [1.70±0.74], GI [1.76±0.55], PD scores [2.47±1.02 mm] and CAL values [4.46±2.11 mm] compared to CO-CR RPDs [p<0.05]. For abutments, the PI [1.6±0.83], GI [1.72±0.57], PD [2.32±1.03] and CAL [4.26±2.08] were higher than their non-abutments counterparts [p<0.05]. CAL scores were found to be significantly higher for mandibular abutments compared to maxillary ones [P=0.002]. The highest PI [1.83±1.10] and GI [2.00±0.00] scores were associated with lingual bars and horse-shoe connectors, respectively. Full palatal coverage and lingual plates were associated with the highest PD [2.80±0.48] and CAL [4.70±0.37] scores. Acrylic RPDs, type of major connector, wrought wire clasps and distal occlusal rests may be considered as risk factors for periodontal disease progression in distal-extension removable partial denture wearers.

INTRODUCTION

Longitudinal and cross-sectional studies have reported long-term harmful effects of removable partial dentures (RPD) on caries incidence and the periodontal tissues of the abutment teeth.[1-3] Whilst, with the non-replacement of molars, there may be undesirable consequences including temporomandibular joint dysfunctions, tooth displacement, over eruption and inadequate chewing ability.[4] Many studies have observed an increase in periodontal breakdown in removable partial denture wearers.[3-6] These harmful effects were related to poor oral hygiene and the amount and direction of the forces transmitted to the abutments.[7] It has been established that using removable partial dentures will lead to harmful changes in the quality and the quantity of plaque around the remaining teeth.[8-11]

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So far, clinical studies which focused on the design and effectiveness of RPDs and their effects on the periodontium are limited while concentrating fundamentally on clasps and their stress distribution on the abutments.[12-14] In the distal extension base removable partial dentures (DE-RPDs), when denture bases are occlusally loaded, functional pressure is exerted and a rotational movement occurs around an axis which connects the most distal supporting abutments.[15,16] This causes both lowering the function of the prosthesis and damaging the supporting structures of these partials as a result of the forces applied toward these structures.[15] Rotational forces that produce torque on the alveolar mucosa and abutment teeth must be minimized by controlling the design of the direct retainers (clasps) of the distal extension RPDs, as with increasing mobility of the abutment teeth, a destruction of the supporting tissues might occur.[17]

In addition, subjects with a lower number of teeth and in many cases only the incisors and who wear DE-RPDs, plaque control is not effective because of the difficulty and inability of successful brushing.[18] The most effective way to disrupt the accumulation of dental biofilm is still the mechanical removal, which is achieved by scaling and root planning for the periodontal treatment.[19,20]

The purpose of this study was therefore to assess the relationship between the clinical periodontal status of abutment teeth and different design components of distal extension removable partial dentures. The null hypothesis is that no significant difference will be found between abutments and non-abutments in subjects wearing acrylic or CO-CR distal extension removable partial denture regarding plaque retention, gingival inflammation, and clinical attachment loss.

MATERIALS AND METHOD

The study population consisted of 100 subjects (55 males and 45 females) who were provided with distal extension removable partial dentures at the Prosthodontic Teaching Clinics of Faculty of Dentistry at Jordan University of Science & Technology, for at least 6 months. This study was approved by IRB (number: 8/2013). Although a high percentage of subjects was well educated, the majority had low income which explains their attendance to the dental clinics in which the treatment is free of charge.

Subjects with maxillary and mandibular distal extension removable partial dentures (DE-RPD) made of acrylic and cobalt-chromium, for at least a 6-months period, were included. Subjects who were smokers, diabetics, pregnant, on medications (immunosuppressants, anticonvulsants and calcium–channel blockers or with syndromes, hematological disorders that have direct relation with periodontal diseases were excluded from this study.

Clinical examination was performed by the same calibrated examiner, blinded to the objective of the study, without any prior information about the fabrication of the RPD. A special periodontal-prosthodontic examination chart was designed. The prosthetic chart inquired the classification of the pattern of partially dentate status using Kennedy classification, type of the denture base, maxillary or mandibular, period of wearing the prosthesis and denture-wearing habits. In addition, information about different components of the prosthesis was collected such as: type of major connector, type and design of direct retainer (clasp), position of occlusal rest, retention and stability.

Dentures were examined for stability by exerting finger pressure on the distal abutments of a DE-RPD base, if this caused the anterior indirect retainer to be lifted, so the prosthesis considered as unstable and vice versa.[21] Retention of the prosthesis was evaluated by applying finger pressure to the clasp on the most distal abutments in an attempt to move the prosthesis in a vertical direction (dislodging force), if this resulted in removing the prosthesis easily then the prosthesis had no retention.[22] The periodontal examination of abutment teeth supporting DE-RPDs and non-abutments included recording the scores of the plaque index (PI), gingival index (GI), probing pocket depth (PD), clinical attachment loss (CAL) and mobility (M).

The periodontal examination was conducted using a calibrated Michigan "O" probe, with William's markings (at 1, 2, 3, 5, 7, 8, 9 and 10 mm) and a 0.5 mm diameter tip. Oral hygiene and gingival conditions were assessed by scoring plaque and gingival indices. Both indices were measured on Ramfjord teeth (UR6, UR2, UL4, LL6, LL2, and LR4) and on the abutments separately as well. If any of the Ramfjord teeth were missing, the adjacent tooth was considered instead.

CLINICAL ATTACHMENT LOSS

Clinical attachment loss was classified as follows: Mild: 1–2 mm of attachment loss, Moderate: 3–4 mm of attachment loss, and Severe: ≥ 5 mm of attachment loss.[23]

PLAQUE INDEX

Plaque index (PI) was measured according to criteria by Silness and Löe (1964) by passing the periodontal probe gently around the gingival sulcus or the periodontal pocket if present.[24]

Score 0 = the tooth surface is clean, Score 1 = The tooth surface appears clean by naked eye, but dental plaque can be removed from the gingival third and appeared at the tip of a sharp explorer, Score 2 = Plaque is visible along the gingival margin, Score 3 = the tooth surface is covered with abundant plaque.

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GINGIVAL INDEX

The gingival index (GI) used was the Loe and Silness (1963) which assessed the signs of gingival inflammation, by gently passing the probe around the gingival sulcus or the pocket if found[25] as follows:

1. No signs of inflammation, 2. Mild inflammation (slight change in color, slight change in texture, slight edema, no bleeding on probing), 3. Moderate inflammation (moderate redness, edema and hypertrophy, glazing and bleeding on probing), 4. Severe inflammation (marked redness, hypertrophy and edema, tendency to spontaneous bleeding or ulceration).

PROBING POCKET DEPTH

The depth of the sulcus or the periodontal pocket was measured as pocket depth (PD) from the gingival margin to the bottom of the clinical sulcus /pocket by using a thinned Michigan "O" periodontal probe with Williams markings (at 1, 2, 3, 5, 7, 8, 9 and 10 mm) with a 0.5 mm tip diameter and gentle pressure. Six readings were obtained from each remaining tooth on (mesio, mid, disto-buccal) and (mesio, mid, disto-palatal) including the abutment teeth. The average of the six registrations was taken to gain a score for each tooth.[26]

CLINICAL ATTACHMENT LOSS

Clinical attachment loss (CAL) was measured from the base of the pocket to the cemento-enamel junction on the mid-buccal, mid-palatal, mesio and disto-palatal tooth surfaces of each remaining tooth including the abutments. The mean of the six registrations was taken to gain a score for each tooth.[26]

TOOTH MOBILITY

Tooth mobility (M) was measured clinically by holding each of the remaining teeth firmly between the handles of two metallic instruments or with one metallic instrument and one finger, an effort was made to move it in all directions, abnormal mobility was graded according to the Millar index[27]:

Class I: Tooth can be moved less than 1 mm in the buccolingual or mesiodistal direction, Class II: Tooth can be moved 1mm or more in the buccolingual or mesiodistal direction and no mobility in the occluso-apical direction (vertical mobility), Class III: Tooth can be moved 1 mm or more in the buccolingual or mesiodistal direction and mobility in the occluso-apical direction is also present.

STATISTICAL ANALYSIS

Data were analyzed by using the Statistical Package for Social Sciences [SPSS] software version 21.0 [SPSS: Inc., Chicago, IL, USA]. Normality of the data was tested by the Kolmogorov-Smirnov test. Accordingly, chi square, Mann-Whitney and Kruskal Wallis tests were used for comparison among groups. Furthermore, multivariate logistic regression analysis was performed to test the differences between having acrylic and CO-CR RPDs with the independent variables that were included in the model. The level of significance was set at P≤0.05.

RESULTS

Of the 100 subjects included in this study, 55 were males and 45 were females. The majority (62%) of the study sample were between 46-65 years old, while only 11% were ≤45 years and 27% were >65 years. Approximately 45% of the recruited patients were using dental hygiene auxillary aids (43.6% males and 46.7% females). Dental floss was used by 4%; tooth picks by 5%, and mouth wash by 32% of the recruited study population. The majority of the patients (93%) visited their dentists on emergency basis only, while 1% were visiting on regular and 6% on irregular basis. The majority of the patients (80%) did not see a periodontist for more than one year. Periodontal visits were recommended, yet not paid and therefore not attended.

Fifty-six percent of the total 140 acrylic RPDS were used by males compared to (62/140) by females. Co-Cr RPDs were used by 50.9% (28/55) males and 49.1% (27/55) females (p=0.54) *(Table 1)*. Removable partial dentures were relatively equally distributed between maxillary (49%) and mandibular (51%) arches. In 66% of subjects, RPDS were found to be retentive and stable upon clinical examination. Only 16% of the study population was wearing their partial dentures at night (10.8% males and 5.6% females).

Table 1. Distribution of socio-demographics of subjects by denture type.

Variables	Total N=100 N (%)	Type of RPD N=195		P- value
		Acrylic N=140 N (%)	Co-Cr N=55 N (%)	
Age group				0.011
≤45	11(11.0)	18(12.9)	2(3.6)	
46-65	62(62.0)	78(55.7)	43(78.2)	
>65	27(27.0)	44(31.4)	10(18.2)	
Mean(SD]	59.2(10.49)			
Gender				0.544
Male	55(55.0)	78(55.7)	28(50.9)	
Female	45(45.0)	62(44.3)	27(49.1)	

For abutment teeth, the mean±SE plaque index (PI) was (1.85±0.49) in subjects ≤ 45 years and (1.83±0.91) in >65 years age group compared to (1.45±0.81) in subjects between (46-65 years) age range (P=0.01). The mean±SE CAL (4.91±1.64) was found to be higher for the >65 age group compared to the other age groups. There was no significant difference between males

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and females in the mean GI and PD scores. However, there was a higher mean score of CAL among males (4.64±2.00) compared to females (3.80±2.10) (P=0.01) *(Table 2)*.

The mean PI values for abutments was higher in subjects wearing acrylic removable partial dentures (1.70±0.74) compared to those with Co-Cr RPDs (1.29±0.96) *(Table 3)*. There was no statistical significant difference between the mean GI scores for abutments supporting both types of RPDs in respect to gender (p=0.125). The mean PD scores around abutments supporting acrylic RPDs was 2.47±1.02 compared to 1.93±0.96 for abutments supporting CO-CR RPDs (P=0.000). The average CAL scores for abutments supporting acrylic RPDs was 4.46±2.11 compared to 3.74±1.93 for abutments supporting Co-Cr RPDs (P=0.022). For acrylic RPDs and in males, 89.3% of abutments were reported to be mobile compared to 48.1% in females, while in Co-Cr RPDs the percentage of mobile abutments in females was 51.9% compared to 10.7% in males (P=0.002).

The PI scores around abutments were increased in subjects wearing Co-Cr RPDs with lingual bar major connectors (1.83±1.10) (P=0.008) *(Table 4)*. The GI scores were significantly increased in association with lingual bar major connectors (1.93±0.15) and horse-shoe designs (2.00±0.00). The scores for PD were significantly decreased (P=0.003) in association with lingual bar designs (1.37±0.35), while increased CAL scores were reported in association with full palatal coverage designs (4.70±0.37) and lingual plates (3.90±1.00) while the least score was for reported in association with the lingual bar designs (1.90±0.89) (P=0.003).

Abutment teeth which had wrought wire retentive clasps had mean PI and GI, PD scores which were significantly higher than those for abutments with cast clasps scores (P<0.05).

There was no significant difference in the mean score of PI, GI, CAL around abutments in association with C or I bar direct retainers (P>0.05). However, PD scores in association with c-clasps were significantly higher than with I- bars (2.60±0.86 vs. 2.10±0.88), with a significant variation (P=0.02). There was

Table 2. Clinical periodontal parameters around abutment teeth by age and gender.

Variables	PI Mean ±SD	P –value	GI Mean ±SD	P –value	PD Mean ±SD	P -value	CAL (mm] Mean ±SD	P –value
Age		0.012**		0.328**		0.850**		0.000**
≤45	1.85±0.49		1.90±0.31		2.15±0.77		2.97±1.56	
46-65	1.45±0.81		1.69±0.62		2.32±1.00		4.18±2.22	
>65	1.83±0.91		1.72±0.53		2.4±1.17		4.91±1.64	
Gender		0.178*		0.089*		0.272*		0.014*
Male	1.69±0.85		1.76±0.54		2.40±1.10		4.64±2.00	
Female	1.48±0.78		1.66±0.60		2.20±0.92		3.80±2.10	

Table 3. Clinical periodontal parameters around abutment teeth is subjects with Co-Cr and acrylic RPDs by gender (N=195 abutments).

Clinical parameters	Male Mean ±SD	Female Mean ±SD	Total Mean ±SD	P –value
Average of PI				0.001
Acrylic	1.73±0.78	1.69±0.69	1.70±0.74	
Co-Cr	1.57±1.03	1.00±0.78	1.29±0.96	
Average of GI				0.125
Acrylic	1.78±0.53	1.73±0.58	1.76±0.55	
Co-Cr	1.70±0.60	1.52±0.64	1.62±0.62	
Average PD				0.000
Acrylic	2.50±1.10	2.45±0.92	2.47±1.02	
Co-Cr	2.15±1.14	1.70±0.69	1.93±0.96	
Average of CAL (mm]				0.022
Acrylic	4.90±1.95	3.85±2.10	4.46±2.11	
Co-Cr	3.80±1.90	3.69±1.98	3.74±1.93	

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no significant differences in the mean scores of all periodontal parameters around abutment teeth in association with the position of occlusal rests (P>0.05).

Both the number of abutments and non-abutments with different grades of mobility were significantly higher in subjects wearing acrylic RPDs compared to CO-CR RPDs (P=0.00) *(Table 5)*.

Sixty-four percent of abutment teeth with no signs of mobility were clasped by cast clasps compared to 48% with wrought wire clasps. As for non-abutments with no mobility, 26% were clasped with cast clasps compared 19% with wrought wire clasps. Around 64% of abutment teeth with no signs of mobility were clasped by an I- bar direct retainer compared to 72% with C-clasps. For non-mobile, non-abutments, 25% were clasped using I-bars and 19% using C-clasps with a statistical significant difference between abutments and non-abutments (P<0.05). A significant association between non-mobile abutments and mesial occlusal rest was observed (p=0.03) *(Table 6)*.

DISCUSSION

The results of the present study showed that more acrylic RPDs were worn by the study population compared to CO-CR removable partial dentures. This variation might be explained by the higher cost of CO-CR that makes people unable to have such quality, but in respect to gender the results revealed no statistical significance between males and females and the denture type demand. This is in agreement with earlier studies.[28,29]

The results of the present study showed that all the clinical periodontal parameter scores around abutments of acrylic RPDs were significant for PI, PD and CAL compared to the scores of Co-Cr RPDs. This is in agreement with many studies which revealed the detrimental effects of acrylic partial dentures.[12,30,31] However, others also established the harmful effects of CO-CR.[32] The justification for this is that acrylic material is considered more porous which absorbs water that

Table 4. Clinical periodontal parameters of abutment teeth by denture characteristics.

Variables		PI Mean±SD	P–value	GI Mean±SD	P–value	PD Mean±SD	P -value	CAL (mm) Mean±SD	P–value
Type of major connector	Lingual plate Lingual bar Mid- PS Full palatal coverage Anterior-posterior strap Horse0shoe	1.04±0.53 1.83±1.10 0.31±0.04 1.40±0.68 1.35±0.87 1.60±0.00	0.008	1.3±0.36 1.93±0.15 1.0±0.39 1.56±0.42 1.62±0.41 2.00±0.00	0.002	2.10±1.00 1.37±0.35 2.20±0.14 2.80±0.48 2.10±0.56 2.70±0.00	0.003	3.90±1.00 1.90±0.89 2.30±1.86 4.70±0.37 3.40±1.70 2.10±0.00	0.003
Type of clasps	Wrought Cast	1.56±0.76 1.20±0.74	0.004	1.69±0.48 1.40±0.43	0.000	2.40±0.82 2.10±0.83	0.031	3.94±1.60 3.50±1.50	0.174
Design of clasp	c-clasp I-bar	1.48±1.30 1.33±0.73	0.897	1.49±0.47 1.51±0.38	0.866	2.60±0.86 2.10±0.88	0.021	3.49±1.00 3.53±1.00	0.971
Position of rest (Co-Cr]	Mesial Distal	1.16±0.60 1.30±0.89	0.379	1.45±0.44 1.40±0.53	0.953	2.17±1.10 2.40±1.10	0.411	3.39±1.60 4.20±1.20	0.318

Table 5. Mobility of abutments and non-abutments according to type of RPD.

Variable	Sub-category	Mobility grade	Teeth		P- value
			Non-abutments	Abutments	
Type of RPD	Acrylic	No Grade I-II Grade III	10(7.1) 109(77.9) 21(15.0)	63(45.0) 70(50.0) 7(5.0)	0.000
	Cr-Co	No Grade I-II Grade III	14(25.5) 34(61.8) 7(12.7)	38(69.1) 15(27.3) 2(3.6)	0.000

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Table 6. Mobility of abutments and non-abutments according to denture characteristics.

Variable	Sub-category	Mobility grade	Teeth		P- value
			Non-abutments	Abutments	
Type of clasps	Wrought	No Grade 1-2 Grade 3	12(8.3] 112(77.8] 20(13.9]	69(47.9] 69(47.9] 6(4.2]	0.000
	Cast	No Grade 1-2 Grade 3	12(25.5] 28(59.6] 7(14.9]	30(63.8] 14(29.8] 3(6.4]	0.001
Design of clasp	c-clasp	No Grade 1-2 Grade 3	6(18.8] 23(71.9] 3(9.4]	23(71.9] 8(25.0] 1(3.1]	0.000
	I-bar	No Grade 1-2 Grade 3	9(25.0] 21(58.3] 6(16.7]	23(63.9] 11(30.6] 2(5.6]	0.004
	Distal	No Grade 1-2 Grade 3	1(11.1] 6(66.7] 2(22.2]	4(44.4] 4(44.4] 1(11.1]	0.282
	Cl II	No Grade 1-2 Grade 3	2(6.7] 27(90.0] 1(3.3]	18(60.0] 12(40.0] 0(0.0]	0.000

subsequently increases plaque accumulation. In addition, CO-CR, as a metal, can be polished and its design requirements need the existence of less mobile teeth, which decreases the opportunity of plaque accumulation and helps the wearer to maintain the oral hygiene more easily as compared to the mobile teeth with acrylic partial denture. As for the CAL, it will inevitably increase as a result of increased plaque,[33] as well as the absence of occlusal rest.[3] The design and preparation of guide planes must be considered as well. Only CAL scores among all clinical periodontal parameters had higher scores for the mandibular abutments as compared to maxillary abutments with a statistical significant difference. This may be interpreted by higher scores of plaque in the mandibular abutments.[34]

In this investigation, and regarding period of wearing the denture, it was noticed that there was no statistical significant difference among all the clinical periodontal parameters in respect to the period of wearing the denture. This is not in agreement with the results of the study conducted by Yvsof and Isa who observed the increase in all clinical periodontal parameters with the increased years of the denture in the patient's mouth.[35] This might be interpreted by extracting the severely harmed abutments during wearing dentures in order to improve the denture requirements retention and stability.

In the present study, no significant association was found between all clinical periodontal parameters and wearing of the prosthesis at night, satisfaction with dentures, or retention of the prostheses. However, only GI and PD were found to be increased in subjects wearing unstable dentures and with signs of tissue trauma.

This might be explained by avoidance of tooth brushing to reach the regions of trauma which increases plaque accumulation and eventually gingival inflammation. The mean PI and GI scores increased in association with lingual bars and decreased with mid palatal straps. This is not in agreement with a previous study which concluded that more dental plaque was associated with lingual plate major connectors.[6] This could be due to the individual variation in the tooth brushing habits and frequent cleaning of dentures. Maxillary full palatal coverage and mandibular lingual plate major connectors were associated with increased PD, CAL scores around abutment teeth. This finding is in agreement with a recent study that concluded that lingual plate s are associated with deeper pockets.[36] This may be attributed to the fact that high scores of PD and CAL existed before wearing the prosthesis and the prosthodontist designed the denture to act as a splint for the remaining teeth.[37]

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The PI, GI, PD and CAL scores increased in association with wrought wire clasps compared to cast clasps. The flexibility of the wrought wire as compared to rigid cast clasps was proved to be affecting the distribution of forces on abutments.[38] C-clasps have been found to be associated with increased PD scores around abutment teeth in contrast to I-bar direct retainers. This may be explained by the reduced torque exerted on abutments by the use of I-bars and eventually less harmful effects on the periodontium.[39,40]

The results revealed no significant association between periodontal parameters and occlusal rest positions. This is inconsistent with the results of previous studies which concluded that mesial rest position with I-bar retainer reduced torque on abutments more than distally positioned rests with cast circumferential clasps, which could be explained by the difference in the distribution of teeth, in which the presence of all of anterior teeth in the study population may have assisted in force distribution.[41]

The results of the present investigation revealed that the highest proportion of abutments and non-abutments teeth had grade I-II mobility for all age groups. These results are reasonable, since mobility may be a consequence of severe periodontal destruction and the latter is directly proportional with age.[42]

From the results of the present study, it was found that the number of abutments and non-abutments with different grades of mobility were significantly associated with wearing acrylic RPDs, than those in Co-Cr RPDs. Previous studies advocated the increased harmful effects of acrylic partial dentures on the remaining teeth as compared to CO-CR.[12,30,31] It was found that number of non-mobile abutments and non-abutment teeth was significantly increased in subjects wearing Co-Cr RPDs with clasps, which relates to difference in the rigidity, which affects stress distribution mainly on abutments.[36,43-46] Regarding rest position, the higher proportions of mobility were seen for abutments and non-abutments with the distal rest position design, except for the non-abutments with grade I-II mobility, which was higher with mesial rest position designs.

Multivariate Logistic Regression Analyses revealed that the higher probability of plaque accumulation with acrylic compared to than Co-Cr removable partial dentures (OR=2.1). Also the retention increased with Co-Cr compared to acrylic partial dentures (OR=2.78). Finally, the probability to have acrylic partials by non-employed subjects were about two and half times more likely as compared with employed subjects (OR=2.45).

The limitation of this study is that it only presents the prevalence of periodontal impairment around abutment teeth supporting distal-extension RPDs. Furthermore, the number of Co-Cr denture wearers was limited and could be expanded in prospective longitudinal studies with longer maintenance periods and follow ups.

CONCLUSIONS

From this study, the following could be concluded:

1. Stability and retention of Co-Cr removable partial dentures were higher than their acrylic counterparts. Plaque accumulated twice higher in acrylic compared to Co-Cr and the retention with Co-Cr removable partial dentures was almost 3 times as high as acrylic.
2. Clinical periodontal parameters around abutment teeth were higher than those of non-abutment teeth.
3. Periodontal status around abutments of Co-Cr removable partial dentures was better compared to acrylic removable partial dentures.
4. Higher CAL scores were noted around mandibular abutment teeth than in maxillary ones.
5. C-clasps were associated with increased PD scores around abutment teeth in contrast to I-bar direct retainers.

DISCLOSURE

The authors declare that they have no conflict of interest.

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