

Comparison between Integrated and Parallel Interlock Designs of an Extra-coronal Attachment-retained Distal Extension Removable Partial Dentures: A Clinical Trial

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ABSTRACT

Objective: Precision attachments may exert unfavorable stresses on abutments in distal extension bases. This study compared between two reciprocation designs in attachment removable partial dentures (RPDs). **Materials and Methods:** Fourteen patients were allocated into two groups. Each patient received an attachment-retained RPD with one of the two types of attachments being studied. Group I received the integrated interlock type of reciprocation and group II received the parallel interlock type. Abutments were examined for modified plaque index, modified bleeding index, periodontal probing pocket depth, clinical attachment level, and modified papillary bleeding Index. **Results:** Comparisons of periodontal parameters between mesial and distal abutments within each group revealed no statistically significant difference. Means of these parameters were used for the comparisons. There was a significant difference at $P < 0.05$ in all parameters between the two groups at time of insertion and at 3, 6, and 9 months of follow-up with values of group (II) higher than group (I). **Conclusion:** RPDs of both designs showed an increase in periodontal parameters. Integrated interlock design showed better scores. It is preferable to use the attachment-retained RPD with integrated interlock instead of parallel interlock design.

KEYWORD: Gingiva, oral hygiene, periodontium, precision attachment, removable partial denture

INTRODUCTION

Distal extension free end edentulous area presents a dilemma to both patient and prosthodontist. This is due to absence of a posterior natural tooth to retain a fixed prosthesis. An implant-retained prosthesis is not always possible as a treatment option due to insufficient bone volume or due to economic reasons. In such a case, an acrylic or cast RPD is the only possible prosthetic solution.

The clasp component provides direct retention of RPD. To perform proper retention, the clasp's retentive tip has to lie in a sufficient undercut below the survey line.^[1] Irrespective of the material, the retentive tip should be able flex and to return to its original form

to avoid damaging excessive stresses on the dental abutment and its periodontium.^[2] The reciprocal arm of the clasp is designed to provide bracing of the abutment during repeated insertion and removal of the RPD.^[1] Retention of the RPD during the mastication and speech functions is the main cause of success of partial dentures.

According to mechanical properties of clasp material, retention of RPD is achieved along the path of

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displacement of the retentive tip across the survey line at different locations and amounts of undercuts.^[3] However, material and fatigue,^[4-6] have already been reported as influential factors on retention forces.

Metal clasps present some disadvantages that include deforming on the long run, leading to decreased direct retention, fatigue failure under repeated loading, and unaesthetic appearance that sometimes leads to placing the clasp arm nearer to the gingival margin. Using larger undercuts caused extra stresses on the abutment tooth.^[4] Abrasion of abutment tooth is another disadvantage of metallic clasps. Some reporters documented scratches on enamel of the abutment tooth due to friction during insertion and removal of the RPD, with more abrasion for stiffer materials.^[4,7] Therefore, there is still a need for retainers that possess greater flexibility, less-induced stress, and enhanced retention of the RPD.^[2,8]

An alternative reconstructive option that satisfies the aesthetic and functional demands of the patient is a combination of fixed and removable partial dentures (RPDs) connected with attachments.^[9] An attachment-retained RPD is considered as an advanced treatment option of partial edentulism.^[10] The retentive component of the RPD should apply the retentive force closest to the long axis of the abutment tooth and to oppose each retentive tip by a reciprocal component of the RPD framework. This design is intended to resist lateral forces exerted on the abutment by the retentive arm.^[11]

Extra-coronal rigid attachments need careful judgment in deciding when to be used because they exert unfavorable stresses on the abutment in distal extension bases, similar to those stresses exerted by a cantilever.^[12] In addition, they make the process of oral hygiene and plaque control more difficult.^[13,14] On the contrary, extra-coronal resilient attachments may not provide sufficient reciprocation due to their resiliency. So, they necessitate the incorporation of a reciprocal component in the design of the RPD.

This study was conducted to compare clinically between parallel and integrated interlock designs of reciprocation of extra-coronal attachment-retained RPD due to lack of previous studies on their biological effect.

MATERIALS AND METHODS

This comparative study was designed as a randomized clinical trial and followed the CONSORT 2010.^[15] Patients were selected from the outpatient clinic, at the Faculty of Dentistry, Beirut Arab University. The

design of this study was accepted by IRB committee at BAU (Approval code: 2014-H-002-D-P-0011).

Sample size calculation was performed using R statistical package (version 3.3.1). The proper sample size was detected using the *T*-test power calculation. The sample size calculation was based on the mean difference of patients with a power of 90% and a two-sided significance level of 5% with equal allocation to two arms. A sample of 14 well-motivated and cooperative patients was randomly allocated by tossing a coin into two groups. Each group consisted of seven patients to whom a mandibular bilateral distal extension RPD with one of the two types of attachments was constructed and evaluated. Patients were selected from both sexes with age ranging from 40 to 55 years, with Kennedy's class I mandibular edentulous ridges posterior to first or second premolar and who refused implant-retained prosthesis.

The distance between the functional depth of lingual vestibule and the free gingival margin of anterior teeth was not less than 8mm. The distance of 7mm or more was available between the mandibular ridge and the opposing maxillary teeth.^[16] All patients had Angle's class I skeletal jaw relation and enough number of opposing teeth to provide a stable occlusion. The crown root ratio of abutment teeth (the canine and first premolar or the two premolars) was 1:1 or more^[17] and their buccolingual dimension was 6mm or more.^[16]

All patients were randomly divided according to the type of attachments used into two groups:

The study group (Group I) consisted of seven patients who received a mandibular class I RPD retained with bilateral extra-coronal semi-precision attachments connected to splinted crowns on the terminal abutments of each side with a lingual bar major connector. The attachment used for this group was Vario-Stud-Snap with shear distributor 1.7mm diameter (Bredent Company, Germany) that had an integrated interlock type of reciprocation [Figure 1].

The control group (Group II) consisted of seven patients who received mandibular class I RPD retained with bilateral extra-coronal semi-precision attachment connected to splinted crowns on the terminal abutments of each side with a lingual bar major connector. The attachment used for this group was Vario-Stud-Snap 1.7mm diameter (Bredent Company) which needs the addition of parallel interlock type of reciprocation in the form of a conventional reciprocal arm placed on the lingual surface of the primary abutment [Figure 2].

CLINICAL PROCEDURE

After assessing the crown/root ratio and periodontal condition of the terminal abutments on both sides of the mandibular arch, a full crown preparation was performed with a heavy chamfer finish line of 1.2mm width on buccal and lingual walls and which was placed 0.5mm subgingival. To ensure a smooth and even finish line, the gingiva was temporarily exposed by gingival retraction using a retraction cord while refining the finish line. An impression with addition silicon (Express, 3M ESPE Dental) was made for the prepared abutments using two-step double-consistency impression technique using both putty consistency as tray material and light consistency for syringe material. Impressions were poured into working models.

For each group, a wax pattern for splinted crowns was constructed. The corresponding plastic castable

patterns of the studied attachments in each group were attached to the distal surface of the wax pattern parallel to the path of insertion of the RPD, as close as possible to the preparation and over the buccolingual center of the edentulous area [Figures 3 and 4]. The plastic patterns were attached using a milling machine BF-2 with paralleling mandrel (Bredent Company). For group II patients, a ledge with a parallel surface to the path of insertion of the RPD and an occlusal mini-rest seat were prepared in the lingual and occlusal surfaces of the wax pattern of the primary abutment to accommodate a reciprocal arm with a mini rest metallic extension at its end.

The patterns of both groups were invested and casted in cobalt-chromium alloy (Colado CC, Ivoclar Vivadent). Metal copings of the crowns with the attachments were then tried in the patient’s mouth for fitting and continuous margins, together with clearance for ceramic material occlusally and axially. Porcelain (Super porcelain EX3, Kuraray Noritake Dental.) was then built up on the metal copings for the desired

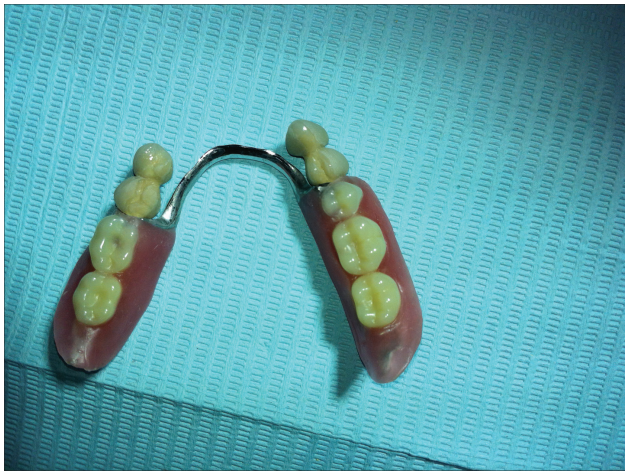


Figure 1: Integrated interlock design for group I. Reciprocation was integrated in the design of the studied attachment

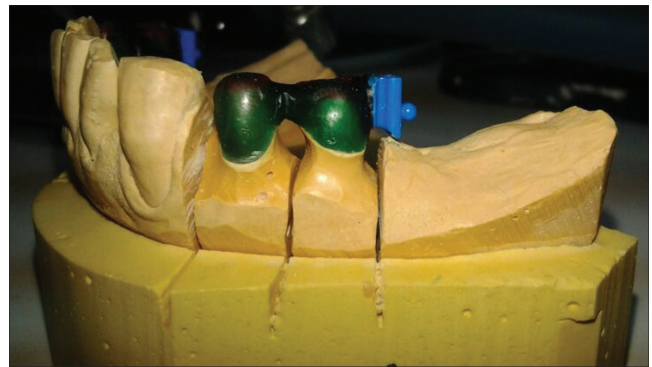


Figure 3: Wax pattern and matrix of integrated interlock design used for group I patients



Figure 2: Parallel interlock design for group II. Reciprocation is in the form of a conventional reciprocal arm placed on the lingual surface of the primary abutment



Figure 4: Wax pattern and matrix of parallel interlock design used for group II patients

dimensions and occlusion. The crowns were checked in the patient's mouth for occlusion, closed margins, and proper proximal contact with adjacent teeth.

Selective pressure impression technique was used using regular body addition silicon (3M ESPE Monophase, 3M ESPE Dental) in a custom tray after border molding with green compound sticks (Kerr) to make an overall pickup impression of the edentulous ridge with the splinted crowns temporarily cemented on the abutment teeth to make sure of their exact seating without movement during the impression [Figure 5].

The produced master cast was surveyed and RPD was designed. RPD framework was waxed up and casted in cobalt-chromium alloy (Zaire, Neodontics). The major connector used for both groups was the lingual bar. Reciprocation in RPD of group I was integrated within the attachment itself. For group II, reciprocation was provided by the lingual bracing arm included in the design of the RPD.

The metal framework of the RPD was tried in the patient's mouth for fit and passive insertion together with the crowns. Jaw relation was registered using a record block with the splinted crowns in place. Casts were mounted on the articulator, and teeth were selected and arranged in bilaterally balanced occlusion. Trial RPDs were tried in the patient's mouth, and then processed.

For each group, crowns were cemented using glass ionomer cement (Ketac Cem, 3M ESPE Dental) with the metallic RPD seated in its place to reduce errors in occlusion that might be introduced by the thickness of luting cement. Excess cement was removed and patients were asked not to remove the RPD for 24 hours. They



Figure 5: Pickup impression registering the distal extension edentulous ridges

were given oral hygiene motivation and instructions. Post insertion care was done on the next day and patients were told to come for recall visits every month.

EVALUATION PROCEDURES

Periodontal parameters of the abutment teeth periodontal tissues were assessed 24h after delivery of attachment-retained RPD and at 3, 6, and 9 months of its use.

Modified Plaque Index (MPI)

This index was measured according to Mombelli to evaluate the amount of microfilm at gingival third of abutments by assessing them at buccal and lingual surfaces. The surfaces were allocated scores 0–3. The MPI score for each tooth was obtained by summation of scores and division by 2.^[18]

Modified Bleeding Index (MBI)

This index was measured according to Mombelli to evaluate bleeding when probing the gingival crevice at middle of buccal and lingual surfaces and at mesial and distal line angles of the abutment teeth. The surfaces were allocated scores 0–3. The MBI score for each tooth was obtained by summation of scores and division by 6.^[18]

Periodontal Probing Pocket Depth (PPD)

Assessment on buccal and lingual aspects of the four abutments was done according to the protocol described by American Academy of Periodontology. Reading were taken at the middle of buccal and lingual surfaces and at their mesial and distal line angles. The PPD score for each abutment was calculated as the average of the six obtained readings.

Clinical Attachment Level (CAL)

Clinical attachment level, as described by American Academy of Periodontology is the distance between the finish line of the crown that was placed 0.5mm subgingivally and the apical extent of the pocket. It is measured according to Glavind and Loe by William's probe on six locations; mid-buccal, mid-lingual and their mesial and distal line angles. The CAL score for each abutment was calculated as the average of the six obtained readings.^[19]

Modified Papillary Bleeding Index (MPBI)

Periodontal probe was carefully introduced in the gingival crevice at the mesial line angle of the gingival papilla between the two splinted crowns and gently moved along into the mesial papilla. Scored from 0 to 3 were given. Each papilla was tested once from the buccal surface.^[20]

STATISTICAL ANALYSIS

The crowned mesial and distal abutments were examined by the periodontal parameters: MPI, MBI, PPD, CAL, and MPBI. These parameters were measured 24h after

RPD delivery and at 3, 6, and 9 months of its use. The data obtained was tabulated and statistically analyzed using the IBM SPSS® statistics version 20 for Windows. PPD and CAL data revealed parametric distribution, whereas MPI, MBI, and MPBI revealed nonparametric distribution. Data were presented as mean, and standard deviation (SD), median, maximum, minimum, and 95% confidence interval (95% CI) values.

RESULTS

Comparisons of periodontal parameters (MPI, MBI, PPD, and MPBI) between mesial and distal abutments within each group revealed no statistically significant difference. Means of these parameters were used for the comparisons between groups I and II.

Comparison of MPI between the two groups and effect of time periods on MPI in each group

At base line, there was no statistically significant difference between MPI in the two groups. But after 3, 6, and 9 months of RPD use, group I showed significantly lower mean MPI than group II. There was a significant

increase in mean MPI from the beginning of the study (base line) till 6 months of RPD use for both groups. However, there was a significant decrease in the mean MPI from 6 till 9 months of RPD use. This decrease was still significantly higher than the baseline in both groups. Values are presented in Chart 1 and Table 1.

Comparison of MBI between the two groups and effect of time on MBI in each group

From base line till 3 months of RPD use, there was no statistically significant difference between MBI in both groups. After 6 as well as 9 months, group I showed statistically significant lower mean MBI than group II. There was a significant increase in mean MBI of both groups from start of study till 3 months of RPD use. This mean did not significantly change from 3 to 6 months of RPD use. Then it was significantly decreased from 6 to 9 months till it returned back to almost base line levels. The mean MBI at 9 months showed statistically nonsignificant difference from base line value. Values are presented in Chart 2 and Table 2.

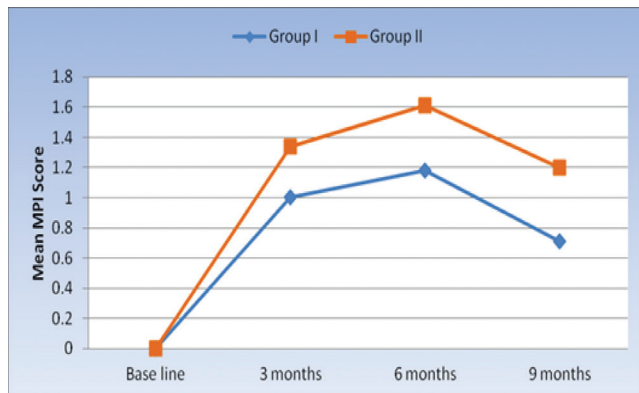


Chart 1: Line chart representing mean MPI at different time periods

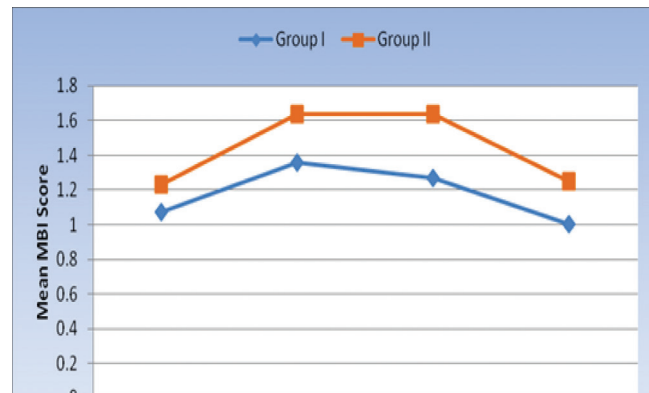


Chart 2: Line chart representing mean MBI at different time periods

Table 1: Comparison of MPI at different time periods for each group

Group	Base line		3 months		6 months		9 months		P-value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Group I	0.00 ^d	0.00	1.00 ^b	0.47	1.18 ^a	0.58	0.71 ^c	0.59	<0.001*
Group II	0.00 ^c	0.00	1.34 ^b	0.92	1.61 ^a	0.82	1.20 ^b	1.02	<0.001*

*Significant at $P \leq 0.05$

Different superscripts in the same row are statistically significantly different Friedman’s test and Wilcoxon signed-rank test

Table 2: Comparison of MBI at different time periods for each group

Group	Base line		3 months		6 months		9 months		P-value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Group I	1.07 ^b	0.76	1.36 ^a	0.84	1.27 ^a	0.73	1.00 ^b	0.57	0.012*
Group II	1.23 ^b	0.87	1.64 ^a	0.82	1.64 ^a	0.84	1.25 ^b	0.74	<0.001*

*Significant at $P \leq 0.05$

Different superscripts in the same row are statistically significantly different Friedman’s test and Wilcoxon signed-rank test

Comparison of PPD between the two groups and the effect of time on PPD in each group

Group I showed significantly lower mean PPD than group II from base line throughout the follow-up period. There was no statistically significant change in mean PPD of both groups, from base line till 3 months of RPD use. There was a significant increase of mean PPD of group II and no significant change in that of group I, from 3 to 6 months of RPD use. From 6 to 9 months of RPD use, there was no significant change in mean PPD of both groups. However, 9 months showed a significantly higher mean PPD than base line value in both of them. Values are presented in Chart 3 and Table 3.

Comparison of CAL between the two groups and effect of time on CAL in each group

At base line, as well as after 3 months; no statistically significant difference was found between mean CAL in both groups. However after 6 as well as 9 months, group I showed statistically significant lower mean CAL than group II. From base line till 3 months of RPD use, there was no statistically significant change in mean PPD of both groups. From 3 to 6 months of RPD use, there was a significant increase of mean CAL of group II and no significant change in that of group I. From 6 to 9 months of RPD use, there was a significant increase of mean CAL of group I and no significant change in mean CAL of group II. However, 9 months showed statistically significant increase of mean CAL than base line value in the two groups indicating clinical attachment loss. Values are presented in Chart 4 and Table 4.

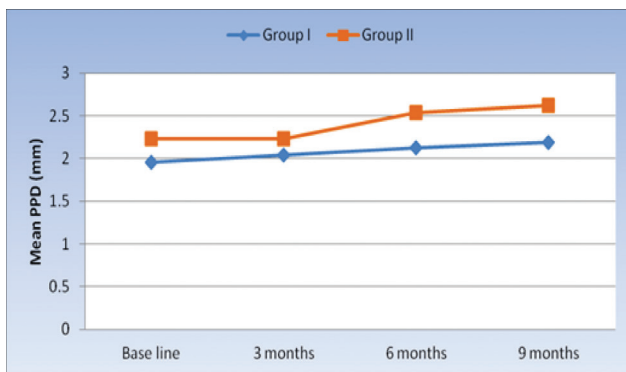


Chart 3: Line chart representing mean PPD at different time periods

Table 3: Comparison of PPD in mm at different time periods for each group

Group	Base line		3 months		6 months		9 months		P-value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Group I	1.96 ^c	0.40	2.04 ^{bc}	0.48	2.13 ^{ab}	0.39	2.19 ^a	0.41	0.012*
Group II	2.23 ^b	0.47	2.23 ^b	0.52	2.54 ^a	0.63	2.62 ^a	0.52	<0.001*

*Significant at P ≤ 0.05

Different superscripts in the same row are statistically significantly different Repeated-measures ANOVA test

Comparison of MPBI between the two groups and effect of time in each group

At base line and after 3, 6 as well as 9 months; no statistically significant difference was found between MPBI in the two groups. In group I, there was no statistically significant change in mean MPBI after 3 months and from 3 months to 6 months. From 6 months to 9 months, there was a statistically significant increase in mean MPBI. However, 9 months showed statistically significant higher mean MPBI than base line value. However, in group II, there was no statistically significant change in mean MPBI through all periods. Values are presented in Chart 5 and Table 5.

DISCUSSION

The study was conducted to compare the outcome between two designs of reciprocation, in extra-coronal semi-precision attachment-retained RPD on periodontal health of abutment teeth with mandibular distal extension bases. The mandibular distal extension ridge was selected for this study rather than maxillary ridge as it presents the least amount of support for RPD and is most difficult to treat satisfactorily.^[21] Patients with firm edentulous ridges were selected to provide good support and stability of the RPD.^[22]

Recruiting patients was a limitation of this study because there was difficulty in collecting those who fulfilled the inclusion criteria and had Class I arches with only missing molars on both sides which lead to the use of canine and first premolar or the two premolars as abutments to retain the RPD. The concept of bilaterally balanced occlusion of the RPD was followed to reduce lateral forces on the abutments as well as on the underlying ridge. In this study, there was no statistical difference between the values of MPI, MBI, PPD, and CAL of the mesial and the distal abutments within each group at base line and though out the follow-up period. The mean of these values were used for the comparisons.

A crown preparation was made on the abutment teeth with a heavy chamfer finish line for better adaptation of the cast metal of the crowns to the finish line area.^[23]

Parallel interlock design of the attachment that was used for group II patients must always be used with a milled shear distributor (lingual bracing arm) to ensure optimal transfer of the resulting forces to the abutment teeth. This design may need less conservative lingual preparation to avoid over contouring of the fixed crowns. On the contrary, the integrated interlock design that was used for group I patients with a new attachment including a built-in shear distributor requires no additional reciprocation, which excludes the need to deepen the tooth preparation lingually and in turn enables preservation of the tooth structure.

The importance of good oral hygiene must not be overlooked. Hygiene instructions included a demonstration of rubbing with gauze under the attachment and careful brushing of the plastic female part in the denture by a proxa-brush, so as to decrease the possibility of plaque accumulation and tissue inflammation, thus enhancing the success of the prosthetic rehabilitation.^[16] All patients were instructed for strict oral hygiene measures starting from the day of examination where scaling was done and hygiene instructions were given and reinforced during the dental treatment. In this study, the lower values of MPI, PPD, and CAL in group I patients at base line may be due to their own physiologic responses. At 6 months period, there was a significant increase in the values of MPI, MBI, and PPD in both groups which could be due to inadequate oral hygiene as the patients were still not accommodated to use the new RPD. This result was in accordance with Ragghianti *et al.*^[24] who showed that good oral hygiene is an important factor for the health of supporting tissues. On the contrary,

there were higher values of periodontal parameters at abutment teeth of group II (parallel interlock) as compared to group I. It was found that the presence of a lingual reciprocal arm that changed the physiologic crown contour favored plaque build-up which is the principal factor of gingival inflammation. This result was in agreement with Donovan *et al.*^[25] who stated that extra-coronal attachment restorations alter the crown contours and result in a clinical situation where it is difficult to maintain adequate oral hygiene leading to gingival inflammation and periodontal disease. In addition, the better periodontal parameters which were found in group I (integrated interlock) were mainly due to keeping the normal lingual crown contour that improved patient's comfort, and reduced plaque retention when compared with a lingual reciprocal arm. The values of MPI, MBI, and PPD were significantly reduced at 9 months period and the MBI scores almost returned to normal base line levels for both groups. This improvement of the periodontal parameters could be related to less plaque accumulation and better oral hygiene which was reinforced in every visit. Besides to patient's motivation for proper hygiene measures, the improvement of masticatory efficiency stimulated the gingival tissues to return to their normal healthy condition. This improvement was in contradiction with reports of clasp retained RPD that described increased plaque accumulation and periodontal inflammation.^[26]

The CAL values were evaluated throughout the 9 months period to differentiate between the changes in pocket depth due to gingival enlargement or due to loss of periodontal attachment. In this study, there was a significant increase in the mean CAL values of group I from 6 to 9 months of follow-up, whereas that of group II showed a significant increase from 3 to 6 months, and kept increasing till 9 months. The mean CAL of group II was statistically higher than that of group I at the end of the study. The more plaque accumulation and the more difficult oral hygiene associated with group II lead to higher scores of CAL as compared to that of group I indicating clinical attachment loss. On the contrary, the values of CAL in both groups at 9 months period remained significantly higher than that of the base line. This may be an indication of a noninflammatory

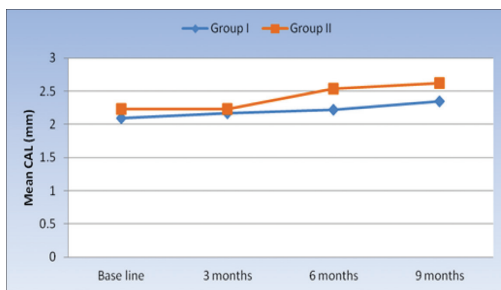


Chart 4: Line chart representing mean CAL at different time periods

Table 4: Comparison of CAL in mm at different time periods for each group

Group	Base line		3 months		6 months		9 months		P-value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Group I	2.09 ^c	0.39	2.17 ^{bc}	0.41	2.22 ^b	0.46	2.35 ^a	0.44	<0.001*
Group II	2.23 ^b	0.47	2.23 ^b	0.52	2.54 ^a	0.63	2.62 ^a	0.52	<0.001*

*Significant at $P \leq 0.05$

Different superscripts in the same row are statistically significantly different Repeated-measures ANOVA test

Table 5: Comparison of MPBI at different time periods for each group

Group	Base line		3 months		6 months		9 months		P-value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Group I	1.43 ^c	0.35	1.71 ^{bc}	0.70	1.86 ^{bc}	0.80	2.43 ^a	0.67	0.011*
Group II	1.79	0.57	2.21	0.70	2.50	0.50	2.50	0.76	0.061

*Significant at $P \leq 0.05$

Different superscripts in the same row are statistically significantly different

Friedman's test and Wilcoxon signed-rank test

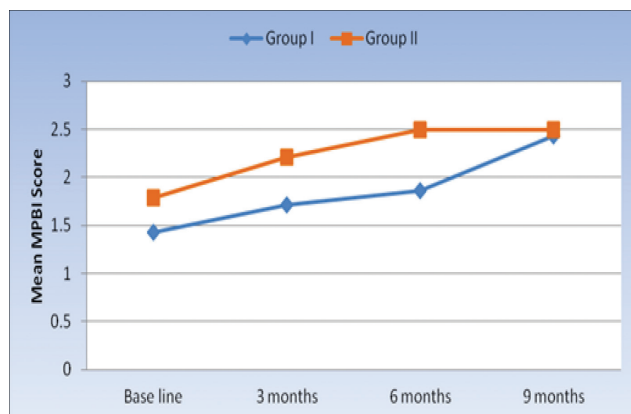


Chart 5: Line chart representing mean MPBI at different time periods

periodontal disease especially that the mean MBI of both groups returned to almost the baseline levels. The probable cause of this result was the stresses transmitted to abutment teeth from the attachment-retained RPD which is associated with marginal bone loss. The research of Mdala *et al.*^[27] could support our explanation of increased CAL values at the end of follow-up period to be due to a noninflammatory disease. They found that the transition probabilities for gingivitis and plaque-induced chronic periodontitis were higher when attachment loss was associated with bleeding on probing.

CONCLUSION

1. Distal extension attachment-retained RPDs with integrated and parallel interlock designs of reciprocation are associated with an increase in clinical parameters.
2. Integrated interlock RPD design is associated with better scores as regards the studied periodontal parameters.
3. It is preferable to use the attachment-retained RPD with integrated interlock instead of parallel interlock design.

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Nil.

CONFLICTS OF INTEREST

There are no conflicts of interest.

AUTHORS CONTRIBUTIONS

Development of study design, study conduction, gathering and processing of data, interpretation and discussion of data, reviewing the literature and manuscript writing.

ETHICAL POLICY AND INSTITUTIONAL REVIEW BOARD STATEMENT

Human subjects in this research were performed in accordance with the regulations and guidelines stipulated by the IRB committee at Beirut Arab University, Lebanon (acceptance number: 2014-H-002-D-P-0011 given on February 13, 2014).

PATIENT DECLARATION OF CONSENT

The authors declare that they have obtained consent forms from the patients. The patients gave their approval about reporting their intra-oral photos and their clinical information to the journal and they understand that their names will not be published.

DATA AVAILABILITY STATEMENT

The additional data of this study are available on request from corresponding author, upon reasonable request.

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