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Impact of Milled Peek Versus Conventional Metallic Removable Partial Denture Frameworks on the Abutment Teeth in Distal Extension Bases. A Randomized Clinical Trial

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Abstract

Objectives: The goal of this clinical study was to evaluate the effect of digitally fabricated removable partial denture frameworks, constructed from new milled peek material (Juvora) on the abutment teeth in distal extension bases versus the conventional metallic frameworks.

Materials and methods: Twenty partially edentulous patients with distal extension bases were participated in this study. They were randomly divided into two groups. For Group I, a removable partial denture (RPD) frameworks were constructed from milled peek (Juvora).While for group II,(the control group) A conventional casted cobalt chromium RPD frameworks were constructed. Then after delivery of the RPDs, their effects on the abutment teeth supporting structures were evaluated after 3,6,12 months of follow-up. Pocket depth, gingival index as well as bone height changes were assessed for each abutment tooth .The results were tabulated and statistically analyzed.

Results: There was statistically significant difference between the two groups, after six and twelve months of follow up regarding the pocket depth and after twelve months of follow up for the gingival index scores. However , the bone height changes values of milled PEEK RPD group was lower than that of the conventional RPD, but the difference was statistically insignificant throughout the follow up periods, as p value >0.05.There was gradual increase in the all measured parameters in the two studied groups throughout the follow up period.

Conclusion: The digitally fabricated removable partial denture frameworks, constructed from new milled peek material (Juvora) showed more favorable effect on the abutment teeth in distal extension bases than the conventional metallic frameworks in terms of Pocket depth, gingival index as well as bone height changes. However, there were inevitable changes associated with RPD insertion.

Key words: Digital RPD frameworks, Milling, PEEK (Juvora), Distal extension bases, Abutment teeth

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Introduction

Removable partial denture is considered as an acceptable and economical treatment modality for patients with partially edentulous arches[1]. Many longitudinal studies were accomplished on their effects on the oral health and the periodontium of the abutment and non-abutment teeth[2-5]

Distal extension RPDs are represented as one of the most critical status for achieving successful long- term treatment outcome and preservation of the remaining natural teeth and their supporting structures. In the bilateral distal extension RPDs, the problems raised were related to the difference in support between the abutment teeth and the residual ridges .Functional load applied on the denture base creates an axis of rotation around the distal abutment teeth. Thus the abutment teeth act as a fulcrum for the partial dentures and are subjected to torque forces. The induced stresses are vertical, horizontal and oblique stress. This problem occurs prevalently in the mandible as it has less supporting structure. Therefore, it is important to consider a properly designed RPDs for the preservation of the remaining natural teeth.[6,7]

Biocompatible metal such as cobalt-chromium is a widely used material for RPD frameworks. Metal -based frameworks have many advantages as they provide high strength and so could be used in thin sections. They have good thermal conductivity for more natural experience. However, esthetic problems with metal display, hypersensitivity, oral galvanism and adverse tissue reactions are recorded with metallic RPDs and increasing the demand to non- metallic frameworks[8,9] Materials used in construction of RPDs play a major role in the periodontal health of the abutment teeth. Several clinical studies have reported that acrylic removable prosthesis tends to develop significant damaging effects on the periodontal status of abutment teeth more than the cast metal removable partial dentures. [10-12]

The Polyether ether ketone (PEEK) is an important high-performance polymer that has been used for industrial applications and medical fields for many years. Nowadays, PEEK is used in implantology and prosthodontics. Based on its favorable chemical, mechanical and physical properties, it is used in producing fixed and removable prostheses .The innovation of computer aided design and computer aided manufacturing (CAD/ CAM) technology increases its use as a removable partial denture framework as their mechanical properties are not adversely affected by the milling process like other materials. The advantages of PEEK partial denture frameworks are many. Its adequate biocompatibility and superior esthetics meet the patient desires, it also taste neutral (no metal taste) and has no thermal or electrical conductivity. Furthermore, its strength and light weight increases the patient comfort [12-17]

JUVORA dental disc made from PEEK-OPTIMA is a high performance polymer solution for long term fixed and removable prosthetic frameworks, provides resilience and more shock absorption than titanium for superior comfort.[18]

Few clinical studies were reported focusing on the PEEK dentures and their effect on the abutment teeth. [19] So this study was carried out to evaluate the effect of CAD/CAM RPD frameworks, constructed from new milled peek material (Juvora) on the abutment teeth in distal extension bases.

Materials and methods:

Twenty partially edentulous patients with distal extension bases (Kennedy class I) were participated in this study. They were selected from the out-patient clinic of the Faculty of dentistry, October University for Modern Science and Arts (MSA). All selected patients were male with age ranging from 40 to 55 years and free from any systemic disease. They had normal maxillo-mandibular relationship (Angle class I) with adequate inter-arch space. The opposing maxillary arch was completely dentulous. Alcoholic, smoker patients and those with para-functional habits, temporo-mandibular joint disorders or xerostomia were excluded. Only co-operative patients who were able to stick to the oral hygiene measures were enrolled in this study. A written consent was obtained from each participant after explaining the procedure of the study. The ethical principles of the faculty of dentistry research ethical Committee, October University for Modern Science and Arts (MSA) were followed (approval reference: ETH 10).

Prosthetic procedures: The participants were treated according to standardized clinical procedures for RPD construction. Both types of prostheses were fabricated from the produced definitive cast of the lower arch. Patients grouping: They were randomly divided into two equal groups. Group I, received a removable partial denture (RPD) frameworks constructed from milled peek (Juvora).While Group II (the control group) received a conventional casted cobalt chromium RPD frameworks For Group1, mandibular casts are scanned using digital scanner (Zirkonzahn S600 ARTI Scanner, Italy) which is a fully automated optical structured-light Scanner with scanning software, that allow for whole arch scan(Figure 1). The scanner was equipped with two high resolution, high speed cameras. The scan image will be sent directly to the CAD Software to design the framework. The CAD software (3Shape Dental System, version 2.9.9.3) was used to design the framework and generate a standard triangulation language (STL file). Digital surveying and determination of the most suitable Path of insertion of the RPD with subsequent block-out of undercuts is carried out (Figure2). The framework components were designed. Lingual plate major connector, denture bases, rests and RPI clasps were drawn by the software (Figure 3).

Finally, digitally designed PEEK RPD frameworks are produced by milling from Juvora block (JUVORA Ltd, Technology centre, Hilhouse International ,Thornton Cleveleys, Lancashire, UK) using the CAD CAM milling unit (Roland DWX-50, 5-Axis Dental milling Machine, Chicago, USA) (Figure 4)

Figure 1: Optical scanning of the master cast

Figure 2: Digital surveying and block-out of undercuts

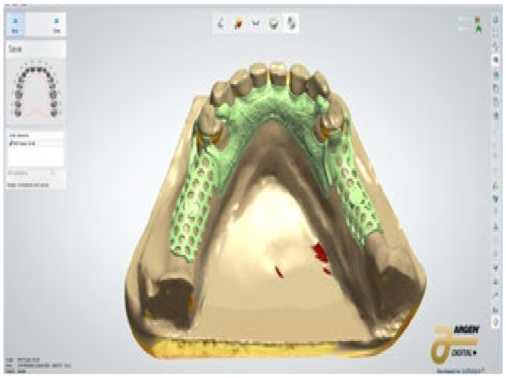

Figure 3: Digital designing of the framework components

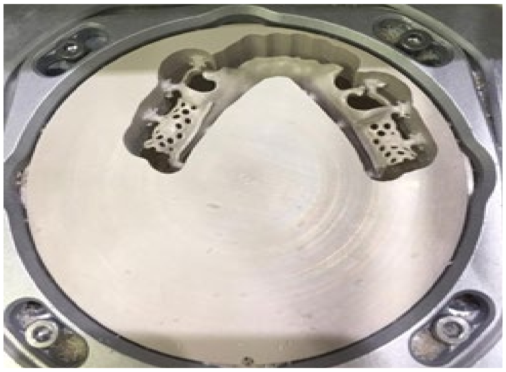

Figure 4: Milling of the framework from Juvora block

For Group II, (the control group) a conventional casted cobalt chromium RPD frameworks were constructed. The RPD frameworks were then trial inserted intra-orally. All components of the framework were checked for being fully seated. Jaw relation registration was carried-out according to the wax wafer technique. Then removable partial dentures were completed in the conventional manner and delivered to patients after necessary occlusal adjustments. (Figure 5)

After delivery of the RPDs, their effects on the abutment teeth supporting structures were evaluated after 3,6,12 months of follow-up. Pocket depth, gingival index as well as bone height changes were assessed for each abutment tooth. The measurements were done by a single examiner to reduce inter-observer error, and each measure was taken for three times and the average of three values was obtained to minimize the intra-observer error.Evaluation of periodontal depth: Periodontal pocket depths were assessed for clinical evaluation of the RPD abutments. Graduated periodontal probe (William's probe) was gently inserted at each surface parallel to the long axis of the tooth between the abutment and the oral sulcular epithelium. Pocket depths were measured as the distance from the gingival margin to the base of the pocket and read to the nearest millimeters (mm). Measurements were made in the four surfaces of abutment teeth: mesial, distal, buccal and lingual surfaces and then mean of four readings were calculated. Evaluation of gingival index: Using the gingival index of Loe and Silness20, Score 0 revels Absence of signs of inflammation. Score 1, for Slight change in color and texture. Score 2, indicate visible inflammation and bleeding on probing. Score 3, for overt inflammation and spontaneous bleeding.

Bone height measurements: periapical x-ray films were taken to the abutment teeth according to the standardization of the periapical radiograph at the time of denture insertion and at each follow up visit. X ray sensor (EZ Sensor classic, vatech , Korea) was used which is connected by a cable to the computer monitor to display the image immediately after exposure. The computer software (EZDent-1 vatech Version 2.0.2.0 client, Korea) was used to estimate abutment alveolar bone height. (Figure 6)

Figure 5: Denture insertion intra-oral

Figure 6: Bone height measurements

Statistical analysis: Data were coded and entered using the statistical package SPSS version[25]. Data was summarized using mean and standard deviation. Comparisons between groups were done using unpaired t test in normally distributed quantitative variables while non-parametric Mann-Whitney test was used for non-normally distributed quantitative variables. For comparison of serial measurements within each group paired t test was used in normally distributed quantitative variables while non-parametric Wilcoxon signed rank test was used for non-normally distributed quantitative variables. P-values less than 0.05 were considered as statistically significant.

Results

From table 1,it was clear that the mean probing depth measurements around the abutment teeth increased gradually in the two studied groups throughout the follow up period and it was statistically significant after six and twelve months of follow up periods. Table 2, revealed gradual increase in the mean value of gingival index scores in the two groups throughout the study period, which was statistically significant after six and twelve months of follow up in milled PEEK RPD group and was statistically significant in all time intervals in the conventional RPD group. The bone height loss around the abutment teeth was presented in table 3, which reveals gradual increase in the two studied groups throughout the follow up period. However, the mean differences of bone loss in the PEEK group were lower than that of the conventional RPD group and it was statistically significant after six and twelve months of follow up in the two studied group.

Up on comparing the two studied groups, the results were represented in table 4,5 and 6. There was statistically significant difference after six and twelve months of follow up regarding the pocket depth with statistically significant difference after twelve months of follow up for the gingival index. On the other hand , statistically insignificant difference was observed between milled PEEK RPD and conventional RPD in the bone height changes of abutment teeth throughout the follow up periods ,as p value >0.05.

Measurement	interval	Peek RPD			Conventional RPD		
		Mean changes	Standard Deviation	P value	Mean changes	Standard Deviation	P value
Pocket depth (mm)	immediate-3 months	0.000	0.000	1	0.100	0.211	0.168
	immediate-6 months	0.300	0.350	0.024*	0.550	0.497	0.007*
	immediate-12 months	0.500	0.471	0.008*	1.150	0.626	< 0.001*
	3 months-6 months	0.300	0.350	0.024*	0.450	0.438	0.010*
	3 months-12 months	0.500	0.471	0.008*	1.050	0.497	< 0.001*
	6 months-12 months	0.200	0.258	0.037*	0.600	0.459	0.003*

Table 1: Effect of time on the pocket depth

Measurement	interval	Peek RPD			Conventional RPD		
		Mean changes	Standard Deviation	P value	Mean changes	Standard Deviation	P value
Gingival index Scores	immediate-3 months	0.200	0.422	0.157	0.500	0.527	0.025*
	immediate-6 months	0.500	0.527	0.025*	1.000	0.667	0.008*
	immediate-12 months	0.900	0.568	0.007*	1.700	0.823	0.004*
	3 months-6 months	0.300	0.483	0.083	0.500	0.527	0.025*
	3 months-12 months	0.700	0.483	0.008*	1.200	0.789	0.01*
	6 months-12 months	0.400	0.516	0.046*	0.700	0.483	0.008*

Table 2: Effect of time on the gingival index scores

Measurement	interval	Peek RPD			Conventional RPD		
		Mean changes	Standard Deviation	P value	Mean changes	Standard Deviation	P value
Bone height (mm)	immediate-3 months	0.000	0.000	1	0.000	0.000	1
	immediate-6 months	-0.023-	0.007	< 0.001*	-0.142-	0.319	< 0.001*
	immediate-12 months	-0.162-	0.048	< 0.001*	-0.548-	0.322	< 0.001*
	3 months-6 months	-0.023-	0.007	< 0.001*	-0.142-	0.319	< 0.001*
	3 months-12 months	-0.162-	0.048	< 0.001*	-0.548-	0.322	< 0.001*
	6 months-12 months	-0.139-	0.047	< 0.001*	-0.406-	0.145	< 0.001*

Table 3: Effect of time on the bone height loss

Measurement	interval	Peek RPD		Conventional RPD		
		Mean	Standard Deviation	Mean	Standard Deviation	P value
Pocket depth (mm)	immediate	1.100	0.316	1.250	0.354	0.331
	3 months	1.100	0.316	1.350	0.337	0.105
	6 months	1.400	0.394	1.800	0.350	0.027*
	12 months	1.600	0.459	2.400	0.516	0.002*

Table 4: Comparison between the two groups regarding the pocket depth

Measurement	interval	Peek RPD		Conventional RPD		
		Mean	Standard Deviation	Mean	Standard Deviation	P value
Gingival index Scores	immediate	0.000	0.000	0.100	0.316	0.739
	3 months	0.200	0.422	0.600	0.516	0.143
	6 months	0.500	0.527	1.100	0.738	0.089
	12 months	0.900	0.568	1.800	0.789	0.023*

Table 5: Comparison between the two groups regarding the gingival index scores

Measurement	interval	Peek RPD		Conventional RPD		
		Mean	Standard Deviation	Mean	Standard Deviation	P value
Bone height (mm)	immediate	15.287	0.730	14.972	0.995	0.430
	3 months	15.287	0.730	14.972	0.995	0.430
	6 months	15.264	0.729	14.830	0.855	0.238
	12 months	15.125	0.738	14.424	0.852	0.065

Table 6: Comparison between the two groups regarding the bone height loss

Discussion

The clinical and radiographic examination in this study revealed that RPD insertion caused some changes, in spite of the strict oral hygiene measures that were followed. These changes were observed in the two studied groups throughout the follow up periods and may be attributed to the fact that wearing a removable partial denture complicates the oral environment and restricts the flow of food and the self-cleaning action of the buccal mucosa and tongue, which results in the accumulation of the dental plaque on the prosthesis and surrounding tissues. Thereby the risk for development of gingivitis and periodontitis was increased, and this was reflected in our results as there is gradual increase in the three measured parameters.[21-24]

The selection of lingual plate as a major connector in this study could be an influencing factor in our results which is supported by previous studies[25,26] who indicated more severe gingival tissue reactions when the gingiva was covered by the denture that increase crevicular temperature, plaque accumulation, gingival inflammation and pocket depth. This finding was in accordance with Markkanen et al who observed an increase in depth of the pocket in RPD users.[27]

Bone height loss around the abutment teeth was reported after six months of denture insertion for the two studied groups which may be explained on the bases that Plaque index increase after six months of wearing dentures as noted by Tatjana et al.[28] Other investigators were in one line with our results, showing correlation between the interdental alveolar bone loss and plaque accumulation following partial denture insertion. Confirming that dental plaque have a negative effect on both attachment level and bone height of the abutment teeth.[5,29] This finding could be attributed also to the horizontal and lateral stress on the abutment teeth in the distal extension bases which may cause breakdown of periodontal tissue and bone loss.[6,7]

There was statistically significant difference between the two groups after six and twelve months of follow up regarding the pocket depth with statistically significant difference after twelve months of follow up for the gingival index scores , milled PEEK RPD group showed lower mean values than the conventional RPD group. This finding could be attributed to the biocompatibility of that material together with the precise designing and manufacturing by computer software that ensure accurate adaptation and fitness of the denture framework components.[30]

Regarding bone height loss of the abutment teeth, milled PEEK RPD group showed lower mean values than the conventional RPD group however the difference is statistically insignificant. This could be referred to its elastic and shock absorbent properties which could aid in favorable stresses transmitted to the abutment teeth.[18]

Conclusion

The digitally fabricated removable partial denture frameworks, constructed from new milled peek material (Juvora) showed more favorable effect on the abutment teeth in distal extension bases than the conventional metallic frameworks in terms of pocket depth, gingival index as well as bone height changes. However, there were inevitable changes associated with RPD insertion.

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