Original Article

EVALUATION OF ANCHORAGE TECHNIQUE ON THE ADAPTION OF PARTIAL DENTURE FRAMEWORK (COMPARATIVE IN VITRO STUDY)

Amel M Lefsaay[a], Mohamed H Elgtlawi[b], Gamal E Burawi[c]

ABSTRACT

The cast partial removable partial denture must be well fitted on the master dental cast and also on the oral tissues to be more successful and fulfill its functions. The objective of this in-vitro study was to evaluate the effect of anchorage on the accuracy of fit in removable partial denture framework. The study consisted of fourteen maxillary partially edentulous refractory casts Class III Kennedy classification modification 1 which were divided equally into two groups **group I** test group (Anchorage technique) and **group II** control group (Conventional technique). Seven cobalt chrome removable partial denture frameworks were constructed for each group, one using conventional technique with performed wax pattern on a refractory casts and other seven cobalt chrome removable partial denture frameworks were constructed using anchorage technique including four holes for anchorage on the refractory casts. Both patterns were invested and casted under the same circumstances using conventional standardized technique.

The resulting metallic removable partial denture frameworks were evaluated to check the fitness of palatal strap the major connector on the master metal cast using digital micrometer.

The statistical results of this study showed significant reduction in the thickness (gap) between the palatal strap major connector and its related site among **group I** (Anchorage) when compared with **group II** (Conventional) which indicating more accurate fit for **group I**. Furthermore, all the frameworks which were constructed by anchorage technique revealed more gap reduction centrally and anteriorly than peripherally and posteriorly.

Keywords: Removable partial denture, Casting, Cobalt Chromium.

INTRODUCTION

Maxillary major connectors play various functions and influence the success of Removable partial denture (RPD). The intimate contact between the metal and the palatal tissue, in addition to their wide mucosal coverage, improve the support, and in turn the retention and stability of the prosthesis.

Although, the fitness of the metal framework on the master cast can be improved with some adjustments in the laboratory. Clinical experience with cast cobalt-chromium alloy partial dentures shows that a framework seldom fits the mouth accurately. This misfit reflects the dimensional inaccuracies that occur at the various stages of framework construction [(1-3)].

The literatures reported a misfit of the various components of the cast partial framework [(4-6)].

Inaccuracies and misfit in frameworks could range from slight, requiring minor modifications in the clinic, to those serious enough to necessitate construction of new frameworks. Those have been attributed to several factors. Inaccuracies in making the final impression due to improper manipulation or handling of the materials may result in ill-fitting frameworks [(7)].

Several studies reveal that the distortion of major connector frameworks could be due to the shrinkage of wax pattern, time and temperature of storage, and the liquid melting range of the wax pattern [(8-10)].

The fit may also alter during the finishing and polishing of the framework, therefore, care must be taken not to build up heat in the framework during polishing, which would cause the framework to warp. A direct relationship was also found between the flow of wax and the casting shrinkage [(11, 12)].

[a] Assistant Lecturer, Prosthodontic Department, Faculty of Dentistry, Benghazi University.

[b] Lecturer, Prosthodontic Department, Faculty of Dentistry, Benghazi University.

[c] Lecturer, Prosthodontic Department, Faculty of Dentistry, Benghazi University.

The casting shrinkage for the metal alloys implies both the solidification shrinkage and the thermal contraction from solidification temperature to room temperature, resulting in discrepancy in the palatal adaptation of the major connector [13, 14].

A similar discrepancy occurs with the acrylic resin denture bases when there is polymerization shrinkage [15, 16].

Knowing that the polymerization shrinkage of acrylic resin can be controlled by means of anchorage on the cast, it is assumed that this principle could also be applied for controlling the solidification shrinkage of metal alloys. Anchoring holes may provide molten metal during solidification and redirect the cooling pattern and the shrinkage of the molten metal.

The mechanism of redirecting the casting shrinkage and improving the fit of the RPD framework was hypothetically encouraged us to evaluate the accuracy of fit of the cast partial denture framework to the palatal surface with or without anchorage technique. All results of the conducted tests were calculated, tabulated and statistically analyzed.

MATERIALS AND METHODS:

A maxillary stone cast representing a partially edentulous Kenndy class III mod I was selected. The cast was surveyed with dental cast surveyor and parallel block-out of the undercuts was done with modeling wax; and designed in the form of a maxillary palatal strap major connector with bilateral two Aker clasps and related rest seats of the standard dimensions next to the both edentulous spaces. Guiding planes were prepared for all abutment teeth. Beading lines were performed to delineate the antero-posterior extension and to standardize the dimension of palatal strap width of 10 mm. This modified stone cast was duplicated into Brass metal cast by (split mold process) [17] which was served as a master cast and used for production of all study refractory casts and evaluation of accuracy of the framework adaptation. Two reference points were marked on the metal master cast and named points A and P, coinciding with the midline on the anterior and posterior borders of the major connector, respectively. Other two points were also marked anterior right (A_R) and posterior left (P_L), these four reference points were diagonal in configuration and used as sites for anchorage holes preparation (Figure 1). Following the modification of the metal master cast, it was duplicated using addition silicon duplicating material[*].

[*]Bego.BremerHerbest GmbH co.

Figure 1: Master cast with reference points for anchorage.

The resultant mold was used to obtain fourteen refractory casts using phosphate bonded investment material.

The obtained refractory casts were divided into two equal groups – test group (group I) and control group (group II), comprising seven specimens each.

Four anchorage holes were drilled in each refractory cast related to test group (group I) with dimensions 2mm in depth and 2mm in diameter using carbide rose head stone (Figure 2). Wax pattern, spruing, investing, and wax burn-out were done. Casting was carried out according to the manufacturer's instructions. The cast metal frameworks were retrieved. The anchoring studs for (group I) were cut, and finishing and polishing were done as per the recommended protocol.

Figure 2: Site of anchorage on refractory cast.

The accuracy of cast partial denture framework fitness was evaluated by measuring the distance between the palatal surface of the major connector and the palatal surface of the metal cast using auto polymerizing fast set acrylic resin (Duralay) at marked six reference points. These points were marked on the metal master cast as (a) and (b) points coinciding with the midline on the anterior (A) and posterior (P) and 2mm from the ends of major connector, respectively. Another four reference points were marked right and left to both (a) and (b) points (a_R, a_L, b_R, b_L) about 2mm from internal finish line laterally and beading line medially. Vacuum cured acrylic resin sheet was fabricated at the site of palatal strap major connector on the metal master cast to be used as a grid to transfer the previously marked reference points by drilling the vacuum sheet using carbide fissure bur (Figure 3). Thin layer of (Duralay) was applied on the metal die cast and fitting surface of each frame work following the application of lubricant. Each framework was completely seated with even finger pressure on the occlusal rests. The duralay material was removed from the cast following complete setting. The thickness at each reference point was measured and recorded using digital micrometer caliper (Figure 4).

Figure 3: Acrylic grid for reference points transfers.

Figure 4: Measuring the thickness of the Duralay.

RESULTS

Duralay layer thickness was used to indicate the gap between each major connector and its related area on the master metal cast. Tables 1 and 2 showed the duralay layer thickness for both studied groups (group I and II).

Table 3 showed comparison of the thickness of the duralay layer at different anterior reference points with posterior reference points (for group I) by comparing reference points a_R with b_R, a with b and a_L with b_L with mean values (0.12 ± 0.05 & 0.16 ± 0.03), (0.22 ± 0.05 & 0.28 ± 0.04), (0.09 ± 0.05 & 0.15 ± 0.02) respectively, which showed no significant difference between studied reference points with p_1 value equal to (0.787, 0.064, 0.106) respectively.

Table 4 showed comparison of the thickness of the duralay layer at different anterior reference points with posterior reference points (for group II) by comparing reference points a_R with b_R, a with b and a_L with b_L with mean vaues (0.26 ± 0.10 & 0.27 ± 0.04), (0.51 ± 0.11 & 0.53 ± 0.12), (0.23 ± 0.04 & 0.26 ± 0.06) respectively, which showed no significant difference between studied reference points with $p_1$value equal to (1.000, 0.996, 0.738) respectively.

The comparison of the duralay layer thickness at different points between both studied groups (group I and II) by comparing the reference points of a_R of both studied groups with mean values of (0.12 ± 0.05 & 0.26 ± 0.10) respectively, there was a significant reduction in the thickness of duralay layer for group I when compared with group II at 0.05 level ($t = 3.345$) ($p = 0.009$) (Table 5).

Also there was a significant reduction of duralay layer thickness at the reference point a for group I when compared with the same point for group II with mean of values of (0.22 ± 0.05 & 0.51 ± 0.11) respectively at 0.05 level ($t = 6.046$) ($p < 0.001$) (Table 5).

At the same time there was a reduction in the value the duralay layer thickness at the reference point of a_L for group I when compared with the same point for group II with mean of values of (0.09 ± 0.05 & 0.23 ± 0.04) respectively which was significant at 0.05 level. ($t = 5.496$) ($p < 0.001$) (Table5).

The same significant reduction related to the thickness of the duralay layer was observed in all reference points posteriorly b_R, b, b_L with mean values of (0.16 ± 0.03 & 0.28 ± 0.04 & 0.15 ± 0.02) respectively for group I when compared with the same points for group II with mean of values of (0.27 ± 0.04

& 0.53 ± 0.12 & 0.26 ± 0.06) respectively with significant difference value p (<0.001, 0.001, 0.003) (Table 5). In general the comparison of thickness of the Duralay layer for both studied groups [group I (anchorage technique) and group II (conventional technique)] at all reference points was significantly less among group I.

Table 6 represented a comparison of the duralay layer thickness at the anterior border of the palatal strap major connector between the studied groups (group I and group II) with mean values of (0.15 ± 0.08 & 0.34 ± 0.15) respectively, which was significantly less among group I at ≤ 0.05 level (t = 5.060) (p < 0.001).

The comparison of the duralay layer thickness at the posterior border of the palatal strap major connector between the studied groups (group I and group II) was represented in table 7 with mean values of (0.20 ± 0.07 & 0.35 ± 0.15) respectively, with significant difference at ≤ 0.05 level (t = 4.341) (p<0.001).

Table 8 decelerated the comparison of the duralay layer thickness between the anterior and posterior reference points for group I, which was significantly reduced at the anterior border of palatal strap major connector at ≤ 0.05 level with mean values of (0.15 ± 0.08 & 0.20 ± 0.07) respectively (t = 5.767) (p<0.001). However, the reduction in the duralay thickness at the anterior border of the palatal strap major connector for group II, was not significant at ≤ 0.05 level when compared with posterior border with mean value of (0.34 ± 0.15 & 0.35 ± 0.15) respectively (t = 1.715) (p = 0.102) (Table 9).

Table 1: Thickness of the duralay layer (in mm) at the different reference points of the palatal strap major connector for group I (Anchorage technique).

No. of framework (n=7)	a_R	a	a_L	b_R	b	b_l
1	0.166	0.326	0.042	0.154	0.343	0.134
2	0.143	0.224	0.186	0.166	0.245	0.176
3	0.144	0.177	0.05	0.149	0.244	0.132
4	0.047	0.208	0.072	0.142	0.323	0.155
5	0.158	0.233	0.118	0.14	0.32	0.137
6	0.065	0.226	0.039	0.127	0.269	0.138
7	0.134	0.179	0.11	0.219	0.243	0.176

Table 2: Thickness of the duralay layer (in mm) at the different reference points of the palatal strap major connector for group II (Conventional technique).

No. of frame work (n=7)	a_R	a	a_L	b_R	b	b_l
1	0.384	0.595	0.239	0.33	0.666	0.252
2	0.277	0.502	0.278	0.287	0.548	0.331
3	0.197	0.512	0.201	0.27	0.481	0.209
4	0.146	0.406	0.156	0.202	0.408	0.207
5	0.144	0.344	0.219	0.226	0.355	0.182
6	0.347	0.691	0.277	0.278	0.666	0.317
7	0.346	0.52	0.255	0.305	0.557	0.315

Reference points for fitting evaluation:
a_R=anterior right point.
a=anterior point.
a_L=anterior left point.
b_R=posterior right point
b=posterior point.
b_L=posterior left point.

Table 3: Comparison of the duralay thickness between the different reference points of evaluation at the same group (group I) Anchorage technique.

	a_R	a	a_L	b_R	b	b_L
Anchorage (group I)						
Min.	0.05	0.18	0.04	0.13	0.24	0.13
Max.	0.17	0.33	0.19	0.22	0.34	0.18
Mean	0.12	0.22	0.09	0.16	0.28	0.15
SD	0.05	0.05	0.05	0.03	0.04	0.02
Median	0.14	0.22	0.07	0.15	0.27	0.14
p_1				0.787	0.064	0.106

p_1: Stands for adjusted Bonferroni p-value for ANOVA with repeated measures for comparison between a_R with b_R, a with b and a_L with b_L.

Table 4: Comparison of the duralay thickness between the different reference points of evaluation at the same group (group II) Conventional technique.

	a_R	a	a_L	b_R	b	b_L
Conventional (group II)						
Min.	0.14	0.34	0.16	0.20	0.36	0.18
Max.	0.38	0.69	0.28	0.33	0.67	0.33
Mean	0.26	0.51	0.23	0.27	0.53	0.26
SD	0.10	0.11	0.04	0.04	0.12	0.06
Median	0.28	0.51	0.24	0.28	0.55	0.25
p_1				1.000	0.996	0.738

p_1: Stands for adjusted Bonferroni p-value for ANOVA with repeated measures for comparison between a_R with b_R, a with band a_L with b_L.

Table 5: Comparison of the duralay layer thickness at different points between the two studied groups [group I (anchorage technique) and group II (conventional technique)].

		Anchorage (n=7)	Conventional (n=7)	t	P
a_R	Min. – Max.	0.05 – 0.17	0.14 – 0.38	3.345^*	0.009^*
	Mean ± SD.	0.12 ± 0.05	0.26 ± 0.10		
	Median	0.14	0.28		
a	Min. – Max.	0.18 – 0.33	0.34 – 0.69	6.046^*	$<0.001^*$
	Mean ± SD.	0.22 ± 0.05	0.51 ± 0.11		
	Median	0.22	0.51		
a_L	Min. – Max.	0.04 – 0.19	0.16 – 0.28	5.496^*	$<0.001^*$
	Mean ± SD.	0.09 ± 0.05	0.23 ± 0.04		
	Median	0.07	0.24		
b_R	Min. – Max.	0.13 – 0.22	0.20 – 0.33	5.664^*	$<0.001^*$
	Mean ± SD.	0.16 ± 0.03	0.27 ± 0.04		
	Median	0.15	0.28		
b	Min. – Max.	0.24 – 0.34	0.36 – 0.67	5.031^*	0.001^*
	Mean ± SD.	0.28 ± 0.04	0.53 ± 0.12		
	Median	0.27	0.55		
b_L	Min. – Max.	0.13 – 0.18	0.18 – 0.33	4.467^*	0.003^*
	Mean ± SD.	0.15 ± 0.02	0.26 ± 0.06		
	Median	0.14	0.25		

t: Student t-test
*: Statistically significant at $p \le 0.05$

Table 6: Comparison of the duralay layer thickness at anterior border of the palatal strap major connector between the two studied groups[group I (anchorage technique) and group II (conventional technique).

	Anchorage (n=7)	Conventional (n=7)	t	P
Anterior				
Min. – Max.	0.04 – 0.33	0.14 – 0.69		
Mean ± SD.	0.15 ± 0.08	0.34 ± 0.15	5.060*	<0.001*
Median	0.14	0.28		

t: Student t-test
*: Statistically significant at $p \leq 0.05$

Table 7: Comparison of the duralay layer thickness at posterior border of the palatal strap major connector between the two studied groups[group I (anchorage technique) and group II (conventional technique).

	Anchorage (n=7)	Conventional (n=7)	t	P
Posterior				
Min. – Max.	0.13 – 0.34	0.18 – 0.67		
Mean ± SD.	0.20 ± 0.07	0.35 ± 0.15	4.341*	<0.001*
Median	0.17	0.32		

t: Student t-test
*: Statistically significant at $p \leq 0.05$

Table 8: Comparison of the duralay layer thickness between anterior and posterior border of the palatal strap major connector for group I (anchorage).

	Anterior (n=7)	Posterior (n=7)	t	P
Anchorage				
Min. – Max.	0.04 – 0.33	0.13 – 0.34		
Mean ± SD.	0.15 ± 0.08	0.20 ± 0.07	5.767*	<0.001*
Median	0.14	0.17		

t: Paired t-test
*: Statistically significant at $p \leq 0.05$

Table 9: Comparison of the duralay layer thickness between anterior and posterior border of the palatal strap major connector for group II (Conventional).

	Anterior (n=7)	Posterior (n=7)	t	P
Conventional				
Min. – Max.	0.14 – 0.69	0.18 – 0.67		
Mean ± SD.	0.34 ± 0.15	0.35 ± 0.15	1.715	0.102
Median	0.28	0.32		

t: Paired t-test
*: Statistically significant at $p \leq 0.05$

DISCUSSION

Clinical experience with cast cobalt-chromium removable partial denture shows difficulty in achieving the desired fit as compared with a single crown. The causes of inaccuracy of fit of Co-Cr cast frameworks are multifactorial and include dimensional changes in wax, refractory casts, investment materials, and properties of base metal alloys [18]. Various studies have been reported that the impression materials and techniques, the duplicating material, the sprue design, the storage time of wax pattern, the casting procedures, as well as mishandling of the framework during finishing and polishing would affect the dimensional stability and the fit of the metallic framework of removable partial denture [2, 19, 20, 21].

This in-vitro study was carried out to improve the accuracy of fit of RPD framework using additional means of anchorage technique as a compensation for solidification shrinkage and the distortion of the wax pattern of the Co-Cr alloy.

The accurate fit of maxillary frameworks with palatal strap major connector was selected to be evaluated in this study as the palatal major connector was indicated to be the most common site for inaccurate fit of RPD as reported by many investigators [2, 8, 19, 20, 22, 23]. A master metal cast fabricated by split mold process using brass material was preferred for laboratory verification in this study, because it was more resistant to abrasion on repeated insertion and removal of the metal frameworks during evaluation procedure [17].

Auto polymerized fast set acrylic resin material (Duralay) was used to measure this gap as it has fine grain size that offer fast set, sufficient flow, superior accuracy and rigidity in thin sections that does not distort when being measured with a micrometer caliper [8,22,24].

The results of this study exhibited a greater gap discrepancy in the palatal major connector related to control group than did the test group which, indicated more accurate fit of the palatal strap major connector with using anchorage stud techniques. The overall fit of the frameworks was better with the provision of anchorage, because the mold space formed due to the elimination of wax in the anchoring holes provided a bulk of metal to redirect solidification shrinkage toward the refractory cast rather than away from it. The anchoring holes may have also provided excess wax to prevent cooling contraction of pattern wax away from the refractory cast [17, 20, 24, 25].

The magnitude of the gap between the palatal strap major connector and its related surface on the master cast was significantly greater at middle sections than the lateral sections at both studied groups of the present study. The same result was previously found by many investigators [8, 22, 23] who conducted their studies on the effect of palatal strap major connector design on the accuracy of fit on the master metal cast and they reported greater discrepancy at the middle sections of the palatal strap major connector which could be attributed to variations in thermal contractions in different portions of the framework and increase in contraction of cast frameworks toward the center of the palate.

By comparing the gap at the middle section of the palatal strap major connector between the two studied groups, there was an improvement in the fit among frameworks of group I. At the same time, it was found that the more accurate fit was obviously greater at the anterior border of the palatal strap major connector than the posterior border of both groups and with more adaptation among (group I) which was in agreement with many previous studies [8, 20, 22]. This result could be attributed to the change of the palatal vault. Since the anterior palatal vault is narrower, the flow of molten metal may sufficient in the area to be cast. In the posterior vault, the surface area increases, and hence the gap may be seen.

Conclusion

Within the limitations of the study the following conclusions were drawn:

1) The adaptation of the major connector in the group using anchorage was better than the group that did not use anchorage as a means to control casting shrinkage.
2) Accuracy was significantly better at anterior border than at Posterior border in the group using anchorage.
3) Anchorage may be used to reduce the solidification shrinkage of the metal.

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