Effect of Anchorage on the Accuracy of Fit in Removable Partial Denture Framework

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Abstract

Purpose: This study evaluated the effect of anchorage on the accuracy of fit in removable partial denture framework.
Materials and Methods: Twenty-four partially edentulous maxillary refractory casts were duplicated from a machine-milled metal cast. Twelve of these were included in the test group, which had the provision for anchorage in the refractory cast, and the remaining 12 were taken as control group, which did not have provision for anchorage. Identical wax patterns for the maxillary strap major connector were invested and cast in cobalt chromium alloy. The accuracy of fit of the cast partial major connector frameworks were measured at two selected points using a profile projector. The resultant data were analyzed using student's *t*-test and unpaired *t*-test.
Results: Student's *t*-test showed statistically significant improvement in the fit of the major connectors of the test group at point A ($p = 0.0003$) and P ($p = 0.0074$). Unpaired *t*-test was performed for the control and test group. The results of the unpaired *t*-test for the control group exhibited a greater gap discrepancy (0.44 $\pm$ 0.20 mm) than for the test group at point A (0.16 $\pm$ 0.10 mm). Similarly, the gap was more at Point P for the specimens in the control group (0.65 $\pm$ 0.10 mm) than the test group (0.42 $\pm$ 0.24 mm).
Conclusion: Within the limitations of the study it is concluded that the accuracy of fit of the palatal major connector was significantly better in the test group than the control group, with 0.1% level of significance at point P. The accuracy was significantly improved in both groups at point A by 1% level of confidence.

Maxillary major connectors can fulfill various functions and influence the success of removable partial dentures (RPD). The intimate contact between the metal and the palatal tissues, in addition to their wide mucosal coverage, enhances the support, and in turn the retention and stability, of an RPD.

Clinical experience with cast cobalt-chromium (Co-Cr) alloy partial dentures shows that a framework seldom fits the mouth accurately without the need for some adjustment, despite the fact that some adjustment has already been performed in the laboratory to fit the framework on the master cast. This misfit reflects the dimensional inaccuracies that occur at the various stages of framework construction.[1–3]

The literature reports numerous inaccuracies concerning the fit of the various components of the cast partial framework.[4–7] Structural flaws in frameworks and inaccuracies in fit could range from slight, requiring minor modifications in the clinic, to those serious enough to necessitate construction of new frameworks. The inability to accurately adapt the framework on the cast and in the patient's mouth has 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. Rudd and Rudd suggested that irreversible hydrocolloid impression material seems to be the material of choice for making RPD definitive impressions.[8]

Some studies reveal that the accuracy of fit of the major connector could be affected by the time and temperature of storage, and the liquid melting range of the wax pattern.[9,10] The distortion of major connector frameworks could be due to the shrinkage of pattern wax. The inlay waxes contract by as much as 0.35% when cooled from 37°C to 25°C.[11,12] A direct relationship was also found between the flow of wax and the casting shrinkage.[13,14] The fit may also alter during the finishing of the framework to adapt it to the master cast. Care must be taken not to build up heat in the framework during polishing, which would cause the framework to warp.

The casting shrinkage for the metal alloys implies both the solidification shrinkage and the thermal contraction from solidification temperature to room temperature. All base metal alloys shrink 2.0% to 2.3% upon solidification.[15] Co-Cr has an average shrinkage of 2.3%, and nickel chromium 2%,[16] resulting in discrepancy in the palatal adaptation of the major connector. A similar discrepancy occurs with the acrylic resin denture bases when there is polymerization shrinkage. To reduce this polymerization shrinkage, various methods have been used to mechanically anchor the resin denture bases to the master cast during processing. These methods include placing a wax extension, anchoring of the denture base with a posterior strap of wax, and making mechanical retention holes in the cast.[17-19]

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. This mechanism of redirecting the casting shrinkage and improving the fit of the RPD framework is hypothetically tested in this study to evaluate the accuracy of fit of the cast partial denture framework to the palatal surface with or without anchorage.

Materials and methods

A partially edentulous (Kennedy class III mod I) maxillary cast was selected. The cast was surveyed with a surveyor, and parallel block-out of the undercuts was done with modeling wax. Occlusal rest seats of the standard dimensions were prepared on the premolars and molars. This cast was used as a model to obtain a metal cast to fabricate the frameworks and measure the accuracy of the frameworks. A metal cast was obtained by machining an aluminum block on a computerized numerically controlled (CNC) machining center using master CAM software. Two reference points were marked on the metal cast and named points A and P, coinciding with the midline on the anterior and posterior borders of the major connector, respectively. These reference points were marked so they could be used as a reference to make the measurement of the fit between the major connector and the metal cast (Fig 1).

The pattern wax (Schuller-Dental, Ulm, Germany) was adapted on the metal cast. The maxillary palatal strap major connector, extending from the distal surface of the second premolar to the mesial surface of the second molar, was adapted using a pattern wax sheet of 0.8 mm thickness. The anterior and posterior borders were kept parallel to each other, as well as to the posterior surface of the cast. The preformed premolar and molar clasps (Dentaurum, Berlin, Germany) were adapted to form an embrasure clasp on premolars and a circumferential clasp on molars, respectively, at their predetermined positions. The rests were made on the rest seats, which were prepared in the metal cast. The minor connectors were made with inlay wax (Dentaurum, Germany), to join the major connector component

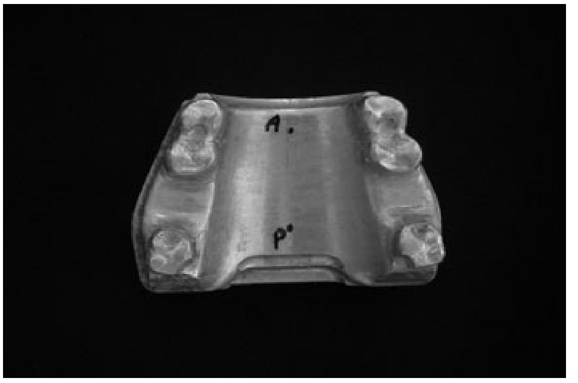

Figure 1 Point A and P marked on the metal cast.

to the clasp assemblies. After the entire framework to be cast was adapted on the metal cast, a shaped block-out was done with hard modeling wax, for standardizing the position of the components in the pattern to be cast.

The blocked-out metal cast was then used to make a duplicating silicone mold (Wirosil, BEGO Bremer, Herbst GmbH, Bremen, Germany) for duplicating the refractory casts. The refractory casts were poured into the mold with phosphate-bonded investment material (Biosint, DeguDent GmbH, Bohmte, Germany). The investment material powder was mixed with the special liquid (Biosol, DeguDent GmbH) as per the ratio specified by the manufacturer in a vacuum mixing unit (Degussa, Dusseldorf, Germany). A total of 24 refractory casts thus obtained were divided into two groups-–Control group and test group, comprising 12 specimens each. The test group had holes in the refractory cast for anchorage adjacent to the major connector (Fig 2). The anchoring holes were 2 mm in depth and were placed at the anterior and posterior borders of the major connector (Fig 3). Wax pattern, spruing, investing, and wax burn-out were done. Casting was carried out according to the manufacturer's instructions.

The cast frameworks were retrieved. The anchoring studs were cut, and finishing and polishing were done as per the recommended protocol. The seating of the castings on the metal cast was confirmed using a magnifying glass. The accuracy of fit was evaluated by measuring the distance between the

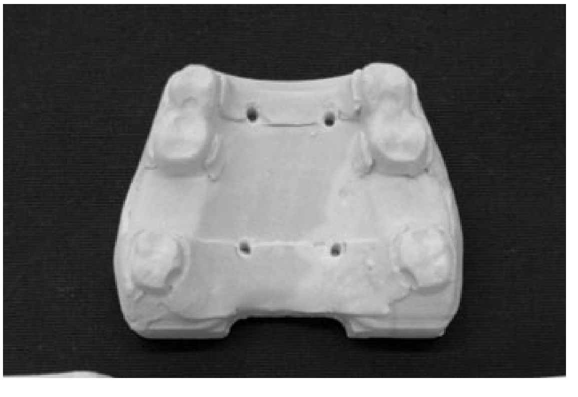

Figure 2 2-mm anchoring holes made on the refractory cast.

Figure 3 Wax pattern with the anchors on the anterior and posterior region.

palatal surface of the major connector and the palatal surface of the metal cast at the anterior border and the posterior border of the major connector at a standardized position on the cast. The gaps between the major connector and the metal cast were measured at reference points A and P already marked on the palatal surface of the metal cast. The space between the major connector and the metal cast was measured using a profile projector with a digital sensor (HF600, Starrett Sigma Profile Projector, Jedburgh, UK) at 10 × magnification. The projector was calibrated to UKAS standard, and this covered the calibration of magnification of lenses, linear error compensation for the x- and y-axis travel of the work stage, screen protractor, and optical edge detector. The readings were accurate to 0.1 μm. The metal cast with the casting was placed on a platform on the profile projector in front of the projector. The projector then gave the reading of the gap between the cast and the palatal surface of the casting in millimeters. The magnitude of the gap between the major connector and the metal cast at the respective locations for all specimens of both the groups were tabulated. These readings formed the basic data for the study. This study used only one dependent variable (provision for anchorage). The basic data collected were analyzed according to student's t-test and unpaired t-test.

Table 1 Gap (mm) between major connector and metal cast for the control and test group specimen at reference points A and P

Point	Control group	Test group
A		
Mean	0.4436	0.1670
SD	0.2002	0.1018
Minimum	0.019	0.089
Maximum	0.643	0.397
CV (%)	45.13	60.93
P		
Mean	0.6521	0.4263
SD	0.1067	0.2426
Minimum	0.486	0.326
Maximum	0.786	0.772
CV (%)	16.36	56.90

n = 12, for each group.

Table 2 Comparison of the mean and standard deviation values of the accuracy of the cast partial denture framework at point A and point P in test and control groups (mm)

Point	Group	Mean	SD	t-value	p-value
A	Test	0.1670	0.1018	−4.2661	0.0003
	Control	0.4436	0.2002		
P	Test	0.4263	0.2426	−2.9523	0.0074
	Control	0.6521	0.1067		

Results

Mean and standard deviation values of the gap between the major connector and metal cast for the control and test group specimens at the anterior and posterior reference points A and P on the metal cast are shown in Table 1. The mean and standard deviation values of the accuracy of fit of the palatal major connector frameworks of test and control groups at points A and P were compared using student's t-test. The test showed that the accuracy of fit of the palatal major connector was significantly better in the test group than the control group, with a 0.1% level of significance at point A and with a 1% level of significance at point P (Table 2). The accuracy of fit between point A and P was compared within the test and control groups using unpaired t-test. The test showed that accuracy was significantly better in both groups at point A. The results were statistically significant at 1% level of significance ($p \leq 0.01$) (Table 3).

Discussion

Precision of fit of dental castings may be difficult to achieve. Kaufman et al discussed the difficulty of seating a casting as simple as a single crown.[20] An RPD framework is a complex casting usually fabricated from a high-fusing base metal alloy resulting in higher shrinkage than gold alloys, so it is not surprising that clinicians may have difficulty in achieving the desired fit. 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.

Diwan et al conducted a study on the effect of storage time of RPD framework wax patterns before casting and the influence of the palatal major connector design on the accuracy of fit on the master casts.[9] They showed that greater discrepancies appeared at the middle sections of the major connectors than the lateral sections, and that the accuracy was greatest when the patterns were cast immediately after their fabrication. Eerikainen and Rantanen reported an increase in contraction of

Table 3 Comparison between the mean and standard deviation values at A and P within the control and test groups (mm)

Group	Point	Mean	SD	t-value	p-value
Control	A	0.4436	0.2002	−3.1837	0.0043
	P	0.6521	0.1067		
Test	A	0.1670	0.1018	−3.4143	0.0025
	P	0.4263	0.2426		

cast frameworks toward the center of the palate and attributed it to variations in thermal contractions in different portions of the framework.[21] Fenlon et al conducted a study to check the accuracy of fit of Co-Cr framework toward the center of the palate,[2] and stated that expansion of the refractory investment may not have compensated adequately for the solidification and cooling contraction of Co-Cr alloy. Hence, the investment expansion alone cannot compensate for the recovery of wax pattern and solidification shrinkage of Co-Cr alloy. Therefore, this study used additional means of anchorage as a compensation for solidification shrinkage and the distortion of the wax pattern of the Co-Cr alloy.

The control group exhibited a greater gap discrepancy in the palatal major connector than did the test group. The gap was more, both at point A (anterior region) and P (posterior region). Statistically significant improvement in the accuracy of fit of the major connector was seen with the specimens of test groups at points A ($p = 0.0003$) and P ($p = 0.0074$). When the gap was compared within the central and test groups, the gap at the anterior border was found to be significantly less than at the posterior border. The gap difference between point A and P may be attributed to the palatal vault. Since the anterior palatal vault is narrower, the flow of molten metal may suffice in the area to be cast. In the posterior vault, the surface area increases, and hence the gap may be seen. 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.

The results of the study strongly advocate the use of an anchoring technique for maxillary cast partial dentures. The technique improved adaptation and decreased gap discrepancies. The suggested technique is easy, less time consuming, and economical. The resulting anchoring pegs distal to the framework can be easily removed with a metal trimmer, since they are not within the borders of the framework. Thus the anchoring holes are beneficial in accuracy of fit of the cast partial frameworks. The magnitude of gap between the palatal major connector and the tissue surface of the metal cast obtained in this study pertains to the materials and methodology used in the preparation of frameworks and testing; however, it may vary if there are any changes in design, materials, and methods used to fabricate the framework of cast partial dentures.

Conclusion

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

(1) The adaptation at the center 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 point A than at point P in both groups.
(3) Anchorage may be used to reduce the solidification shrinkage of the metal.

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