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Effect of Relining Method on Dimensional Accuracy of Posterior Palatal Seal. An In Vitro Study

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Abstract

Purpose: The posterior palatal seal contributes to the retention of the complete denture. Distortion of this area can occur during reline procedures. The purpose of this study was to evaluate the dimensional accuracy of various denture relining methods and materials on the maxillary posterior palatal seal area.
Materials and Methods: A stainless steel cast was constructed from a maxillary edentulous cast. Fifty identical complete dentures were fabricated on 50 definitive casts made from the original metal cast. Five relining methods and materials were evaluated during this study, in regards to posterior palatal seal distortion: (I) laboratory conventional heat-polymerizing method (Lucitone), (II) laboratory heat/pressure-polymerizing method (SR-Ivocap), (III) laboratory autopolymerizing method (Perm), (IV) chairside autopolymerizing method (Tokuso Rebase), and (V) chairside light-polymerizing method (Astron). The dimensional changes of the posterior palatal seal areas were determined by placing a low-viscosity silicone impression material between the metal cast and the tissue surface of the relined dentures. The silicone thickness was measured at five predetermined points, under a measuring microscope. Statistical analysis was performed using descriptive statistics, one-way analysis of variance, and Student-Newman-Keuls tests ($\alpha = 0.05$).
Results: The gap at the posterior palatal seal area ranged from 68.76 to 331.55 μm, when measured at the five predetermined points. Group IV exhibited the smallest mean gap (137.62 μm) and Group I revealed the largest mean discrepancy (192.35 μm). The different relining methods and materials presented statistically significant differences ($p < 0.0001$).
Conclusion: The chairside autopolymerizing method exhibited smaller gap recordings than the rest of the tested complete denture relining methods.

Complete dentures have been used extensively for the rehabilitation of edentulous patients. The success of these restorations depends greatly on retention, support, and stability.[1–4] Due to the inevitable process of alveolar bone resorption, the complete denture may become loose and less retentive, resulting in soreness, loss of vertical dimension of occlusion, and poor function. Thus, complete dentures need to be relined or rebased to improve retention, stability, oral health, and esthetics.[5–9] Various denture relining procedures have been used in dentistry for years with different degrees of success. The posterior palatal seal is probably the most important area for retention and must be carefully considered during and after the reline procedures of a maxillary denture.

Acrylic resin, which is used for reline procedures, has the disadvantage of polymerization shrinkage, regardless of the processing procedure.[10–12] Many reline materials and methods used have been specifically developed to minimize shrinkage and distortion.[13–25] The different procedures of denture relining use either auto- or heat-polymerizing acrylic resins, which are processed in the laboratory. Auto- or light-polymerizing resin materials have also been developed for clinical use.[26–28] The laboratory reline method has relatively good dimensional stability and strength, but presents a major drawback: the patient has to be without the denture for a certain period of time. On the other hand, the chairside reline method seems to be convenient and easy and requires a short working time. Although the materials employed constantly improve, problems still exist. Autopolymerizing acrylic resins have the potential of causing chemical or thermal burns of the oral mucosa. Other disadvantages include poor color stability, porosity, and a foul odor. In addition, they are difficult to position correctly, are technique-sensitive, and can be toxic due to the residual monomer.[29–31]

Most studies that have evaluated the accuracy of relining methods did not simulate either the human mouth or the complete dentures per se. On the contrary, in those studies, bar-shaped, circular-shaped, or pentagonal-shaped metal dies and denture base material without teeth were used.[13,15,22,23] The evaluation of dimensional accuracy after relining procedures with a human arch and denture base with teeth could produce different results. Findings from Barco et al[22] support that the denture processing and relining procedures with teeth, as compared to dentures without teeth, can produce differences of shrinkage and distortion of the denture. No study has evaluated their effect on the posterior palatal seal area of the human maxillary edentulous arch. The purpose of this study was to evaluate the dimensional accuracy of various complete denture relining methods and materials on the maxillary posterior palatal seal area.

Materials and methods

An average-sized human maxillary edentulous arch cast was selected, and undercuts were removed. Two lines were made on the land area in the regions of the canines and of the posterior palatal border. A stainless steel cast was fabricated from the original edentulous stone cast (Fig 1). This metal cast was duplicated using a poly(vinyl siloxane) impression material (Wirosil, Bego, Pawtucket, RI) and allowed to set under 3.5 bar (50.76 psi) pressure (Wiropress, Bego). Each one of the six molds fabricated was poured five times using a type IV dental stone (Vel-Mix, Kerr, Orange, CA), giving a total of 30 duplicated definitive stone casts for the relining procedures (Fig 2).

Base plate wax (Hygenic Corp., Akron, OH) with a thickness of 1.5 mm was applied on the metal cast to provide relining space. Afterwards, eight tissue positioners were created (Fig 3). The spaced stainless steel cast was duplicated using a poly(vinyl siloxane) impression material (Wirosil) and allowed to set under 3.5 bar (50.76 psi) pressure (Wiropress). Each one of the ten molds fabricated was poured five times using a type IV dental stone (Vel-Mix), giving a total of 50 identically spaced definitive casts that were 1.5-mm bigger than the original unspaced metal cast. The wax space provided a simulated relief area to be filled with the relining material.

A denture base was waxed on one of the spaced definitive casts to a thickness of 2.0 mm. A silicone mold was then made on the waxed spaced definitive cast to duplicate identical denture bases on the 50 spaced definitive casts (Fig 4). A customized full arch of acrylic teeth was fabricated in one piece. A jig allowed the same positioning of the acrylic teeth on all 50 casts. The 50 complete dentures (hereafter called *specimen dentures*) were processed using the SR-Ivocap system (Ivoclar North America, Inc., Amherst, NJ) (Fig 5). After processing, the 50 specimen dentures were stored in water for 2 weeks and were then randomly divided into five groups.

Relining procedures

Laboratory conventional heat-polymerizing method

Ten specimen dentures were placed on the duplicated definitive stone casts and were then flasked in a conventional manner. Conventional heat-polymerizing resin (Lucitone, Dentsply/Trubyte, Milford, DE) was mixed using a polymer-to-monomer ratio of 21 mg/10 ml and placed onto the tissue surface area of the specimen dentures. The dentures were then processed for 9 hours at 73.8°C (165° F).

Laboratory heat/pressure-curing method

Ten specimen dentures were placed on duplicated definitive stone casts and then packed into the special flask (Ivoclar North America, Inc.). The whole relining procedure was performed following manufacturer's recommendations: injection of the relining material into the provided special flask, maintenance for 10 minutes at room temperature, placement in boiling water for 35 minutes and for 20 minutes at room temperature, under 6 bar (87 psi) pressure.

Laboratory autopolymerizing method

A stone definitive cast with a specimen denture was attached to the lower part of a reline jig (Heraeus Kulzer, South Bend, IN). A small quantity of laboratory plaster (Laboratory Plaster, Heraeus Kulzer) was used to make an index of the occlusal and palatal part of the denture and attach it to the upper part of the reline jig. The reline jig was separated after the final set of the plaster index. Autopolymerizing resin (Perm, Hygenic Corp.) was used. Polymer and monomer (20 cc/9 cc) were mixed and placed onto the tissue surface area of the specimen denture. The reline jig was completely closed and immediately placed into a pressure tank (Aquapress, Lang Dental Mfg., Wheeling, IL). The pressure tank was subsequently filled with room temperature water and closed, and pressure was increased to 2 bars (29 psi) for 20 minutes.

Chairside autopolymerizing method

Autopolymerizing resin for chairside use (Tokuso Rebase, Tokuyama America, Inc., San Mateo, CA) was employed. Polymer and monomer (1.6/1 ml) were mixed and placed onto the tissue surface area of the specimen denture. A static load of 2 kg[32,33] was applied on the top of the specimen denture on the stainless steel cast. Polymerizing time was 8 minutes. All procedures were performed in 37°C (98.6°F) distilled water in order to simulate the oral environment.

Chairside visible light-polymerizing method

Visible light-polymerizing resin for chairside use (Astron, Astron Dental Corp., Wheeling, IL) was employed. Polymer and monomer (2 parts/1 part by volume) were mixed and placed onto the intaglio surface area of the specimen denture. A static load of 2 kg was applied to the specimen denture on the metal

Figure 1 Stainless steel cast used for this study.

Figure 2 Duplicated stone definitive cast.

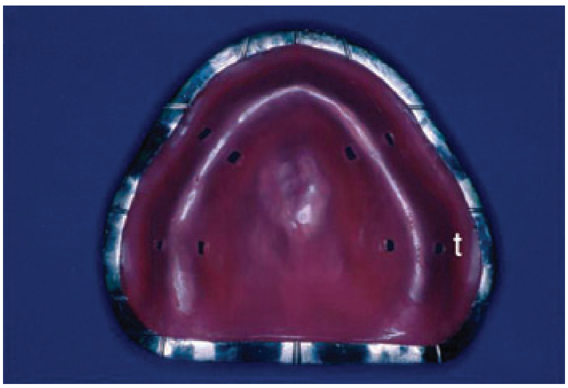

Figure 3 The 1.5-mm thickness base plate wax spacer on the metal cast. t: 8 tissue positioners were created.

cast, which was placed in a water bath at 37°C, to simulate oral environment conditions. After 3 minutes, the reline material reached its propagation stage, and the specimen denture was separated from the stainless steel cast. The specimen denture was then placed in a visible light-polymerizing unit (Triad 2000, Dentsply/Caulk) for 5 minutes. All materials used in this study are presented in Table 1.

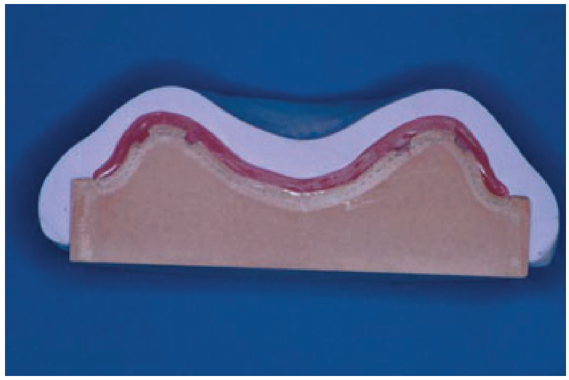

Figure 4 Cross-section view of silicone mold placed on the waxed spaced stone cast.

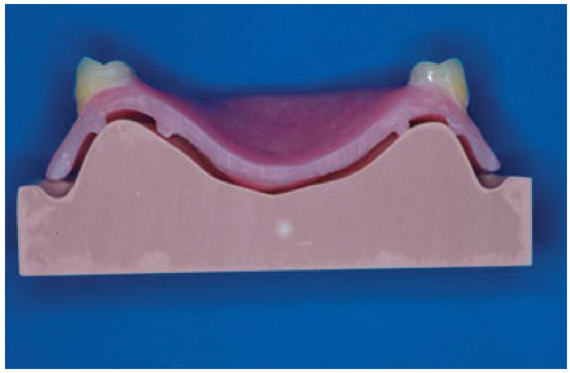

Figure 5 Cross-section view of processed specimen denture on the stone definitive cast.

Measurements

The dimensional change of the relined dentures was determined by placing a low-viscosity silicone impression material (Reprosil, Dentsply/Caulk) on the tissue surface of the relined dentures. The dentures were then seated under a static load of 2 kg on the metal cast. A comparison of the space between the definitive cast and the relined denture base was measured by the amount of impression material remaining.

The impression material was placed on and then evenly spread over the entire tissue surface of the relined denture. The denture was then seated on the stainless steel cast and aligned with the lines located at the land area of the cast (Fig 6). A static load of 2 kg was applied on the denture for 9 minutes, until the impression material polymerized completely. Afterwards, the excess material was trimmed with a scalpel. The relined denture was then removed from the metal cast. The impression material was attached on the cast. The land area of the stainless steel cast was dammed using boxing wax (Boxing Wax, Hygenic Corp.). Another poly(vinyl siloxane) material (Wirosil) was poured onto the thin layer of the low viscosity addition silicone material, which was attached on the dammed metal cast. After the poly(vinyl siloxane) material was completely polymerized under 3.5 bar (50.76 psi) pressure (Wiropress), the silicone block was removed from the metal cast (Fig 7). This

Table 1 Reline materials used

Group	Method	Brand	Manufacturer	Batch
Group I	Laboratory heat-polymerizing	Lucitone	Dentsply/Trubyte, Milford, DE	051229
Group II	Laboratory heat/press-polymerizing	SR-Ivocap	Ivoclar North America, Inc., Amherst, NJ	G22036
Group III	Laboratory autopolymerizing	Perm	Hygenic Co., Akron, OH	04231
Group IV	Chairside autopolymerizing	Tokuso Rebase	Tokuyama America, Inc., San Mateo, CA	572048
Group V	Chairside light-polymerizing	Astron LC	Astron Dental Corp., Wheeling, IL	280527

poly(vinyl siloxane) block was then placed upside down and dammed using boxing wax (Boxing Wax). The same addition silicone material (Wirosil) was then poured onto the opposite side (the tissue surface of the denture) of the low viscosity poly(vinyl siloxane). After the complete polymerization of the poly(vinyl siloxane) material under 3.5 bar (50.76 psi) pressure (Wiropress), this block of silicone was sectioned on the posterior palatal border using a sharp blade. The thickness of each block was 8 mm. The two sectioned surfaces of this addition silicon block were measured in 0.001-mm units using a measurescope (Olympus SZ-PT; Tokyo, Japan) on the following five points: the two deepest portions of the flange (A, E), the two highest portions of ridge (B, D), and one central portion (C) (Figs 8 and 9). Each point was measured five times by one investigator. The same process was repeated on each sectioned surface for all 50 specimens. All observations were performed immediately after the relining procedure. Room temperature was constantly 20 ± 2°C (68 ± 3.6°F), while relative humidity was 50 ± 10%.

Results

The descriptive statistics with the means and standard deviations for each measurement point for all groups are displayed in Table 2. One-way analysis of variance was performed to analyze the statistical significance ($\alpha = 0.05$) of the results. The Student-Neuman-Keuls test was performed to evaluate between intergroup significance. Both the ANOVA and the Student-Neuman-Keuls tests were performed for all five measuring points.

The ANOVA among groups is presented in Table 3. Statistically significant differences ($p < 0.0001$) were found between the groups. The Students-Neuman-Keuls test (Table 4) revealed that Group IV, with a mean gap of 137.626 μm, was statistically significantly different ($p < 0.0001$) from Group V, which presented a mean gap of 178.295 μm, and from Group I, which exhibited a mean gap of 192.356 μm. Statistically significant differences ($p < 0.0001$) were found between Group II, with a mean gap of 152.868 μm, and Group I, and also between Group III and Group I. Group V was found to be statistically significantly ($p < 0.0001$) different from Group IV. Group I was found to be statistically significantly different ($p < 0.0001$) from Groups II, III, and IV. No statistically significant difference could be found among Groups II, III, and IV ($p = 0.058$) and between Groups II, III, and V ($p = 0.055$).

Group IV revealed the smallest silicone thickness (gap) (mean = 137.626 μm, SD = 61.452). Group I had the largest silicone thickness (gap) (mean = 192.356 μm, SD = 69.795) (Fig 10). The distribution of the silicone thickness of all groups at each point is depicted in Figure 11. All tests were performed among groups at points A, B, C, D, and E. Both the analysis of variance and the Student-Neuman-Keuls tests were

Figure 6 Relined denture, with poly(vinyl siloxane) impression material placed on its intaglio surface, positioned on the metal cast.

Figure 7 Silicone block removed from metal cast.

performed among groups at the five predetermined measuring points. These tests revealed statistically significant differences ($p < 0.0001$) among the different methods and groups of materials for points A, B, and D. For point C, the only statistical difference ($p < 0.0001$) was between Group IV, with a mean gap of 142.82 μm, and Group I, with a mean gap of 195.01 μm. No statistical difference was found among groups for point E ($p > 0.05$).

Discussion

This study evaluated the dimensional accuracy of five denture relining methods. Three of these groups were laboratory relining procedures, and two groups were chairside direct relining procedures.

Conventional heat-polymerizing acrylic resins have been used in reline procedures for many years. These materials have good mechanical and physical properties, but need a stone matrix for flasking, heat for polymerization, and a certain amount of time for laboratory processing.[1,14] The different coefficients of thermal expansion of the acrylic resin and the gypsum matrix aggravate shrinkage by causing an internal elastic stress in the polymerized base plate. The combination of polymerization

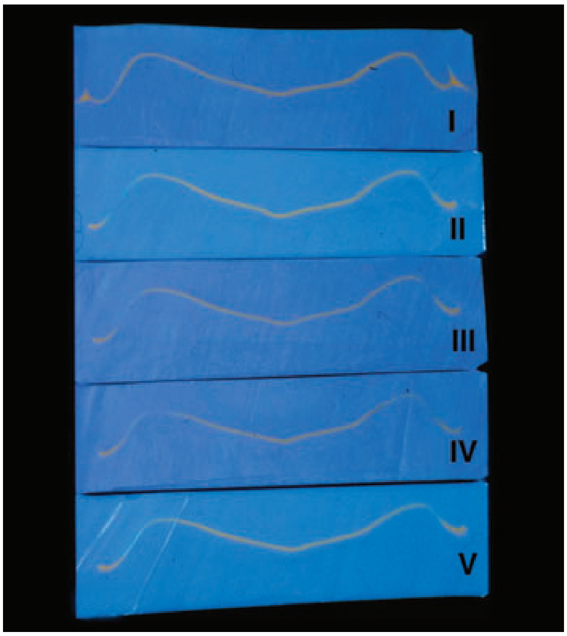

Figure 8 Specimens of 5 groups.

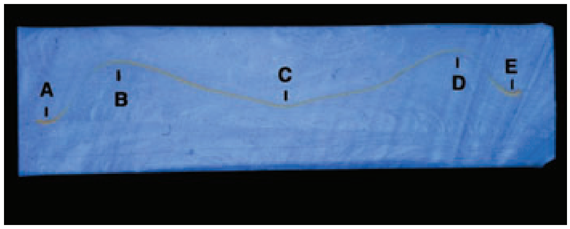

Figure 9 Five measuring points of a specimen.

Table 2 Descriptive statistics for the gap produced at the posterior palatal seal area by different relining methods (in μm)

Point	Group	n	Mean	SD
A	I	10	294.060	30.000
	II	10	221.180	48.001
	III	10	166.560	38.255
	IV	10	210.900	29.145
	V	10	331.550	45.431
	Total	50	244.850	70.861
B	I	10	155.330	26.456
	II	10	116.890	27.134
	III	10	131.880	32.595
	IV	10	88.440	29.470
	V	10	93.140	24.158
	Total	50	117.136	36.787
C	I	10	195.010	43.566
	II	10	177.820	35.750
	III	10	179.080	52.741
	IV	10	142.820	35.391
	V	10	178.770	32.695
	Total	50	174.700	42.680
D	I	10	106.480	23.580
	II	10	94.380	23.696
	III	10	158.760	42.538
	IV	10	68.760	21.452
	V	10	86.570	27.325
	Total	50	102.990	41.301
E	I	10	210.900	29.458
	II	10	154.070	20.294
	III	10	177.730	41.544
	IV	10	177.210	37.881
	V	10	201.445	81.599
	Total	50	184.271	49.483
Total	I	50	192.356	69.795
	II	50	152.868	54.900
	III	50	162.862	43.876
	IV	50	137.626	61.452
	V	50	178.295	100.709
	Total	250	164.789	70.967

Table 3 Statistical analysis (one-way ANOVA) for groups

Source	Type III sum of squares	df	Mean square	F	Sig.
Correct model	18262.385*	4	4565.596	8.016	0.000
Intercept	1357777.32	1	1357777.32	2383.843	0.000
GROUP	18262.385	4	4565.596	8.016	0.000
Error	25630.876	45	569.575		
Total	1401670.58	50			
Corrected total	43893.261	49			

Tests of between-subjects effects. Dependent variable: measure (average gap).
*$R^2 = 0.416$ (Adjusted $R^2 = 0.364$).

shrinkage, thermal contraction, and internal elastic strain may create denture distortion.[14,34] During polymerization, these materials need higher temperatures than autopolymerizing acrylic resins. There is a close correlation between the degree of shrinkage and the amount of heat applied during processing.[16,35,36]

A previous study[16] found that an autopolymerized acrylic denture base is more dimensionally accurate when compared to a heat-polymerized acrylic denture base. As the temperature increase in the mold is low, and there is a narrow cooling range, the shrinkage that occurs is largely an indication of the polymerization shrinkage. Smith et al[15] have reported that relines that employ autopolymerizing resins have significantly less ($p < 0.001$) change than those with heat-polymerizing resins. The best results come from compressed air processing in water at 37.7°C (100°F) with an air pressure of over 0.7 bars (10 psi) for at least 10 minutes.

The current study reports similar results to those of Anthony and Peyton[16] and Smith et al,[15] because Group III (Perm, autopolymerizing laboratory reline) and Group IV (Tokuso Rebase, autopolymerizing direct chairside reline) demonstrated a smaller gap than Group I (Lucitone, heat-polymerizing laboratory reline).

Recently, autopolymerizing direct chairside relining materials have been used widely in clinical settings.[37,38] It should be mentioned, however, that these materials present problems such as foul odor, poor color stability, porosity, poor physical and mechanical properties, and irritation of the oral mucosa.[29–31] The oral tissue irritation is caused by methyl methacrylate (MMA), the major constituent of the liquid. The monomer of autopolymerizing resin of Group IV replaces the MMA with iso-butyl-methacrylate, which is less irritating to oral tissues. The polymer of this material replaces the polymethyl-methacrylate (PMMA) with polyethyl-methacrylate (PEMA). In addition, the particle size (20 to 50 μm) is smaller than that of other materials (50 to 100 μm). As a result, less monomer is required. This material has also a high percentage of cross-linking agent in the monomer, a fact that probably contributes to better physical and mechanical properties.[13,18,39]

Table 4 Statistical analysis for groups (means in μm)

Group	N	Subset 1	Subset 2	Subset 3
IV	10	137.6260		
II	10	152.8680	152.8680	
III	10	162.8020	162.8020	
V	10		178.2950	178.2950
I	10			192.3560
Sig.		0.058	0.055	0.194

Student-Newman-Keuls a, b: measure (average gap). Means for groups in homogeneous subsets are displayed, based on type III sum of squares. The error term is mean square (error) = 569.575. Uses harmonic mean sample size = 10; alpha = 0.05.

The use of autopolymerizing direct chairside relining materials presents the significant advantage that patients never need to be without their restorations; however, chairside relines are technique-sensitive and require experience. In addition, these methods cannot assure a posterior palatal seal. As a result, retention and stability of the complete denture may be lost. Furthermore, errors in maintaining the centric relation position may produce some pressure points. It should also be mentioned that the major problem with these methods is the possibility of a faulty forward and downward repositioning of the complete denture.[2–4,7] Regarding the distortion at the posterior palatal seal area, the current study showed that Group IV (autopolymerizing direct chairside reline) presented the smallest gap among all groups.

As compared to the chairside relines, laboratory relining methods can prepare a posterior palatal seal area and can use pressure during polymerization to improve physical and mechanical properties.[15,40] Early injection molding processing methods produced more distortion than conventional heat-polymerizing methods. But, as materials and systems have improved (i.e., the SR-Ivocap method), better results are observed. The heat/pressure method (Group II) uses a continuous-pressure injection technique to compensate for the polymerization and thermal shrinkage occurring during the heat-polymerizing acrylic resin denture technique. Salim et al,[19] Strohaver,[20] and Anderson et al[21] have demonstrated that this system consistently produces dentures with less distortion. The current study showed that Group II (heat/pressure-polymerizing method) has a smaller mean gap and smaller standard deviation than Group I (heat-polymerizing laboratory reline).

Visible light polymerizing materials have been developed to simplify clinical and laboratory procedures. Breeding et al[23] demonstrated that a visible light-polymerizing material (Triad, Dentsply) has a greater dimensional change and distortion when compared to heat-polymerized acrylic resins (Lucitone 199, Dentsply, and Accelar 20, Columbus Dental, St. Louis, MO) after the reline procedure. Sadamori et al[13] found that a light-polymerizing reline material (Rebaron LC, GC America, Alsip, IL) presents greater dimensional changes than heat-, auto-, or microwave-polymerizing reline materials. The current study supports the above-mentioned results, as Group V (chairside, visible light-polymerizing method) exhibited the largest mean gap of all groups.

The results of the current study showed that distortion after a reline procedure displays a particular type of pattern ("W" type of pattern): points A, C, and E exhibited more distortion than points B and D. In other words, the distobuccal corners at the posterior border and the midpalatal area presented more distortion than the pterygomaxillary notch area. Another interesting

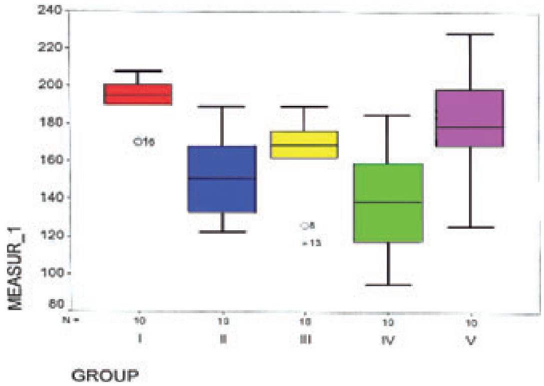

Figure 10 Overall distribution of silicone thickness (gap) between groups.

finding of the present study is that although points A and E would be expected to present the same distortion pattern, this was not the case. Different groups revealed greater gap differences in point A than in point E. It should also be mentioned that clinically, the midpalatal area is one of the most critical areas for the posterior palatal seal.[13,14,16,25]

Chairside reline procedures revealed a higher standard deviation when compared to the laboratory procedures. Therefore, it can be concluded that the results of reline procedures performed in the laboratory are more consistent. This conclusion could be attributed to the fact that the laboratory provides a more controlled environment. The use of a flask or a reline jig may be an additional parameter for the reduction of the variability of the results observed in the laboratory relines. Combining chairside autopolymerizing acrylic materials and a laboratory relining method using a reline jig and a pressure tank may yield the best results for a maxillary denture reline. This is due to better control of the procedures and preparation of the posterior palatal seal, especially in the midpalatal area.

As previously discussed, dimensional accuracy of dentures after a reline procedure is greatly influenced by both the methods and materials employed. Use of a static load of 2 kg was selected, because previous studies[32,33] have demonstrated that

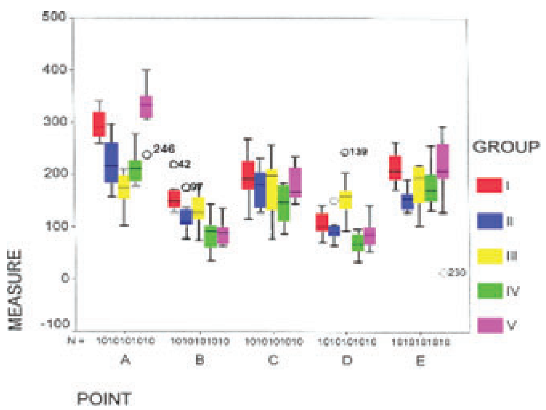

Figure 11 Distribution of the silicone thickness (gap) of each group among points.

in denture patients, closing forces during chewing approximate this value. However, the fact that the force employed was static instead of dynamic and the absence of a wet environment with thermal fluctuations present some limitations. It should also be mentioned that in the current study a solid cast was used for the simulation of the chairside procedures, which obviously did not possess the resiliency of the mucosa. In addition, the 40- to –55-μm gap difference between various materials and methods employed in this study, which was found to be statistically significant, is probably of a small clinical significance.

Further studies are needed to combine different materials and methods. An evaluation of the physical and the mechanical properties, as well as of the dimensional stability of the relined dentures after a period of time will help the clinician to draw definite conclusions.

Conclusions

Within the limitations of this in vitro study, it was concluded that:

1. The dimensional accuracy of relined dentures is influenced by relining materials and methods.
2. Statistically significant differences ($p < 0.0001$) were revealed among the tested groups.
3. According to this study, the autopolymerizing direct chairside relining method is significantly more likely to produce smaller gaps in the posterior palatal seal area than the rest of the examined methods. It should be mentioned, however, that there is no statistically significant difference ($p = 0.058$) among the autopolymerizing direct chairside relining, the laboratory heat/press-polymerizing, and the laboratory autopolymerizing methods.

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