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RESEARCH AND EDUCATION

Comparative analysis of denture base adaptation performance between pour and other conventional fabrication techniques

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ABSTRACT

Statement of problem. Studies assessing the comparative denture base adaptation performance of the pour technique for various palatal vault depths are sparse.

Purpose. The purpose of this in vitro study was to investigate the denture base adaptation performance of the pour technique compared with other conventional fabrication techniques (light-polymerization, injection, compression molding) for shallow and deep palatal vault depths.

Material and methods. Edentulous maxillary study models with 2 palatal vault depths were prepared. Based on the power analysis, the sample size of each conventional fabrication technique was 12 (N=96). After denture bases for each technique had been fabricated on the casts according to the manufacturers' recommendations, the casts and the intaglio surfaces of the denture bases were scanned by using a laboratory scanner (InEos X5). The standard tessellation language (STL) files of the casts and the intaglio surfaces of acrylic resin bases were transferred into a software program (Romexis, version 5.0), and the software superimposed each cast and its corresponding denture base scan with the reference pyramids semi-automatically. After superimposition, the mean gap distances (mm) were calculated by using the software and recorded from the identified 4 specific regions (denture border apex, palate, ridge crest, and posterior palatal seal). A statistical analysis was performed by using the 3-factor factorial ANOVA. Post hoc comparisons among the subgroups were performed by using the Tukey HSD test.

Results. Two- and 3-way interactions among palatal vault depth, polymerization technique, and location variables were statistically significant ($P<.05$). For shallow palatal vault depth, injection and pour polymerization techniques demonstrated similar mean gap distances irrespective of location ($P>.05$). The light-polymerization technique showed the highest mean gap distances among the tested polymerization techniques in all regions except for the posterior palatal seal area ($P<.05$).

Conclusions. The pour technique showed similar denture base adaptation to compression molding and injection. Light-polymerization exhibited the highest mean gap distance between the denture base and the cast for both palatal vault depths for most of the locations. A deep palatal vault depth led to inferior denture base adaptation performance for light-polymerization in the ridge crest and compression molding in the posterior palatal seal location. (J Prosthet Dent 2020;123:183.e1-e5)

Since the late 1930s, polymethyl methacrylate (PMMA) has been used as a base material for complete dentures.[1,2] Fabrication techniques for complete dentures have included compression molding (pack and press), fluid resin (pour) technique, and injection molding,[2,3] with compression and injection molding being the most commonly used polymerization methods.[4] The pour technique has the advantage of decreased processing time; however, disadvantages including denture tooth movement during polymerization and lack of bonding between denture teeth and the base material have been reported.[3] By combining the advantages of heat-polymerization with the reduced processing time of the pour technique, injection molding may increase the accuracy and stability of the denture bases; however, this technique is more expensive than the other conventional processing techniques.[3] Additional polymer materials instead of PMMA have been used as denture base, and urethane dimethacrylate (UDMA)-based, visible light-polymerized resin (Eclipse; Dentsply Sirona) has been claimed by the manufacturer

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Clinical Implications

While innovative techniques have been developed for the fabrication of complete dentures, cost efficiency and ease of production are still important factors. Therefore, the pour technique is a viable alternative for clinicians and dental technicians for its acceptable denture adaptation performance, decreased processing time, and cost of fabrication.

to have advantages including no residual methyl methacrylate monomer, ease of manipulation and fabrication, and increased dimensional accuracy compared with conventional heat-polymerized PMMA.[2,4] In recent years, computer-aided design and computer-aided manufacturing (CAD-CAM) methods have become popular for the fabrication of complete dentures,[5] although traditional processing still dominates.

The palatal vault depth, classified as shallow, medium, and deep, may affect denture base adaptation.[6,7] Sekar et al[8] compared the palatal adaptation of denture bases produced by injection or compression molding for the shallow and deep palatal vaults. They reported that the fabrication technique and material choice play a bigger role than the shape of the vault when evaluating the palatal adaptation of the denture.

The dimensional stability and adaptation of denture base materials have been evaluated by using different techniques.[3,9,10] Recently, laser and contact scanners have become popular for measuring the dimensional changes of denture bases with the help of different software programs to analyze the processing deformation.[3,4]

Data evaluating the effect of the pour technique and palatal vault depth differences on the performance of complete denture base adaptation are lacking. The purpose of this in vitro study was to compare the denture adaptation of the pour technique with that of conventional light-polymerization, injection molding, and compression molding fabrication techniques for shallow and deep palatal vaults. The null hypotheses were that the pour technique would have similar denture adaptation performance to the other fabrication techniques and that the palatal vault depth would not affect the adaptation of the complete denture base.

MATERIAL AND METHODS

Two identical edentulous maxillary study models in Type A residual ridge morphology according to the American College of Prosthodontists classification[11] were prepared and then modified to obtain 2 types of palatal depth configurations by using the method suggested by Avci and Iplikçioğlu.[12] The vertical distances at which the midpoint of the line connects the hamular notches and crosses the palatal vault of the duplicated study models were adjusted to 12 mm for shallow and 20 mm for deep palatal form. The palatal vault depths of the models were modified by adding baseplate wax on the palatal surfaces of the casts so that only the palatal depth was changed, and the ridge configuration was maintained. After adjusting the palatal depth of the models, 3 reference pyramids were added, 2 on the crest of the ridges over each tuberosity and 1 on the anterior crest of the ridge at the midline. These pyramids were used to superimpose the scans of the casts and the corresponding denture bases and to ensure that the measurements were made at the same locations.

Two rubber molds (Klas Dental) were obtained from 2 modified study models with deep and shallow palatal depths to reproduce the models. Based on the power analysis with a 0.8 power factor and 0.01 significance level, the sample size of each test group was 12 (N=96). Definitive casts were poured in Type IV gypsum (Elite Stone; Zhermack). The casts were allocated into 8 test groups according to 2 palatal depths and 4 fabrication techniques (Table 1).

Table 1. Summary of tested groups and product information of materials used

Palatal Vault Depth	Fabrication Technique	Product Information	n
Deep and Shallow	Injection	IvoBase Hybrid; Ivoclar Vivadent AG	12+12
Deep and Shallow	Compression molding	Integra Heat Cure Acrylic; Birlesik Grup Dental	12+12
Deep and Shallow	Pour	Futura Basic Cold; Schütz Dental GmbH	12+12
Deep and Shallow	Light-polymerization	Eclipse; Dentsply Sirona	12+12

Each definitive cast was allowed to dry completely for 24 hours and was scanned by using a laboratory scanner (InEos X5; Dentsply Sirona) to generate a standard tessellation language (STL) file. For fabrication of the bases, 2 layers of 1-mm modeling wax (Jewellery normal modeling wax; Cera Reus) were adapted on each cast,[4,13] and the thickness of the wax was verified by using a scored periodontal probe.[14] This procedure was repeated for all specimens except for the light-polymerization group, where a sheet of UDMA-containing baseplate (Eclipse Resin Materials-Upper Baseplate Resin; Dentsply Sirona) was manually adapted on the cast and polymerized immediately by using a visible light source unit (Eclipse Junior VLC curing unit; Dentsply Sirona). The intaglio surfaces of each completed acrylic resin base were coated with a thin layer of scanning preparation spray (CEREC Optispray; Dentsply, Sirona) by using a uniform dosage and particle size of 40 to 60 μm.[15] Then, the intaglio surfaces of the acrylic resin bases were digitized by using a laboratory scanner (InEos X5; Dentsply

Table 2. Results of three-factorial ANOVA

Source	SS	df	MS	F	P
Palatal vault depth	0.465	1	0.465	4.471	.035
Technique	68.544	3	22.848	219.491	<.001
Location	1.885	3	0.628	6.036	.001
Depth×technique	3.914	3	1.305	12.535	<.001
Depth×location	0.962	3	0.321	3.079	.028
Technique×location	19.602	9	2.178	20.923	<.001
Depth×technique×location	8.869	9	0.985	9.467	<.001
Error	36.850	354	0.104	–	–
Total	925.303	386	–	–	–

Table 3. Mean ±standard deviation (mm) for deep palatal vault

	Location			
Polymerization Technique	Denture Border Apex	Palate	Ridge Crest	Posterior Palatal Seal
Injection	0.87 ±0.16Ab	1 ±0.40Ab	0.81 ±0.16Ab	0.82 ±0.12Ab
Compression molding	0.96 ±0.34Ab	1.04 ±0.40Ab	1.6 ±0.22Bc	2.3 ±0.60Cc
Pour	0.98 ±0.22Ab	1.09 ±0.26ABb	1.48 ±0.32Bc	1.34 ±0.19ABa
Light-polymerization	2.5 ±0.20Aa	2.4 ±0.15Aa	2.62 ±0.26Aa	1.5 ±0.43Ba

Different uppercase letters in same row and different lowercase letters in same column show statistically significant difference ($P<.05$).

Sirona). The STL files of the casts and the intaglio surfaces of acrylic resin bases were transferred into a software program (Romexis, v5.0; Planmeca) to superimpose each cast and its corresponding denture base scan semi-automatically on to the reference pyramids. After superimposition, 4 specific regions of interest were defined as the denture border apex, palate, ridge crest, and posterior palatal seal. The measurements between the cast and the denture base were made at 500 points for each acrylic resin base by using an overlay guide to verify the location of the measurements. The mean gap distances (mm) were automatically calculated by using the software and recorded by an observer (K.O.) from the identified regions. The surface matching and measurements provided the basis for the evaluation of discrepancies along with the acrylic resin bases.

Statistical analysis was performed by 3-factor ANOVA. Two between-group variables (palatal vault depth and fabrication technique) and 1 within-group variable (measurement location) were used. As the triple interactions were significant ($P<.05$), post hoc comparisons among the subgroups were performed by using the Tukey HSD test.

RESULTS

The 3-factorial ANOVA showed that 2- and 3-way interactions among the palatal vault depth, polymerization technique, and location variables were statistically significant ($P<.05$) (Table 2). The results of post hoc analysis for deep palatal vault depth are shown in Table 3. Light-polymerization showed the highest mean gap distance among the tested polymerization techniques in all regions except for the posterior palatal seal area ($P<.05$). At the denture border apex and palate, the gap distances obtained for injection, compression molding, and pour techniques were not statistically different from each other ($P>.05$). In the ridge crest area, the mean gap distance of injection was significantly lower than that of the other polymerization techniques ($P<.05$). At the posterior palatal seal region, compression molding showed the highest mean interface gap distance, while the injection technique showed the lowest mean value among the tested polymerization techniques ($P<.05$).

Upon evaluating each polymerization technique with respect to the location of the deep palatal vault (Table 3), injection had approximate mean values at all tested locations for the deep palatal vault ($P>.05$). The light-polymerization technique showed its lowest gap distance at the posterior palatal seal ($P<.05$). The compression molding technique demonstrated its highest mean gap distance at the posterior palatal seal region ($P<.05$). The pour technique showed the lowest mean value at the denture border apex and the highest mean value at the ridge crest ($P<.05$).

Multiple comparisons among the polymerization techniques in each location for shallow palatal vault depth are shown in Table 4. At the denture border apex, light-polymerization showed the highest mean gap distance compared with the other tested techniques ($P<.05$), while the rest of the techniques showed comparable mean values ($P>.05$), similar to the results of the deep palatal vault group. At the palatal region, the highest mean gap distance was obtained for light-polymerization, while the lowest value was observed for injection ($P<.05$). At the ridge crest, the injection and pour techniques showed similar gap distances. At the posterior palatal seal region, the mean gap distance for injection was significantly lower than that for the other techniques ($P<.05$).

In the evaluation of each polymerization technique according to the location for shallow palatal vault depth (Table 4), the injection and pour polymerization techniques demonstrated similar mean gap distances irrespective of location ($P>.05$). In the compression molding technique, a statistically significant difference was found only between the denture border apex and ridge crest ($P<.05$). The light-polymerization technique showed higher gap distances at the denture border apex and palatal regions than at the other 2 locations ($P<.05$).

When evaluating the gap distances between deep and shallow palatal vault depths, the injection and pour techniques showed no significant differences at any of the locations ($P>.05$). Nevertheless, higher mean values were observed for the casts with deep palatal vault depth than for those with shallow palatal depth at the ridge crest for the light-polymerization technique and at the posterior palatal seal region for the compression molding ($P<.05$).

Table 4. Mean ±standard deviation (mm) for shallow palatal vault

	Location			
Polymerization Technique	Denture Border Apex	Palate	Ridge Crest	Posterior Palatal Seal
Injection	0.90 ±0.09Ab	0.79 ±0.12Ab	1.08 ±0.29Ab	0.79 ±0.16Ab
Compression molding	1.18 ±0.38Ab	1.43 ±0.29ABc	1.70 ±0.20Bac	1.56 ±0.26ABa
Pour	1.13 ±0.38Ab	1.48 ±0.30Ac	1.31 ±0.36Abc	1.46 ±0.53Aa
Light-polymerization	2.18 ±0.48Aa	1.97 ±0.34Aa	1.64 ±0.54Bac	1.61 ±0.46Ba

Different uppercase letters in same row and different lowercase letters in same column show statistically significant difference ($P<.05$).

DISCUSSION

The retention of a complete denture has been correlated with the adaptation of the denture base to the supporting tissues and depends on physical factors including adhesion, cohesion, saliva film thickness, surface tension, and atmospheric pressure.[16,17]A stable and accurate fit of the denture base to the supporting tissues will maximize the retention of the denture.[14,17,18] According to the results of the present study, denture adaptation was significantly different, with different fabrication techniques and types of palatal vault depth. Therefore, both null hypotheses were rejected.

The adaptation of denture base has been evaluated with 2D measuring methods, including a visual measuring system with an optical scanner and a software program,[8] a traveling microscope (precision, 0.001 mm),[19] a unitron measuring microscope (precision, 0.005 mm),[14] and computerized tomography including a stereomicroscope and software program.[9] Three-dimensional measurements have included a scanner and surface-matching software program.[3-5] For the complex 3D shape of a denture base, 2D linear measurements between points may be inadequate to evaluate the effect of processing deformation. Surface matching and best-fit algorithms adapt the denture base and the model as closely as possible and allowed digital 3D measurements to be recorded. In the present study, a 3D measuring technique was used, and the scanned data were superimposed by using a software program as in previous studies.[3-5] Goodacre et al[3] reported that CAD-CAM showed the best performance, injection and pour showed similar results, and compression molding showed the least uniform adaptation. Consistent with the study by Goodacre et al,[3] the results of the present study for the shallow palatal form, pour and injection techniques showed more uniform adaptation to the cast for all measuring locations than other tested techniques. However, for the deep palatal form, the injection technique had the most uniform distribution of base adaptation.

The palatal depth of the denture base can affect distortion and palatal adaptation.[3] Sykora and Sutow[19] reported that shallow palates displayed more distortion and significantly greater gap distances along the posterior border than steep palates. Laughlin et al[14] also reported that shallow palates had significantly higher mean gap distances at the vestibule and lateral palate locations than a steep palate. Those previous studies[14,19] differed from the present study in terms of methodology and measurement techniques, and the present study found that the deep palatal form caused greater mean gap distance for the compression molding technique in the posterior palatal seal area. Therefore, the palatal vault depth appears to be a critical factor in determining the appropriate processing technique for complete dentures.

The shrinkage of the denture base resin that occurs during the polymerization process may affect dimensional stability,[17] although defining the threshold at which distortion measurement becomes clinically significant is not possible.[3] The retention, stability, and, support of the dentures have been reported to be reduced by the distortion of dentures that occurs during processing.[19,20] Denture processing techniques have been developed to decrease these distortions while enhancing productivity of the dental laboratory. Previous studies[2,21,22] evaluated the flexural strength of denture base materials, and Eclipse showed the highest mean flexural strength values, which may be a useful alternative to conventional denture base resins. Those studies differed from the present study in the test method and materials evaluated. The manufacturer claimed that light-polymerized UDMA-based resin have better dimensional accuracy than PMMA-based heat-polymerized resins. Consistent with the study by Artopoulos et al,[4] the results of the present study found that light-polymerization had the highest gap distances between the denture base and the cast for most of the tested locations. Laughlin et al[14] investigated the effects of a resin anchoring system and the palatal depth on the denture base adaptation after polymerization, reporting that the anchoring system significantly decreased the mean gap distance at the vestibule, lateral palate, and mid-palate locations. The lateral palate and mid-palate locations play an important role in providing a peripheral seal.[14] Sekar et al[8] also compared the palatal adaptation between shallow and deep vaults with different fabrication techniques. For the posterior palatal seal area, they reported that the mean palatal adaptation for both shallow and deep palates was significantly different among the tested groups. The results of the present study are consistent with those of these previous studies in that significant differences were observed for the ridge crest and the posterior palatal seal locations; however, previous studies[8,14] differ from the present study in the materials used and data collection methods, and the results should be interpreted accordingly.

To simulate clinical conditions in previous studies,[3,19] dentures have been immersed in water for different times

before gap measurements. A limitation of the present study was that the dentures were not immersed in water before making the measurements. Future in vitro and in vivo studies are needed to determine additional anatomic variations of the palate.

CONCLUSIONS

Based on the findings of this in vitro study, the following conclusions were drawn:

1. The pour technique showed similar denture base adaptation performance to the compression molding and injection techniques.
2. The light-polymerization technique demonstrated the highest mean gap distance between the cast and denture base for both palatal vault depths at most of the locations.
3. For deep palatal vault depth, the fabrication techniques showed similar denture adaptation performance for the denture border apex and palate, while differences were observed for the ridge crest and posterior palatal seal locations.
4. A deep palatal vault depth was associated with reduced denture adaptation for only the light-polymerization technique at the ridge crest and the compression molding technique at the posterior palatal seal location.

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