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Research Article

Comparison of the Internal Adaptation of Restorations Manufactured with Different Materials and Techniques

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Comparison of the Internal Adaptation of Restorations Manufactured with Different Materials and Techniques

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Abstract

Purpose: This study aimed to evaluate and compare the internal adaptation of restorations produced with different materials and techniques.

Material and Method: In the study, tooth 36 was prepared on a dental training model (Kavo Basic study model, KavoGMBH, Germany) by an experienced prosthodontist. Using computer-aided manufacturing methods, 10 feldspathic ceramic crowns (Cerec Blocs, Sirona, Bensheim, Germany), monolithic zirconia crowns (Ceramill ZI CAM, Amann Girrbach, Germany), zirconia frameworks (Aidite, Superfect Zir, USA), metal frameworks (Bego, Germany) by laser sintering, and metal frameworks (using conventional methods) were fabricated. The metal and zirconia frameworks were completed with superstructure ceramics (VITA, Germany) by an experienced technician. The restorations were placed on the prepared teeth, and a silicone replica of the cement gap was obtained using the replica technique with additive-type silicone impression material (Heraeus Kulzer, Germany). Sections obtained from replicas were measured at 10 points using a light microscope. Statistical analysis of the data was performed using SPSS (ver. 21.0; SPSS, Inc., Chicago, IL, USA). ANOVA and post hoc Tukey HSD tests were applied to the obtained data.

Results: A statistically significant difference was observed only between axio-occlusal measurement points ($p<0.05$).

Conclusion: The internal range values were measured at a clinically acceptable range value of less than 200 micrometers. The highest internal range values were observed in the occlusal region and the lowest values in the axio-gingival region. The mean value of the highest internal range was measured at the occlusal measurement point in the monolithic zirconium group. The lowest mean value of internal range was measured at the axio-gingival measurement point in the zirconia-supported ceramic group.

Keywords: CAD/CAM, Dentures, Internal Adaptation, Selective Laser Sintering.

Özet

Amaç: Bu araştırmanın amacı farklı materyal ve teknikler ile üretilen restorasyonların internal uyumlarının değerlendirilmesi ve karşılaştırılmasıdır.

Gereç ve Yöntem: Çalışmada diş hekimliği eğitim modeli (Kavo Basic study model, KavoGMBH, Germany) üzerinde 36 numaralı diş, deneyimli bir protetik diş tedavisi uzmanı tarafından prepare edildi. Bilgisayar destekli üretim yöntemleri kullanılarak her biri 10 adet, feldspatik seramik kron (Cerec Blocs, Sirona, Bensheim, Almanya), monolitik zirkonya kron (Ceramill ZI CAM, Amann Girrbach, Almanya), zirkonya altyapı (Aidite, Superfect Zir, Amerika), lazer sinterizasyon yöntemi ile metal altyapı (Bego, Almanya) ve konvansiyonel yöntemle metal altyapılar elde edildi. Metal ve zirkonya altyapılar deneyimli bir teknisyen tarafından üstyapı seramiği (VITA, Almanya) ile tamamlandı. Restorasyonlar, prepare edilmiş diş üzerine yerleştirilip ilave tipi silikon ölçü maddesi ile (Heraeus Kulzer, Almanya) replika tekniği kullanılarak siman aralığının silikon replikası elde edildi. Replikalardan elde edilen kesitler ışık mikroskobu yardımıyla 10 noktadan internal aralık ölçüldü. Verilerin istatistiksel analizi SPSS (ver.21.0; SPSS, Inc., Chicago, IL, ABD) programı kullanılarak yapıldı. Elde edilen verilere ANOVA ve post Hoc Tukey HSD testleri uygulandı.

Bulgular: Sadece aksiyo-oklüzal ölçüm noktaları arasında istatistiksel anlamlı fark olduğu görüldü. ($p<0.05$).

Sonuç: Örneklerin internal aralık değerleri 200 mikrometreden az olduğu belirlenmiştir. İnternal aralık değerlerinin klinik olarak kabul edilebilir olduğu görülmüştür. Konvansiyonel ve bilgisayar destekli yöntem ile üretilen bütün restorasyonların internal aralık değerleri; en yüksek okluzal, en düşük aksiyo-gingival bölgede gözlenmiştir. En yüksek internal aralık ortalama değeri, monolitik zirkonyum grubunda okluzal ölçüm noktasından; en düşük internal aralık ortalama değeri ise zirkonya destekli seramik grubunda aksiyo-gingival ölçüm noktasından elde edilmiştir.

Anahtar Kelimeler: CAD/CAM, Dental Restorasyonlar, İnternal Uyum, Selektif Laser Sinterleme.

Introduction

The main purpose of prosthetic dentistry is to restore anomalies or losses in the mouth and to eliminate functional disorders caused by these deficiencies. Regardless of the type of restoration, marginal and internal fits are important parameters for long-term success. The wide marginal space causes rapid dissolution of the cement and microleakage. This situation will disrupt the harmony of the restoration and shorten the duration of the restoration in the mouth.

In the process of producing a restoration, it goes through many stages. Different material types and production methods cause differences in restorations. For this reason, researchers are looking for ideal materials and techniques.

Marginal and internal adaptation directly affect the duration of clinical use of restorations (1). The marginal cement film thickness value, which has long been discussed in the literature, is considered to be 120µm for full crowns. Ranges greater than this value increase the risk of exposure of the abutment tooth to oral fluids and make the abutment tooth vulnerable to chemo-mechanical factors (2). Internally, it has been determined in studies that the cement material, which is prepared as a thick layer on the inner surface of the restoration, increases residual stresses and causes fracture formation (3). The production processes are classified under two main headings as traditional and digital measurement methods. Both of these methods have advantages and disadvantages in themselves (4). The CAD/CAM (Computer Aided Design / Computer Aided Manufacturing) system, which is a current method to produce the restorations, is gaining more and more popularity in clinical practice (5).

At the beginning of the advantages of the system is the direct digital impression technique. Some studies show that intraoral scanners used in the direct digital technique are effective to producing more compatible restorations. (6). With this system, the clinician can simultaneously evaluate the procedure applied to the relevant tooth, examine its relationship with the opposite arc, apply the necessary corrections in the same session by taking advantage of technical advantages such as magnification and reduction, and there is no need for 'size renewal' as in the conventional measurement method for all these procedures (7).

In this context, the study aims to evaluate the difference between the internal compatibility of restorations produced using conventional and computer-aided manufacturing methods and to observe the difference between the internal harmony of restorations manufactured using various restorative materials.

The null hypothesis of the study is that the internal adaptations of restorations manufactured using conventional versus computer-aided manufacturing techniques will not differ. The second null hypothesis of this study is that there will be no difference in the internal compatibility of restorations made from different materials.

Materials and Methods

Table 1. Group name, type of material, and sample numbers

Group Name	**Material Type**	**Brand Name and Manufacturer**	**Sample Numbers**
Group 1	Feldspathic ceramic blocks	Cerec Blocs, Sirona, Bensheim, Germany	10
Group 2	Zirconia Supported Ceramic	Superfect Zir, Aidite, USA	10
Group 3	Monolithic zirconia	Ceramill ZI CAM, Amann Girbach, Germany	10
Group 4	Metal-supported ceramic produced by the method of Selective Laser Sintering	Bego, Germany	10
Group 5	Metal-supported ceramic produced by the lost wax casting method	VITA, Germany	10

Table 2. Impression materials and instruments utilised for research

Material	**Product Name(Manufacturer)**
Impression material	Variotime Easy Putty Base-Catalyst (Heraeus Kulzer, Germany)
Impression material (silicone replica)	Variotime Easy Putty Base-Catalyst (Heraeus Kulzer, Germany)
Impression material (silicone replica)	(Variotime Light Flow Refil, Heraeus Kulzer, Germany)
Light microscope	Nikon(Eclipse 920248,USA)
Camera	Nikon(DS-Fi2-U3,USA)
CAD/CAM milling device	IMES-ICORE Coritec 550i CAD/CAM milling machine
3D Scanner	Identica T300
Design Program	Exocad(Darmstadt, Germany)

Tooth Preparation

The research employed a mandibular first molar tooth model. The tooth was placed within a phantom study model (Kavo Basic study model, Kavo GMBH, Germany). This model is designed to replicate a mandible and includes gum tissue. The teeth that remain in the phantom jaw are composed of a thermoset material that possesses rigidity, rendering it suitable for both analogue and digital impressions.

An experienced prosthodontist prepared tooth number 36 for a single crown restoration using a modified shoulder step technique. In addition, the axial walls will prepared at an angle of 6 degrees using a milling machine (Paraskop M - precision milling device, Bego, Germany) with a step width of 1 millimetre. On the surface of the prepared phantom tooth, sharp edges, corners, and rough surfaces were removed using finishing and polishing rubber. The primary model to be created had a smooth surface structure, and any potential stresses were minimised. The silicone matrix obtained before the preparation was used as a guide to control the depth of the preparation.

Impression, Design, and Restoration Production

An extra-oral scanner (Identica T300 model and impression scanner) was used to take the digital impression. A digital impression was taken of the study model, and the data were transmitted to the CAD/CAM system. The resin model was printed with a 3D printer (w2p onex Dental) to be used as a definitive model in the internal fit measurement.

Figure 1. During the scan of the prepared tooth

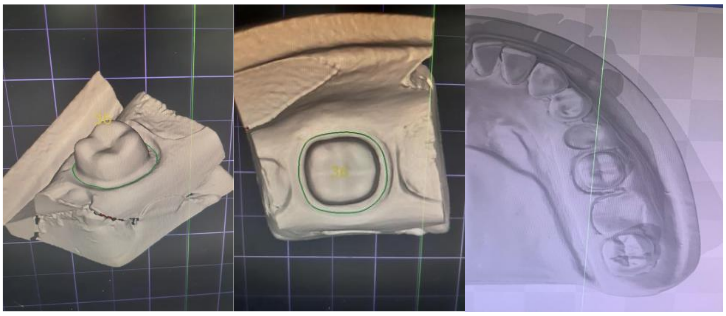

Figure 2. Images of the scanned tooth

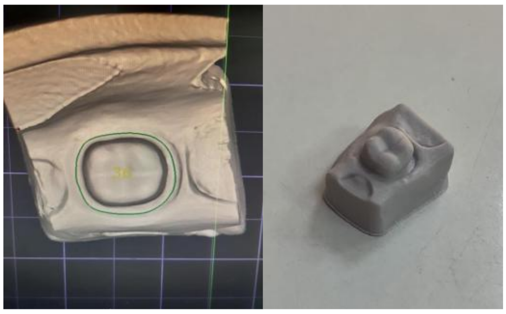

Figure 3. The primary model's digital image and printed resin model

The design process was conducted for each group using the Exocad (Darmstadt, Germany) design software. The cement film thickness was designed to be 40 microns, and the material thicknesses were designed according to the manufacturer's specifications. The same restoration design file was used to produce crown restorations from feldspathic ceramic blocks (Cerec Blocs, Sirona, Bensheim, Germany) for group 1 and monolithic zirconia material (Ceramill ZI

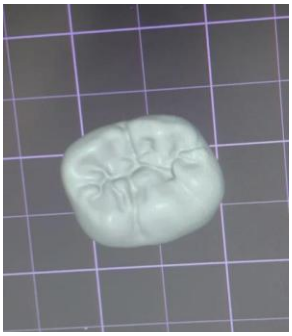

Figure 4. Digitally designed crown restoration

CAM, Amann Girbach, Germany) for group 3. Using the same infrastructure design file, group 2 zirconia (Superfect Zir, Aidite, USA) and group 4 metal (Bego, Germany) infrastructures were produced. Groups 1, 2, and 3 were produced using the subtractive method (IMES-ICORE Coritec 550i), group 4 was produced using the selective laser sintering method, and group 5 was produced using the conventional fabrication method with the assistance of an experienced technician. All infrastructures were completed with porcelain superstructures with the assistance of an experienced technician.

Internal range measurement

After the production of the restorations, the marginal and internal alignment was evaluated using the silicone replica technique. Numerous studies recommend the silicone replica technique because it is simple to perform, cost-effective, quick, and reliable (8, 9). As described by Molin and Karlsson (10, 11), this technique was utilised to evaluate the internal and marginal fit of restorations.

In the silicone replica technique, both fluid and viscous forms of type A silicone (Variotime Easy Putty, Heraeus Kulzer, Germany) were used to fill the space between the restoration and the preparation surface in order to simulate cement.

To ensure standardization, the fluid silicone measuring device was applied to the inner surface of the restoration using a silicone mixing gun (Variotime Light Flow Refil, Heraeus Kulzer, Germany). The flowable silicone used in the restoration was deposited on the resin model with finger pressure to simulate the clinical cement and cementation procedure and allowed to polymerize for two and a half minutes per the manufacturer's instructions.

Figure 5: Prepared model to obtain a silicone replica on the prepared tooth model

Following completion of polymerization, the restorations were removed from the resin model so that the silicone replica remained on the inner surface. To support the silicone replica and stabilise the duplicated interface, the silicone-containing restorations were filled with a dense silicone material (Variotime Easy Putty, Heraeus Kulzer, Germany) of a different colour.

After polymerization was complete, the restorations were removed from the resin model, leaving the silicone replicas on the inner surface. The silicone-containing restorations were filled with a dense silicone material (Variotime Easy Putty, Heraeus Kulzer, Germany) of a different colour to support the silicone replica and stabilise the dubliqued interface.

After the polymerization of the dense silicone material (Variotime Easy Putty, Heraeus Kulzer, Germany) was complete, the silicone was separated in one piece from the interior surface of the restoration. The replicas for each experimental group were obtained by individually placing the produced crowns on the resin model.

First, the silicone materials were divided into two equal halves in the mesiodistal direction using a sharp scalpel (blade number 11, Braun 78532, Tuebingen, Germany).

The mesial portion was then photographed using a stereomicroscope (Nikon, Eclipse 920248, USA) and divided into buccal and lingual portions in the mesiodistal orientation. Thanks to the initial incision, the silicone replica was divided into two equal sections in the frontal plane, allowing for the measurement of the buccal and lingual regions. Descriptive markers were placed on each incision so that localizations could not be confused.

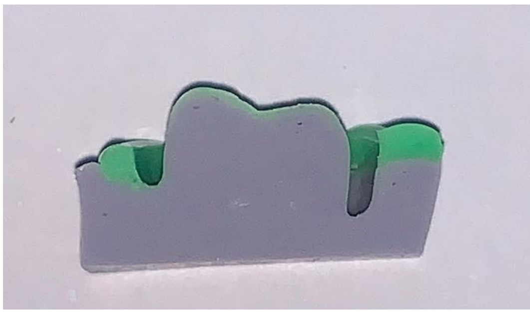

Figure 6: Silicone replica divided into two equal parts with the help of a scalpel in the mesio-distal direction

Under a light microscope (Nikon, Eclipse 920248, USA) with 1x magnification, the acquired replicas were digitised and compared by calculating the distance between the tooth and the crown. As shown in Figure 1, 10 specific points were determined in order to perform calculations. Internal range measurement points, marginal measurement points (from zone 1, 10), intermarginal measurement points (from zone 2, 9), axiogingival measurement points (from zone 3, 8), axio-occlusal measurement points (from zone 4.7), and occlusal measurement points (from region 5, 6) were established.

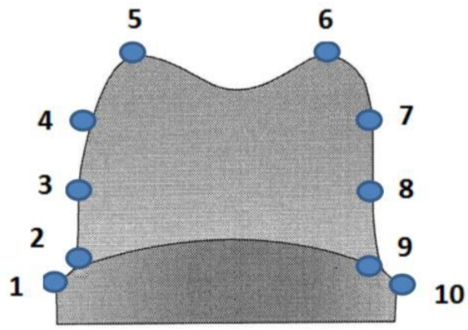

Figure 7. Internal range measuring points: marginal measuring points (1, 10), intermarginal measuring points (2, 9), axiogingival measuring points (3, 8), axio-occlusal measuring points (4.7), occlusal measuring points (5, 6)

Under 1x magnification, the marginal and internal ranges were investigated and photographed with a camera (Nikon, DS-Fi-U3, USA).

After completing the microscopy photography session, the obtained images were transferred to the computer environment using completely compatible software. On a computer, the internal and marginal range values are defined using ImageJ (ImageJ and NIH Image software; National Institutes of Health, Bethesda, Maryland), and the results were saved in an Excel file. For each silicon sample, measurements were taken from a total of 10 different locations. Internal and marginal range measurements were performed on samples from each of the five study groups, yielding a total of 500 numerical values. Transferring the collected data to the SPSS 24.0 programme, statistical analyses were conducted. Due to the homogeneous distribution of data, statistical analyses were conducted with ANOVA and Tukey HSD tests.

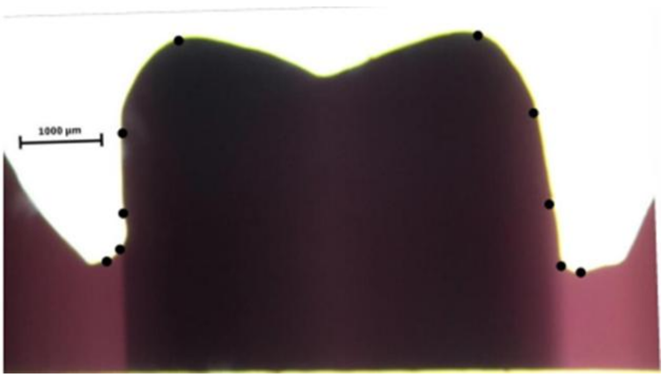

Figure 8: 1x magnified silicone replica under light microscope

Results

Sectioned silicone replicas of each crown were examined under a 1x magnification light microscope, and length measurements were taken at the marked points.

Internal range measuring points:

- Marginal measuring points (1, 10)
- Intermarginal measuring points (2, 9)
- Axiogingival measuring points (3, 8)
- Axiooclusal measuring points (4,7)
- Occlusal measuring points (5, 6)

Table 3. Table of internal range measurement values

Group Name		**Marginal Measuring Points(1)**	**(10)**	**Intermarginal Measuring Points(2)**	**(9)**	**Axiogingival Measuring Points(3)**	**(8)**	**Axioocclusal Measurement Points(4)**	**(7)**	**Occlusal Measuring Points(5)**	**(6)**
Group 1	Avg.	32,31	33,02	33,05	34,61	30,32	31,02	35,47	39,10	38,45	36,72
	Standard deviation	9,81	10,79	13,03	13,36	12,89	8,76	8,93	7,98	9,14	13,08
Group 2	Avg.	33,53	34,11	34,32	34,11	28,92	32,64	32,04	34,14	34,79	34,42
	Standard deviation	5,30	4,37	5,02	5,89	4,48	1,99	3,70	2,74	5,47	3,01
Group 3	Avg.	34,53	30,35	35,66	32,01	34,39	29,56	30,45	32,03	37,21	39,07
	Standard deviation	4,10	4,41	4,90	4,64	6,15	5,12	6,09	3,38	5,59	7,00
Group 4	Avg.	32,48	32,58	37,83	35,66	29,39	33,23	29,41	33,00	35,37	35,67
	Standard deviation	1,62	2,00	2,35	2,30	4,24	2,58	3,68	2,21	2,91	5,17
Group 5	Avg.	33,79	33,87	36,38	35,78	29,77	32,54	33,20	32,82	38,17	36,35
	Standard deviation	2,84	3,47	2,68	1,55	3,73	2,33	3,74	4,74	2,90	3,88

Upon examination of the groups, it was observed that the measurement point 6 (occlusal measurement point) in group 3 (monolithic zirconium group) showed the highest mean value for internal range. The group 2 (zirconia-supported ceramic group) showed the lowest mean value for the internal range at the measurement point 3 (axiogingival measurement point).

Upon comparing the measurement points across the groups, it was found that a statistically significant difference was observed only at measurement point 7 (axio-occlusal measurement point).

Table 4. Table of internal range measurement values

Case Summaries

Groups		I	X	II	IX	III	VIII	IV	VII	V	VI
1,00	Maximum	37,73	36,45	42,09	46,02	40,02	34,05	39,31	41,81	41,29	46,88
	Minimum	26,86	28,56	24,91	27,75	23,98	28,37	31,82	35,53	34,92	31,76
	Mean	32,316	32,290	33,050	34,612	30,328	31,020	35,474	39,108	38,658	36,72
	Std. Deviation	4,229	3,039	8,242	7,104	6,083	2,059	3,239	2,447	2,570	5,865
	Median	32,44	32,51	30,99	32,88	28,30	30,72	34,56	40,02	39,32	35,28
2,00	Maximum	41,43	40,69	37,06	40,02	32,78	34,47	36,98	35,48	40,85	38,30
	Minimum	29,56	32,71	36,26	29,17	24,73	30,93	30,05	29,57	31,83	33,15
	Mean	34,81	35,46	36,57	35,85	30,31	33,31	33,16	33,47	36,30	35,49
	Std. Deviation	4,456	3,165	0,314	4,451	3,255	1,383	2,755	2,296	4,366	1,837
	Median	34,82	35,24	36,60	35,90	31,39	33,81	33,20	34,27	36,45	35,37
3,00	Maximum	35,98	35,18	37,48	36,56	40,22	34,33	39,41	35,70	38,66	42,97
	Minimum	33,24	25,82	33,40	24,92	26,65	22,02	25,85	28,12	36,23	34,17
	Mean	34,53	30,35	35,66	32,01	34,39	29,56	30,45	32,03	37,21	39,07
	Std. Deviation	1,365	4,419	1,683	4,645	6,153	5,129	6,096	3,381	0,953	3,148
	Median	34,28	28,82	36,14	32,50	35,71	29,28	26,78	33,29	36,98	39,48
4,00	Maximum	34,05	35,41	41,03	36,38	35,05	35,80	30,29	35,61	38,92	42,46
	Minimum	30,37	30,74	34,80	35,03	25,43	30,21	27,78	29,92	32,95	28,81
	Mean	32,48	32,58	37,83	35,66	29,39	33,23	29,41	33,00	35,37	35,67
	Std. Deviation	1,622	2,005	2,358	0,633	4,242	2,585	1,003	2,218	2,919	5,176
	Median	33,41	31,50	37,35	35,43	28,71	34,20	29,43	32,55	33,65	36,95
5,00	Maximum	37,38	37,17	40,29	37,20	34,54	33,20	37,13	34,22	39,25	37,85
	Minimum	30,45	29,63	34,07	33,71	25,50	31,89	27,71	31,62	37,03	34,47
	Mean	33,79	33,87	36,38	35,78	29,77	32,54	33,20	32,82	38,17	36,35
	Std. Deviation	2,846	3,475	2,686	1,558	3,731	,4913	3,748	0,958	0,853	1,219
	Median	34,02	35,61	34,95	36,57	28,96	32,51	34,11	32,94	38,43	36,59

Table 5. Analysis of variance for measurement points

Measurement Point	Sig.
I	,629
X	,202
II	,460
IX	,601
III	,498
VIII	,200
IV	,122
VII	,001
V	,320
VI	,614

Table 6: Tukey HSD test data of the groups

Multiple Comparisons			
Tukey HSD			
Dependent Variable			Sig.
VII	1,00	2,00	,010
		3,00	,001
		4,00	,005
		5,00	,004
	2,00	1,00	,010
		3,00	,874
		4,00	,998
		5,00	,992
	3,00	1,00	,001
		2,00	,874
		4,00	,967
		5,00	,984
	4,00	1,00	,005
		2,00	,998
		3,00	,967
		5,00	1,000
	5,00	1,00	,004
		2,00	,992
		3,00	,984
		4,00	1,000
*. The mean difference is significant at the 0.05 level.			

A significant difference is observed for all groups only at the 7th measurement point.

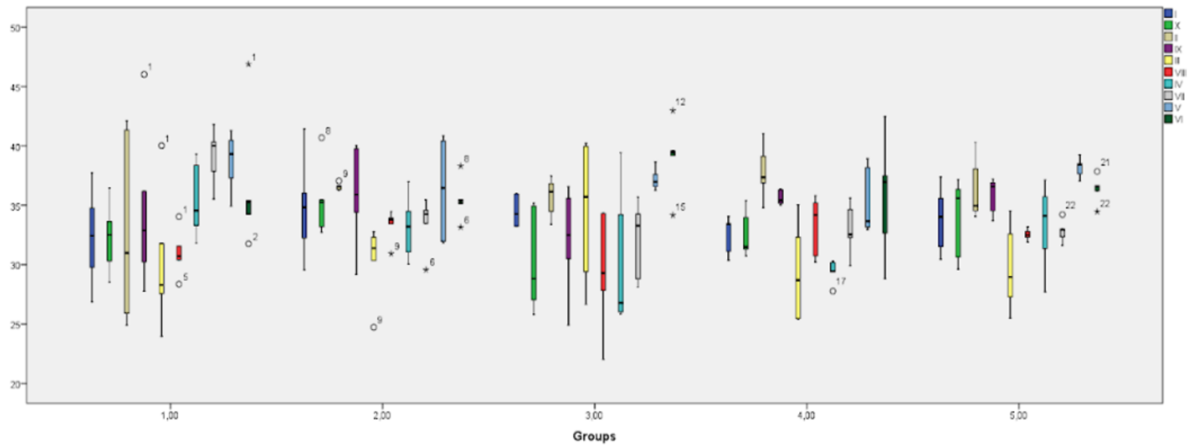

Figure 9. Graph of Internal Range Measurement Values of Research Groups

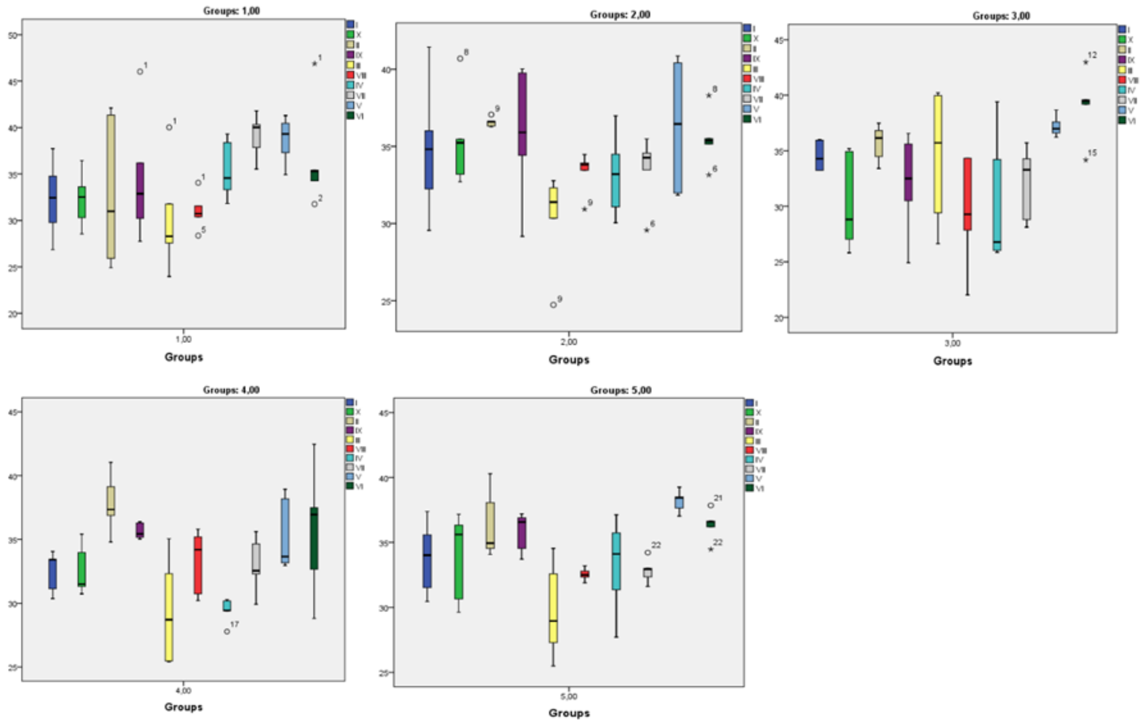

Figure 10. Graph of internal gap measurement values for research groups

When performing a regional comparison of internal range values, it was observed that the occlusal region (specifically, measurement point 6) had the greatest average internal range values across all groups. The computed values for Group 1, Group 2, Group 3, Group 4, and Group 5 were 36.7200 µm, 35.4940 µm, 39.0760 µm, 35.6740 µm, and 36.3520 µm, respectively.

The axiogingival region (measurement point number 3) has the lowest average values of internal range. Specifically, Group 1 has an average of 30,3280 µm, Group 2 has an average of 30.3120 μm, Group 3 has an average of 34.3900 μm, Group 4 has an average of 29.3960 μm, and Group 5 has an average of 29.7740 μm.

Discussion

Modern dentistry makes extensive use of dental ceramics in order to satisfy the aesthetic and functional expectations of patients. However, the development of computer-aided manufacturing technologies and the search for alternative materials have ushered dentistry into a new era. With the advent of digital systems, a variety of materials began to be used, providing an alternative to conventional porcelain restorations. Due to the advancement of technology, impression systems have made progress, and digital impression and production systems have gained popularity.

However, studies are continuing to investigate the advantages and disadvantages of these innovations. In this context, the effects of crowns obtained from different materials using digital and traditional manufacturing methods on internal compatibility were investigated.

The final outcome of a restoration is inevitably influenced by variations in production methods arising from different workflows. The emergence of varying outcomes among distinct groups is believed to be influenced by the structural characteristics of the materials utilised in crown manufacture. The impact of this on the internal adaptation metrics, which are the focus of this investigation, is documented in the existing literature and is acknowledged as a limitation of the study (12, 13).

Nakamura et al., in their research examining the effect of the preparation angle of the fully ceramic crowns produced with the Cerec 3 CAD-CAM system on the marginal fit, stated that the marginal gap between the crowns produced on the main model with a preparation angle of 4 degrees was statistically significantly less than the other two groups (preparation angle 8 and 12 degrees), and that there was no statistically significant difference between the teeth with a preparation angle of 8 and 12 degrees in terms of marginal gap (14).

According to Shillingburg et al. suggested that an appropriate preparation angle ranging from 2 to 6 degrees can provide favourable outcomes in terms of restorative retention and resistance. The results derived from these studies have been acknowledged as fundamental concepts in the field of tooth preparation (15). In this study, the preparation angle of the master resin model was conducted in accordance with the studies mentioned above. To achieve this, a 6-degree preparation angle was created using a precision milling device and a diamond bur with an angle of 6 degrees.

In the studies that were performed on marginal compliance, different sample numbers were preferred. Beschnidt and Strub (16) used 10 samples for each group, while May et al. (17) used 5 samples for each group, and Schaerer et al. (18) used 6 samples for each group. In this study, 10 samples were used for each group.

Luthart et al. (19) in 2005, in their study, compared the accuracy of replicating a model situation using intraoral digitization versus the conventional method of impression taking, model production, and extraoral digitization. This study recommended that extraoral digitization with impression taking and model production was more accurate than intraoral digitization, and since the inaccuracies of the conventional impression under real clinical conditions may be greater than the values determined above, a clinical comparison should be performed in the future. In their study comparing digital and conventional impression methods, Ender and Mehl (20,46) also found that the conventional impression method is more sensitive and reliable than the digital impression method. According to current literature, a deviation of around 10 μm occurs during conventional measurement and obtaining the plaster model, and this value is thought to be negligible in a clear restoration process (21).

In other studies where the intraoral scanner is used, it is emphasized that the direct digital technique has more advantageous qualities in terms of precision and trueness (22). A systematic review by Abduo et al. found that the results obtained in different studies using the same systems in the literature have significant variations (23,47). This requires method homogenization in order to make an objective evaluation and reduce standard deviation. Based on this information, an extraoral scanner was used in the research.

Laurent et al. compared the marginal and internal range values obtained by the replication method they applied using silicone impression material with the values obtained after cementation with zinc phosphate cement. As a result, there was no difference between cervical, axial, occlusal, and marginal range values measured by zinc phosphate cement and silicone, and they reported that the silicone replica method is a successful method among internal range measurement methods (24). Kahramanoğlu and Özkan applied the replica technique by using light-bodied silicone impression material in their studies (25).Reich et. Al., filled the samples with a light-bodied silicone and affixed them to the abutment tooth. After the silicone material was polymerized, it was stabilized by injecting a heavy-bodied silicone impression material (26). In their study evaluating the internal compatibility of all-ceramic and metal-ceramic systems, Martins and colleagues mimicked cement thickness by using a silicone impression material with a light-bodied silicone impression material (27). Renne et al.; they maintained the restorations filled with heavy-bodied silicone impression material on the support tooth with finger pressure until the material polymerized (28). Studies have demonstrated that measuring cement thickness with light-bodied silicone impression material is an accurate technique. In addition, because the samples are not cut and can be stored, reproducible measurements are possible (29).

For this purpose, in the study, the 'silicone replica technique', which is the most widely used method in the literature to evaluate the compatibility between tooth and restoration, was preferred (30).

To mimic the cementation procedure, the light-bodied silicone impression material was applied to the inner surface of the restoration and placed on the tooth surface with finger pressure. Weaver et al. stated that although a standardized pressure cannot be applied with finger pressure, this does not produce a significant change in the thickness of the silicone material (31).

The material used in marginal and internal adaptation studies, where the replica technique is applied, also affects the result to a significant extent. In this study, the inner surface of the restorations was filled with light-bodied silicone impression material in vitro and placed on the teeth with finger pressure. After the light-bodied silicone impression material polymerized, a heavy-bodied silicone impression material was injected to stabilize it and prevent its deterioration.

Other factors affecting the results of the study are the sample size, type of tooth, and localizations measured. In studies where marginal fit assessment was carried out, there was no consensus on how many points should be measured (32, 33).

In addition, there is no consensus on how many micrometres the cement spacing will be during the design of CAD/CAM restorations. Numerous authors (34-36) have determined in their investigations (37) that the cement range is 30 m. In their study comparing the marginal and internal harmony of all-ceramic restorations with cement spacing of 10 μm, 30 μm, and 50 μm produced by CEREC 3, they found that the group with cement spacing of 30 μm had the finest edge fit (38).

In marginal fit assessment, there is no established standard for the number of measurement points (39-41). In our investigation, ten distinct points were measured on the silicone replica sections obtained, and the results were statistically analysed.

Various types of microscopes are frequently used in marginal and internal adaptation assessment because they provide a precise and accurate evaluation at specified measurement points (42). Some researchers preferred the digital microscope (43-46) while others preferred the stereomicroscope (44,48-51). Some researchers have preferred light microscopes (52-54). In the study conducted by Groten et al. (55), the reliability of the light microscope was evaluated. And they stated that the data obtained by the light microscope method were reliable. In accordance with the conducted research, light microscopy was selected for accurate examination of the study data.

One notable limitation of the study is that no measurements were made regarding the effect of the intraoral environment. This limitation stems from the fact that the study was conducted in vitro; therefore, potential differences between intraoral temperature (32°C) and room temperature, which significantly impact the accuracy of standard impression techniques, were ignored.

For all groups, the highest internal range measurement was calculated from the occlusal measurement point, and the lowest internal range measurements were calculated from the occlusal and axial measurement points. According to research, the occlusal surface seems to be affected by factors that can be interpreted differently regarding the accuracy of the optical images obtained (56-58). Kokubo et al. reported that the scanner sensitivity of the CAD/CAM system affected the internal harmony of the final restoration. They reported that the internal spaces of the crowns produced by the CAD/CAM system were largest in the occlusal region and smallest in the proximal and marginal regions (57).

Ueda et al. evaluated the marginal gaps of zirconia fixed partial dentures produced using the conventional impression method after using the digital impression method (59). They stated that there was no significant difference between the crowns produced with the conventional impression technique (mean, 141 μm) and the digital impression technique (mean, 121 μm). Silva et al. investigated the internal harmony of zirconia substructures and stated that there was no statistically significant difference between the conventional impression technique and digital impression techniques (60).

In their study, Syrek et al. performed a comparison of impression techniques, reporting that the digital impression technique exhibited a notably superior internal fit in comparison to the conventional impression technique (55). The digital impression technique showed an average internal range of 49 μm, while the conventional impression technique showed an average internal range of 71 μm ($p<0.05$) (61). According to the findings of Ender and Mehl's investigation, it was concluded that the conventional impression technique shows more accuracy and reliability compared to the digital measurement technique (62). Nevertheless, the digital impression technique has demonstrated a higher level of preference as a viable substitute for the conventional impression technique owing to its streamlined workflow, economic advantages, and enhanced patient comfort.

According to McLean and von Fraunhofer (63), for the long-term efficacy of the prosthetic restoration, the clinical internal range values should be 120 μm. Brojn et al. (64) determined that this value cannot exceed 200 μm. As a result of this study, the average internal range values in all groups were calculated below the values determined by McLean and Brojn.

For all restorations in the study, the occlusal region (measurement points 5 and 6) had the highest average internal range values, while the axiogingival region (measurement points 3 and 8) had the lowest internal range values.

Limitations Of The Study

The most significant limitation of this study is that its effect in the oral environment could not be measured because it was conducted in vitro. The conventional impression technique is affected by the difference between the intraoral temperature (32°) and the outside temperature. The structure of the material used in crown construction is a further factor that contributes to differences in outcomes between groups. This is a limitation of the research because there is evidence in the literature that this circumstance affects the internal harmony parameters discussed in the study. The measurement precision is affected by the polymerization shrinkage of the impression materials used in internal compliance measurements. In addition, the investigation was limited by the fact that internal range measurement values were obtained using the optical microscope method.

Conclusions

Within the limitations of this in vitro study:

1. There is no difference between the internal adaptation of crowns manufactured using digital workflow and crowns manufactured using traditional workflow.
2. Internal range values of all samples produced with digital and conventional manufacturing methods were measured to be less than 200 micrometres, which is clinically acceptable.
3. In the highest occlusal region and the lowest axiogingival region, the internal range values of all samples generated by digital and conventional workflows were observed.
4. Between axiooclusal measurement points, only statistically significant differences were observed.
5. In the monolithic zirconium group, the highest internal range mean value was measured at the occlusal measurement point.
6. At the axiogingival measurement point, the zirconia-supported ceramic group exhibited the lowest mean value of internal range.

Contributions of the authors involved in the research

A.Ş.: Author, Researcher, **L.C.H.:** Co-Author, Researcher

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Conflict of Interest Statement:

There is no conflict of interest regarding the materials, techniques and support received in the research.

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